## ACRONYM LIST

| | |
|---|---|
| **A/I** | Anti-Ice |
| **AMM** | Air Management Module |
| **AMSAC** | Air Management System Automatic Controller |
| **AMSEC** | Air Management System Emergency Controller |
| **APU** | Auxiliary Power Unit |
| **BALDS** | Bleed Air Leak Detection System |
| **BAS** | Bleed Air System |
| **BLD** | BLeeD |
| **CB** | Circuit Breaker |
| **ECS** | Environmental Control System |
| **EMM** | Emergency Management Module |
| **HP** | High Pressure |
| **LCV** | Load Control Valve |
| **LP** | Low Pressure |
| **MP** | Mixed pressure |
| **OP** | Overhead Panel |
| **PAX** | Passenger |
| **PCS** | Precooler System Controller |
| **PRSOV** | Pressure Regulating Shut Off Valve |
| **SOV** | Shut Off Valve |
| **SSPC** | Solid State Power Controllers |
| **T/O** | Take-Off |
| **WAI** | Wing Anti Ice |
| **XBLEED** | Cross Bleed |

## INTRODUCTION

The Bleed Air System refers to the air distributed to provide following functions:

- Engine start,
- Air conditioning, also referred to as Environmental Control System (ECS),
- Wing and S-Duct anti-icing,
- Wheel well brakes heating.

Other functions such as pressurization of fuel tanks or anti icing of engine air intake are not performed by the airplane Bleed Air System (BAS), and are addressed respectively in ATA chapters 28 and 30.

The Bleed Air System (BAS) of the Falcon 7X uses bleed air provided by the 3 engines.

On ground, bleed air can also be provided by the APU or by an air cart.

Following table shows which functions are available depending on the bleed air source:

| | **BLEEED AIR SOURCE** | | |
|---|---|---|---|
| **FUNCTION AVAILABLE** | ENGINES | APU<br>(ground only) | AIR CART<br>(ground only) |
| **ENGINE START** | Yes | Yes | Yes |
| **AIR CONDITIONING (ECS)** | Yes | Yes | Yes |
| **ANTI-ICING :<br>WING, S-DUCT AND BRAKE HEATING** | Yes | No (*) | No (*) |

**NOTE (*)**

S-Duct and Brake Heating are available on ground, but must not be used with APU or air cart bleed air sources.

## FLIGHT DECK OVERVIEW

### CONTROLS

Crew control of bleed air system is performed via:

- The "BLEED" panel on the Overhead Panel (OP).

There is no control available through the synoptic.

### INDICATIONS

Cockpit indications are displayed:

- On the "BLD" synoptic page,
- On the ENG CAS window for CAS messages,
- On the STATus synoptic / FAULT tab for fault messages.

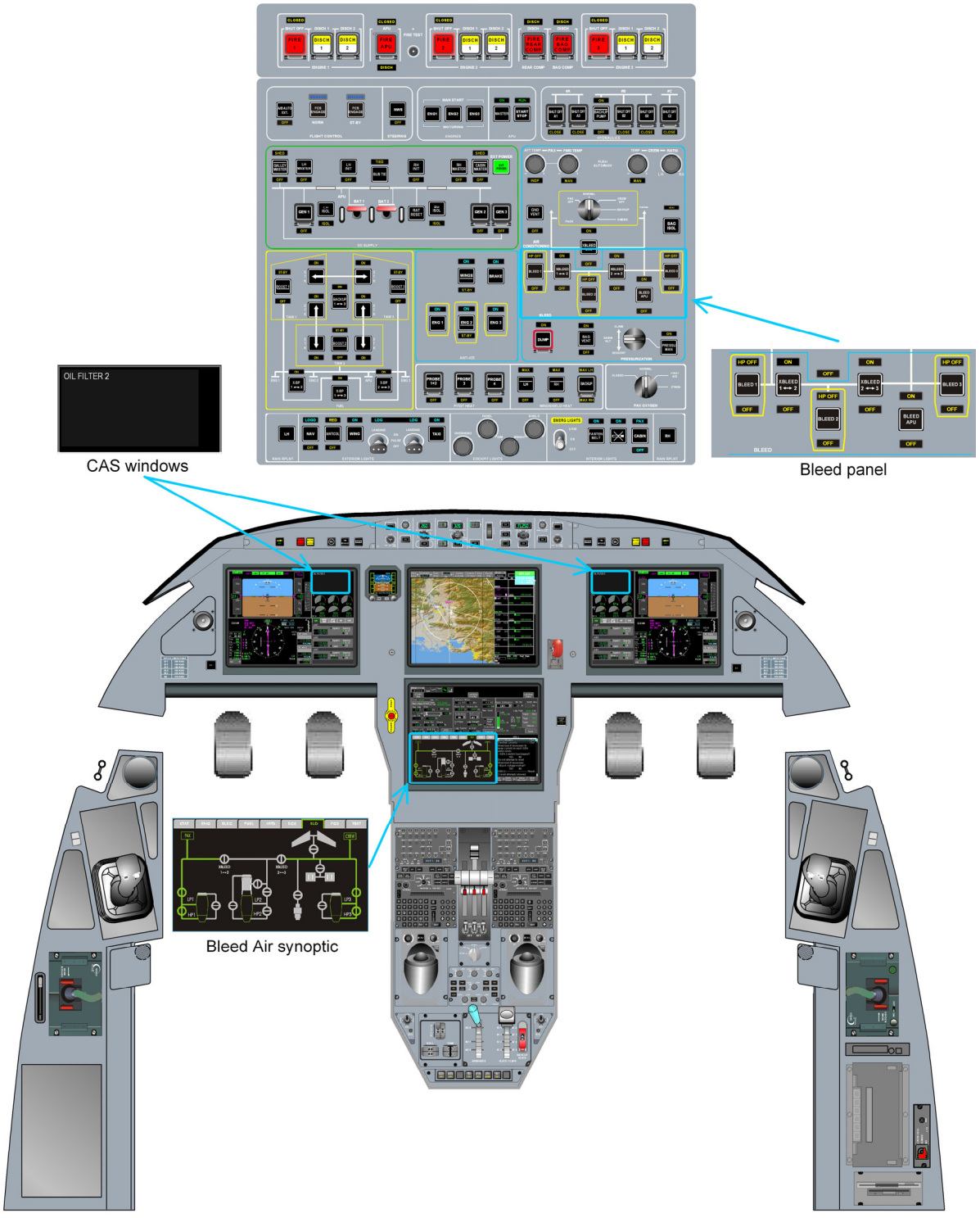


**FIGURE 02-36-05-00 – FLIGHT DECK OVERVIEW**

## GENERAL

The Bleed Air System (BAS) uses air:

- On ground only:
  - From the APU through the APU BLEED valve, or
  - From the air cart via the ground connector,
- In flight and on ground:
  - From each engine, by mixing the HP air (controlled through the HP valve) and LP air through an MP valve,
  - The mixed air is then supplied to the bleed air manifold.

A precooler is installed downstream of each MP valve in order to limit the bleed temperature.

Control of the bleed air system depends on ECS (Environmental Control System) mode of operation:

- Normal ECS operation (i.e. PACK of the Overhead Panel selector not in EMERG position), or
- EMERG ECS operation.

### NORMAL ECS OPERATION

During normal ECS operation, the BAS is managed by the AMSAC (Air Management System Automatic Controller).

The bleed air valves will be automatically configured depending on the bleed sources and downstream bleed consumers (Wing Anti Ice, S Duct Anti Ice …).

### PACK SELECTOR IN EMERG POSITION

In EMERG ECS operation, the BAS is managed by the AMSEC (Air Management System Emergency Controller).

Some valves will be set to closed position and the crew will have to manually control the other bleed valves.

## GROUND BLEED AIR SUPPLY

### APU AND ENGINE BLEED

APU bleed air supply is automatically managed by the APU controller (without temperature and pressure regulation).

Bleed air supply priority between APU and engine during ground operation is managed by the AMSAC as follows:

- 1: APU bleed air supply,
- 2: Engine bleed air supply.

