Airplane Multiengine Land
Private, Commercial, ATP, and CFI

N1231P 1955 Piper Apache Geronimo Systems and Procedures

- THIRD EDITION -

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Revision 6-Aug-24

Changes From First Edition

Includes system description updates to account for work done on N1231P since the First Edition.

Includes regulatory updates to account for the changes to 14 CFR Part 23 in August 2017.

Changes From Second Edition

Adds profile-based landing check list and emphasizes using fewer, if any, power changes during descent, base, and final.

Expands explanation of V_{MC} and zero sideslip.

Corrects minor errata and harmonizes selected procedures with the Apache checklist.

Corrects minor errata in historical references.

Adds regulatory cross-reference links for both historical and current references.

Adds excerpts from the 1956 edition of 14 CFR Part 3 for historical reference.

Introduction

> *"The real value of twin-engine aircraft is it will double your chances of engine failure."*
>
> *"You can always depend on twin-engine aircraft. When the first engine quits, the second will surely fly you to the scene of an accident."*

These are two aviation clichés born from a period in multiengine airplane history when personal general aviation twins were becoming affordable and popular with the public. During that time, any CFI with Airplane Multiengine on his or her pilot's certificate could teach in a multiengine airplane. The concept of a Multiengine Instructor simply did not exist. The hazards of training during that time were compounded by questionable airplane design and testing, the pervasive notion that two is always better than one, and the belief that training should consist of creating REAL emergencies at any time versus realistic simulations under safe conditions.

So, while those clichés are overly dramatic and ridiculously fatalistic, they carry a fair level of truth that guides modern multiengine training.

One thing to understand from the start is that flying with more than one engine adds COMPLEXITY. Whether more than one engine adds SAFETY is a difficult question with many answers that depend on the airplane's capabilities, types of operations, and the pilot's training / experience.

A pilot should always strive to practice maneuvers, emergency procedures, and fly regularly to stay proficient rather than simply legal. This becomes more important when you earn your Instrument Rating and reaches peak importance when you pass your multiengine check ride.

Hopefully, you are still reading…

All of that said, learning to fly a multiengine airplane is an incredibly fun and rewarding experience. You will experience the same joy and wonder you felt the first time you sat behind the controls of your single-engine trainer. You will feel like the coolest pilot on Earth and have an unshakable desire to buy aviator sunglasses (assuming you do not already own a pair). And, in the same way that challenging yourself to earn an Instrument Rating will make you a better VFR pilot, challenging yourself to add Airplane Multiengine to your pilot's certificate will make you a better single-engine pilot.

For some readers, adding Airplane Multiengine will be one of the last steps toward flying commercially under Part 91 or 135, or earning their ATP certificate and flying for the airlines. Others may just want to add Airplane Multiengine to their Private Pilot certificates so they can fly farther and faster. In all cases, this training will be a foundational step that shapes you into a more professional, situationally aware pilot.

A Note About Checklists

Flying a multiengine airplane requires prompt, but DELIBERATE, action by the pilot. This means two things. First, you should develop a Do-Verify flow for checklist items. Second, you must act deliberately and calmly. You have two throttles, not one; two propeller controls not one; two mixture controls, not one; two sets of magneto pairs; etc.

Touch the item you intend to change, verbally say what you intended to do ("Feather RIGHT engine") even if you are alone, then verify you are touching the correct item before doing anything.

How to Use This Book

This book is an airplane-specific supplement to commercial textbooks and study guides, as well as a quick reference for multiengine concepts and maneuvers. This is a reference book only. Cross-check all the information with the approved AFM for N1231P.

The System Overviews and Diagrams should provide enough information to pass a Private or Commercial Pilot check ride. The System Descriptions should provide enough information to pass an ATP or CFI check ride. Private and Commercial Pilot students are strongly encouraged to at least read the System Descriptions for better insight into the airplane. "Knowing is half the battle!"

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Free reproduction of this book is allowed in its entirety with the title page and copyright. Standalone systems diagrams will be made available for free upon request. The diagrams are vector art and may be increased to any size.

Credits

Procedures adapted from "Apache Procedures Guide" by Kelly Wiprud with input from Brian Musson.

Systems Descriptions and Diagrams adapted from the Piper Apache Service Manual.

N1231P Apache Geronimo Familiarization

Photo Credit: Twin Oaks Airpark

V-Speeds

V_{S0}	56 MPH	Stall speed in the landing configuration.
V_{S1}	62 MPH	Stall speed in the clean configuration.
V_{LOF}	85 MPH	Liftoff speed. **WARNING: V_{MC} is 85 MPH.**
V_X	87 MPH	Best Angle of Climb speed.
V_{XSE}	95 MPH	Single-Engine Best Angle of Climb speed.
V_Y	95-105 MPH	Best Rate of Climb speed.
V_{YSE}	102 MPH	Single-Engine Best Rate of Climb speed, or Minimum Sink speed. Marked as BLUE radial line on the airspeed indicator.
V_{CC}	120 MPH	Cruise Climb speed. Best forward visibility and engine cooling.
V_{MC}	85 MPH	Minimum Control speed. Minimum speed at which it is still possible to maintain directional control with one engine inoperative. Marked as RED radial line on the airspeed indicator.
V_A	130 MPH	Design Maneuvering speed.
V_{NO}	190 MPH	Maximum Structural Cruising speed.
V_{NE}	217 MPH	Never Exceed speed.
V_{FE}	100 MPH	Flap Extension speed.
V_{LO}	125 MPH	Landing Gear Operation speed. Maximum speed at which the landing gear may be raised or extended.
V_{LE}	125 MPH	Landing Gear Extension speed. Maximum speed with landing gear extended.

Maximum Crosswind Component: 15 MPH.

Geronimo Conversion STCs

- 180 HP engines
- Larger vertical stabilizer
- Extended, aerodynamic nose
- Hoerner wing tips
- 24-gallon wing tip tanks on each wing (DISABLED)
- Modified tail cone
- Vortex generators

Engines

The Geronimo conversion equips the Apache with two, 180 horsepower Lycoming O-360, normally aspirated, horizontally opposed, 4-cylinder engines. The Apache uses augmenter tubes to effect engine cooling rather than cowl flaps. The exhaust manifold directs exhaust gasses into the augmenter tube which is also open to ambient air inside the cowling. The high-velocity exhaust gasses create a low-pressure area in the tube that pulls the cool ambient air entering the cowling from the front over the engine. On paper, this also provides a minor amount of thrust. Sure, it does.

The O-360 engine uses a wet sump oil system that lubricates the engine and feeds the propeller governor. Each engine requires 6 – 7 quarts of oil.

Propellers

The Apache uses two-blade, full-feathering, constant speed propellers. The propeller governor pumps oil into the hub to move the blades to a LOW pitch position. In the event of a loss of oil pressure, the blades move to the HIGH pitch feathered position by spring and nitrogen pressure. Centrifugal locks prevent feathering below approximately 800 RPM, e.g., during engine shut down on the ground.

Cabin Heat

The Apache uses an 18,000 BTU Southwind combustion heater to supply cabin heat. The heater is located on the LEFT side of the nose and requires fuel pressure to operate.

The pilot should take care to shut down the heater at least two minutes prior to shutting down the engines and securing the airplane. This gives the heater's exhaust fan enough time to run before losing power.

Refer to the Fuel System section for more details.

Landing Gear and Flaps

The Apache hydraulic system powers retraction and extension of the landing gear and wing flaps. A single engine-driven hydraulic pump on the LEFT engine provides pressure to the hydraulic system. A backup hand pump system and emergency CO_2 system provide redundancy if the single hydraulic pump fails, or the system loses pressure. Refer to the Hydraulic System section for more details.

Fuel

The Apache has two 36-gallon main tanks and two 18-gallon auxiliary tanks for a total fuel capacity of 108 gallons. Each wing has a 24-gallon tip tank that is DISABLED. Each engine has an engine-driven fuel pump and an electric boost pump that draw from their respective wing tanks. The Apache's fuel control system allows selecting MAIN, AUX, or OFF for each side as well as a pressure cross-feed system. Refer to the Fuel System section for more details.

Electrical

The Apache has a 14-Volt electrical system powered by a 12-Volt, 35-Amp battery located on the RIGHT side of the nose and dual, 50-Amp, alternators limited to 35 Amps. Refer to the Electrical System section for more details.

Vacuum

The Apache has a single engine-driven vacuum pump on the RIGHT engine to provide suction to the attitude indicator and heading indicator gyroscopes.

Pitot-Static

The Apache has a single Pitot-Static mast on the underside of the LEFT wing that integrates the Pitot ram air inlet, the static air inlet, and drain port.

Deicing

The Apache has minimal deicing equipment and is not certified for flight into known icing. Each carburetor has a carburetor heat control, and the Pitot-Static mast has an electric heater.

Aerodynamic Devices

The Geronimo conversion added vortex generators to the forward edge of the upper side of both wings, the underside of the horizontal stabilizer, and both sides of the vertical stabilizer. The vortex generators delay boundary layer separation improving performance of the airfoils and reduce stall speed.

The Geronimo STC allows for up to 5 of these vortex generators to be missing in total. Their presence must be checked during pre-flight.

The Geronimo conversion also added Hoerner wing tips that reduce drag and stall speed.

The Apache has an electric stall warning device on the leading edge of the LEFT wing.

N1231P Hydraulic System

Overview

The Apache's hydraulic system powers the landing gear and flaps. A single, engine-driven hydraulic pump on the LEFT engine provides pressure to the hydraulic system under normal conditions. A hand pump in the cabin provides pressure when the engine-driven pump is unavailable. In the event of a loss of system pressure due to a line breakage, an emergency CO_2 system may be used to extend the landing gear.

