

SECTION 2-15

ICE AND RAIN PROTECTION

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GENERAL

Airplane ice protection system is provided by heating critical ice build up areas through the use of either hot air or electrical power. The system is fully automatic and under icing conditions, activates the entire protection system (the only exception is the windshield heating system).

The hot air-heated areas are:

- Wing and horizontal stabilizer leading edges.
- Engine air inlet lips.

The electrically heated areas are:

- Windshields.
- Pitot tubes, Pitot-static tube, AOA sensors, TAT probes, ADCs and pressurization static ports.
- Lavatory water drain and water service nipples.

Two fully independent wiper systems remove rain from the windshields.

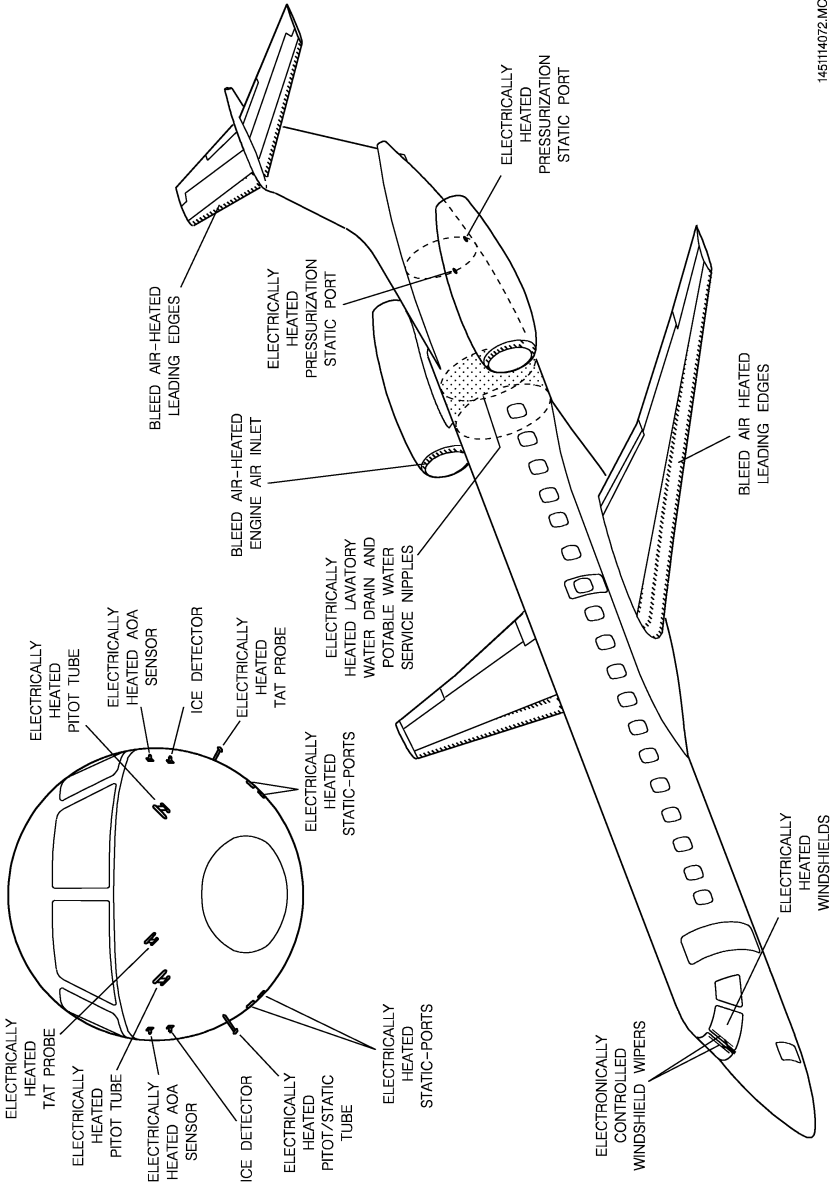
All ice protection systems provide signals to the EICAS for malfunctioning system display.



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ICE AND RAIN PROTECTION SYSTEM



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BLEED AIR THERMAL ANTI-ICING SYSTEM

The bleed air thermal anti-icing system is supplied with hot air tapped from the engines. In the automatic mode, the system is turned on through activation of either ice detector. Manually, setting the OVERRIDE Knob to the ALL position activates the system.

Adequate ice protection for the wing and horizontal stabilizer leading edges and engine air inlet lips is ensured by heating these surfaces. Hot air supplied by the Pneumatic System is ducted through perforated tubes, known as Piccolo tubes. Each Piccolo tube is routed along the surface, so that hot air jets flowing through the perforations heats the surface. Dedicated slots are provided for hot air exhaustion after the surface has been heated.

During night flights, inspection lights, installed on the wing-to-fuselage fairing, illuminate the wing leading edges, allowing the crew to check for ice accumulation.

