2A-36-10: General:

The pneumatics system provides control, regulation and monitoring of bleed air temperature, pressure, and flow in the left and right bleed air manifold. Digital controllers are incorporated to perform these functions and, in addition, provide data to the Engine Instrument and Crew Alerting System (EICAS) for display information and fault messages, and visual representation on the ECS/PRESS synoptic page. The delivered air services the cabin air conditioning, wing leading edge anti-ice, engine starting, baggage door sealing, aspiration of the aircraft total temperature probes, and other miscellaneous bleeds.

The pneumatics system is divided into the following subsystems:

- 2A-36-20: Pneumatic Distribution and Indication System

2A-36-20: Pneumatics Distribution and Indication System:

1. General Description:

The pneumatics distribution and indication system distributes mid-stage or high-stage bleed air to the bleed air manifold where it is available to the systems that require bleed air, and provides visual indication of the pressure and temperature of the bleed air within the bleed air manifold. System design is such that mid-stage (5th) bleed is the preferred air source and high-stage (8th) bleed air serves as an alternate or supplemental source whenever mid-stage pressures are not adequate for aircraft needs.

In the standard aircraft configuration, mid-stage bleed air will supply all bleed flow during takeoff, climb and cruise conditions. The high stage bleed valve will remain closed due to existing mid-stage pressure being greater than 14 psi. Should mid-stage pressure fall below 14 psi for any reason, the high stage bleed valve will open and regulate pressure to 14 psi. In all cases, bleed air passes through manifold pressure regulator valves into the left or right bleed air manifold, where pressure is maintained at a maximum of 40.5 psi by these valves.

The pneumatics distribution and indication system is composed of the following units and components:

- Bleed Air Controllers
- High Stage Bleed Valves
- Manifold Pressure Regulator Valves
- Bleed Air Isolation Valve
- Fan Air Valves/Precoolers
- APU and Ground Air Connection Check Valves
- Door Seal Pressure Regulator
- Temperature and Pressure Sensors

2. Description of Subsystems, Units, and Components:

A. Bleed Air Controllers:

(1) Description:

There are two Bleed Air Controllers (BACs) located in the baggage compartment Electronic Equipment Rack (EER). They are microprocessor-based units designed to automatically regulate the

bleed air manifold temperature and bleed air supply pressure. They receive ARINC 429 data bus data including aircraft altitude, static air temperature and engine speed (N_1). They also monitor precooler inlet and outlet temperature, bleed air manifold pressure, wing anti-ice temperature, and receive cockpit switch selection data including: L/R BLEED AIR selection, L/R WING ANTI ICE selection and L/R PACK selection. With this input and software logic, the BACs establish high stage regulation set points.

System control outputs include variable current torque motor drivers for the high stage bleed valve (servo air regulator torquemotor), fan air valve and wing anti-ice valve. When a fault is detected by a BAC, that data is transmitted to the corresponding Data Acquisition Unit (DAU) for display as Crew Alerting System (CAS) messages and to the Maintenance Data Acquisition Unit (MDAU).

The first set point regulates high stage pressure from 14 to 22 psi for descent, holding, or V_{MIN} operation. This regulation is provided to ensure adequate air flow at low power settings to properly pressurize the aircraft.

A high stage regulation set point is also available to increase airflow through one air conditioning pack when the opposite pack is selected OFF. During single pack operation, the high stage bleed valve regulation set point is reset to 35 psi. If mid-stage pressure exceeds 35 psi, the high stage bleed valve will remain closed. If mid-stage pressure falls below 35 psi, the high stage bleed valve will open and regulate at 35 psi.

The final possibility for high stage regulation occurs when wing anti-ice is selected ON. If existing bleed flow is less than 620° F at the precooler inlet sensor, the controller will command opening of the high stage bleed valve to achieve 620° F. This may result in mixing of mid-stage and high stage, all high stage or all mid-stage flow.

Bleed air into the manifold is cooled if necessary to maintain a maximum of 400° F, at the precooler outlet sensor, for normal operations. If a single manifold pressure regulator valve or a single wing anti-ice valve is selected on, bleed air is cooled to maintain a maximum of 500° F. Bleed air is cooled with fan air through the engine bleed air precooler heat exchanger when necessary. The bleed air controller monitors precooler outlet temperature and modulates the opening of the fan air valve as required.

(2) Built-In Test Function:

The BAC incorporates fault diagnostics for certain electrically-interconnected components of the system. It has two Built-In Test (BIT) modes: continuous BIT (C-BIT) and power-up BIT (P-BIT).

P-BIT is performed upon the application of electrical power to the BAC, or after a power interrupt long enough to cause the microprocessor to be reset. P-BIT performs a self-test of the controller power supplies, Central Processing Unit (CPU), and memory circuits prior to engaging the control functions.

