

Gulfstream IV

OPERATING MANUAL

ENGINE STARTING

2A-80-10: Engine Starting System

1. General:

A. Description:

The engine starting system can receive pneumatic starting air from any of the following sources:

- Auxiliary Power Unit (APU)
- An already running engine (crossbleed)
- An external air source (i.e., engine start cart)

Engine starting can be accomplished on the ground (ground starts) or in the air (air starts), with or without the starter motor. The air used for starting is ducted by means of the bleed air manifold from any of the three sources listed above. The cranking operation is accomplished by a pneumatic starter mounted on the right hand (HP) gearbox. The motion of the starter (rotation) engages a series of gears and a drive shaft. The drive shaft is connected to the HP spool of the engine, causing it to turn. The starter rotates the engine up to approximately 15% HP RPM, at which point fuel is introduced with ignition from the ignitors within the two liners. The starter now assists engine spool-up to approximately 38 to 45% HP RPM.

Each engine ignition system incorporates two transistorized high energy ignition units. They are operated automatically when the engine is being started to deliver high voltage and amperage to the igniter plugs. Each igniter plug is served by a high-energy ignition unit. The plugs, when fired, ignite the fuel/air mixture and the resultant flame passes through interconnectors located between each liner to complete the flame propagation. Cranking the engine over without ignition can be accomplished by selective switching by the crew. Ignition may also be used independently of the engine starting system if a relight in flight is required.

NOTE:

For additional information pertaining to the engine ignition system, see Section 2A-74-10, Engine Ignition System.

Electrical power for ground starting and ignition power is obtained from the Essential 28V DC bus. Ignition indication is displayed through the Engine Instrument and Crew Advisory System (EICAS) located on the center console.

B. Operation:

The engine starting system provides the flight crew with a means of using supplied pneumatic power (starting air) for the following tasks:

- (1) Normal Engine Starts (Ground): See Section 03-03-20, Starting Engines.
- (2) Alternate Engine Starts (Ground):

The five types of alternate engine starts available on the ground are as follows:

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- Cold start: see 03-08-10, Cold Start
- External air start: see 03-08-20, External Air Start
- Crossbleed start: see 03-08-30, Crossbleed Start
- Engine cranking cycle: see 03-08-40, Engine Cranking Cycle
- Engine start (battery power only): see 03-08-50, Engine Start - Battery Power Only

(3) Engine Airstarts:

The two types of engine airstarts are as follows:

- Immediate: see 05-10-20, Airstart - Immediate
- Normal: see 05-10-30, Airstart - Normal

(4) Starter-Assisted Air Starts:

Engine starting mode in flight within the starter-assist region of the airstart envelope in which the flight crew controls the start sequence.

(5) Wet And Dry Cranks:

Engine operating mode in which the engine is motored but without igniters ON. Wet cranking allows fuel to the engine whereas dry cranking does not. See Section 03-08-40: Engine Cranking Cycle, for engine cranking procedures.

C. Subsystems, Units and Components:

The engine starting system is composed of the following subsystems, units and components:

- Pneumatic Starter
- Shutoff Differential Pressure Regulator

NOTE:

The pneumatic starter and the shutoff differential pressure indicator are combined together to form the starter motor assembly.

2. Description of Subsystems, Units and Components:

A. Pneumatic Starter:

The pneumatic starter is electrically controlled and pneumatically operated. It consists of a single-stage turbine rotor, a 16:1 reduction gear, output shaft assembly exhaust housing and gear housing assembly.

Starter motor operation is controlled by the following four switches located on the ENGINE START panel on the cockpit overhead panel (see Figure 1 and Figure 2):

- MASTER (two switches, CRANK and START, both with ON / OFF positions)
- START (L ENG and R ENG)

B. Shutoff Differential Pressure Regulator:

The shutoff differential pressure regulator consists of a pneumatic actuator, a filter, a switcher solenoid valve assembly, a metering valve assembly, servo assembly, overpressure limiter, butterfly valve, valve body assembly and actuator assembly. The regulator functions both as an air pressure

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regulator and as an air flow shutoff valve.

