SECTION 6-11

ICE AND RAIN PROTECTION

TABLE OF CONTENTS

INTRODUCTION

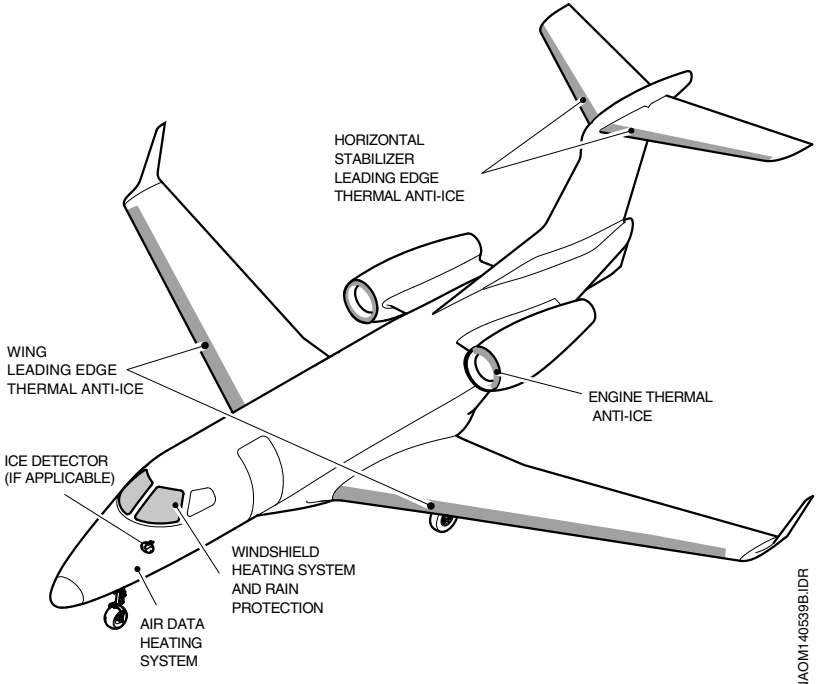
The ice and rain protection system provides protection against visual and flight authority degradation due to ice formation on leading edge surfaces, engine air inlet, external sensor, and ice and fog formation on the windshield.

The ice and rain protection system is used to:

- Prevent the ice formation and remove the ice formed on the wing and the horizontal stabilizer leading edges. Bleed air is routed from both engines to the wing and horizontal stabilizer anti-ice systems.
- Provide the pilot and the copilot with a way to inspect the airplane against icing while flying at night. There is one lamp installed on the left fuselage that shines in the left wing for visible ice detection.
- Remove or prevent ice formation around the engine inlet cowls, supplied with bleed air from the related engine.
- Remove and prevent ice, frost, fog, or rain from the windshield. The windshield heating system uses electrical heaters and the windshield rain protection uses a rain repellent coating applied to the windshield external surface.
- Prevent ice formation on the airplane sensors. Pitot static probe and IASP (Integrated Air Data and Stall Protection Probe) units are heated electrically.

The ice and rain protection system includes:

- Wing and Stabilizer Anti-Ice System;
- Engine Anti-Ice System;
- Windshield Heating System;
- Windshield Rain Protection System;
- ADS Probes Heating System.



ICE AND RAIN PROTECTION SYSTEM

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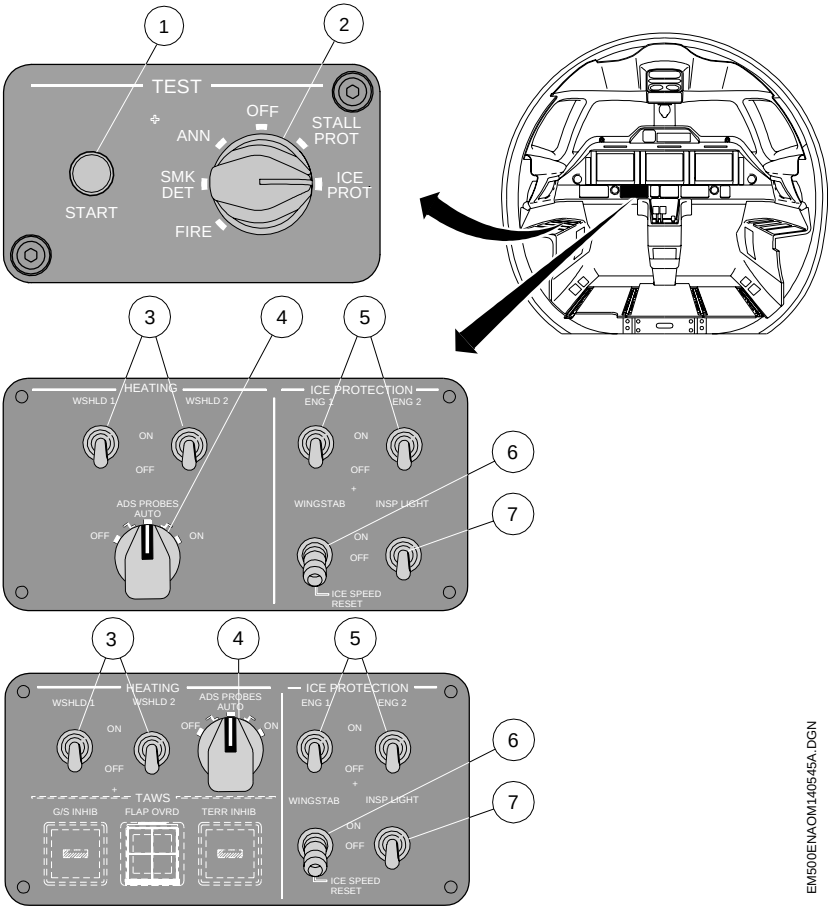
CONTROLS AND INDICATIONS

ICE AND RAIN PROTECTION CONTROL PANEL



NOTE: TAWS control buttons are available only on the HEATING/ICE PROTECTION control panel of airplanes with the TAWS-A (optional) installed.