Therefore, the engine bleed valves will automatically close when the APU bleed is available.

APU and engines are protected against reverse flow.

On ground with APU BLEED source, XBLEED valves are automatically open.

| | XBLEED 1-2 | XBLEED 2-3 |
|---|---|---|
| **APU BLEED SOURCE** |  Valve open |  Valve open |

### AIR CART

An air cart can be connected to ground air connector for engine start purpose only.

**NOTE**

There is no priority between APU and air cart, therefore it should be avoided to use simultaneously the two bleed sources of APU and ground cart.

Nominal pressure should be 30 psi minimum (50 psi maximum).

## ENGINE BLEED AIR DURING NORMAL ECS OPERATION

### BLEED AIR MANAGEMENT

Normal ECS operation is managed by the AMSAC:

- With PACK selector on NORMAL, PAX OFF, CREW OFF or BACKUP mode, and
- With or without Anti-Icing.

The AMSAC will manage the bleed valves (HP, MP and X-BLEED) to achieve:

- Sufficient bleed air supply to the ECS system, and to the Wings/S-duct/brake anti-icing when required, by regulating the HP and MP valves,
- Ensure bleed overpressure protection and temperature regulation by closing automatically the corresponding HP and MP valve and triggering CAS messages,
- When WAI is on, ensure wing skin protection against too high temperature by closing the corresponding HP valves,
- Balance bleed air extraction among engines by opening/closing the XBLEED valves

For each engine, "HP" or "HP and LP" bleed air sources can be isolated using BLEED pushbuttons of the overhead panel.

### BLEED AIR DISTRIBUTION

The position of XBLEED valves will be configured depending on bleed air source and bleed air consumers.

**Engines and Wing Anti Ice OFF**

Bleed air is provided by engines 1 and 3.

Engine 2 does not supply any bleed air.

XBLEED valves are automatically closed to separate engines bleed flow.

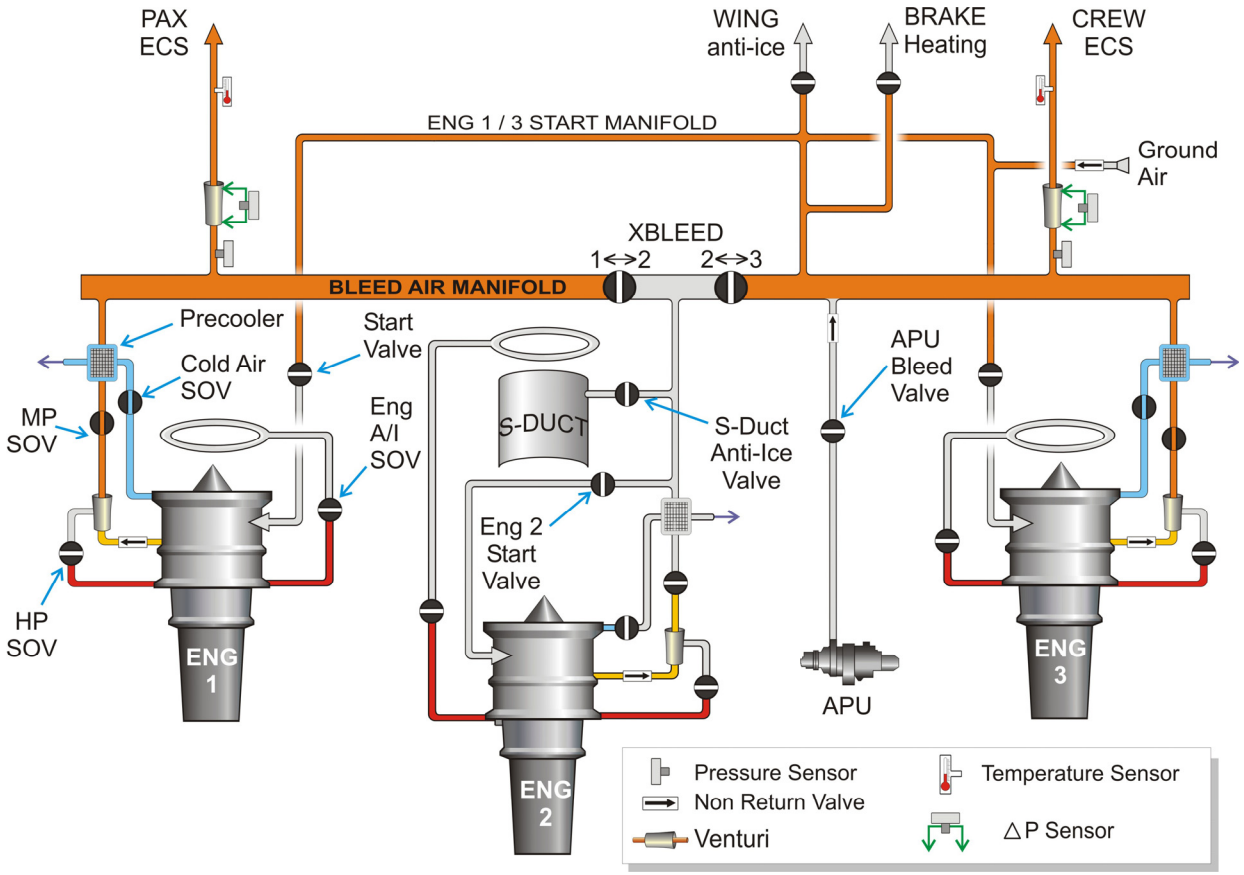


**FIGURE 02-36-10-00 - NORMAL ECS OPERATION WITHOUT ANTI-ICING**

**Engine 2 Anti Ice ON, Wing Anti Ice OFF**

S-duct Anti Ice is supplied by engine 2 bleed system.

Bleed air to other bleed air consumers is still provided by engines 1 and 3.

