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Federal Aviation
Administration

Advisory Circular

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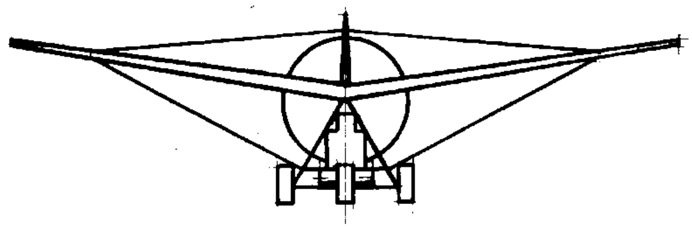

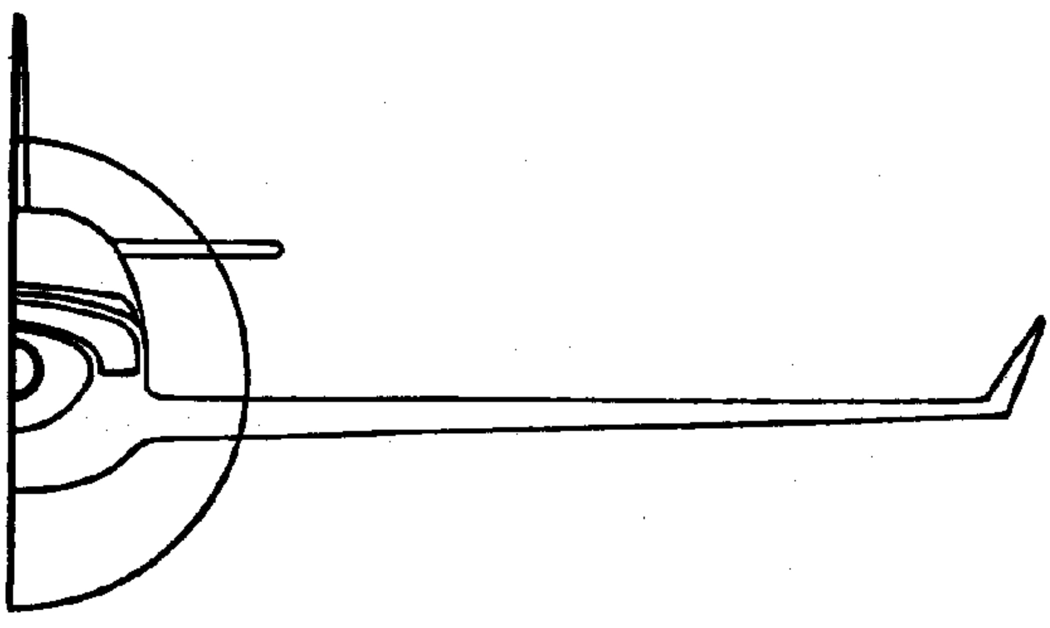

This advisory circular (AC) provides suggestions and safety related recommendations primarily to assist amateur and ultralight builders in developing individualized aircraft flight-test plans. It also provides guidance for experimental light sport aircraft flight testing after modifications to the aircraft. It provides recommendations and suggestions you can combine with other sources on test flying, such as the aircraft plan/kit manufacturer’s flight testing instructions and other flight testing data. This will help you develop a detailed flight-test plan, tailored for your aircraft and resources.

This AC attempts to make you aware that test flying an aircraft is a critical undertaking, which you should approach with thorough planning, skill, and common sense. The flight-test plan is the heart of all professional flight testing. The plan should account for every hour spent in the flight-test phase and you should adhere to it with the same respect for the unknown that all successful test pilots share. The time allotted for each phase of a personalized flight-test plan may vary, and each phase may have more events or checks than suggested in this AC, but your goals, should be the same. You should add flight-test operational and performance data to the aircraft’s flight manual so you can reference the data prior to each flight.

This AC is not mandatory and does not constitute a regulation. This AC describes an acceptable means, but not the only means, to develop flight-test plans. However, if you use the means described in the AC, you must follow it in all important respects. This AC applies to amateur and ultralight builders, and individuals involved in flight testing those aircraft.

John S. Duncan
Director, Flight Standards Service

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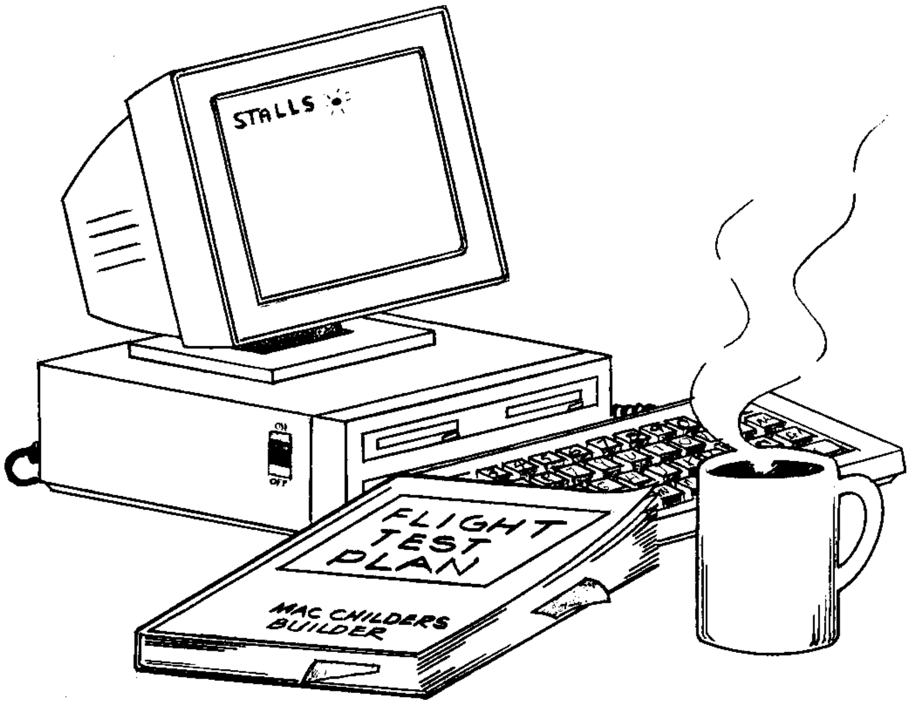
CHAPTER 1. PREPARATION

"The Laws of Aerodynamics are unforgiving and the ground is hard." Michael Collins (1987)



SECTION 1. HOMEWORK

"If you have no plan—you have no goal." Harold Little, Aircraft Manufacturer (1994)

1-1. OBJECTIVE. A planned approach to flight testing.

a. Develop a Flight-Test Plan. Your most important task is to develop a comprehensive flight-test plan. You should tailor this plan to define the aircraft's specific level of performance, so it's important that the entire flight-test plan be developed and completed before the aircraft's first flight.

NOTE: As part of the comprehensive flight-test plan, the test pilot should read and comprehend this entire AC before proceeding in accomplishing any suggested task.

b. Objective of a Flight-Test Plan. The objective of a flight-test plan is to determine the aircraft's controllability throughout all the maneuvers and to detect any hazardous operating characteristics or design features. You should use this data to develop a flight manual that specifies the aircraft's performance and defines its operating envelope. Additionally, the plan should reference the use of checklists to assure that all relevant steps and elements are covered.

c. Time Required for Flight Testing Amateur-Built Aircraft. Your original issued airworthiness certificates should be limited to operation within an assigned flight-test area for a minimum of 25 hours when a type certificated (TC) engine/propeller combination is installed. A minimum of 40 hours is required when a non TC'd engine, propeller, or engine/propeller combination is installed. Furthermore, if the TC'd engine, propeller, or engine/propeller combination installed has been altered in a way that differs from an approved type design in a Type Certificate Data Sheet (TCDS), a minimum of 40 hours shall be required.

d. Time Required for Flight Testing Experimental Light Sport Aircraft (ELSA). If you own an ELSA experimental aircraft under Title 14 of the Code of Federal Regulations (14 CFR) part 21, § 21.191(i)(2), and it has not been modified, conduct a test flight as per their operations manual in an assigned flight-test area for a minimum of 5 hours. This applies for all classes of light sport aircraft (LSA) to determine aircraft controllability throughout its design limits.

e. Best Practices for Flight Testing After Modifying an Experimental Amateur-Built Aircraft. Before considering any modification to an aircraft previously issued an experimental certificate for the purpose of operating as an amateur-built (E-AB) aircraft, there are two things you need to consider. First is the level of modification; the other is the corresponding flight testing required for the modification. When considering the level of modification, you should first check the E-AB operating limitations. They will detail what, if any, reporting requirements there are for a given modification. This is especially important when the E-AB modification approaches the same level of a major change to TC aircraft as defined in part 21, § 21.93. Usually the owner of the E-AB aircraft is required by the aircraft operating limitations to notify the geographical responsible Flight Standards District Office (FSDO) following a "major change" as defined by § 21.93. This regulation states that a "major change" is any that affects the "weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product. The corresponding flight testing for a major change will require at least 5 hours minimum of supplemental Phase I flight testing be completed to comply with 14 CFR part 91, § 91.319(b). The aircraft owner must obtain concurrence from the FSDO as to the suitability of the proposed test area.

(1) Flight testing in some form is advisable following any modification to the aircraft. Not only will a structured series of test flights reveal any malfunctions or unintended consequences associated with a modification, but it will also allow the pilot to become familiar with the operation of the aircraft after a given change before returning to "operational" flying. For example, flight testing a new instrument will verify its proper operation and ensure the pilot understands how to use it. This is important to accomplish before operating the aircraft in a situation where the proper operation of the instrument may affect the safe outcome of the flight.

(2) This sort of flight testing is at the sole discretion of the owner or pilot, so it may or may not be as formal as Phase I. In general, however, the owner or pilot should conduct it in uncongested airspace local to an airport, to keep distractions at a minimum. Passengers flying for the sole purpose of pleasure should be avoided, however, because this is not Phase I testing, a passenger may be carried to monitor aircraft systems or perform other functions relevant to the purpose of the flight, if appropriate. As with any test flight, there should a clear plan with clear objectives.

(3) It is important to note that, while some modifications are neither mandatory nor necessary to report to the FSDO, you should document all changes appropriately. The aircraft records should be updated with the date the work was completed, the hours in service of the components affected, and the total hours on the aircraft noted in the logbook along with the changes performed and the equipment added or removed. The weight and balance data and the equipment list should also be updated. Note the areas that affect operational differences in the pilot's operating handbook (POH). In situations where the changes affect installed or needed placards and decals, they should be in place before flying with the new configuration.

(4) If the major change includes installing a different type of engine (reciprocating to turbine) or a change of a fixed-pitch from or to a controllable propeller, the aircraft owner must fill out a revised FAA Form 8130-6 to update the aircraft's file in the FAA Aircraft Registration Branch (AFS-750). You must conduct all operations under day visual flight rules (VFR) in a sparsely populated area. The aircraft must remain in flight test for a minimum of 5 hours.

(5) At the completion of flight testing, the results should be posted in the aircraft log. Changes should be incorporated into the POH and other affected records. The statement should, at a minimum, state the scope of the changes, the tests performed along with the results. The total hours as of that date on the aircraft should be included, and the aircraft be declared to be in a condition for safe operation.

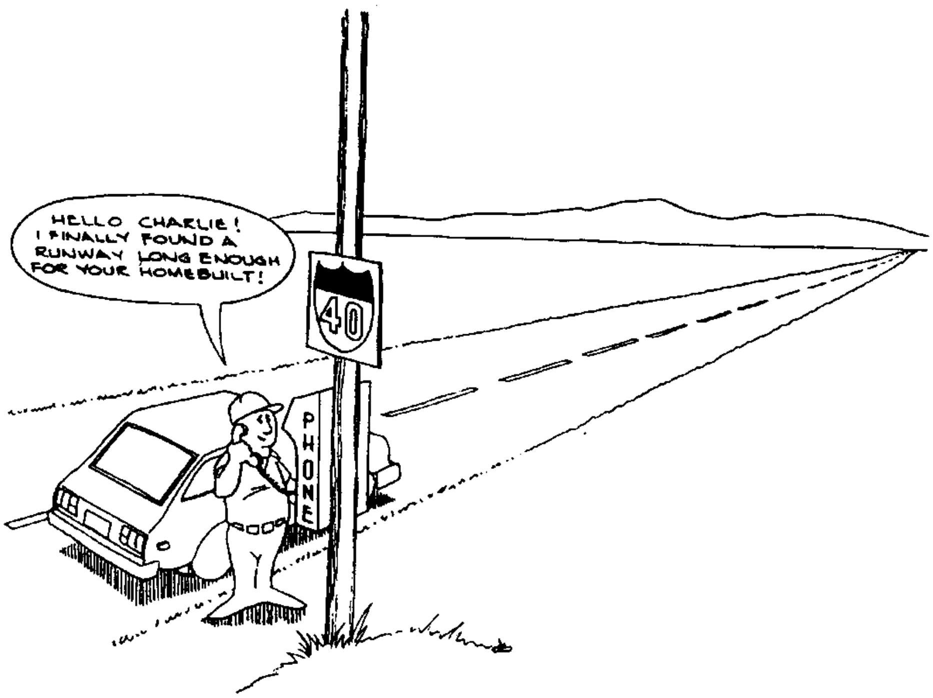
f. Modifying ELSAs. All alterations, modifications, and additions or deletions to your ELSA must be approved in writing by the LSA kit manufacturer and recorded in the aircraft records before the original certification in experimental purpose for operation of LSA under § 21.191(i)(2).

(1) Additionally for a major change to your ELSA (such as an alteration, modification, addition, or deletion), the FAA has the authority under part 91 § 91.319(i) to modify your experimental LSA operating limitations with special restrictions for flight testing due to the aircraft modification.

(2) Following any major change, your ELSA must be assigned to a flight-test area for an appropriate time to conduct a flight test and evaluate that your aircraft is in a condition for safe operation. The guidance baseline for this testing is 5 hours of flight time within the flight-test area. The FAA may prescribe any additional limitations and/or flight time within the flight-test area deemed necessary in the interest of safety.

SECTION 2. AIRPORT SELECTION

"An airport should be chosen with the same care and consideration as getting a second doctor's opinion." Fred Wimberly, EAA Flight Test Advisor (1994)

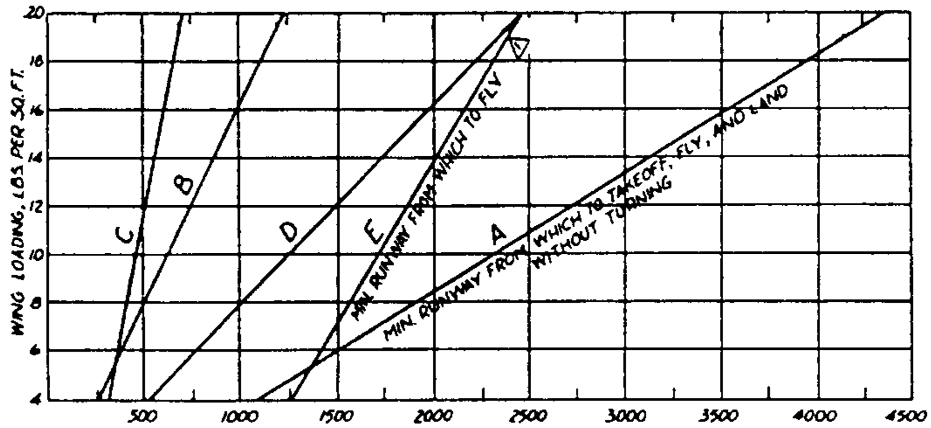


1-2. OBJECTIVE. To select an airport to test fly the aircraft.

a. Runway Alignment. The airport should have one runway aligned into the prevailing wind with no obstructions on the approach or departure end. Hard surface runways should be in good repair and well maintained to avoid foreign object damage (FOD) to the propeller and landing gear. Grass fields should be level with good drainage. Avoid airports in densely populated or developed areas and those with high rates of air traffic. The runway should have the proper markings with a windsock or other wind direction indicator nearby.

b. Ideal Runway. The ideal runway at sea-level elevation should be at least 4,000 feet long and 100 feet wide. For each 1,000-foot increase in field elevation, add 500 feet to the runway length. If testing a high-performance aircraft, the airport's runway at sea level should be more than 6,000 feet long and 150 feet wide for a wider margin of safety. You should factor other considerations, such as power-to-weight ratio, wing design, and density altitude, into the equation for picking the best runway for the initial flight testing. You can also use the chart in Figure 1.

FIGURE 1. RUNWAY LENGTH CHART



Takeoff Distance in feet

A - Distance to takeoff at minimum smooth lift-off speed, fly for 5 seconds at that speed without climbing, land, and stop straight ahead.
B - Distance to reach minimum smooth lift-off speed.
C - Distance covered in 5 seconds of flight at minimum smooth lift-off speed.
D - Distance to stop from minimum smooth lift-off speed (includes air and ground distance).
E - Distance to takeoff at slow approach speed and climb thereafter at an angle of 1 in 20 to 50 ft. altitude, this distance will allow most airplanes to accelerate to normal climb speed before crossing end of runway.

c. Emergency Fields. Identify emergency landing fields located within gliding distance from anywhere in the airport pattern altitude. Since engine failures are second only to pilot error as the major cause of amateur-built aircraft accidents, preparations for this type of emergency should be a **mandatory** part of the flight-test plan.

d. Communications. You should perform flight tests from an airport with an active Unicom or tower, even if the aircraft either doesn't have an electrical system or doesn't have a radio. Even at an uncontrolled field, you should improvise a communications base. For both situations, the FAA recommends a handheld radio with aviation frequencies and a headset with a microphone and a push-to-talk switch. Good radio communications improves the overall level of safety and reduces cockpit workload.

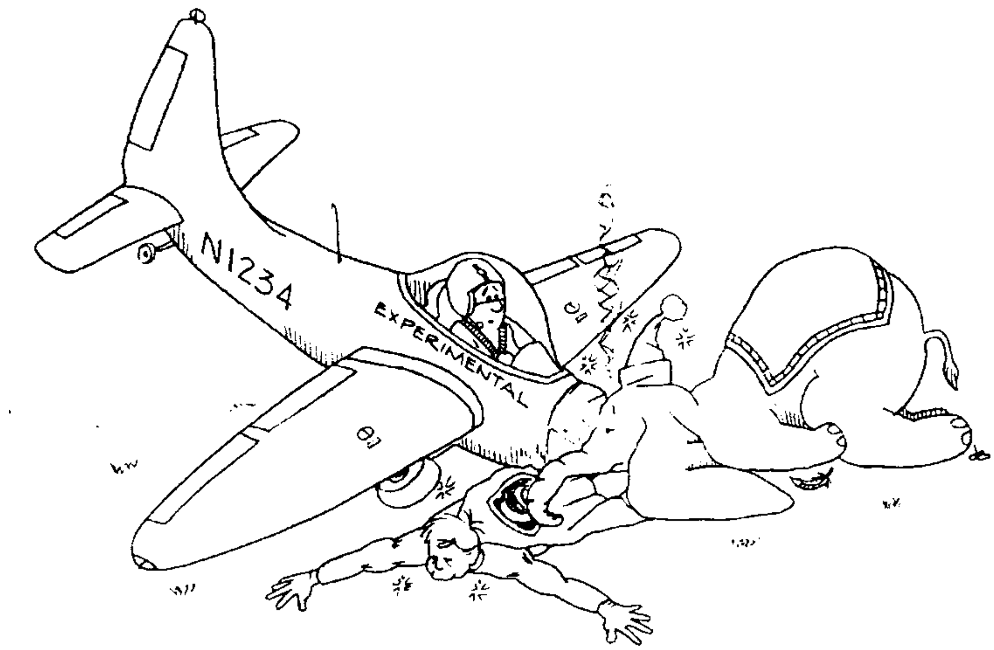
e. Physical Space. The FAA recommends you also consider the availability of hangar space and ramp areas. These facilities will provide protection from inclement weather and vandalism while the aircraft is being tested, maintained, and inspected.

f. Safety. The airport should have a telephone and firefighting equipment complying with relevant municipal codes.

g. Local Management. Explain the flight-test program and emergency plans to the airport manager or owner who may help you obtain temporary hangar space, provide ground/air communications, and supply emergency equipment for use during the flight test.

SECTION 3. EMERGENCY PLANS AND EQUIPMENT

"The object of the game, gentlemen, is not to cheat death: the object is not to let him play."
Patrick Poteen, Sgt. U.S. Army



SOME THINGS ARE HARD TO PLAN FOR!

1-3. OBJECTIVE. To develop a flight-test plan with two sets of emergency plans; one for in-flight emergencies and another for ground emergencies.

a. In-Flight Emergencies. Your in-flight emergency plan should address the following:

(1) Complete or partial engine failure, especially after takeoff.

(2) Flight control problems and severe out-of-rig conditions.

(3) Fire in the engine compartment or cockpit.

b. Ground Emergencies. The ground emergency plan should train the ground crew and/or airport fire department crash crew on:

(1) The airplane canopy or cabin door latching mechanism.

(2) The pilot's shoulder harness/seat belt release procedure.

(3) The location and operation of the fuel shut-off valve.

(4) The master switch location and its OFF position.

(5) The magneto switch location and its OFF position.