System Description

Refer to Figure 1 - Apache Hydraulic System on Page 6.

When both the landing gear selector and flap selector are in the NEUTRAL position, the engine-driven pump drives a circulation of hydraulic fluid that pulls from the reservoir via the PURPLE supply line, passes through a filter, enters the power pack through a check valve that prevents reverse flow, passes through the landing gear control (2), passes through the flap control (1), and returns to the reservoir via the GREEN return line.

When the pilot places the landing gear selector in the UP detent, the landing gear control (2) routes fluid into the RED retraction line. As the system pushes fluid into the landing gear actuators, fluid in the ORANGE extension line returns to the landing gear control and back to the reservoir via the return line. Once the actuators reach their stops, pressure builds and pops the landing gear selector out of its detent thus trapping pressurized fluid in the retraction lines.

The anti-retraction valve on the left landing gear opens when there is weight on the gear. This valve prevents landing gear retraction on the ground by allowing fluid to flow directly back to the supply line instead of applying pressure to the actuators.

This entire process reverses when the landing gear selector is in the DOWN detent. While the extension lines remain under pressure with the gear down, over-center struts ensure the landing gear remain locked down even if there is a loss of hydraulic pressure.

The flaps operate in the same fashion.

The system is unable to operate the flaps and gear simultaneously. If the pilot moves both the flap and landing gear selectors simultaneously, the system will operate the landing gear first and then the flaps (Apache Service Manual, Notation on Paragraph 6-10, Page 1G19).

Relief valves (5) protect the system from over-pressurization (either from thermal expansion or a mechanical failure) by allowing fluid to flow into the return line.

If the engine-driven hydraulic pump fails or the LEFT engine fails, the pilot may operate the hydraulic system using the hand pump (3). The only difference between extending / retracting the gear or flaps in this situation is that the pilot provides pressure to the power pack using the hand pump.

The hand pump may also be used on the ground to extend the flaps for pre-flight inspection.

The pilot can activate the emergency CO_2 system to extend the landing gear in the event of a loss of hydraulic system pressure. The CO_2 system is located under a panel on the cabin floor beneath the pilot's seat. When activated CO_2 flows through the BLUE CO_2 lines to shuttle valves (4) that allow the CO_2 into the landing gear actuators.

NOTE: The Landing Gear Selector must be DOWN to allow any fluid in the retraction lines to return to the reservoir (Apache Handbook, Page 37).

NOTE: DO NOT attempt to retract the landing gear after using the CO_2 system.

NOTE: The system may only be used once and then the CO_2 bottle must be replaced and the hydraulic lines bled.

NOTE: DO NOT ATTEMPT TO USE THE CO_2 SYSTEM TO EXTEND FLAPS. The CO_2 system is not connected to the flap actuator.

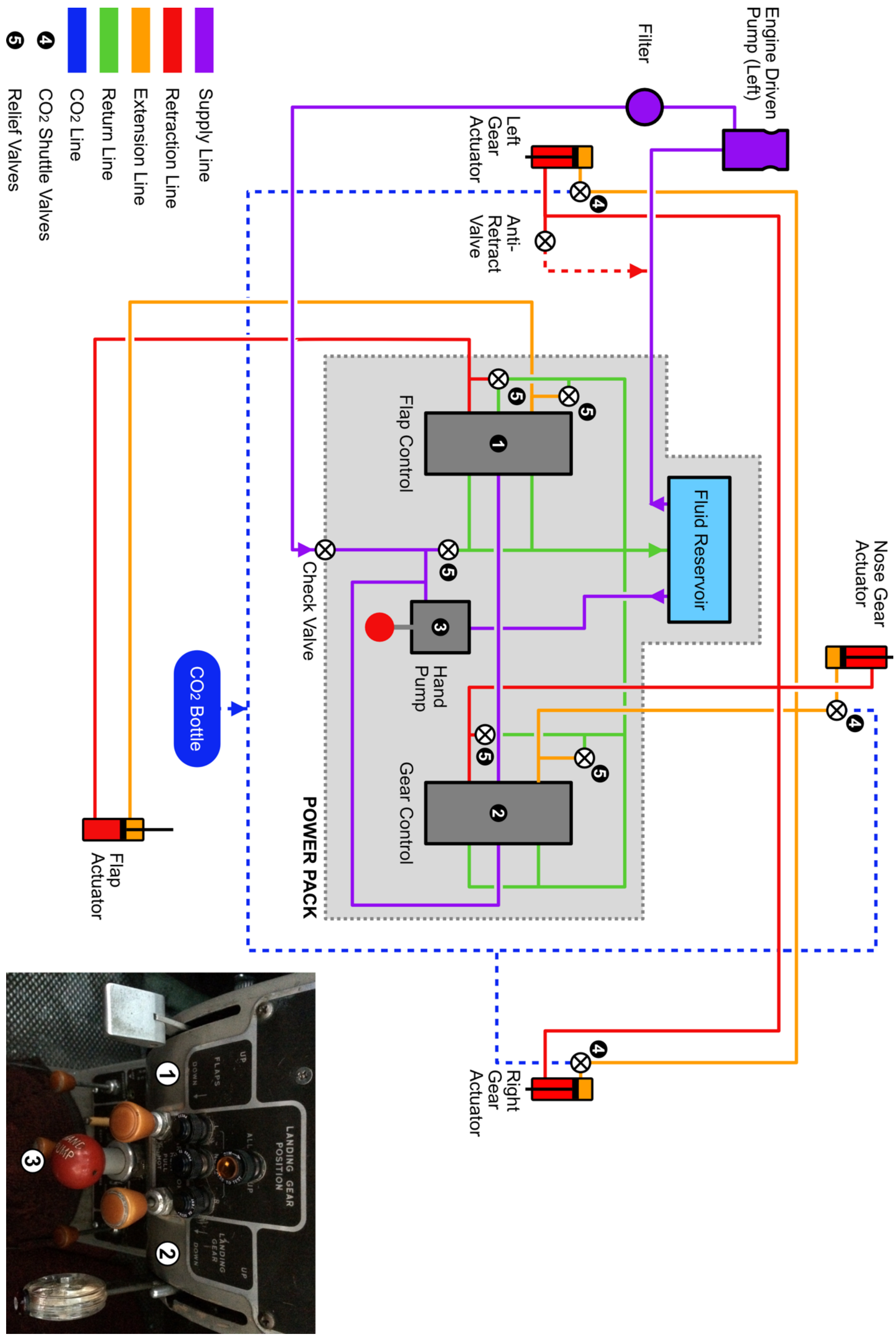

Figure 1 - Apache Hydraulic System

N1231P Fuel System

Overview

The Apache carries 100LL aviation fuel in two 36-gallon main fuel tanks and two 18-gallon auxiliary fuel tanks. The Geronimo modifications included the addition of two 24-gallon wing tip tanks that flow directly into the auxiliary tanks; however, these tanks are DISABLED. In total, the Apache can carry 108 gallons of fuel. Each engine has both an engine-driven fuel pump and an electric boost pump, and the Apache is equipped with a pressure cross-feed.

The Apache's fuel tanks are the nylon and neoprene cell type. When not being used, the auxiliary tanks should have a small amount of fuel in them to prevent the rubber from drying out. Be sure to include a couple gallons for each tank in Weight & Balance calculations.

On average, the Apache consumes approximately 20 gallons per hour, or 10 gallons per hour per engine.

System Description

Refer to Figure 2 - Apache Fuel System on Page 9.

For normal operations both fuel selectors, (1) and (2), should be on MAIN to feed each engine from its respective main fuel tank via the engine-driven fuel pump. Boost pumps should be used for engine start, takeoff, maneuvering, and landing to provide immediate backup in the case of an engine-driven fuel pump failure.

During extended cruise operations, setting the fuel selectors to AUX will feed each engine from its respective auxiliary tank. Set the fuel selectors back to MAIN prior to descent and landing.

The Apache only has one fuel quantity indicator for each side of the fuel system. The indicators display the quantity of fuel in the selected tank. For example, setting the left fuel selector to AUX will cause the LEFT fuel quantity indicator to display the amount of fuel in the LEFT auxiliary tank.

The pressure cross-feed valve allows fuel to flow from the side with normal fuel pressure to the side with low or no pressure.

In the event of an engine-driven fuel pump failure, the pilot has two options: run the affected engine using that engine's electric boost pump or use the pressure cross-feed system to feed the affected engine from the unaffected engine's fuel tanks using the unaffected engine's fuel pump(s).

For example, if the LEFT engine-driven fuel pump fails, opening the pressure cross-feed valve will allow the RIGHT engine-driven fuel pump to supply both the LEFT and RIGHT engine with fuel from the RIGHT fuel tanks.

Feeding both engines from one set of wing tanks will create a fuel imbalance. While the Apache has no published imbalance limit, an imbalance may affect controllability. To correct the imbalance, turn on the electric boost pump (if the engine-driven pump has failed) for the side with more fuel, set the cross-feed selector to ON, then set the fuel selector for the side with less fuel to OFF. The side with more fuel will now be feeding both engines.

Continuing the example of a LEFT engine-driven fuel pump failure, we will have more fuel on the LEFT side than the RIGHT side after supplying both engines from the RIGHT fuel tanks. By turning the LEFT boost pump ON, setting the cross-feed selector is ON, then setting the RIGHT fuel selector to OFF, the LEFT boost pump will supply both the LEFT and RIGHT engines with fuel from the LEFT fuel tanks.