Control air enters the valve body assembly through the upstream pressure sensing tube. The air passes through the filter to the metering valve assembly and to the switcher solenoid valve assembly. With the solenoid de-energized, control air passes through the switcher valve and is transmitted to the pneumatic actuator closing chamber. The force of the control air pressure acting on the pneumatic actuator piston supplements the force of the piston spring to maintain the butterfly valve to the closed position, preventing the flow of air.

As the inlet air pressure rises above the predetermined value, the air pressure acting on the piston of the metering valve assembly overcomes the force of the spring, closes the valve, and regulates the pressure to the switcher solenoid valve assembly.

When the solenoid is energized, control air passes through the switcher solenoid valve assembly and is transmitted to the pneumatic actuator opening chamber at a rate determined by the pneumatic actuator chamber orifice. The pneumatic actuator closing chamber is vented to the atmosphere through the switcher solenoid valve assembly. As the butterfly valve opens, downstream air pressure increases and air flows through the servo assembly to the metering valve assembly, resetting the metering valve assembly to a desired value for the servo assembly supply pressure.

With air flowing through the unit, the servo assembly acts to regulate the downstream air pressure at a constant, predetermined value. Downstream air pressure is sensed in the actuator housing assembly downstream of the butterfly valve. As downstream air pressure increases, pressure acting on the servo piston overcomes the force of the piston spring and the piston lifts the ball valve from the seat, allowing air to bleed from the pneumatic actuator opening chamber. As control air pressure in the pneumatic actuator opening chamber increases, the pneumatic actuator piston spring acts to move the butterfly valve toward the closed position, reducing the flow of air through the regulator. When downstream pressure decreases, the servo assembly piston spring moves the piston and seats the ball valve, stopping the bleed-off of control air pressure from the pneumatic actuator opening chamber. This cycle modulates the butterfly valve to control downstream pressure.

Downstream pressure is also sensed through the internal downstream air pressure sensing port and transmitted to the normally closed overpressure limiter. In the event of malfunction of the servo assembly, the resulting high pressure acts on the overpressure limiter piston, overcoming the spring force and unseating the ball valve. This vents the pneumatic actuator opening chamber to the atmosphere. When opening chamber pressure drops, the actuator spring moves the actuator piston, rotating the butterfly valve toward the closed position and reducing the flow of air through the unit.

When the butterfly valve rotates more than 6° from the full closed position, the position indicator switch is actuated, indicating an open butterfly valve. As the solenoid becomes de-energized, control air passes through the switcher valve to the pneumatic actuator closing chamber. At the same time, the pneumatic actuator opening chamber is vented to the atmosphere through the switcher valve. The force of the control air pressure in the

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closing chamber and the piston spring then moves the butterfly valve to the closed position.

3. Controls and Indications:

A. Circuit Breakers (CBs):

The engine starting system is protected by the following CBs:

| Circuit Breaker Name: | CB Panel: | Location: | Power Source: |
|-----------------------|-----------|----------------|----------------|
| ENGINE START | P | K-6 | ESS 28V DC Bus |
| WARN LTS PWR #3 | P | F-2 | ESS 28V DC Bus |
| WARN LTS PWR #5 | P | F-5 | ESS 28V DC Bus |
| WARN LTS PWR #6 | P | G-1 or G-2 (1) | ESS 28V DC Bus |
| WARN LTS PWR #7 | P | G-2 or G-3 (1) | ESS 28V DC Bus |
| OVHD ANN LTS PWR #1 | P | A-1 or C-1 (1) | ESS 28V DC Bus |
| OVHD ANN LTS PWR #2 | P | A-2 or C-2 (1) | ESS 28V DC Bus |
| OVHD ANN LTS PWR #3 | P | A-3 or C-3 (1) | ESS 28V DC Bus |

NOTE(S):

(1) Depending on effectivity.