(6) Engine cowling removal procedures to gain access to the battery location or for firefighting.

(7) The battery location and disconnect procedures.

(8) Fire extinguisher application and use.

(9) How to secure a ballistic parachute system.

c. Ground Crew. A minimum ground crew of two experienced persons should support every test of an amateur built aircraft. Your ground crew's function is:

(1) To ensure that the aircraft is in airworthy condition for safe operation.

(2) To provide assistance to the test pilot in an emergency.

d. The Airport.

(1) If the airport does not have a fire rescue unit, the FAA suggests the ground crew have a four-wheel-drive vehicle equipped with a portable radio, first aid kit, metal-cutting tools, and a fire extinguisher. At least one person should have completed first aid training.

(2) If the airport provides a fire rescue unit, the test pilot should ensure the rescue unit and the ground crew are trained and competent in performing ground emergency functions as identified in the flight-test plan.

(3) For a small donation, some local volunteer fire and rescue companies may provide standby crew during the initial critical portions of the flight-test phase.

e. Hospital Location. The ground crew should know the location and telephone numbers of the hospitals and fire rescue squads in the vicinity of the airport and the flight-test area. If the test pilot is allergic to specific medications, or has a rare blood type, the test pilot should carry or wear a medical alert bracelet or card to alert medical personnel of the condition.

f. Fire Extinguisher. Fire extinguishers should be available to the ground crew, and a fire extinguisher should be securely mounted in the cockpit within easy reach of the test pilot. A fire axe, or other tool capable of cutting through the canopy, also should be in the cockpit.

g. Fire Protection. There is always danger of a flash fire during test flights. To prevent burns, the pilot should wear an aviation/motorcycle helmet, NOMEX coveralls/gloves, and smoke goggles. If NOMEX clothing is not available, cotton or wool clothing will offer some protection from heat and flames. Pilots should never wear nylon or polyester clothing because synthetic materials melt when exposed to heat and will stick to the skin.

h. Pilot Protection. A modern aviation/motorcycle helmet, a properly installed shoulder harness, a well-designed seat, a clean cockpit design free of protruding components/sharp edges, NOMEX clothing, smoke goggles, and a memorized emergency plan ensure safety during flight testing.

i. Parachute. The decision to wear a parachute depends on the type of aircraft you are testing. Some aircraft have forward hinged canopies without quick release pins, or have pusher propellers, increasing the chance of injury to the pilot while exiting the aircraft. Other aircraft designs may pose no exit problems. If the pilot decides to wear a parachute, check that a qualified parachute rigger has packed the parachute within 180 days. Ensure that the parachute has not been exposed to rain/moisture and, when worn, does not interfere with cockpit management. The test pilot should be thoroughly trained on how to exit the aircraft and deploy the parachute.

j. Ballistic Parachutes. Ballistic parachutes are the latest development in dealing with in-flight emergencies. A ballistic parachute is attached to the aircraft and when activated, lowers the whole aircraft and the pilot to the ground at the rate of descent of about 20 feet per second or about 1,200 feet per minute.

(1) Deployment Scenarios. You might deploy a ballistic parachute in case of:

(a) Structural failure.

(b) Mid-air collision.

(c) Stall/spin.

(d) Loss of control/icing.

(e) Engine failure over bad terrain.

(f) Pilot incapacitation.

(2) Installation Considerations. You should consider the following when installing a ballistic parachute:

(a) Match the parachute to the aircraft's size, weight, and V_{ne} speed. Check with the parachute manufacturer.

(b) How to position and mount the parachute.

(c) The parachute's effect on the aircraft's weight and balance before deployment and aircraft's touchdown attitude after deployment.

(d) Compatibility of the opening loads and the aircraft's structural design limits.

(e) The routing of the bridle and harness.

(f) The routing of the activating housing.

(g) The placement of the activating handle in the cockpit.

(h) Incorporation of parachute deployment procedures in the in-flight emergency plan and emergency checklist.

(i) The deployment time, from activation to full parachute opening.

(3) Inspection Recommendations. If a ballistic parachute is installed, the builder should *add the appropriate ballistic parachute inspection items to the aircraft's preflight inspection checklist*. The builder also should add the ballistic parachute manufacturers repack/refitting schedule and maintenance inspections to the flight manual and the conditional annual inspection checklist.

SECTION 4. TEST PILOT

"We are looking for a few good Men and Women!" Marine Corps advertisement (1991)

1-4. OBJECTIVE. Select a qualified individual as the test pilot.

1-5. GENERAL. The test pilot should be competent in an aircraft of similar configuration, size, weight, and performance to the test aircraft.

1-6. TEST PILOT REQUIREMENTS.

a. Minimum Requirements. A test pilot should meet the following minimum qualifications:

(1) Physically fit: Test flying an aircraft is a stressful and strenuous task.

(2) No alcohol or drugs in the last 24 hours.

(3) Rated, current, and competent in the same category and class as the aircraft being tested.

(4) Current medical and biennial or flight review as appropriate, or a current USUA certification and flight review.

b. Suggested Test Pilot Flight Time Requirements. Each test pilot must assess if his or her level of competency is adequate, or if additional flight training is necessary. If you determine you are not qualified to flight test an unproven aircraft, you must find someone who is qualified. The following suggested number of flight hours is only an indication of pilot skill, not an indicator of pilot competence.

(1) One hundred hours solo time before flight testing a kit plane or an aircraft built from a time-proven set of plans.

(2) Two hundred hours solo time before flight testing a unique design or high-performance aircraft.

(3) A minimum of 50 recent takeoffs and landings in a tailwheel aircraft) if the test aircraft is tailwheel equipped.

c. Pilot Recommendations. The test pilot should:

(1) Be familiar with the airport and the surrounding terrain that could be used for emergency landing fields in the area.

(2) Talk with and, if possible, fly with a pilot in the same kind of aircraft to be tested; the Experimental Aircraft Association (EAA) maintains a list by state of instructors that hold a Letter of Deviation Authority (LODA). The experimental aircraft model used by the instructor for the purposes of type-specific training is also listed. This list changes often and can be found at: http://www.eaa.org/govt/loda.asp.

(3) Take additional instruction in similar TC'd aircraft, as addressed in AC 90-109, Airmen Transition Experimental or Unfamiliar Airplanes. For example, if the aircraft to be tested is tailwheel equipped, a Bellanca Citabria or Super Cub is appropriate for training. For testing an aircraft with a short wingspan, the Grumman American Yankee or Globe Swift is suitable for training.

(4) For amateur aircraft built from commercial kit manufacturers, consider using an additional pilot, as referenced in AC 90-116, Additional Pilot Program for Phase I Flight Test.

(5) Be considered competent when the test pilot has demonstrated a high level of skill in all planned flight-test maneuvers in aircraft with performance characteristics similar to the test aircraft.

(6) Study the ground and in-flight emergency procedures developed for the aircraft and practice them in aircraft with similar flight characteristics.

(7) Have logged a minimum of 1 hour of training in recovery from unusual attitudes within 45 days of the first test flight.

(8) Have logged a minimum of 10 tailwheel take-off and landings within the past 30 days, if appropriate.

(9) Study the performance characteristics of the aircraft to be tested. Refer to the designer's or kit manufacturer's instructions, articles written by builders of the same make and model aircraft, and study actual or video tape demonstrations of the aircraft.

(10) Review the FAA/National Transportation Safety Board (NTSB)/EAA accident reports for the same make and model aircraft to be aware of problems the aircraft has experienced during previous operations (see appendix 2 for the address).

(11) Memorize the cockpit flight controls, switches, valves, and instruments. A thorough knowledge of the cockpit will result in controlled and coordinated mental and physical reactions during emergencies.

(12) Use checklists for both normal and emergency actions and procedures. The Emergency procedures should be also memorized. Add additional notes on the instrument panel to aid in their use if necessary.

NOTE: The EAA has developed a Flight Advisor Program which offers builders/pilots assistance in performing a self-evaluation of the flight-test program and/or selection of the test pilot. To obtain additional information, see the following EAA Web page: http://www.eaa.org/flightadvisors.

SECTION 5. MEDICAL FACTS FOR PILOTS

"*If the pilot is unairworthy, so is the airplane!" Bill Chana, Aeronautical Engineer*

1-7. OBJECTIVE. Identify well-known medical causes for aircraft accidents and stress the importance of a personal pre-flight checklist in addition to an aircraft pre-flight checklist.

a. Alcohol. Test flying an aircraft places additional mental and physical demands on the pilot. In addition to the 8 hour requirement of part 91, § 91.17, General Operating and Flight Rules, the FAA strongly recommends a minimum of 24 hours between the last drink and the test flight. This is because small amounts of alcohol in the blood stream can affect judgment and reaction time, and decrease a pilot's tolerance to hypoxia.

b. Anesthetics. Local and dental anesthetic can affect a pilot's performance in many adverse ways. The FAA recommends that a minimum of 48 hours elapse from the time of anesthesia to the time the pilot climbs into the cockpit.

c. Blood Donations. If you donate 1 unit or 500 ml of blood or less, the FAA recommends that you do not pilot an aircraft for 24 hours; if you give more than 1 unit or more than 500 ml, the FAA recommends that you do not pilot an aircraft for 72 hours. Although the physical effects may not be noticeable at sea level, they will become apparent when flying at higher altitudes.

d. Carbon Monoxide (CO). CO is a colorless, odorless, tasteless gas that is always present in engine exhaust fumes. CO prevents oxygen absorption by the blood, and exposure to the gas creates vision problems, headaches, disorientation, and diminished rational thinking. See the current edition of AC 20-23, Carbon Monoxide (CO) Contamination in Aircraft Detection and Prevention.

e. Drugs. Similar to alcohol, illegal drugs will reduce or impair judgment and affect reflexes and hand/eye coordination. Prescription drugs and over-the-counter remedies may be dangerous when combined with flying. The FAA recommends that all pilots who must take medication consult with an aviation medical examiner (AME) to understand the medication's effects on their ability to think and react while in the cockpit.

f. Ear and Sinus Pain.

(1) Ear and sinus pain is usually caused by the eardrum or sinuses failing to equalize the air pressure during a descent. Blocked ears and sinuses can be caused by a head cold. The pain can be considerable and is most noticeable during descents. For ear blockages try yawning, swallowing, or chewing gum which may give some relief. The Valsalva procedure—pinch the nose, close the mouth, and try to force air through the nostrils— can be effective.

(2) If ear blockage occurs during flight, try climbing back to a higher altitude—lower air pressure—until the pain lessens. Then begin a gradual rate of descent, giving the ears and sinuses time to adapt to the increasing pressure.

(3) After landing, nasal sprays will give some sinus pain relief. To relieve ear pain, wet paper towels with hot water and place in the bottom of two cups. Hold the cups over the ears—the warmth will help ease the inflamed tissues and reduce the pain. If pain continues, see a doctor.

NOTE: The best way to avoid this problem is not to fly with a head cold, upper respiratory infection, or nasal allergic condition. Be advised that some nasal and oral decongestants could be ineffective at altitude and have side effects such as drowsiness that can significantly impair pilot performance. Again, consult with an AME to understand the effects of medication before flying.

g. Fatigue. Fly only when healthy, fit, and alert. Mental and physical fatigue will generally slow down a pilot's reaction time and affect decision-making and attention span. Lack of sleep is the most common cause of fatigue, but family and business problems can create mental fatigue which can have the same effects on the pilot as lack of sleep.

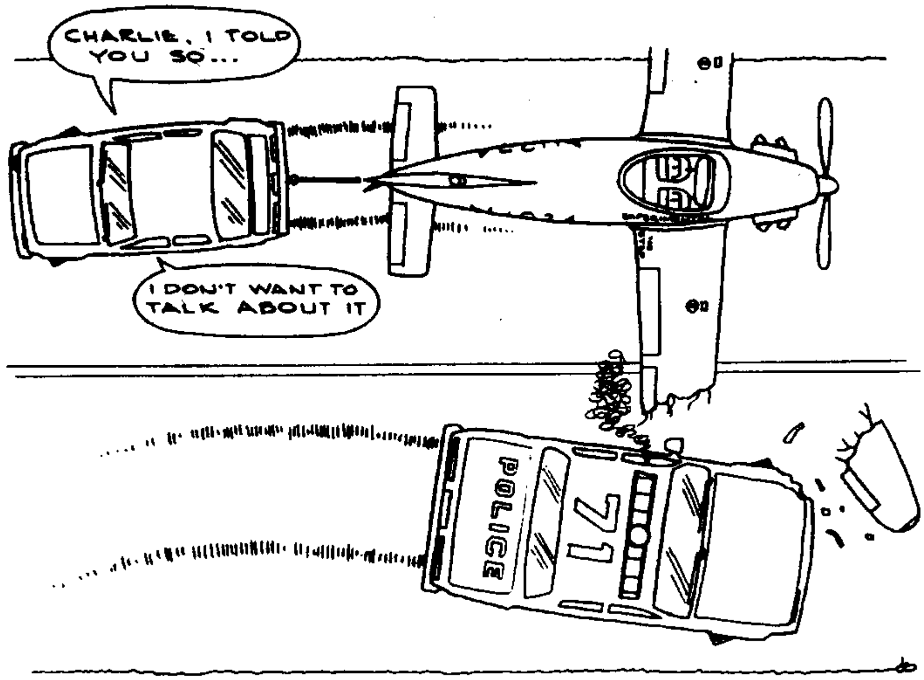
h. Flicker Vertigo. Light, when flashing at a frequency between 4 to 29 cycles per second, can cause a dangerous physiological condition in some people called flicker vertigo. These conditions range from nausea and dizziness to unconsciousness or even reactions similar to an epileptic episode. When heading into the sun, a propeller cutting the light may produce this flashing effect. Avoid flicker vertigo, especially when the engine is throttled back for landing. To alleviate this when the propeller is causing the problem, frequently change engine revolutions per minute (rpm). When flying at night and the rotating beacon is creating flicker vertigo, turn it off.

i. Underwater Diving. Never fly immediately after scuba diving. Always allow 24 hours to elapse before flying as a pilot or a passenger in order to give the body sufficient time to rid itself of excessive nitrogen absorbed during diving.

j. Stress. Stress from the pressures of a job and everyday living can impair a pilot's performance, often in subtle ways. A test pilot may further increase the stress level by setting unreasonable test flying schedules in order to meet an arbitrary "done by date." Stress also may impair judgment, inducing the pilot to take unwarranted risks, such as flying into deteriorating weather conditions or flying when fatigued to meet a self-imposed deadline.

SECTION 6. TRANSPORTING THE AIRCRAFT TO THE AIRPORT

"Best laid plans of mice and men are often stuck in traffic."
Ben Owen, EAA Executive Director (1994)



1-8. OBJECTIVE. Reduce damaging the aircraft in transit.

a. Use a truck or flatbed truck/trailer large enough to carry the aircraft and the additional support equipment.

b. If the aircraft wings are removable, build padded jigs, cradles, or fixtures to hold and support them during the trip to the airport.

c. Secure the fixtures to the truck/trailer, and then secure the wings to the fixture.

d. Use two or more ropes at each tie down point.

e. Use heavy moving pads used for household moves to protect wings and fuselage. Most rent-a-truck firms offer them for rental.

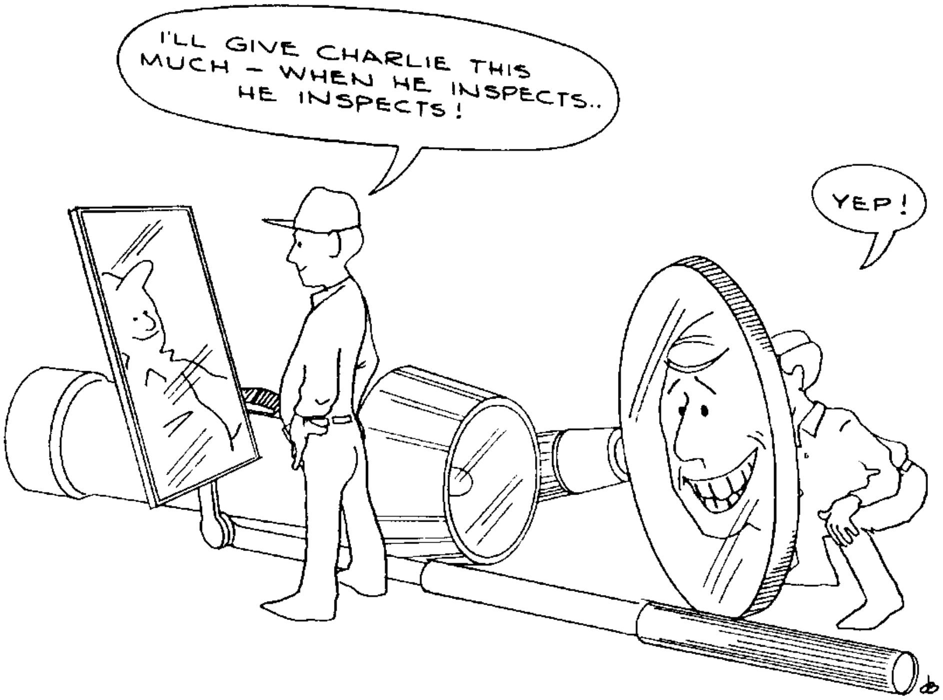
f. During the planning stage, obtain applicable permits and follow the local ordinances for transporting an oversized load. Ask the local police if they can provide an escort to the airport.

g. Brief the moving crew thoroughly before loading and unloading the aircraft.

h. Ensure the designated driver has recent experience driving a truck/trailer and is familiar with the roads to the airport.

SECTION 7. ASSEMBLY AND AIRWORTHINESS INSPECTION

"Complacency is one of the major causes of accidents, no matter how well things are going, something can go wrong" Art Scholl



1-9. OBJECTIVE. To determine the airworthiness of the aircraft and its systems.

1-10. GENERAL.

a. If you must reassemble the aircraft after moving it to the airport—take time to do so carefully. This is a critical event because mistakes can easily occur due to the builder's preoccupation with the impending first flight of the aircraft. One of the most common and deadly mistakes is to reverse the rigging on the ailerons. To prevent errors in reassembling the aircraft, follow the designer's or kit manufacturer's instructions, or use a written checklist specifically designed as part of the flight-test plan. At the completion of each major operation, have another expert check the work.

b. After reassembling the aircraft, perform a pre-flight "fitness inspection." This inspection should be similar to an annual inspection. You should perform the fitness inspection even if the FAA has just issued a special airworthiness certificate for the aircraft. Even if a builder was 99 percent perfect and performed 10,000 tasks building the aircraft, there would still be a hundred items that would need to be found and corrected before the first flight.

1-11. FITNESS INSPECTION—AIRFRAME. A builder-developed comprehensive post assembly checklist should be used, and the results of that inspection should be recorded on the checklist to provide increased assurance that all items of concern have been addressed and the results documented. The following additional safety checklist items may not be applicable to all amateur-built make and model aircraft, but the FAA presents them here for consideration and review.

a. Control Stick/Wheel. The control stick/wheel should have a free and smooth operation throughout its full range of travel. There should be no binding or contact with the sides of the fuselage, seat, or instrument panel. There should be no free play (slack) in the controls, nor should the controls be tight as to have stick-slip movement.

b. Rudder Pedals. Move the rudder pedals through the full range of travel. The pedal movement should be smooth, and without any binding. The test pilot's shoes should not catch on exposed metal lines, fixtures, or electrical wire harness.

c. Brakes. Hand and/or toe brake pressure should be firm with no tendency to bleed down or lock up. Spongy brakes that must be "pumped up," or that show a drop in the brake fluid reservoir level after a few brake applications, indicates a brake fluid or air leak in the system.

d. Main Landing Gear. Ensure that the gear attach points, shimmy damper, bungees, wheels, brakes, and wheel fairings are airworthy. If applicable, check that the tailwheel pivot point is centered and vertical compared to the longitudinal axis of the aircraft. It is critical that the main landing gear alignment toe in/toe out is zero or matches the specifications for fuselage/landing gear alignment called out in the plans. Even one landing gear wheel out of alignment can cause a ground loop.

e. Control Surfaces. Perform rigging checks to ensure that control input for ailerons, rudder, elevators, and trim tabs results in the correct amount of travel and direction of the control movement and that these control surfaces make contact with their stops. Also, ensure that the flaps, if installed, have the proper travel, operate as a single unit, and cannot be extended beyond the maximum extended position. It is important to ensure that the control cable tension is correct by (1) checking it with a calibrated tensiometer and (2) confirming that all the attachment hardware is secured and turnbuckles are properly safetied.

(1) If the cable tension is less than required by specifications, in-flight air loads will prevent full travel of the control, even if the control has the right amount of deflection and hits all the stops in the cockpit/wing/tail when tested on the ground. With low cable tension, the slack in the cables will absorb the desired control movement input.

(2) While checking cable tension, make sure there is no "free play" in the flight control hinges and rod ends. Free play and loose cable tension combined with control mass imbalance can bring on control surface "flutter." Do not, however, rig the controls at too high a cable tension. This will cause high wear rate on the pulleys and prevent good control feel, especially at low airspeeds.

f. Instrument Panel.