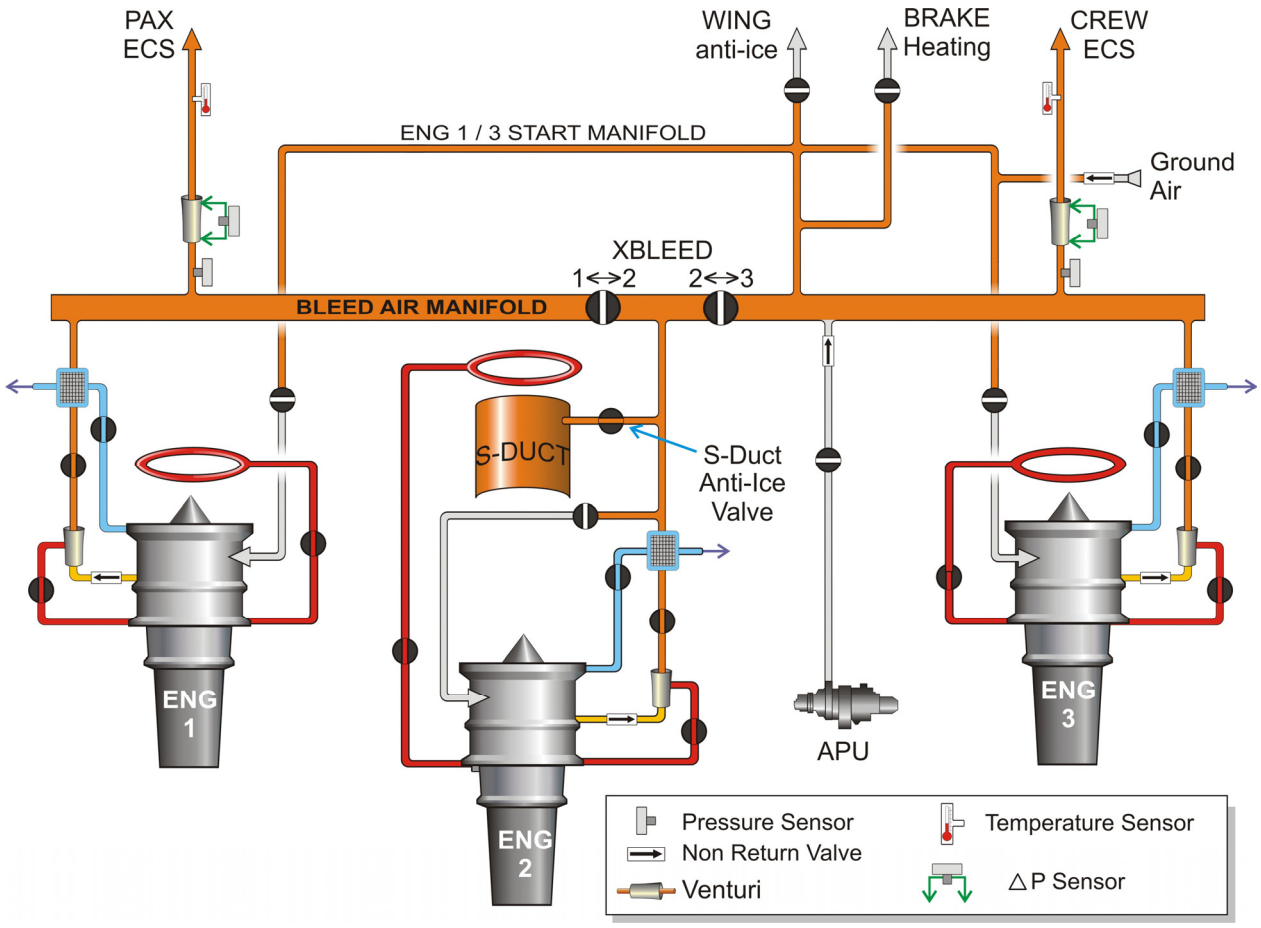


**FIGURE 02-36-10-01 - NORMAL ECS OPERATION WITH ENG2 ANTI ICE ON**

### Wing Anti Ice ON

Bleed air is provided by all engines (XBLEED valves are automatically open).

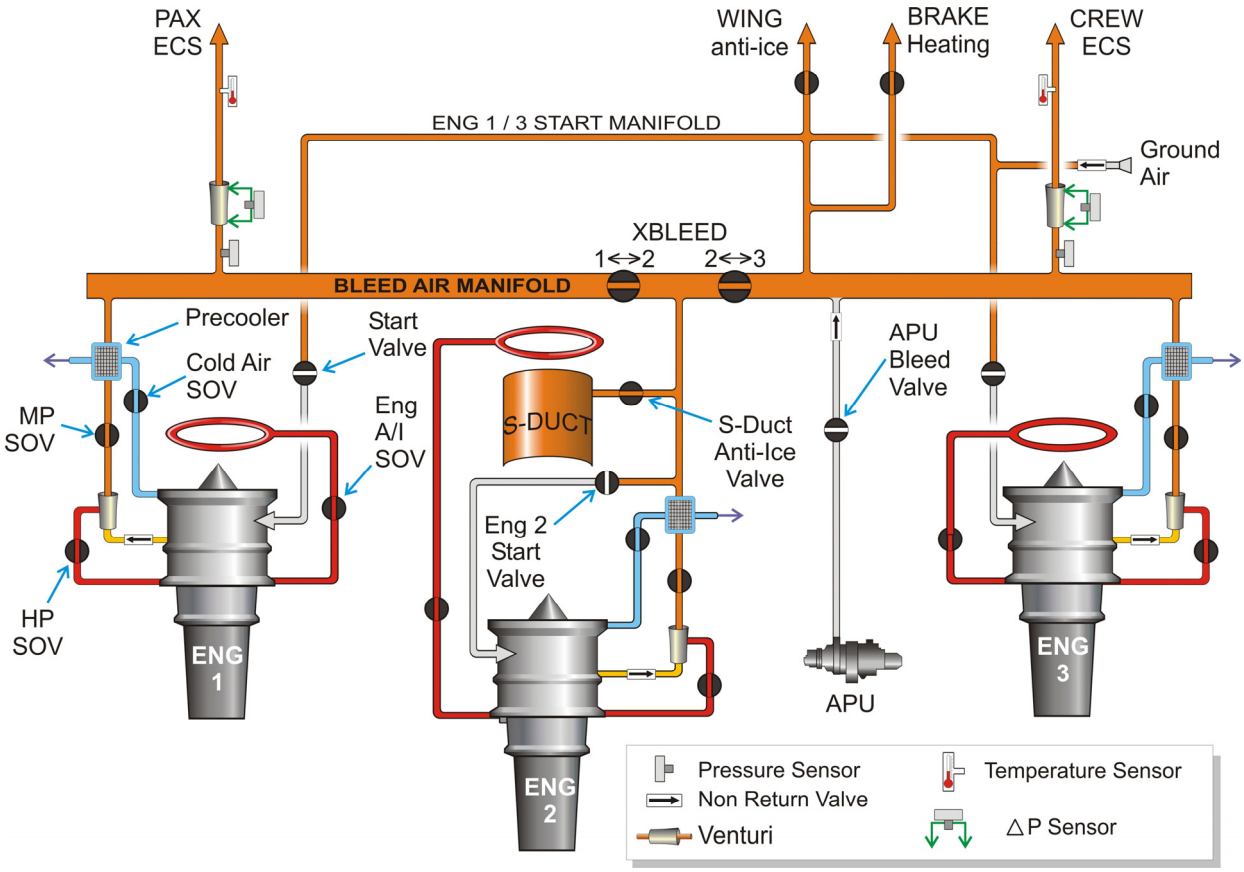


**FIGURE 02-36-10-02 - NORMAL ECS OPERATION WITH ANTI-ICING ON, BRAKE HEATING ON, S DUCT ON, ENGINE ON**

### Synthesis of XBLEED valves position in flight

During normal operation, without any bleed system failure, the XBLEED valves will be automatically set as follows:

| | XBLEED 1-2 | XBLEED 2-3 |
|---|---|---|
| **ENGINES RUNNING WING AI OFF** | Valve closed | Valve closed |
| **ENGINES RUNNING WING AI ON** | Valve open | Valve open |

In the event of an engine bleed system failure, manual control of XBLEED function is available from the Overhead Panel.

**BLEED AIR TAKE OFF MODE**

Managed by the AMSAC, the bleed air Take-Off mode minimizes bleed air extraction (closure of bleed air valves) to ensure maximum engine performance during take-off.

In case of Take Off with Engine 2 Anti Ice ON, bleed air is still available to ensure engine 2 S-Duct Anti Icing.

## ENGINE BLEED AIR DURING EMERGENCY ECS OPERATION

EMERG ECS operation is managed by the AMSEC, with PACK selector on EMERG position.

The AMSAC is no more electrically supplied, and stops supplying power to the HP and MP valves:

- All the HP valves close (HP valves are sprung-loaded closed),
- MP 1 and 2 valves are pneumatically controlled.

The AMSEC:

- Closes the MP 3 and XBLEED 2-3, isolating completely the BLEED 3 system,
- Closes the WAI and S-DUCT valves,
- Ensures sufficient bleed air by engine 1 and 2 to supply the ECS system (and pressurization),
- Continues to ensure bleed overpressure and temperature monitoring by triggering CAS messages,
- Provides Bleed Air Leak Detection System function (BALDS),
- And provides the crew with the capability of isolating the BLEED 1&2, and XBLEED 1-2 through the overhead panel commands.