Each subsystem comprises an anti-icing valve (pressure regulating/shutoff valve). A restrictor limits the airflow rate supplied by the Pneumatic System. It is monitored by pressure sensors, that indicate abnormal low and high air pressure conditions. The pressure sensors protect the respective subsystem against either insufficient or excessive airflow rate.

The wing and stabilizer low pressure protection mode has a redundant detection by means of a second low pressure sensor on the stabilizer system and a differential pressure switch (± 2 psi) that compares root pressure on the left and right half-wing Piccolo tubes.

Air leakage is detected by thermostats installed close to each duct connection. Low pressure switches provide an additional protection against unacceptable leakage level.

The Piccolo tubes integrity is monitored as follows:

- Horizontal stabilizer: By one differential pressure switch comparing the left and right Piccolo tubes pressure.
- Half-wing: It depends on the airplane model. By one differential pressure switch in each Piccolo tube comparing the root and tip pressures or, by manometric switches measuring the tip pressure only.



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Engine ice protection is provided by heating the engine air inlet lip, through the use of non-temperature-controlled hot air tapped directly upstream of each high stage valve. As the engine air inlet has enough airflow surrounding the lip when the engine is running, the engine air inlet lip anti-icing system can be operated on the ground normally and with no limitations. Each engine has its own protection system independent of the airplane's pneumatic system.

The left hand Pneumatic System supplies the horizontal stabilizer anti-icing subsystem. Each half-wing anti-icing subsystem is supplied by its respective side of the Pneumatic System.

The bleed air thermal anti-icing system may be deactivated by buttons, located on the overhead panel.

On the ground, the FADEC incorporates an automatic logic to reduce the maximum available thrust to avoid a sudden engine thrust loss during lift-off, even with the thrust lever set at MAX position.

In flight, the FADEC allows the engines to deliver the maximum rated thrust to compensate for the effect of the high bleed air consumption by the wing and horizontal stabilizer thermal anti-icing subsystems. Moreover, the FADEC provides an automatic logic to ensure a minimum available thrust during icing conditions, even during low thrust setting conditions. This logic is automatically inhibited when the landing gear is extended, in order to improve the airplane's rate of descent and glide slope path adjusting capability.

The APU bleed air is not hot enough to perform anti-icing functions. Therefore it must not be used for such applications.

A caution message is presented on the EICAS if the thermal anti-icing system is turned on during non-icing conditions.

WING, STABILIZER AND ENGINE ANTI-ICING VALVES OPERATIONAL LOGIC

Since the Bleed Thermal Anti-icing System is supplied by the Pneumatic System, it is integrated to the functional logic that provides automatic control and protection for the system.

The Wing and Stabilizer Anti-icing Valves receive an electrical input that open when the following conditions occur:

- The Ice Detection Test Knob is set to 1 or 2, or
- The airplane is in-flight or attained a ground speed above 25 knots, and
- The Ice Detection Override Knob is set to ALL, or
- The Ice Detection Override Knob is set to AUTO or ENG and any ice detector is activated.

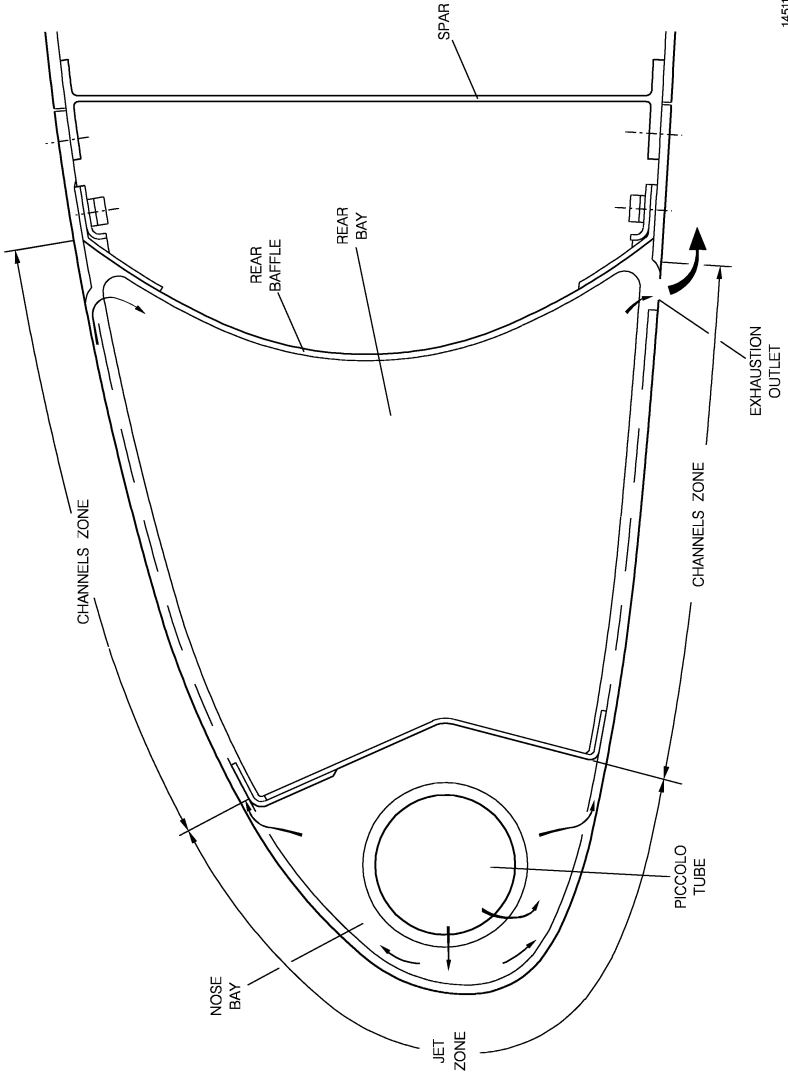
NOTE: The Wing and Stabilizer Anti-icing Valves are inhibited from opening on the ground and at a ground speed below 25 knots to prevent structural damage caused by surface heating, except during ice detection testing. The ice detection test should not be activated for more than 15 seconds.