> NOTE: In this configuration, the fuel system no longer has any redundancy. Should the LEFT boost pump fail, immediately return the RIGHT fuel selector to MAIN.

> NOTE: The Apache can continue to fly with both engine-driven fuel pumps failed using both electric boost pumps. However, while not an immediate emergency, this situation warrants landing as soon as practical due to loss of redundancy.

The Apache has a fuel strainer sump on each engine (shown as open triangles in the Fuel System diagram).

> NOTE: The fuel strainer sumps only drain the SELECTED tank. After switching tanks, it will take roughly 20 seconds of draining to purge the residual fuel from the previous tank.

The pressure cross-feed system has a drain opened by a knob (5) on the front face of the fuel console. The pilot should drain the pressure cross-feed system during pre-flight. The drain port is located on the underside of the airplane just below the fuel console.

Be sure to place a bucket under the drain. A significant amount of fuel will drain from the system.

Cross-Feed Drain Procedure

Master.. ON
Pressure Cross-Feed Switch.................. ON
  RIGHT Boost Pump............................ ON
  Drain Knob... OPEN momentarily (3 seconds)
  RIGHT Boost Pump............................ OFF
Pressure Cross-Feed Switch.................. OFF
  LEFT Boost Pump .... ON
  Drain Knob... OPEN momentarily (3 seconds)
  LEFT Boost Pump .... OFF
Master.. OFF

A valve (4) branching from the left side of the pressure cross-feed supplies the Southwind combustion heater with fuel. The heater requires fuel pressure from either an engine-driven fuel pump or electric boost pump.

The heater consumes approximately one quart of fuel per hour. With the pressure cross-feed OFF, the heater will take fuel from the left tanks, otherwise it will take fuel from both tanks or the right tank if the left fuel pumps are inoperative.

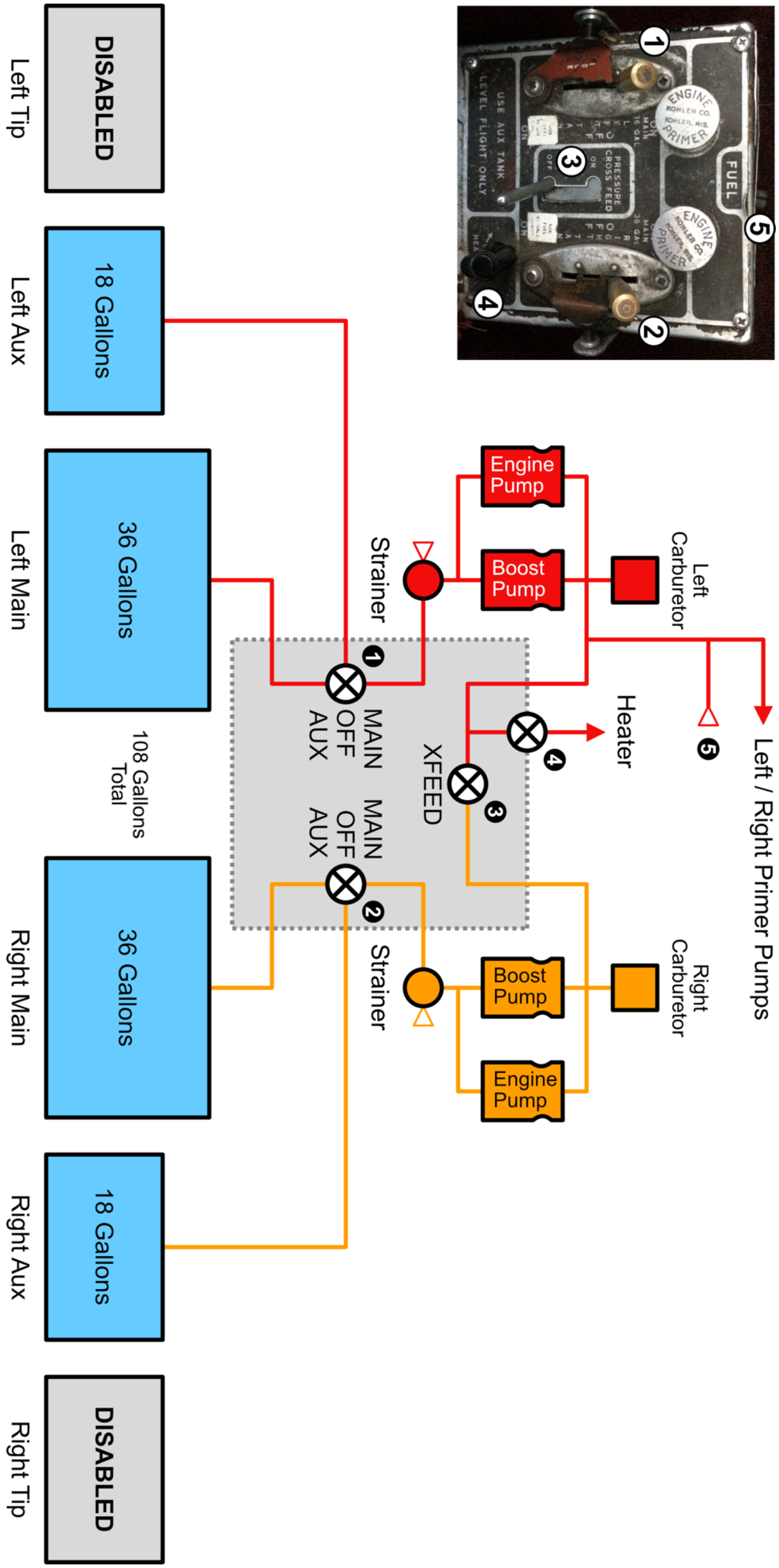

Figure 2 - Apache Fuel System

N1231P Electrical System

Overview

The Apache has a 14-Volt electrical system that consists of a single 12-Volt, 35-Ampere battery, and dual, 50-Ampere engine-driven alternators (limited to 35 Amperes) with a parallel relay to equally divide load between the alternators. Each alternator has its own field switch and circuit breaker. An avionics bus protected by two switch-type circuit breakers provides power to the radios, GPS, etc.

System Description

Refer to Figure 3 - Apache Electrical System on Page 11.

The Apache's master switch connects the master solenoid to ground allowing power to flow from the battery to the main bus and the left and right starter solenoids. The Apache does not have a direct battery bus.

Additionally, the master switch connects each alternator's field to the alternator field switches. The alternator field switches, in turn, complete the alternator field circuits through the regulators.

The alternator regulators modify resistance in the alternator field circuits to regulate output from alternators.

Turning off an alternator field switch prevents the alternator from generating power. Pulling an alternator's circuit breaker prevents load on the alternator.

NOTE: The alternator field switches are labelled "GEN" on the Apache's panel. The Apache originally had 50-Ampere, shunt-type DC generators. These were replaced with alternators, but the label is correct even if a little confusing at first. An alternator is an AC generator, or alternating current generator, hence "alternator".

The Apache's three-position starter switch connects to the main bus via a circuit breaker. Moving the starter switch to the LEFT or RIGHT contact position connects the main bus to the selected starter solenoid allowing power to flow to the respective starter motor.

With the engines running and the alternators supplying power, power flows in reverse from the main bus, through the master solenoid, and to the battery to charge it.

After starting the engines, closing the avionics switch-type circuit breakers will supply power to the avionics bus. The switches should be OPEN during engine start and stop to protect the avionics from power surges.

The parallel relay divides the electrical system load equally between each alternator.