C-BIT is only an observer to the system and provides no control of the system. C-BIT is active during normal operation of the BAC whenever electrical power is applied and P-BIT is successfully

completed. The electrical portion of all servo air regulator torque motors, sensors, and the BAC are subject to continuous testing. These components are tested by the BIT module on a periodic on-line basis. Detected faults are time-filtered as necessary to avoid the declaration of nuisance faults. Confirmed faults are stored in nonvolatile memory and are annunciated to CAS. The following tests are performed during C-BIT:

- Validity checks of BIT module
- Temperature sensor open/short circuit tests
- Pressure sensor out-of-range checks
- Controller/sensor interface verification tests
- High stage bleed valve, fan air valve, and wing anti-ice valve servo air regulator torque motor load open/short tests

Once a fault is detected, it undergoes a validation process, which consists of detecting the same fault on two consecutive cycles before it is declared valid. This helps to preclude annunciation of nuisance faults. Once validity is determined, the fault is logged in the fault storage memory.

Confirmed faults remain in nonvolatile memory for retrieval by maintenance. Fault storage is formatted into a circular buffer in which the oldest fault data are overwritten when a new fault is validated. Validated faults are sent to the MDAU and as messages to CAS.

B. High Stage Bleed Valves:

There are two high stage bleed valves, one located on each engine. They are spring-loaded closed, pneumatically-operated modulating/shutoff valves, controlled by the BACs through servo air regulator torque motors. The purpose of the valves are to supply supplemental air to maintain bleed manifold pressure of 14, 22, or 35 psi depending upon configuration and existing conditions. As long as the mid-stage bleed air supply meets bleed air pressure demands, the valves will remain closed.

C. Manifold Pressure Regulator Valves:

There are two manifold pressure regulator valves, one located on each engine. They are butterfly-type, pneumatically-operated, modulating/shutoff valves. The purpose of the valves is to maintain a bleed manifold pressure of 40.5 psi. The L/R BLEED AIR switches provide 28V DC to the valve solenoid to allow the valve to pneumatically open and begin regulation.

D. Bleed Air Isolation Valve:

Located in tail compartment, the bleed air isolation valve provides the mechanism to isolate the left and right bleed air manifolds in the normal operating modes and to provide the means to supply APU bleed air to both ECS packs for air conditioning during ground operations. The bleed air isolation valve also allows engine starting and cranking from the opposite engine bleed source, as well as the APU during ground operations. During flight operations the isolation valve opens automatically to provide APU bleed air for main engine start assist only.

E. Fan Air Valves/Precoolers:

A fan air valve and precooler is installed in each engine pylon. The BAC monitors precooler outlet temperature and controls a servo air regulator torque motor that modulates the opening of the fan air valve. Fan (cooling) air, supplied by the fan air valve, controls the temperature of the air passing through the precooler (single pass heat exchanger). This process regulates air temperature in the bleed air manifold.

F. APU and Ground Air Connection Check Valves:

Flapper-type check valves are used to check airflow at the APU and ground connection. Each is installed in the supply duct connected to the right bleed air manifold. Whenever either APU or ground cart bleed air is used, the respective check valve opens to allow airflow into the bleed air manifold. Whenever bleed manifold pressure exceeds APU or ground cart supply pressure, the check valve closes to prevent reverse flow.

G. Door Seal Pressure Regulator:

The door seal pressure regulator connects to the bleed air manifold through a supply manifold and check valves so that either left or right bleed air manifold can furnish a supply of bleed air. The regulator is designed to provide 18 psi output to operate the inflatable baggage door seal.

H. Temperature and Pressure Sensors:

(1) Precooler Inlet Temperature Sensor:

The precooler inlet temperature sensor is located in the bleed air manifold, upstream of the precooler. Sensor output is routed to the Bleed Air Controller (BAC). The BAC processes sensor input and routes data to the on-side DAU via the ARINC 429 data bus for display on the ECS/PRESS synoptic page. Sensor data is also routed to the fan air valve. If the precooler inlet temperature increases to 765 ±10° F, an amber L/R BLEED AIR HOT message is prompted for display on the Crew Alerting System (CAS).

(2) Precooler Outlet Temperature Sensor:

The precooler outlet temperature sensor is located in the bleed air manifold, downstream of the precooler. Sensor output is routed to the BAC. The BAC processes sensor input and routes data to the on-side DAU via the ARINC 429 data bus for display on the ECS/PRESS synoptic page. Sensor data is also routed to the fan air valve. If the precooler outlet temperature increases to 550 ±10 °F, an amber L/R BLEED AIR HOT message is prompted for display on CAS.

(3) Manifold Pressure Sensor:

The manifold pressure sensor is located in the bleed air manifold, downstream of the precooler. The BAC processes sensor input and routes data to the on-side DAU via the ARINC 429 data bus for display on the ECS/PRESS synoptic page. If manifold bleed air pressure exceeds 75 psi, an amber L/R BLEED PRESS HI message is prompted for display on CAS. If manifold bleed air pressure drops below 5 psi for 10 seconds, an amber L/R BLEED PRESS LO message is prompted for display on CAS.

