

CHAPTER 15 – ICE AND RAIN PROTECTION SYSTEM

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1. INTRODUCTION

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

Hot, 14th stage engine bleed air is used for anti-icing the:

- Wing leading edges
- Engine cowlings.

Electrical power is used to provide anti-icing of the:

- Windshields
- Side windows
- Pitot static probes
- Static ports
- Ice detectors
- Total air temperature probe
- AOA sensors.

Electric windshield wipers provide rain removal for the pilot and copilot's windshields.

Independent ice detection probes sense the formation of ice and supply indications to the flight crew when the formation is greater than 0.020 inch.

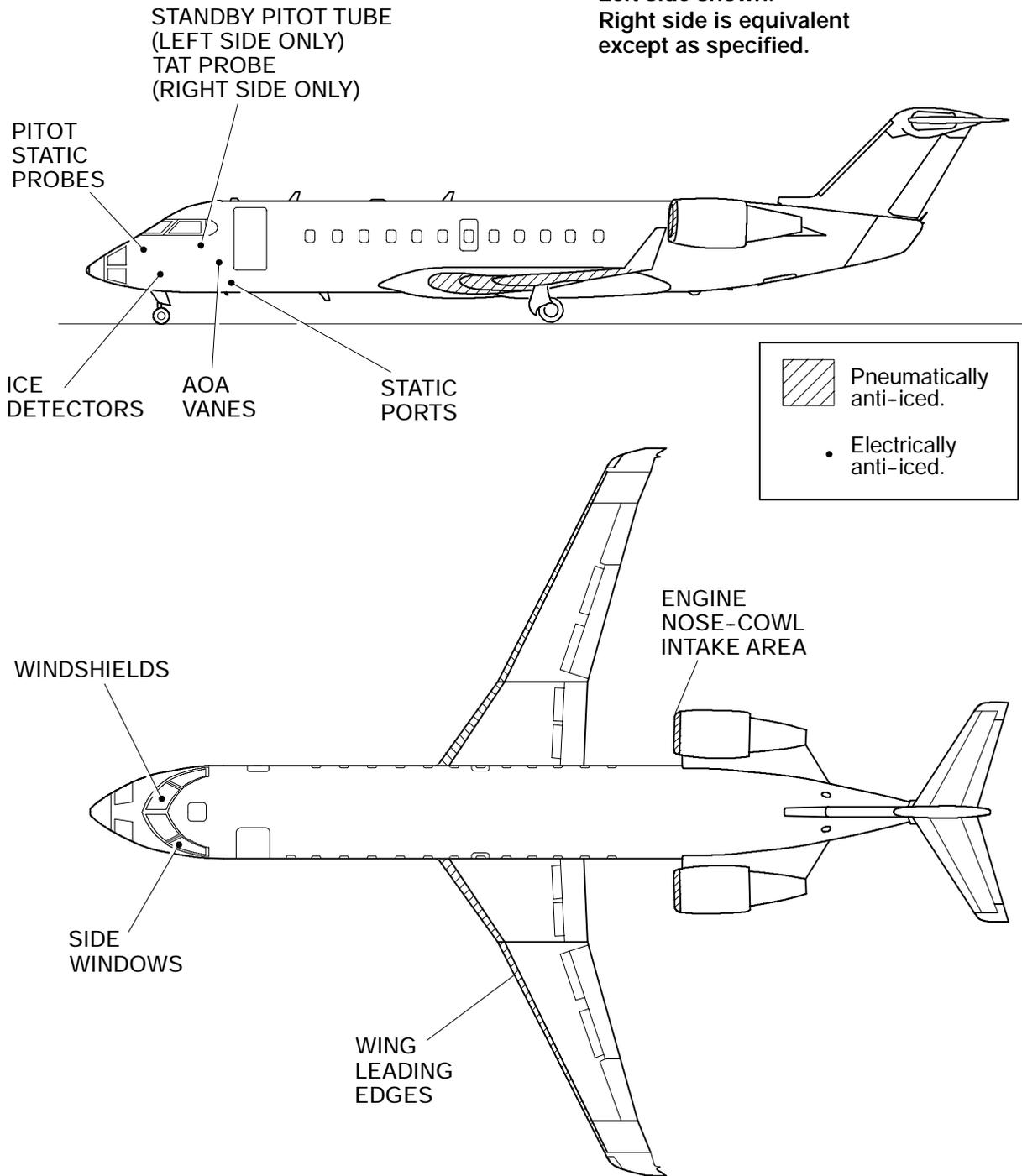
A bleed air leak detection system monitors the pneumatic ducting (refer to Chapter 19).

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.

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NOTE

Left side shown.
Right side is equivalent
except as specified.



Anti-Iced Areas
Figure 15-10-1

	ICE AND RAIN PROTECTION SYSTEM Ice Detection System	Vol. 1	15-20-1
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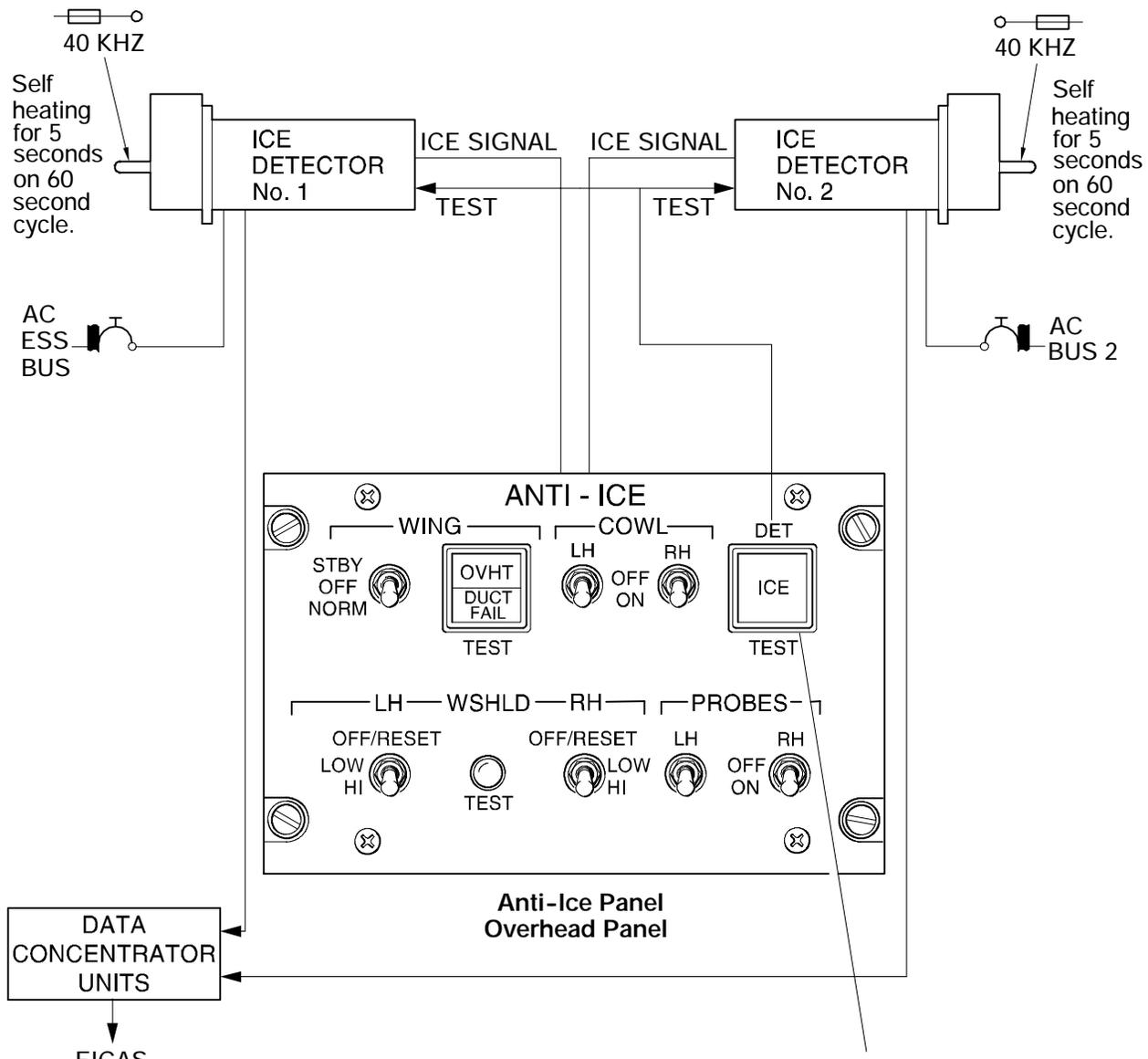
1. ICE DETECTION SYSTEM

The aircraft is equipped with an ice detection system to alert the flight crew of impending icing conditions. The ice detection system consists of two independent ice detector probes located on each side of the forward fuselage and extending into the airstream. The ice detection system operates continuously when AC power is available. During icing conditions, each detector is electrically deiced (for 5 seconds every 60 seconds) to clear the probe of ice build-up to allow continuous detection of ice formation.

