2A-71-10: General Arrangement

1. **General:**

(See Figure 1.)

The Gulfstream G550 is powered by two BMW / Rolls-Royce BR710C4-11 engines. The engine is a high bypass ratio turbo fan with two concentric spools each containing compressor and turbine stages. The inner spool contains the large forty-eight inch (48 in) diameter fan stage compressor at the forward end that is driven by two turbine stages at the aft end of the engine. Since these two turbine stages are located within the larger diameter and cooler section of the engine exhaust where gases expand, the inner spool is referred to as the low pressure or LP turbine. The outer spool rotates freely around the inner spool and is termed the high pressure or HP turbine since it contains a ten (10) stage compressor section at the forward end that is driven by two turbine stages positioned in the narrower high pressure section of the engine immediately aft of the combustion chambers. Each spool is supported by roller / thrust bearings that both enable rotation and maintain the position of each spool. The bearings are lubricated by a recirculating oil system that is cooled by a fuel-oil heat exchanger.

As the engine rotates (counter-clockwise when viewed from the front), the fan draws in a large volume of air and compresses it, forcing the air aft through the engine. Most of the air is ducted into the nacelle around the engine core, providing thrust and cooling the turbine section before mixing with and cooling the combustion section exhaust. The air flowing around the engine core is termed bypass air and the engine has a bypass ration of four to one (4 : 1), so only one fifth (1/5) of all of the air drawn into the engine is ducted into the engine core for combustion. The fan air used for combustion is fed into the ten (10) compressor stages of the outer spool. Each compressor stage increases the pressure of the air by interaction with stators between each compressor stage. As the name implies, the stators are fixed and do not rotate, however the angle of incidence of the inlet guide vanes directing LP air into the compressor and the angle of the first three stators is variable in order to control the level of pressure generated by the compressor stages.

After the compressor stages, high pressure air is forced into a annular shaped combustion chamber. The circular chamber surrounds the core of the engine and is shaped to impart a swirling motion to the airflow to ensure smooth distribution. Fuel is injected into the combustion chamber by twenty (20) spray nozzles arranged around the circumference of the chamber. Two ignitor plugs, positioned at the four (4) o’clock and seven (7) o’clock position provide a high energy spark to ignite the fuel / air mixture.

The high temperature / high velocity air produced within the combustion chamber is first directed against the two high pressure (HP) turbine blades and subsequently the two low pressure (LP) turbine blades. The high energy of the rapidly expanding air produces rapid rotation of both the HP and LP turbine stages. Rotation of the turbine stages powers the rotation of the associated LP fan compressor stage and the ten (10) HP compressor stages through the common shafts connecting the turbine and compressor stages.

After dissipating substantial energy in producing the rotation of the turbine stages, combustion air enters the engine exhaust area where it is mixed with cool fan stage air flowing around the engine core within the nacelle. The engine exhaust section is fitted with a crenelated flange surrounding the inside of the nacelle to thoroughly mix the flow of fan and exhaust air. The resultant exhaust mix is lower in temperature and distinctly quieter enabling compliance with noise reduction regulations.

All engine operation is controlled by a Full Authority Digital Engine Control (FADEC) mounted at the twelve (12) o'clock position on each engine core. The FADEC is powered by a self-contained generator, but can use aircraft direct current (DC) if the generator fails. The FADEC is electrically linked to the cockpit power levers and switches and communicates with all three (3) Modular Avionics Units (MAUs) over ARINC-429 data buses.

A. Engine Data:

(1) Configuration:

- Single stage twenty-four (24) blade wide chord fan LP compressor
- Ten (10) stage HP compressor
- Annular combustion chamber
- Two (2) stage HP turbine
- Two (2) stage LP turbine
- Exhaust section
- Full Authority Digital Engine Control (FADEC)

(2) Ratings (Takeoff At ISA Sea Level, Static):

- Thrust — 15,385 lb
- Flat Rating — ISA + 15°C
- Pressure Ratio — 25.7:1
- Mass Flow — 445 lb / sec

(3) Dimensions:

- Length — 201 in
- Fan Diameter — 48.0 in
- Basic Weight — 4,840 lb

(4) 100% Shaft Speeds:

- LP — 7,431 RPM
- HP — 15,898 RPM

B. Subsections Within this Section:

This section is divided into the following subsections:

- 2A-71-20: Nacelle Arrangement
- 2A-71-30: Mechanical Accessories

2. Limitations:

A. Primary Operating Limits:

The following limitations exist for the BR710C4-11 engines installed on the Gulfstream G550:

Condition	MAX LP (%)	MAX HP (%)	MAX TGT	Time Limit
Ground Start (1)	—	—	700°C	Momentary
Airstart (Relight)	—	—	850°C	Momentary
Takeoff (2)	101.1	99.6	900°C	5 Minutes
Maximum Continuous	101.0	98.9	860°C	Unrestricted
Maximum Overspeed	101.5	99.8	—	20 Seconds
Maximum Overtemperature	—	—	905°C	20 Seconds
Reverse Thrust (3) (4)	70.0	—	—	30 Seconds

NOTE(S):

(1) Maximum TGT prior to ground start is one hundred fifty degrees centigrade (150°C).