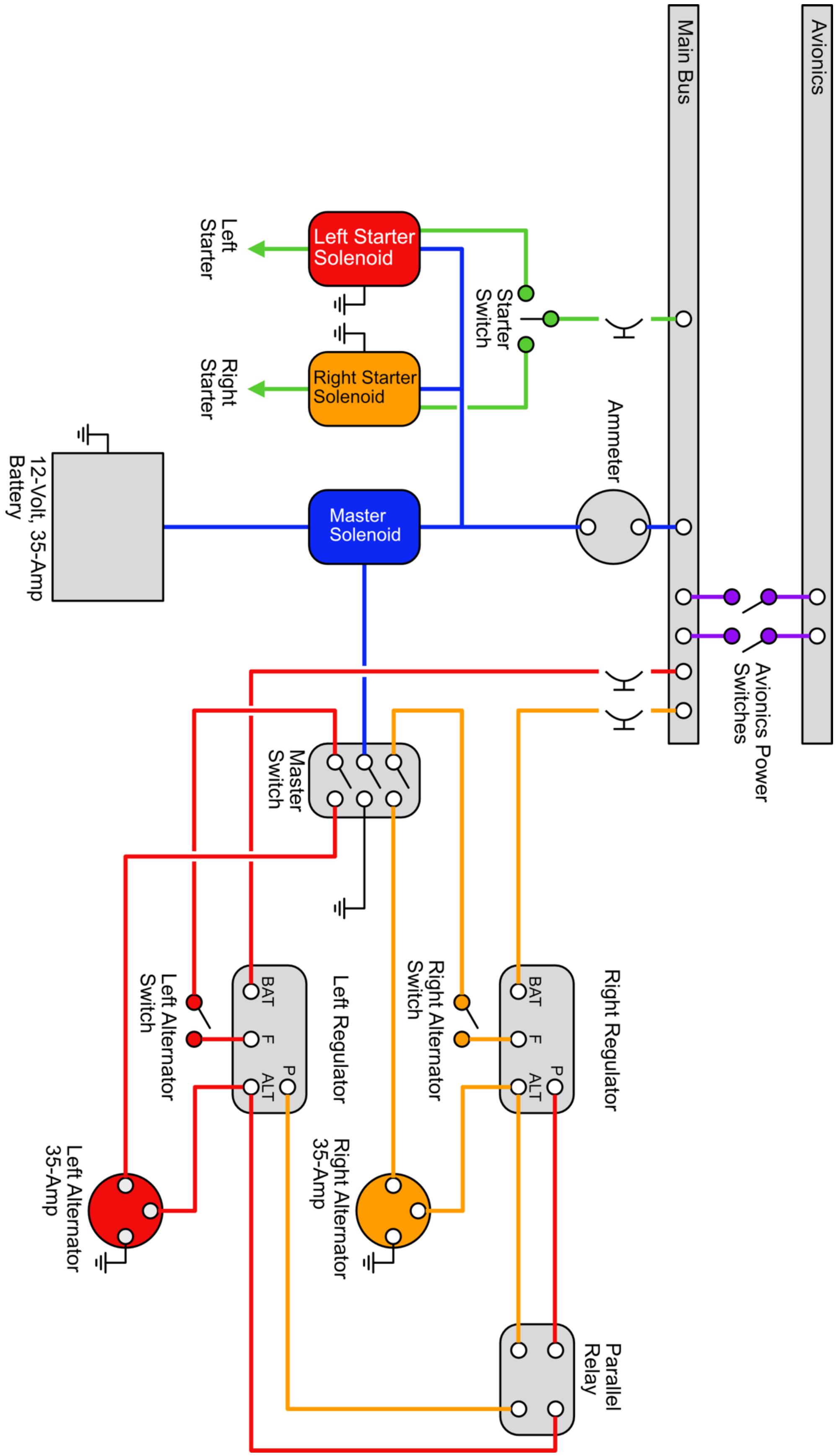

Figure 3 - Apache Electrical System

N1231P Selected Procedures

FLY THE AIRPLANE; MAINTAIN DIRECTIONAL CONTROL AND SITUATIONAL AWARENESS

Abnormality or Engine Failure on Takeoff – BEFORE 85 MPH

Maintain directional control.
Throttles .... CLOSE
Brakes... MAXIMUM AS REQUIRED

Abnormality or Engine Failure on Takeoff – INSUFFICIENT RUNWAY REMAINING

Maintain directional control.
Brakes... MAXIMUM
Mixtures... CUTOFF
Magnetos .... OFF
Master .... OFF
Fuel .... OFF
Avoid obstacles.

Engine Failure After Takeoff – GEAR DOWN AND RUNWAY REMAINING

Maintain directional control.
Throttles .... CLOSE
Land straight ahead, brakes MAXIMUM AS REQUIRED.

Engine Failure After Takeoff – INSUFFICIENT RUNWAY REMAINING

Maintain directional control.
Airspeed .... 102 MPH (V_{YSE})
Mixtures / Propellers / Throttles .... FULL (Power Up)
Gear / Flaps .... UP (Clean Up)
Identify Dead Engine .... IDENTIFY (Dead Foot, Dead Engine)
Dead Throttle.. VERBALLY ANNOUNCE, THEN CLOSE (Verify)
Propeller .... VERBALLY ANNOUNCE, THEN FEATHER
Mixture... VERBALLY ANNOUNCE, THEN CUTOFF
Bank and Rudder.................................. Toward Operative Engine as Required for Zero Sideslip
Declare and emergency and land as soon as possible on the longest runway possible.

Engine Failure En Route

Maintain directional control.
Airspeed .... 102 MPH (V_{YSE})
Dead Engine .... IDENTIFY (Dead Foot, Dead Engine)
Dead Throttle.. VERBALLY ANNOUNCE, THEN CYCLE (Verify)
Operating Engine.................................. Increase Throttle as Required
Boost Pumps .... ON
Engine Instruments................................ Check
Fuel Selectors / Cross-Feed .... Check / Try
Mixtures .... As Required
Secure engine if restart not possible.

Securing Engine

Verbally announce "LEFT" or "RIGHT" on each step.

Propeller .... FEATHER
Mixture .... CUTOFF
Throttle.. CLOSE
Boost Pump .... OFF
Fuel Selector .... OFF
Magnetos .... OFF, ONE AT A TIME
Alternator .... OFF
Cross-feed .... OFF

Unfeathering and Restarting

Magnetos .... ON
Alternator .... ON
Fuel Selector .... FULLEST TANK
Cross-feed .... OFF
Boost Pump .... ON
Mixture .... RICH
Propeller .... FULL
Airspeed .... > 120 MPH
Prime .... Pump throttle 3 times
Throttle.. IDLE
Starter .... Engage
Boost Pump .... OFF
Engine Instruments................................ Check
Allow engine to warm up before increasing power.

Extending the Landing Gear (Loss of Hydraulic Pump)

Airspeed .... Below 125 MPH
Landing Gear Selector........................... DOWN
Hand Pump Lever.................................. Extend
Pump .... Approximately 40 strokes
Landing Gear Indicators .... Verify 3 GREEN
Precautionary Landing........................... Execute

Retracting the Landing Gear (Loss of Hydraulic Pump)

Airspeed .... Below 125 MPH
Landing Gear Selector........................... UP
Hand Pump Lever.................................. Extend
Pump .... Approximately 40 strokes
Landing Gear Indicators .... Verify 1 ORANGE

Extending the Landing Gear (LOSS OF PRESSURE)

Airspeed .... Below 125 MPH
Landing Gear Selector .... DOWN
CO_2 Pin .... PULL
Landing Gear Indicators .... Verify 3 GREEN
Precautionary Landing........................... Execute

Takeoff Briefing

V_{LOF} .... 85 MPH
V_Y .... 95 - 105 MPH
V_{YSE} .... 102 MPH
V_{MC} .... 85 MPH
Review emergency actions.
Review emergency landing options and preset frequencies.
Review pilot roles and responsibilities.

Short-Field Takeoff

Priority #1: V_{MC} + 5, Priority #2: V_Y
Lights / Xpndr / Fuel / Boost Pumps .... ON / ALT / MAIN / ON
Brakes .... Stop on centerline with nose wheel straight
Throttles .... 2,000 RPM
Engine Gauges .... Verify GREEN
Brakes .... Release
Throttles .... FULL
85 MPH .... Announce and gently rotate
Positive Rate / No Remaining Runway... Announce and set gear UP
Airspeed .... V_Y
Passing 1,000' AGL…
  Throttles .... 24"
  Propellers .... 2,400 RPM
  Boost Pumps .... OFF
  Airspeed .... 120 MPH

> NOTE: Landing after an engine failure requires a significant amount of runway. If the runway is less than 4,000' long, no useful runway remains after liftoff and establishing a positive rate of climb.

Cruise

Pitch .... Level
Throttles .... As Required (18" for training)
Propellers .... As Required (2,400 RPM for training)
Elevator / Rudder Trim .... Set
Mixtures .... As Required (9 – 10 GPH displayed on fuel flow meters)
Fuel Selectors .... As Required (MAIN for training)

Short-Field Landing

NOTE: An engine failure with flaps and gear down will increase sink rate significantly.
Seats and Seatbelts .... Secure
Heater .... OFF
Throttles / Propellers .... 16 - 17" / 2,400 RPM
Fuel Selectors / Boost Pumps / X-feed... MAIN / ON / OFF
Gear (below 125 MPH) .... DOWN / Verify 3 GREEN
Mixtures .... RICH
Throttles / Propellers .... 13" / FULL (After reducing power)
Flaps (below 100 MPH) .... HALF (Base), FULL (Final)
Airspeed .... 100 MPH, 80 MPH (Short Final)
Gear .... Verify 3 GREEN on Short Final

NOTE: Brief the Normal Landing checklist before entering the pattern. Thereafter, perform a memory GUMPS check on Downwind, Base, and Final setting each item for that phase of the landing.

Downwind

Seats & Seatbelts .... Secure
Gas .... Fuel Selector on MAIN and Boost Pumps ON
Undercarriage .... Gear DOWN and 3 GREEN lights
Mixtures .... RICH
Throttles / Propellers .... 16 - 17”, then 13” / FULL when Abeam
Airspeed .... 110 MPH

Base

Seats & Seatbelts .... Secure
Gas .... Fuel Selector on MAIN and Boost Pumps ON
Undercarriage .... Gear DOWN and 3 GREEN lights
Mixtures .... RICH
Throttles / Propellers .... 13” / FULL
Airspeed .... 100 MPH
Flaps .... HALF

Final

Seats & Seatbelts .... Secure
Gas .... Fuel Selector on MAIN and Boost Pumps ON
Undercarriage .... Gear DOWN and 3 GREEN lights
Mixtures .... RICH
Throttles / Propellers .... 12”-13” / FULL
Airspeed .... 80 MPH
Flaps .... FULL

Single-Engine Landing

A single-engine rejected landing is a HAZARDOUS maneuver, therefore…
Choose the longest runway available for the current conditions.
Conserve altitude and maintain minimum drag to ensure landing.
Plan ahead for landing gear extension…
Extension takes 10-15 seconds with engine-driven pump.
Extension takes 40 strokes with the hand pump.

Seats and Seatbelts .... Secure
Operative Throttle / Propeller .... As Required to maintain altitude until abeam the numbers
Fuel Selectors / Boost Pumps / X-feed... MAIN / ON / OFF
Mixtures .... RICH
Airspeed .... 100 MPH
Gear .... DOWN on Base, Verify 3 GREEN
Flaps .... As Required when Landing Assured
Gear .... Verify 3 GREEN on Short Final

N1231P Maneuvers

Steep Turns

Clearing turns

Throttles.. 16” – 17” (add 2” in turn)
Propellers .... 2,400 RPM
Airspeed .... 120 MPH

STALL SAFETY BRIEFING:

Should an engine fail during a POWER-OFF stall, immediately PITCH DOWN to increase airspeed above V_{MC} before attempting to add power.