The ice detectors interface with the data concentrator units (DCU) to provide visual indications of icing conditions.

The ice detectors interface with the data concentrator units (DCU) to provide aural and visual indications of icing conditions. <0022>

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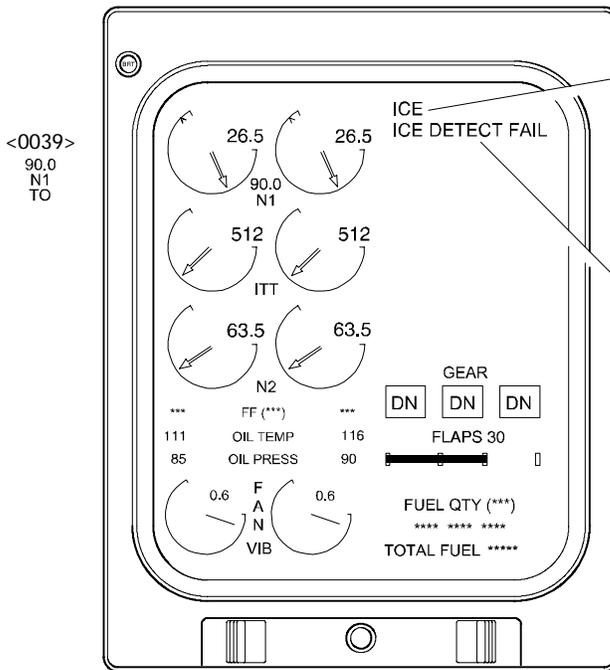
ICE Detector Switch/light <0022>

- ICE - Lamp comes on red to indicate airplane entry into icing conditions with both anti-icing systems not selected on. (Both wing and cowl anti-ice must be on to cancel alert.)

ICE Detector Switch/light

- ICE - Lamp comes on amber to indicate airplane entry into icing conditions with both anti-icing systems not selected on. (Both wing and cowl anti-ice must be on to cancel alert.)
- TEST - When switch is pressed, system is tested simulating an accumulation of ice on the ice detectors. This test also checks the probes heater system.

Ice Detection Functional Schematic <MST>
Figure 15-20-1



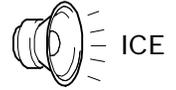
Primary Page

ICE caution (amber)

Comes on to indicate that ice has been detected and the wing/cowl anti-ice systems are not on. (Both wing and cowl anti-ice must be on to cancel alert.)

ICE warning (red) <0022>

Comes on to indicate that ice has been detected and wing/cowl are not selected on. (Both wing and cowl anti-ice must be on to cancel alert.)



ICE DETECT FAIL caution (amber)

Comes on to indicate that both channels of the ice detector unit are failed.



ICE status (white)

Comes on to indicate that ice has been detected and the wing/cowl anti-ice systems are on. Message will go off if probe no longer detects ice during its heating/detection cycle.

ICE advisory (green) <0039>

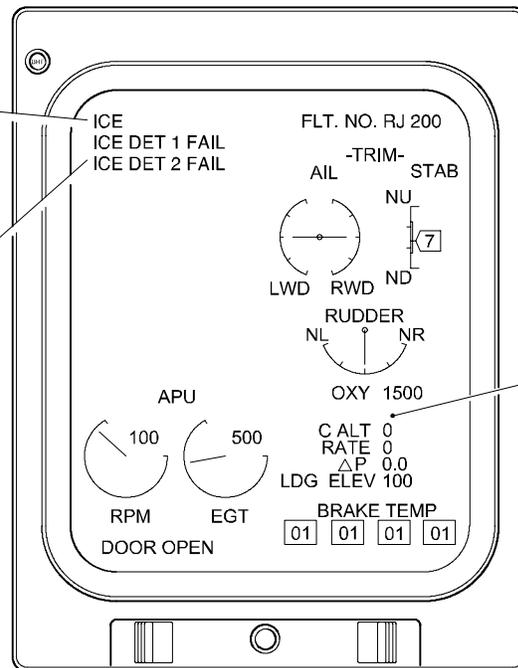
Comes on to indicate that ice has been detected and the wing/cowl anti-ice systems are on. Message will go off if probe no longer detects ice during its heating/detection cycle.

ICE DET 1, 2 FAIL status (white)

Comes on to indicate failure of corresponding ice detector unit.

ICE DET 1, 2 FAIL advisory (green) <0039>

Comes on to indicate failure of corresponding ice detector unit.

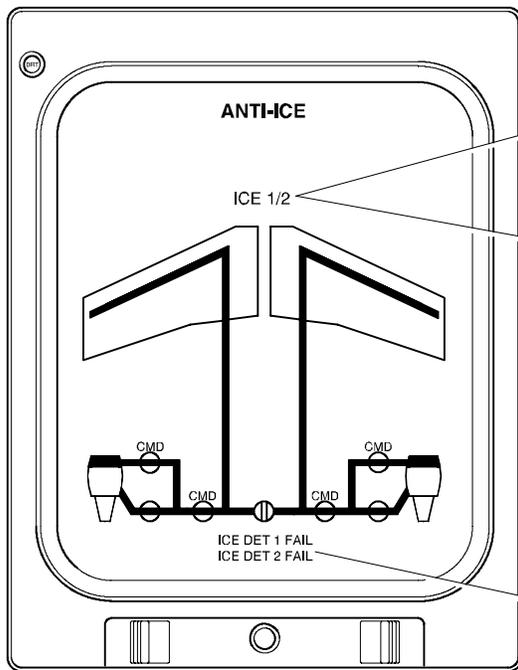


Status Page

<0039>
7.2

<0039>
C TEMP 23°C

Ice – EICAS Messages and Synoptic Page Indications <MST>
Figure 15-20-2 Sheet 1



Anti-Ice Page

ICE 1, 2 warning (red) <0022>

Comes on to indicate that ice has been detected (by respective detector) and that wing/cowl anti-ice systems not selected on.

ICE 1, 2 caution (amber)

Comes on to indicate that ice has been detected (by respective detector) and that wing/cowl anti-ice systems not selected on.

ICE 1, 2 status (white)

Comes on to indicate that ice has been detected (by respective detector) and that wing/cowl anti-ice systems are on.

ICE 1, 2 advisory (green) <0039>

Comes on to indicate that ice has been detected (by respective detector) and that wing/cowl anti-ice systems are on.

ICE DET 1, 2 FAIL status (white)

Comes on to indicate single failure of corresponding ice detector unit.

ICE DET 1, 2 FAIL advisory (green) <0039>

Comes on to indicate single failure of corresponding ice detector unit.