1 – START TEST BUTTON

Refer to Section 6-14-05.

2 – SELECTOR TEST KNOB

Refer to Section 6-14-05.

3 – WINDSHIELD HEATING SWITCH

ON: activates the associated windshield heating system.

OFF: deactivates the associated windshield heating system.

4 – AIR DATA SYSTEM/ANGLE OF ATTACK HEATING KNOB

OFF: deactivates the ADS heating system.

AUTO: allows automatic operation of the ADS heating system.

ON: activates the ADS heating system.

5 – ENGINE ICE PROTECTION SWITCH

ON: activates the associated engine anti-ice system.

OFF: deactivates the associated engine anti-ice system.

6 – WING/STABILIZER ICE PROTECTION SWITCH

ON: activates the wing and the horizontal stabilizer anti-ice systems.

OFF: deactivates the wing and the horizontal stabilizer anti-ice systems.

ICE SPEED RESET: resets the SWPS to non-icing schedule and removes the SWPS ICE SPEED message.

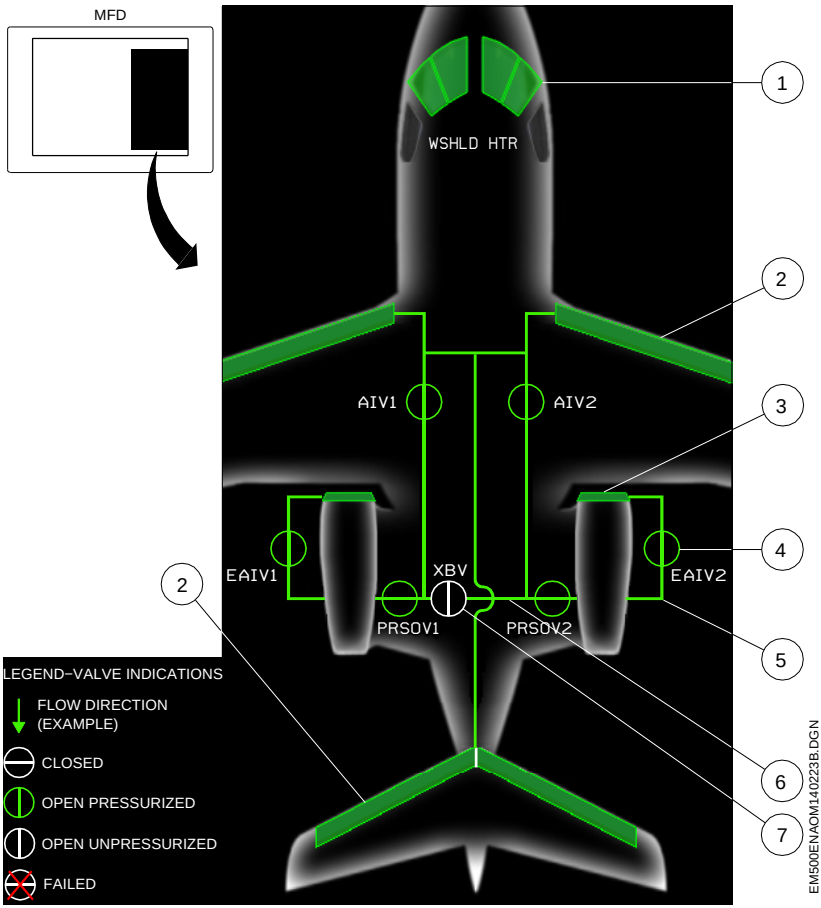
NOTE: The ICE SPEED RESET must be activated when the pilot is sure that there is no more ice on the airplane.

7 – INSPECTION LIGHT SWITCH

Refer to Section 6-01-40.

SYNOPTIC PAGE ON MFD

The ice and rain protection synoptic page provides a visual representation of the system operation, and can be selected by the flight crew for viewing on the MFD.



1 – WINDSHIELD HEATING STATUS

– Digital Indication:

GREEN: normal activated operating condition.

WHITE: system deactivated.

RED X: system failed.

NOTE: When the windshield heating knobs are in the OFF position, the red X will also be displayed.

2 – WING/STABILIZER ANTI-ICE LINE INDICATION

– Digital Indication:

GREEN: normal activated operating condition.

WHITE: system deactivated.

3 – ENGINE ANTI-ICE LINES INDICATION

– Digital Indication:

GREEN: normal activated operating condition.

WHITE: system deactivated.

4 – ICE PROTECTION VALVE INDICATION

– Ice protection valves are shown as a circle and an internal line representing the valve position.

CLOSED: a white circle and a white line perpendicular to the flow line.

OPEN PRESSURIZED: a green circle and a green line aligned with the flow line.

OPEN UNPRESSURIZED: a white circle and a white line aligned with the flow line and no bleed air available.

FAILED: a white circle and a white line perpendicular to the flow line covered by a red X.

5 – ENGINE ANTI-ICE LINE INDICATION

– Digital Indication:

GREEN: line pressurized.

WHITE: no bleed air available (engine not running).

6 – ANTI-ICE BLEED LINES INDICATION

– Digital Indication:

GREEN: line pressurized.

WHITE: no bleed air available.

FAILED CONDITION: line indication covered by a red X.

7 – CROSSBLEED VALVE (XBV)

– Ice protection valves are shown as a circle and an internal line representing the valve position.

CLOSED: a white circle and a white line perpendicular to the flow line.

OPEN PRESSURIZED: a green circle and a green line aligned with the flow line.

OPEN UNPRESSURIZED: a white circle and a white line aligned with the flow line and no bleed air available.

FAILED: a white circle and a white line perpendicular to the flow line covered by a red X.