Should an engine fail during a POWER-ON stall, immediately CLOSE BOTH THROTTLES and PITCH DOWN to increase airspeed above V_{MC} before attempting to add power.

NEVER ATTEMPT SINGLE-ENGINE (REAL OR SIMULATED) STALLS.

Power-Off Stall

Clearing turns

Boost Pumps .... ON

Clean…

Throttles.. 13”
Airspeed .... 120 MPH

Landing Configuration…

Throttles.. Reduce as required
Mixtures / Propellers............................ RICH / FULL
Gear (below 125 MPH)......................... DOWN / Verify 3 GREEN
Airspeed .... 100 MPH
Flaps... HALF, then FULL

Establish a descent before inducing the stall
Throttles.. IDLE
Pitch... Gently increase and hold to induce stall

RECOVERY

Pitch.. Level to reduce angle of attack
Throttles.. FULL
Flaps... HALF
Airspeed .... 100 MPH until flaps UP, then V_Y
Establish positive rate of climb
Gear... UP
Flaps... UP
Configure for cruise at altitude specified by the examiner.

Power-On Stall

Clearing turns

Boost Pumps .... ON
Throttles.. 13”
Mixtures / Propellers.............................. RICH / FULL
Airspeed .... 85 MPH
Throttles.. SIMULATED max (18” for first indication or 16” for full break)
Pitch... Gently increase and hold to induce stall

RECOVERY

Pitch.. Level to reduce angle of attack
Airspeed .... V_Y
Configure for cruise at the altitude specified by the examiner.

Accelerated Stall

Clearing turns

Throttles.. 13”
Mixtures / Propellers.............................. RICH / FULL
Airspeed .... 100 MPH
Establish coordinated turn at 45° bank, induce stall with back pressure on elevator.

RECOVERY

Pitch.. Level to reduce angle of attack
Roll... Level
Airspeed .... V_Y
Configure for cruise at the altitude specified by the examiner.

Single-Engine Landing Demonstration

Refer to Single-Engine Landing Procedure

Inoperative Engine Throttle / Propeller ... 12” / 2,000 RPM
Execute Single-Engine Landing Procedure
Verbalize simulating manual gear extension if simulating LEFT engine failure.

V_{MC} DEMONSTRATION SAFETY BRIEFING:

THE V_{MC} DEMONSTRATION WILL NOT BE CONDUCTED WITH AN ENGINE SHUT DOWN. The V_{MC} demonstration will be conducted at or above 4,000’ AGL or as specified by the examiner. The lower density altitude may reduce V_{MC} below stall speed if the Apache is flown with zero sideslip.

V_{MC} Demonstration

Clearing turns; maintain heading at all times; recover within 20°
Initiate recovery at first indication of stall or loss directional control

Flaps / Gear .... UP
Boost Pumps .... ON
Mixtures / Propellers .... RICH / FULL
Airspeed .... 110 MPH
Inoperative Engine Throttle .... Slowly reduce to IDLE
Airspeed .... V_{YSE}
Bank .... No more than 5° toward operative engine
Operative Engine Throttle .... Slowly increase to FULL
Pitch .... Gently increase to lose 1 MPH per second

<u>RECOVERY</u>
  Operative Engine Throttle .... Reduce to half to regain directional
  Pitch .... Reduce to increase airspeed to V_{YSE}
  Operative Engine Throttle .... FULL when ABOVE V_{MC}
  Throttles .... Slowly return to 18” on each
  Configure for cruise

Drag Demonstration (Simulated Feathering)

Clearing turns

Boost Pumps .... ON
Mixtures / Propeller .... RICH / FULL
Throttles .... Inoperative IDLE, Operative FULL
Airspeed .... 102 MPH / **NOTE VSI**
Gear / Airspeed .... DOWN / 102 MPH / **NOTE VSI**
Flaps / Airspeed .... DOWN / 102 MPH / **NOTE VSI**
Inoperative Engine Throttle / Propeller ... 12” / 2,000 RPM / **NOTE VSI**
Flaps / Airspeed .... UP / 102 MPH / **NOTE VSI**
Gear / Airspeed .... UP / 102 MPH / **NOTE VSI**
Configure for cruise

Drag Demonstration (Full Feathering)

Clearing turns

Boost Pumps .... ON
Inoperative Engine Mixture .... CUTOFF
Propellers .... FULL
Throttles .... FULL
Airspeed .... 102 MPH / **NOTE VSI**
Gear / Airspeed .... DOWN / 102 MPH / **NOTE VSI**
Flaps / Airspeed .... DOWN / 102 MPH / **NOTE VSI**
Inoperative Engine Propeller / Airspeed . Feather / 102 MPH / **NOTE VSI**
Flaps / Airspeed .... UP / 102 MPH / **NOTE VSI**
Gear / Airspeed .... UP / 102 MPH / **NOTE VSI**
Restart Inoperative Engine
Configure for cruise

Multiengine Concepts Quick Reference

Critical Engine

§1.1 – The engine whose failure would most adversely affect the performance or handling qualities of an aircraft.

For U.S. aircraft with clockwise-rotating propellers, this is the LEFT engine.

- **P-FACTOR** from the RIGHT propeller is farther from the longitudinal axis than P-factor from the LEFT propeller. Thus, when the LEFT engine is inoperative, the RIGHT propeller has a longer arm producing a larger yaw tendency.
- **ACCELERATED SLIPSTREAM** over the RIGHT wing is farther from the longitudinal axis than the accelerated slipstream over the LEFT wing causing a larger bank tendency.
- **SPIRALING SLIPSTREAM** from the RIGHT engine tends not to strike the tail, whereas the spiraling slipstream from the LEFT engine strikes the tail and opposes yaw caused by the LEFT engine.
- **TORQUE** from RIGHT engine causes an additional LEFT turning tendency, whereas torque from the LEFT engine opposes the bank created by the LEFT engine accelerated slipstream.

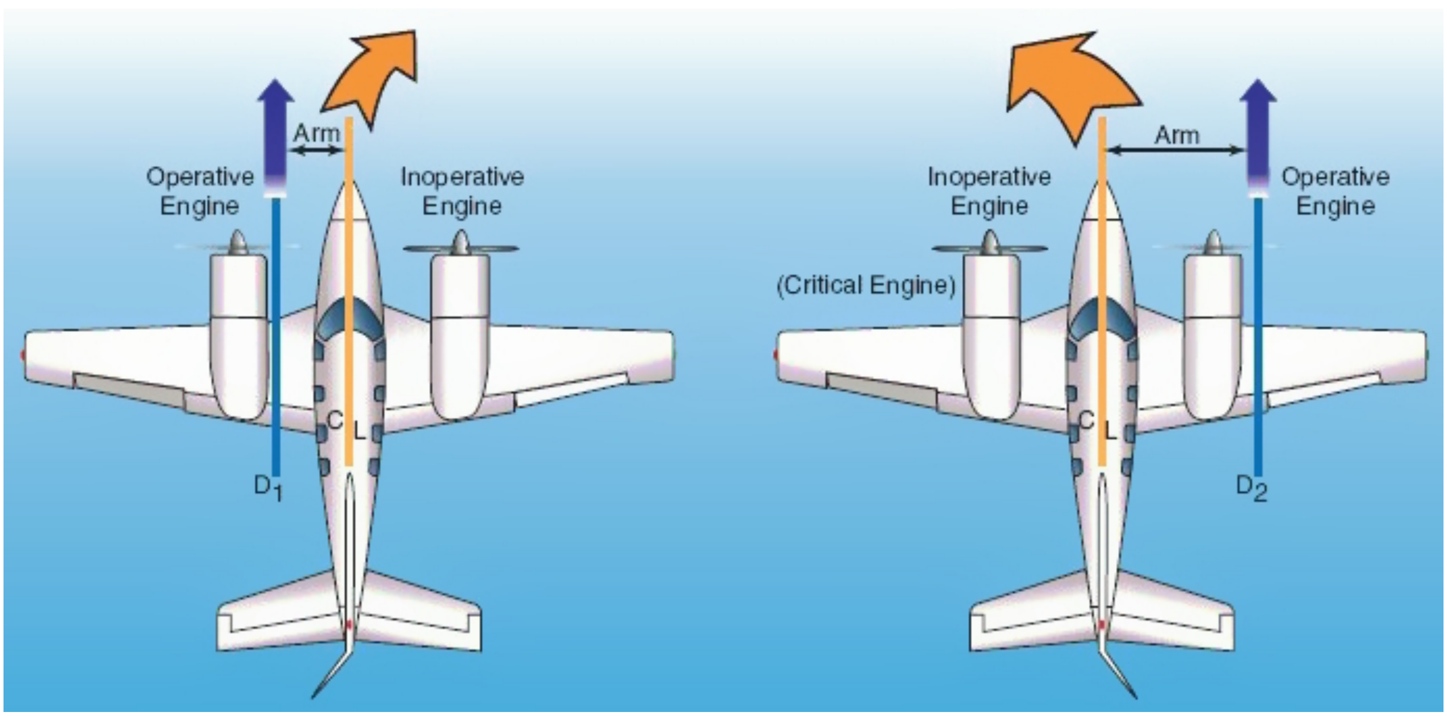

Figure 4 - Thrust Arms (Airplane Flying Handbook)

For propeller aircraft WITH counter-rotating propellers, these effects are balanced and the loss of either engine affects performance and controllability equally, i.e., neither is more critical than the other.

