2A-49-10: General

The Gulfstream IV is equipped with a GTCP 36-100(G) gas turbine Auxiliary Power Unit (APU) that serves as an auxiliary supply of electrical power and pneumatic pressure for airplane systems. The APU is installed in the tail section of the airplane, aft of the pressure bulkhead within a stainless steel and titanium enclosure. The APU is mounted transversely on supports, or rails, for ease of maintenance and repair.

The APU can supply both electrical and pneumatic power on the ground, but is restricted to providing only electrical power in flight. On the ground, the APU may be started with the airplane batteries or with an external DC power source. When the APU reaches normal operating RPM, it is capable of powering the full airplane electrical system and supplying pneumatic bleed air for air conditioning and engine starting. APU bleed air output is rated at a nominal 253°C (487°F) at a pressure of 47.6 psi minimum. Minimum bleed air pressure under full load is 30 psi.

In the air, the APU alternator can produce thirty (30) kVA at twenty-two thousand (22,000) feet, with a linear reduction with altitude to 15 kVA at thirty thousand (30,000) feet for airplanes SN 1000-1155 (except 1034). On airplanes Serial Number (SN) 1156 and subsequent (and 1034) the APU air intake is modified with an airscoop that increases airflow to the APU, allowing a higher operating envelope. For these airplanes, the APU alternator will supply 30 kVA up to 30,000 feet with a linear reduction of sixty-seven percent (67%) to 20 kVA at maximum operating altitude of 35,000 feet. This expansion of the operating envelope requires shedding some of the airplane electrical load. On SN 1156 to 1429 (and 1034) an Electrical Load Warning System (ELWS) provides indications to the crew of excessive electrical loads and automatically sheds some non-essential items to reduce the electrical load on the APU. For airplanes SN 1430 and subsequent, electrical loads are monitored and reduced if necessary by the flight crew in response to Crew Alerting System (CAS) messages. For more information, see the description of the APU AC Power System in section 2A-24-00 of this manual.

The APU assembly is composed of the following subsystems:

- 2A-49-20: APU Powerplant Assembly and Accessories
- 2A-49-30: APU Controls and Indications

2A-49-20: APU Powerplant Assembly and Accessories

1. APU Powerplant:

The APU powerplant assembly is composed of the following subsystems:

- Basic Powerplant
- Starting and Ignition
- Electronic and Fuel Controls
- Lubrication

A. Basic Powerplant:

The APU powerplant consists of a single-stage compressor and single-stage turbine mounted on a common rotating shaft. The compressor is surrounded by an air chamber (plenum) that is connected to the air intake duct. The turbine surround receives pressurized air from the compressor, routing some to the combustor where air is mixed with fuel, ignited and directed onto the turbine blades. Some compressed air is reserved for

turbine cooling, flowing around the turbine and joining the exhaust flow prior to venting overboard. See the illustration in Figure 1.

A planetary gearbox is attached to and driven by the rotating compressor section. The gearbox converts the high RPM of the compressor to lower values for driving the oil pump, fuel control and pump and the AC alternator. The gearbox also provides a mounting for the APU starter.

Air for the APU is drawn through an intake door located on the top of the airplane near the vertical stabilizer fairing (with an air scoop on Serial Number (SN) 1034 and 1156 and subsequent). Rotation of the compressor draws in outside air (supplemented by ram pressure for those airplanes equipped with an air scoop). The air flow is accelerated by the rotating compressor and directed through a diffuser that converts air velocity to pressure. Pressurized air is routed to the turbine plenum. The mechanical design of the plenum directs a precise amount of air into the combustion liner where it is mixed with fuel and ignited. The remaining pressurized air is used to cool the APU exhaust and/or extracted through the load control valve for engine starting or air conditioning.

A surge valve, mounted on the turbine section, pneumatically unloads the APU during starting to aid acceleration, and opens in flight (controlled by the nutcracker system) to maintain stable APU RPM. Air bled off by the surge valve is vented into the APU exhaust.

Spent exhaust gases from the APU turbine section are directed through a tailpipe exhaust assembly overboard, venting beneath the right engine nacelle. The tailpipe shroud has a larger diameter than the APU turbine exhaust exit opening. As exhaust gases pass through the shroud, ambient air in the APU compartment is drawn into the tailpipe assembly by the ejector pump action of the gas flow. Ambient air flow decreases the temperature of the APU exhaust and creates a lower pressure within the compartment, causing additional airflow that cools APU components and accessories.

Modifications have been made to the APU ducting and exhaust components to enhance APU component cooling and to moderate the effects of exhaust impingement on the airplane exterior:

- Airplanes SN 1133 and subsequent have a check valve in the alternator cooling duct that draws in air from the aft equipment bay for cooling
- Airplanes SN 1310 and subsequent have additional cooling ducts piped from the air intake manifold to enhance airflow and prevent soot buildup on APU internal components
- Airplanes SN 1310 and subsequent, and prior airplanes having part three (3) of ASC 390 have a venturi in the APU bleed air duct that limits the initial volume of air extracted from the APU for engine start or air conditioning. Limiting the amount of air that may immediately be removed from the compressor diffuser prevents temperature spikes associated with the loss of cooling air in the turbine section.
- Airplanes SN 1311 (sic) and subsequent and prior airplanes having part two (2) of ASC 390 have an exhaust deflector that directs the gases away from the right engine nacelle.

B. Starting and Ignition:

The APU start sequence is initiated by crew activation of the switchlight controls on the APU panel on the cockpit overhead. When the APU MASTER switchlight is selected ON, the APU air inlet opens, the APU OIL PRESS LOW circuit is armed and the APU fuel shutoff valve is opened. When the APU air inlet door is fully open, the APU START switchlight is armed. Pressing the APU START switch powers the APU starter from the airplane batteries or external DC power source, and initiates the automatic start sequence controlled by the Electronic Control Unit or ECU (see the description of the start sequence in the Controls and Indications topic of this section).

The APU starter, mounted on the gearcase, is a DC powered electric motor that spins the APU up to a speed sufficient to support ignition and light off, approximately sixty percent (60%) RPM. A clutch delivers starter torque to the gearbox. When the APU RPM reaches approximately 60%, DC power is removed from the starter, the clutch disengages the starter from the gearbox, and the starter slows to a stop.

It is important that the crew have an indication of APU starter disengagement. If the starter remains engaged and the APU continues to accelerate to 100% RPM, damage and/or catastrophic failure of the starter may occur. In initial production of the GIV airplanes, there was no indicator monitoring DC power application to the starter. ASC 13, applicable to SN 1000-1155, and incorporated into production assembly with SN 1156 and subsequent, provided circuitry to the APU START switchlight to illuminate the ON legend whenever DC power is applied to the starter. Starter cutout can be monitored by confirming that the ON legend extinguishes above 60% RPM. ASC 212 (applicable to airplanes SN 1000-1155 having ASC 13) and ASC 212 AM1 (applicable to airplanes SN 1156 and subsequent) improved on the reliability of the monitoring circuit by powering the circuit from the Essential DC bus and adding auxiliary contacts to the circuit. (The circuitry installed with ASC 13 and incorporated in SN 1156 was powered by the Battery Tie bus that is de-energized when the APU reaches 60% RPM, and thus could not provide starter monitoring should the starter remain powered at higher APU speeds.)