The Engine Anti-icing Valves receive an electrical input to open when the following conditions occur:

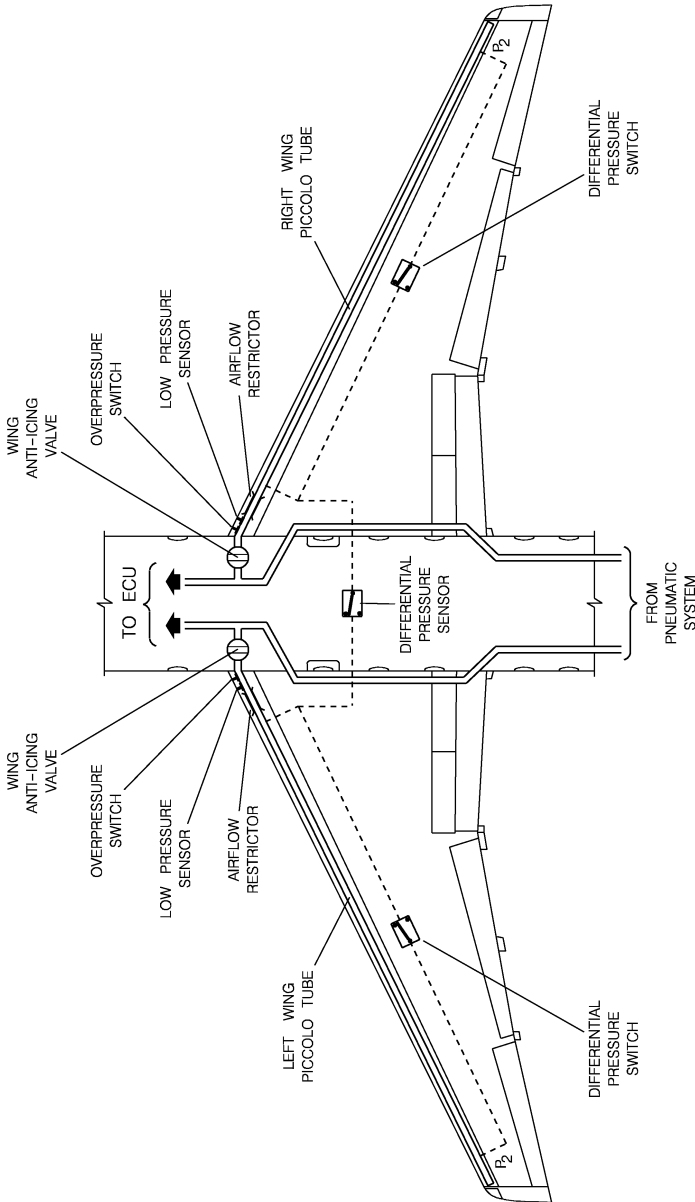
- The Ice Detection Override Knob is set to ALL or ENG, or
- The Ice Detection Override Knob is set to AUTO position and any ice detector is activated, or
- The Ice Detection Test Knob is set to 1 or 2.

The engine anti-ice system logic has a narrow range between normal operating pressures and a low pressure value that, if reached, would trigger an E1(2) A/ICE FAIL message on the EICAS. This message may be presented in flight whenever the engines are set at low thrust settings. This message may be cleared increasing the engine anti-ice system pressure by advancing the thrust levers with Ice Detection Override Knob in AUTO. If the message does clear and the related Engine Air Inlet OPEN inscription remains illuminated, the system is operating normally and the flight may be continued.