(1) All the instruments should be properly secured in the panel and have preliminary markings on them. The airspeed indicator and engine tachometer should be marked with the expected performance range markings. Oil temperature and oil pressure must have the engine manufacturer's recommended operating range marked. If the markings are on the instrument glass face, paint a white slippage mark on both the glass and on the instrument case to alert the pilot in case the glass/range marks have moved. Attach a temporary placard to the instrument panel with the expected stall, climb, and glide speeds. It is a handy reference in times of emergency.

(2) Angle of attack systems may require in-flight calibration. Information displayed prior to that calibration may not be accurate.

(3) Electronic data collection systems, when installed, must be checked if possible before flight according to the manufacturer's instructions. Recording of electronic data through flight and engine instruments can be very useful, but only if it is ensured that accurate information is being collected. Therefore, verification of this data prior to flight is important.

g. Behind the Instrument Panel. Very few amateur-built aircraft of the same make and model have the same instrument panel design. Amateur builders should inspect this area to ensure that all line connections are tight, that nothing interferes with control travel, and there are no loose wires or fuel, oil, or hydraulic leaks.

h. Carbon Monoxide (CO). CO leaks also can be performed. Wait until night or put the aircraft in a dark hangar. Climb into the cockpit and have a friend shine a bright flood light close to the firewall. If light leaks into the cockpit, CO can seep in. Mark it and seal it.

i. Engine and Propeller Controls. All controls should be visually inspected, move in the proper direction, and securely mounted. The friction lock on both controls should be checked for operation. Each control should have full movement with at least a ¼-inch of "cushion" at the full travel position. The control cables should be firmly attached to the fuselage along each 24 inches of their runs to prevent whipping of the cable and loss of cable movement at the other end. Control cables with ball sockets should have large area washers on either end of the bolt connection. This will ensure the control will remain connected, even if the ball socket fails and drops out.

j. Static System. The best procedure to check the altimeter for leaks and accuracy is to have the entire static system checked using 14 CFR part 43, appendix E, at an FAA-approved repair station.

1-12. FIELD CHECK. You need two people to accomplish the following field check by which an amateur-builder can detect if the aircraft's instrument system is leaking:

NOTE: This field check is not an accuracy check. Additionally, you should check the manufacturer's manuals for the installed pitot-static instruments to ensure that this test method will not damage any associated electronics.

a. Airspeed Check. Slip a long rubber hose over the pitot mast (The FAA recommends surgical tubing). As one person reads the airspeed, the other should very slowly roll up the other end of the tubing. This will apply pressure to the instrument. When the airspeed indicator needle reaches the aircraft's approximate recommended cruise speed, pinch the hose shut, and hold that reading. The airspeed needle should remain steady for a minute if the system is sound. A fast drop off will indicate a leak in the instrument, fittings, lines, or the test hose attachment. Never force air in the pitot tube or orally apply suction on a static vent—this action will damage the instruments.

b. Altimeter/Vertical Speed Check.

(1) To check the static side, apply low suction at the end of the static vent port. The easiest way to gain access to the static system is to remove the static line at the static port. If there are two static ports, tape the unused port closed. Next, get two feet of surgical tubing, seal one end, and tightly roll it up. Attach the open end to the static line and slowly unroll the tubing. This will apply a suction, or low pressure, to the static system.

(2) The altimeter should start to show an increase in altitude. The vertical speed indicator also should indicate a rate of climb. The airspeed may show a small positive indication. When the altimeter reads about 2,000 feet, stop and pinch off the tube. There will be some initial decrease in altitude and the vertical speed will read zero. The altimeter should then hold the indicated altitude for at least a minute. If altitude is lost, check for leaks.

NOTE: The above airspeed and altimeter field checks are a check of the system for possible leaks, and are not the same as airspeed or static system accuracy tests done by a certificated repair station. The checks do not include the pitot tube and static ports located on the airframe. The FAA recommends the builder not deviate from the designer's original plans when installing the pitot and static system.

c. Fuel System. Since 1983, more than 70 percent of the engine failures in amateur-built aircraft were caused by fuel system problems. Many times the direct cause of engine failure was dirt and debris in the fuel tank and lines left behind during the manufacturing process.

(1) Before filling the aircraft's fuel tanks, the amateur-builder should vacuum any manufacturing debris from each tank and wipe them down with a "tack" cloth (available from a paint supply store). Next, the builder should flush the system with aviation grade gasoline several times in order to remove any small or hard to reach debris from the tanks and lines. The builder should also clean the fuel filter/gasolator screen/carburetor finger screen. The amount of time spent "sanitizing" the fuel system will provide big safety benefits for the life of the aircraft.

(2) When filling the tanks, place the aircraft in the straight and level cruise position. Add fuel in measured amounts to calibrate the fuel tank indicators. While allowing the aircraft to sit for a short time to observe for possible leaks, inspect the fuel tank vents to see if they are open and clear. Check that the fuel tank caps seal properly. If there are no leaks and the fuel system has an electric boost pump, pressurize the system and again check for leaks. The fuel selector, vents, and fuel drains should be properly marked and tested for proper operation.

NOTE: Many amateur-built aircraft take 5 to 8 years to build. During that time, many rubber-based oil and fuel lines and cork gaskets installed early in the building process may have age hardened, cracked, and/or turned brittle.

The builder should carefully inspect these components and replace as necessary to prevent a premature engine failure.

d. Retractable Landing Gear System. If equipped with a retractable landing gear system, whether hydraulic, electrical, or mechanical, the system should function dependably and positively in accordance with the designer's intent. The builder/pilot should rigorously cycle the retractable landing gear in the appropriate ground setup, using both the normal and emergency landing gear extension system. There should be no hang-ups or binding. If equipped, a function check of the weight on wheel switch and on-board landing gear indicators should also be performed.

e. Safety Belt and Shoulder Harness. You should check these items for condition and proper installation. A review of amateur-built aircraft accidents has disclosed a significant number of accidents in which the seat belt mounting hard points failed. You should check each seat belt and shoulder harness mounting hard point to the designer's specifications so it will hold the harness and pilot in the aircraft at the ultimate design "G" load specification, both positive and negative, for the aircraft.

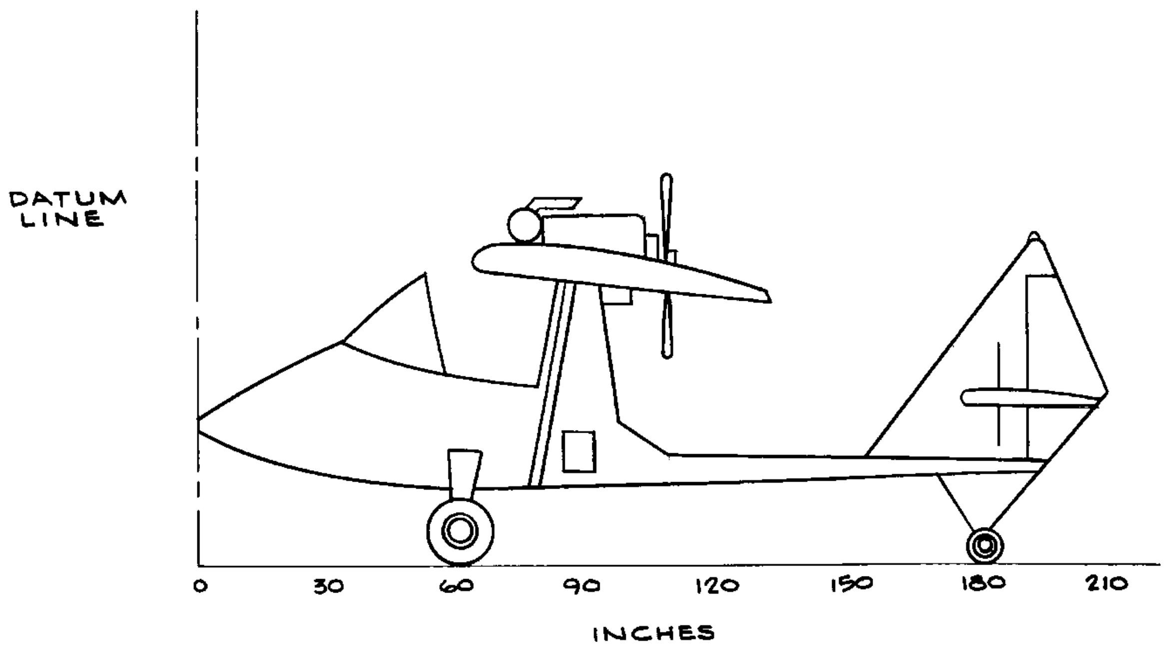
f. Avionics and Electrical Checks. Test the avionics systems. Perform an operational check to ensure the radio(s) transmit and receive on all frequencies. Inspect circuit breakers/fuses, microphones, and antennas for security and operation. Test the emergency locator transmitter for proper operation and battery life. Check electrical systems for operation of lights, instruments, and basic navigation/communication performance. You can check other electrical systems, such as generator/alternator output, during engine run-ins, taxi, and flight tests. Check the battery and the battery compartment for security and if applicable, proper venting to the outside of the aircraft. Check the condition of the engine-to-airframe bonding (grounding) wire. Ensure that all electrical instruments operate properly.

g. Cowling and Panel Checks. Ensure that all inspection panels are in place, the cowling is secured, and cowl flap operation is satisfactory. Inspect the propeller spinner and its backing plate for cracks.

h. Canopy/Door Locks Checks. Ensure the canopy or doors on the aircraft work as intended. Double check the canopy or door lock(s) so the canopy and doors will not open in flight and disturb the airflow over the wings and stall the aircraft. If a canopy jettison system is installed, check for proper operation when the aircraft on the ground and when it is on jacks. (Jacks will simulate flight loads on the aircraft.)

SECTION 8. WEIGHT AND BALANCE

"Never argue with your spouse or a mathematician"
Phil Larsh, Accident Prevention Counselor, Colfax IN (1994)



1-13. OBJECTIVE. Discuss the importance of developing accurate weight and balance calculations for both test and recreational flights. You can find additional information on weight and balance in FAA-H-8083-1A, Aircraft Weight and Balance Handbook.

a. Accuracy. A good weight and balance calculation is the keystone of flight testing. Accurately determining the aircraft's take-off weight and ensuring that the center of gravity (CG) is within the aircraft's design for each flight is critical to conducting a safe flight test.

b. Method. An aircraft should be level when weighed, spanwise and fore and aft using the manufacturer's instructions, and should be in a level flight position. The FAA highly recommends you weigh the aircraft in an enclosed area, using three calibrated scales. The FAA does not recommend bathroom scales because they are not always accurate. Ensure all fuel tanks are empty.

c. A Word about Lateral Balance. Aircraft lateral balance (side to side) is often overlooked, because in most situations it is a matter of loading ballast in the form of cargo or people inside the aircraft that is placed very close to its centerline. The effects on lateral unbalance from difference in ballast weight inside the aircraft are usually minimal.

(1) Aircraft that have fuel in the wings usually have one or more fuel tanks located symmetrical from one wing to the other so lateral balance is not affected. The lateral center of gravity may become important if the fuel load is mismanaged by supplying the engine(s) unevenly from tanks on one side of the aircraft. Care should be taken when fueling the aircraft evenly so lateral balance is not affected on takeoff unexpectedly. Mismanagement of fuel or uneven fuel loading on aircraft with tip tanks or modified (enlarged or repositioned) fuel tanks can affect the aircraft controllability in all phases of flight.

(2) The airplane is designed so that the primary flight controls (rudder, aileron, and elevator) are streamlined with the non-movable airplane surfaces when the airplane is in a cruising straight-and-level at normal weight and loading configuration. If the airplane is flying out of that basic balanced condition, one or more of the control surfaces is going to have to be held out of its streamlined position by continuous control input. An improperly balanced airplane requires constant control pressures, produces pilot tension and fatigue, distracts the pilot from scanning, and contributes to abrupt and erratic airplane attitude control. The use of inflight adjustable trim tabs and/or autopilot systems can relieve pilot fatigue but can also mask a potential catastrophic controllability problem until it is too late to take corrective action.

(3) Caution should be exercised before undertaking any modification to the aircraft fuel system. Along with fuel flow test, proper fuel line routing, changes in performance in flight maneuvers from changes in the aircraft lateral balance need to be addressed. Phase I flight testing needs to be conducted for any modification that can change the lateral balance of the aircraft.

FIGURE 2. EMPTY WEIGHT CG

ITEMS	WEIGH (LBS)	ARM (INCHES)	MOMENT (IN-LBS)
Left Wheel	101	60	6060
Right Wheel	99	60	5940
Tail wheel	42	180	7560
TOTALS	242	80.8	19560

$$\frac{TOTAL\ MOMENT}{TOTAL\ WEIGHT} = EMPTY\ WEIGHT\ CG$$

OR

$$\frac{19560}{242} = 80.8$$

1-14. DETERMINING EMPTY WEIGHT CG.

a. Sample Aircraft. The sample airplane for determining empty weight is a single seater, with a design empty weight of 253 pounds and a gross weight limit of 500 pounds. The datum line is located at the nose of the aircraft and the CG range is between 69 to 74 inches from the datum.

b. To Work a CG Problem. Figure the empty weight CG first. On a piece of paper, draw four blocks. Title each block from left to right as shown in Figure 3, Takeoff CG.

(1) Under the block titled “Items,” vertically list “left wheel,” “right wheel,” and “nose/tailwheel.”

(2) Place a calibrated scale under each wheel and record the weight on each gear, in pounds, in the weight block beside the appropriate wheel.

(3) Measure the distance in inches from the datum line, or imaginary point identified by the manufacturer (e.g., nose of the aircraft), to the centerline (C/L) of the three wheels. Record the distance of each wheel and place it in the "arm" block beside the appropriate wheel See Figure 2, Empty Weight CG.

(4) Multiply the inches (arm) by the weight on each wheel to get the moment (inch-pounds) for each wheel. Add the weight on the three gears and the three moments in inch-pounds and divide the total weight into the total moment. The sum is the "empty weight center of gravity" in inches. In the sample case, the empty weight CG is 80.8.

NOTE: All calculations should be carried out to two decimal places.

FIGURE 3. TAKEOFF CG

ITEMS	WEIGHT (LBS)	ARM (INCHES)	MOMENT (IN-LBS)
A/C	242	80.8	19560
Pilot	170	65	11050
Fuel	30	70	2100
TOTALS	442	74	32710
OR $\frac{TOTAL\ MOMENT}{TOTAL\ WEIGHT} = Takeoff\ CG$ $\frac{32710}{442} = 74$			

1-15. DETERMINING TAKEOFF WEIGHT CG.

a. Since the aircraft's empty weight and empty weight CG are fixed numbers, the only way an aircraft's CG can be changed is by adding weight in other locations.

b. For example, in Figure 3, the aircraft's empty weight has been written in the appropriate blocks. The pilot weighs 170 pounds and fuel—5 gallons—weighs 30 pounds.

c. Again, all measurements are made from the datum to the centerline of the object that has been added. Weight multiplied by inches from the datum equals moment. Add the weights and moments to find the take-off CG for that particular flight.

d. Loaded in this configuration, the aircraft is within the CG flight envelope and is safe to fly.

FIGURE 4. ADDITIONAL EQUIPMENT ADDED

ITEMS	WEIGHT (LBS)	ARM (INCHES)	MOMENT (IN-LBS)
A/C	242	80.8	19560
Pilot	170	65	11050
Fuel	30	70	2100
S/B	15	75	1125
Strobe	1.5	179	268.5
Fuel	1.5	55	82.5
TOTALS	460	74.3	34186

$$\frac{TOTAL\ MOMENT}{TOTAL\ WEIGHT} = Alteration\ Takeoff\ Weight\ CG$$

OR

$$\frac{34186}{460} = 74.3$$

1-16. ADDING ADDITIONAL EQUIPMENT.

a. During flight testing, a strobe battery and handheld radio are added. The battery/battery box weight is 15 pounds and the location is 75 inches aft of the datum. The strobe assembly weight is 1.5 pounds and is located 179 inches aft of the datum. The radio's weight is 1.5 pounds and is located 55 inches aft of the datum. See Figure 4, Additional Equipment Added.

b. In the sample problem, the previous figures for takeoff weight and moment are still accurate, hence those numbers have been listed in the appropriate blocks.

(1) Add the battery, strobe, and radio data in the appropriate locations and calculate the totals. At 465 pounds, the aircraft is still 35 pounds under its design gross weight limit of 500 pounds but is out of balance because the CG has moved 0.3 inches further aft (74.3 inches) than the allowable rear CG limit of 74 inches.

(2) Since the aircraft is out of balance with an aft CG, it is no longer 100 percent stable in pitch and would be dangerous to fly. In most cases, it is not the amount of weight added to the aircraft that can cause a major safety problem but its location.

(3) To bring this aircraft back into the safe CG range, the battery would have to be moved 9 inches forward or 66 inches from the datum line. Another alternative is to install 8 pounds of ballast in the nose, 20 inches from the datum.

(4) If the sample aircraft exceeded the designer's gross weight limit, such as with a 300-pound pilot instead of the CG limit, its climb, stall, and performance capability would be poor and the possibility for in-flight structural failure would be high.

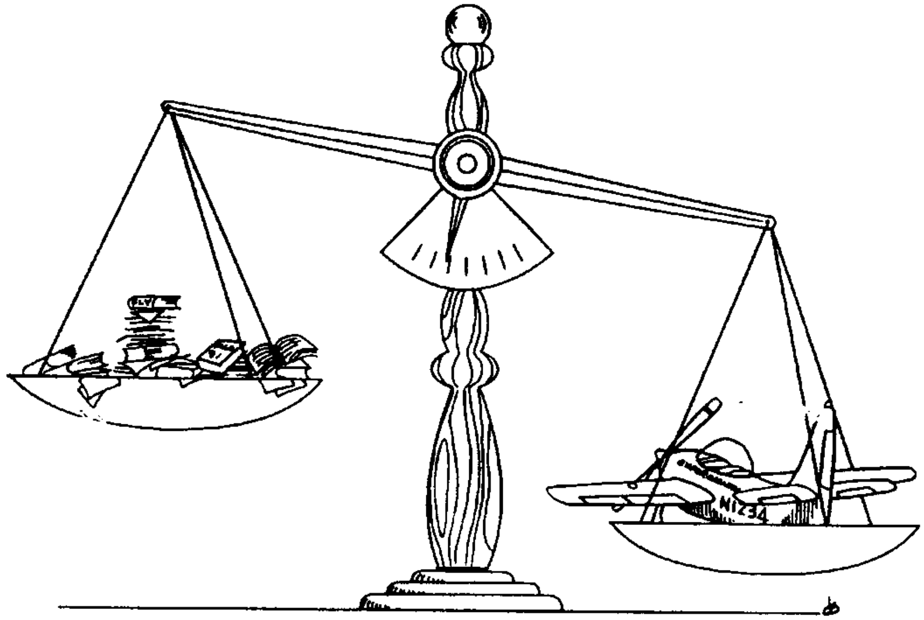
NOTE: In the sample weight and balance, positive numbers were chosen by placing the datum line on the nose of the aircraft. Some manufacturers prefer to use a datum located somewhere between the aircraft's nose and the leading edge of the wing.

(5) This kind of datum will set up a system of positive arms, or items located aft of the datum, and negative arms—items located forward of the datum.

(6) When working a weight and balance problem with negative and positive moments, subtract the sum of all negative moments from the sum of all positive moments to reach a "total moment" for the aircraft.

SECTION 9. PAPERWORK

"It is harder to write a lie in a logbook than tell one, because your eyes see it and your fingers feel it." Bob Moorman, Ultralight Instructor (1994)



THE WEIGHT OF THE PAPERWORK = THE WEIGHT OF THE AIRCRAFT
FLY!!

1-17. OBJECTIVE. Have the proper documentation and paperwork to conduct the flight test.

a. Weight and Balance. The weight and balance for the aircraft should be carefully done. The gross weight and CG range should be determined prior to every flight. An equipment list should be developed and maintained to identify the appliances and articles installed in the aircraft at the time of weighing for certification. It should also be kept current as installed equipment changes from additions or removals.

b. Airworthiness/Registration/Operating Limitations/Placards/Weight and Balance. Must be on board, or the aircraft is not legal for operation.

c. Checklists. In addition to the assembly/airworthiness inspection previously discussed in Chapter 1, Section 7, the builder should prepare the following checklists:

(1) Preflight;

(2) Before starting;

(3) Starting the engine;

(4) Before takeoff;

(5) Takeoff/cruise;

(6) Descent/before landing;

(7) After landing;

(8) Securing the aircraft; and

(9) Emergency procedures.

NOTE: A checklist to cover the above procedures may seem a tedious task, but it may only be the size of a 5x8-card similar to a checklist for a Cessna 150 or a Piper Cherokee.