Ice – EICAS Messages and Synoptic Page Indications <MST>
Figure 15-20-2 Sheet 2



ICE AND RAIN PROTECTION SYSTEM
Ice Detection System

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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 ESS	3	B8	
		ICE DET 2	AC BUS 2	2	C7	



ICE AND RAIN PROTECTION SYSTEM
Ice Detection System

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	ICE AND RAIN PROTECTION SYSTEM Wing Anti-Ice System	Vol. 1	15-30-1
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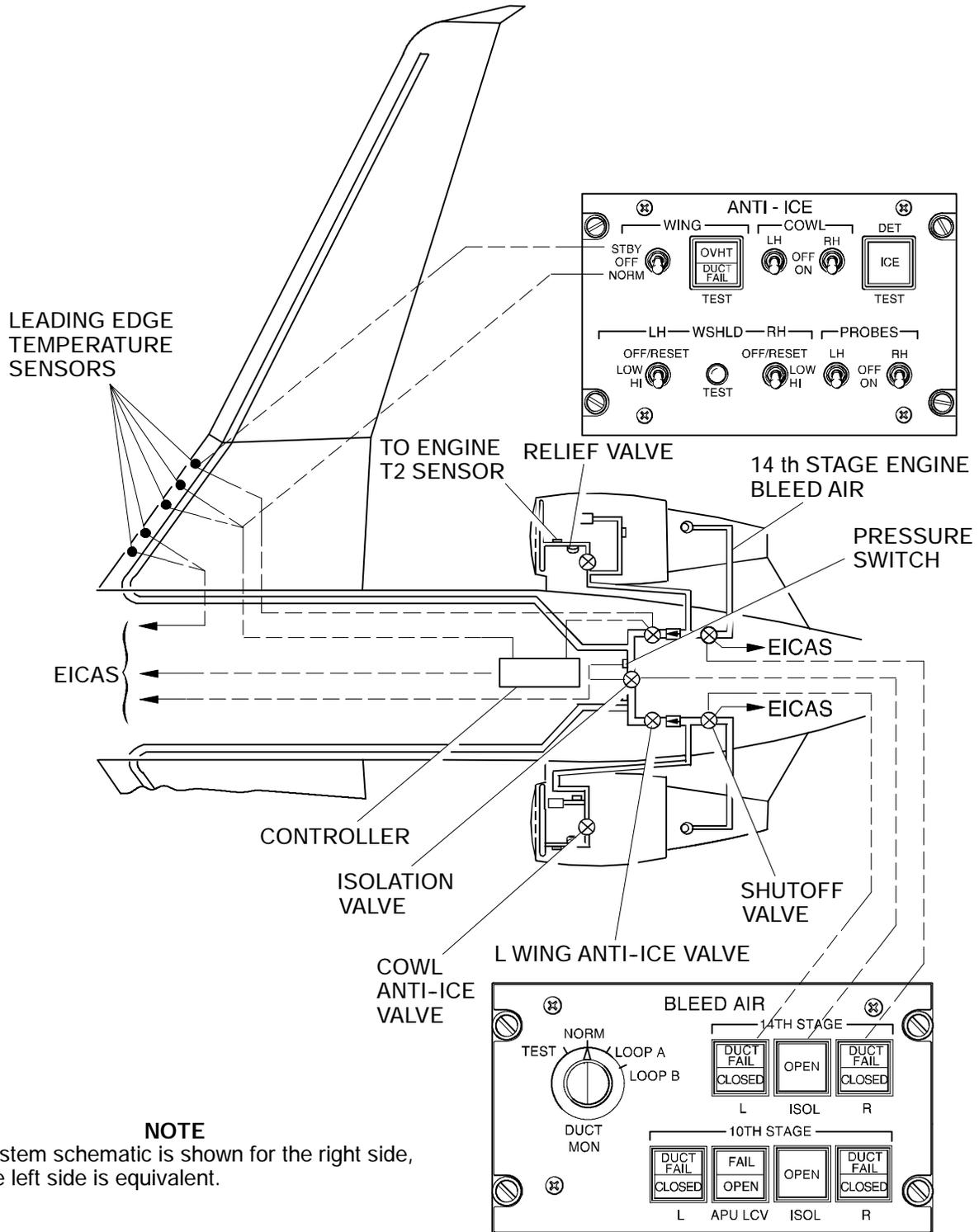
1. WING ANTI-ICE SYSTEM

The wing anti-ice system prevents ice formation on the wing leading edges by heating the surfaces with hot 14th stage engine bleed air. The hot bleed air is supplied through insulated ducting and released through piccolo tubes to the inner surface of the wing leading edges. When normal anti-icing is selected, the wing leading edges are maintained at a constant temperature to shed ice and to prevent further ice accumulation.

The wing anti-ice system is divided into identical left and right systems. In normal operation, each engine supplies hot bleed air to its respective wing anti-ice system. The systems are connected by a, normally closed, 14 stage isolation valve. In the event one system fails, the isolation valve is opened to permit cross bleeding between systems. This ensures that wing anti-icing is maintained to both systems.

The system is manually activated and is automatically controlled by an anti-ice temperature controller located in the aft equipment compartment. The anti-ice temperature controller controls the wing anti-ice system by using inputs, received from temperature sensors located on each wing leading edge, to modulate the wing anti-ice valves to provide sufficient hot air to the leading edges to prevent ice formation.

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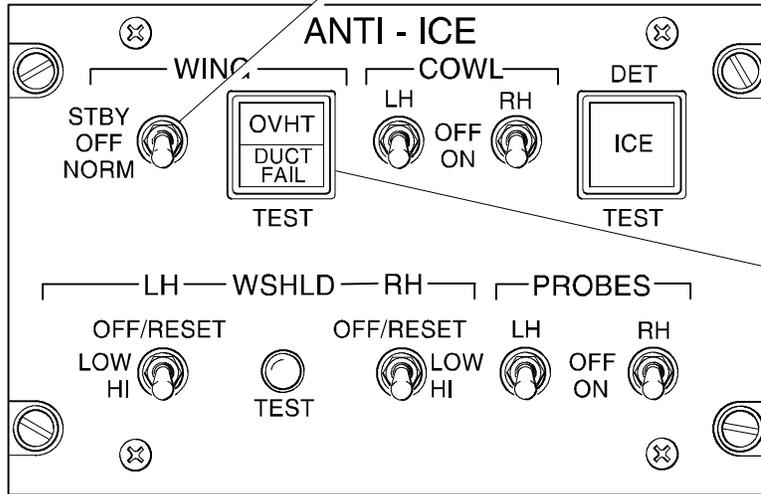


Wing Anti-Ice System
Figure 15-30-1

WING Anti-Ice Switch

Controls operation of left and right wing (modulating and shutoff) valves.

- NORM - Anti-icing controller operates modulating / shutoff valves to maintain a constant wing leading edge temperature of $107 \pm 8^\circ \text{C}$ ($225 \pm 15^\circ \text{F}$).
- OFF - Closes modulating / shutoff valves and shuts down air supply.
- STBY - Modulating / shutoff valves cycle open / closed to maintain wing leading edge temperature of $49 \pm 4^\circ \text{C}$ ($120 \pm 8^\circ \text{F}$).



Anti-Ice Panel Overhead Panel

Wing Overheat/Duct Failure Switch/Light

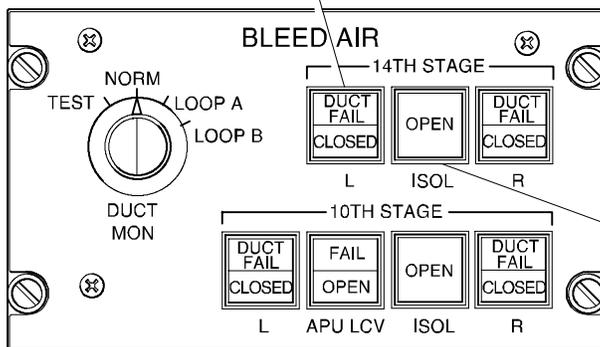
Used to test bleed air leak detection system and to indicate failures/overtemperature conditions.

- OVHT (red) - OVHT light comes on when overheat condition exists in wing leading edge.
- DUCT FAIL (red) - Light comes on when bleed air leak is detected in wing left or right anti-ice ducts. Light goes out when the failed duct is isolated and temperature sensor cools.
- TEST - When switch is pressed, the normal mode of the overheat system is tested. WING OVHT warning message, "Wing overheat" aural, OVHT light and WING A/ICE OK status message will come on. The position of the wing switch (either STBY, OFF or NORM) does not alter the test.

14TH STAGE L/R Switch/Lights

When pressed in, associated bleed air shutoff valve opens and CLOSED (white) goes out. When pressed out, valve closes and CLOSED (white) comes on.