(2) The use of takeoff rated thrust is limited to five (5) minutes with all engines operating or ten (10) minutes for one engine in the event of an engine failure.

NOTE:

Engine exceedances will be recorded after five (5) minutes, but should be ignored if single engine performance is required.

(3) Static operation of thrust reversers is limited to thirty percent (30%) LP maximum.

(4) Maximum reverse thrust must be selected only at airplane speeds above sixty (60) knots.

B. Engine Ground Start:

(1) Maximum crosswind component for engine ground start is thirty (30) knots.

(2) Maximum tailwind component for engine ground start is twenty (20) knots.

C. Engine Airstart:

The preferred method of engine airstart is an automatic airstart. Manual starter assisted and windmill airstarts are also permitted.

D. Takeoff Power:

(1) Minimum acceptable power for takeoff is shown in G550 Airplane Flight Manual Section 5: Normal Takeoff Planning.

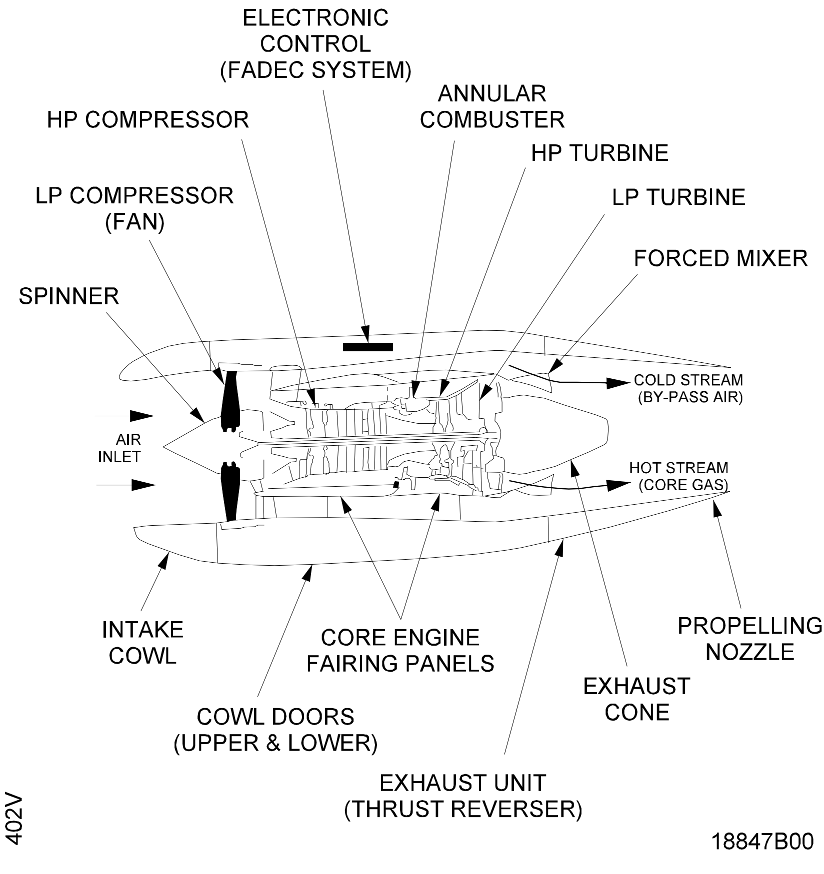
(2) Takeoff in the Alternate Control (LP) mode is prohibited.

E. Crosswind Takeoff:

For acceleration to takeoff with crosswinds above twenty (20) knots, the fan speed is limited to less than 66% LP RPM until a forward speed of 20 knots has been reached. Above 20 knots forward speed, a slam acceleration to takeoff power is required. Add six hundred (600) feet to the required field length when using this procedure.

F. Static Ground Run:

While the airplane is static on the ground, stabilized engine operation in the band between 66% and 80% LP RPM (fan speed) is prohibited. Any acceleration or deceleration through this band must not exceed 10 seconds. This limitation only applies to forward thrust.



Powerplant General Arrangement
Figure 1

2A-71-20: Nacelle Arrangement

1. General Description:

The engine nacelles are an aerodynamic enclosures for the engines that duct fan stage air around and past the engine core to provide engine thrust and cool the combustion section and engine exhaust gases. The nacelles contain the engine fire detection loops and provide the mounting surface for the engine thrust reversers.

The nacelles are composed of cowlings and doors that may be opened to accomplish engine maintenance and servicing. (See Figure 2.)