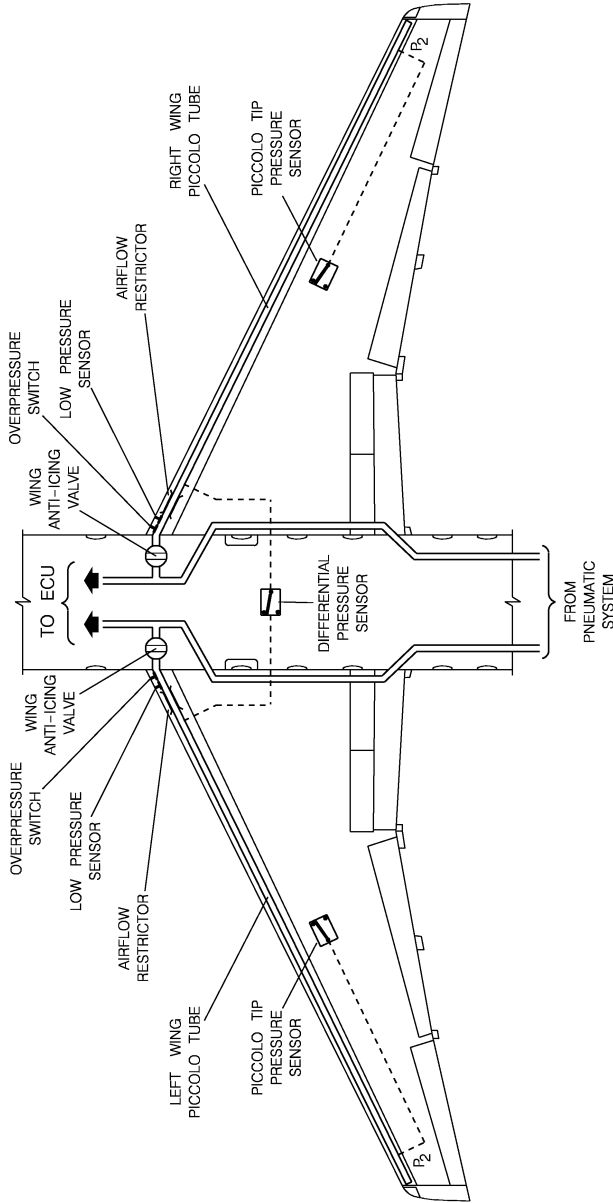
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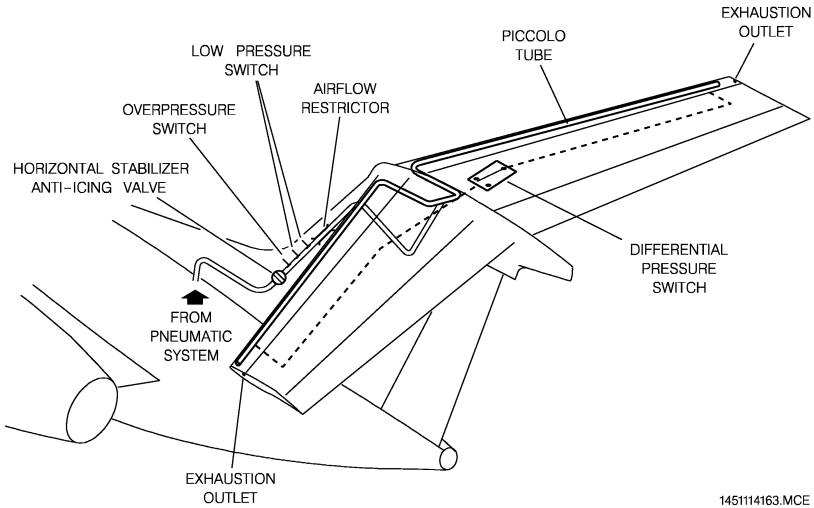
WING ANTI-ICING SYSTEM SCHEMATIC