- DUCT FAIL (red) - Comes on if sensors detect a failure in associated duct section. DUCT FAIL goes out when the failed duct is isolated and temperature sensor cools.

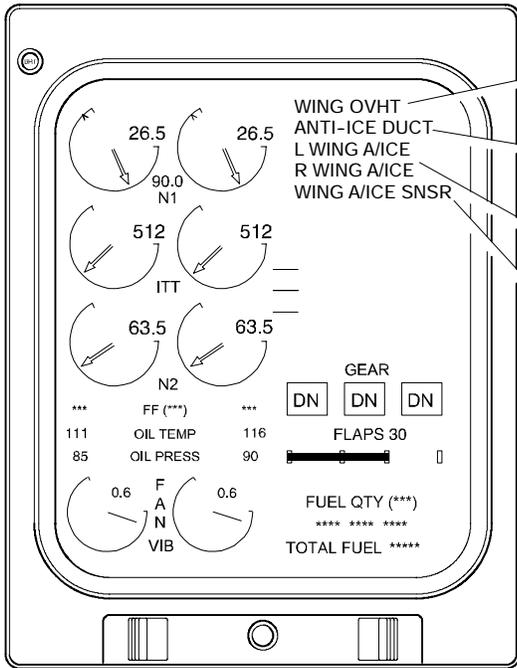


Bleed Air Panel Overhead Panel

14TH STAGE Isolation Valve Switch/Light

- When pressed in, bleed air isolation valve opens and OPEN (white) comes on.
- When pressed out, isolation valve closes and OPEN light goes out.

Wing Anti-Ice Controls
Figure 15-30-2



Primary Page

WING OVHT warning (red)

Comes on when overheat condition exists in wing leading edge. Accompanied by voice alert:



ANTI-ICE DUCT warning (red)

Comes on when bleed air leak is detected in left and/or right fuselage or wing anti-ice ducts. Accompanied by voice alert:



L/R WING A/ICE caution (amber)

Comes on when failure is detected in wing anti-ice system (left or right).

WING A/ICE SNSR caution (amber)

Comes on to indicate that a fault is detected in the wing anti-ice sensor.



WING A/ICE OK advisory (green)

Comes on to indicate sufficient heat available for use of anti-ice and both overheat detectors are operational.

DUCT TEST O.K. advisory (green)

Comes on to indicate that corresponding loop test is successful.

WING A/ICE ON advisory (green) <0039>

Comes on to indicate that the wing anti-ice system has been selected on and is operating normally.

WING / COWL A/I ON advisory (green) <0039>

Comes on to indicate that the wing and cowl anti-ice systems have been selected on and are operating normally.

14 TH ISOL OPEN status (white)

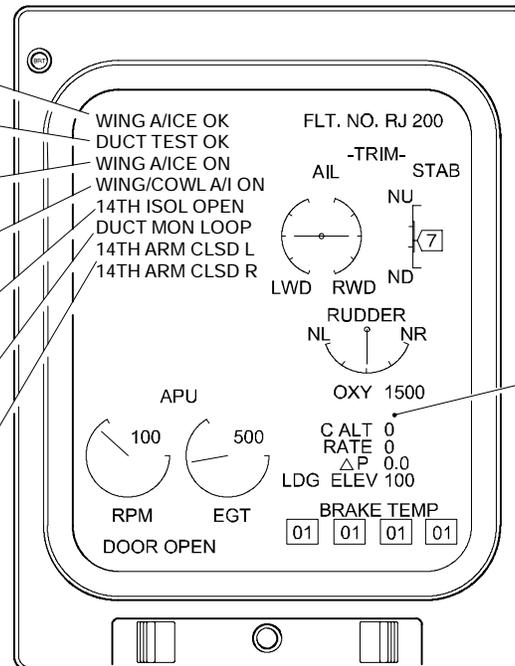
Comes on when the 14th stage bleed air isolation valve is open.

DUCT MON LOOP A, B status (white)

Comes on to indicate that corresponding loop is under test.

14 TH ARM CLSD (L, R) status (white) <0039>

Comes on to indicate that the applicable 14th stage bleed air switch is selected closed but the SOV is open.



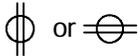
Status Page

Wing Anti-Ice EICAS Messages <MST>
Figure 15-30-3

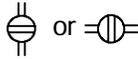
**Wing Anti-Ice Duct,
Fuselage Duct and
Piccolo Tube Synoptic**

- Green - Operational
- Amber - Temperature caution 39 °C (102 °F) and pressure is less than or equal to 7 psig.
- Red - Overheat warning 148 °C (300 °F).

Valve Position Indicator
Indicates open



Indicates closed

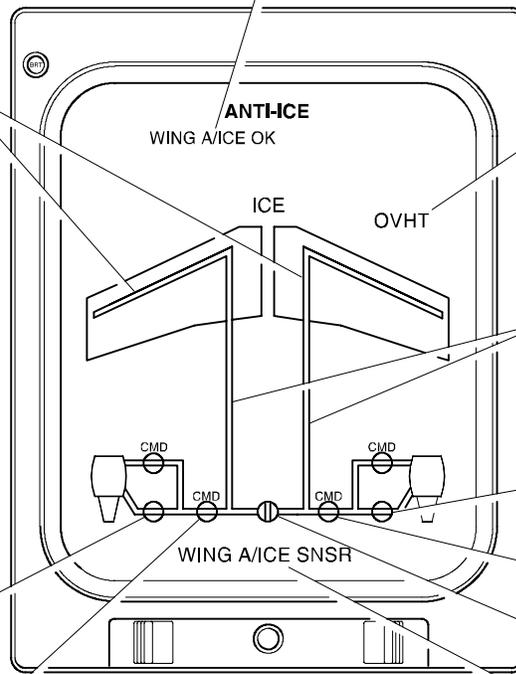


Indicates invalid data
⊖ or ⊕ (no tube)

Left 14th Stage Shutoff Valve

Left Wing Anti-Icing Valve

WING A/ICE OK Message (green)
Successful test of wing anti-ice system.



Anti-Ice Page

OVHT warning (red)
Comes on to indicate overheat condition in respective wing anti-ice system.

Wing Anti-Ice Flow Line (green) <0039>
Comes on (with applicable EICAS advisory message) to indicate that wing anti-ice system has been selected on and is operating normally.

Right 14th Stage Shutoff Valve

Right Wing Anti-Icing Valve

14th Stage Isolation Valve

WING A/ICE SNSR
Comes on to indicate wing anti-ice sensor failure.

Wing Anti-Ice Synoptic Page Indications <MST>
Figure 15-30-4



**ICE AND RAIN PROTECTION SYSTEM
Wing Anti-Ice System**

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A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Wing and Cowl Anti-Ice	Anti-ice Controller	MAN 1	DC ESS	4	B4	
		MAN 2	DC BAT	2	N5	
		A/ICE AUTO 1	DC BUS 1	1	G2	
		A/ICE AUTO 2	DC BUS 2	2	G2	
	14th Stage Bleed Air	B/AIR ISOL	DC BUS 1	1	F9	
		B/AIR ISOL L			F10	
		B/AIR ISOL R	DC BUS 2	2	F10	

	ICE AND RAIN PROTECTION SYSTEM Engine Cowl Anti-Ice System	Vol. 1	15-40-1
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1. ENGINE COWL ANTI-ICE SYSTEM

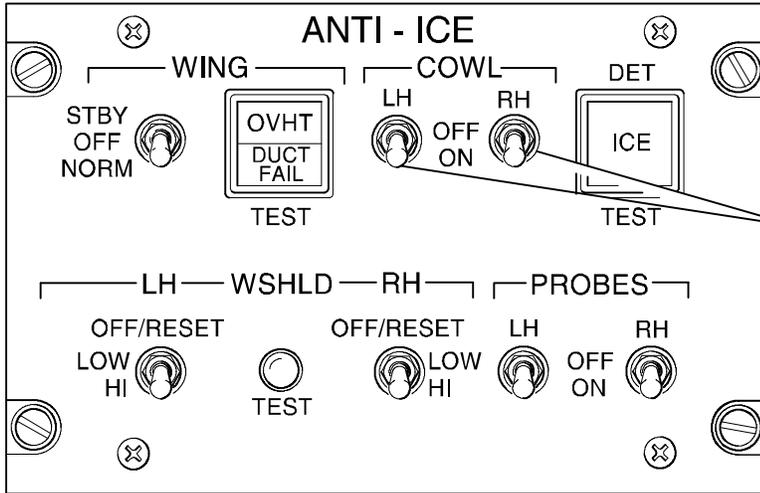
The engine cowl anti-ice system prevents ice formation on the engine intake leading edges and the engine T2 sensors by heating the surfaces with hot 14th stage engine bleed air. The hot bleed air is supplied to the intake leading edges through respective L/R cowl anti-ice valves. (Refer to figure 1, section 30 of this chapter)

The left and right cowl anti-ice pressure regulating and shutoff valves are manually controlled by the respective LH and RH COWL switches on the ANTI-ICE control panel. The valves are electrically controlled and pneumatically operated and are failed-safe to the open position. When power is applied to the aircraft, the valves go to close. Crew activation of each system, opens the respective cowl anti-ice valve.