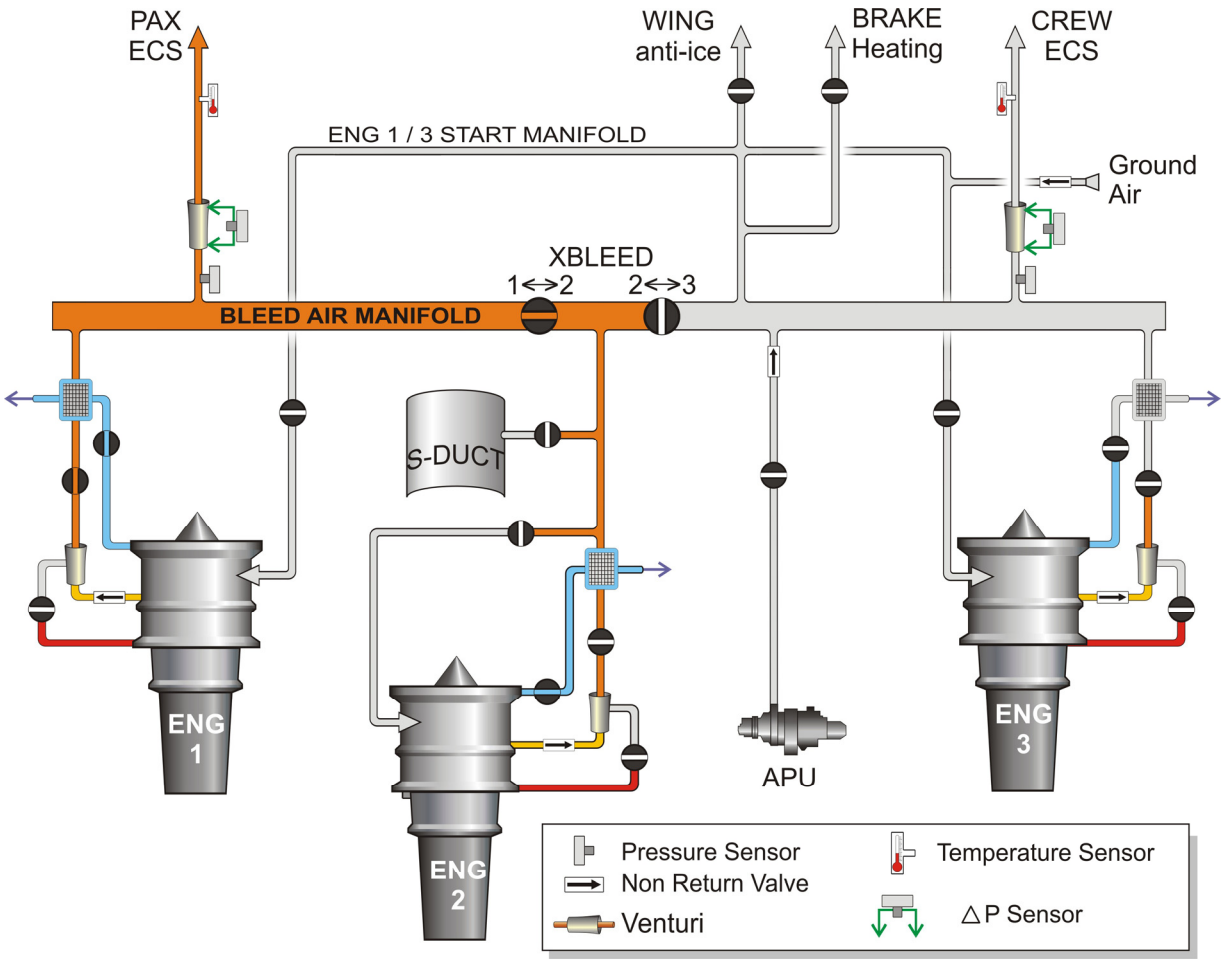


**FIGURE 02-36-10-03 - EMERGENCY ECS CONFIGURATION**

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## DESIGN PRINCIPLES

The Bleed Air System was designed considering the following design principles:

- With regard to Bleed Air System architecture:
  - The Bleed Air System components are identical for all three engines,
  - Each system can be isolated by the crew,
  - In case of failure of one engine, all systems using bleed air are still supplied.
- With regard to bleed air regulation:
  - Regulation of bleed air is entirely automatic, and the crew can only act on source supplies and interconnection of bleed air flows,
  - Minimization of High Pressure bleed air as long as Low Pressure bleed air is sufficient, in order to minimize impact on engine performance,
  - Equalization of bleed air extraction between engine 1 and 3 only when wing Anti Ice is not selected, and between the three engines when wing Anti Ice is selected
  - Absence of bleed air supply at take off to allow maximum engine thrust, except for S-duct anti icing,
- With regard to safety:
  - Detection of leaks for areas in the vicinity of fuel or flammable fluid,
  - Limitation of bleed air temperature by precoolers in order to eliminate risks of high bleed air temperature in the vicinity of flammable fluids.

## EQUIPMENT LOCATION

The AMSAC is installed in the baggage compartment, which is normally pressurized.

The AMSEC is installed in the un-pressurized equipment bay aft of frame 41.

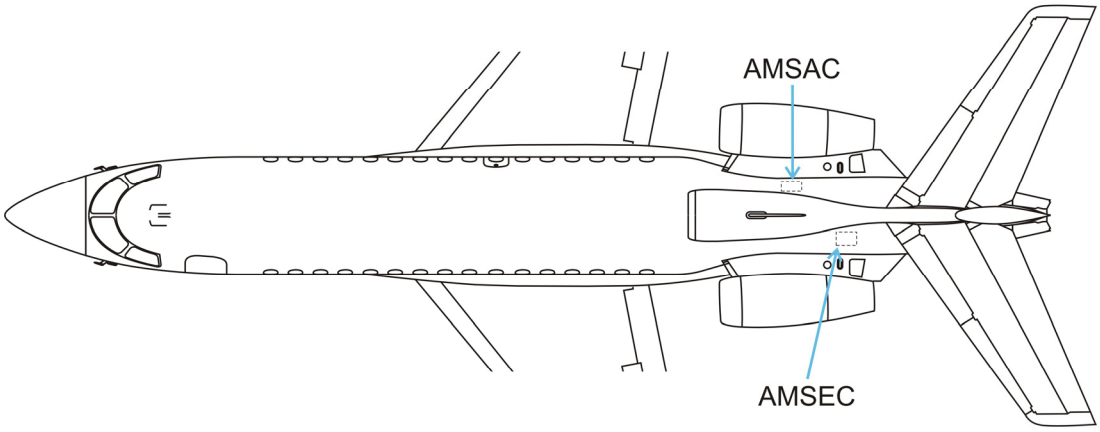



**FIGURE 02-36-15-00 - BLEED AIR EQUIPMENT LOCATION**

## ELECTRICAL POWER SOURCE

The following paragraph describes the power supply of the different equipment of the Bleed Air System.

Electrical protection is provided either:

- By Solid State Power Controllers (SSPC) ,
- By Circuit Breakers (CB).

➢ *Refer to ATA 24 – ELECTRICAL POWER for additional information.*

| EQUIPMENT | POWER SUPPLY | TYPE OF PROTECTION |
|---|---|---|
| AMSAC AMM1 & AMM3 | LH main bus | CB |
| AMSAC AMM2 | RH main bus | SSPC |
| AMSEC EMM | LH and RH Essential bus | CB |
| AMSEC BALDS | LH Essential bus | CB |
| Engine 1 Precooler System Controller (PSC1) | LH Essential<br>LH main | SSPC |
| Engine 3 Precooler System Controller (PSC3) | LH Essential<br>LH main | SSPC |
| Engine 2 Precooler System Controller (PSC2) | RH Essential<br>RH main | CB |

Valves are electrically powered by the AMSAC and/or AMSEC, except for Cold Air SOV which are supplied by their respective engine precooler.

## ENGINE BLEED AIR PORTS

Each engine is equipped with 2 HP and 2 LP ports referred as main and auxiliary.

Main HP port: The amount of HP air extraction depends on the opening of the HP valve which is regulated automatically by the AMSAC. Examples: HP air is used when wings or s-duct anti-icing is required, or when LP bleed air is not sufficient such as in descent with engines running at idle.

Main LP port: LP air is extracted at the last LP compressor stage.

HP and LP air coming from the main ports are mixed in a jet pump and supply the bleed air manifold through an MP valve.