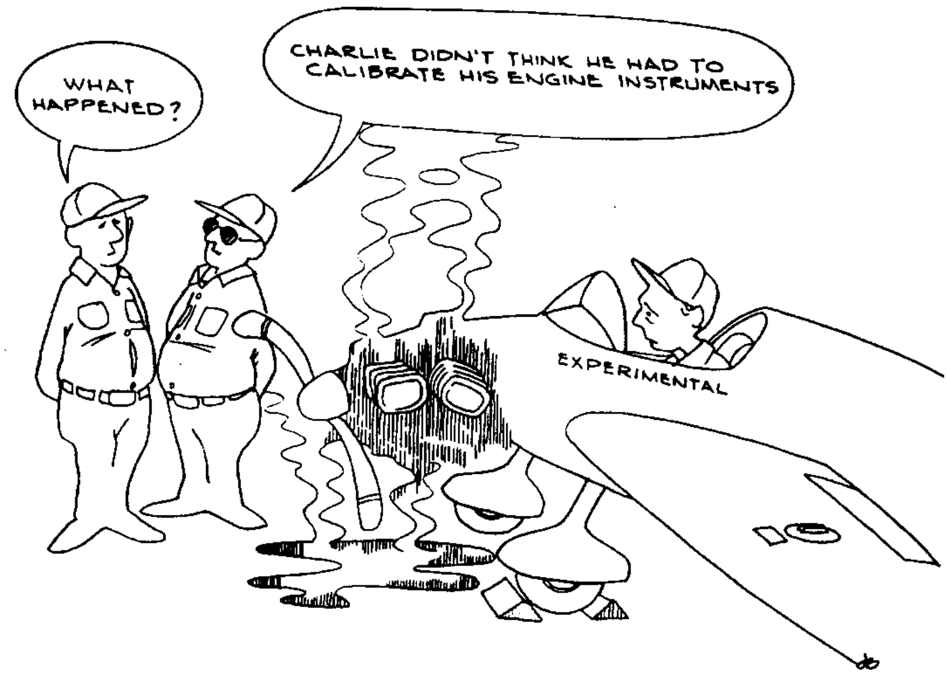
NOTE: The amateur builder should anticipate several revisions to the checklists.

d. Flight Manual. It is imperative that a flight manual describing the anticipated performance of the aircraft be written by the aircraft builder/kit manufacturer. The manual will be revised several times during the flight-test phase until it accurately reports the aircraft's performance, as well as limitations, normal and emergency procedures, and descriptions of those systems installed.

e. Maintenance Records (Logbooks). Operators of amateur-built aircraft must maintain a record of the annual condition inspection in accordance with their operating limitations. The FAA recommends that owners record all inspections and maintenance performed in the aircraft's logbooks. This will create a history of the aircraft's maintenance and will be invaluable in spotting trends.

SECTION 10. POWERPLANT TESTS

"Don't short-change the engine tests or you won't be around to give your grandkids a ride."
Dick Koehler, A&P Instructor (1994)



1-18. OBJECTIVE. Ensure that the engine has been properly run-in and is safe to operate in all rpm ranges.

a. Testing. You can conduct an engine pre-oil and cold compression test as follows:

(1) Remove the rocker-box covers and one spark plug from each cylinder.

(2) Using an external oil pump, or by rotating the propeller in the direction of rotation, pump a substantial supply of oil up from the sump into the rocker arms.

(3) When the engine is pre-oiled, run a cold compression test of each cylinder.

(4) The results will serve only as an initial benchmark for comparing other compression tests taken after the engine has been run-up to operating temperature.

b. New/Newly Overhauled Engine Run-In Procedures.

(1) Most amateur-builders start with a new or newly overhauled engine and proceed to "run it in" on the airframe. This practice is followed because builders usually don't have either a test cell or a special "club" propeller that is specifically designed to aid in engine cooling during run-in. There are pros and cons to using an airframe to run in an engine, but the best advice has always been to follow the engine manufacturer's instructions, found either in the manufacturer's overhaul manuals, service bulletins, or service letters. Following the manufacturer's instructions is especially important if the engine has chrome cylinders which require special run-in procedures.

(2) Also, before running-up the engine, be certain that it has the proper grade oil in the sump. Some new and newly overhauled engines are shipped with a special preservative oil to prevent corrosion. Drain this out and reservice the engine with the correct oil before starting.

c. Used Engine Run-In procedures. Some amateur-builders install a used engine from a flyable aircraft. The same checks and adjustments as are performed on a new or newly-overhauled engine should be conducted on a used engine.

NOTE: Both new and used engines require special attention to engine cylinder baffling to ensure cylinder cooling is within the engine manufacturer's CHT specifications.

d. Pre Run-In Checks.

(1) Before beginning the powerplant tests, inspect the engine and propeller carefully. All fuel and oil line connections should be tight. Check the torque on the engine mount attaching bolts. Be certain that there are no tools, hardware, or rags lying between the cylinders or under the magnetos.

(2) Check for the proper amount of oil in the engine and that the dipstick gives an accurate reading of the oil quantity. Be advised that some engines are mounted on an angle in TC'd aircraft. These engines have a special oil dipstick, which corrects for the different angle of oil in the crankcase. The same engine, mounted level in an amateur-built aircraft with the original dipstick, will not show the correct oil quantity.

e. Test and Support Equipment.

(1) A cylinder head temperature (CHT) gauge is needed to ensure that all cylinders are receiving the proper flow of cooling air.

(2) On the newer aircraft engines, the cylinders are drilled and tapped to accept a bayonet-type CHT thermocouple probes. For older engines, the thermocouple is designed like a spark plug washer and fits under a spark plug. It can be installed in any cylinder, under either the top or bottom spark plug.

(3) CHT monitors can have multiple thermocouples which may be connected to a selector switch in the cockpit, which the pilot uses to select a cylinder to monitor. This also is an excellent troubleshooting tool for identifying fouled plugs and bad ignition leads.

(4) If there is only one CHT thermocouple, attach it to the rearmost cylinder on the right side of the engine, as viewed from the cockpit, and run up the engine. Run the same test on the opposite rearmost cylinder to be certain the hottest running cylinder is monitored. You also need calibrated oil pressure and oil temperature gauges to test the accuracy of the engine instruments installed in the aircraft.

(5) Exhaust gas temperature (EGT) thermocouple probes, commonly known as EGTs, are becoming popular in amateur-built experimental aviation. EGTs help monitor the engine and can be an excellent way of determining which spark plug/plug wire requires attention during a magneto check and provides information on the health of the valves and cylinders. Just like CHTs, there can be one for the entire engine or one for each cylinder exhaust pipe. EGT manufacturer installation instructions and cautions should be closely followed. Accurate readings for EGTs are greatly affected by placement on the exhaust and the relation to airflow around the engine.

(6) The following support equipment is recommended:

- Fifty feet or more of tiedown rope,
- Tiedown stakes,
- Two chocks for each wheel,
- Fire extinguisher,
- Assorted hand tools,
- Safety-wire,
- Cotter-pins,
- Ear and eye protection,
- Grease pencils,
- Logbooks,
- Clip board,
- Pen and paper,
- A watch to time the tests,
- Rags, and
- Manufacturer's instructions.

f. Safety Precautions. Before the first engine run, ensure the aircraft is tied down, brakes on, and the wheels are chocked. The builder and flight-test team should wear ear and eye protection. All flight-test participants should be checked out on fire extinguisher use and operation. During engine runs, do not allow anyone to stand beside the engine, or inline or close to the propeller. Making minor adjustments to a running engine, such as idle and mixture settings, *is a very dangerous procedure* and should be done with great care by experienced individuals.

g. The First Engine Run.

(1) The first start of the engine is always a critical operation. The engine should be pre-oiled using the manufacturer's instructions. For aircraft using other than FAA-approved oil pressure and temperature gauges, the FAA recommends attaching an external calibrated oil temperature and pressure gauge to calibrate the engine instruments. After priming the engine and completing the starting engine checklist items, the first concern is to get an oil pressure reading within the first 20 to 30 seconds after engine start. If there is no oil pressure reading, shut down the engine.

(2) There are three common problems that would cause low or fluctuating oil pressure.

(a) Air in the oil pressure gauge line. This is easily fixed by loosening the line connection near the oil pressure gauge and squirting oil into the line until full. Another option is to use a preoiler to provide the pressure and carefully bleed the air out of the line near the oil gauge by loosening the B-nut connecting the oil line to the gauge.

(b) A misadjusted oil pressure relief valve. Cleaning the pressure relief ball, checking for the proper number of washers, correcting spring tension, and re-adjusting the setting could solve the problem.

(c) An internal problem within the engine, most likely the oil pump. An engine tear down would be required.

(3) With good oil pressure/temperature readings and the engine running smoothly, ensure that the engine oil pressure and temperature gauges in the cockpit match the calibrated oil pressure and temperature gauges attached to the aircraft for the first run. Do not overlook this test. It is critical to determine the accuracy of the cockpit engine gauges not only for the ground engine run-in period, but also for in-flight engine cooling tests.

(4) Work through the engine manufacturer’s run-in schedule. Most engine manufacturers recommend a series of engine runs from low rpm to maximum rpm. Each run usually incorporates a 200-rpm increase and lasts no longer than 10 minutes. The secret to a successful engine run is not to let the engine temperatures exceed manufacture’s limits during engine runs.

NOTE: Engines with chrome cylinders or chrome rings require different high power run-in programs. Follow the manufacturer’s run-in instructions to ensure the engine will perform satisfactorily over its lifetime.

h. Engine Cooldown. After a ground run, the cooling off period takes approximately an hour. This is because a newly overhauled engine needs time for the internal parts, such as rings, cylinders, valves, bearings, and gear faces, to expand and contract several times to obtain a smooth surface that retains its “memory.” This is a lengthy process even when done right, but it is important not to skip any of the recommended runs. You risk increasing oil consumption and reducing overall engine performance, reliability, and engine life span -which could be costly in the long-term—if you skip any of the runs.

i. Record the Engine Run-In Data. During the engine run, monitor the CHTs, oil temperature, and oil pressure. Record the readings and adjustments for future reference. If the CHTs are rising close to the red line, reduce power and stop the test. Some causes of high CHTs include:

- Using spark plugs with the improper heat range;
- CHT gauges installed on the wrong cylinder;
- Missing or badly designed cylinder head cooling baffles;

- Partially plugged fuel nozzles (applicable to fuel injected engines);
- Fuel lines of improper internal diameter (creates lean mixtures);
- Engine improperly timed either mechanically and/or electrically; and
- The carburetor fuel mixture set excessively lean.

j. Selecting Adjustments. Narrow down what adjustments need to be made by recording the change and its resulting effects. The record of the change and its effects is then used for making a logical decision for follow-on adjustments as needed to reach the proper engine performance parameters. Two ways of recording the engine performance parameters are:

(1) Keep a detailed paper log of each applicable engine instrument on each run-up.

(2) Some new Electronic Flight Instrumentation Systems (EFIS) for experimental aircraft which are either a stand-alone system or connected to a Multi-Functional Display (MFD) have the capability to record all engine performance indications for all engine runs in their entirety.

k. After Shut-Down.

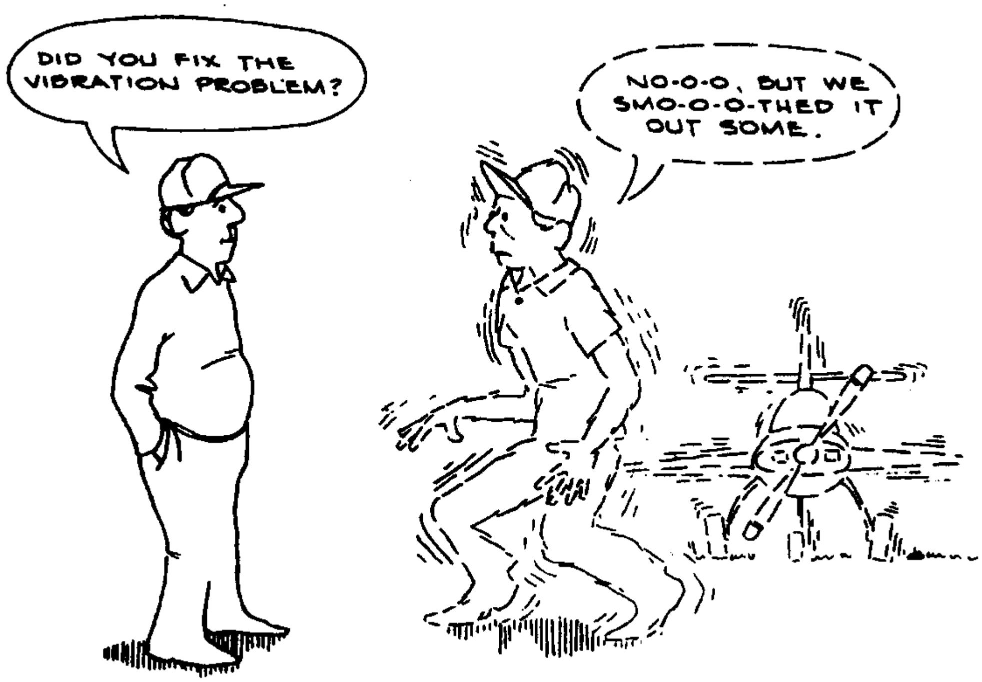
(1) After each engine run, check for fuel and oil leaks, loose connections, and hot spots on cylinders, which can be indicated by burnt paint. The FAA recommends draining the oil and removing the oil screen/filter within the first 2 hours of running the engine. Check the screen/filter for ferrous metal with a magnet. Wash and inspect the screen/filter for non-ferrous metal like brass, bronze, or aluminum.

(2) A very *small quantity* of metal in the screen is not uncommon in a new or newly overhauled engine. It is part of the painful process of "running-in." If subsequent oil screen checks—2 hours apart—show the engine is "making metal," this indicates a problem inside the engine and a tear down inspection is required.

(3) The FAA also recommends all fuel sumps, filters, and gascolators should be checked for debris after each engine run. Special attention should be given to the fuel system by builders who use composite or fiberglass fuel tanks. Composite and fiberglass strands can be very fine, making visual detection difficult. Frequent cleaning of the fuel filters and screens early in the flight testing phase will avoid a gradual buildup of loose composite fibers, which would reduce or stop the flow of fuel to the engine.

SECTION 11. ADDITIONAL ENGINE TESTS

"Always go with the best fix not the cheapest fix." Bill Deeth, Master Mechanic (1994)



1-19. OBJECTIVE. All of the engine and fuel system tests and inspections should be listed and recorded on a checklist designed for that purpose. That document should note the completion of each of the above tests with information obtained during that test. Record the fuel flow, compression test, magneto timing, idle speed, oil pressure, hot and cold etc. These checks will determine if the engine supply of fuel is adequate at all angles of attack.

a. Mixture and Idle Speed Check. After completing the initial engine "run-in" tests, check the idle speed and mixture settings. To determine if the mixture setting is correct, perform the following:

(1) Warm up the engine until all readings are normal.

(2) Adjust the engine rpm to the recommended idle rpm.

(3) Slowly pull the mixture control back to idle cut-off.

(4) Just before the engine quits, the engine rpm should rise about 50 rpm if the mixture is properly adjusted. If the rpm drops off without any increase in rpm, the idle mixture is set too lean. If the rpm increases more than 50 rpm, the idle mixture is set too rich.

(5) Because most air-cooled aircraft engines need excessively rich fuel air mixtures to provide cooling for full-throttle operation, the condition should be confirmed. This is most easily accomplished by running the engine at full throttle (with the aircraft properly secured), manually leaning the mixture, and observing an increase in EGTs and in some cases an actual rise in rpm.

While the amount of EGT rise is variable, the important aspect is that there is a rise of 25 to 50 degrees Fahrenheit (F) or more. This will help alleviate engine overheating situations during the first few hours of inflight operation.

NOTE: Some amateur builders, after properly setting the idle mixture/rpm to the manufacturer's specification, increase the engine idle rpm by 100 rpm for the first 10-plus hours of flight testing. This is to ensure that the engine will not quit when the throttle is pulled back too rapidly, or when power is reduced on the final approach to landing. Be aware that in some situations, particularly with light wing loading or low drag types of aircraft, adding 100 rpm to the idle speed could cause the landing distance to be increased significantly and also have an unexpected adverse effect on landing behavior.

b. Magneto Check.

(1) The magneto checks should be smooth and the difference between both magnetos rpm drops should average about 50 rpm. The builder also should perform a "hot mag" check, to prevent unexpected engine self-starts. To perform this check, run up the aircraft until the engine is warm. At idle rpm, turn the magneto switch off, the engine should stop running. If the engine continues to run, one or both of the magnetos is not grounded, or "hot."

(2) The usual causes for a hot magneto are a broken "P" lead coming out of the magneto or a bad magneto switch. THIS IS AN IMMEDIATE THREAT TO THE PERSONAL SAFETY OF ANYONE NEAR THE AIRPLANE AND MUST BE REPAIRED AT ONCE.

c. Cold Cylinder Check.

(1) The builder should perform a cold cylinder check if the engine is running rough and an ignition system problem could be contributing. A cold cylinder can be detected easily by switching magnetos and reading modern EGT monitors (if equipped) or by aiming a handheld laser thermometer at each exhaust stack. If you have neither one, perform the following:

(a) Run the engine on the bad magneto for about 30 seconds at 1,200 rpm. Without switching the mag switch back to "both," shut off the engine.

(b) One of the test crew should quickly use a grease pencil to mark an area of the exhaust stacks approximately an inch from the flange that attaches the stacks to the cylinders.

(c) Check the marks on the stacks. If one or more of the exhaust stacks with a grease mark has NOT been burned to a grayish-white color and the mark on the stack still retains most of the original color of the grease pencil, the "cold cylinder" has been identified.

(2) Probable causes of the cold cylinder problem are (1) defective spark plugs, (2) ignition leads, or (3) a cracked distributor in one of the magnetos. To detect if the spark plugs are bad, switch both plugs to another cylinder. If the grease pencil proves the problem moved to the new cylinder, the spark plugs are bad. If the problem remains with the original cylinder, the ignition lead or magneto is bad.

d. Carburetor Heat.

(1) The FAA strongly recommends that all amateur builders using a carbureted engine install a carburetor heat, or "carb heat," system that complies with the engine manufacturer's recommendation. If no recommendation is available, we suggest a carburetor heat system for a sea-level engine. A conventional venturi should be designed so that it will provide a 90 degrees F increase in the venturi at 75 percent power. For altitude engines using a conventional venturi carburetor, 120 degrees F increase in venturi temperature at 75 percent power will prevent or eliminate icing. Remember: Too little carburetor heat will have no effect on carburetor icing, and too much carburetor heat will cause an overly rich mixture which will reduce power and may shut down the engine.

(2) During the engine tests, make numerous checks of the carburetor heat system. To avoid overly rich mixtures from oversized carburetor heat ducts, ensure that the carburetor heat duct is the same size as the inlet of the carburetor.

(3) Be certain there is a positive reduction in rpm each time "carb heat" is applied. If there is no reduction, or the rpm drop is less than expected, check the carb heat control in the cockpit and on the carb heat air box for full travel. Also, check for air leaks in the "scat tube" connecting the heat muff to the carburetor air box.

e. Fuel Flow. A fuel flow and unusable fuel check is a field test to ensure the aircraft engine will get enough fuel to run properly, even if the aircraft is in a steep climb or stall attitude, and is accomplished by:

(1) Place the aircraft's nose at an angle 5 degrees above the highest anticipated climb angle. The easiest and safest way to do this with a conventional gear aircraft is to dig a hole and place the aircraft's tail in it. For a nose gear aircraft, build a ramp to raise the nose gear to the proper angle.

(2) Make sure the aircraft is tied-down and chocked. With minimum fuel in the tanks, disconnect the fuel line to the carburetor. The fuel flow with a gravity flow system should be 150 percent of the fuel consumption of the engine at full throttle. With a fuel system that is pressurized, the fuel flow should be at least 125 percent. When the fuel stops flowing, the remaining fuel is the "unusable fuel" quantity.

(3) The formula for fuel flow rate for a gravity-feed fuel system is 0.55 times engine horsepower (HP) times 1.50. This gives a fuel flow rate in pounds of fuel per hour. Divide the pounds-per-hour number by 60 to calculate pounds per minute, and divide again by 6 to calculate gallons per minute. To get gallons per hour for Avgas divide pounds per hour by 6; or multiple gallons per minute by 60. For a pressurized system, substitute 1.25 for 1.50 to calculate the fuel flow rate.