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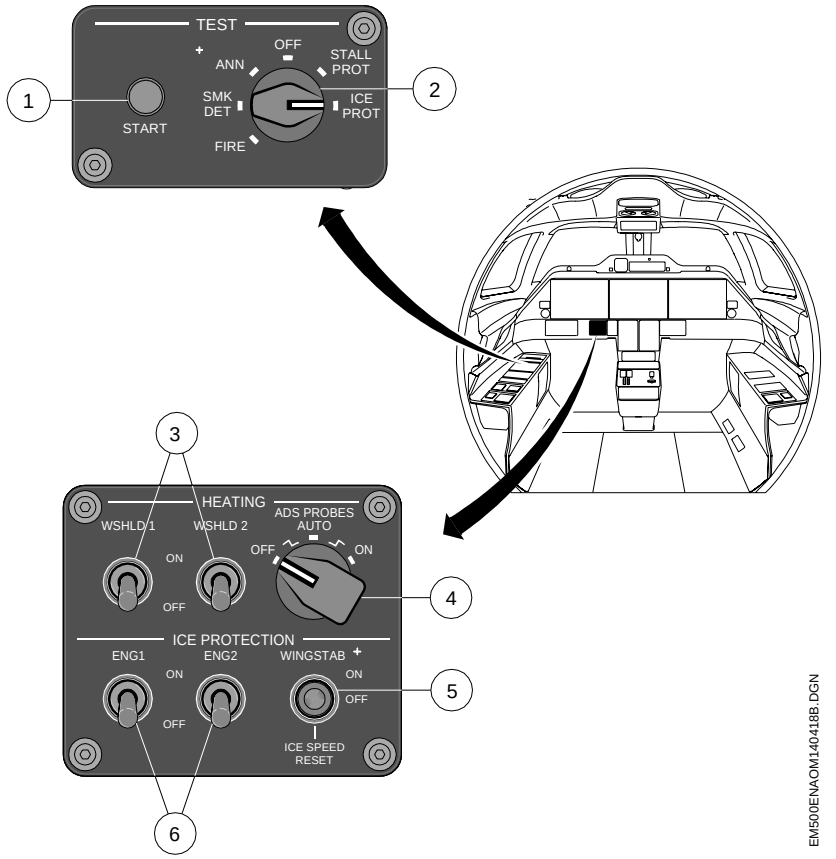
CONTROLS AND INDICATIONS

ICE AND RAIN PROTECTION CONTROL PANEL



1 – START TEST BUTTON

Refer to Section 6-14-05.

2 – SELECTOR TEST KNOB

Refer to Section 6-14-05.

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AUTO: allows automatic operation of the ADS heating system.

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ON: activates the wing and the horizontal stabilizer anti-ice systems.

OFF: deactivates the wing and the horizontal stabilizer anti-ice systems.

ICE SPEED RESET: resets the SWPS to non-icing schedule and removes the SWPS ICE SPEED message.

NOTE: The ICE SPEED RESET must be activated when the pilot is sure that there is no more ice on the airplane.

6 – ENGINE ICE PROTECTION SWITCH

ON: activates the associated engine anti-ice system.

OFF: deactivates the associated engine anti-ice system.

SYNOPTIC PAGE ON MFD

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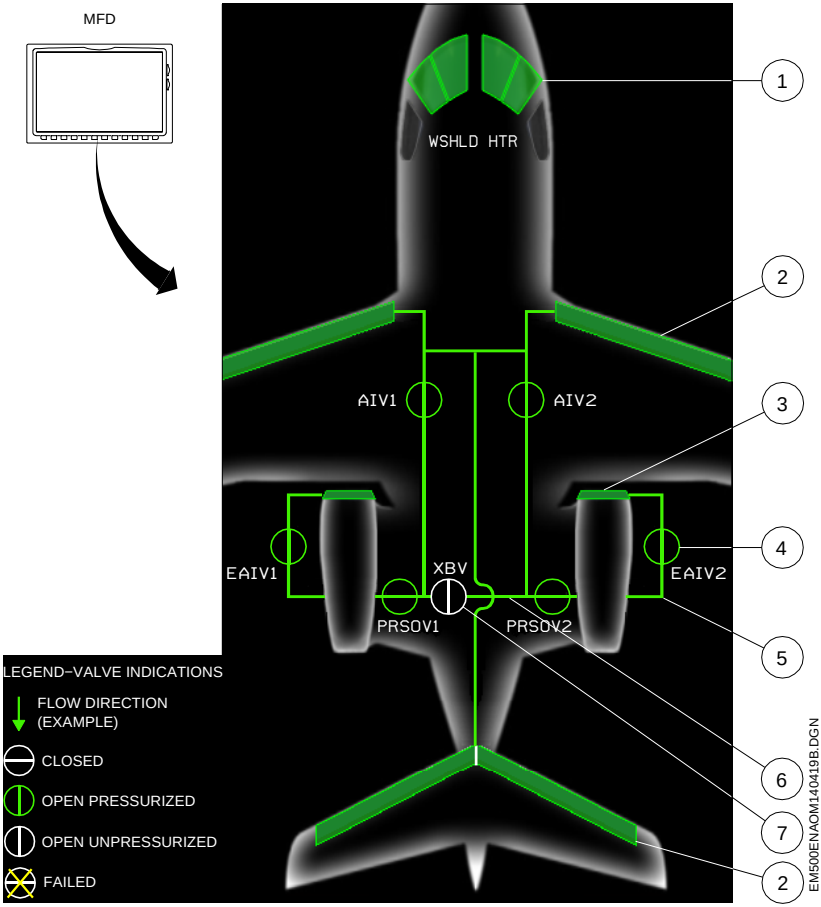

1 – WINDSHIELD HEATING STATUS

– Digital Indication:

GREEN: normal activated operating condition.