AIRPLANES PRE-MOD. SB 145-30-0019
WING ANTI-ICING SYSTEM SCHEMATIC

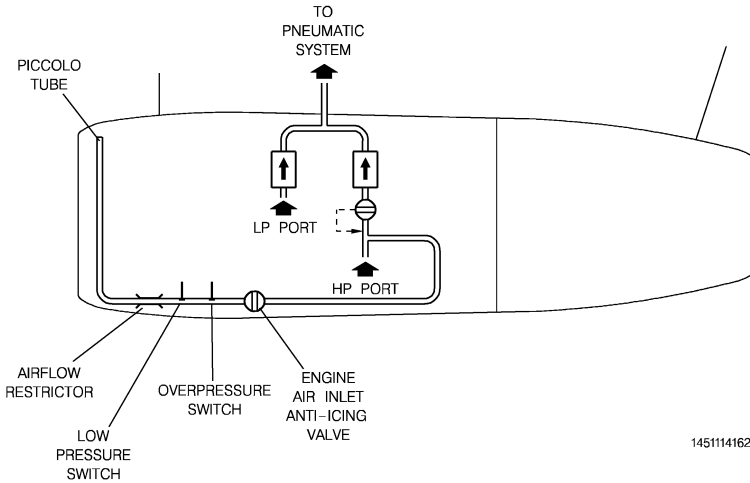


**AIRPLANES POST-MOD. SB 145-30-0019
 WING ANTI-ICING SYSTEM SCHEMATIC**



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HORIZONTAL STABILIZER ANTI-ICING SYSTEM SCHEMATIC



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ENGINE AIR INLET ANTI-ICING SYSTEM SCHEMATIC

EICAS MESSAGES

TYPE	MESSAGE	MEANING
WARNING	ICE COND-A/I INOP	Any Bleed Air Thermal anti-icing subsystem not functioning properly under icing conditions.
CAUTION	A/ICE LOW CAPACITY	Low pressure condition downstream of any wing or stabilizer anti-ice valve or wing pressure asymmetry.
	NO ICE-A/ICE ON	Any anti-icing valve opened in flight out of icing conditions.
	A/ICE SWITCH OFF	Any Bleed Air Thermal anti-icing button turned off.
	E1 (2) A/ICE FAIL (if applicable)	<ul style="list-style-type: none"> - Low pressure condition. - Valve failure. - Any switch failure. - Overpressure condition. - Any system failure.
	ENG1 (2) A/ICE FAIL (if applicable)	<ul style="list-style-type: none"> - Low pressure condition (on ground or inflight), or - Disagreement between valve position and system command.
	WG1 (2) A/ICE FAIL (if applicable)	<ul style="list-style-type: none"> - Low pressure condition. - Valve failure. - Any switch failure. - Duct leakage. - Any system activation failure.
	WG A/ICE FAIL (if applicable)	<ul style="list-style-type: none"> - Low pressure condition, or - Disagreement between valve position and system command, or - Piccolo tube failure.
	WG A/ICE ASYMETRY	Asymmetrical degradation of half-wings anti-ice systems thermal performance.
	STAB A/ICE FAIL	<ul style="list-style-type: none"> - Low pressure condition. - Valve failure. - Any switch failure. - Duct leakage. - Any system activation device failure.
ADVISORY	ENG A/ICE OVERPRES	Inflight overpressure condition detected.

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WINDSHIELD HEATING SYSTEM

The windshields are electrically heated to prevent ice and fog formation or for deicing and defogging purposes. Due to a higher thermal inertia to bring heat to windshield inner layer, when Descent phase is initiated the system must be turned ON to prevent fogging. During all the others flight phases, the system must be kept OFF except when icing conditions are anticipated or if situation requires. For airplanes equipped with PPG windshield, the windshield heating system may be selected ON during all flight phases.

The outer glass layer has no structural significance but provides a rigid, hard and protected surface.

Windshield heating is accomplished through an electric conductive grid embedded in its interlayer, which functions as an electric resistor.

Individual buttons located on the overhead panel control left and right windshield heating. Separate power supplies are provided for each windshield heating element and its control circuit.

Each windshield element is provided with three temperature sensors. One sensor is used for temperature control and a second sensor is used for overheat protection. A third sensor is provided as a spare for use by maintenance personnel, should a failure occur in any of the two sensors.

For airplanes Pre-Mod. SB 145-30-0033, each windshield element has a dedicated temperature controller that receives a signal from the associated temperature sensors and controls the windshield temperature. When the temperature reaches the upper limit (45°C), power supply to the heater is interrupted. When the temperature is below the lower limit (40°C), power supply is automatically restored. A caution message W/S HEAT FAIL is presented on the EICAS when a system failure is detected or the windshield temperature exceeds 55°C.

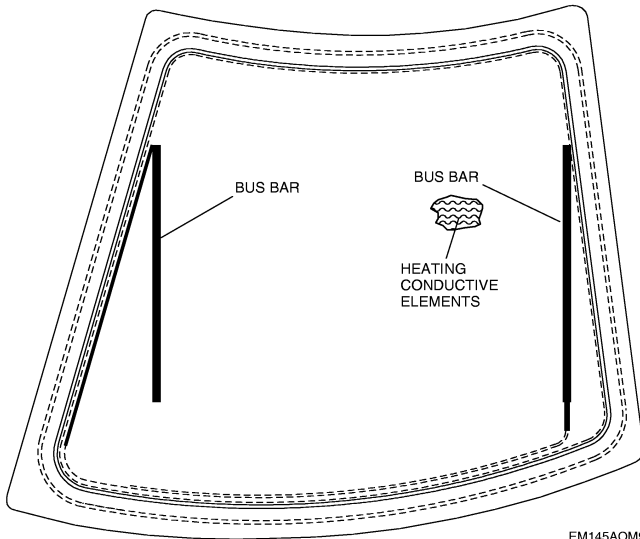
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For airplanes Post-Mod. SB 145-30-0033 or with an equivalent modification factory-incorporated, the temperature controller has two modes of operation, defog heat and anti-ice heat mode. When the windshield heating push button is set to ON, the controller continuously monitors the windshield temperature; as temperature drops below 26°C (defog mode), it modulates power input to the electric conductive grid and maintains this temperature. If ice detectors sense ice formation, the controller automatically increase power input to maintain the temperature at 43°C (anti-ice mode). If both ice detectors are inoperative, the Override knob on the Overhead Panel set to ALL position provides manual means to put both systems into anti-ice mode automatically increasing power input to maintain the temperature at 43°C. A caution message W/S HEAT FAIL is presented on the EICAS when a system failure is detected or the windshield temperature exceeds 65°C.