AUX HP port supply air for engine air inlet anti-icing and is commanded by the ENG x pushbutton (See ATA 30 – ICE AND RAIN PROTECTION)

AUX LP port of engines 1 and 3: Supplies bleed air for the fuel tank pressurization at a constant pressure 2.9 psi.

AUX LP port of engine 2 is not used.

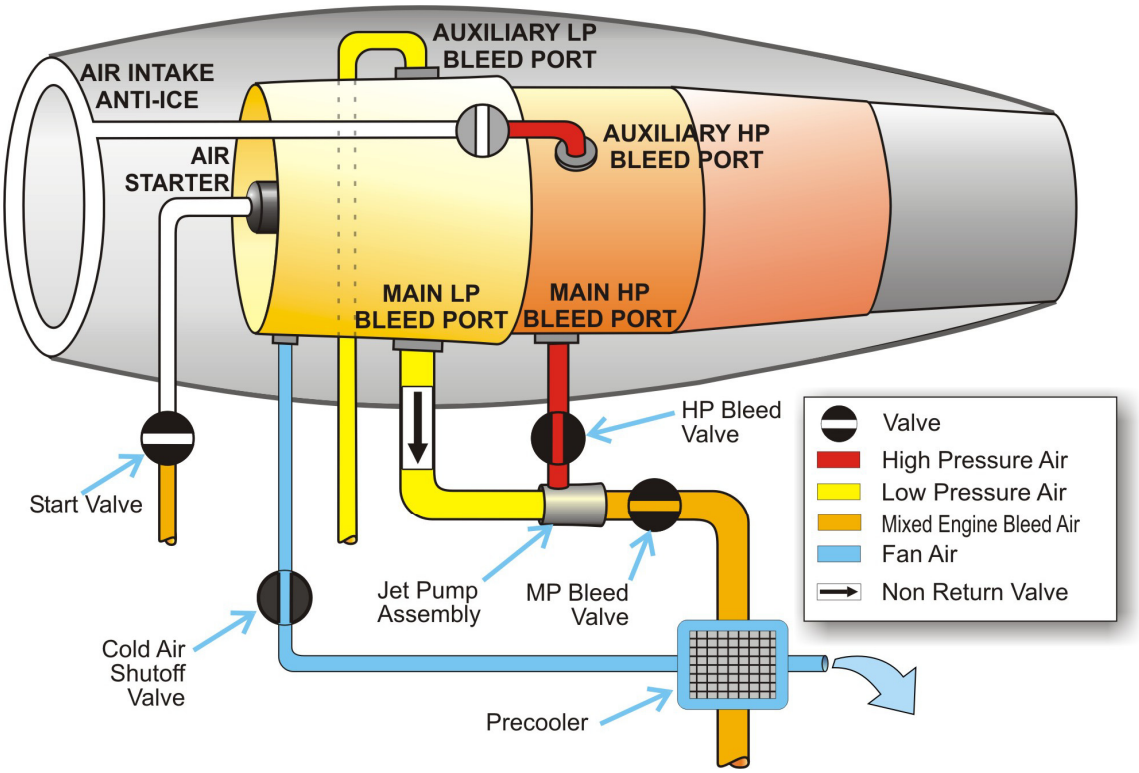



**FIGURE 02-36-15-01 - ENGINE BLEED AIR PORTS**

## PRECOOLER

Three precoolers regulate the temperature downstream of their respective MP valve at 204°C by using fan air.

Main components of each precooling system are:

- A Precooler System Controller (PSC),
- A temperature sensor before the bleed air manifold,
- A precooler,
- A Cold Air SOV.

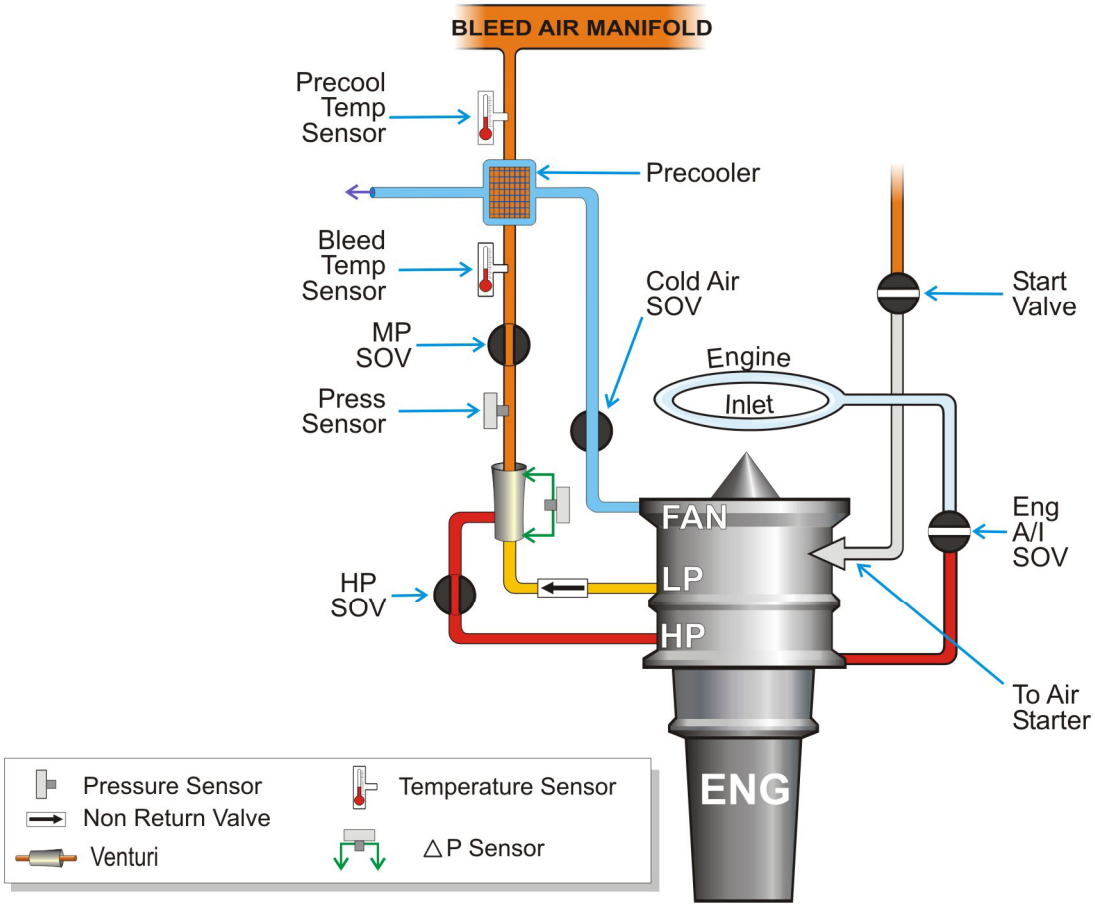


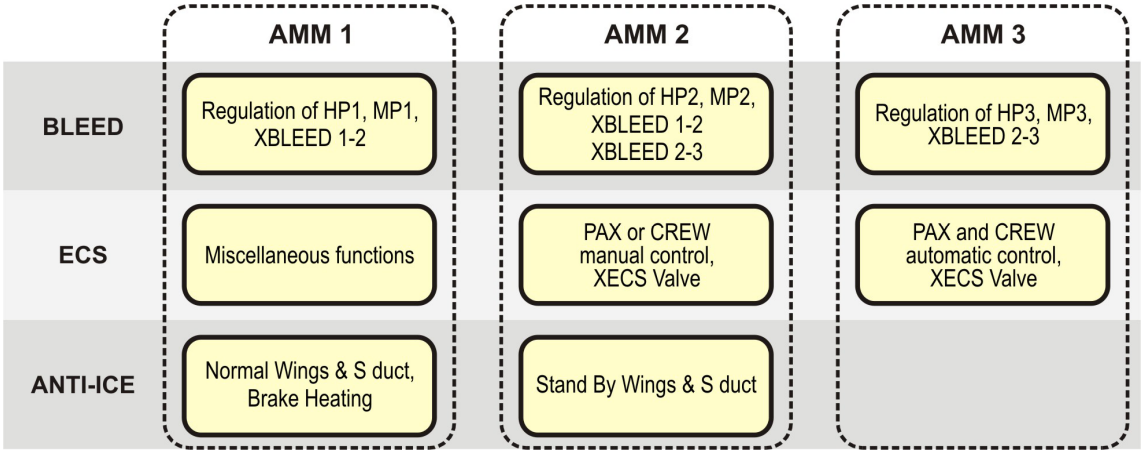

**FIGURE 02-36-15-02 - PRECOOLERS**

## BLEED AIR MANAGEMENT

### AMSAC

The AMSAC comprises 3 Air Management Module cards (AMM).