The ECU sequences the start process initiated with the APU START switchlight. RPM is displayed on the APU control panel as soon as the starter begins rotating the APU gearbox. At 10% RPM, the fuel control opens, injecting atomized fuel into the combustor and the igniter is energized.

The igniter is a high energy capacitive discharge unit consisting of a single plug with a long shank protected by a heat shield. The plug is mounted on either the turbine plenum or the left side of the turbine intake (depending on APU model). The igniter plug produces approximately five thousand (5,000) volts and remains energized until the APU reaches 95% RPM with an additional four (4) second delay to ensure stable APU idle RPM. There is no indication of ignitor cut-out. A high-voltage APU ignition system is installed on airplanes SN 1363 and subsequent, and available for retrofit into pervious airplanes as ASC 404. The higher voltage increases service life and improves in-flight starting.

C. Electronic and Fuel Controls:

APU operation is monitored and controlled by the ECU through inputs from the cockpit control panel, APU speed sensing and temperature elements and outputs to the Fuel Control Unit (FCU). The ECU is a solid state electronic control mounted outside of the APU enclosure to minimize exposure to heat and vibration. On airplanes SN 1436 and subsequent, a second ECU is installed as a “cold spare”, making a replacement ECU readily available if needed.

The unit receives RPM information from a speed sensing monopole device installed on the APU gearbox. The monopole is a cylindrical pointer with a magnetically charged tip. The tip is closely aligned a rotating gear train in the gearbox. As the teeth of the gear pass the tip of the monopole, an AC electric current is generated with a frequency proportional to gear rotation (and APU) speed. At an APU RPM of 100%, the frequency is approximately 17,600 Hz. The ECU senses this frequency as APU RPM.

The operating temperature of the APU is sensed by a single thermocouple positioned in the APU exhaust stream aft of the turbine. The thermocouple generates a voltage proportional to Exhaust Gas Temperature (EGT) and transmits the voltage to the ECU where it is translated as EGT.

The ECU uses the RPM and EGT inputs to correctly sequence APU starting, adjust the fuel flow through the FCU to maintain the APU within normal operating ranges, and with additional inputs from oil temperature, oil pressure and amperage readings from system sub-components, protect the APU with an auto-shutdown feature if abnormal conditions are detected. The conditions prompting and automatic APU shutdown are discussed in the Controls and Indications topic of this section.

The ECU controls the speed and temperature of the APU by adjusting the amount of fuel available for combustion in the APU (ignition is not necessary above 95% RPM). Fuel for the APU is drawn from the left fuel tank hopper through a shutoff valve. The left tank boost pump (or the right tank boost pump with the crossflow open) pressurizes the fuel line. When APU RPM reaches 10% during start, the shutoff valve opens and fuel passes through the fuel line to the APU FCU.

The FCU is a high pressure gear pump attached to and driven by the APU oil pump. Within the FCU are filters, a relief valve, a servo valve to maintain constant fuel pressure, a metering valve, a shutoff valve and a fuel nozzle. Fuel drawn from the left wing tank is filtered, pressurized, metered to satisfy APU load requirements, passed through the shutoff valve and sprayed into the combustor through a dual orifice nozzle. During APU start, fuel is initially supplied through the primary orifice. As the APU accelerates, fuel pressure increases with the increasing speed of the gearbox (and oil pump rotation and pressure) and fuel requirements of the APU increase. The secondary orifice opens to supply additional fuel to support APU acceleration and maintain full RPM.

The protective functions of the ECU shut down the APU by closing the FCU shutoff valve (positioned just prior to the fuel nozzle) if normal limitations are exceeded. Closure of the shutoff valve causes a surge in fuel pressure. The relief valve opens with the pressure surge and routes the excess fuel back to the pump inlet. As APU RPM slows from fuel starvation, fuel pressure decreases and the relief valve closes.

D. Lubrication:

The oil pump that drives the FCU fuel pump supplies pressure and splash lubrication to all gears, shafts and bearings within the APU. The oil pump draws oil from a sump beneath the pump through a suction line. Oil passes through a pressure regulating valve, an oil filter and a low oil pressure switch before distribution to the APU lubrication points. The oil is then gravity scavenged back to the oil sump. If APU oil pressure drops below thirty-one (31) psi, the low oil pressure switch will cause the illumination of the red OIL PRESS LOW light on the APU control panel. Cooling is provided by external cooling fins on the sump that transfer heat to the surrounding air. The oil sump (or tank) has a high oil temperature switch and a drain plug with a magnetic chip detector. If cooling air is insufficient and the APU oil temperature reaches 141°C - 147°C, the red OIL TEMP HIGH light will illuminate on the APU control panel. APU oil level is read on a dipstick attached to the sump (tank) filler opening cap. Normal capacity is 2.5 U.S. quarts. An access panel on the APU enclosure must be removed in order to reach the dipstick / filler cap.

2. APU Accessories:

The APU is equipped with the following accessories:

- Electrical Alternator
- Bleed Air System
- Fire Detection, Warning and Extinguishing System

A. Electrical Alternator:

The APU alternator is identical and interchangeable with the engine-driven alternators. It is mounted on the APU gearbox and cooled by an integrated fan. The alternator delivers 115 V AC, 400 Hz (±20) three phase power at loads up to 30 kVA, enabling the alternator to power all airplane electrical systems. Because the APU alternator runs at a constant speed (approximately 8,000 RPM) it does not require a converter and can power airplane buses directly.

The alternator can provide electrical power in flight as well as on the ground, however the amount of load (kVA) available from the alternator decreases at higher altitudes due to APU performance degradation with decreasing air density. For airplanes SN 1000-1155, the available load decreases linearly from 30 kVA to 15 kVA from 22,000 feet to 30,000 feet. On airplanes SN 1156 and subsequent the APU air intake is modified with an air scoop to provide more air to the APU at higher altitudes. For these airplanes, 30 kVA is available up to 30,000 feet with a reduction to 20 kVA at 35,000 feet, the maximum APU operating altitude.

An APU ALTNR OFF light (blue) on the APU overhead panel illuminates when the APU has reached 95% RPM for four (4) seconds, signalling that the alternator may be selected ON to power airplane systems. The APU alternator is connected to the airplane electrical system by pressing the AUX PWR switchlight on the ELECTRIC MASTER section of the ELECTRIC POWER MONITOR panel to ON. The voltage and frequency of the APU alternator may then be monitored by pressing the AUX switchlight next to the AC VOLTS / FREQ display. The AUX PWR % display on the AC POWER CONTROL should read 100 with the APU alternator powering all airplane buses.