WINDSHIELD DIFFERENTIATION

SIERRACIN WINDSHIELD

Sierracin windshields can be easily identified by their green colored tint and by the positions of the bus bars to which the heater filaments are attached, in the vertical direction, as shown below:



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SIERRACIN WINDSHIELD SCHEMATIC

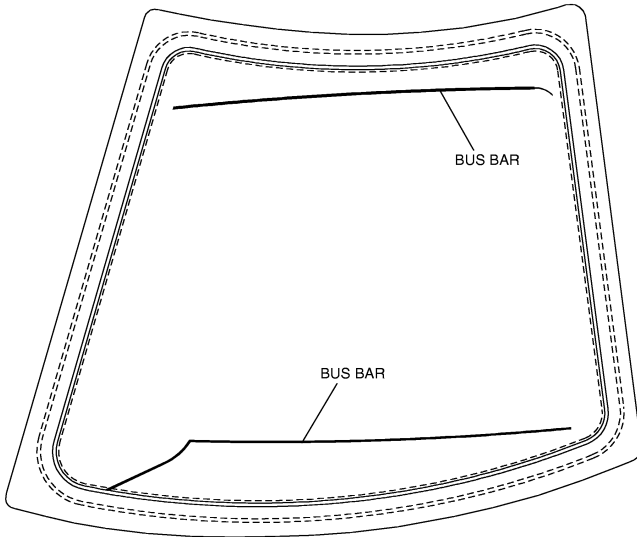
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PPG WINDSHIELD

PPG windshields can be easily identified by the positions of the bus bars to which the heater filaments are attached, in the horizontal direction, as shown below:



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PPG WINDSHIELD BUS BARS POSITIONS

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EICAS MESSAGES

TYPE	MESSAGE	MEANING
CAUTION	W/S 1 (2) HEAT FAIL	For airplanes Pre-Mod. SB 145-30-0033, associated windshield heating system failure (< 38°C) or associated overheat condition (> 55°C). For airplanes Post-Mod. SB 145-30-0033, associated windshield heating system failure or associated overheat condition (> 65°C).

SENSOR HEATING SYSTEM

The Sensor Heating System provides automatic operation for the heater elements of Pitot tubes 1 and 2, Pitot/Static 3, Pressurization System and ADS Static Ports, TAT sensors 1 and 2, and AOA vanes 1 and 2, thus providing constant temperature and ice-free operation during all flight phases.

All the sensors are electrically heated and controlled by three buttons, located on the overhead panel.

In the automatic mode, the sensor heating system operates according to three functional logics:

- Pitot 1 and 2 and Pitot/Static 3, AOA 1 and 2, ADS Static Ports 1, 2, 3 and 4, and Pressurization Static Ports 1 and 2 are heated whenever at least one engine is running (N2 above 54.6%).
- A separate logic assures Pitot/Static 3 and Pressurization System Static Port 2 heating in any flight condition.
- TAT 1 and 2 are heated provided either Engine 1 or 2 anti-icing subsystem is functioning or airplane is in flight (the TAT sensor normal range of operation is from - 99°C to + 99°C).

NOTE: For airplanes Pre-Mod. SB 145-30-0028, when operating in icing conditions on the ground with the Engine Anti-Ice turned ON, if a TAT invalid indication is displayed on the MFD due to temperature values beyond the sensor normal range (TAT digits replaced by three amber dashes) with the consequent AHRS reversion to the Basic Mode, disregard the information and continue the takeoff normally. The TAT invalid indication and AHRS reversion will remain until the airplane reaches a sufficient speed to bring the TAT sensors into the normal range of operation.

This may occur on the ground or when airplane is airborne and the airplane will return to the normal condition (AHRS Full Performance) and no pilot's or maintenance personnel's action is required.

Heater deactivation is accomplished either when the above conditions are not met or when the associated control button is manually pressed.

Caution messages are presented on the EICAS to indicate that the sensor heating is inoperative. These messages are inhibited during the takeoff and approach phases.

EICAS MESSAGES

TYPE	MESSAGE	MEANING
CAUTION	PITOT 1 (2, 3) INOP	<ul style="list-style-type: none"> – Associated sensor heating inoperative with any engine running (N2 above 60%). – Both engines N2 below 50%.
	AOA 1 (2) HEAT INOP	<ul style="list-style-type: none"> – Associated sensor heating inoperative with any engine running (N2 above 60%) and airplane airborne. – Both engines N2 below 50%.
	TAT 1 (2) HEAT INOP	Associated sensor heating inoperative in icing conditions and airplane airborne.

LAVATORY WATER DRAIN AND NIPPLE HEATING SYSTEM

The lavatory waste water drain and water service nipples (overflow and fill) are heated by electric resistors to prevent clogging by water freezing under any atmospheric conditions on the ground and in flight.

The heating is automatically turned on when the DC BUS 1 is powered.