WHITE: system deactivated.

YELLOW X: system failed.

NOTE: When the windshield heating knobs are in the OFF position, the yellow X will also be displayed.

2 – WING/STABILIZER ANTI-ICE LINE INDICATION

– Digital Indication:

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3 – ENGINE ANTI-ICE LINES INDICATION

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FAILED: a white circle and a white line perpendicular to the flow line covered by a yellow X.

5 – ENGINE ANTI-ICE LINE INDICATION

– Digital Indication:

GREEN: line pressurized.

WHITE: no bleed air available (engine not running).

6 – ANTI-ICE BLEED LINES INDICATION

– Digital Indication:

GREEN: line pressurized.

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FAILED CONDITION: line indication covered by a yellow X.

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OPEN UNPRESSURIZED: a white circle and a white line aligned with the flow line and no bleed air available.

FAILED: a white circle and a white line perpendicular to the flow line covered by a yellow X.

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WING AND STABILIZER ANTI-ICE SYSTEM

The Wing and Horizontal Stabilizer Anti-Icing System (WHSAIS) prevents the ice formation and remove the ice formed on the wing and the horizontal-stabilizer leading edges. The Pneumatic System supplies bleed air at controlled temperature and pressure to the WHSAIS.

The wing and horizontal stabilizer anti-ice system works independently on each side. In case of single bleed source operation, the Pneumatic System closes the affected side Pressure Regulating and Shutoff Valve (PRSOV) and opens the Cross Bleed Valve in order to provide airflow to the system.

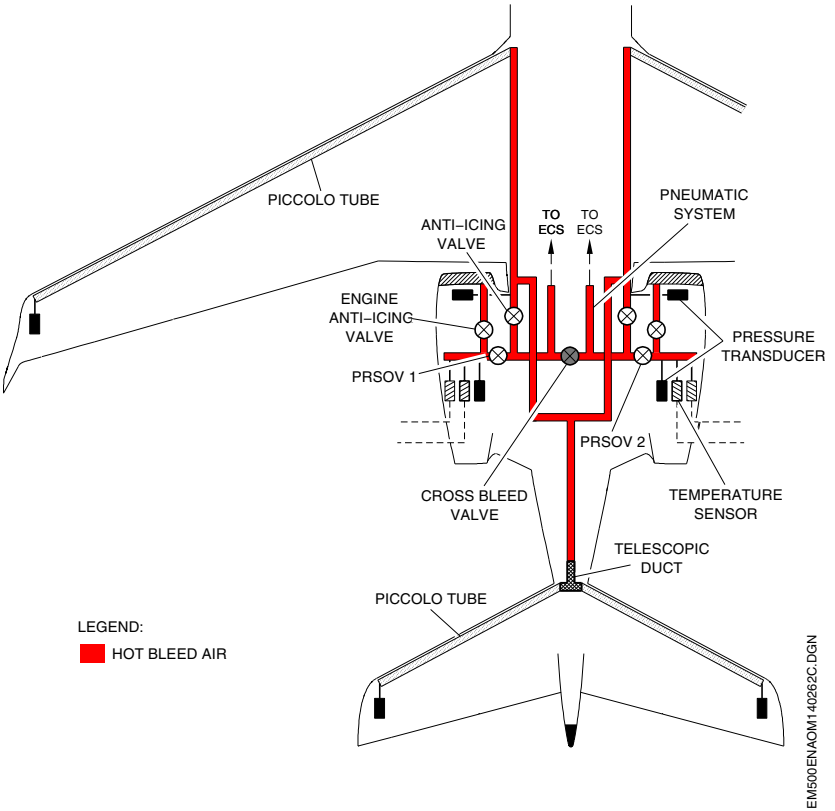
Each airplane side has an Anti-ice Valve (AIV) that is a pressure regulating and shut-off valve. There is a pressure transducer downstream of each AIV, which is used to provide feedback for AIV control and also to detect system failures. The WHSAIS does not operate with one AIV open and the other closed. It operates only if both AIVs are opened.

Airflow to the wing leading edges is provided directly from downstream of each AIV. Airflow for the horizontal stabilizer leading edges is obtained through duct taps downstream left and right AIVs. These taps merge in a single duct that delivers bleed air through the vertical tail to the horizontal stabilizer. In both cases, hot air is delivered to piccolo tubes (tubes with small holes) that provide hot air impinging on the leading edge inner surfaces.

There is one pressure transducer installed on each wing piccolo tube tip and one on each horizontal stabilizer piccolo tube tip.

The WHSAIS uses pressure transducers as well as the Pneumatic System temperature sensors for monitoring purposes in order to:

- Guarantee a minimum pressure downstream each Anti Ice Valve to assure adequate flow to the protected surfaces;
- Avoid over pressure to protect the system ducts or excessive bleed air consumption;
- Detect system failures.