Each cowl anti-ice system also contains an overpressure relief valve mounted downstream of the cowl anti-ice valves. When an overpressure condition occurs, the relief valve opens to dump the excess pressure overboard and an indicator extends out the nose cowl to indicate that the relief valve is open. After an overpressure, the relief valve remains open and the indicator is visible during a walkaround. Maintenance should be advised before resetting the relief valve.

Valve status is displayed on the EICAS, ANTI-ICE synoptic page.

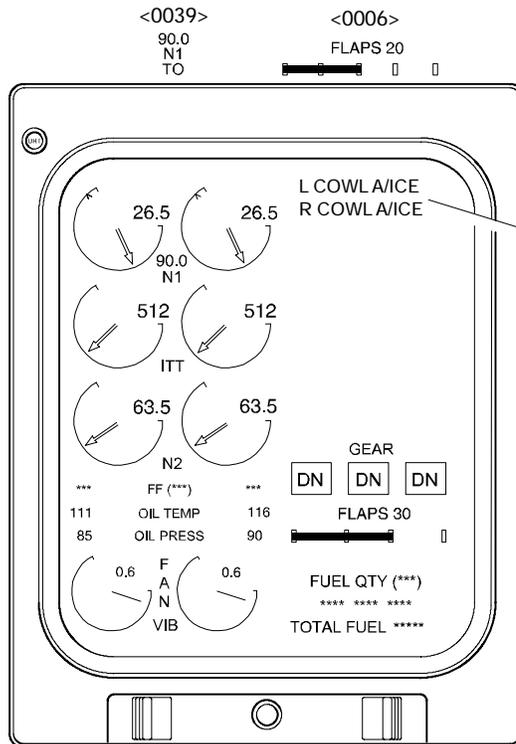
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COWL Anti-Ice LH/RH Switches
Controls operation of cowl anti-ice shut-off valves.

- ON - Opens applicable cowl anti-ice shut-off valve, to provide 14th stage bleed air to the cowl and T2 probe at the engine inlet.
- OFF - Closes applicable cowl anti-ice shutoff valve.

Anti-Ice Panel



L, R COWL A/ICE caution (amber)
Comes on to indicate failure of cowl anti-ice valve.

If applicable cowl anti-ice valve is switched on then the message indicates insufficient pressure.
If applicable cowl anti-ice valve is switched off, the message indicates pressure is in the system (i.e., valve failed open).

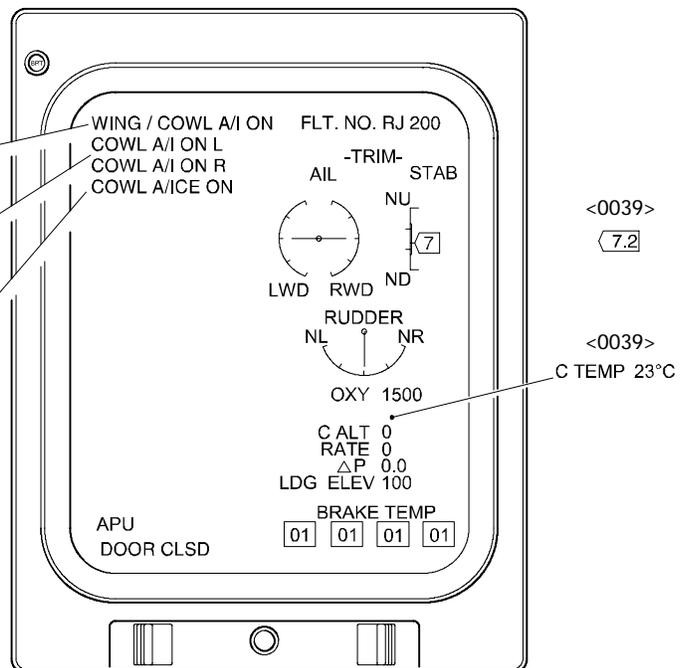
Primary Page

**Cowl Anti-Ice Control and Primary Page Instructions <MST>
Figure 15-40-1**

WING / COWL A/I ON advisory (green)
Comes on to indicate that the wing and cowl anti-ice systems have been selected on and are operating normally.

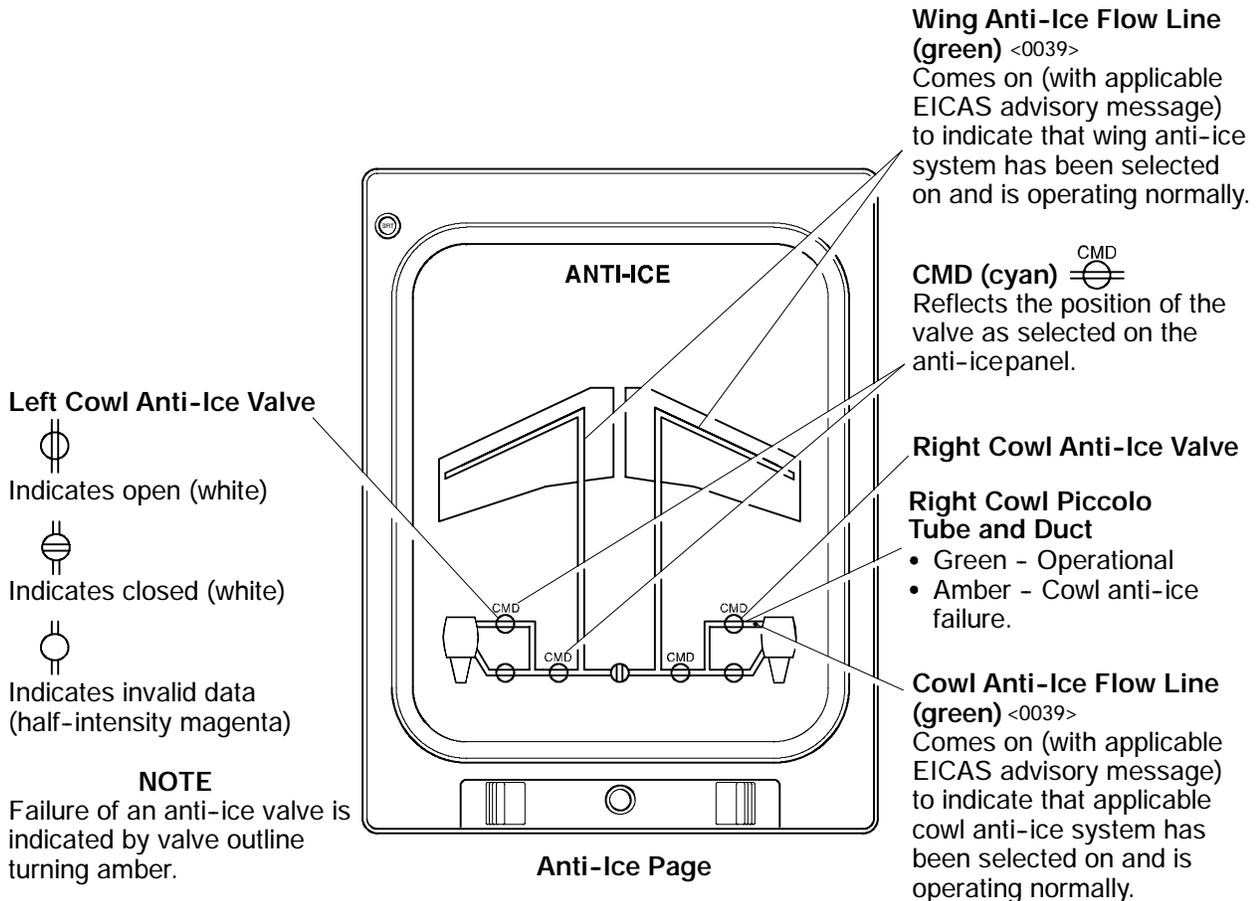
COWL A/I ON (L, R) advisory (green)
Comes on to indicate that the applicable cowl anti-ice system has been selected on and is operating normally.