(4) The fuel consumption rate of most modern engines is about 0.55 pounds per hour per brake HP. The chart below illustrates the results of this calculation for a 100 HP engine:

FIGURE 5. 100 HP FUEL FLOW RATE CHART

If your fuel is…	**Then the fuel flow rate for a 100 HP engine is…**		
	Pounds per hour	Pounds per minute	Gallons per hour
Gravity feed	82.5	1.38*	13.75
Pressurized	68.75	1.15*	11.49*
***-rounded to the nearest 100th.**			

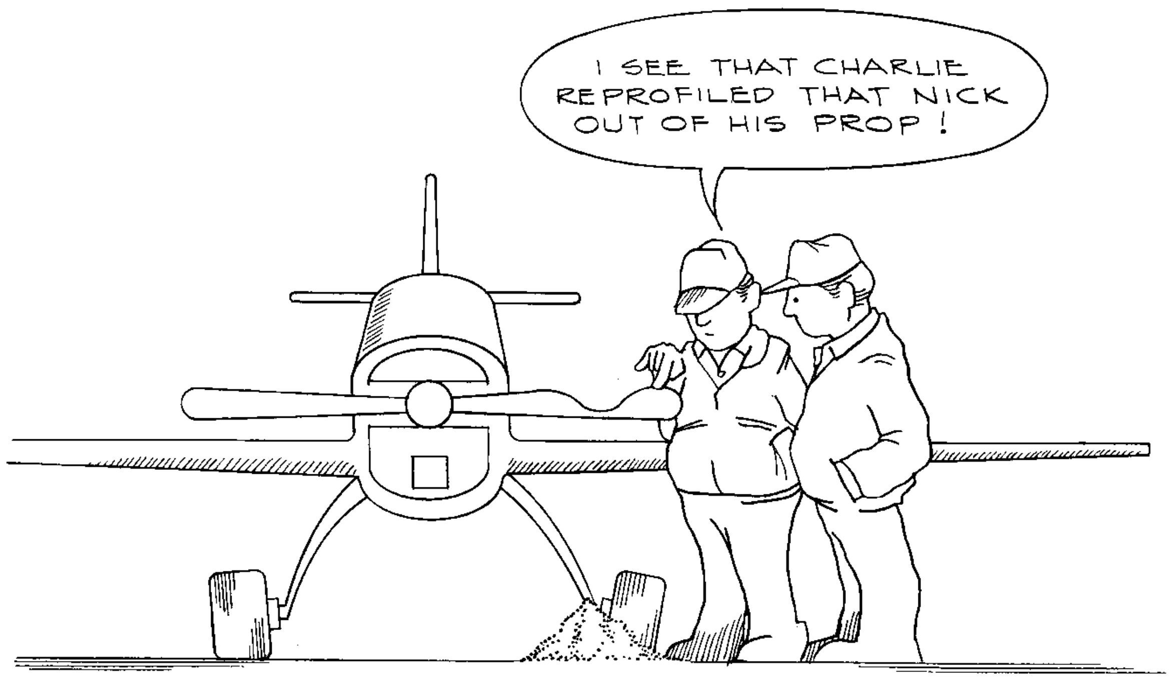
f. Changing Fuel Flow or Pressure. If the aircraft's fuel flow rate is less than planned, there is a volume or pressure problem. An increase in the fuel flow volume may necessitate installation of larger fuel line fittings on the fuel tanks, fuel selector, and carburetor in addition to larger internal diameter fuel lines. To increase fuel pressure, install an electrically driven or engine-driven mechanical fuel pump prior to the first flight.

g. Compression Check. When the engine run-in procedures have been completed, perform an additional differential compression check on the engine and record the findings. If a cylinder has *less than 60/80 reading* on the differential test gauges on a hot engine, that cylinder is suspect. Have someone hold the propeller at the weak cylinder's top dead center and with compressed air applied, listen. If air is heard coming out of the exhaust pipe, the exhaust valve is not seating properly. If air is heard coming out of the air cleaner/carb heat air box, the intake valve is bad. When the oil dipstick is removed and air rushes out, the piston rings are the problem.

h. Last Check. Drain the oil and replace the oil filter, if applicable. Check the oil and screens for metal, visually inspect the engine, and do a run-up in preparation for the taxi tests. Do not fly the aircraft if anything is wrong, no matter how small or how insignificant. The sky, like the sea, is an unforgiving and uncompromising environment.

SECTION 12. PROPELLER INSPECTION

"A tough decision is what a man makes when he cannot form a committee to share the blame"
George Lutz, Col. U.S. Air Force, Retired (1994)



1-20. OBJECTIVE. Help you develop an inspection program to maintain your propeller.

a. Propeller Designs. There are three kinds of propeller designs: metal, wood, and composite. Because of weight considerations, metal propellers are used more on amateur-built aircraft than ultralight aircraft. Wood and composite propellers are the overwhelming choice for ultralight aircraft. Wood propellers are light, reliable, and inexpensive but require frequent inspections. Composite carbon-graphite material props are more expensive than wood, but are stronger and require less maintenance.

b. Choosing a Propeller. All types of propellers have one thing in common: they are constantly under high levels of vibration, torque, thrust, bending loads, and rotational stress. Even small nicks in the leading edge of the blade can very quickly lead to a crack, followed by blade separation. Propeller tip failure and a subsequent violent, out of balance situation can cause the propeller, engine, and its mounts to be pulled from the airframe in less than 5 seconds. Choose your make and model of propeller carefully. A propeller with the wrong size and pitch will give a poor rate of climb, cruise, or could cause the engine to "overspeed." Always follow the manufacturer's recommendations.

1-21. RECOMMENDATIONS FOR ALL PROPELLERS.

a. Never approach the vicinity of the propeller unless the ignition switches have been confirmed to be in the OFF position and the key is removed.

b. Never use a propeller for a tow bar when moving the aircraft.

c. Never stand in front of or in-line of a rotating propeller.

d. Never hand prop an engine on uneven or wet/snow covered ground.

e. Always inspect the propeller before and after a flight.

f. When working on a propeller, make sure the ignition is off first.

g. Always maintain the propeller to manufacturer’s instructions.

h. To avoid nicks and cuts, do not perform run-ups near gravel or loose stones.

i. Apply a coat of automotive wax once a month to protect the finish and keep out moisture.

j. Assume a propeller is unairworthy if it has suffered any kind of impact or ground strike.

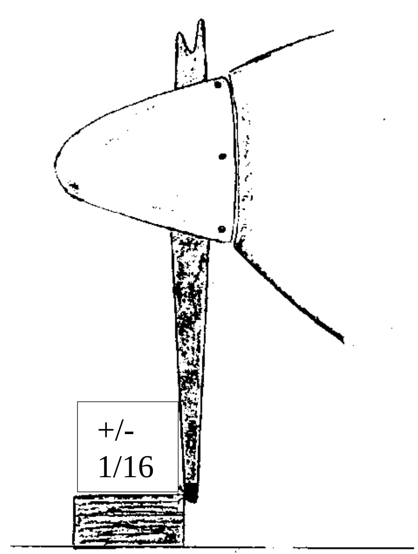
k. After any repair or repainting, or if vibration or roughness is noted, re-balance the propeller.

l. Propeller blades should be balanced within 1 gram of each other to avoid over stressing the gear reduction system and propeller shaft.

m. Check the bolt torque on all newly installed propellers every hour of operation for the first 10 hours and once every 5 hours thereafter.

n. After torqueing the propeller, track the blades.

FIGURE 6. PROPELLER TRACKING



1-22. PROPELLER TRACKING CHECK.

a. Installation. Ensuring good powerplant operation starts with a properly installed propeller. You should check the propeller for proper tracking—the blades rotating in the same plane of rotation. The following procedure is simple and takes less than 30 minutes:

(1) Chock the aircraft so it cannot be moved. **Remove one sparkplug from each cylinder—**this will make the propeller easier and safer to turn.

(2) Rotate the blade so it is pointing straight down.

(3) Place a solid object (e.g., a heavy wooden block that is at least a couple of inches higher off the ground than the distance between the propeller tip and the ground) next to the propeller tip so it just touches.

(4) Rotate the propeller slowly to see if the next blade "tracks" through the same point (touches the block, see Figure 6). Each blade should be within 1/16-inch from one another.

b. Tracking. If the propeller is out of track, one or more propeller blades may be bent, a propeller flange may be bent, or propeller mounting bolts that are over or under torqued. An out-of-track propeller will cause vibration and stress to the engine and airframe and may cause premature propeller failure.

1-23. METAL PROPELLER INSPECTION. Perhaps the two biggest problems affecting the airworthiness of metal propellers are corrosion and nicks on the leading edge.

a. Identifying Corrosion.

(1) Surface corrosion can occur on the surface of metal blades due to a chemical or electrochemical action. The oxidation product usually appears on the surface of the metal as a white powder.

(2) Pitting corrosion causes small cavities or pits extending into the metal surface. This is an advanced form of corrosion, appearing as small dark holes that usually form under decals or blade overlays.

(3) Intergranular corrosion, rare and difficult to detect in propellers, is the most dangerous form of corrosion. It attacks the boundary layers of the metal, creating patches of lifted metal and white/gray exfoliation on the surface of the propeller. It is sometimes found in propellers that had a ground strike and have been straightened.

(4) If any of these signs of corrosion are found, do NOT fly the aircraft. Refer to the manufacturer's maintenance manual for corrosion limits and repairs or the current editions of AC 43-4, Corrosion Control for Aircraft, and AC 20-37, Aircraft Propeller Maintenance, for additional maintenance information and corrective actions.

b. Nicks and Metal Blades.

(1) Nicks in the leading and trailing edge of a metal blade are usually V-shaped. They are caused by high-speed impact between the propeller and a stone or piece of gravel. Properly trained individuals can "dress out" the nick or pit if the nick is not too wide and/or deep. Before each nick is dressed out, each nick and surrounding area should be inspected with a 10-power magnifying glass for cracks. If an area looks suspicious, inspect the area again using the propeller manufacturer's approved dye penetrant or fluorescent penetrant method.

(2) If the nick is left unattended, the high propeller operational stresses will be concentrated at the bottom of the nick's V and, in time, will generate a crack. The crack can migrate across the blade until the blade fails, producing a massive imbalance between the propeller and the engine, ultimately causing structural failure. Cracks in metal blades cannot be repaired. A cracked propeller must be marked unserviceable and discarded.

WARNING. Metal propellers are matched/tuned to the engine and airframe resonant frequency by being manufactured with a particular diameter to minimize vibration. DO NOT SHORTEN METAL BLADES for any reason unless the manufacturer specifically permits this major alteration.

1-24. WOOD PROPELLER INSPECTION.

a. Inspection Frequency. Wood propellers should be inspected before and immediately after a flight. Inspect to ensure the following:

(1) The drain holes are open on metal edged blade tips.

(2) The metal/composite leading edge is secured and serviceable.

(3) The blades, hub, and leading edge have no scars or bruises.

(4) The mounting bolt torque and safety wire or cotter pins are secure.

(5) There are no cracks on the propeller spinner (if applicable), and the safety wire is secure.

(6) There are no small cracks in the protective coating on the propeller. Ultraviolet radiation can cause these cracks.

(7) There is any charring around either the mating surface of the prop and engine flange. Charring in either location indicates a loose propeller.

b. Torque Check. You should check for proper torque on the mounting bolts of a new, wooden propeller within the first hour of flight and every hour for 10 operational hours thereafter.

(1) After 10 hours, check the bolt torque every 5 hours of operation. You should also check the mounting bolt torque before flight if the aircraft has been in storage for 3 to 6 months.

(2) If you need to torque the bolts, we suggest that all the bolts be loosened for an hour to allow the wood to relax. "Finger tighten" the bolts until snug and tighten the attaching bolts in small increments, moving diagonally across the bolt circle. It is good practice to check the propeller track (see Chapter 1, Section 7) as the bolts are torqued down. The torqued bolts should be safety wired in pairs.

(3) If nylon/fiber insert type nuts are used, you should change them every time you re-torque the propeller bolts. Never match this type of nut to a bolt with a cotter key hole in its threaded area—the sharp edges around the hole will cut the nylon/fiber insert and reduce the fastener's effectiveness. All self-locking nuts should have at least two bolt threads visible past the nylon/fiber insert after torqueing.

c. Wood Propeller Repairs. You should remove a wood propeller from an aircraft and send it back to the manufacturer for repair, if any of the following damage is found:

(1) Any cracks in the blades or hub;

(2) Deep cuts across the wood grain;

(3) Blade track that exceeds ¹⁄₁₆-inch limits after attempts to repair;

(4) Any warpage or obvious defect;

(5) Extreme wear such as leading edge erosion or bolt hole elongation; and

(6) Any separation between lamination.

NOTE: When parking the aircraft, always leave the wood propeller in the horizontal position. This position will allow the wood to absorb small amounts of moisture evenly across its entire span rather than concentrating the moisture (weight) in the low blade and creating a vibration problem.

1-25. COMPOSITE PROPELLER INSPECTION. There are generally two types of composite propellers: thermo-plastic injection molded propeller and the carbon/graphite fiber composite propeller.

a. Thermoplastic. The thermoplastic injection-molded propeller is a low cost, thin bladed propeller used on engines of 80 HP or less. Propeller inspection is straightforward: examine blades and hub for cracks and nicks. If a crack is found, do not fly until the propeller is replaced. Small nicks of ³⁄₁₆-inch or less can be dressed out and filled with a two-part epoxy.

b. Carbon/Graphite. The carbon/graphite composite propellers are generally used on engines of 40 HP and more. You should look for hairline cracks in the gel coat. Spider cracks are usually caused by vibration generated by a mismatch of the engine and propeller combination. If you find a crack in the base material of the propeller—other than the gel coat—do not fly until the manufacturer inspects the propeller.

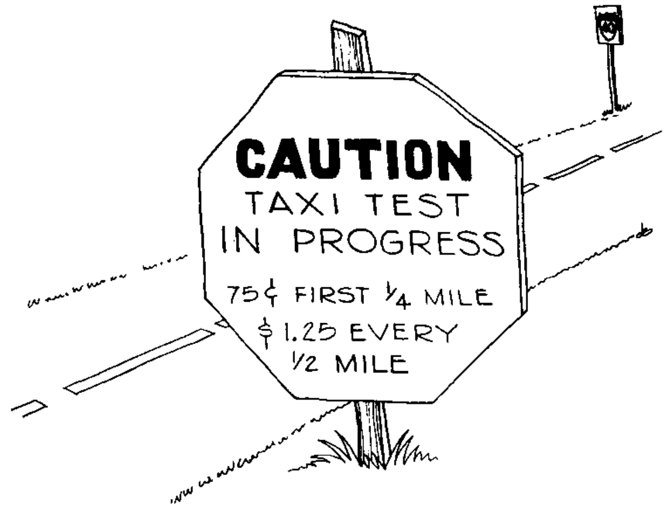
(1) Nicks of ½-inch or less in the leading or trailing edges of carbon/graphite propellers can be dressed out and filled using a two-part epoxy. But if the nick has severed the fiberglass roving—which looks like a fiberglass wire bundle—that runs hub to tip on the leading and trailing edge, do not fly. The propeller has severe damage and must be sent back to the factory for inspection and repair.

(2) Before making even small repairs on a composite propeller, check with the manufacturer.

CHAPTER 2. TAXI TESTS

SECTION 1. LOW-SPEED TAXI TESTS

"Yelling 'Clear the Prop!' before you start an aircraft is the first of a series of well planned, choreographed steps to make you a professional."
Jack Crawford, Pilot, Mechanic, Airport Operator (1994)



2-1. OBJECTIVES. Ensure that the aircraft "tracks" straight and there is adequate directional control at 20 percent below the anticipated take-off speed. Determine if the aircraft's engine cooling and the brake system are adequate. Predict the flight trim of the aircraft and its handling characteristics during takeoff and landings. Enable the pilot to become proficient with the handling and braking characteristics of the aircraft.

> **NOTE: You should conduct a low- or high-speed taxi test as if it were the first flight. The pilot should be wearing the proper clothing, seat belt/shoulder harness, and helmet and be mentally and physically prepared for the possibility of flight.**

2-2. TAXI TESTS.

a. Preparation. Before taxi tests in a conventional, or tailwheel, aircraft, the tail should be physically raised until the aircraft is just about in the takeoff position. The pilot should spend an hour or more in the cockpit to become accustomed to the aircraft's takeoff position. This small but important aspect of training will help the pilot avoid overreacting to an unexpected deck angle on the first flight. Now is the time for the pilot at the controls to have identified all the controls and devices necessary to fly the aircraft. The checklist should be in an advanced state of development, the seating and seat belts must be fully fitted, and the seat height position must be established. Seating the pilot too low is a major problem in properly identifying pitch altitude during operation.

NOTE: A minimum of one other flight-test team member should always be monitoring taxi tests. This team member can watch for evidence of fire/smoke or other problems the pilot can't see.

b. Beginning the Test. The taxi tests should begin with a taxi speed no faster than a walk. The pilot should spend this time getting acquainted with the aircraft's low speed handling characteristics by practicing 90-, 180-, and 360-degree turns and braking action. The pilot should also remember the importance of monitoring the oil pressure, oil temperature, CHT, and maintaining them within limits, and must not overlook these checks.

NOTE: Some aircraft brake manufacturers have specific brake lining conditioning procedures (break-in) for metallic and nonasbestos organic linings. You should complete proper brake lining conditioning before starting the low and high-speed taxi tests. If not properly conditioned, the brake lining will wear quickly and give poor braking action at higher speeds.

c. Instrument Check. The pilot should check the flight instruments for operation each time the pilot taxies the aircraft. The compass should match the direction in which the aircraft is pointed, such as the magnetic heading of the runway or taxi way. When making a right hand turn, the turn coordinator/turn and bank should indicate a right hand turn but the ball should skid to the left. The vertical speed indicator should read zero and the artificial horizon should indicate level.

d. After Taxi Run. After each taxi run, inspect the aircraft for oil and brake fluid leaks. You should not consider a leak as a minor problem, but repair every leak and service the system before the next taxi test

SECTION 2. HIGH-SPEED TAXI TESTS

"First get used to the fact that you are now 30 feet wide and you steer with your feet." Wayne Nutsch

2-3. OBJECTIVE. Determine the aircraft's high-speed handling and braking parameters.

a. Direction of Rotation. Propeller rotation will determine which rudder pedal you press to compensate for the asymmetrical thrust of the propeller blades. For example, when viewed from the cockpit, a Volkswagen automotive engine mounted in a tractor configuration will rotate the propeller counterclockwise. In this case, the pilot must use the left rudder pedal for high-speed taxi and takeoff. For a propeller turning clockwise, you would apply right rudder pedal.

b. Follow the Flight-Test Plan. As with every part of the flight testing program, the high-speed taxi tests should follow the flight-test plan. Start slowly and do not progress to the next step until the flight-test team is thoroughly satisfied with the aircraft and the team's performance.

c. Increasing Taxi Speed. Each taxi run should be 5 mph faster than the last run until the aircraft is within 80 percent of the predicted stall speed. Prior to reaching the predicted stall speed, the pilot should test aileron effectiveness by attempting to rock the wings slightly. As taxi speeds increase, the rudder becomes more responsive and directional control will improve.

(1) In a nose gear aircraft, the pilot should be able to raise the nose of the aircraft at 80 percent of the predicted stall speed. If the nose cannot be raised at this speed, the weight and balance and CG range should be rechecked. Most likely, there is a forward CG problem or the main gear is too far aft.

(2) In a tailwheel aircraft at 80 percent of stall speed, the pilot should be able to lift the tail and assume a takeoff position. Again, if the tail cannot be raised, recheck the weight and balance and CG range. Most likely, there is a rearward CG problem or the main gear is too far forward.

CAUTION: Heavy braking action at high speeds in tailwheel aircraft may cause directional problems, such as ground loops or nose overs.

d. Taxi with Flaps. If runway conditions permit, duplicate each taxi test with the flaps in the takeoff and landing configuration. Record the flap effects on directional control and insert the information in the draft copy of the aircraft's flight manual.

e. Lift-Off Point. Estimate the point on the runway where lift-off will occur and mark it with a green flag if no other existing reference is available.

f. Braking Distance.

(1) Determine how much runway the pilot will need if it becomes necessary to abort the takeoff. This is usually accomplished by accelerating to 80 percent of lift off speed, bringing the engine back to idle, and applying heavy braking action to bring the aircraft to a full stop. After a takeoff/abort test, give the brakes time to cool down. The brake lining must be examined carefully and replaced if necessary.

(2) After determining the distance required to come to a full stop after aborting, add 30 percent to the distance. Measure that distance from the opposite end of the active runway. If no existing reference is available, mark it with a red flag. The taxi tests are completed when the test pilot is satisfied with both the aircraft's and the test pilot's individual performance. Before the first flight, you should thoroughly inspect the aircraft and give special attention to the landing gear, brake system, engine, and propeller.

g. Repairs. During this inspection, you must fix all discrepancies. Examine the screens/filters for metal, flush the fuel system, and clean all the screens/filters. Perform a leak check on the engine and the fuel system by running-up the engine.

NOTE: The first high-speed taxi tests should be made in a no wind or a light head wind condition. The pilot should ensure that the tests will not interfere with the normal airport operations or create a safety hazard for other aircraft.

NOTE: Pilots of tailwheel aircraft must always be aware that ground loops are possible at any speed. This is true especially if the main landing gear is located too far forward of the aircraft's CG.

CHAPTER 3. THE FIRST FLIGHT

"It is critically important that a test pilot never succumb to the temptation to do too much too soon, for that path leads but to the grave."
Richard Hallion (1987)

SECTION 1. GENERAL

3-1. OBJECTIVE. Take every precaution to ensure that the first test flight is an uneventful one.

3-2. GENERAL.

a. The first flight is an important event for you. As important as it is, it should not be turned into a social occasion. This puts enormous peer pressure on the pilot to fly an aircraft that may not be airworthy or to conduct the flight in inclement weather.

b. A professional will avoid this trap by following the flight-test plan and inviting only those members of the crew needed to perform specialized tasks when testing the aircraft.

c. The first flight should be flown a thousand times: the first 500 on paper, the next 499 flights in the test pilot's mind, and once in actuality. The first flight test should be so well-rehearsed by the test pilot and ground crew that the first flight is a non-event.