ICE PROTECTION SYSTEM SCHEMATIC

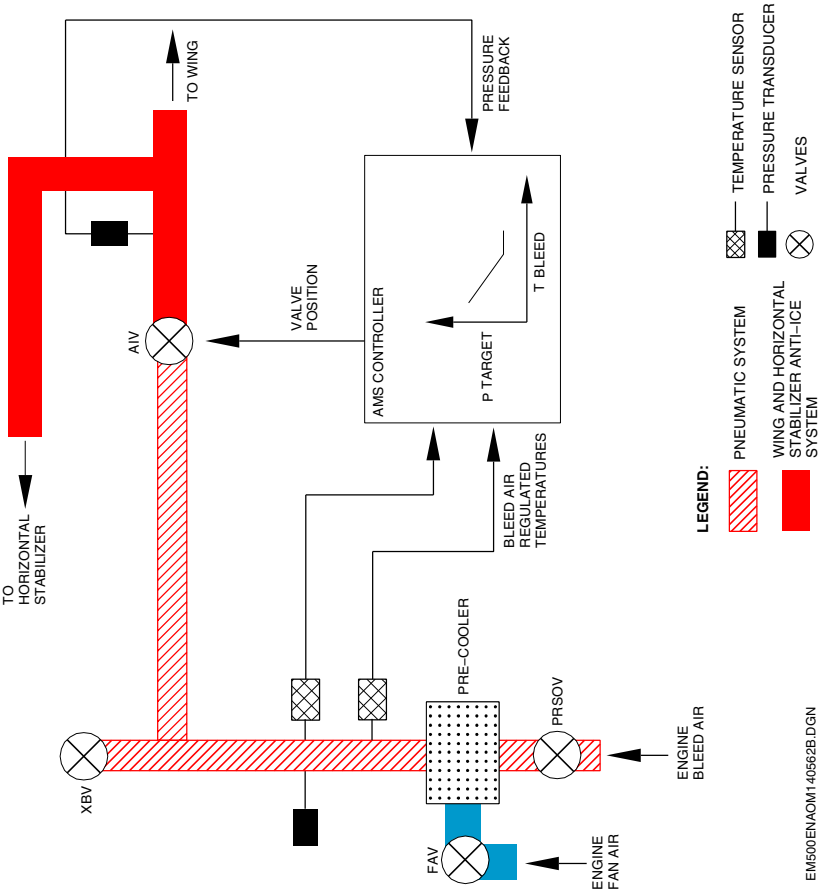
In order to deal with the engine bleed air flow extraction limitations, each AIV regulates pressure as a function of the engine bleed air temperature measured downstream of each pre-cooler.

When the engine is at high speed, bleed air is at high temperature. In this case, each AIV regulates pressure at a lower set-point to reduce bleed air extraction. When the engine is at low speed, bleed air is at low temperature. In this case, each AIV regulates pressure at a higher set-point to increase bleed air extraction.

The balance between engine bleed air flow and temperature assures an adequate energy level at the leading edges to perform the anti-ice function.

In order to avoid leading edge overheating, the WHSAIS is inhibited on ground when airplane wheel speed is below 40 kt.

A knob on the test control panel is used to do a test of the integrity of the system. With this selector in the ICE PROT position, when the START button is pressed, the test is initiated.



ICE PROTECTION SYSTEM
AIR FLOW PRESSURE AND TEMPERATURE CONTROL

OPERATION

When flying in icing conditions, the pilot must activate the ice protection system and operate the airplane according to the recommendations given in the Airplane Flight Manual (Section 2 – Limitations and Section 3 – Normal Procedures).

When the WINGSTB Switch is placed to the ON position, the stall warning system activation angles are anticipated. The effect in the airplane is higher stall warning speeds and the CAS message SWPS ICE SPEED is displayed on MFD.

Because of that stall speed increase, before turn the system ON, it is important to comply with the AFM limitation minimum airspeed for operation in icing condition (FLAP ZERO and Gear UP), in order to guarantee the airplane is faster than the increased stall warning speeds.

Note that the minimum airspeed for operation in icing conditions is different if the airplane is flying inside the wing and stabilizer anti-ice operational envelope (A-I WINGSTB ON) and if the airplane is flying outside it (A-I WINGSTB INHB or A-I WINGSTB ARM).

These speeds provide the airplane the capability to perform a coordinated turn of 40 degrees bank without the stall warning activation. This is especially helpful when performing holding procedures.

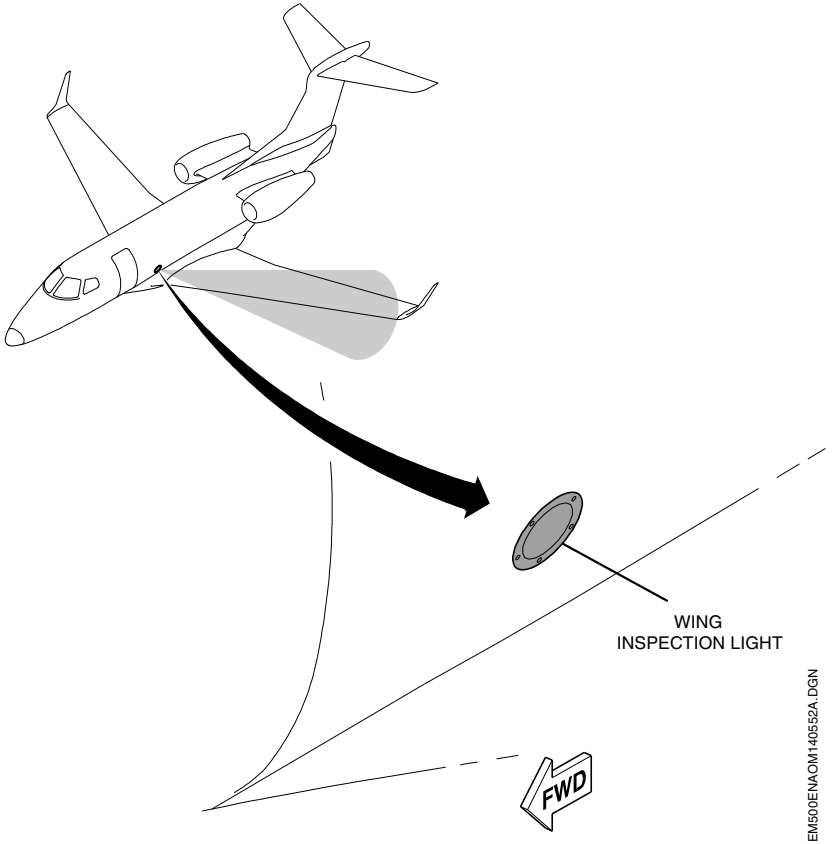
If a driftdown is required (OEI), the pilot must refer to the driftdown speed schedules for ice protection ON or OPERA software.