Allocation of inputs/outputs and functions is such that the loss of one AMM card does not lead to the complete loss of Bleed Air System, Environmental Control System or Cabin Distribution System.



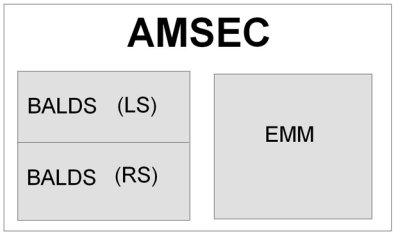

### AMSEC

The AMSEC contains two electrically isolated modules:

- The Emergency Management Module (EMM),
- The Bleed Air Leak Detection System (BALDS) Module.

Although housed in the same assembly there is no communication between the two modules.

The AMSEC provides the Bleed Air Leak Detection function no matter the position of the ECS selector. The BALDS module has two independent and electrically isolated channels on one card, although only one of the channels will be used at any time in this application.



## APU SEQUENCE BLEED AIR SUPPLY

Air is bled through an APU Load Control Valve managed automatically by the APU controller in normal operation.

If the APU is « ready to bleed » (i.e APU running), the AMSAC closes the MP and HP valves.

Then, when all the engine bleed valves are detected closed by the AMSAC, a discrete signal is sent to the APU controller which opens the LCV.

## BLEED AIR TAKE OFF MODE

Activation and de-activation conditions are:

- Main activation conditions:
  - On ground,
  - At least 2 engine throttles in T/O position,
- De-activation condition:
  - Transition ground to flight with all engines operative.

With 2 engine throttles at take off position and one engine inoperative (below idle), below 15,000 ft:

- Bleed air will be available only for S-Duct and Wing Anti Icing,
- No Bleed air will be provided to the ECS.

## MP AND HP PRSOV (PRESSURE REGULATING SOV) REGULATION

### ECS only operation

The primary function of the MP PRSOV is to regulate the pressure in the bleed manifolds, using an electronic control and pneumatic actuating torque motor. The pressure regulating set point, controlled electronically, is a function of the airplane altitude.

The secondary function of the MP PRSOV is to equalize bleed flow extraction from each engine. When LP pressure is sufficient, the MP PRSOV regulates the manifold pressure and the engine bleed flows are equalized. When LP bleed pressure is insufficient, the MP PRSOV is full open and therefore cannot provide engine bleed flow equalization.

The HP PRSOV regulates the pressure downstream of the bleed jet pump using an electronic control and pneumatic actuating torque motor. The pressure regulation set point, controlled electronically, is a function of the airplane altitude. This pressure regulation set point is lower than the manifold pressure regulation set point to ensure that the MP PRSOV is full open and that the functionality of the two bleed valves does not interact. The HP bleed regulation pressures represent the minimum pressure required by the ECS in order to provide sufficient fresh air to the cockpit and cabin. Scheduling the HP bleed extraction in this way ensures that the HP bleed extraction is minimized.

The secondary function of the HP PRSOV is to equalize bleed flow extraction from each engine. When HP pressure is sufficient, the HP PRSOV regulates the manifold pressure and the engine bleed flows are equalized. When HP bleed pressure is insufficient, the HP PRSOV is full open and therefore cannot provide engine bleed flow equalization (in flight idle descent for example).

The AMSAC also limits HP PRSOV opening to prevent the bleed air temperature from exceeding 345°C. This takes the precedence over the pressure regulation and bleed flow equalization.

**ECS and Anti ice operation**

The primary function of the MP PRSOV is to regulate the pressure in the bleed manifolds, as in ECS only operation. The pressure regulation point, controlled electronically, is a function of:

- The airplane altitude,
- Ambient temperature,
- Slats position.

The secondary function of the MP PRSOV is to equalize bleed flow extraction from each engine. When LP pressure is sufficient, the MP PRSOV regulates the manifold pressure and the engine bleed flows are equalized. When LP bleed pressure is insufficient, the MP PRSOV is full open and therefore cannot provide engine bleed flow equalization.

The AMSAC regulates the HP PRSOV when either the S-duct AI valve or the WAI valve is full open or regulating the AI pressure limit. The HP PRSOV collectively controls the Wing or S Duct skin temperature using their respective bleed pressure sensors in a feedback loop.

The secondary function of the HP PRSOV is to equalize bleed flow extraction from each engine.

The HP PRSOV limits the bleed pressure downstream of the bleed jet pump and this takes precedence over the Wing or S-duct skin temperature regulation and bleed pressure equalization. The pressure limitation, controlled electronically, is a function of

- The airplane altitude,
- Ambient temperature,
- Slats position.

The AMSAC also controls the HP PRSOV to prevent the ECS supply pressure from falling below that required by the ECS in order to provide sufficient fresh air for the cockpit and cabin. This function takes precedence over the skin temperature control function.

The AMSAC also limits HP PRSOV opening to prevent the bleed air temperature from exceeding 336°C. This takes the precedence over the Wing or S-duct skin temperature regulation, ECS minimum pressure regulation and bleed flow equalization.

When ECS pressure is sufficient and HP boost is required for Wing or S-Duct AI but neither AI valve is fully open, the AMSAC limits HP PRSOV opening to prevent the bleed air temperature exceeding 204°C. This takes the precedence over the Wing or S-duct skin temperature regulation and bleed flow equalization.

## CONTROLS

The crew has control on engine and APU bleed air system through the BLEED section of the Overhead Panel (OP).