Operation of the APU alternator is monitored by the same self-protective functions as the engine-driven alternators. The APU alternator will trip off for over and undervoltage, over and under frequency, polarity, overcurrent, short circuit and feeder fault malfunctions. Like the engine-driven alternators, the APU alternator has dual bearings. If the main bearing fails, the APU ALT FAILED BRG light on the overhead annunciator panel will illuminate accompanied by a CAS message. If the APU alternator exceeds normal temperature limits (300°F / 149°C), a CAS message of APU ALT HOT will be displayed.

B. Bleed Air System:

Bleed air may be extracted from the APU compressor for engine starting or operating the air conditioning system while the airplane is on the ground (the APU cannot be used for bleed air while the airplane is in flight). After starting the APU and RPM has reached at least 95% for four (4) seconds, the APU switchlight on the BLEED AIR panel may be selected ON. When the switch is selected, a signal is sent to the ECU to open the load control valve, porting compressed air into the pneumatic manifold. When air is bled from the APU compressor, less is available to cool the turbine section of the APU. For this reason, the load control valve does not open immediately, but takes one to one and a half (1-1½) seconds to fully open, allowing the ECU to adjust fuel flow to avoid EGT spikes. On airplanes SN 1000-1310 having part 3 of ASC 390 and production airplanes SN 1311 and subsequent, a venturi is installed downstream of the load control valve to further moderate the initial air extraction flow and the rate of EGT rise.

To avoid reverse air flow into the APU that would disrupt the path of cooling air around the turbine, a check valve is installed in the pneumatic system ducting that prevents the flow of engine bleed air back to the APU. An interlock is also incorporated that closes the load control valve if the APU air bleed is open and engine air bleeds are open and engine power levers are advanced from the idle position. In normal circumstances only one bleed air source should be selected at a time (either APU or engine bleed).

The ECU maintains the APU at normal operating temperatures (665°C and 100% RPM) during bleed air extraction by balancing fuel flow with air bleed demands. The ECU can add fuel flow to maintain operating temperatures, but can reduce EGT only by reducing the amount of air bled from the APU (since RPM cannot by reduced), thereby increasing compressor discharge air available to cool the turbine section. Operation of the load control valve and ECU result in the following indications:

- Initial selection of APU ON for bleed air on the BLEED AIR panel will result in an initial rise in APU EGT until the ECU balances fuel flow
- The APU can deliver more bleed air pressure on cold days than on hot days
- If APU EGT rises above normal, the ECU will start to close the load control valve (if open) to cool the APU. If EGT reaches 732°C, the load control valve will be fully closed and no air will be available from the APU

C. Fire Detection, Warning and Extinguishing System:

There are four fire detectors positioned around the APU. Three of the detectors are installed in the walls of the APU enclosure and one is

installed in the APU air inlet. The detector installed on the top of the turbine section near the load control valve is set at a trip point of 600°F, the other three are set at 450°F. The fire detection and extinguishing system is powered by 28V DC, and will operate from airplane batteries in order to test the system prior to starting the APU. If the temperature within the APU enclosure reaches a detector trip point, a ground is furnished to the detection circuits and the following indications are displayed:

- Red APU FIRE light on the APU overhead panel
- Red APU FIRE light on the Standby Warning Lights Panel for SPZ-8000 airplanes
- APU FIRE message on CAS
- Both red MASTER WARNING lights illuminate
- The APU FIRE checklist is displayed on the lower center portion of the copilot's navigation display (DU 5) in MAP or COMP or PLAN mode (airplanes SN 1144 and subsequent and SN 1000 through 1143 with ASC 178 incorporated)
- A warning bell / tone sounds in the nose wheel well if the airplane is on the ground

The ECU initiates an automatic shutdown sequence that accomplishes the following:

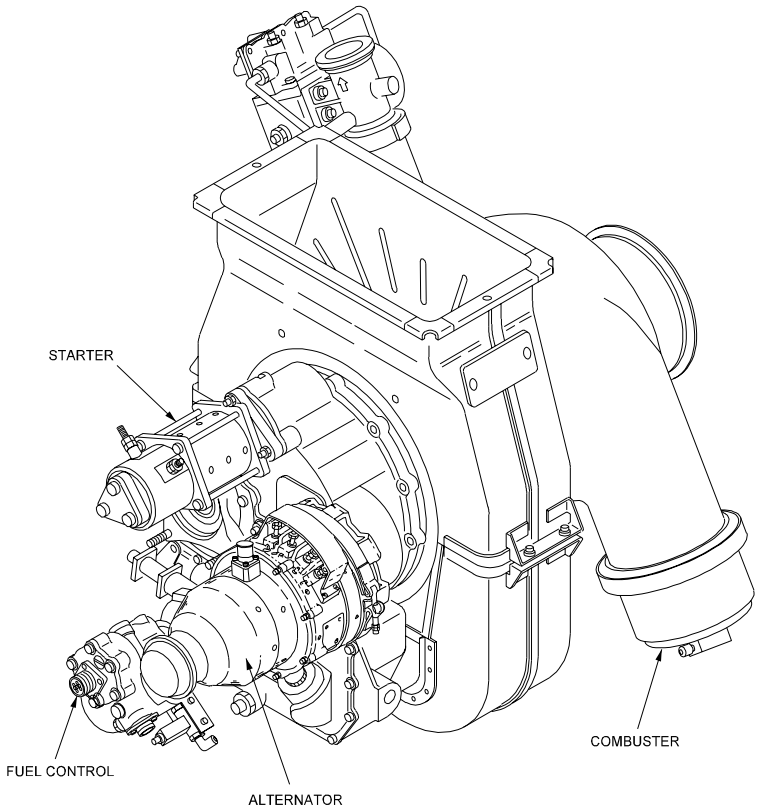
- The APU shutdown relay is activated and held closed by the fire detection circuit
- Fuel is shut off at the ECU
- The air inlet door closes, de-energizing the APU MASTER switch
- Fuel valve closes at the left wing tank

The APU fire extinguisher must be manually discharged with the switch on the APU overhead panel. When the switch is pushed, the contents of the APU fire bottle are discharged into the APU enclosure. The bottle contains 2½ lbs. of CF_3Br pressurized with nitrogen gas. Normal bottle pressure at 70°F is 600 psi (+50/-25). The bottle is a single use installation - the entire bottle contents are discharged if the APU FIRE EXT switch is pushed. A confirmation that the bottle has discharged is shown in the legend of the switch that will illuminate FIRE EXT DSCHD when the bottle is depleted.