Each nacelle includes the following components:

- Inlet Cowl
- Upper and Lower Cowl Doors
- Fixed Cowl Structure
- Exhaust Unit
- Fire Detection / Protection System

All of the nacelle aerodynamic components except the front of the inlet cowl are made of carbon fiber composite. The composite incorporates a copper mesh laminate to shield engine electronic installations such as the FADEC against High Intensity Radiated Fields (HIRF) interference in the event of a lightning strike.

2. Description of Subsystems, Units and Components:

A. Inlet Cowl:

The forward section of the engine inlet cowl is manufactured from titanium and encloses the ducting for the warm anti-ice bleed air drawn from the fifth (5^{th}) stage of the HP compressor. The warm air is distributed by a circular duct with perforations that direct the air against the interior of the metal cowling. The anti-ice air is exhausted through a vent at the bottom of the cowl. The interior of the inlet cowl surrounding the compressor fan stage has an acoustic liner to reduce fan noise. Immediately aft of the acoustic liner is a ring of three layers of a kelvar fabric incorporated to prevent a fan blade from puncturing the cowling and entering the fuselage in the event of a catastrophic failure. See Section 2A-30-30: Cowl Anti-Ice System for a discussion of the cowl anti-icing system.

B. Upper And Lower Cowl Doors:

(See Figure 3 and Figure 4.)

(1) General:

Two cowl doors (upper and lower) extend from the rear of the inlet cowl to the front of the exhaust unit. The upper door is hinged to the upper edge of the fixed cowling on the inside of the nacelle that is attached to the engine pylon. The lower door is mounted in a similar manner to the lower edge of the fixed cowling . The doors are latched together by five latches. Both doors are provided with rods to hold open the doors and dampening struts to control the rate of door opening and closing. Ventilation inlets are installed in the upper door. The lower door incorporates a ventilation outlet.

When properly supported by the hold-open struts, the lower cowl door can be used as a seating area for performing maintenance on the lower engine area. The following paragraphs briefly describe how to open and close the cowl doors. For the full procedure, see the G550 Maintenance Manual.

NOTE:

Whenever the cowl doors are open, ensure that they are secured with front and rear hold-open struts.

- Ensure the aircraft is safe for opening the cowl doors.
- Position a maintenance platform adjacent to the cowl doors.
- Visualize the cowl door latches as being numbered one (1) through five (5) from front to rear.
- Release tension on all five latches. Do not disengage them.
- Manually support the weight of the lower door and disengage all five latches in the following order: 1, 5, 2, 4 and 3.
- Lower the lower cowl door and secure it with front and rear hold-open struts.
- Raise the upper cowl door and secure it with front and rear hold-open struts.

Closing the cowl doors:

- Inspect the area inside the cowl doors to ensure it is safe to close the doors.
- Manually support the upper cowl door. Release and stow the front and rear hold-open struts.
- Lower the upper cowl door.
- Manually support the lower cowl door. Release and stow the front and rear hold-open struts.
- Raise the lower cowl door and engage all five latches.
- Lock all five latches by firm overcenter pressure. Verify each latch is flush and locked.
- Remove the maintenance platform from the adjacent area.

(2) Access Doors:

Access doors for the cowl anti-ice valve and the starter air valve are incorporated in the lower cowl doors. An access panel that allows viewing the engine oil level sight glass is also installed in the LH lower cowl door.

(3) Door Position Indication:

When any of the following doors are not properly closed, a blue “Service Door” Crew Alerting System (CAS) advisory message is shown on the cockpit CAS display window. The Doors synoptic page can be consulted to determine the location of the open door(s). See Section 2B-07-00 for a description of the DOORS synoptic page. Engine nacelle doors that are monitored by position contact switches are:

- LH / RH cowl doors
- LH / RH anti-ice valve access doors (2 left, 2 right)
- LH / RH starter air valve access doors

- LH / RH engine oil level sight gage access doors

(4) Drains:

Drains are incorporated into the LH and RH lower cowl doors to ensure that unused fuel from engine shutdown or any leakage of fluids within in the cowls is drained overboard, providing a visual indication to the flight crew. The drains are classified as two types: wet (normally draining fluid) and dry (fluid flow is abnormal).

The drains exit at two locations on the lower cowl door. The forward drain set is referred to as the dry drains and comprises seven drains that empty into a single exit hole in the cowl. The drains are:

- Fuel pump
- Fuel metering unit
- Air starter
- Integrated drive generator
- Hydraulic pump case
- Hydraulic pump cavity
- Fuel return to tank / overspeed splitter unit

The aft drain set is a combination of three dry and wet drains as follows:

- Drains tank overflow (wet)
- Combined structural bypass duct / interservice fairing (wet)
- Variable stator vane actuator (dry)

NOTE:

Any fluid visible at a dry drain indicates possible leakage. If any leakage is evident, the cowl door should be opened, the drain tube and applicable unit identified, and the allowable leakage rate checked.