The level off of the AFM driftdown table is limited to the maximum altitude of the OEI wing and stabilizer anti-ice operational envelope. The OPERA software provides the actual performance of the airplane (without the system limitation).

The driftdown speed schedule allows the airplane to perform a coordinated turn of 30 degrees bank without the stall warning activation.

WING INSPECTION LIGHT

A wing inspection light installed only on the left side provides visual means for crew to verify ice formation at night on wing leading edges.



WING INSPECTION LIGHT

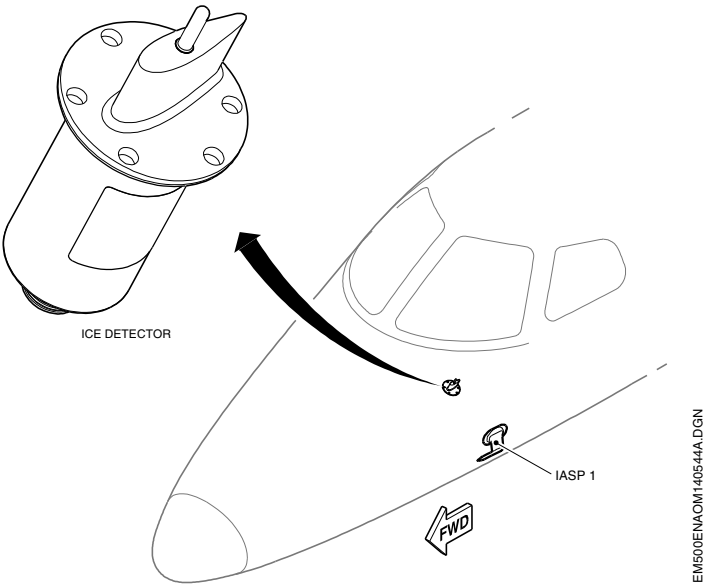
ICE DETECTOR (IF APPLICABLE)

The ice detector helps the pilot to identify that the airplane is flying in icing conditions. An associated CAS message is displayed whenever ice is detected or a failure on the ice detector has been detected.

The pilot remains responsible for recognizing icing conditions in flight, and the primary mean of ice formation detection remains the presence of visible moisture and TAT at or below 5°C. The icing protection system is activated by the pilot.

The ice detector consists of a probe installed below the left side windshield and exposed to the airstream. As ice accumulates on the sensing element, ice accretion is detected by a change in the sensing element's resonant frequency.

When the ice protection system is being tested, the ICE CONDITION and ICE DET FAIL CAS messages will be tested when the start button is pressed on the test control panel. The ICE CONDITION message will always appear while the ICE DET FAIL may blink during the test. The Ice detector is considered failed if the message ICE CONDITION does not appear or if the message ICE DET FAIL remains latched.



ICE DETECTOR

ENGINE ANTI-ICE SYSTEM

The Engine Anti-Ice System removes or prevents ice formation around the engine inlet cowls (lip), using hot bleed air from the related engine compressor (dedicated bleed port).

The system also supplies hot bleed air from the engine to the Starter/Generator air inlet to prevent ice accumulation in this region.

The bleed air supply is always available to the system when the engine is running, but each Engine Anti-Ice system is independent of the other engine and the bleed air supply cannot be shared between engines.

The Engine Anti-Ice System components are:

- Supply duct;
- Shutoff valve (EAI valve);
- Flow limiter (venturi);
- Pressure transducer;
- Piccolo tube and;
- Exhaust vent.

The engine anti-ice system operates continuously when the respective ENG 1 (2) switches are set to ON position. When the EAI System is turned ON, the engine inlet temperature sensor heater (TT0 probe heater) is also turned ON.

The EAI system is activated via an electrically controlled, pneumatically actuated pressure regulating shutoff valve (Engine Anti-Ice Valve). The valve controls the bleed airflow from the engine to the engine anti-ice system. The EAI shutoff valve actuating solenoid must be energized in order to drive the valve closed. In the absence of an electrical signal, the engine bleed valve will fail safe open. The valve may be locked in the open position, thus allowing dispatch the airplane in ice conditions. The procedures are described in the dispatch documents.

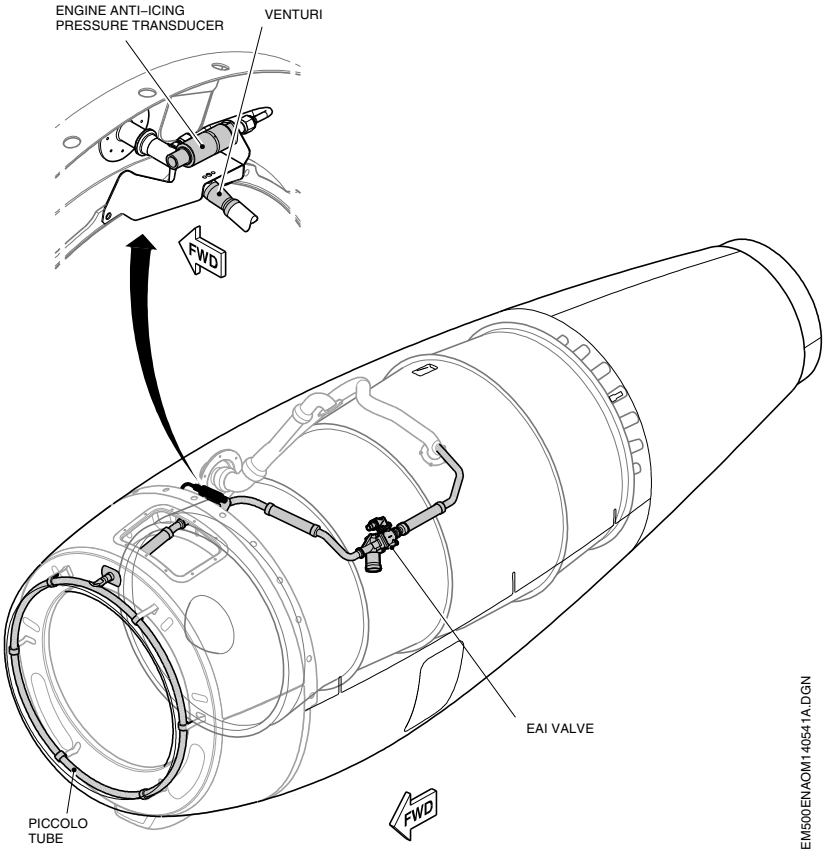
Next, the air flow passes through a flow limiter (venturi), which has the purpose of limiting the mass air flow entering the forward D-chamber in the event of a burst duct.