A test of the APU fire detection system is performed prior to starting the APU. The test is initiated by pressing the APU TEST switch on the FIRE TEST panel on the cockpit overhead. During the fire test, all of the indications listed above will be displayed.

NOTE:

Pushing the APU FIRE TEST switch while the APU is running will shut down the APU.



Auxiliary Power Unit
Figure 1

2A-49-30: APU Controls and Indications

1. Cockpit APU Controls and Indications:

Controls and indications for the APU are installed on five panels in the cockpit. Illustrations of the panels are shown in Figure 2 and in sections 2A-24-00, 2A-26-00 and 2A-36-00 of this manual.

A. APU Panel:

The APU panel has the following controls and indications:

- APU MASTER - alternate action switch illuminates ON in white when selected to connect battery power to the APU for starting and open APU air inlet. When the air inlet is fully open, a limit switch

routes power to the ECU, opens the fuel shutoff valve in the left wing tank, arms the APU START switch and overspeed switch, and illuminates of the red OIL PRESS LOW light signalling that the APU is ready to start. On airplanes SN 1096 and subsequent, and SN 1041-1095 having ASC 119, aborting an APU start prior to 60% RPM by selecting the APU MASTER switch off will disengage the APU starter. On all other airplanes, the OVSP TEST - STOP switch must be used to disengage the starter if a start is discontinued prior to the APU reaching 60% RPM.

- START - momentary action switch illuminates ON in white when power is applied to the APU starter initiating the start sequence controlled by the ECU. The start may by monitored by observing the EGT and RPM readouts on the APU panel. For airplanes not having ASCs 13, 212 and 212 AM1, the ON indication only monitors the APU start relay. For airplanes SN 1000-1155 having ASCs 13 and 212 and SN 1156 and subsequent having ASC 212 AM1, the ON light monitors actual DC power application to the APU starter. The ON light should extinguish at 60% RPM, normal starter cutout speed.
- OVSP TEST-STOP - momentary action switch illuminates TEST in white when selected. Pushing switch sends an overspeed signal of 114% RPM to the ECU, prompting the ECU to shut down the APU. Automatic overspeed shutdown is commanded by the ECU at 110% RPM. This switch is the normal means of shutting down the APU.
- APU FIRE EXT - guarded single action switch illuminates amber text FIRE EXT DISCHD after APU fire bottle has been used
- APU FIRE - light capsule illuminates APU FIRE in red if a fire is detected in the APU enclosure. ECU automatically shuts down the APU.
- OIL TEMP HIGH - light capsule illuminates OIL TEMP HIGH in red and ECU automatically shuts down the APU if oil temperature exceeds 141°- 147°C. APU MASTER switch must be on for the warning to be armed.
- OIL PRESS LOW - light capsule illuminates OIL PRESS LOW in red when APU air inlet door is fully open and APU is ready for start. When APU is operating (RPM above 95%) the light will illuminate and the ECU automatically shuts down the APU if oil pressure falls below 31 psi for longer than 10 (±2) seconds. APU MASTER switch must be on for the warning to be armed.
- ALTNR OFF - light capsule illuminates ALTNR OFF in white when APU alternator is available for electric power (APU RPM at 95% or above for more than 4 seconds) and AUX PWR switch on the ELECTRIC MASTER panel has not been selected. When AUX PWR is selected on the ELECTRIC MASTER panel, the ALTNR OFF light on the APU panel will extinguish.
- EGT - digital readout of APU EGT in °C displayed in amber numerals. An amber warning circular light above the readout comes on if APU is at 100% RPM and EGT reaches 688°C.
- RPM - digital readout of APU RPM displayed in amber numerals. An amber warning circular light above the readout comes on if APU

RPM exceeds 104%.

B. BLEED AIR Panel:

Selecting APU bleed air for engine starting and air conditioning (ground operation only) is accomplished by pressing the APU switch on the BLEED AIR panel:

- APU - alternate action switch, signals ECU to open the APU load control valve (after APU has reached a stabilized RPM of 95% or more for at least 4 seconds). Indications of load control valve operation are ON (amber) indicated in the switchlight, a rise in APU EGT and readout of APU bleed air pressure on the BLEED AIR panel. Selecting APU bleed air ON will also open the ISOLATION valve in the pneumatic system to allow APU bleed air to pressurize both sides of the system. For more information regarding APU bleed air and the airplane pneumatic system, see section 2A-36-00 of this manual.

NOTE:

Both engine power levers must be at the idle position (whether engines are operating or not) for the load control valve to open and supply bleed air to the pneumatic system.

C. ELECTRIC MASTER Panel:

Selecting the APU alternator to power the airplane electrical systems is accomplished by pressing the AUX PWR switch on the ELECTRIC MASTER panel:

- AUX PWR - pressing the switchlight (with APU RPM stabilized at 95% or more for at least 4 seconds) connects APU alternator AC power to the airplane electrical system. ON will illuminate in amber above the switch and APU alternator frequency, voltage and load percentage may be read on the ELECTRIC POWER MONITOR panel.

D. Standby Warning Lights Panel (SPZ-8000 Equipped Airplanes):

- APU ALT FAILED BRG - light capsule illuminates amber when the main bearing of the APU alternator has failed and the APU is operating on the alternate bearing. APU operation using the alternate bearing is limited to fifteen (15) hours at full load or fifty (50) hours with no load (air bleed only).

E. Electrical Load Warning System (ELWS):

For airplanes SN 1156-1429 with the ELWS installed, a gauge on the lower pilot side forward instrument panel indicates the electrical load of the APU when it is used to power the electrical system in flight. The gauge aids the flight crew in monitoring the APU alternator when operating near the limits of the APU altitude envelope. The ELWS contains a processor unit, called the Electrical Load Warning Computer (ELWC) that uses inputs from the Digital Air Data Computers (DADCs) to aid in configuring the airplane electrical load to meet APU alternator capabilities. If the APU alternator is powering the right AC electrical bus and the airplane altitude exceeds 34,000 feet, the ELWS will load shed heat to the right windshield controller.

If the APU is powering the left AC electrical bus, the left windshield heat controller will be shed above 34,000 feet. If the APU alternator is powering the right AC electrical bus and the left converter / alternator fails (single alternator operation), the ELWS will shed the galley master electrical load in addition to the right windshield heat controller if airplane altitude exceeds 34,000 feet. See the description of the ELWS and illustration of the gauge in section 2A-24-00 of this manual.

F. Forward Instrument Panel:

Two APU electrical load indicators, shown in Figure 3, are included in the warning/caution lights panels located above the EFIS display units 2 and 5 on the pilot and copilot forward instrument panels. The indicators signal APU electrical load and/or load monitoring abnormalities when using the APU at high altitudes (above 30,000 feet). For more information, see the discussion in section 2A-24-00 of this manual.