C. Fixed Cowl Structure:

The fixed cowl extends from the inlet cowling to the engine exhaust section, inboard of the nacelle and attached to the pylon. Penetrations through the fixed cowl are provided for engine services. The right engine fixed cowl contains the access door for the engine oil level sight glass.

D. Exhaust Unit:

(1) Exhaust Nozzle:

The exhaust nozzle is formed by a convergent duct that efficiently mixes the turbine exhaust with LP fan air to reduce engine noise.

(2) Oil Breather System Outlet:

An oil breather outlet is plumbed into the exhaust unit to vent overboard any air from the bearing chambers, accessory gearbox and oil tank. See Section 2A-79-00: Engine Oil, for a description of the oil breather system.

(3) Thrust Reverser Unit:

The thrust reverser unit is incorporated into the exhaust nozzle. The thrust reverser consists of two hydraulically actuated doors that pivot to move into the flow of the engine exhaust to redirect the gases forward to slow the aircraft during landing or an aborted takeoff. See Section 2A-78-00: Engine Exhaust for a description of the thrust reverser system.

E. Fire Detection / Protection System:

(See Figure 5 and Figure 6.)

The nacelle is divided into two ventilation / fire protection zones that are isolated by fireproof shields. Each zone is ventilated to prevent buildup of flammable vapors and to provide cooling flow to the engine components. If a fire detector loop senses an engine fire, an extinguishing agent from fire bottles mounted in the tail compartment can be introduced into the nacelle by the flight crew. See Section 2A-26-20: Engine and Auxiliary Power Unit (APU) Fire and Overheat Detection and Warning System for a full description of the engine fire detection system.

3. Controls and Indications:

A. Circuit Breakers (CBs):

The following CB powers equipment in the nacelle:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
SERVICE DOORS	REER	C-19	Ground Service Bus

B. Crew Alerting System (CAS) Messages:

The following CAS messages are associated with the nacelle:

Area Monitored:	CAS Message:	Message Color:
L-R Cowl Door Switches 1 and 2 L-R Cowl Anti-ice Valve Access Door Switch L-R Starter Air Valve Access Door Switch L-R Oil Level Access Door Switch	Service Door	Blue

4. Limitations:

A. Flight Manual Limitations:

There are no limitations established for the nacelle at the time of this writing.

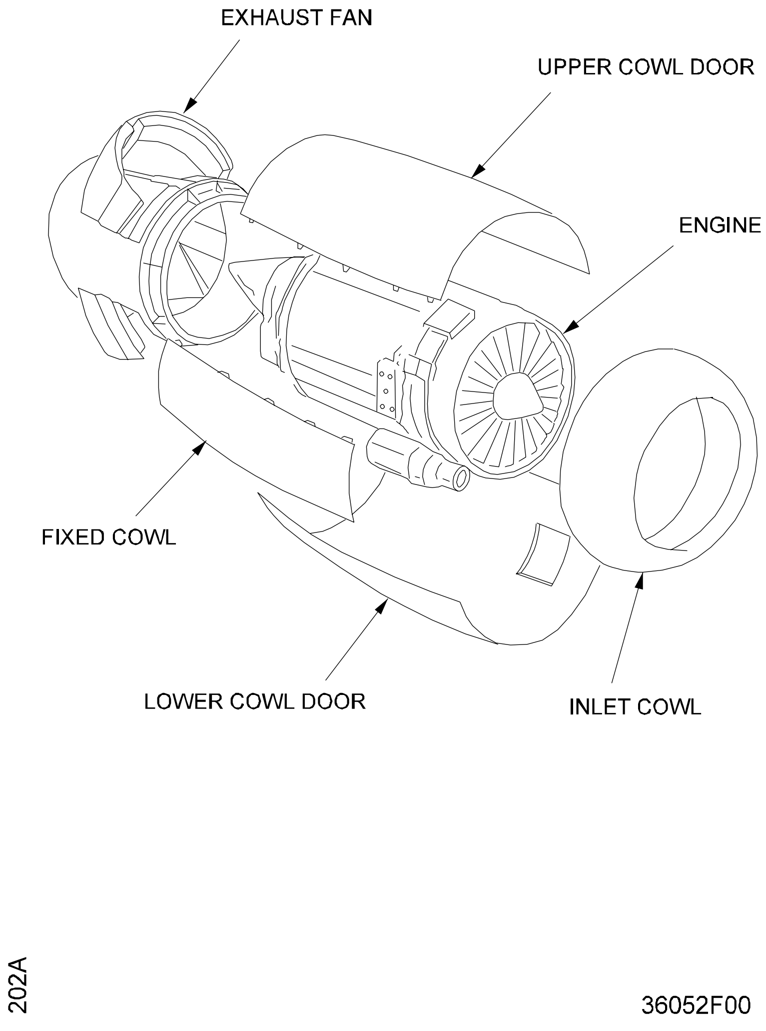
B. Other Limitations:

(1) **Lower Cowl Door Weight Limit:**

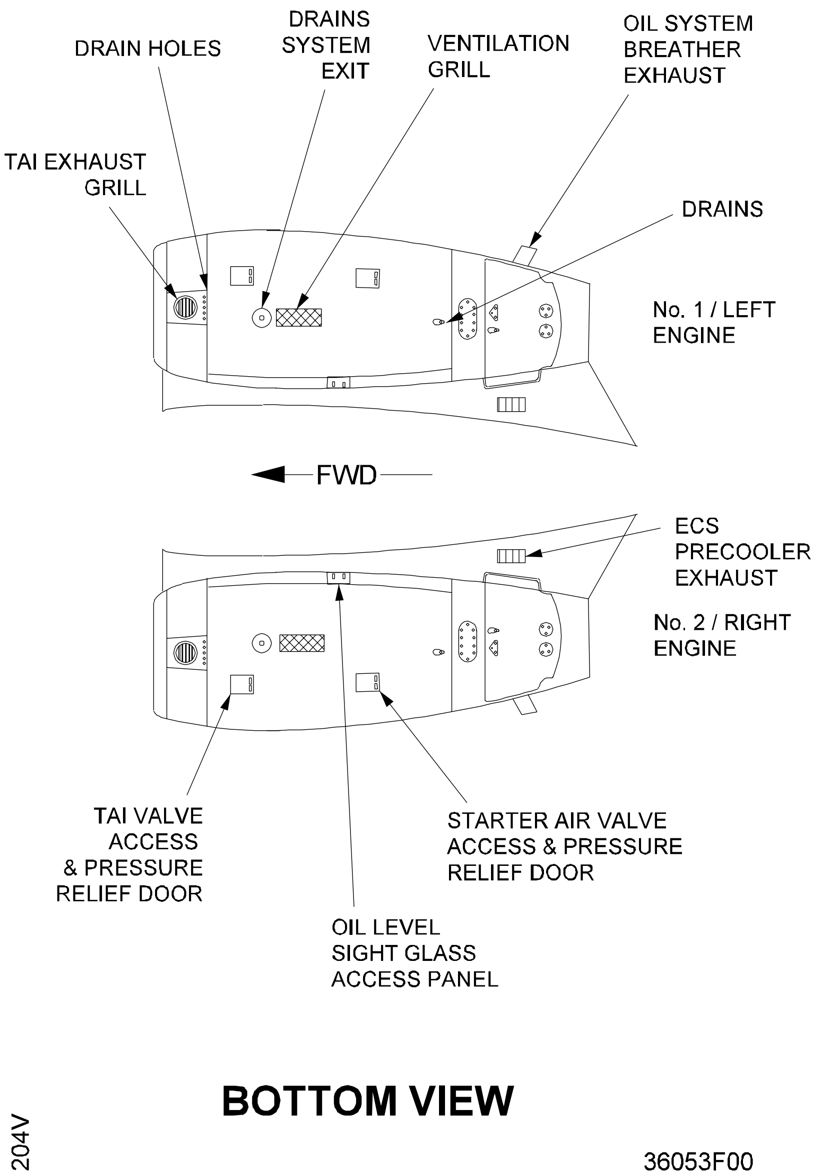
The lower cowl door is designed to support the weight of up to two average weight persons (190 lbs) and an average weight toolbox (75 lbs).

(2) **Maximum Wind Velocity With Cowl Doors Open:**

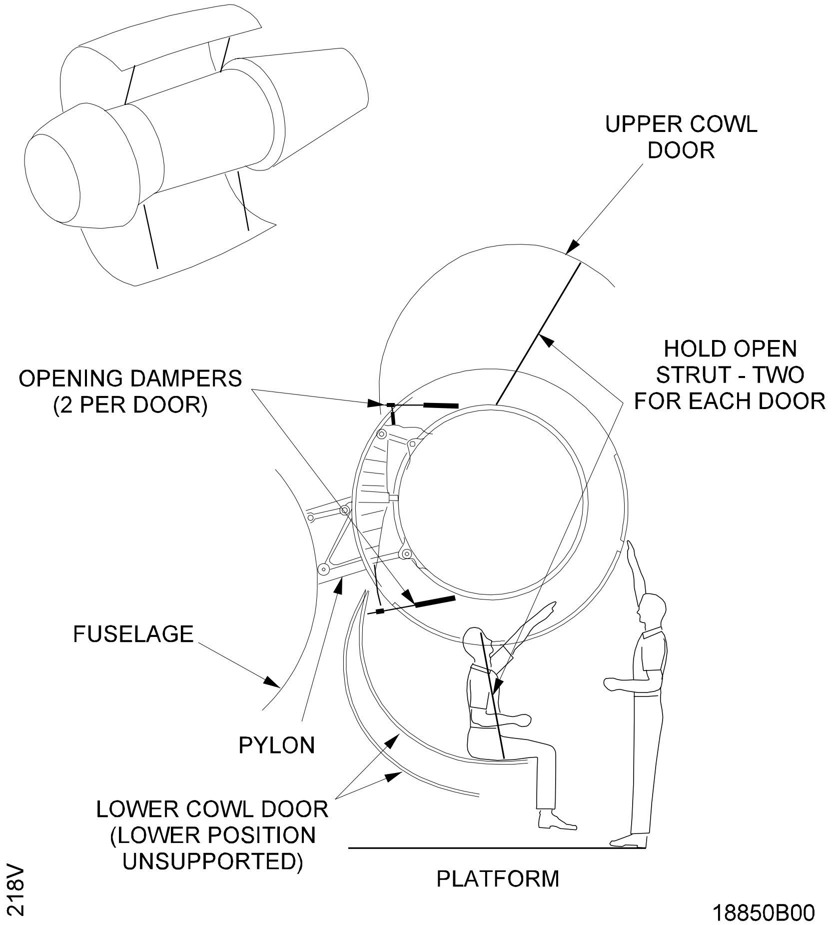
Open cowl doors are designed to withstand wind speeds of up to sixty (60) knots when properly secured with front and rear hold-open struts.