3-3. RECOMMENDATIONS.

a. The best time to test fly an aircraft is usually in the early morning when the winds are calm, and the pilot is well rested.

b. In addition to a pilot's kneeboard, a small portable tape recorder or video camera properly mounted to the aircraft is an excellent way to record data.

c. Good communication with the ground is essential for data exchange and safety.

3-4. FIRST FLIGHT INSPECTION. Before the first flight, the test pilot and at least one other experienced person should give the aircraft a good pre-flight inspection. As part of a thorough aircraft pre-flight inspection, check that:

a. Fuel, Weight and Balance, and Fluids.

(1) The fuel on board is four times the amount of usable, clean, and proper octane fuel than is needed for the first flight. If the aircraft has a 2-cycle engine, check that the oil-to-fuel ratio is correct.

(2) A current weight and balance check is completed. The aircraft's CG should be in the forward half of the safe CG range. This will reduce the possibility of instability during approach to a stall and enhance recovery from one.

(3) Check oil, brake fluid, and hydraulic system for the correct fluid and quantity.

(4) The canopy or cabin door latches lock securely and will not vibrate loose in flight.

(5) The fuel valve is in the proper position and vent lines are open.

(6) The trim tabs are set in the takeoff position.

(7) The altimeter set to the field elevation and cross-checked with the local altimeter setting.

(8) The complete control system functions properly.

(9) All ground and air communications frequencies operate properly.

(10) Engine cowling and airframe inspection plates/fairings are secured.

(11) The airspeed indicator is marked with sticky tape or set electronically on the MFD, if so equipped, at the "predicted" best climb speed, best glide speed and maneuvering speed. If these speeds are not available from prototype flight-test data, the following are conservative guidelines:

(a) Best angle of climb (V_x) = 1.5 times the aircraft's predicted lift-off speed.

(b) Best glide speed = 1.5 times the aircraft's predicted lift-off speed.

(c) Maneuvering speed (V_a) = 2 times the aircraft's predicted stall speed.

(d) For applicable aircraft, we advise putting the maximum landing gear operating speed (V_{lo}) and maximum flap extension speed (V_{fe}) on a piece of masking tape and attaching it to the instrument panel for reference.

SECTION 2. THE ROLE OF THE CHASE PLANE

3-5. OBJECTIVE. Determine if you should use a chase plane during the flight-test phase.

3-6. GENERAL. It should be a test pilot's decision to use or not to use a chase plane. If you use a chase plane, it must serve specific functions listed in the flight-test plan. Its overall purpose is (1) to contribute to gathering flight-test data and (2) flight safety. The chase plane should not be a distraction to the test pilot nor only serve as a platform for a home camcorder/camera.

a. The primary functions of the chase plane are:

(1) To watch the parts/systems of the test aircraft not visible to the test pilot and report any problems.

(2) To assist the test pilot in following the flight-test plan.

(3) Watch for and inform the test pilot of other aircraft.

(4) Assist in an emergency situation.

b. If you use a chase plane, the FAA offers the following suggestions:

(1) You should use a single chase plane on the first two flights and the first time the amateur-built aircraft's landing gear is retracted. The chase plane pilot should be experienced in formation flying and thoroughly briefed before each flight.

(2) There should be at least two pilots on board the chase plane. One pilot's sole duty is to fly the aircraft and maintain a safe distance from the amateur-built aircraft. The other pilot serves as an observer who (1) checks for other traffic, (2) checks the condition of the test aircraft, and (3) communicates with the pilot on the test aircraft on a frequency assigned by air traffic control (ATC) or on the air-to-air communication frequency of 122.75 megahertz (MHz).

(3) A good chase plane position is about 100 to 200 feet off the right side and slightly behind and below the test aircraft. Avoid flying directly behind the test aircraft. It is not uncommon that on first flights, fuel and oil leaks develop and small hardware and fasteners could also vibrate off the aircraft.

NOTE: Pilots of both aircraft must keep each other informed of their intended action or maneuver prior to execution.

c. In an emergency situation:

(1) If the test aircraft's radio fails, the chase plane should serve as an airborne communication relay with the tower/ATC facility for the test aircraft.

(2) For other emergency situations, the chase plane should give the test pilot information or assistance as required. If necessary, the chase plane can guide the test pilot to a safe landing at the airport or an emergency field. If the test aircraft makes an off-airport landing, the chase plane can serve as an overhead spotter that can direct emergency personnel to the test aircraft location.

SECTION 3. EMERGENCY PROCEDURES

"At the worst possible time, the worst possible thing will happen." Murphy's Law

3-7. OBJECTIVE. Develop a complete set of in-flight emergency procedures for the aircraft that are designed to make unmanageable situations manageable.

3-8. GENERAL.

a. The flight-test plan should have a special section on emergency procedures. The responses to each emergency should be based on the aircraft's predicted flight characteristics, airport location, surrounding terrain, and nearby emergency fields. The following is a partial list of possible emergencies—and suggested responses—that may arise during the flight-test phase:

(1) Problem: Engine failure on takeoff.

Response: Fly the aircraft. Establish best glide speed. If time permits, try to restart engine. If altitude is below 800 feet and the engine will not start, land straight ahead or 20 degrees on either side of the runway centerline. We suggest this because, in most cases, the aircraft will lose altitude or airspeed while attempting a 180-degree turn back to the airport. *Declare an emergency and shut off the master switch, fuel, and magnetos to reduce the possibility of fire on landing.* Above 800 feet, successfully making a 180-degree turn to land downwind on the runway or a nearby emergency field is directly proportional to the wind velocity and the numbers of practice emergency landings the pilot has made in similar make and model aircraft.

(2) Problem: Engine vibration increases with rpm.

Response: Fly the aircraft. Adjust power to minimize the effect of vibration, but maintain safe airspeed and altitude. Run through the emergency checklist and land as soon as possible.

(3) Problem: Smoke in the cockpit.

Response 1: Fly the aircraft. If the smoke smells like burnt plastic wire installation, shut off the master switch. Put on smoke goggles, open the fresh air vents to clear the cockpit, and land as soon as possible.

Response 2: Fly the aircraft. If the smoke is bluish/grey and has an acrid odor like burning oil, shut off the fresh air/hot air vents and put on the smoke goggles. Monitor oil pressure and temperature. Be prepared to shut the engine down and land as soon as possible.

(4) Problem: Cabin door opening in flight.

Response: Fly the aircraft**.** A partially open door usually affects the airflow over the tail causing reduced control response and vibration. Reduce speed, maintain level flight, and yaw/slip the aircraft left or right to reduce vibration. Open the side vent window to reduce air pressure resistance in the cabin and attempt to shut the door. Sometimes, placing the aircraft in a skid will help close a partially open door.

(5) Problem: Engine fire.

Response: Fly the aircraft. Shut off the fuel selector, mixture master switch, and magnetos. Land as soon as possible.

(6) Problem: Out of rig condition.

Response: Fly the aircraft. Try to use the appropriate trim to offset adverse control pressures. Maintain altitude with airspeed. Make small control inputs, reduce power slowly to avoid controllability problems, and land as soon as possible.

b. Other possible emergencies you should plan for include:

(1) Canopy opening unexpectedly, if applicable.

(2) Loss of communications.

(3) Throttle stuck in one position.

(4) Oil on the windshield.

(5) Separation of a propeller blade.

(6) Fire in the cockpit.

SECTION 4. FIRST FLIGHT

"Always leave yourself a way out." Chuck Yeager

3-9. OBJECTIVES. Determine engine reliability and flight control characteristics.

a. After completing the pre-flight inspection, the test pilot should properly fit the seat/shoulder harness, making sure the harness enables easy access to all the cockpit controls. The harness fit should be verified by a flight-test crewmember. Following the flight-test plan and using the starting checklist, warm up the engine until the engine instruments indicate normal operating temperatures and pressures.

b. The test pilot should conduct a complete check of each aircraft system, such as carburetor heat, magnetos, static rpm, and brakes.

c. If the airport does not have a tower/Unicom available, the pilot should transmit over 122.9 MHz the following message: “This is experimental aircraft N___ on the first test flight, departing runway ___ at ___ airport, and will remain in the local area for the next hour.” Transmit the aircraft N number, location, and intentions every 10 minutes.

d. If the airport has a tower, notify tower personnel that an experimental aircraft is on its first test flight and requests takeoff instructions.

e. After the tower clears the test pilot for takeoff, clear the area, line up on the runway centerline, release the brakes, and slowly add power to provide “thinking time.” When the throttle is fully advanced, glance at the oil pressure gauge and tachometer to confirm they are in the green and indicating takeoff rpm. If either oil pressure or tachometer reads low, abort the takeoff. A TC’d engine of 100 HP will produce between 2,100 to 2,300 rpm on the takeoff roll, depending on the propeller installed.

f. If there is any unusual vibration, if engine rpm exceeds the red line limit, or if the engine hesitates, abort the takeoff!

g. If the test aircraft has a tailwheel, keep the tail on the runway until the rudder is effective. This usually happens at approximately 35 mph on most aircraft.

h. As the aircraft accelerates and approaches the predicted/manufacturer’s lift off speed/point—indicated by the green flag beside the runway— gently ease back on the stick. The first takeoff should be a gentle and well-controlled maneuver with the aircraft doing all the work.

i. If the aircraft does not rotate or the test pilot experiences unusual stick forces, abort the takeoff!

j. If the aircraft has retractable gear, do not raise the gear on the first two to three flights until the aircraft’s stability/control responses have been explored.

k. The FAA recommends that after establishing a safe climb angle, the pilot not throttle back, switch tanks, or make large inputs into the flight controls for the first 1,000 feet AGL. At a preselected altitude, reduce power slowly to avoid a pitch up or pitch down attitude.

NOTE: Check for any additional aileron or rudder input pressure during the climb. Try reducing any abnormal stick pressures with trim. Each control input should be small and slow.

l. If you notice unusual engine vibrations, rapid oil pressure fluctuation, oil temperature or CHTs approaching red line, or decreasing fuel pressure, refer to the emergency checklist and land as soon as possible.

SECTION 5. FIRST FLIGHT PROCEDURES

"In my opinion, about 90 percent of your risk in a total program comes with a first flight. There is no nice in-between milestone. You have to bite it off in one chunk." Deke Slayton

3-10. OBJECTIVE. Perform a series of tests to develop data that will ensure a safe landing.

a. The First Test Flight.

(1) After takeoff, climb to 3,000 feet above ground level (AGL) and level off. Reduce power slowly. Complete the cruise checklist items. Following the flight-test plan, circle the airport or emergency field as the engine performance is being monitored.

(2) Limit the cruise speed to no more than 1.5 the predicted stall speed of the aircraft. This will reduce the chances of flutter. If the engine appears to be operating smoothly, try testing the flight controls.

(3) With the airspeed being monitored, each control input should be gentle and small. Start with the rudder first. Yaw the nose of the aircraft 5 degrees left and right. Note the response. Raise the aircraft's nose 3 degrees up, note the response. After the aircraft is stabilized, level off and try 3 degrees nose down, trim, and note the response. Try a gentle bank of no more than 5 degrees to the left, then one to the right. If the aircraft is stable and is operating smoothly, try a few 90-degree clearing turns, followed by two 360-degree turns: one to the left and one to the right, at a bank angle of 10 degrees.

NOTE: From this point forward, the FAA recommends that all flight-test maneuvers be preceded with two 90-degree clearing turns to ensure that the flight-test area is free of other aircraft.

(4) If the aircraft is responding to the prescribed specifications, increase the bank angle in succeeding turns to 20 degrees bank angle. If you don't encounter any problems, climb to 5,000 feet AGL using the climb checklist and monitoring engine gauges, level off, fly an imaginary landing pattern, and test the flaps. Do not forget to announce every 5 to 10 minutes the aircraft's location, altitude, and intentions. Practice approach to landing by descending to 4,000 feet AGL first, then to 3,000 feet. *Remember, use the descent checklist.*

(5) During these maneuvers, control pressures should increase in proportion to control deflection. If control pressure remains the same as control deflection increases or if stick forces become lighter as control deflection increases, the aircraft may have a stability problem. Avoid large control movements and land as soon as possible.

(6) Keep informing the tower/UNICOM/chase plane of what is happening. For 10 minutes of anticipated flight time, plan a brief rest period for the pilot. Fly straight and level, monitor the gauges, and enjoy the experience.

(7) At low cruise power setting, straight and level, observe how the aircraft trims out. Do "fixed" trim tabs on the rudder and aileron need adjustment? Are adjustable aileron and elevator trim controls effective? Is the control stick/yoke slightly forward of the middle position in straight and level flight?

(8) Climb slowly back up to 5,000 feet. You must answer two questions before landing:

- Is the aircraft controllable at low speeds?
- What is the estimated stall speed?

(9) These questions can be answered with an approach to a stall maneuver. Don't perform a full stall check at this time!

(10) An approach to a stall check helps establish a preliminary stall speed (V_{si}) in mph/knots so you can calculate the approach speed for landing. The pilot will also know the aircraft's handling characteristics at low speed.

b. Stall Testing. Suggested procedure below is for the first stall testing.

(1) Level off at altitude; make two clearing turns; stabilize airspeed, heading, and altitude; apply carb heat; set the flaps in the landing configuration, reduce power slowly to 900 rpm, TRIM. If you can't trim the aircraft properly, you can still proceed with the check as long as control forces are not unusually heavy.

(2) With the aircraft airspeed about 1.4 mph/knots times the predicted stall speed, raise the nose slowly. Look for the aircraft to start decelerating slowly, about ½ mph/knot a second. A 30 mph/knot deceleration at ½ mph/knot per second will take about a minute.

(3) As the aircraft slows down, note all the things that happen as the speed bleeds off. Observe the changing nose attitude and how the control forces change. Keep the turn coordinator indication level or the turn and bank "ball" in the middle.

(4) Note how much rudder it takes to keep the ball centered. Every few seconds make very small control inputs to check that the aircraft is operating as expected. If the aircraft does not respond to small control inputs—and you should not expect it to respond as quickly as it did at higher speeds—make the inputs a little bit larger. Increase the amount of input progressively. Do not simultaneously put in all three control inputs. Give particular attention to the response to nose-down elevator inputs, which is necessary for recovery.

(5) Notice any changes in flight characteristics and the speeds at which they occur. Be especially alert for the onset of pre-stall buffet. Is the buffet felt through the stick? Through the airframe? Though the seat of the pants? Does the nose of the airplane want to rise or drop on its own? How strong is the buffet? Is the buffet continuous? Would it get the pilot's attention if they were concentrating on something else?

NOTE: On some high-performance aircraft or aircraft with unusual wing designs, a pre-stall buffet may not exist, and the stall may be abrupt and violent with a large amount of wing drop.

(6) Keep making small control inputs at intervals to check the aircraft's responses. At approximately 5 mph/knots before the predicted stall speed, or at the first sign of a prestall buffet, note the airspeed and stop the test. Recover and write down the prestall indicated airspeed. This airspeed should be the reference stall speed for the first landing.

(7) The prestall recovery response should be a smooth and quick forward stick movement. This response should be enough to reduce the angle of attack to the point where the airplane is flying normally again.

(8) A wing drop would be unexpected so early in the approach to a stall, but if it becomes necessary to raise a low wing do it with rudder, NOT OPPOSITE AILERON. Use of ailerons at lower speed would increase the chances for a stall or a sudden departure from controlled flight.

(9) You don't need to gain more airspeed than the extra few mph/knots to fly out of a prestall condition. After returning to straight and level flight and using the information learned, the pilot can practice a few more recoveries from a prestall condition. Remember the aircraft will constantly be losing altitude so you may have to climb back up to 5,000 feet AGL to continue further flight testing. Do not get so involved that the overall objective of the first flight is lost—getting the pilot and aircraft safely back on the ground.

(10) The flight-test plan for the first flight should call for a maximum of 1 hour of actual flight time. This is to reduce pilot fatigue and the possibility of an engine failure or airframe malfunction occurring due to vibration or construction errors.

NOTE: The pilot may elect to make several practice approaches to landing at altitude or low approaches to the active runway to get a solid understanding of the lower airspeeds, aircraft attitude, and overall feel of the aircraft in the landing configuration. Before each low approach at the airport, you should advise the tower/UNICOM/chase plane of your intentions. Avoid other traffic in the pattern, and use the landing checklist.

(11) When the pilot has completed all the tests called for by the flight-test plan, notify the tower/UNICOM/chase plane of your intent to land. Complete the landing checklist *before entering downwind*. Keep all turns less than 20 degrees of bank, but do not cross-control by using the rudder to move the nose. This will increase the bank angle, which most pilots will correct by using opposite aileron. If allowed to continue, and with backpressure on the stick, this will result in a cross-control stall and a roll to a near vertical bank attitude at the beginning of a spin with no altitude left for recovery.

(12) On final approach, the aircraft speed should be no less than 1.3 but no more than 1.4 times the recorded first flight pre-stall speed. Homebuilt biplanes—high drag aircraft—should use an approach speed of 1.5 times stall speed on landings.

(13) Landings, especially the first one in an amateur-built or kit plane, are always exciting. Proceed slowly and do not over control. If the landing conditions are not ideal, be prepared to go around.

(14) The actual touchdown should take place within the first 1,000 feet with braking action being applied before the red (abort) flag marker on the runway.

(15) After taxiing in, secure the aircraft, debrief the flight with members of the team, and then together perform a careful post-flight inspection of the aircraft.

NOTE: Remember to allow enough time to absorb what has been learned about the aircraft's performance and the pilot's and ground crew's responses to it.

CHAPTER 4. THE FIRST 10 HOURS

"One can get a proper insight into the practice of flying only by actual flying experiments."
Otto Lilienthal (1896)

SECTION 1. THE SECOND FLIGHT

4-1. OBJECTIVE. Reaffirm the first flight findings.

a. Before the second flight, you should correct all discrepancies noted on the first flight. Additional ground run-ups, rigging adjustments, or taxi tests may be required. Under no circumstances should a pilot takeoff in an aircraft with known airworthiness problems.

b. The pre-flight inspection should be the same as performed for the first flight, including draining the oil and inspecting the oil and fuel screens for contamination.

c. The second flight, again lasting approximately an hour, should be a carbon copy of the first one, with the exception that all first flight discrepancies are corrected. If problems are not corrected, all further flight testing should be canceled until solutions are found.

SECTION 2. THE THIRD FLIGHT

"Plan the flight, fly the Plan."
Sign on the wall at the Naval Test Pilot School, Patuxent River, MD

4-2. OBJECTIVE. Validate the engine reliability.

4-3. GENERAL. The third flight should concentrate on engine performance. Do not forget to record the engine's response to any application of carb heart, leaning of the fuel mixture, changes to airspeed, and switching fuel tanks.

a. You should monitor and record engine oil pressure, oil temperature, fuel pressure, and CHTs from 55 percent through 75 percent engine power. At the higher rpm, be sure not to exceed 80 percent of the maximum cruise speed. This action avoids the possibility of encountering a flutter condition. Do not forget to record the engine responses to any applications of carb heat, leaning the fuel mixture, changes to the power settings, such as rpm and manifold pressure, changes to airspeed, and switching fuel tanks. Certain EIS and MFD can record these events automatically and make them available for viewing at any time.

b. Resist the temptation to explore the more exciting dimensions of flight. Stick to the flight-test plan and perform a conscientious evaluation of the engine. After landing, review the data with ground crew members. Make adjustments as needed, perform another post-flight inspection of the aircraft, and record oil and fuel consumption.

c. After 3 hours of flight testing, the pilot should be able to confirm that the aircraft is stable and engine is reliable in cruise configuration.

d. If installed, calibrate the angle of attack indicator (AOAI) or lift reserve indicator as per the manufacturer's instructions and use it during all subsequent flights. This will require wings-level stalls in various flight configurations. Be sure to climb to a safe altitude of at least 5000 feet AGL before performing these tests.

NOTE: In an effort to reduce maneuvering accidents in all aircraft the FAA and the EAA strongly urge all amateur builders to install an angle of attack indicator or lift reserve indicator in their aircraft and learn how to use it effectively. Since most experimental amateur-built aircraft do not have any stall warning device installed, the AOAI can fulfill the need to serve that safety function. In addition, it is very useful to determine best angle and rate of climb airspeeds and best glide airspeed. The potential life-saving benefit of these devices should not be underestimated.

SECTION 3. HOURS 4 THROUGH 10

"Keep your brain a couple steps ahead of the airplane." Neil Armstrong

4-4. OBJECTIVE. Build on data established by the first 3 hours and start expanding on the flight-test envelope in a thorough and cautious manner. This operational data will be added to the aircraft's flight manual.

4-5. GENERAL. These next seven 1-hour test segments should confirm the results of the first 3 hours and explore:

a. Gear retraction, if applicable.

b. Climbs and descents to preselected altitudes, monitor engine performance.

c. Airspeed indicator in-flight accuracy check.

NOTE: After each test flight, all discrepancies must be cleared before the next flight. You must also thoroughly inspect the aircraft before the next flight.

NOTE: The FAA recommends that all flight-test maneuvers be preceded with two 90-degree clearing turns to ensure that the flight-test area is free of other aircraft.