Accessories do NOT make an engine critical. For example, if the Apache had counter-rotating propellers, the presence of a single hydraulic pump on the left engine would not make the left engine critical per §1.1.

V_{MC} – Minimum Control Speed (Prior to August 2017)

Prior to 1965, 14 CFR Part 3 was the predecessor to Part 23 under the Civil Aeronautical Regulations. N1231P is a 1955 model, so the V_{MC} requirements in Part 3 are relevant. Copies of Part 3 are hard to find, but in 1956 the V_{MC} requirements were:

> §3.111(a) – A minimum speed shall be determined under the conditions specified below, such that when *any one engine* is suddenly made inoperative at that speed, it shall be possible to recover control of the airplane, with the one engine still inoperative, and to maintain it in straight flight at that speed, either with zero yaw or, at the option of the applicant, with a bank not in excess of 5 degrees. Such speed shall not exceed *1.3* V_{S1} with:
>
> (1) Take-off or maximum available power on all engines,
> (2) Rearmost center of gravity,
> (3) Flaps In take-off position,
> (4) Landing gear retracted.

Following the creation of Part 23 in 1965 and several edits over the decades, the V_{MC} requirements in effect just prior to August 2017 were:

> §23.149(a) – V_{MC} is the calibrated airspeed at which, when *the critical engine* is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative, and thereafter maintain straight flight at the same speed with an angle of bank of not more than 5 degrees. Indicated by a █ RED █ radial line on the airspeed indicator.

Manufacturers were required to determine V_{MC} to certify piston aircraft types of 6,000 pounds or less maximum weight in accordance with §23.149(b) & (c):

- V_{MC} must not exceed *1.2* V_{S1} where V_{S1} is determined at maximum takeoff weight.
- The airplane must be loaded at the most unfavorable weight and CG location.
- The airplane must be airborne with ground effect negligible.
- All engines must be set for maximum available takeoff power.
- The airplane must be trimmed for takeoff.
- Flaps must be in the takeoff position and the landing gear must be retracted.
- All propeller controls remain in the takeoff position (i.e., the failed engine is not feathered).
- The Critical Engine failure simulation must represent the most critical mode of power plant failure expected in service with respect to controllability.
- The airplane must not be banked more than 5 degrees toward the operative engine.

V_{MC} – Minimum Control Speed (After August 2017)

A rewrite of Part 23 to use Performance-Based Standards went into effect in August 2017. The concept was to set the performance the FAA expects and allow manufacturers to develop ways to demonstrate that an aircraft meets the standards. §23.2010 requires applicants for certification to provide the FAA with a means of compliance for approval. The new performance standards for V_{MC} remove means of compliance and simply say:

> §23.2135(c) – V_{MC} is the calibrated airspeed at which, following the sudden critical loss of thrust, it is possible to maintain control of the airplane. For multiengine airplanes, the applicant must determine V_{MC}, if applicable, for the most critical configurations used in takeoff and landing operations.

Rote repetition of `§23.149(b) & (c)` is NOT the correct answer when asked how manufacturers determine V_{MC}. The correct answer depends on the date of type certification and what methods were used during development of aerodynamic STCs on the airplane. Piper likely used a method similar to `§3.111(a)`, however keep in mind the provided excerpt is from 1956 after Piper certified the PA-23.

Absent any specific information in the approved AFM for the airplane used during a practical test, being able to state the history of Part 23 and being able to state the `§23.149(b) & (c)` method should be a safe answer for how manufacturers determine V_{MC}.

What is V_{MC} Really and What Factors Affect It?

Flight below V_{MC} results in a loss of directional control because the pilot no longer has enough rudder authority to counteract the yaw and bank tendencies with an engine inoperative.

The conditions used for determining V_{MC} generally represent a worst-case scenario and result in the highest V_{MC} for the airplane. Anything that reduces the yaw and bank moments or provides more authority to the rudder will reduce V_{MC}.

Loss of an engine, however, results in a loss of about 80% of that airplane's performance. Certain actions to reduce V_{MC} may further reduce already deficient single-engine performance.

The following actions reduce V_{MC}:

- **PROPELLER** – Feathering the propeller on the inoperative engine REDUCES drag, REDUCES the yaw moment and REDUCES V_{MC}. This results in a safe reduction of V_{MC}.

- **POWER** – REDUCING power on the operative engine REDUCES the yaw and bank moment and REDUCES V_{MC}. A reduction in power will aid in recovering directional control (refer to the V_{MC} Demonstration maneuver). A power reduction results in a performance penalty.

- **WEIGHT** – Additional weight requires more *total* lift from the wings. Thus, an INCREASE in weight results in a larger *horizontal* component of lift at the same bank angle. An INCREASE in the horizontal component of lift REDUCES the required rudder input when banked toward the operative engine and REDUCES V_{MC}. Inertia is another common explanation for weight opposing yaw and reducing V_{MC}, however inertia is negligible for weight concentrated near the CG. Weight due to passengers, for example, has a much smaller (if any) effect on V_{MC} than, say, wing-tip fuel tanks. In either case, an increase in weight results in a performance penalty.

- **CG** – A FORWARD center of gravity will REDUCE V_{MC} by creating a longer arm between the rudder and the CG thus making the rudder more effective.

- **DENSITY ALTITUDE** – An INCREASE in density altitude will REDUCE V_{MC} by making the operative engine less effective thus decreasing the yaw and bank moment. An increase in density altitude results in a performance penalty.

- **ZERO SIDESLIP** – Establishing the proper amount of bank toward the operative engine and the proper amount of rudder input toward the operative engine results in the airplane moving parallel to its longitudinal axis. This results in significant drag REDUCTION, an INCREASE in rudder authority, and results in a safe REDUCTION of V_{MC}.

- **FLAPS AND LANDING GEAR** – Flaps and landing gear can provide a "keel" effect that assists in maintaining directional control. FLAPS AND LANDING GEAR RESULT IN A COSTLY REDUCTION OF PERFORMANCE (refer to the Drag Demonstration maneuver).

- **BANK OF MORE THAN 5°** - Banking more than 5° toward the operative engine will use more horizontal lift to counter the yaw and bank moments thus requiring less rudder. MORE THAN 5° OF BANK WILL RESULT IN A COSTLY REDUCTION OF PERFORMANCE.

Zero Sideslip

Think back to your Private Pilot training when you were learning crosswind landings. You most likely learned to bank into the wind to prevent lateral drift from the centerline and opposite rudder to keep the airplane parallel with the runway. This is an intentional sideslip into the wind! Aerodynamically, the bank creates horizontal lift to oppose the wind and the rudder keeps you from turning. Without the wind, you would be moving diagonally in the direction of the bank. Without the bank and opposite rudder, you would be moving diagonally in the direction of the wind. When combined, however, you zero out sideslip in both directions and fly straight over the ground toward the runway.

Now think of a multiengine airplane with an engine failure. The operative engine tries to bank and yaw the airplane toward the inoperative engine. Your first natural tendency will be to use rudder toward the operative engine to maintain directional control with your ball centered and level the wings. However, you are now in the same situation only the asymmetric thrust from the operative engine is the "wind" moving you diagonally in the direction of the inoperative engine. A slight bank toward the operative engine, into the "wind", and relaxing the rudder pressure toward the operative engine will zero out the sideslip.

Flying in a sideslip condition creates two problems: 1) moving diagonally through the air causes excessive drag on the airplane and reduces performance, and 2) it requires more rudder to control direction thus reducing the amount of rudder authority you have and increasing V_{MC}.

Zero Sideslip is a combination of BANK and YAW toward the operative engine to maintain flight parallel to the longitudinal axis of the airplane. Using a slight amount of bank toward the operative engine counteracts yaw with horizontal lift and reduces the amount of rudder required to maintain directional control. Excessive bank, however, creates drag and decreases performance. Thus, using 2-3° of bank toward the operative engine and enough rudder to split the ball toward the operative engine, you achieve coordinated, maximum performance (such as it is) single-engine flight.

V_{MCG} – Minimum Control Speed on the Ground (Prior to August 2017)

Prior to 1965, §3.106 was roughly similar to post-2017 Part 23. From 1965 to August 2017, however, V_{MCG} optionally applied to multiengine jets of more than 6,000 pounds maximum weight and commuter category airplanes under Part 23. The V_{MCG} requirements in effect just prior to August 2017 were:

> §23.149(f) – At the option of the applicant, to comply with the requirements of §23.51(c)(1), V_{MCG} may be determined. V_{MCG} is the minimum control speed on the ground, and is the calibrated airspeed during the takeoff run at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane using the rudder control alone (without the use of nose wheel steering), as limited by 150 pounds of force, and using the lateral control to the extent of keeping the wings level to enable the takeoff to be safely continued.

Controllability (After August 2017)

> §23.2135(a) – The airplane must be controllable and maneuverable, without requiring exceptional piloting skill, alertness, or strength, within the operating envelope –
>
> (1) At all loading conditions for which certification is requested;
> (2) During all phases of flight;
> (3) With likely reversible flight control or propulsion system failure; and
> (4) During configuration changes.

V_{XSE} – Single-Engine Best Angle of Climb Speed

The speed at which the airplane gains the most altitude over the least ground distance on a single engine. The pilot should use V_{XSE} to clear obstacles after an engine failure on initial climb out. Refer to What is V_{MC} Really and What Factors Affect It? regarding single-engine climb performance. V_{XSE} may not result in a climb for all airplanes at all altitudes. Additionally, V_X and / or V_{XSE} may be below V_{MC}. In those cases, the pilot should use V_{MC} + 5.