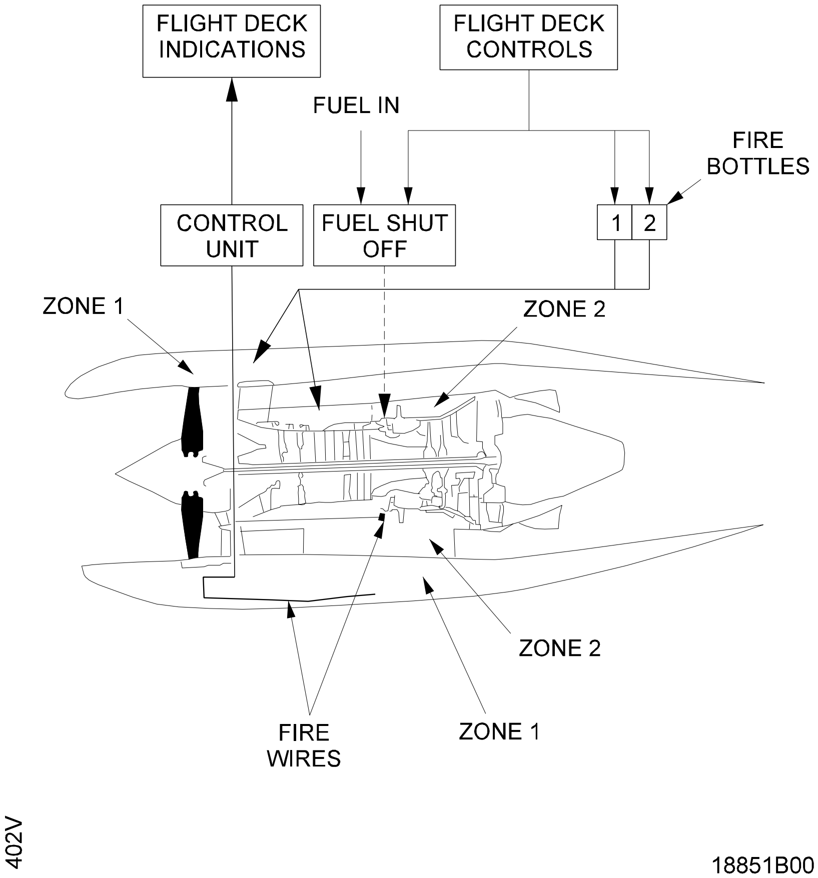
Nacelle Components
Figure 2



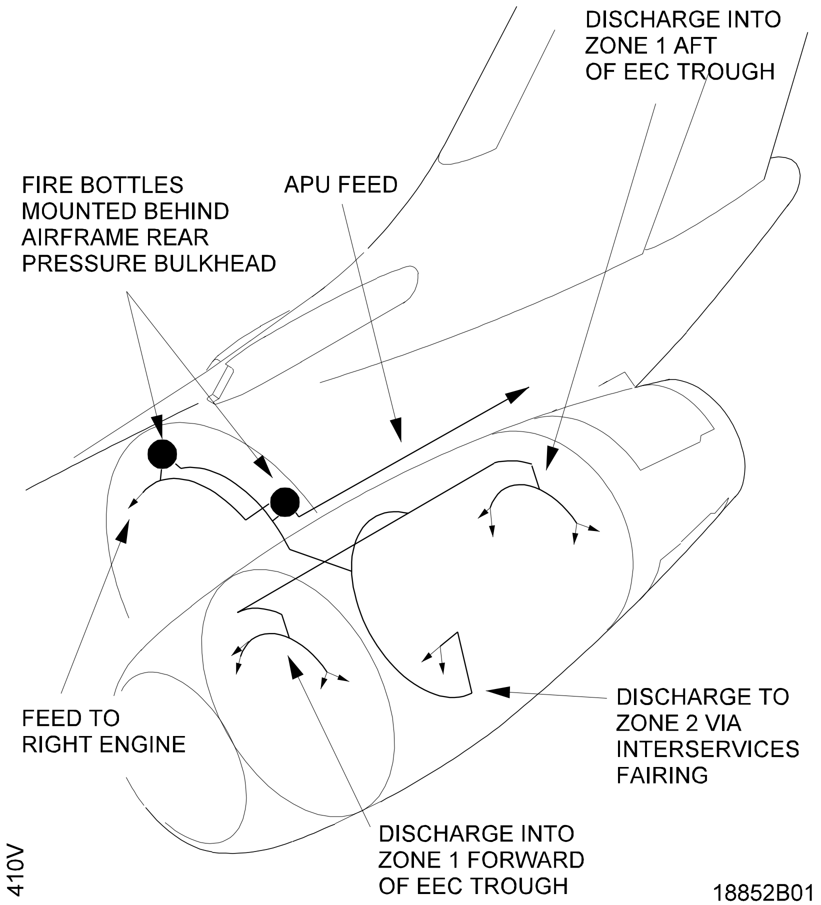
Nacelle Access Doors, Drains and Exhausts
Figure 3



Opening Engine Cowl Doors
Figure 4



Fire Detection / Protection Layout
Figure 5



Fire Extinguishing Layout
Figure 6

2A-71-30: Mechanical Accessories

1. **General Description:**

   In addition to furnishing thrust to power the aircraft, aircraft engine operation provides an energy source for other aircraft and engine systems. High pressure air at elevated temperatures generated by the engine compressor section is used to supply pneumatic power to the aircraft air-conditioning and pressurization system, provides a means to prevent ice formation on the aircraft wings and engine air intake cowl, and furnishes energy to operate the air-driven engine starter during crossbleed starts with the pneumatic supply manifold isolation valve open. The pressure levels of air within the engine compressor can be reduced to ensure engine operational stability, prevent engine power surges and protect the engine against flameout.

The rotational energy of each engine powers a gearbox that supplies the motive force for operating the hydraulic pump, an electrical generator, the engine fuel pump and oil pump, and the dedicated generator of the Full Authority Digital Engine Control (FADEC).

2. Description of Subsystems, Units and Components:

A. Engine Pneumatic Bleed System:

(See Figure 7.)

(1) High pressure engine compressor air at elevated temperatures is supplied to aircraft systems through a common duct connected to valves located at the fifth (5^{th}) and eighth (8^{th}) stage of the engine high pressure (HP) compressor. At normal power settings, the pressure and temperature of the air drawn from the fifth (5^{th}) stage of the HP compressor air is sufficient to meet system requirements. If the engine is operating a low power settings as during a prolonged descent, air of increased temperature and pressure will be extracted from the eighth (8^{th}) HP compressor stage to satisfy requirements. A check valve in the common duct prevents eighth (8^{th}) stage air from entering into the (5^{th}) stage of the compressor and disrupting airflow through the engine.