COWL A/I ON advisory (green)
Comes on to indicate that both cowl anti-ice systems have been selected on and are operating normally.



Status Page

**Cowl Anti-Ice Status Page Indications <MST>
Figure 15-40-2**



Cowl Anti-Ice Synoptic Page Indications <MST>
Figure 15-40-3



**ICE AND RAIN PROTECTION SYSTEM
Engine Cowl Anti-Ice System**

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A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Engine Cowl Anti-Ice	Cowl Anti-Ice Valves	A/ICE VALVE L ENG	DC BAT	2	N3	
		A/ICE VALVE R ENG			N4	



**ICE AND RAIN PROTECTION SYSTEM
Engine Cowl Anti-Ice System**

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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 probes and sensors are monitored and controlled by three independent and identical air data sensor heater controllers (ADSHC's). Controller 1 monitors the heater elements for the left pitot, left and right base heaters, left angle of attack (AOA) vane and left static port. Controller 2 monitors the right pitot, right AOA vane, total air temperature (TAT) probe and right static port. Controller 3 monitors the standby pitot probe. The ADSHC's electronically control the heating elements to prevent ice formation that may cause erroneous air data information. 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. 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 (The APU does not control this function). The static ports, base heaters, TAT probe, and the AOA vanes are not powered automatically in the ground mode. However, they can be heated by selecting the LH and RH PROBES switches to ON.

NOTE

During ground operations, when AC power is on-line and the air-bridge is being used, the probes will be powered and the ground crew should be advised of the hazard areas.

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, regardless of PROBES switch position.

NOTE

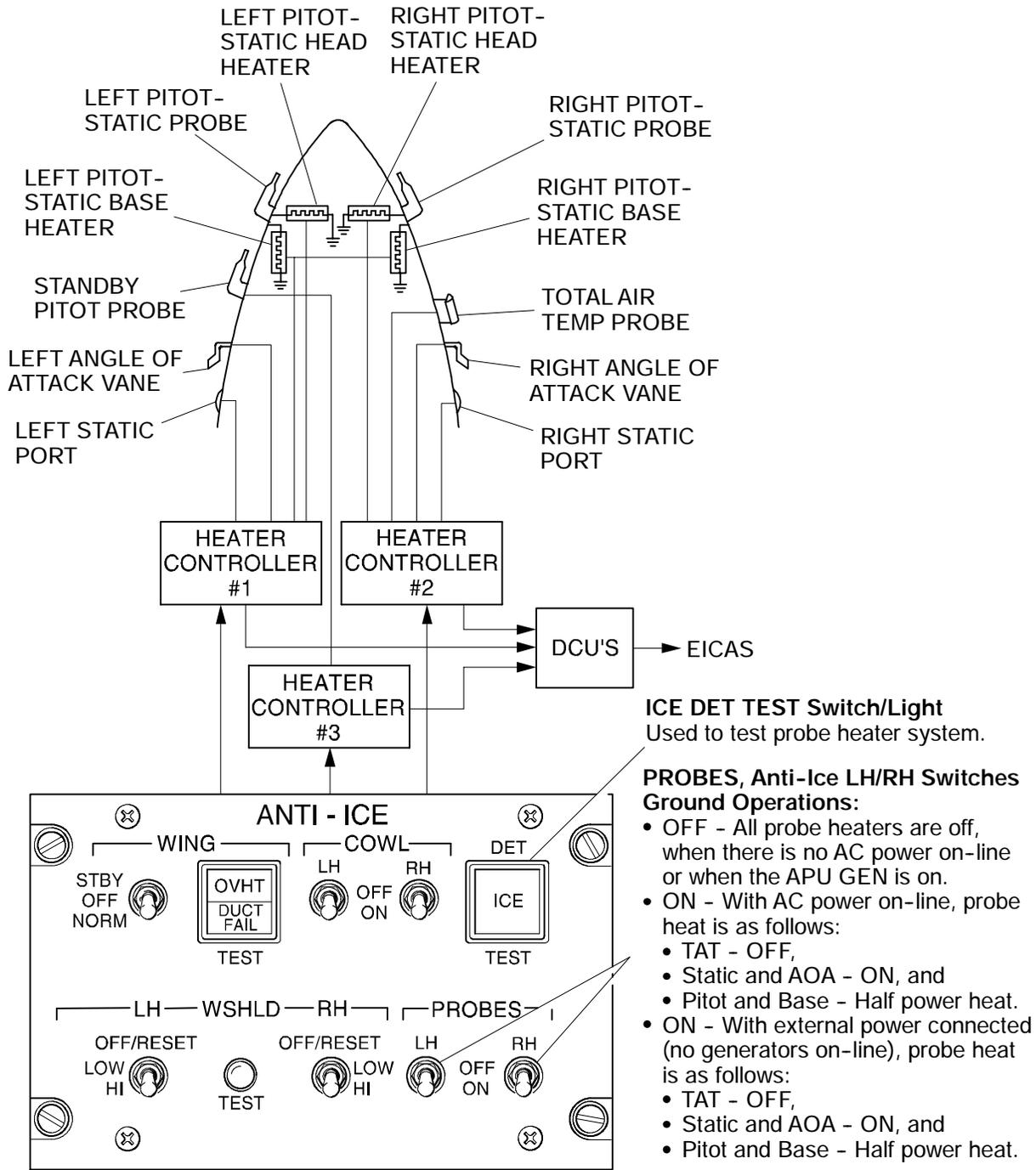
Following an ADG deployment, if the power interruption lasts longer than 5 seconds, the PITOT BASE HEAT caution message will remain latched. After landing, the heater ADS CONT 1 circuit breaker (CB4-A7) may be pulled and reset to remove the caution message.

Effectivity:

- Airplanes 7003 to 7189 incorporating SB 601R-24-082 and aircraft 7190 and subsequent.