- APU LOAD (amber) / APU LOAD (red) - is a split annunciator installed on airplanes SN 1156-1252 equipped with SPZ-8000 DAFCS. The upper half contains the red text annunciation of APU LOAD that is illuminated if electrical loads exceed limits and must be reduced when operating above 30,000 feet. The lower half contains the amber text annunciation of APU LOAD that illuminates when APU electrical loads are nearing limits when at high altitudes.
- ELWS FAIL (amber) / ELWS CONFIG (amber) - is a split annunciator installed on airplanes SN 1034, and 1156-1429. The upper half contains the amber text annunciation of ELWS FAIL that is illuminated when the system is unreliable for monitoring APU electrical loads. The lower half contains the amber text ELWS CONFIG that illuminates when the Electrical Power Monitoring Panel (EPMP) is not properly configured for ELWS operation.

2. Tail Compartment Controls and Indications:

A. APU Remote Failure Indicator Box:

A remote failure indicator box for the APU is mounted in the tail compartment to facilitate maintenance on the APU. The box has magnetic “cat’s eye” indicators that are activated whenever a malfunction causes an automatic shutdown of the APU. The box has indicators for:

- H-OIL TEMP - high oil temperature auto-shutdown
- L-OIL PRESS - low oil pressure auto-shutdown
- OV CUR - auto-shutdown caused by an overcurrent in the APU ECU circuitry (not the alternator)
- OV TEMP - high EGT auto-shutdown

The indicator box also has two toggle switches. One toggle switch resets the failure indicators, the other toggle switch shuts down the APU using the same overspeed signal as the OVSP TEST-STOP switch on the cockpit APU control panel.

B. Hourmeter:

An hourmeter is installed in the tail compartment near the APU enclosure (location varies) to log the operating time of the APU. The meter is activated when the APU RPM reaches 95% and displays the cumulative time of APU operation. The meter is used to determine when to perform

required maintenance checks that are specified after a certain number of APU operating hours.

3. APU Start Sequence:

During an APU start, the following indications are normally observed (it is assumed that normal preflight and prestart procedures outlined in section 03-02-00 of this manual have been accomplished):

- APU MASTER switch ON - air inlet door opens, fuel shutoff valve in left wing tank opens, and, when air inlet fully open, OIL PRESS LOW indicator illuminated
- START switch depressed and held until RPM rise indicated, switch is then held in electrically
- At 10% RPM, APU fuel valve opens and ignition is powered, EGT rises
- At 25% RPM, an acceleration timer started by ECU. Timer monitors start for 16 seconds or until RPM reaches 95% for 4 seconds
- At 30% RPM, OIL PRESS LOW light should extinguish and oil pressure should indicate approximately 40 psi
- Acceleration up to 60%, EGT should not exceed 988°C
- At 60% RPM, the START switch disengages, indicated by the ON legend in switch extinguishing, surge valve opens, EGT begins decreasing
- At 95% RPM, after a 4 second ECU initiated delay, ignition is terminated, the bleed air load control valve and alternator are available, and the hourmeter begins tracking APU operating hours
- At 100% (±3%), EGT should stabilize at approximately 665°C. After RPM has stabilized for 1 to 2 minutes, electrical and pneumatic loads may be placed on the APU.

4. CAS Messages:

A. Warning (Red) CAS Messages:

CAS Message	Cause or Meaning
APU FIRE	APU fire detected
APU LOAD **(1)**	APU electrical load not within limits for operation above 30,000 feet

NOTE(S):

(1) SN 1034, 1156-1252 with SPZ-8400 and 1253-1429

B. Caution (Amber) CAS Messages:

CAS Message	Cause or Meaning
APU ALT BRG FAIL	Main bearing of APU alternator has failed and alternator is operating using the auxiliary bearing
APU ALT HOT	APU alternator above 300°F /149°C
APU LOAD **(1)**	APU electrical load not within limits for operation above 30,000 feet
APU MASTER WARN	APU MASTER switch in the ON position but APU is not running
AUX AC POWER FAIL	APU alternator has failed or dropped off line

NOTE(S):

(1) SN 1034, 1156-1252 with SPZ-8400 and 1253-1429

C. Advisory (Blue) CAS Messages:

CAS Message	Cause or Meaning
APU ALT OFF	AUX PWR switch on Electric Master panel not selected ON with APU alternator operating
APU EXCEEDANCE	FWC has recorded an APU operating limit exceedance

5. Circuit Breakers (CBs):

Circuit Breaker Name	CB Panel	Location	Power Source
APU CONT	P	G-10 **(1)** L-9 **(2)**	BATT #1 BUS B / BATT #2 BUS B / ESS 28V DC
APU START	P	H-10	ESS 28V DC
APU PWR #1	P	J-10	BATT #1 BUS B
APU PWR #2	P	K-10	BATT #2 BUS B
APU PWR #3	P	L-10	ESS 28V DC
APU FIRE WARN	P	B-4 **(3)** A-4 **(4)**	ESS 28V DC
APU FIRE EXT	P	I-10	ESS 28V DC
AIR INLET DOOR	PO	C-11	ESS 28V DC
ELWS #1 **(5)**	PO	A-9	ESS 28V DC **(6)**
ELWS #2 **(7)**	PO	B–9	ESS 28V DC **(8)**

NOTE(S):

(1) SN 1001, 1018 & subs

(2) SN 1000, 1002-1017

(3) SN 1280-1309, 1436 & subs

(4) SN 1000-1279, 1310-1435

(5) SN 1034, 1156-1429

(6) L MAIN 28V DC for SN 1183-1207

(7) SN 1034, 1156-1429

(8) R MAIN 28V DC for SN 1183-1207

6. Limitations:

A. Flight Manual Limitations:

(1) **APU Operating Limits:**

(a) **General:**

The APU can be operated on the ground, during takeoff, in flight and during landing. In flight it is an optional source of electrical power via the AUX PWR switch instead of one or both engine-driven alternators. The APU cannot be used to supply pressurization airflow in flight.

(b) **Maximum Permissible EGT:**

- Up to 60% RPM during start: 988°C
- 60% RPM to 100% during start: 821°C to 732°C (linear decrease)

- Running: 732°C

(c) **Maximum Rotor Speed:**

The maximum rotor speed for all conditions is 110%.

(2) **APU Starting Limits:**

(a) **When Powered By Airplane Batteries:**

Continuous operation of the APU starter when powered by airplane batteries is limited to thirty (30) seconds per start with a maximum of three (3) consecutive start attempts. Before attempting another start, allow twenty (20) minutes for starter cool-down. Three (3) additional start attempts may be made, after which a one (1) hour cool down period must be observed before the next full starter cycle is commenced.