The operation of the fifth (5^{th}) stage and eighth (8^{th}) stage bleed valves is regulated by the Bleed Air Controller (BAC) of each engine. The BAC also maintains the temperature of the engine bleed air supply at a constant level by operating the bleed air precooler. The precooler is an air to air heat exchanger that uses cool ambient air extracted from the engine air inlet at the low pressure (LP) fan stage. The fan stage air circulates within the interior of the precooler to reduce the temperature of the fifth (5^{th}) stage and eighth (8^{th}) stage bleed air that passes through the precooler. The BAC opens and closes the supply valve from the engine fan stage to maintain engine bleed air at four hundred degrees Fahrenheit (400°F) for normal operations. If higher temperature air is required for wing anti-icing or if an engine fails and cannot supply bleed air, the BAC increases the regulated temperature of the air supply to five hundred degrees Fahrenheit (500°F) by passing less fan stage air through the precooler.

An independent fifth (5^{th}) stage bleed valve supplies warm air to the engine intake cowling to prevent the formation of ice. The bleed valve is controlled by the L COWL and R COWL anti-ice switches on the cockpit overhead panel. The switches may be used to electrically select the bleed valve open to provide ice protection or to enable the aircraft ice detectors to control the operation of the valve. Additional ice protection for the engine is provided mechanically by the rubber tip on the spinner of the fan stage compressor. The spinner tip is made of a soft elastic rubber compound designed to distort at the high centrifugal forces generated by engine rotation in order to dispel any ice buildup.