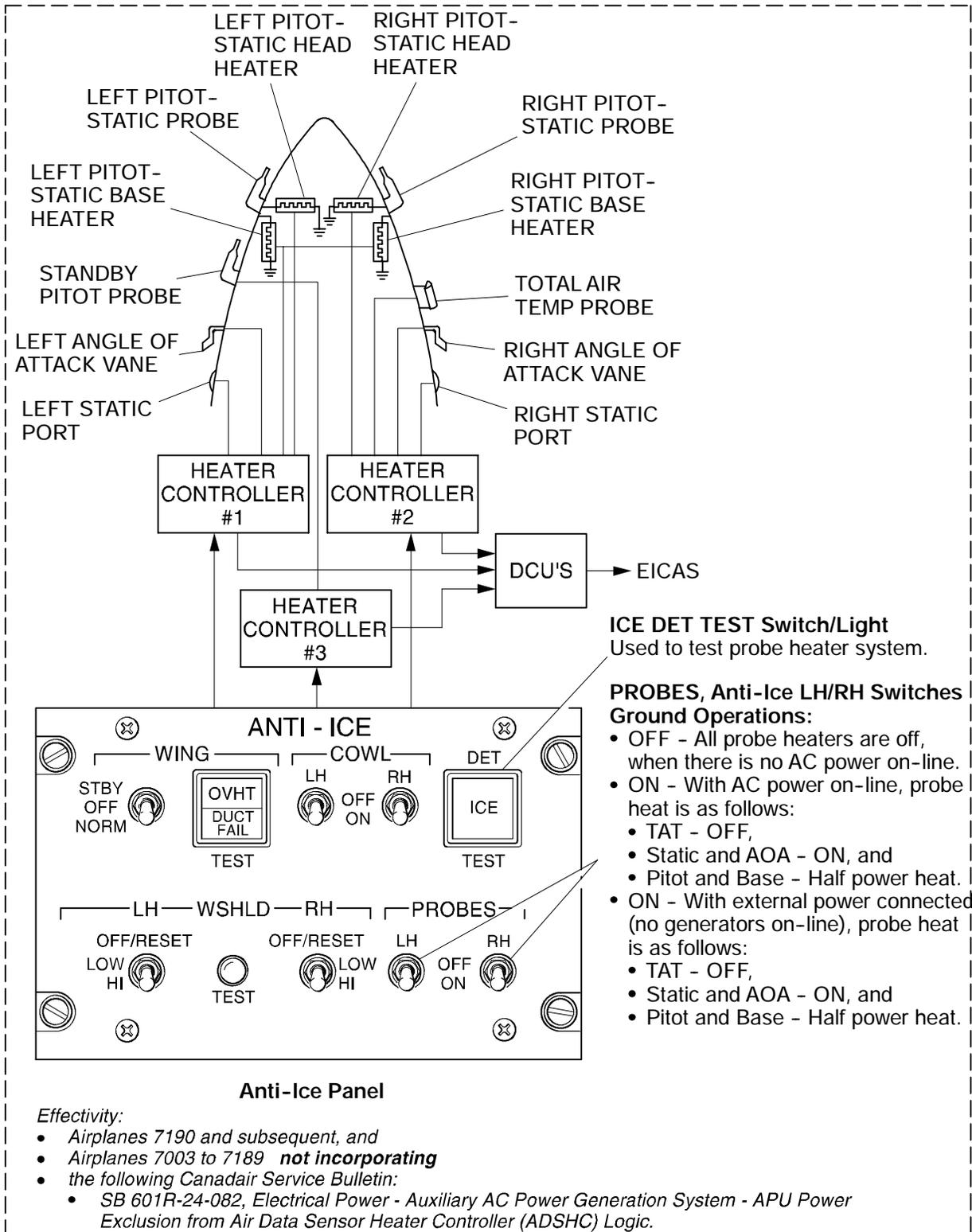
NOTE

After engine start, with the engine generators off, the L, R and STBY PITOT HEAT caution messages will remain displayed until an engine generator is brought on line.

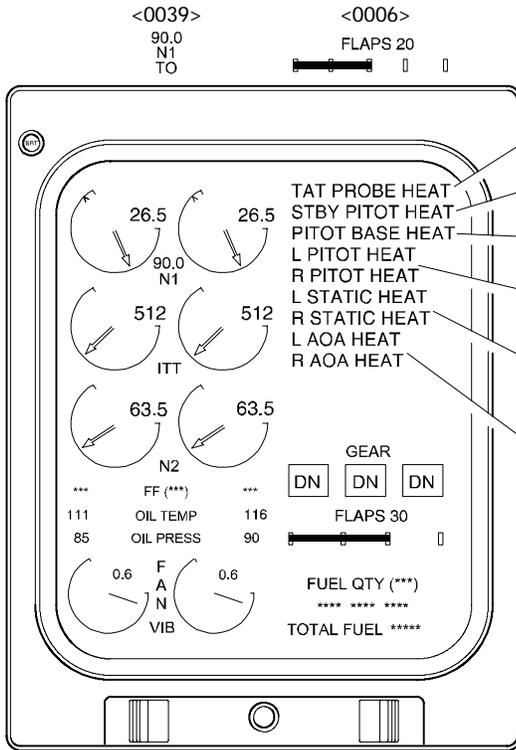


Anti-Ice Panel

Air Data Anti-Ice System and Control
Figure 15-50-1



Air Data Anti-Ice System and Control
Figure 15-50-1



Primary Page

TAT PROBE HEAT caution (amber)

Comes on to indicate failure of total air temperature probe heater.

STBY PITOT HEAT caution (amber)

Comes on to indicate failure of the standby pitot heater.

PITOT BASE HEAT caution (amber)

Comes on to indicate failure of the pitot base heat.

L, R PITOT HEAT caution (amber)

Comes on to indicate no current to corresponding pitot-static heater (or PROBES switch not at ON).

L, R STATIC HEAT caution (amber)

Comes on to indicate failure of corresponding static port heater.

L, R AOA HEAT caution (amber)

Comes on to indicate failure of corresponding angle of attack vane heater.

**Air Data Anti-Ice EICAS Messages <MST>
Figure 15-50-2**



**ICE AND RAIN PROTECTION SYSTEM
Air Data Sensor Anti-Ice System**

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A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Air Data Sensor Anti-Ice	Pitot	PITOT L	AC ESS	3	B4	
		PITOT R	AC BUS 1	1	A14	
		PITOT STBY	AC ESS	3	B6	
	Static	STATIC L	DC ESS	4	A6	
		STATIC R	DC BUS 1	1	F14	
	AOA	AOA L	AC ESS	3	B5	
		AOA R	AC BUS 1	1	A13	
	TAT	TAT				A12
	ADS Controllers	ADS CONT 1	DC ESS	4	A7	
		ADS CONT 2	DC BUS 1	1	F13	



**ICE AND RAIN PROTECTION SYSTEM
Air Data Sensor Anti-Ice System**

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	ICE AND RAIN PROTECTION SYSTEM Windshield Wiper System	Vol. 1	15-60-1
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1. WINDSHIELD AND SIDE WINDOW ANTI-ICE AND DE-FOGGING SYSTEM

Anti-icing and defogging of the windshields and side windows is achieved by electrically heating the windshields 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 if one of the other sensors fail.

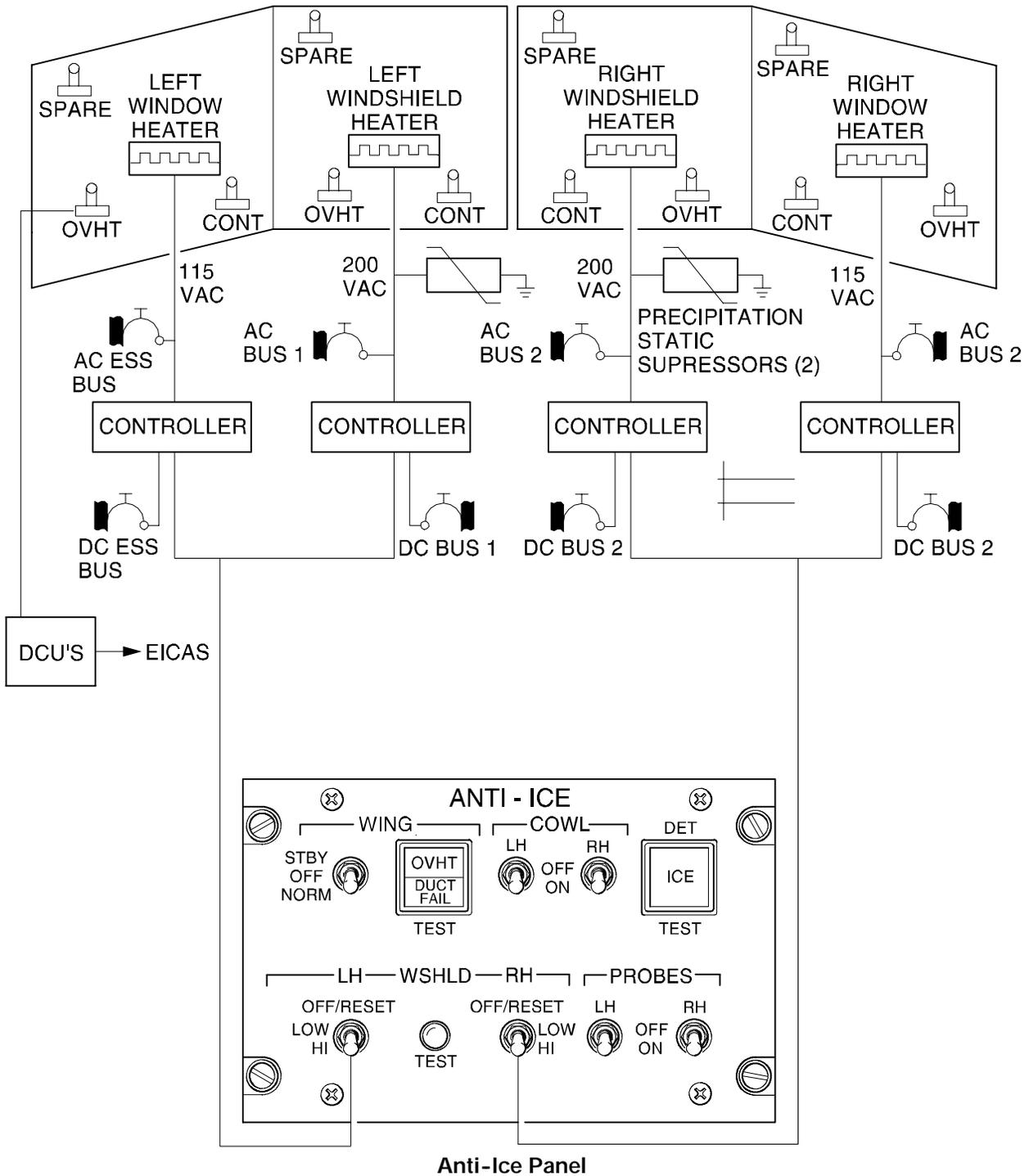
The amount of heat supplied to the windshields and side windows is controlled by four identical temperature controllers, one for each window. The controllers automatically regulate power to the heating elements as selected by the LOW/HI WSHLD switches on the ANTI-ICE control panel. When the switches are set to HI, the windshields are heated at a high temperature, but the side window temperatures are maintained at the LOW setting.