(b) **When Powered By An External DC Power Source:**

Continuous operation of the APU starter when powered by an external DC power source is limited to fifteen (15) seconds per start with a maximum of two (2) consecutive start attempts. Before attempting another start, allow twenty (20) minutes for starter cool-down. Two (2) additional start attempts may be made and, if unsuccessful, a one (1) hour cool down period must be observed before the next full starter cycle is commenced.

NOTE:

An inspection is required within ten (10) APU operating hours if the APU is operated above 30,000 ft for more than one (1) hour during flight, or if the APU is operated above 30,000 ft more than five (5) times. Refer to the APU Maintenance Manual for specific inspection requirements.

NOTE:

Successful consecutive starts are limited to six (6) at ten (10) minute intervals per start.

NOTE:

See APU OPERATING ENVELOPE (SN 1000 Through 1155 Without APU Loadmeter), Figure 5 or ELWS APU ALTERNATOR OPERATING ENVELOPE (SN 1156 and Subsequent, SN 1000 Through 1155 With APU Loadmeter Installed or Removed By ASC 420, and SN 1430 and Subs), Figure 7.

(3) **APU Alternator Electrical Load:**

(a) **Airplanes SN 1000 Through SN 1155 Without APU Loadmeter Installed:**

The APU alternator can deliver 100% electrical power (30 kVA) on ground or in flight from Sea Level to 22,000 ft. From 22,000 ft to 30,000 ft, the limit load decreases linearly to 50%

electrical power (15 kVA). Load shedding may be required. See APU ALTERNATOR ELECTRICAL LOAD (SN 1000 Through 1155 Without APU Loadmeter), Figure 4.

(b) **Airplanes SN 1156 And Subs, And SN 1000 Through SN 1155 With APU Loadmeter Installed:**

The Increased Altitude APU alternator can deliver 100% electrical power (30 kVA) on ground or in flight from Sea Level to 30,000 ft. From 30,000 ft to 35,000 ft, the limit load decreases to 67% electrical power (20 kVA). Load shedding may be required. See ELWS APU ALTERNATOR ELECTRICAL LOAD (SN 1156 and Subsequent, SN 1000 Through 1155 With APU Loadmeter Installed or Removed By ASC 420, and SN 1430 and Subs), Figure 6.

(c) **Airplanes SN 1156 And Subs, SN 1000 Through SN 1155 With ASC 420 (Removal Of APU Loadmeter) Incorporated, and SN 1430 And Subs:**

With the ram air scoop installed over the APU inlet door, the APU alternator can deliver 100% electrical power (30 kVA) on ground or in flight from Sea Level to 30,000 ft. From 30,000 ft to 35,000 ft, the limit load decreases to 67% electrical power (20 kVA). Load shedding may be required. See ELWS APU ALTERNATOR ELECTRICAL LOAD (SN 1156 and Subsequent, SN 1000 Through 1155 With APU Loadmeter Installed or Removed By ASC 420, and SN 1430 and Subs), Figure 6.

B. System Notes:

If the APU is started with the right lower engine cowling open, the high temperature APU exhaust will cause significant damage to the engine cowling. A visual inspection of the area surrounding the right engine should be accomplished prior to starting the APU. On airplanes SN 1455 and subsequent, an amber COWL OPEN annunciator is installed on the APU control panel. With the annunciator illuminated, APU starting is inhibited until the right lower engine cowling is closed. On airplanes SN 1000 through 1454, this feature was available for installation as an option during outfitting.

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EGT Digital Readout
Indicates APU exhaust gas temperature (amber).

EGT Warning Light
Illuminates (amber) if APU EGT reaches 688°C when RPM is stabilized at 100%.

RPM Digital Readout
Indicates APU speed in percent (amber).

RPM Warning Light
Illuminates (amber) if APU RPM exceeds 104%.

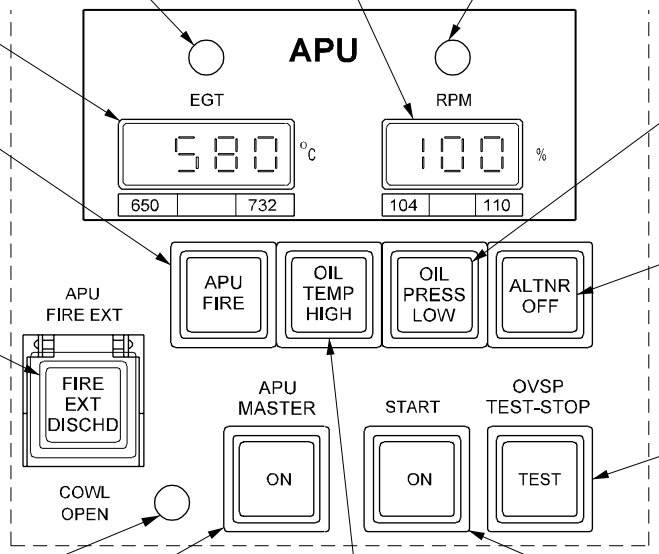
OIL PRESS LOW Indicator
Illuminates (red) if APU oil pressure falls below 31 psi for longer than 10 seconds (± 2 seconds). ECU shuts down APU.

APU FIRE Indicator
Illuminates (red) if a fire is detected in APU compartment. APU is automatically shut down.

ALTNR OFF Indicator
Illuminates (white) with APU alternator available (RPM above 95% for more than 4 seconds) and AUX PWR not selected on ELECTRIC MASTER panel.

APU FIRE EXT Switch
Guarded single action switch. Raising guard and pushing switch discharges fire extinguisher into the APU compartment. Legend FIRE EXT DISCHD illuminates after discharge.

OVSP TEST-STOP Switch
Pushing the switch illuminates the white TEST legend in the switch and sends an overspeed signal of 114% RPM to the ECU that causes a shutdown of the APU (normal means of stopping the APU).



COWL OPEN Annunciator
Illuminates (amber) when right lower engine cowl door is open. APU starting is inhibited.

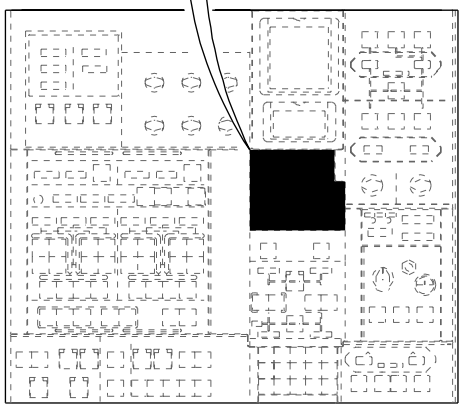
OIL TEMP HIGH Indicator
Illuminates (red) if APU oil temperature exceeds 141°-147°C. ECU automatically shuts down APU.