4-6. GEAR RETRACTION.

a. Before you retract the gear in flight for the first time, the FAA advises that you put the aircraft up on jacks and perform several gear retraction tests, including the emergency gear extension test. These tests will determine if, in the last 3 hours of flight testing, any structural deformation or systems malfunctions have occurred. Added to the gear retraction test, the pilot/chase pilot/ground crew should use this time to review the aircraft's kit/designer instructions and emergency checklist procedures for malfunctioning gear and plan accordingly. If at any time the aircraft has suffered a hard landing or side loading on the gear during flight testing, the aircraft and its gear should be tested for operation and condition on the ground.

b. You should conduct the first gear retraction test with the aircraft flying straight and level at or above 5,000 feet AGL, over an airport or emergency field. The airspeed must be well under the maximum landing gear retraction airspeed. When the gear is being retracted, note if there is any tendency for the aircraft to yaw, pitch, or roll. Record what changes to the aircraft's trim are required to maintain straight and level flight. If there are no adverse flight reactions or system malfunctions, cycle the gear several times. When satisfied with the straight and level gear retraction test, try an emergency gear extension but only if this is practical.

c. With the gear extended, slow the aircraft to 1.3 times the pre-determined stall speed, stabilize, lower the flaps to the take-off position, trim, and maintain straight and level flight.

d. Simulate a normal takeoff by increasing rpm to full power. Raise the nose 3 degrees, trim, and then retract the gear. Observe the following: aircraft reaction, such as pitch or roll; length of time for gear to retract; trim requirements, and the time necessary to climb 1,000 feet higher in altitude before leveling off.

e. Practice a simulated takeoff several times to confirm that the aircraft's response is predictable and the gear retraction system is mechanically reliable.

4-7. CLIMBS AND DESCENTS. These tests monitor engine performance and reliability. The pilot should start the test only after the aircraft has been flying straight and level for a minimum of 10 minutes. This time in level flight will help stabilize engine oil pressure and temperatures. Engine oil pressure and temperatures must be kept within the manufacturer's limits at all times during these tests. High summer temperatures restrict the flight-test program because both oil and CHTs will increase 1 degree for each 1-degree increase in outside temperature. As applicable, an EFIS, MFD, or paper log should be utilized for recording the following indications below.

a. Climbs. Start the first climb at a 15-degree climb angle, full power, at a predetermined altitude. Maintain the climb angle for 1 minute. Record the engine temperatures and pressures. Reduce power, stabilize the engine temperature, and repeat the test. For the second climb test, the flight-test plan should call for increasing the climb time. Record the results of the second climb test. When satisfied that an engine-cooling problem does not exist at the 1-minute duration, repeat the tests increasing the duration until the pilot has:

(1) Reached 15 degrees climb angle and whichever occurs first;

(2) Has been in climb for 5 minutes at full throttle; or

(3) Encountered an engine manufacturer's limit.

b. Descents. Should begin above 5,000 feet AGL with both the engine temperatures and pressures stabilized.

(1) The test pilot should apply carb heat and also clear the airspace below the aircraft before starting the descent. The first descent should be at a shallow angle, at low rpm and last for 30 seconds, not exceeding 1.5 times the estimated stall speed of the aircraft. During long, low-power descents, the pilot must be aware of rapid engine cooling, usually marked by a large drop in oil and CHT. If a noticeable drop occurs, increase the engine rpm and reduce the angle of descent. If not corrected, the repeated rapid cooling of the engine may cause thermal shock to the engine cylinders and eventually cause cylinder head cracking or seizure.

(2) Conduct each test as before, but increase the time by 30 seconds until you either are (1) limited by the engine manufacturer's restrictions or (2) you reach a 5-minute descent. Record temperatures, pressures, altitudes, and airspeeds data for climbs and descents for addition into the aircraft's flight manual.

4-8. AIRSPEED IN-FLIGHT ACCURACY CHECK. The following procedures are commonly used to calibrate airspeed:

a. The measured course method uses a stopwatch with readily identifiable landmarks at each end. The landmarks should be a known distance apart, and the length of the course should be at least 1 to 2 miles long.

(1) The pilot must fly a precision course, maintaining a constant altitude, such as 1,000 feet, constant airspeed, constant magnetic heading, and constant engine rpm. The pilot must record the temperature, altitude, indicated airspeed and the time over each landmark for both directions. The average of these speeds is the ground speed of the aircraft. An E6B computer will convert the temperature, altitude, and ground speed into true indicated airspeed for the tests.

(2) The air should be as smooth as possible with a minimum of turbulence and wind. The wind velocity, while conducting the test, should not exceed approximately 10 knots.

NOTE: The difference between the E6B computer readings and the aircraft's groundspeed readings is the error in the instrument and the error caused by the installation of the system in the aircraft.

(3) The pilot should make several airspeed calibration runs in opposite headings for selected airspeeds the pilot wants to check. Such accuracy test runs should start at the lowest safe airspeed and work up to cruise speed using 10-mph/knot increments. Most errors will be found at the low end of the speed range due to the angle of the pitot mast to the relative wind and/or the location of the static ports.

NOTE: Flight testing of all amateur-built aircraft is restricted to a flight-test area. If a pilot must run additional aircraft tests requiring more airspace, the pilot should notify FSDO personnel who issued the aircraft's operating limitations, and request a change to those limitations. The FAA reminds you that the pilot must operate an experimental aircraft using the aircraft's operating limitations. Otherwise, the FAA may take certificate action.

b. GPS method provides an accurate and easy-to-use means of determining speed during the flight-test period. Since it measures ground speed it will be necessary to calculate true airspeed, and from that confirm indicated airspeed.

(1) A triangular course with each leg 120 degrees apart from the previous one will ensure accurate results in any wind condition. The ground speeds from each of the three legs should be averaged to get the no-wind ground speed, which is equal to the true airspeed.

(2) A true airspeed can be calculated using an E6B or other aviation computer if the indicated airspeed, temperature, altitude, and barometric pressure are noted for each test course. This true airspeed can be compared to the previously determined no-wind ground speed in step one for clarity.

(3) The pilot must fly precisely during these tests to get accurate numbers. Altitude, airspeed, heading and engine rpm need to be held as steady as possible during each test. Allow the aircraft to stabilize for at least one minute after any change in heading, altitude, or power setting before taking a speed reading.

(4) Most errors will be found at the low end of the speed range due to the angle of the pitot mast to the relative wind and/or the location of the static port(s).

c. If the aircraft has retractable gear or flaps, test the accuracy of the airspeed indicator using applicable method with the gear/flaps up and down.

d. Record all the data in a log if not automatically recording on an electronic Primary Flight Display (PFD) unit.

CHAPTER 5. EXPANDING THE ENVELOPE

"Checklist! Checklist!! Checklist!!!" Jim Byers, Flight Instructor/Examiner

SECTION 1. GENERAL

5-1. OBJECTIVE. Move from a known flight environment to an unknown flight environment using a series of planned and carefully executed steps.

a. Before beginning the next series of test flights, the FAA highly recommends that the aircraft undergo the same condition inspection that would normally only be done annually at this time. The FAA strongly recommends that the builder and/or pilot take the time to inspect the aircraft because within the previous 10 hours, the test pilot has subjected the aircraft to a "shakedown cruise."

b. During the inspection, check the torque paint marks on the engine mounts, propeller bolts, and landing gear. Double check the flight control hinges and rod end bearings for attachment and play. Check all cable installations, cable tension, and control travel, and complete all the standard inspection and maintenance items. This inspection also should include checking the oil and fuel filters for metal or other forms of contamination.

c. Even if there have been no indications of CO contamination, perform another CO test using the floodlight procedure—review Chapter 1, Section g—or an industrial CO test meter. There is a strong possibility that operational vibration and landing stresses may have opened new paths for CO to enter the cockpit.

SECTION 2. HOURS 11 THROUGH 20

"Fly Scared!" Admiral Jack Ready, USN

5-2. OBJECTIVE. Focus the next 10 hours of flight testing on stall speed, best rate of climb speed, best angle of climb speed, and slow flight. The FAA recommends that stall speed tests be conducted with the aircraft's fuel tanks full.

NOTE: Stall speeds, best rate of climb, best angle of climb, best glide speed, and various slow flight maneuvers are best and most safely performed with the aid of an angle of attack indicator (AOAI). The installation, calibration and proper use of such a device is highly recommended.

a. As with any unknown, approach flight testing slowly, incrementally, and follow the flight-test plan. The stall test objective is to verify the aircraft conforms to the expected responses for this particular design in this flight regime. Acquire a thorough description of how the aircraft is expected to behave near, at, and after stall. This provides a reference point to compare against the flight-test results. To improve safety and reduce the possibility of spins, the aircraft should be tested with a forward CG loading. Starting the stall tests at 8,000 feet AGL is good for most homebuilts, but it depends on the aircraft type. Make clearing turns and stabilize the airspeed and altitude. The first full stall should be conducted with power off, no flaps, and gear up if applicable. After clearing the area, reduce the airspeed to 1.3 times the predicted stall speed and trim.

NOTE: Make sure the engine's idle speed is properly set; faster idle speeds result in higher nose-up attitudes and lower indicated stall speeds.

NOTE: Don't trim within 10 knots of stall.

NOTE: Some clean, high performance aircraft may not have any noticeable pre stall buffet. The actual stall may be abrupt and violent with a large amount of wing or nose drop.

b. The preferred pre stall and stall behavior is an unmistakable warning buffet starting lightly about 5 to 10 mph/knots above the eventual stall speed, growing in intensity as the aircraft slows down.

c. The desired stall characteristics should be a straight forward nose drop with no tendency for roll or pitch up. This docile and forgiving behavior implies a stall that has started at the wing root and progressed smoothly outboard. The buffet warns the pilot about separated airflow over the wings and or tail in the form of the buffet. The ailerons will continue to operate in the attached air flow until the aircraft's stall speed is reached and the wing stalls.

d. Use the same procedures as on the first flight. Secure cockpit items and use carburetor heat. Begin by stabilizing in level flight at 15-20 knots above the predicted stall speed. When stable, make a control input in each axis; roll, pitch and yaw. The inputs should be just enough to generate about 3-5 degrees of aircraft response, then move the controls right back to neutral (usually a 1-2 second input pulse).

(1) Then watch for the aircraft response. In roll, is there any accompanying adverse yaw? Does the aircraft stop rolling when the input is released to neutral? In pitch, does the aircraft return to the previous attitude? Is there any tendency for the pitch to continue to rise after releasing the stick? Does the pitch attitude continue to oscillate? The same questions apply in the yaw axis. If all is as expected, slow 3-5 knots and repeat the process.

(2) At each incremental airspeed point ensure that you still have nose down control authority, since that is your most important recovery input. Make note of any changes in response as the aircraft gets slower (it is normal for the aircraft to be more sluggish, but it should still respond positively). Make note of any warning cues. Watch closely for any uncommanded motions. At the first sign of any uncommanded motion (nose rise, or nose slice, wing rock, or nose drop), recover the aircraft by lowering the nose, adding power and increasing speed. Uncommanded motions are likely linked to being at a higher angle of attack than previously flown. The most correct initial response is to lower that angle of attack with a nose down input. Even if the uncommanded motion is a roll off, the quickest way to stop it is most likely a pitch down, not a countering roll input. After airspeed increases and aircraft still continues to roll use opposite rudder to stop it with ailerons neutralized.

e. If there are no surprises down to 3-5 knots above expected stall speed, then continue to a complete stall by applying backpressure on the stick/yoke to slow the airplane down at roughly 1 knot/mph per second. Stall warning should occur about 5 knots/mph before the stall itself. Do not depend too much on an uncalibrated stall warning system.

(1) As the airplane decelerates, ensure that the airplane requires an increasingly heavier pull force. If the force lightens or changes to a push force, abandon the test. Once you get to the stall, initiate recovery and record the altitude required to return to level flight as well as the stall speed. Also make note of aircraft responses during the recovery such as wing rock, secondary stall or any uncommanded motions. All these observations need to be compared in your post- flight analysis to the expected behavior written down before the test.

NOTE: Some airplanes reach the up elevator stop before the wing stalls. This is acceptable as long as the elevator has the authority to flare the aircraft at its maximum landing weight with the forward most CG allowed for that weight. Also, at the stall, many airplanes tend to roll toward one wing or the other. A properly designed and rigged airplane will be able to maintain the wings within 15 degrees of level with normal aileron inputs. Make sure you're not cross-controlling the airplane (the slip-skid ball is centered). If you need excessive aileron or rudder inputs to keep the airplane straight and the wings level, abort the test. On the ground assess the airplane for miss-rigging or some inadvertent wing twist or asymmetry.

f. Practice the same stall sequence several times at a ½-mph/knot-per-second deceleration rate to determine the power off, 1-G stall speed. Practice the same stall series with flaps, starting with the lowest setting first and working slowly to the full flap configuration. Record the findings.

g. After exploring the stall and recovery behavior in a slow deceleration with ball centered, try a series of stalls with flaps up and flaps down, with a faster deceleration. Do not exceed the deceleration rate expected in normal operations.

5-3. STALLS.

a. Power-On Stalls. As before, use the same procedures moving from the known to the unknown. Increase power incrementally and run a stall test at each new power setting until full power is reached. We do not advise jumping straight from idle to full power with the resultant large changes in pitch attitude, torque reaction, and slipstream effect on the wing and tail.

b. Conducting Power-On Stalls. The FAA recommends that you stabilize the aircraft in level flight at low cruise power. The power-on stall is reached by slowly increasing the power to the desired power setting. The pilot then steadily increases the pitch attitude until the aircraft experiences the stall buffet. Remember to keep the ball centered until the onset of the stall buffet.

(1) The power-on stall may be more likely to cause a wing drop than one at idle. This is due to torque reaction and because the propeller slipstream tends to keep the flow of higher velocity air over the inboard, or root, section of the wing despite the higher angle of attack. This allows the root portion of the wing to continue flying after the wing tip stalls, dropping a wing.

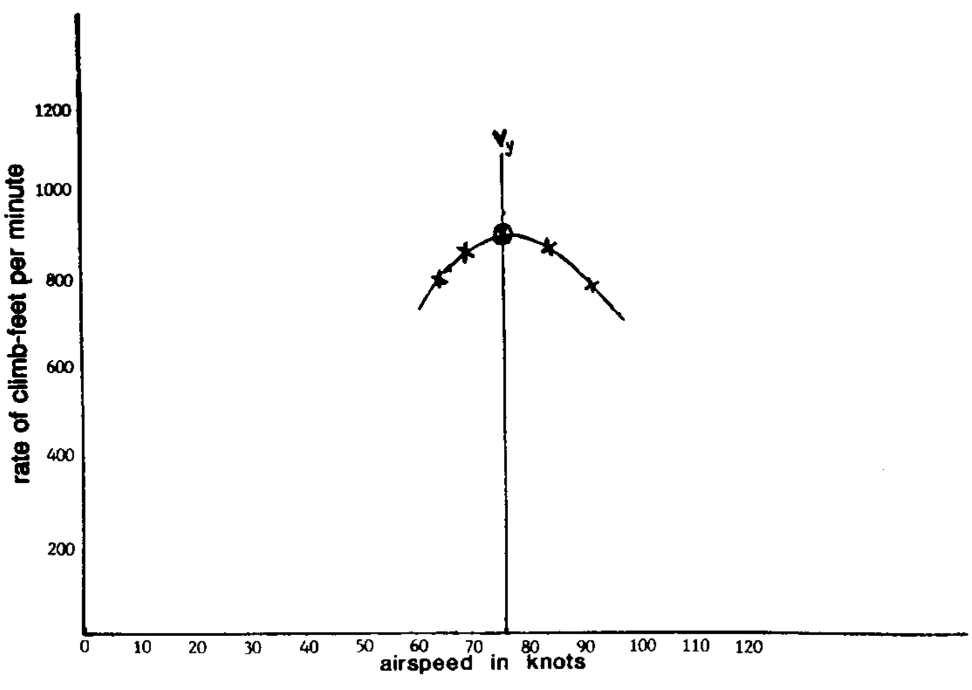
(2) Tip stalls usually do not give advance warning and will almost invariably result in severe wing drop. These stalls are more likely to result in a spin, even if the controls are not mishandled. If the spin does not develop, considerably more height will be lost in the recovery than if the stall had been straight-ahead nose down.

(3) If the pilot yields to instinct and tries to correct the wing drop with aileron, it could result in a spin. Since a sharp wing drop could be regarded as the onset of spin auto-rotation, the recommended corrective action is reducing power, full opposite rudder, and lowering the nose to the horizon or below. Take care to avoid this situation until the aircraft's spin behavior has been tested.

(4) Perform the same sequence of events for power-on stalls as power-off stalls, unless limited by the designer's instructions. Record all findings in a log if not automatically recording on an electronic PFD for the aircraft's flight manual.

NOTE: Aircraft with retractable gear will have to go through a separate series of slow flight and stall checks with gear extended, with and without flaps. Record the different stall speeds for each configuration in the aircraft's flight manual.

FIGURE 7. CLIMB AIRSPEED AND ALTITUDE GRAPH



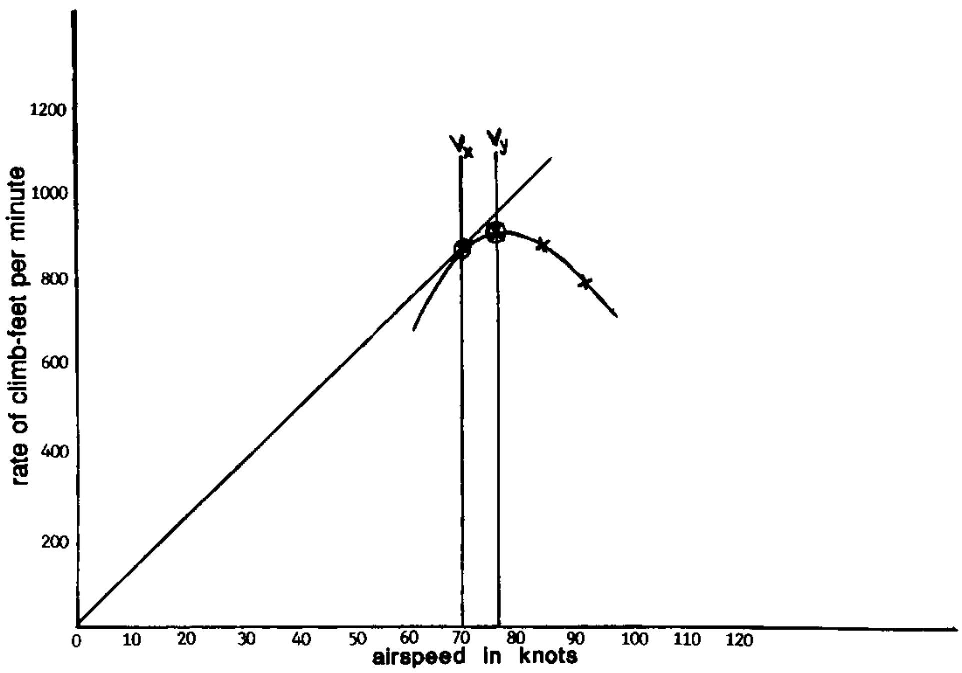
c. Best Rate of Climb Speed Tests. To determine the best rate of climb for the aircraft, the FAA suggests the following procedures:

(1) Perform the tests in smooth air, free from thermal activity. Select an altitude such as 1,000 feet AGL, as a BASE attitude. Use a heading 90 degrees to the wind, and for the best results, reverse the heading 180 degrees after each climb test.

(2) Begin a full throttle climb well below the predetermined BASE altitude and stabilize at a preselected airspeed approximately 15 mph/knots above the predicted best rate of climb speed. As the aircraft passes through the base altitude, begin a 1-minute time check.

(3) After 1 minute, record the altitude gained. Descend down below the base altitude. Decrease the airspeed by 5 mph/knots and run the test again. After each succeeding test, the pilot should decrease the airspeed by 5 mph/knots until reaching an airspeed that is 10 mph/knots higher than the stall speed of the aircraft. Record the airspeed and altitude gained for each climb on a graph similar to Figure 7. The airspeed that shows the greatest gain in altitude is the aircraft's best rate of climb speed (V_y).

FIGURE 8. BEST RATE OF CLIMB SPEED GRAPH



d. Best Angle of Climb Speed Tests. You can find the best angle of climb speed can by using the same chart developed for the best rate of climb tests. Draw a line (tangent) from the zero rate of climb feet per minute (see Figure 8) outward to a point on the rate of climb airspeed curve. The airspeed that the line intersects is the best rate of climb airspeed. The airspeed that the line intersects is the best angle of climb airspeed.

e. Slow Flight Test. For added safety, the slow flight tests should be performed at 6,000 AGL or higher to allow room for spin recovery. These tests primarily show the pilot the aircraft's handling qualities at the minimum gear up/down airspeeds and power settings.

(1) You should do the tests with and without flaps. Start the tests at airspeed of 1.3 times the stall speed of the aircraft. Once the aircraft is stabilized and maintaining its altitude, reduce the airspeed by 5 mph/knots. Maintain the altitude. Keep reducing the airspeed until approaching a stall.