A complete description of the systems powered by engine compressor air is found in Section 2A-21-00: Air Conditioning and Pressurization, Section 2A-30-00: Ice and Rain Protection, and

Three additional air bleed valves located on the fifth (5^{th}) stage of the HP compressor operate in conjunction with an additional eighth (8^{th}) stage valve to modulate engine performance. The valves are referred to as engine handling valves. The operation of all four (4) valves is controlled by the FADEC.

During engine starting the bleed valves are open to promote engine acceleration. The FADEC closes the valves sequentially as engine rpm increases to a normal setting of one hundred percent (100%). The FADEC will also selectively open the bleed valves if an engine surge is detected or if water (rain) is sensed entering the engine intake.

NOTE:

If inclement weather is detected, continuous ignition is automatically selected ON by the FADEC.

B. Engine Accessory Gearbox:

The rotational force of the engines is used to provide the mechanical drive for aircraft system components mounted on the accessory gearbox. The gearbox is attached to the engine exterior and connected to the HP compressor through a drive shaft. The gearbox reduces engine rpm to a lower speed in order to power the following components:

- Integrated Drive Generator (IDG)
- Fuel Pump and Metering Unit
- Oil Pump
- Hydraulic Pump
- Full Authority Digital Engine Control (FADEC) Generator

The accessory gearbox also provides mounting and mechanical connection to the engine for the pneumatically driven engine starter.

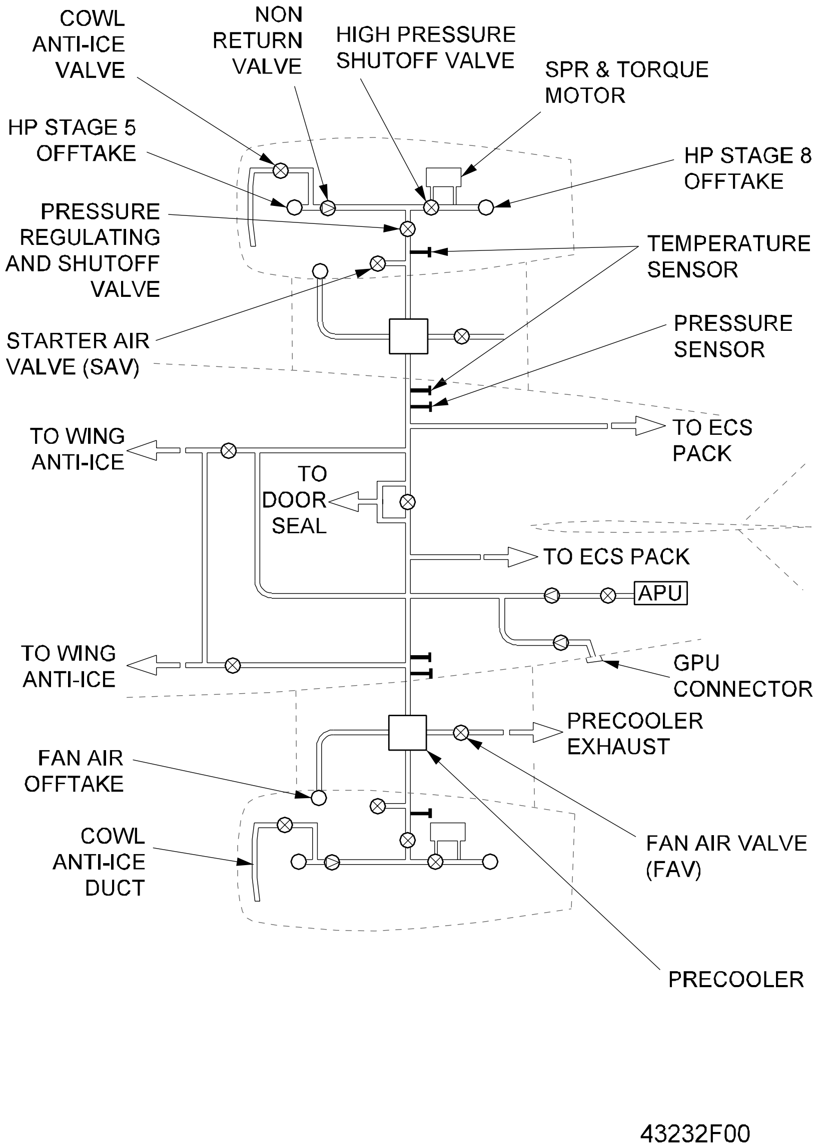
3. Controls and Indications:

The engine mechanical accessories have no controls independent of the powered systems. See the following sections for specific controls and indications:

- Section 2A-21-00: Air Conditioning
- Section 2A-30-00: Ice And Rain Protection
- Section 2A-36-00: Pneumatics
- Section 2A-80-00: Engine Starting

4. Limitations:

There are no limitations established for the mechanical accessories at the time of this writing.



Bleeds System Simplified Block Diagram
Figure 7