Refer to Section 2-2 – Equipment and Furnishings.

ICE PROTECTION CONTROLS AND INDICATORS

ICE PROTECTION CONTROL PANEL

1 - ENGINE AIR INLET ANTI-ICING BUTTONS

- Turns off (released) or permits (pressed) the automatic activation of the associated engine air inlet anti-icing subsystem.
- A striped bar illuminates inside the button to indicate that it is released.
- An OPEN inscription illuminates inside the button to indicate that the associated engine air inlet anti-icing valve is open.

2 - WING ANTI-ICING BUTTON

- Turns off (released) or selects the automatic mode (pressed) of the half-wing anti-icing subsystems.
- A striped bar illuminates inside the button to indicate that it is released.
- An OPEN inscription illuminates inside the button to indicate the following conditions:
 - Both valves are open with the system commanded to open.
 - At least one valve is open with the system not commanded to open.

3 - HORIZONTAL STABILIZER ANTI-ICING BUTTON

- Turns off (released) or permits (pressed) the automatic activation of the horizontal stabilizer anti-icing subsystem.
- A striped bar illuminates inside the button to indicate that it is released.
- An OPEN inscription illuminates inside the button to indicate that the horizontal stabilizer anti-icing valve is open.

4 - SENSOR HEATING BUTTONS

- The left button controls Pitot tube 1, AOA 1 vane, TAT 1 probe, ADC Static Ports 1 and 3, and pressurization static port 1.
- The central button controls Pitot/Static tube 3 and pressurization static port 2.
- The right button controls the Pitot tube 2, AOA 2 vane, TAT 2 probe and ADC static ports 2 and 4.
- When pressed, the associated sensor heating system operates in the automatic mode according to its functional logic. When released, the associated sensor heating system is turned off.
- A striped bar illuminates inside the button to indicate that it is released.

5 - ICE DETECTION TEST KNOB

Permits the half-wing, horizontal stabilizer and engine air inlet anti-icing subsystems to operate for test purposes, by simulating an icing condition on ice detectors 1 and 2. The adequate system operation is confirmed by the illumination of the OPEN inscriptions in the anti-icing buttons, which indicate the current valve position.

NOTE: The ICE CONDITION, ICE DET 1 (2) FAIL and BLD 1 (2) LOW TEMP messages are displayed during test. The CROSS BLD OPEN message is also presented for airplanes Pre-Mod. SB 145-36-0028.

6 - ICE DETECTION OVERRIDE KNOB

ENG - Turns on the engine air inlet anti-icing subsystems for ground speeds below 25 knots. Above 25 knots the wing and horizontal stabilizer anti-icing subsystems are also turned on if icing condition is detected.

AUTO- Allows the automatic operation of the bleed air anti-icing system.

NOTE: If ground speed is equal or above 25 knots and an icing condition is detected, wing and horizontal stabilizer anti-icing subsystems are turned on. The engine anti-icing subsystem is turned on as soon as an icing condition is detected.

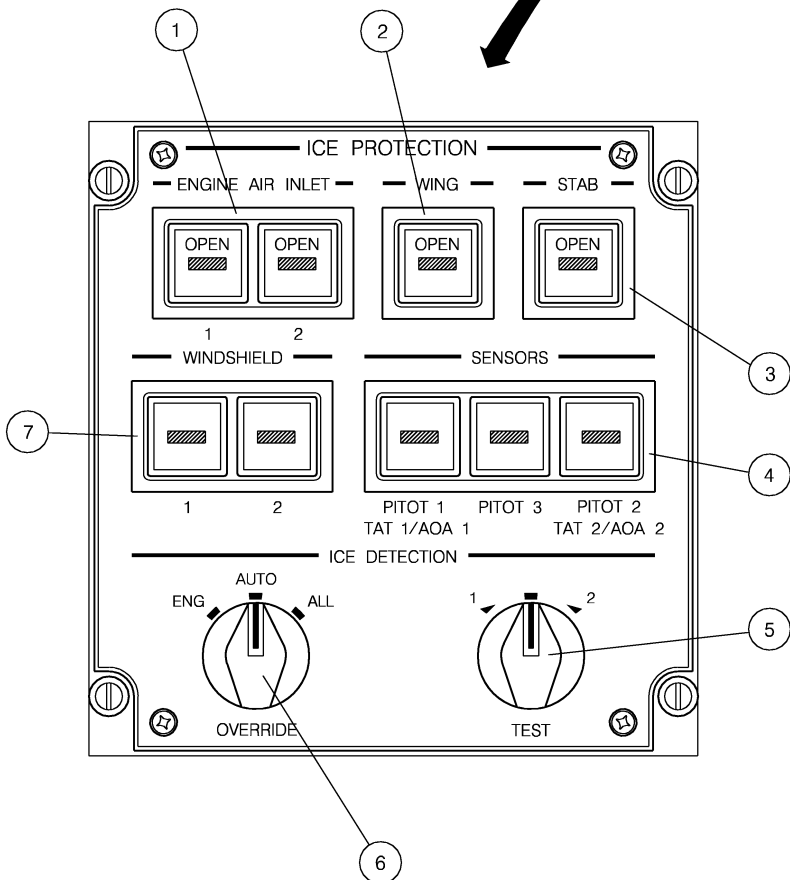
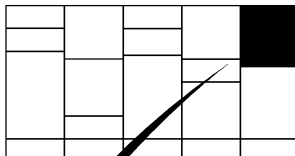
ALL - Turns on the complete bleed air anti-icing system provided airplane is on ground at speed equal or above 25 knots or in flight.