The D-chamber is the space formed by the inner surface of the engine inlet lip skin and the forward bulkhead.

The pressure transducer is connected to the anti-ice air supply duct and monitors the anti-ice system pressure.

At the inlet connection, the air passes into the circular piccolo tube mounted inside the D-chamber. The anti-ice air fills the piccolo tube and exits through holes distributing the air over the inner surface of the inlet lip skin and heats it up to prevent ice formation on the outer surface.

After that, the air flows toward the bottom where it exits the D-chamber through an exhaust vent. The exhausted air from the D-chamber is used to heat the Starter/Generator air inlet and prevent ice accumulation.



ENGINE ANTI-ICING SYSTEM

WINDSHIELD HEATING SYSTEM

The function of the Windshield Heating System is to regulate the temperature of each heating mat embedded in the windshield, in order to prevent the icing formation on the exterior surface of the windshield, and fog formation on the inside surface.

The windshield is an electrically heated, double curvature, laminated glass windshield. To prevent damage to the windshield heating mats, the outboard glass is coated by an antistatic film. For a protection against rain, an additional hydrophobic coating is also provided on the outer glass.

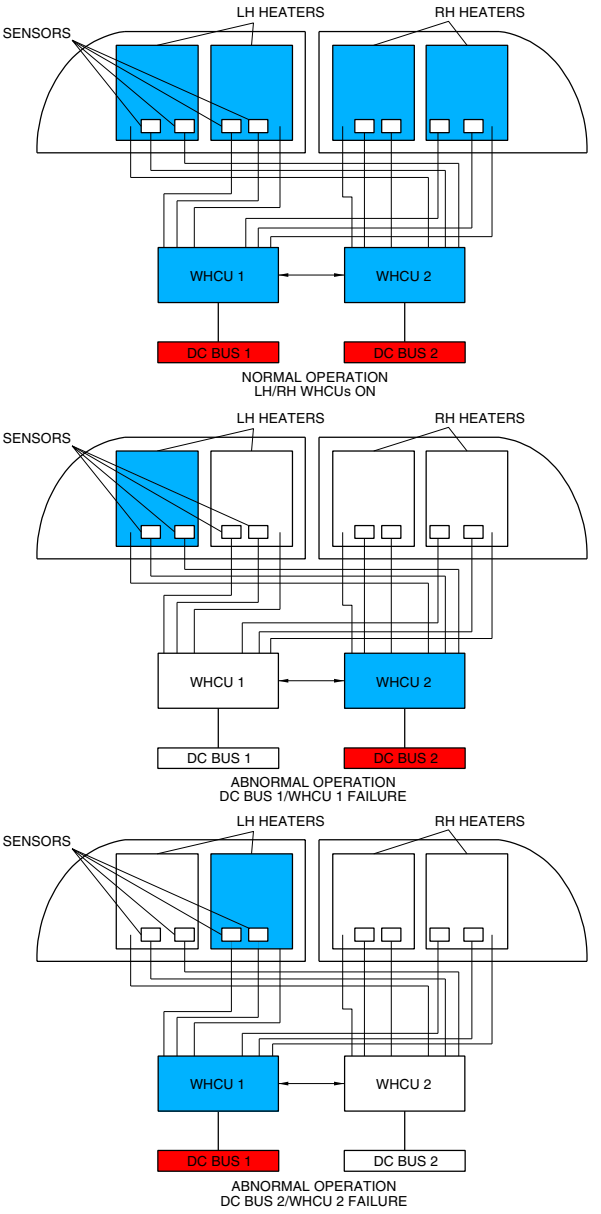
The windshield heating system consists of four independent subsystems, two for each windshield. Each subsystem comprises a heater mat integrated into the windshield and two temperature sensors that are used to regulate the temperature by each Windshield Heating Control unit channel. One sensor is used for control while other monitors for overheats and back-up for control if the first sensor fails.

OPERATION

The left and right windshields heaters are controlled by individual switches on the control panel. During normal operation (WSHD 1(2) Switches set to ON position), the Windshield Heating Control Units (WHCU) automatically controls the windshield temperature within a specific range, between 35°C (95°F) and 43°C (110°F). The overheat set point is 60°C (140°F).

The overheat occurrence removes power from the windshield and triggers the CAS message WSHLD 1 (2) HTR FAIL. The CAS message is only activated and latched when current is flowing through the windshield. Because of that and the architecture of the system (refer to Windshield Heating System Schematic illustration), both WSHD 1 (2) Switches must be cycle in order to reset the system, even if only one side has detected an overheat condition.

If only a single power source is available (one starter generator failed), the left windshield side has the priority and one of its sections (left or right) is heated according to the remaining starter generator.



WINDSHIELD HEATING SYSTEM SCHEMATIC

WINDSHIELD RAIN PROTECTION SYSTEM

The windshield rain repellent coating is a wiperless system that permits a safe flight under rain conditions, by maintaining a sufficient portion of the windshield so clear as to provide each pilot with adequate vision along the flight path.