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.

NOTE

If a windshield or side window heater fails, the related windshield or side window may fog up during high humidity conditions.

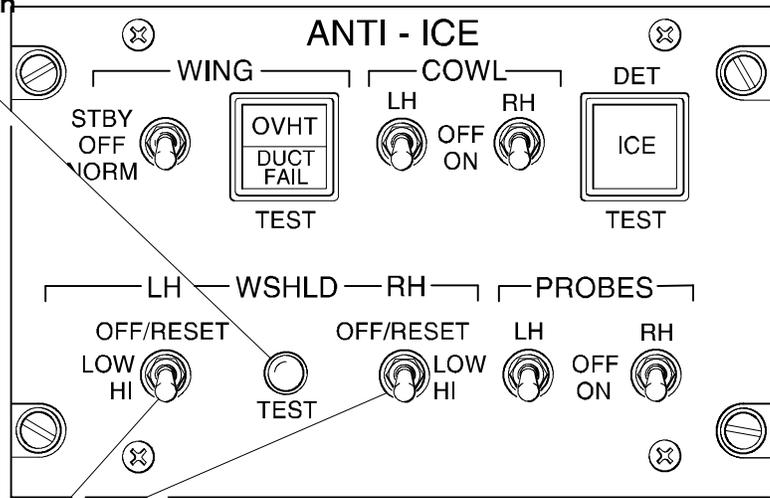
	Flight Crew Operating Manual CSP A-013	MASTER
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Windshield and Side Window Anti-Ice and De-Fogging
Figure 15-60-1

Windshield Anti-Ice TEST Switch

Used to test windshield anti-ice system; simulates a no-heat condition.

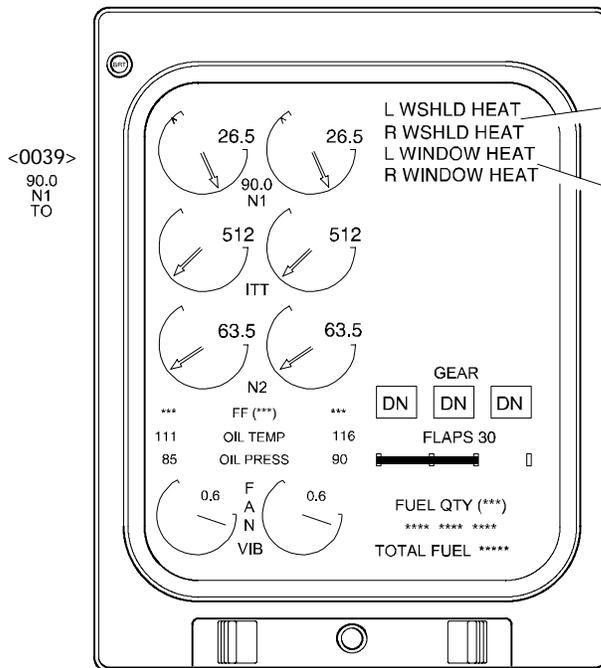


Anti-Ice Panel

Windshield Anti-Ice/Anti-Fog LH/RH Switches

Used to heat windshields and windows.

- **HI** - High temperature heat 41 °C (105 °F) to corresponding windshield (and low level 24 °C (75 °F) to side window).
- **LOW** - Low temperature heat 24 °C (75 °F) to corresponding windshield, and side window.
- **RESET/OFF** - Windshield and window heat not in use and resets corresponding overheat circuit.



Primary Page

L, R WSHLD HEAT caution (amber)

Comes on to indicate actual failure of corresponding windshield anti-ice system, or during a test.

L, R WINDOW HEAT caution (amber)

Comes on to indicate actual failure of corresponding window heating system, or during a test.

Windshield and Side Window Anti-Icing and De-Fogging –
Control and Primary Page Instructions <MST>

Figure 15-60-2



**ICE AND RAIN PROTECTION SYSTEM
Windshield Wiper System**

Vol. 1	15-60-4
REV 56, Jan 31/03	

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Windshield and Side Window Anti-Ice	Windshields	HEATER LEFT WSHLD	AC BUS 1	1	A10-A11	
		HEATER CONT L WSHLD	DC BUS 1		F12	
		HEATER RIGHT WSHLD	AC BUS 2	2	A10-A11	
		HEATER CONT R WSHLD	DC BUS 2		F12	
	Side windows	HEATER WIND L	AC ESS	3	B3	
		HTR CONT WIND L	DC ESS	4	A11	
		HEATER WIND R	AC BUS 2	2	A12	
		HTR CONT WIND R	DC BUS 2		F13	

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1. WINDSHIELD WIPER SYSTEM

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

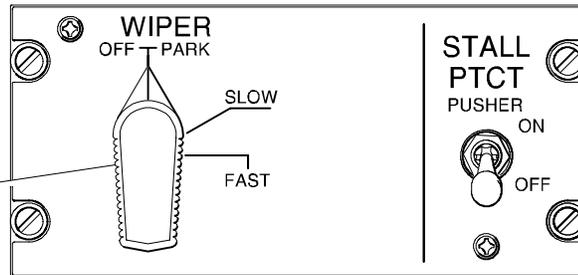
The windshield wiper system consists of independent pilot and copilot systems. Each system consists of a windshield wiper and motor. Each pilot has a selector, located on the WIPER control panel that actuates both wipers. Under normal operations, both wipers will operate in the same mode when selected 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.

With either switch selected to the SLOW position, the wipers operate at approximately 80 cycles per minute. At FAST position the wipers operate at approximately 125 cycles per minute.

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Wiper Selector

- OFF-PARK - Stows the wiperblades and stops the motors.
- SLOW/FAST - Wiper speed selections.



Wiper Control Panel

Windshield Wiper – Control Panel
Figure 15-70-1



**ICE AND RAIN PROTECTION SYSTEM
Windshield Wiper System**

Vol. 1

15-70-3

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A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Windshield Rain and Snow Removal	Wipers	WIPER 1 MOTOR	DC BUS 1	1	G5	
		WIPER 1 CONTROL			G6	
		WIPER 2 MOTOR	DC BUS 2	2	G5	
		WIPER 2 CONTROL			G6	



**ICE AND RAIN PROTECTION SYSTEM
Windshield Wiper System**

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