V_{YSE} – Single-Engine Best Rate of Climb Speed

The speed at which the airplane gains the most altitude over the least amount of time on a single engine. Refer to What is V_{MC} Really and What Factors Affect It? regarding single-engine climb performance. V_{YSE} may not result in a climb for all airplanes at all altitudes, however V_{YSE} will result in minimum sink rate if the airplane cannot sustain a climb. Indicated by a BLUE radial line on the airspeed indicator.

§3.85a(b) had nothing to say about the single-engine climb performance of multiengine airplanes with a V_{S0} less than 70 MPH. Thus, Piper was not required to collect any data on single-engine climb performance for the PA-23 Apache.

From 1965 to August 2017, §23.67(a)(2) required that manufactures of multiengine airplanes of 6,000 pounds or less and V_{S0} of 61 knots or less determine the single-engine steady gradient of climb OR DESCENT at a pressure altitude of 5,000 feet. A positive rate of climb was not required.

Most twin-engine trainer types certified after August 2017 will likely meet the new criteria for low-speed, Level 1 and 2 airplanes defined in §23.2005(b) & (c). For these airplanes, §23.2120(b)(1) requires a CLIMB gradient of 1.5 percent at a pressure altitude of 5,000 feet in the cruise configuration.

Service Ceiling

The density altitude at which an airplane can sustain a 100 foot-per-minute climb at V_Y with all engines operating at maximum continuous power.

Absolute Ceiling

The density altitude at which any change in pitch will result in a loss of altitude with all engines operating at maximum continuous power.

Single-Engine Service Ceiling

The density altitude at which an airplane can sustain a 50 foot-per-minute climb at V_{YSE} with the inoperative engine feathered and the operative engine operating at maximum continuous power.

Single-Engine Absolute Ceiling

The density altitude at which any change in pitch will result in a loss of altitude with the inoperative engine feathered and the operative engine at maximum continuous power.

NOTE: Part 91 does not require the density altitude at ground level to be lower than the Single-Engine Absolute Ceiling for takeoff. You should exercise EXTREME CAUTION and plan for an engine failure should you choose to takeoff with a density altitude close to the Single-Engine Absolute Ceiling or the Single-Engine Service Ceiling.

Drift Down

Loss of an engine above the Single-Engine Absolute Ceiling will result in a loss of altitude, or Drift Down. Drift Down is one of the primary hazards to consider en route.

NOTE: Piper did not provide Drift Down charts for the Apache.

Accelerate-Stop Distance

The total distance required to accelerate the twin engine airplane to a specified speed and, assuming failure of an engine at the instant that speed is attained, to bring the airplane to a stop on the remaining runway.

NOTE: Piper did not provide Accelerate-Stop Distance charts for the Apache.

NOTE: Do not confuse the abort speed in an Accelerate-Stop Distance table with the V_1 concept.

NOTE: Except for turbine-powered transport category aircraft, §91.605(c), Part 91 does not require a runway length longer than the Accelerate-Stop Distance. You should exercise EXTREME CAUTION and plan for an engine failure should you choose to use a runway shorter than the Accelerate-Stop Distance for the current conditions.

Accelerate-Go Distance

The total distance required to accelerate the airplane to a specified speed and, assuming failure of an engine at the instant that speed is attained, continue takeoff on the remaining engine to a height of 50 feet.

NOTE: Piper did not provide Accelerate-Go Distance charts for the Apache.

Sample Takeoff Briefing

We are taking off on runway 20 (visually verify holding at the correct runway) and will be making a left turn to the Southeast.

V_{LOF}.. 85 MPH
V_Y... 95 - 105 MPH
V_{YSE}.. 102 MPH
V_{MC}... 85 MPH

After lining up on the runway, I will bring the engines up to 2,000 RPM and will verify proper operation before releasing the brakes and adding full power.

If anything occurs that affects the safety of flight before 85 MPH, I will immediately close the throttles and apply braking as necessary to stop the airplane on the runway.

Runway 20 is 2,400' long. Once airborne with a climb shown on the altimeter, I no long have any usable runway and I will raise the landing gear. If an engine failure occurs, I will:

Pitch for and maintain V_{YSE}.
Clean up (gear up)
Power up (mixtures, propellers, throttles FULL)
Identify (dead leg, dead engine)
Verify (announce closing LEFT or RIGHT throttle)

If I need to secure the engine, I will declare an emergency with Hillsboro Tower and proceed to land at Hillsboro.

Excerpts from the 1956 Edition of 14 CFR Part 3

21 FR 3339

CIVIL AERONAUTICS BOARD

WASHINGTON, D. C.

CIVIL AIR REGULATIONS

PART 3—AIRPLANE AIRWORTHINESS; NORMAL, UTILITY, AND ACROBATIC CATEGORIES

As amended to May 15, 1956

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TAKE-OFF

§ 3.84 *Take-off.* (a) The distance required to take off and climb over a 50-foot obstacle shall be determined under the following conditions:

(1) Most unfavorable combination of weight and center of gravity location,

(2) Engines operating within the approved limitations,

(3) Cowl flaps in the position normally used for take-off.

(b) Upon obtaining a height of 50 feet above the level take-off surface, the airplane shall have attained a speed of not less than 1.3 V_{S_1} unless a lower speed of not less than V_2 plus 5 can be shown to be safe under all conditions, including turbulence and complete engine failure.

(c) The distance so obtained, the type of surface from which made, and the pertinent information with respect to the cowl flap position, the use of flight-path control devices and landing gear retraction system shall be entered in the Airplane Flight Manual. The take-off shall be made in such a manner that its reproduction shall not require an exceptional degree of skill on the part of the pilot or exceptionally favorable conditions.

§ 3.84a *Take-off requirements; airplanes of 6,000 lbs. or less.* Airplanes having a maximum certificated take-off weight of 6,000 lbs. or less shall comply with the provisions of this section.

(a) The elevator control for tail wheel type airplanes shall be sufficient to maintain at a speed equal to 0.8 V_{S_1} an airplane attitude which will permit holding the airplane on the runway until a safe take-off speed is attained.

(b) The elevator control for nose wheel type airplanes shall be sufficient to raise the nose wheel clear of the take-off surface at a speed equal to 0.85 V_{S_1}.

(c) The characteristics prescribed in paragraphs (a) and (b) of this section shall be demonstrated with:

(1) Take-off power,

(2) Most unfavorable weight,

(3) Most unfavorable c. g. position.

(d) It shall be demonstrated that the airplane will take off safely without requiring an exceptional degree of piloting skill.

CLIMB

§ 3.85 *Climb*—(a) *Normal climb condition.* The steady rate of climb at sea level shall be at least 300 feet per minute, and the steady angle of climb at least 1:12 for landplanes or 1:15 for seaplanes with:

(1) Not more than maximum continuous power on all engines,

(2) Landing gear fully retracted,

(3) Wing flaps in take-off position,

(4) Cowl flaps in the position used in cooling tests specified in §§ 3.581–3.596.

(b) *Climb with inoperative engine.* All multiengine airplanes having a stalling speed V_{S_0} greater than 70 miles per hour or a maximum weight greater than 6,000 pounds shall have a steady rate of climb of at least 0.02 $V_{S_0}^2$ in feet per minute at an altitude of 5,000 feet with the critical engine inoperative and:

(1) The remaining engines operating at not more than maximum continuous power,

(2) The inoperative propeller in the minimum drag position,

(3) Landing gear retracted,

(4) Wing flaps in the most favorable position,

(5) Cowl flaps in the position used in cooling tests specified in §§ 3.581–3.596.

(c) *Balked landing conditions.* The steady angle of climb at sea level shall be at least 1:30 with:

(1) Take-off power on all engines,

(2) Landing gear extended,

(3) Wing flaps in landing position.

If rapid retraction is possible with safety without loss of altitude and without requiring sudden changes of angle of attack or exceptional skill on the part of the pilot, wing flaps may be retracted.

§ 3.85a *Climb requirements; airplanes of 6,000 lbs. or less.* Airplanes having a maximum certificated take-off weight of 6,000 lbs. or less shall comply with the requirements of this section.

(a) *Climb; take-off climb condition.* The steady rate of climb at sea level shall not be less than 10 V_{S_1} or 300 feet per minute, whichever is the greater, with:

(1) Take-off power,

(2) Landing gear extended,

(3) Wing flaps in take-off position,

(4) Cowl flaps in the position used in cooling tests specified in §§ 3.581 through 3.596.

(b) *Climb with inoperative engine.* All multiengine airplanes having a stalling speed V_{S_0} greater than 70 miles per hour shall have a steady rate of climb of at least 0.02 $V_{S_0}^2$ in feet per minute at an altitude of 5,000 feet with the critical engine inoperative and:

(1) The remaining engines operating at not more than maximum continuous power,

(2) The inoperative propeller in the minimum drag position,

(3) Landing gear retracted,

(4) Wing flaps in the most favorable position,

(5) Cowl flaps in the position used in cooling tests specified in §§ 3.581 through 3.596.

(c) ***Climb; balked landing conditions.*** The steady rate of climb at sea level shall not be less than 5 V_{S_0} or 200 feet per minute, whichever is the greater, with:

(1) Take-off power,

(2) Landing gear extended,

(3) Wing flaps in the landing position.

If rapid retraction is possible with safety, without loss of altitude and without requiring sudden changes of angle of attack or exceptional skill on the part of the pilot, wing flaps may be retracted.

LANDING

§ 3.86 *Landing.* (a) The horizontal distance required to land and to come to a complete stop (to a speed of approximately 3 miles per hour for seaplanes or float planes) from a point at a height of 50 feet above the landing surface shall be determined as follows:

(1) Immediately prior to reaching the 50-foot altitude, a steady gliding approach shall have been maintained, with a true indicated air speed of at least 1.3 V_{S_0}.