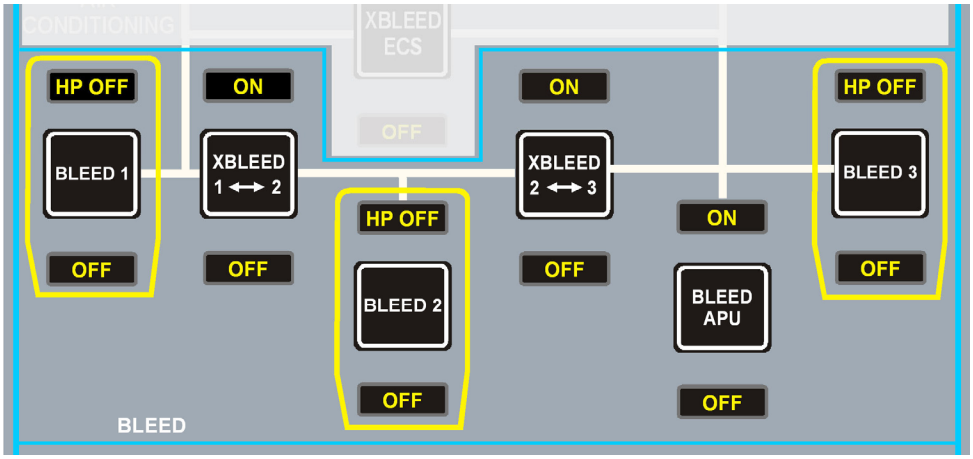
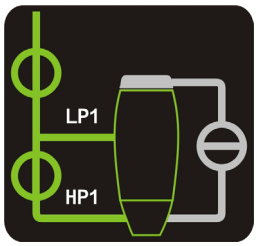
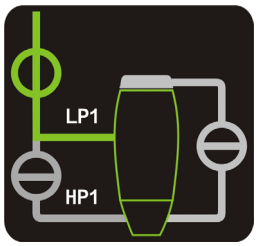
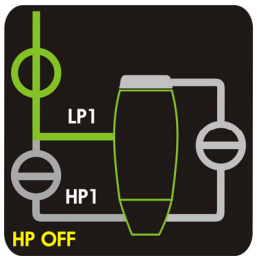
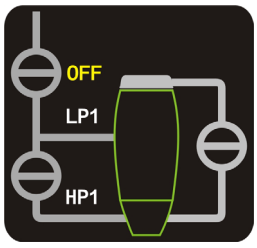
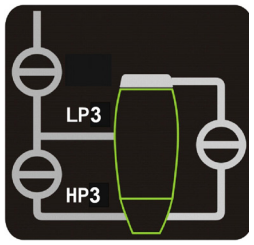
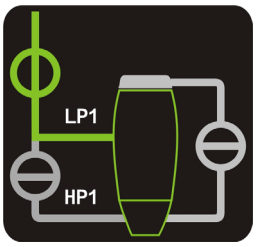
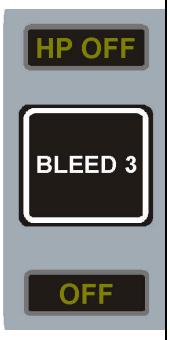
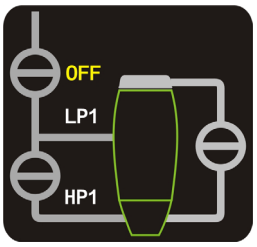
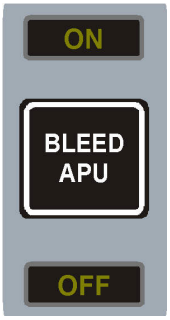
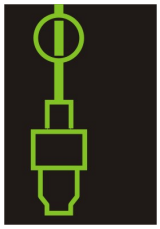
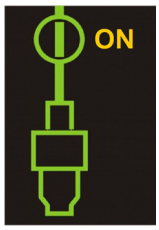


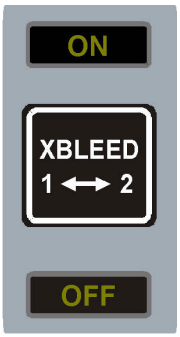
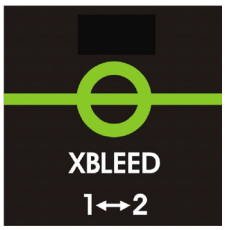
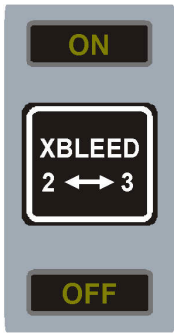

**FIGURE 02-36-20-00 - OVERHEAD BLEED AIR CONTROL PANEL**

## SYNTHETIC TABLE

| CONTROL | FUNCTION | TO ACTIVATE / TO DEACTIVATE | | SYNOPTIC |
|---|---|---|---|---|
|    | **BLEED 1/2/3**<br>**During ECS standard operation:**<br>When pushed, cycles the corresponding HP/MP valves through the positions:<br>- Unlighted on (HP and LP flow managed by AMSAC): normal Ground / Flight configuration<br>- HP OFF (HP valve closed),<br>- OFF (HP and LP flow) valves closed), | Unlighted on with HP |  |  |
| | | Unlighted on without HP |  |  |
| | | Push HP OFF |  |  |
| | | Push OFF |  |  |

| CONTROL | FUNCTION | TO ACTIVATE / TO DEACTIVATE | | SYNOPTIC |
|---|---|---|---|---|
|  | **BLEED 1/2/3**<br>**During ECS Emergency operation:**<br>- HP is automatically turned OFF for all three bleed systems<br>- BLEED 1 and 2 remain operative in "on" mode (managed by the AMSEC) or OFF mode<br>- BLEED 3 system is inoperative | |  |  |
|  | | |  |  |
|  | | |  |  |

| CONTROL | FUNCTION | TO ACTIVATE<br>TO DEACTIVATE | | SYNOPTIC |
|---|---|---|---|---|
|  | **BLEED APU**<br>When pushed, cycles the APU bleed through the positions:<br>- Unlighted auto (APU bleed valve managed by the APU controller when the APU is in operation): normal Ground/ Flight configuration<br>- ON (APU Bleed valve open )<br>- OFF (APU Bleed valve closed) | Automatic mode |  |  |
| | | Push<br>ON |  |  |
| | | Push<br>OFF |  |  |

| CONTROL | FUNCTION | TO ACTIVATE / TO DEACTIVATE | | SYNOPTIC |
|---|---|---|---|---|
|  | **XBLEED 1↔2, 2↔3**<br>**During ECS normal operation:**<br>When pushed, cycles through the positions:<br>- Unlighted auto, (XBLEED valve managed by the AMSAC ): normal Ground/ Flight configuration,<br>- ON (XBLEED valve open),<br>- OFF (XBLEED valve closed, allowing isolation of manifolds).<br>**During ECS Emergency operation:**<br>- XBLEED 1↔2 valve remains in auto mode (managed by the AMSEC) or OFF mode,<br>- XBLEED 2↔3 valve is closed. | Normal mode: |  |  <br>  |
|  | | Push ON |  |  |
| | | Push OFF |  |  |

## INDICATIONS

Cockpit indications are displayed:

- On the "BLD" synoptic page,
- On the ENG CAS window for CAS messages,
- On the STATus synoptic / FAULT Tab for fault messages.

### BLEED AIR SYNOPTIC

The bleed air system feedback is provided within the “BLD” synoptic, along with anti ice system. This synoptic provides following information:

- Position and condition of MP, HP for each engine,
- Position and condition of APU load control valve,
- Position of both XBLEED valves,
- Position and condition of engines, S-duct and wing anti ice valves,
- Position and condition of brake heat valve.