There are two rain repellent coatings, one on the windshield left panel and the other on the windshield right panel.

The windshield rain protection system consists of a synthetic polymer that repeals water in the glass surface, maintaining an appropriate portion of the windshield clear. The windshield treated with Rain Repellent Coating (RRC) does not present distortion and keep it without any effect on glass strength, index of refraction, light transmittance, haze or color.

When the glass surface is treated with a chemical repellent, the water draws up into beads which cover only a portion of the glass and the area between the beads stay dry. The high velocity slipstream continually removes the beads.

Due to the rain repellent coating not remain effective indefinitely, the service life depends on operational environmental and cleaning practices.

Kits containing supportive and additional tools are used for windshield with RRC system re-application.

ADS PROBE HEATING SYSTEM

The ADS probes heating system contributes to safe operation under icing conditions preventing ice formation on:

- Integrated Air Data and Stall Protection Probes;
- Standby Pitot-Static Probe.

The IASP is basically made up of a Multi-Functional Probe (MFP) and a dual channel Air Data and Stall Protection Computer (ADSPC). The MFP heater control is responsible to activate the anti-ice protection as function of airplane configuration and to avoid on ground overheating. An automatism to turn on the Pitot-Static probe heater based on airplane configuration is implemented by relays connections, acting similarly to the logic used by the IASP. The relays connection is designed to be fail-safe, so that relays not commanded or failed (at resting position) guarantees power to the heater.

During normal operation, the knob located on the HEATING control panel is set to AUTO position. In this mode, the probe heating elements will be automatically energized if at least one engine is running or the airplane weight is not on the wheels.

The knob can be set to ON position when the airplane is on ground and is needed a removal of ice from the IASP and/or Pitot-Static Probe before engine start. It also can be used during flight in case of failure of the automatic control.

CAS MESSAGES

TYPE	MESSAGE	MEANING
CAUTION	ADS 1 (2) HTR FAIL	Associated heater is off or failed.
	A-I E1 (2) FAIL	Nacelle anti-ice valve is closed when commanded to open, or an engine anti-ice duct failure is detected.
	A-I LO CAPACITY	There is not enough thermal energy available for WHSAIS operation.
	A-I WINGSTB INHB (Airplanes Pre-Mod. SB 505-31-0005)	Pilot commands the WINGSTAB Switch to ON position outside Wing and Stabilizer Anti-Ice System operational envelope.
	A-I WINGSTB INHB (Airplanes Post-Mod. SB 505-31-0005 or with equivalent modification factory incorporated)	Pilot commands the WINGSTAB Switch to ON position outside Wing and Stabilizer Anti-Ice System operational envelope below 30000 ft.
	A-I WINGSTB LEAK	There is a bleed hot air leakage on WHSAIS pneumatic ducting.
	A-I WINGSTB FAIL	A wing/stab anti-ice system failure has been detected or with a significant thrust lever asymmetry.
	ICE CONDITION	Indicates that the airplane is flying under icing conditions. This message is available only on airplanes with ice detector (optional item).

TYPE	MESSAGE	MEANING
CAUTION	STBY HTR FAIL	ADS-Standby heater is off or failed.
	WSHLD 1 (2) HTR FAIL	Associated windshield is overheated or heating system is failed.
ADVISORY	ADS HTR SW ON	ADS Probe knob is on.
	A-I E1 (2) FAULT	Engine anti-ice system valve failed when commanded to close.
	A-I E1 (2) ON	Engine anti-ice system is turned on and operating normally.
	A-I WINGSTB ARM (Airplanes Pre-Mod. SB 505-31-0005)	Pilot commands the WINGSTAB Switch to ON position prior to takeoff.
	A-I WINGSTB ARM (Airplanes Post-Mod. SB 505-31-0005 or with equivalent modification factory incorporated)	Pilot commands the WINGSTAB Switch to ON position prior to takeoff or above 30000 ft.
	A-I WINGSTB ON	Wing/stabilizer anti-ice system is turned on and operating normally.
	ICE DET FAIL	Ice detector is failed. This message is available only on airplanes with ice detector (optional item).

CAS MESSAGES

TYPE	MESSAGE	MEANING
CAUTION	ADS 1 (2) HTR FAIL	Associated heater is off or failed.
	A-I E1 (2) FAIL	Nacelle anti-ice valve is closed when commanded to open, or an engine anti-ice duct failure is detected.
	A-I LO CAPACITY	There is not enough thermal energy available for WHSAIS operation.
	A-I WINGSTB INHB	Pilot commands the WINGSTAB Switch to ON position outside Wing and Stabilizer Anti-Ice System operational envelope below 30000 ft.
	A-I WINGSTB LEAK	There is a bleed hot air leakage on WHSAIS pneumatic ducting.
	A-I WINGSTB FAIL	A wing/stab anti-ice system failure has been detected or with a significant thrust lever asymmetry.
	ICE CONDITION	Indicates that the airplane is flying under icing conditions. This message is available only on airplanes with ice detector (optional item).
	STBY HTR FAIL	ADS-Standby heater is off or failed.
	WSHLD 1 (2) HTR FAIL	Associated windshield is overheated or heating system is failed.

TYPE	MESSAGE	MEANING
ADVISORY	ADS HTR SW ON	ADS Probe knob is on.
	A-I E1 (2) FAULT	Engine anti-ice system valve failed when commanded to close.
	A-I E1 (2) ON	Engine anti-ice system is turned on and operating normally.
	A-I WINGSTB ARM	Pilot commands the WINGSTAB Switch to ON position prior to takeoff or above 30000 ft.
	A-I WINGSTB ON	Wing/stabilizer anti-ice system is turned on and operating normally.
	ICE DET FAIL	Ice detector is failed. This message is available only on airplanes with ice detector (optional item).