4. Limitations:

A. Flight Manual Limitations:

(1) Starter Duty Cycle:

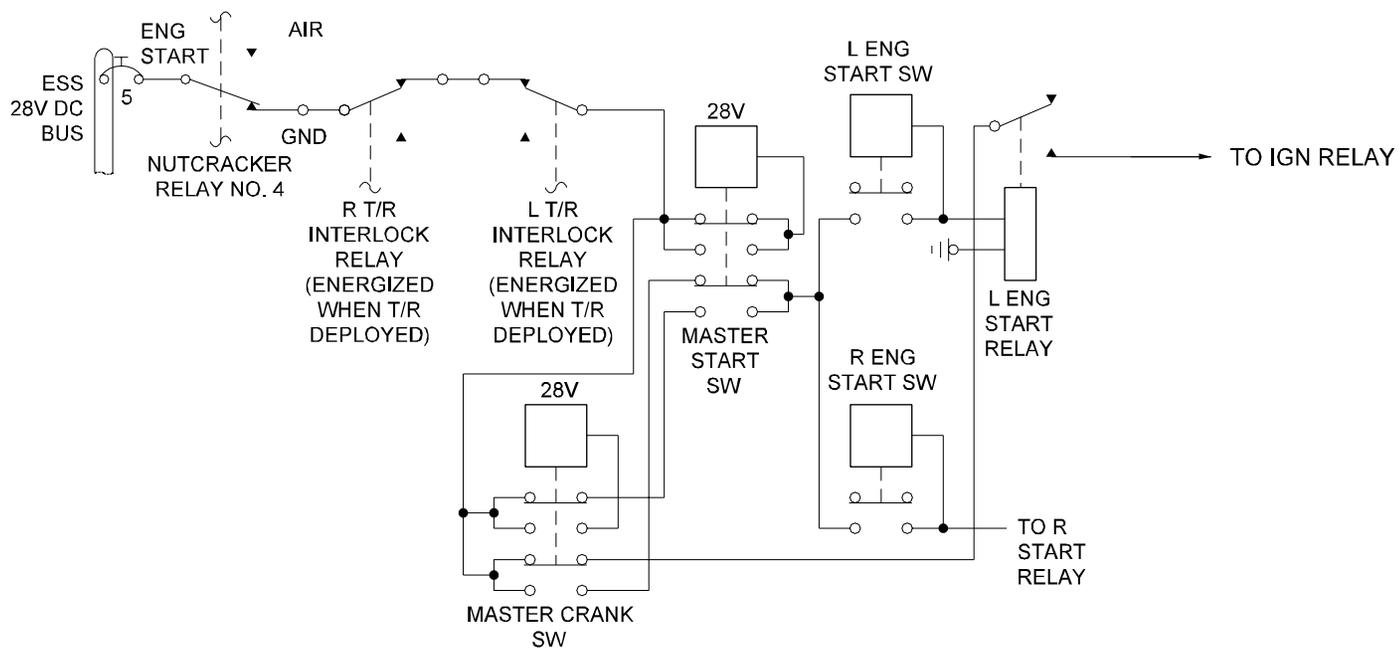
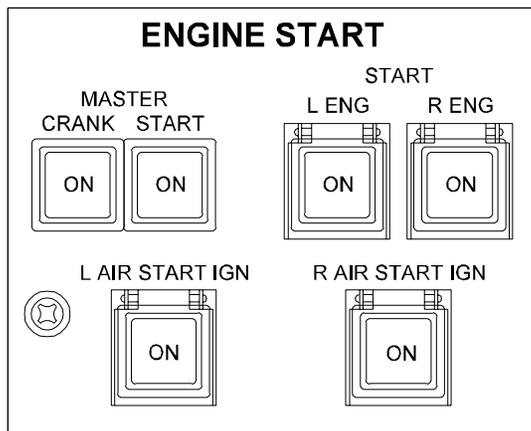
Continued use of starter is limited to three (3) crank cycles with a maximum of thirty (30) seconds per cycle. Delay three (3) minutes between start attempts. After three (3) cycles, delay use of starter for at least fifteen (15) minutes.

(2) Starter Re-engagement:

The starter may be re-engaged at HP RPM speeds up to starter cutout of 42% HP RPM.

(3) Airstart Envelope:

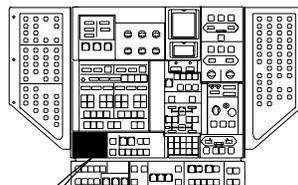
See Figure 3: Airstart Envelope.