START Switch
Pushing in APU start switch illuminates the white ON legend in switch and:

- Applies power to the APU starter through the ECU
- Monitors the start relay (S/N without ASC 13, 212 or 212 AM1) or
- Monitors DC power applied to the APU starter (S/N with ASC 13, 212 or 212 AM1)
- ON legend should extinguish at 60% RPM

APU MASTER Switch
Pushing in switch illuminates the white ON legend and initiates the following:

- Connects aircraft batteries (or external DC power) to APU ECU
- Opens APU air inlet
- Opens fuel shutoff in left wing tank
- Arms APU START switch
- OIL PRESS LOW (red) switch illuminates when air inlet door is open and APU is ready to start



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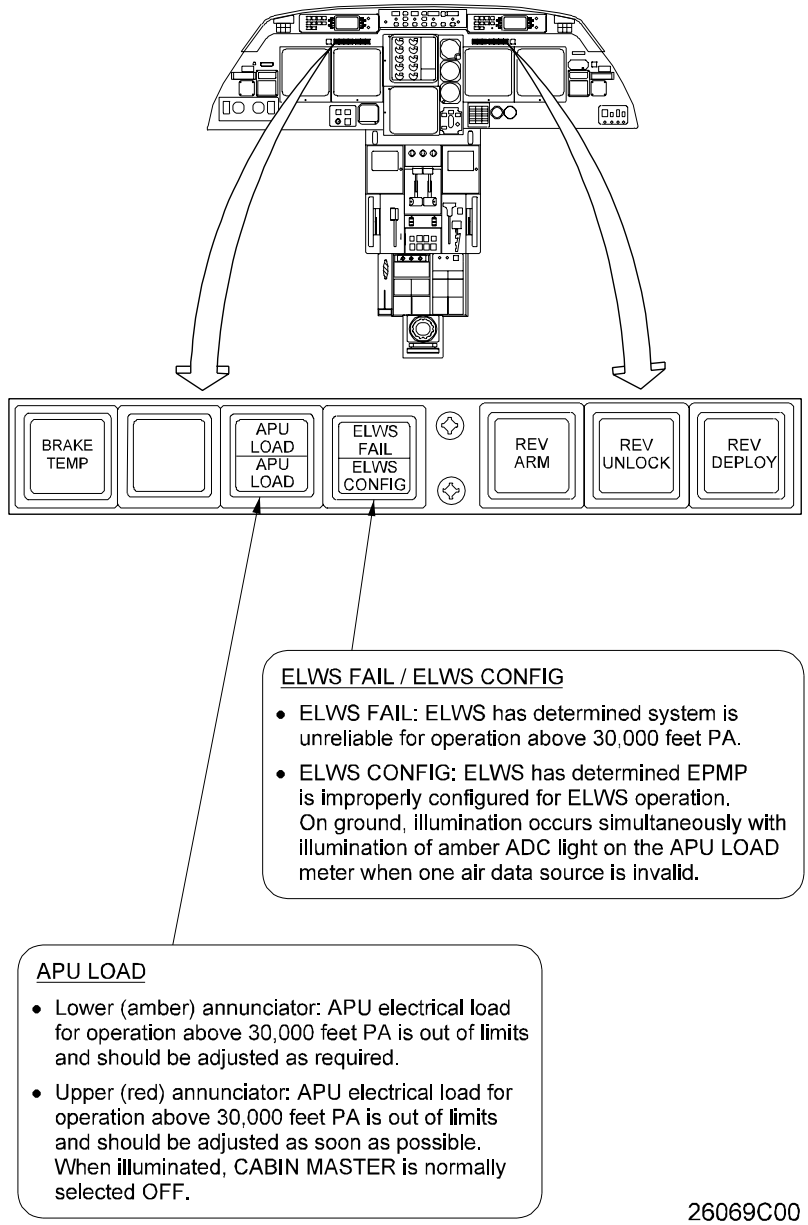
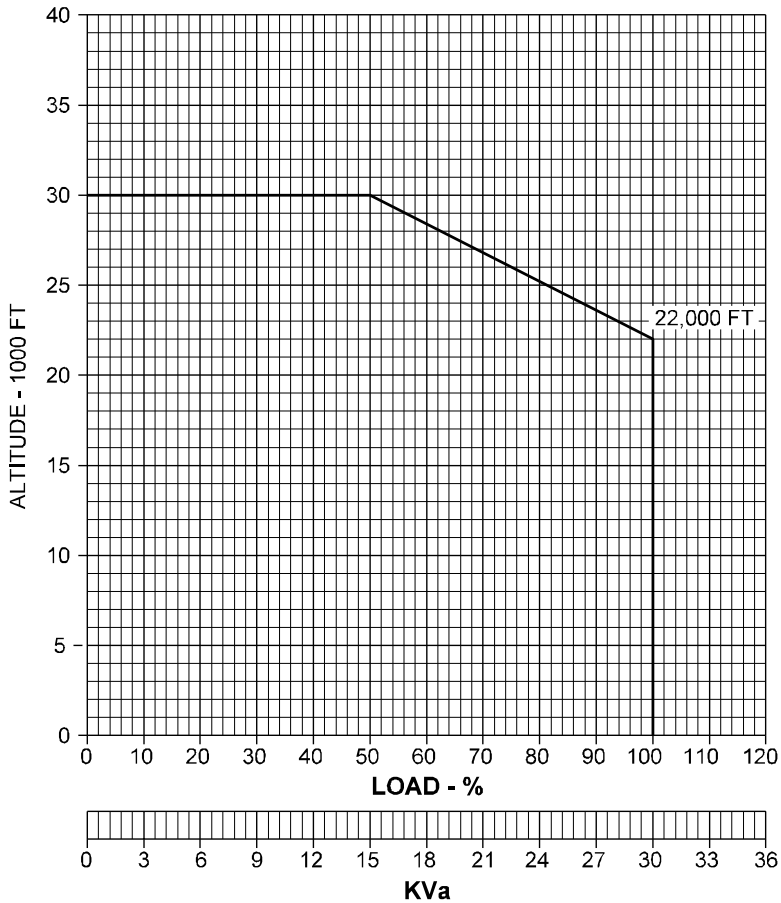
APU Control Panel
Figure 2