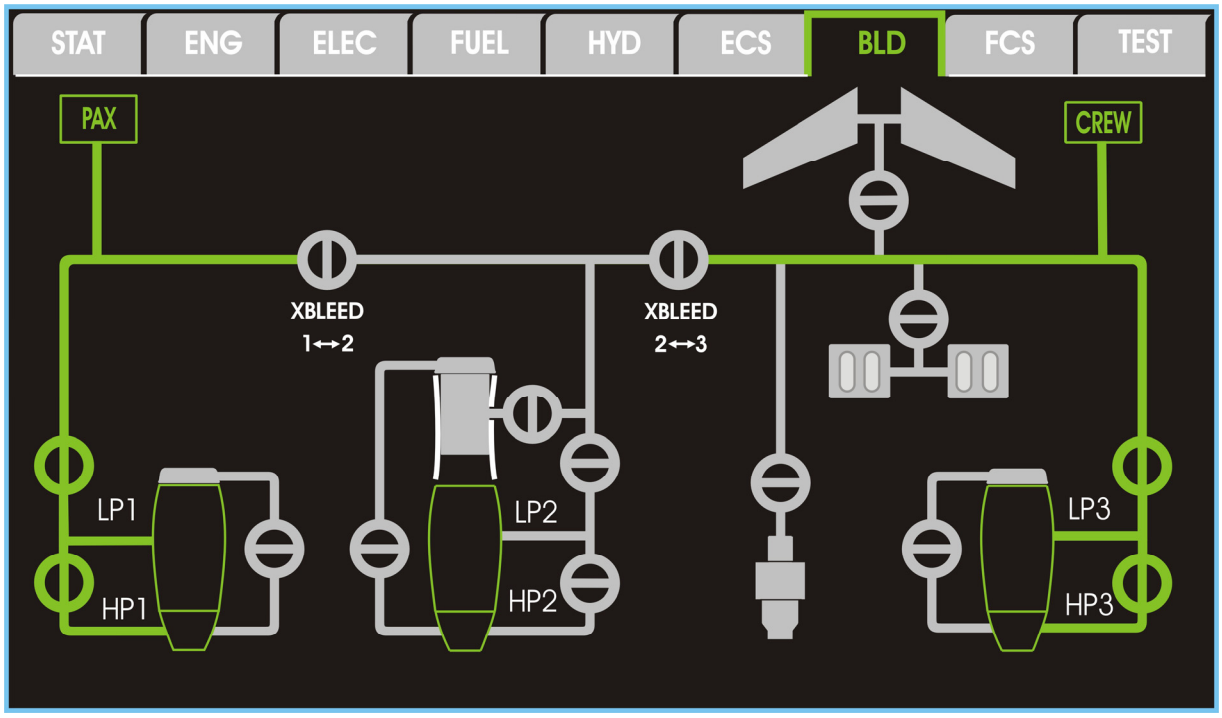



**FIGURE 02-36-20-01 - BLEED SYNOPTIC IN NORMAL OPERATION**

## COLOR SYMBOLOGY


**FIGURE 02-36-20-02 - COCKPIT SYMBOL COLOR CODE**

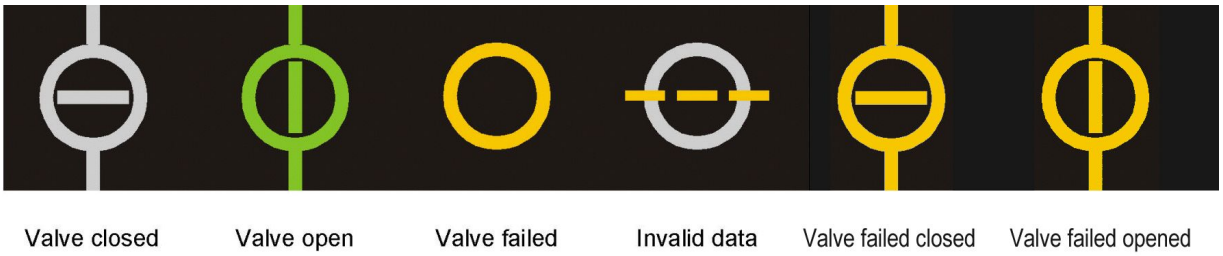



**FIGURE 02-36-20-03 - VALVE SYMBOL COLOR CODE**

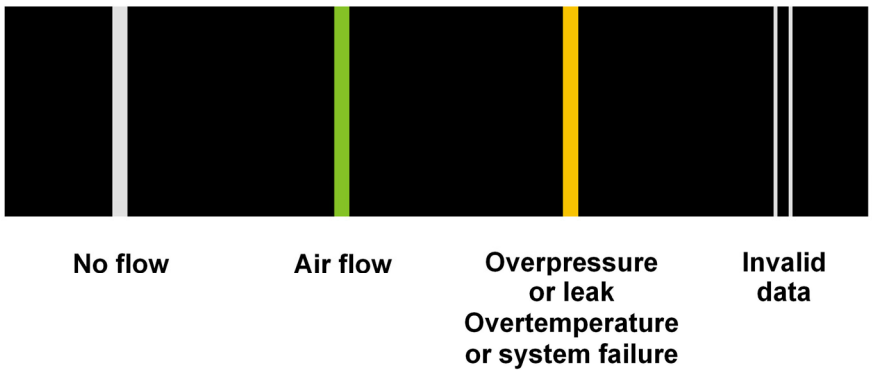



**FIGURE 02-36-20-04 - FLOW LINE COLOR CODE**

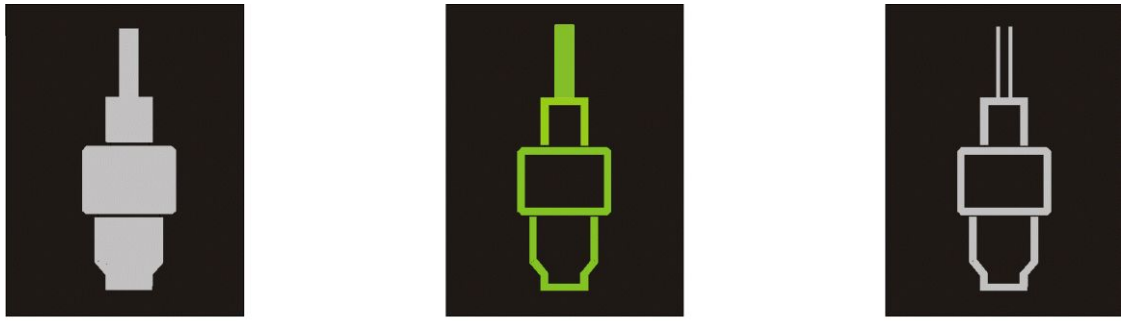



**FIGURE 02-36-20-05 - APU SCHEMATIC SYMBOL**

No supplementary information to be provided on Controls and Indications at present time.

## SYSTEM MONITORING

The Bleed Air System provides monitoring of following parameters:

- Bleed air pressure, for detection of overpressure,
- Bleed air temperature, for detection of overtemperature,
- Bleed air leak detection,
- Integrity of AMSAC, AMSEC and PSC modules
- Integrity of bleed air and pre-cooling valves and sensors.

➢ *Refer to CODDE 2 for a complete list of CAS messages and to the "Controls and Indications" section for information related to the indications.*

### BLEED AIR LEAK DETECTION

The Bleed Air Leak Detection System (BALDS) provides detection of high temperature bleed air leaks to allow protection of systems and structure, using sets of leak detection sensors located:

- In the left and right engine pylons,
- In the baggage compartment around hot air ducts.

The BALDS triggers CAS messages but does not provide any automatic protection.

During APU bleed operation, bleed air pressure is monitored for leak detection purpose.

## ACTIVE PROTECTIONS

Automatic configuration of bleed air valves is provided by the Bleed Air System in normal ECS operation, in case of:

- Bleed air overpressure,
- Bleed air overtemperature.

In EMERG ECS operation, this automatic configuration of bleed air valves is not available; only CAS messages are triggered

## OVERHEAT PROTECTION

The AMSAC uses bleed temperature sensors to provide feedback for the control and monitoring of the bleed temperature.

In case of a high temperature before the precooling system (T > 365°C) the AMSAC automatically closes the HP and the MP valves and generates a **BLEED : .. FAIL** message.

In case of a high temperature downstream of the precooling system, the PSC will automatically generate:

- In case of overheat (T > 232°C during more than 30s), the **BLEED: .. HI TEMP** message,
- In case of overheat (T > 260°C during more than 2s), the **BLEED: .. OVHT** message.

## OVERPRESSURE PROTECTION

The AMSAC provides feedback for the control and monitoring of the MP bleed air valves and for overpressure alerts.

In case of overpressure ($\Delta P > 55$ psi without wings anti-icing or $\Delta P > 105$ psi with wings anti-icing operating) the AMSAC automatically closes the HP and the MP valves and generates a **BLEED : .. FAIL** message.

In Emergency ECS operation there is no overpressure protection, but in this mode the HP bleed air valves are automatically closed and cannot be selected open by the crew members.

## BLEED AIR LEAK DETECTION SYSTEM

The BALDS determines, from the electrical characteristics of the sensors, the presence of a bleed air leak: in such a case a CAS message is generated.

### PYLON BLEED LEAK DETECTION

BALDS performs hot air leak detection in the pylons. If the sensors detect a temperature equal or above 154°C, the **A/I: PYLON .. HI TEMP** CAS message is displayed.

### CABIN CONDITIONING BLEED LEAK DETECTION

BALDS performs leak detection in the cabin ECS distribution: the **COND: PAX SUPPLY LEAK** CAS message is displayed if a temperature of 84°C is detected near the cabin hot air duct located in baggage compartment.

On the ground, the BAS also distributes pressurized air from the APU and the ground cart to the ECS and engine start systems.

The ground cart supplies pressurized air to the bleed air system

Ground cart pressurized air is supplied via the high pressure ground connector, with integral non-return valve to prevent reverse flow, to the RH bleed manifold. There is no pressure or temperature regulation of the pressurized air from the APU or ground cart.

Engines can be started on the ground using the high pressure ground cart.