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Engine Start System
Simplified Block Diagram
Figure 1

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MASTER CRANK

OFF:

- Blue ON legend is extinguished
- De-energizes start relay
- Automatically closes isolation valve (on ground only)

ON:

- Blue ON legend illuminates
- Allows the START switches to energize the start relay without energizing the auto-ignition relay
- Allows for cranking of engine without ignition or starting of engine
- Automatically opens isolation valve (on ground only)

MASTER START

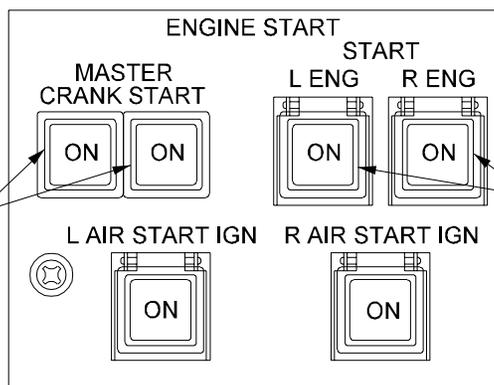
OFF:

- Blue ON legend is extinguished
- De-energizes start and auto-ignition relay
- Automatically closes isolation valve (on ground only)

ON:

- Blue ON legend illuminates
- Allows the START switches to energize the start relay and the auto-ignition relay
- Allows for cranking of engine without ignition or starting of engine
- Supplies ignition when starter is selected
- Automatically opens isolation valve (on ground only)

NOTE: For aircraft 1000 through 1155 (excluding 1034) having ASC 135, aircraft 1034, and aircraft 1156 and subsequent, selection of the MASTER CRANK or MASTER START switch closes the LEFT ECS PACK valve (on ground only). The valve will automatically reopen when the MASTER CRANK or MASTER START switch is deselected.



L/R ENG START

OFF:

- Blue ON legend is extinguished
- De-energizes start relay
 - Can be used to manually terminate power that energizes start relay (in lieu of automatic power termination at 42% HP RPM)

ON:

- Blue ON legend illuminates
- Start relay energized

NOTE: For aircraft 1000 through 1155 (excluding 1034) having ASC 135, aircraft 1034, and aircraft 1156 and subsequent, selection of the L ENG START or R ENG START switch closes the RIGHT ECS PACK valve (on ground only). The valve will automatically reopen when the start valve closes.

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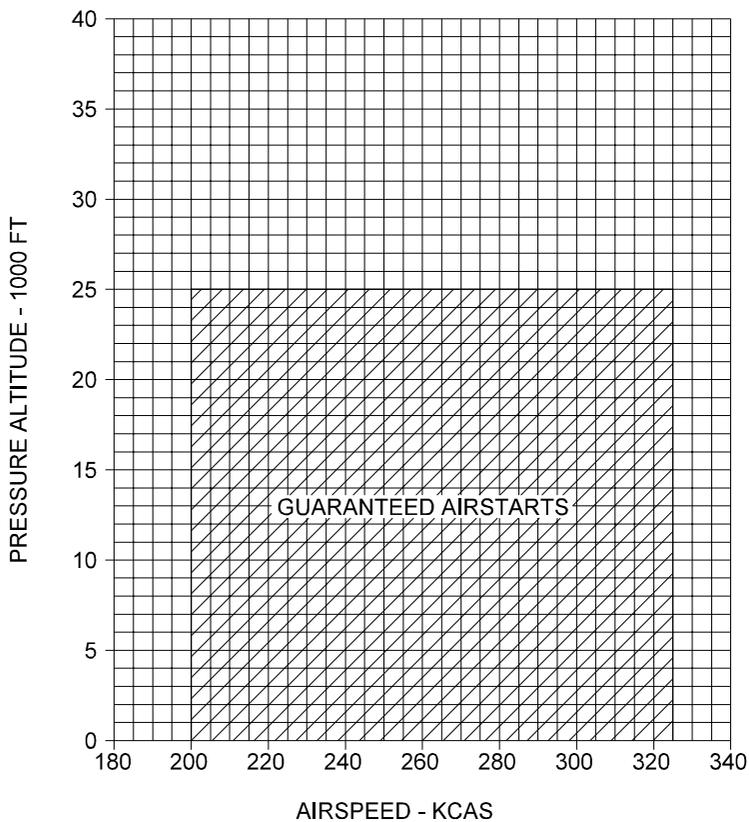
Engine Start System
Controls
Figure 2

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Airstart Envelope
Figure 3

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