APU Load and ELWS Warning Indications
Figure 3



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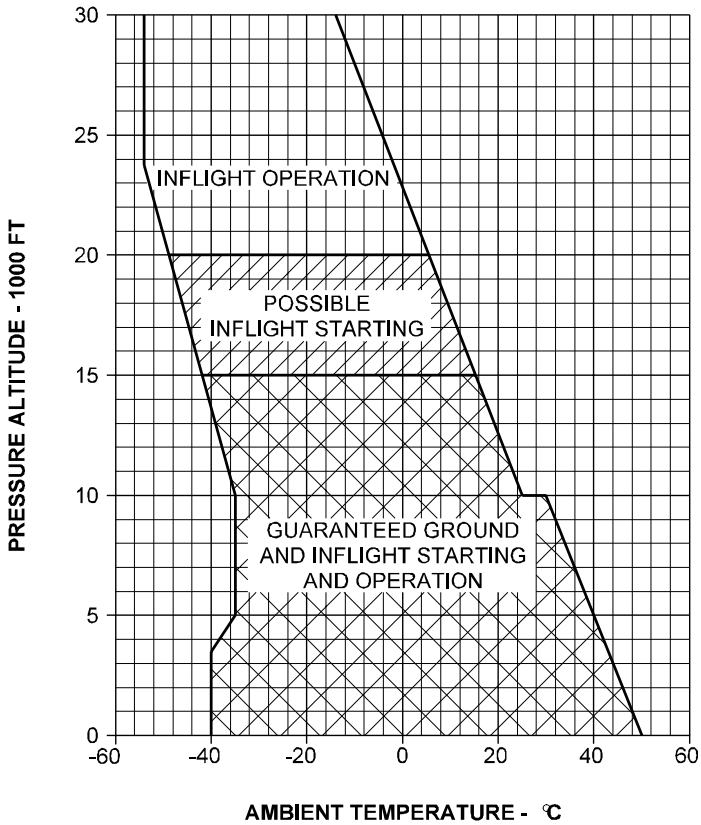
APU ALTERNATOR ELECTRICAL LOAD (SN 1000 – 1155 Without APU Loadmeter)
Figure 4



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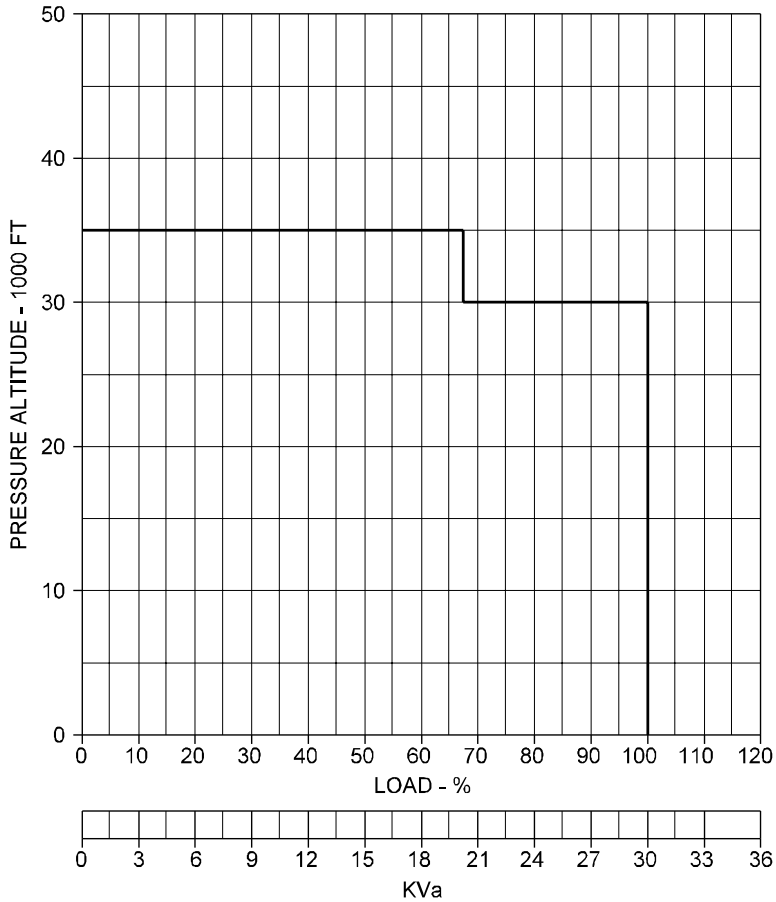
APU Operating Envelope (SN 1000 – 1155 Without APU Loadmeter)
Figure 5



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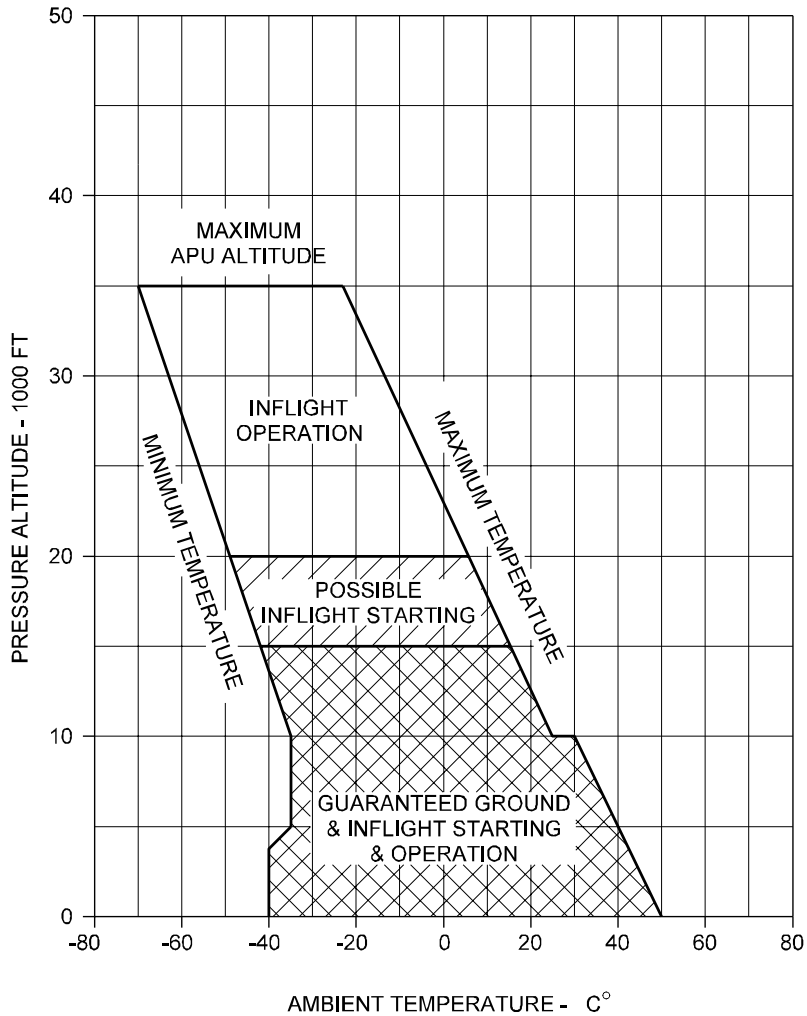
ELWS APU Alternator Electrical Load (SN 1156 & Subs, SN 1000 – 1155 With APU Loadmeter Installed or Removed By ASC 420, SN 1430 & Subs)
Figure 6



ELWS APU Alternator Operating Envelope (SN 1156 & Subs, SN 1000 – 1155 With APU Loadmeter Installed or Removed By ASC 420, SN 1430 & Subs)
Figure 7

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