3. Controls and Indications:

(See Figure 1.)

NOTE:

A full description of the ECS/PRESS synoptic page can be found in Section 2B-03-30: Crew Alerting System Description.

A. Circuit Breakers:

The pneumatics distribution and indication system is protected by the following Circuit Breakers (CBs):

Circuit Breaker Name:	CB Panel:	CB Location:	Power Source:
L BLEED AIR CONT	LEER	E-10	L ESS DC Bus
R BLEED AIR CONT	REER	E-9	R ESS DC Bus
BLD AIR ISO VLV SOL	LEER	E-7	L ESS DC Bus

B. Crew Alerting System (CAS) Messages:

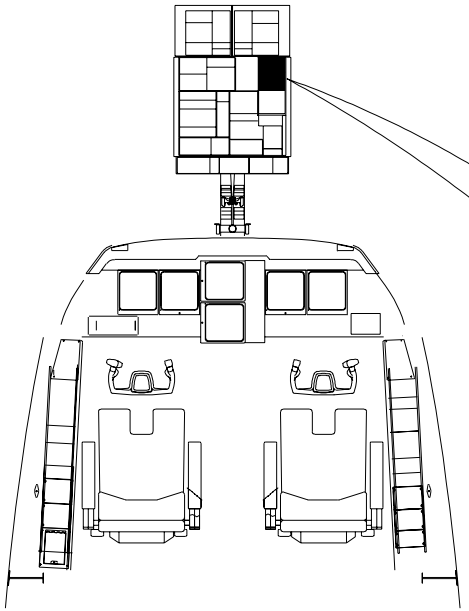
CAS messages associated with the pneumatics distribution and indication system are:

Area Monitored:	CAS Message:	Message Color:
L/R Bleed Air / Wing Anti-Ice Controller	L/R BAS FAIL	Amber
L/R Bleed Air Switch Relay	L/R BAS OFF	Amber
L/R Precooler Inlet/Outlet Temperature	L/R BLEED AIR HOT	Amber
L/R Bleed Air Controller	BLEED CONFIG	Amber
L/R Bleed Air Manifold Pressure Sensor	L/R BLEED PRESS HI	Amber
L/R Bleed Air Manifold Pressure Sensor	L/R BLEED PRESS LO	Amber
L/R Bleed Air Controller	L/R BAS DEFLT MODE	Blue
L/R Bleed Air Controller	L/R BAS MAINT REQD	Blue
Bleed Air Isolation Valve Shutoff Valve Switch	ISOLATION VLV OPEN	Blue

4. Limitations:

A. Flight Manual Limitations:

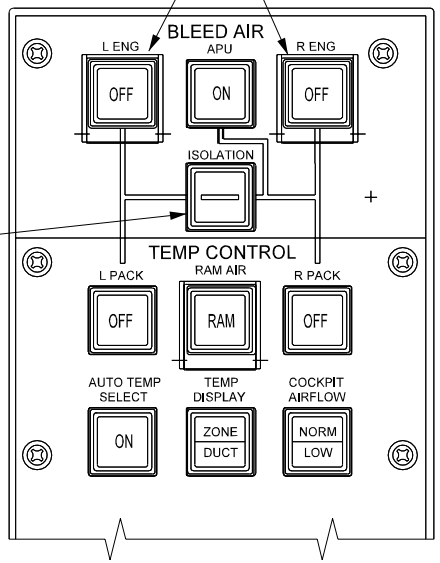
There are no limitations for the pneumatics distribution and indication system at the time of this revision.



L ENG / R ENG BLEED AIR

When selected to ON:
- Amber OFF legend is extinguished.
- Essential (ESS) 28V DC Bus power is provided to the associated system (L ESS DC for L ENG side; R ESS DC for R ENG side).
- Associated Bleed Air Controller performs BIT check and establishes operational parameters.
- Associated manifold pressure regulator valve is opened, allowing bleed air to using systems.
- APU bleed air is inhibited when sufficient engine bleed air is available (APU Bleed Air Interlock).

When selected to OFF:
- Amber OFF legend illuminates.
- Associated manifold pressure regulator valve closes.
- Power is removed from associated system.
- APU air is available when selected.



ISOLATION

When manually or automatically selected open (on ground):
- White bar in switch capsule illuminates.
- Left and right bleed air manifolds are combined.
- Crossbleed air from opposite engine is available.
- APU air is available for ECS packs and engine starting.

When manually or automatically selected open (in air):
- Same conditions listed above are present except APU air is available for engine starting only.

When selected to OFF:
- White bar in switch capsule extinguishes.
- Left and right bleed air manifolds are isolated.
- Crossbleed air from opposite engine is inhibited.
- APU air is available for R ENG bleed air manifold only.

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Pneumatics System
Controls and Indications
Figure 1