NOTE: On ground, below 25 knots, only engine anti-icing is turned on.

7 - WINDSHIELD HEATING BUTTON

- Turns on (pressed) or turns off (released) the windshield heating system.
- A striped bar illuminates inside the button to indicate that it is released.

OVERHEAD PANEL



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ICE PROTECTION CONTROL PANEL

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ICE DETECTION SYSTEM

Ice detectors 1 and 2 are respectively installed at the airplane's left and right nose section, to provide icing condition detection.

The ice detector was designed to pick up ice quickly. Therefore, in the most cases, ice will be detected before it can be noticed by the crew.

NOTE: Notwithstanding ice detector monitoring, the crew remains responsible for monitoring icing conditions and for manual activation of the ice protection system if icing conditions are present and the ice detection system is not activating the ice protection system.

A 0.5 mm (0.020 inch) ice thickness, on any probe, causes bleed air anti-icing system automatic mode activation, a SPS angle of attack set values reduction (refer to Stall Protection System on Section 2-4 – Crew Awareness), and an advisory message to be presented on the EICAS.

During ice encounters, the icing signal remains active during 60 seconds. Simultaneously, an internal ice detector heater is activated to de-ice the unit and probe. When the probe's natural frequency is recovered, heating is de-energized. Once deiced, the sensing probe cools within a few seconds and is ready to once more monitor ice build-up. Then a new detection cycle begins and remains as long as the ice condition persists.

In case of failure of any or both ice detectors, a caution message is presented on the EICAS and the bleed air thermal anti-icing system may be activated through the OVERRIDE knob on the Ice Detection panel. The system's normal operation may be checked through the TEST knob on the Ice Protection panel.

EICAS MESSAGES

TYPE	MESSAGE	MEANING
CAUTION	ICE DETECTORS FAIL	Both ice detectors have failed.
	ICE DET 1 (2) FAIL	Associated ice detector has failed.
ADVISORY	ICE CONDITION	Airplane is flying under icing conditions.

WINDSHIELD WIPER SYSTEM

A two-speed windshield wiper is provided for the left and right windshields. Each system comprises a motor-converter, a wiper arm, and blades. A control box provides speed control, synchronization, and off-screen park functions for both systems through independent channels.

Each system has its own independent power supply and a four-position knob on the overhead panel.

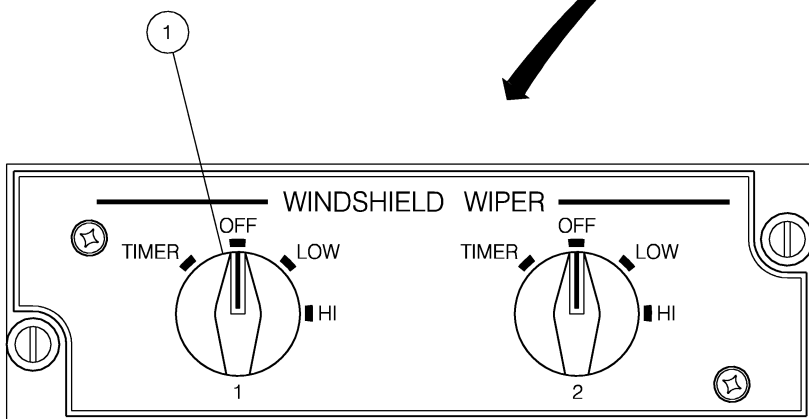
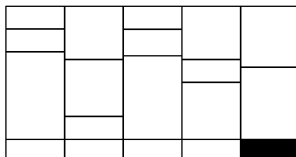
WINDSHIELD WIPER CONTROL PANEL

1 - WINDSHIELD WIPER SELECTOR KNOB

- TIMER - Provides intermittent operation of the associated windshield wiper in single cycles (two strokes) with an 8 second time interval between two cycles, in high speed.
- OFF - Associated wiper blades travel to the windshield inboard position, parking out of pilots vision.
- LOW - Associated wiper operates at approximately 80 strokes per minute.
- HIGH - Associated wiper operates at approximately 140 strokes per minute.

NOTE: Dry windshield operation leads the motor-converter to a stall condition, due to the high friction level. The controller senses the motor-converter current surge and drives the arm directly to the parked position. The system remains inoperative until the Windshield Wiper Selector Knob is set to OFF position and a new operation mode is selected.

OVERHEAD PANEL



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WINDSHIELD WIPER CONTROL PANEL



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