(2) The landing shall be made in such a manner that there is no excessive vertical acceleration, no tendency to bounce, nose over, ground loop, porpoise, or water loop, and in such a manner that its reproduction shall not require any exceptional degree of skill on the part of the pilot or exceptionally favorable conditions.

(b) The distance so obtained, the type of landing surface on which made and the pertinent information with respect to cowl flap position, and the use of flight path control devices shall be entered in the Airplane Flight Manual.

§ 3.87 *Landing requirements; airplanes of 6,000 lbs. or less.* For an airplane having a maximum certificated take-off weight of 6,000 lbs. or less it shall be demonstrated that the airplane can be safely landed and brought to a stop without requiring an exceptional degree of piloting skill, and without excessive vertical acceleration, tendency to bounce, nose over, ground loop, porpoise, or water loop.

FLIGHT CHARACTERISTICS

§ 3.105 *Requirements.* The airplane shall meet the requirements set forth in §§ 3.106 to 3.124 at all normally expected operating altitudes under all critical loading conditions within the range of center of gravity and, except as otherwise specified, at the maximum weight for which certification is sought.

CONTROLLABILITY

§ 3.106 *General.* The airplane shall be satisfactorily controllable and maneuverable during take-off, climb, level flight, dive, and landing with or without power. It shall be possible to make a smooth transition from one flight condition to another, including turns and slips, without requiring an exceptional degree of skill, alertness, or strength on the part of the pilot, and without danger of exceeding the limit load factor under all conditions of operation probable for the type, including for multiengine airplanes those conditions normally encountered in the event of sudden failure of any engine. Compliance with "strength of pilots" limits need not be demonstrated by quantitative tests unless the Administrator finds the condition to be marginal. In the latter case they shall not exceed maximum values found by the Administrator to be appropriate for the type but in no case shall they exceed the following limits:

	Pitch	Roll	Yaw
(a) For temporary application:			
Stick	60	30	150
Wheel [1]	75	60	150
(b) For prolonged application	10	5	20

[1] Applied to rim.

§ 3.107–U *Approved acrobatic maneuvers.* It shall be demonstrated that the approved acrobatic maneuvers can be performed safely. Safe entry speeds shall be determined for these maneuvers.

§ 3.108–A *Acrobatic maneuvers.* It shall be demonstrated that acrobatic maneuvers can be performed readily and safely. Safe entry speeds shall be determined for these maneuvers.

§ 3.109 *Longitudinal control.* The airplane shall be demonstrated to comply with the following requirements:

(a) It shall be possible at all speeds below V_x to pitch the nose downward so that the rate of increase in air speed is satisfactory for prompt acceleration to V_x with:

(1) Maximum continuous power on all engines, the airplane trimmed at V_x.

(2) Power off, airplanes of more than 6,000 pounds maximum weight trimmed at 1.4 V_{s_1}, and airplanes of 6,000 pounds or less maximum weight trimmed at 1.5 V_{s_1}.

(3) (i) Wing flaps and landing gear extended and

(ii) Wing flaps and landing gear retracted.

(b) During each of the controllability demonstrations outlined below it shall not require a change in the trim control or the exertion of more control force than can be readily applied with one hand for a short period. Each maneuver shall be performed with the landing gear extended.

(1) With power off, flaps retracted, and the airplane trimmed as prescribed in paragraph (a) (2) of this section, the flaps shall be extended as rapidly as possible while maintaining the air speed at approximately 40 percent above the instantaneous value of the stalling speed.

(2) Same as subparagraph (1) of this paragraph, except the flaps shall be initially extended and the airplane trimmed as prescribed in paragraph (a) (2) of this section, then the flaps shall be retracted as rapidly as possible.

(3) Same as subparagraph (2) of this paragraph, except maximum continuous power shall be used.

(4) With power off, the flaps retracted, and the airplane trimmed as prescribed in paragraph (a) (2) of this section, take-off power shall be applied quickly while the same air speed is maintained.

(5) Same as subparagraph (4) of this paragraph, except with the flaps extended.

(6) With power off, flaps extended, and the airplane trimmed as prescribed in paragraph (a) (2) of this section, air speeds within the range of 1.1 V_{s_1} to 1.7 V_{s_1} or V_f, whichever is the lesser, shall be obtained and maintained.

(c) It shall be possible without the use of exceptional piloting skill to maintain essentially level flight when flap retraction from any position is initiated during steady horizontal flight at 1.1 V_{s_1} with simultaneous application of not more than maximum continuous power.

§ 3.110 *Lateral and directional control.* (a) It shall be possible with multiengine airplanes to execute 15-degree banked turns both with and against the inoperative engine from steady climb at 1.4 V_{s_1} or V_y for the condition with:

(1) Maximum continuous power on the operating engines,

(2) Rearmost center of gravity,

(3) (i) Landing gear retracted and

(ii) Landing gear extended.

(4) Wing flaps in most favorable climb position,

(5) Maximum weight,

(6) The inoperative propeller in its minimum drag condition.

(b) It shall be possible with multiengine airplanes, while holding the wings level laterally within 5 degrees, to execute sudden changes in heading in both directions without dangerous characteristics being encountered. This shall be demonstrated at 1.4 V_{s_1} or V_y up to heading changes of 15 degrees, except that the heading change at which the rudder force corresponds to that specified in § 3.106 need not be exceeded, with:

(1) The critical engine inoperative,

(2) Maximum continuous power on the operating engine(s),

(3) (i) Landing gear retracted and

(ii) Landing gear extended,

(4) Wing flaps in the most favorable climb position,

(5) The inoperative propeller in its minimum drag condition,

(6) The airplane center of gravity at its rearmost position.

§ 3.111 *Minimum control speed (V_{mc}).* (a) A minimum speed shall be determined under the conditions specified below, such that when any one engine is suddenly made inoperative at that speed, it shall be possible to recover control of the airplane, with the one engine still inoperative, and to maintain it in straight flight at that speed, either with zero yaw or, at the option of the applicant, with a bank not in excess of 5 degrees. Such speed shall not exceed 1.3 V_{s_1}, with:

(1) Take-off or maximum available power on all engines,

(2) Rearmost center of gravity,

(3) Flaps in take-off position,

(4) Landing gear retracted.

(b) In demonstrating this minimum speed, the rudder force required to maintain it shall not exceed forces specified in § 3.106, nor shall it be necessary to throttle the remaining engines. During recovery the airplane shall not assume any dangerous attitude, nor shall it require exceptional skill, strength, or alertness on the part of the pilot to prevent a change of heading in excess of 20 degrees before recovery is complete.

TRIM

§ 3.112 *Requirements.* (a) The means used for trimming the airplane shall be such that, after being trimmed and without further pressure upon or movement of either the primary control or its corresponding trim control by the pilot or the automatic pilot, the airplane will maintain:

(1) Lateral and directional trim in level flight at a speed of 0.9 V_h or at V_c, if lower, with the landing gear and wing flaps retracted;

(2) Longitudinal trim under the following conditions:

(i) During a climb with maximum continuous power at a speed between V_x and 1.4 V_{s_1},

(*a*) With landing gear retracted and wing flaps retracted,

(*b*) With landing gear retracted and wing flaps in the take-off position.

(ii) During a glide with power off at a speed not in excess of 1.4 V_{s_1},

(*a*) With landing gear extended and wing flaps retracted,

(*b*) With landing gear extended and wing flaps extended under the forward center of gravity position approved with the maximum authorized weight.

(*c*) With landing gear extended and wing flaps extended under the most forward center of gravity position approved, regardless of weight.

(iii) During level flight at any speed from 0.9 V_h to V_x or 1.4 V_{s_1} with landing gear and wing flaps retracted.

(b) In addition to the above, multiengine airplanes shall maintain longitudinal and directional trim at a speed between V_y and 1.4 V_{s_1} during climbing flight with the critical of two or more engines inoperative, with:

(1) The other engine(s) operating at maximum continuous power,

(2) The landing gear retracted,

(3) Wing flaps retracted,

(4) Bank not in excess of 5 degrees.

(c) For aircraft having a maximum certificated take-off weight of 6,000 lbs. or less, the value specified in paragraph (a) (2) (ii) of this section shall be 1.5 V_{s_1} or, if the stalling speed V_{s_1} is not obtainable in the particular configuration, 1.5 times the minimum steady flight speed at which the airplane is controllable.

STABILITY

§ 3.113 *General.* The airplane shall be longitudinally, directionally, and laterally stable in accordance with the following sections. Suitable stability and control "feel" (static stability) shall be required in other conditions normally encountered in service, if flight tests show such stability to be necessary for safe operation.

§ 3.114 *Static longitudinal stability.* In the configurations outlined in § 3.115 and with the airplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system shall be such that:

(a) A pull shall be required to obtain and maintain speeds below the specified trim speed and a push to obtain and maintain speeds above the specified trim speed. This shall be so at any speed which can be obtained without excessive control force, except that such speeds need not be greater than the appropriate maximum permissible speed or less than the minimum speed in steady unstalled flight.

(b) The air speed shall return to within 10 percent of the original trim speed when the control force is slowly released from any speed within the limits defined in paragraph (a) of this section.

§ 3.115 *Specific conditions.* In conditions set forth in this section, within the speeds specified, the stable slope of stick force versus speed curve shall be such that any substantial change in speed is clearly perceptible to the pilot through a resulting change in stick force.

(a) *Landing.* The stick force curve shall have a stable slope and the stick

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