(2) Maintain 5 mph/knots above the previously determined stall speed; this is the initial slow flight airspeed. Practice with each flap setting, noting its effect on the aircraft's performance. If the aircraft has retractable gear, test in all gear and flap combinations. These tests will have to be run later in the flight-test program—but with the aircraft at gross weight—to determine the actual slow flight airspeed and stall speeds.

(3) Remember, to help reduce the possibility of unplanned stalls in slow flight configurations, avoid bank angles of more than 5 degrees. When all the test data has been evaluated, and if the aircraft is equipped with a stall warning horn or indicator, set the stall warning at 5 mph/knots above the aircraft's highest stall speed.

SECTION 3. HOURS 21 THROUGH 35: STABILITY AND CONTROL CHECKS

"A superior pilot uses his superior judgment to avoid those situations which require the use of superior skill." Old Aviation Proverb

5-4. OBJECTIVE. Determine the aircraft's stability limits and range of control.

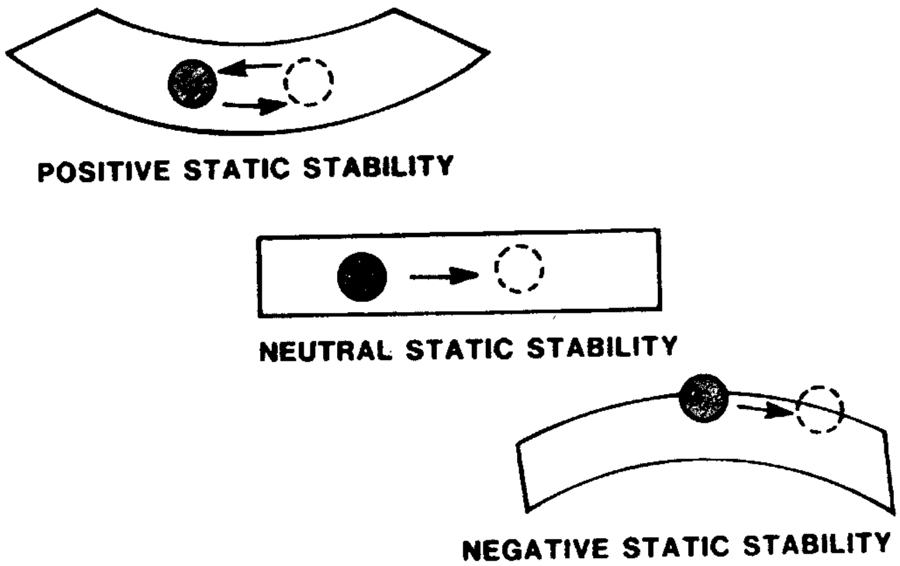
5-5. GENERAL. You must do two things before declaring that the aircraft is controllable throughout the normal range of speeds per part 91, § 91.319, Aircraft Having Experimental Certificates: Operating Limitations.

a. First. Perform another complete inspection of the aircraft, including oil changes and fuel system filter checks.

b. Second. Carry out a close examination of the stability and control characteristics of the aircraft. Stability and control checks will be centered around the three axes of the aircraft: longitudinal or roll axis (ailerons), the lateral or pitching axis (elevators), and the vertical or yaw axis (rudder).

c. All Tests Need a Starting Point. The starting point for stability and control checks is called the state of equilibrium. An aircraft is said to be in a state of equilibrium when it experiences no acceleration and remains in a steady trimmed condition until the force or moment balance is disturbed by an atmospheric irregularity or by pilot input.

FIGURE 9. STATIC STABILITY



5-6. DEFINITIONS.

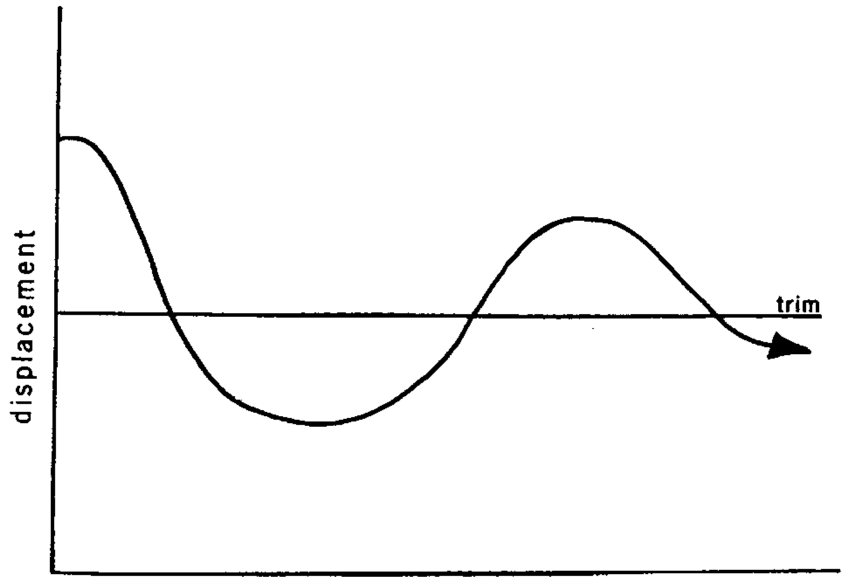
a. Positive Static Stability. When an aircraft tends to return to the state of initial equilibrium position following a disturbance.

b. Neutral Static Stability. When an aircraft remains in equilibrium in a "new" position, following a disturbance from an initial equilibrium position.

c. Negative Static Stability. When an aircraft tends to move further in the same direction as the disturbance that moved it from the initial equilibrium position.

NOTE: See Figure 9 for a graphic of these three stability states.

FIGURE 10. TIME



d. Dynamic Stability. The **time** history of the movement of the aircraft in response to its static stability tendencies following an initial disturbance from equilibrium. Refer to Figure 10.

e. Test for Static Longitudinal Stability.

(1) This test should be done first. All tests should be conducted with the aircraft in the forward of center CG. Climb to at least 6,000 feet AGL and trim the aircraft for zero stick force in straight and level flight at low cruising speed.

NOTE: Do not retrim the aircraft once the test has begun.

(2) Apply a light "pull" force and stabilize at an airspeed about 10 percent less than the trimmed cruise speed. At this reduced airspeed, it should require a "pull" force to maintain the slower speed.

(a) If it requires a "pull" force, pull a little further back on the stick and stabilize the airspeed at about 20 percent below the initial cruise trim speed.

(b) If it requires a still greater "pull" force to maintain this lower airspeed, the aircraft has positive static longitudinal stability.

(c) If at either test points, no "pull" force is required to maintain the reduced airspeeds, the aircraft has neutral static longitudinal stability.

(d) If either of these test points requires a "push" force to maintain the reduced airspeed then the aircraft has negative static longitudinal stability.

(3) Repeat another series of static longitudinal stability tests using a "push" force on the control stick. At an airspeed 10 percent above the trim cruise speed, the control stick should require a "push" force to maintain the airspeed. If a "pull" force is required, the aircraft has negative static longitudinal stability.

WARNING: If the aircraft exhibits negative static longitudinal stability, seek professional advice on correcting the problem before further flight.

(4) After confirming the aircraft has positive static longitudinal stability, the pilot can check for short-period positive dynamic longitudinal stability. First, trim the aircraft to fly straight and level at normal trim cruise speed. With a smooth, but fairly rapid motion, push the nose down a few degrees.

(a) Quickly reverse the input to nose up to bring the pitch attitude back to trim attitude. As the pitch attitude reaches trim attitude, release the stick but keep your hands close to it. The aircraft with positive dynamic longitudinal stability will oscillate briefly about the trim attitude before stopping at the trim attitude position.

(b) To test the aircraft for long-period positive dynamic longitudinal stability, begin from trimmed, straight and level flight. Without re-trimming, pull (or push) the stick to a speed about 5 mph/knots off trim and release the stick. You don't have to stabilize at the new speed. Expect the aircraft to oscillate slowly about the trim airspeed a number of times before the motion dampens out. If there is significant friction in the control system, the aircraft may settle at a speed somewhat different from the original trim speed.

(c) If the amplitude increases with time, the dynamic longitudinal stability is negative or divergent. This is not necessarily dangerous as long as the rate of divergence is not too great. It does mean, however, the aircraft will be difficult to trim and will require frequent pilot attention.

(d) An aircraft with long-period neutral dynamic longitudinal stability will continue to oscillate through a series of increasing/decreasing airspeeds and never return to the original trim airspeed.

f. Lateral-directional Stability Control Tests. Lateral (dihedral effect) and directional stability tests show if the aircraft tends to raise the low wing in a sideslip once the ailerons are freed. They also determine if the rudder is effective in maintaining directional control.

CAUTION: This test may impose high flight loads on the aircraft. Do not exceed the design maneuvering speed or any other airspeed limitation.

(1) To check lateral and directional stability, the aircraft should be trimmed for level flight at a low cruise setting and an altitude above 5,000 feet AGL. Slowly enter a sideslip by maintaining the aircraft's heading with rudder and ailerons. The aircraft should be able to hold a heading with rudder at a bank angle of 10 degrees or the bank angle appropriate for full rudder deflection. The control forces and deflection should increase steadily, although not necessarily in constant proportions with one another-in some cases, rudder forces may lighten until either the rudder or the ailerons reach full deflection or the maximum sideslip angle is reached.

(2) At no time should there be a tendency toward a force reversal, which could lead to an overbalance condition or a rudder lock.

(3) Release the ailerons while still holding full rudder. When the ailerons are released, the low wing should return to the level position. Do not assist the ailerons during this evaluation.

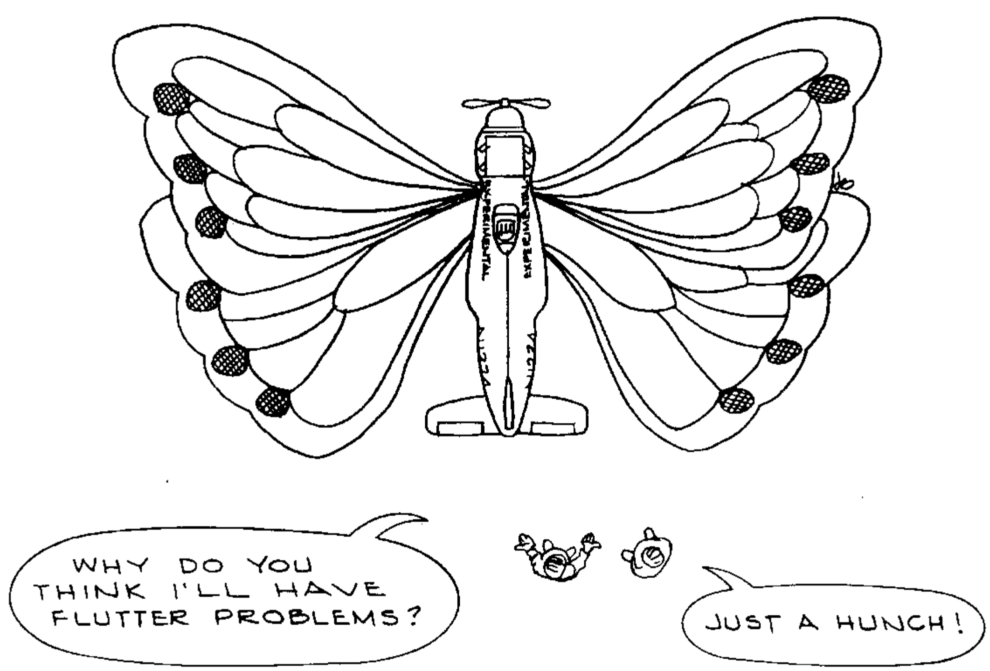
(4) To check static directional stability, trim the aircraft at a low cruise setting above 5,000 feet AGL. Slowly yaw the aircraft left and right using the rudder. Simultaneously, the wings should be kept level by using the ailerons. When the rudder is released, the aircraft should tend to return to straight flight.

g. Spiral Stability. This is determined by the aircraft's tendency to raise the low wing when the controls are released in a bank. To test for spiral stability, apply 15 to 20 degrees of bank either to the left or right, and release the controls. If the bank angle decreases, the spiral stability is positive. If the bank angle stays the same, the spiral stability is neutral. If the bank angle increases, the spiral stability is negative. Negative spiral stability is not necessarily dangerous, but the rate of divergence should not be too great or the aircraft will require frequent pilot attention and will be difficult to fly, especially on instruments.

NOTE: Friction in the aileron control system can completely mask the inherent spiral characteristics of the airframe.

SECTION 4. A WORD OR TWO ABOUT FLUTTER

"Stay up on the edge of your seat." Scott Crossfield, Test Pilot



5-7. OBJECTIVE. Understand the causes and cures of the condition known as flutter.

5-8. DESCRIPTION. Flutter in an aircraft structure is an interaction between aerodynamic inputs, the elastic properties of the structure, the mass or weight distribution of the various elements, and airspeed.

a. To most people, the word "flutter" suggests a flag's movement as the wind blows across it. In a light breeze, the flag waves gently but as the wind speed increases the flag's motion becomes more and more excited. It takes little imagination to realize if something similar happened to an aircraft structure, the effects would be catastrophic. The parallel to a flag is appropriate.

b. Think of a primary surface—a wing—with a control, such as an aileron, hinged to it. Imagine that the airplane hits a thermal. The initial response of the wing is to bend upwards relative to the fuselage.

c. If the center of mass of the aileron is not exactly on the hinge line, it will tend to lag behind the wing as it bends upwards.

d. In a simple, unbalanced, flap-type hinged control, the center of mass will be behind the hinge line and the inertial lag will result in the aileron being deflected downwards. This will result in the wing momentarily generating more lift, increasing its upward bending moment and its velocity relative to the fuselage. The inertia of the wing will carry it upwards beyond its equilibrium position to a point where more energy is stored in the deformed structure than can be opposed by the aerodynamic forces acting on it.

e. The wing "bounces back" and starts to move downward but, as before, the aileron lags behind and is deflected upwards this time. This adds to the aerodynamic down force on the wing, once more driving it beyond its equilibrium position and the cycle repeats.

f. Flutter can happen at any speed, including takeoff speed. At low airspeeds, however, structural and aerodynamic damping quickly suppresses the flutter motion. But as the airspeed increases, so do the aerodynamic driving forces generated by the aileron. When they are large enough to cancel the damping, the motion becomes continuous.

g. Further SMALL INCREASES will produce a divergent or increasing oscillation, which can quickly exceed the structural limits of the airframe. Even when flutter is on the verge of becoming catastrophic it can still be very hard to detect. What causes this is the high frequency of the oscillation, typically between 5 and 20 Hz (cycles per second). It will take but a small increase in speed (¼-knot or less) to remove what little damping remains and the motion will become divergent rapidly.

h. Flutter also can occur on a smaller scale if the main control surface has a control tab on it. The mechanics are the same with the tab taking the place of the aileron and the aileron taking the place of the wing. The biggest differences are the masses involved are much smaller, the frequencies much higher, and there is less feedback through the control system. This makes tab flutter more difficult to detect. The phenomenon known as "buzz" is often caused by tab flutter. Since flutter is more prevalent at higher speeds, it is not recommended that the flight-test plan call for high speed runs within 10 percent of red line.

i. What can be done about it? Having described how flutter happens, the following suggestions should help reduce the possibility of it happening to the amateur-builder's aircraft:

(1) Perform a mass balance of all flight controls in accordance with the designer/kit manufacturer's instructions.

(2) Eliminate all control "free play" by reducing slop in rod end bearings, hinges, and every nut and bolt used in attaching flight controls.

(3) Ensure that all rigging and cable tension is set accurately to the design specifications using a calibrated cable tensiometer.

(4) Re-balance any flight control if it has been repaired, repainted, or modified in any way.

NOTE: If the pilot experiences flutter, or believes he did, reduce power immediately, and land as soon as possible. Do not attempt further flight until the aircraft has been thoroughly inspected for flutter-induced damage. This inspection should include all wing/tail attach points, flight controls, their attach points/hinges, hardware, control rods, and control rod bearings for elongated bolt/rivet holes, cracks, (especially rod end bearings) and sheared rivets.

SECTION 5. SPINS

"Go from the known to the unknown -slowly!" Chris Wheal, Military Test Pilot

5-9. OBJECTIVE. To determine if spin testing is required.

NOTE: All FAA spin tests for type certification require a spin parachute attached to the aircraft. Even though amateur-built aircraft have no such certification requirement, use of a spin parachute during testing should be considered.

5-10. CAUTION.

a. If the manufacturer/designer of the aircraft has not demonstrated satisfactory spin characteristics and safe recovery, avoid all types of high angle of attack flight testing and placard the aircraft: "spins prohibited."

b. If the prototype aircraft has satisfactorily demonstrated spin recovery and the builder's aircraft is identical to the prototype aircraft, the pilot may confirm the aircraft will recover promptly from inadvertent spin entries. Further tests to prove that the aircraft will recover from a fully developed spin (three turns or more) are not necessary unless the aircraft is designed for, and will be routinely flown in, aerobatic flight.

c. During all spin tests, it is strongly recommended that the pilot wear a parachute and that a quick release mechanism to jettison the canopy or door be installed. If the pilot is unable to exit the aircraft because of the design restraints, it is recommended that intentional spins not be conducted even though the design has successfully demonstrated spin recovery.

d. If any modifications or alterations have been made to the airframe's original design or configuration (e.g., adding tip tanks or fairings), it is not safe to assume that the aircraft still has the same spin recovery characteristics as the prototype aircraft. Spins in a modified aircraft should not be attempted without consulting a qualified test pilot and/or flight-test engineer.

e. The pilot who conducts the spin tests should have experience in entry into and recovery from fully developed spins, preferably in makes and models similar to the aircraft being tested. If the pilot needs additional experience, aerobatic training with an emphasis on spins from a qualified instructor is highly recommended.

5-11. PLANNING THE FLIGHT. At this point, nearly all the preparatory work for spin testing has been accomplished. Planning the next flight should be identical to planning for the first flight through stalls. IT IS EXTREMELY IMPORTANT THAT THE CENTER OF GRAVITY OF THE AIRCRAFT IS AT THE FORWARD CG LIMIT AND ANY BALLAST USED SHOULD BE SECURELY ATTACHED TO THE AIRCRAFT.

a. The aircraft should be tested with landing gear (if applicable) and flaps in the up position. The pilot's minimum entry altitude for these tests should be no less than 10,000 feet AGL with the cockpit secured.

NOTE: The following procedure is one way, but not the only way, of conducting a spin test and executing a recovery. Non-conventional aircraft may require significantly different spin recovery control applications. The pilot should evaluate these procedures and determine if they are compatible with the aircraft before attempting any spin testing.

b. The basic technique used to get a clean spin entry is to continue to reduce airspeed at about a 1-mph/knot-per-second rate in level flight, carburetor heat on, and the power at idle.

(1) As the aircraft stalls, APPLY FULL RUDDER in the desired spin direction, followed immediately by full aft movement of the control stick keeping the ailerons neutral.

(2) The transition from a horizontal to a vertical flight path takes approximately three or four turns and is referred to as the incipient stage of the spin.

(3) During the incipient spin, the dynamic and inertia forces have not achieved equilibrium. Many aircraft can recover from the incipient spin phase, but may not be able to recover from a steady spin.

(4) The normal spin recovery technique is to apply full rudder opposite to the direction of yaw (check the turn needle). Move the control stick smoothly and fairly rapidly forward towards the instrument panel until the rotation stops.

(5) Quickly center the rudder and ease out of the dive. Do not attempt to pull up too rapidly because the structural limits of the aircraft can easily be exceeded, or the aircraft can stall again. Recover from the first deliberate spin after a half a turn.

(6) If the aircraft is not built for aerobatics, no further spin testing is required. It is recommended the instrument panel be placarded "SPINS PROHIBITED."

(7) If further spin testing is required, it is strongly recommended the services of a professional flight-test pilot be used.

SECTION 6. ACCELERATED STALLS

"Does it pass the Common Sense test?" U.S. Air Force, Thunderbird

5-12. OBJECTIVE. To further explore the stall characteristics of the aircraft.

a. An accelerated stall is not a stall reached after a rapid deceleration. It is an in-flight stall at more than 1 G, similar to what is experienced in a steep turn or a pull up.

NOTE: Do not attempt this or any other extreme maneuver unless the designer or kit manufacturer has performed similar tests on a prototype aircraft identical to the amateur-builder's aircraft.

b. The two standard methods for accelerated stalls are the constant G (constant bank) and constant speed (increasing bank). Most preferred of the two is the constant bank method in which the airspeed is decreased and the angle of bank is held constant, until the aircraft stalls. It is the most preferred because the potential violence of any accelerated stall is largely governed by the increasing g load and airspeed.

c. Performing recommended constant bank method. First, review the techniques described for wing level stall tests card and apply them here as well. If you are not spin-qualified and comfortable, hire a professional test pilot for these tests. Start with light forward CG. The amount of fuel in the tanks while performing the stall test should be enough fuel for 1 hour minimum.

(1) Normal takeoff and climb to 8,000 feet AGL.

(2) Verify engine readings in the green.

(3) Trim airplane to 1.5 times estimated stall speed.

(4) Set the flaps (and landing gear) appropriate to test.

(5) Power to idle (carb heat if applicable).

(6) Establish—and maintain—a coordinated 30-degree bank turn.

(7) Decelerate at 1 knot/mph per second.

(8) Note positive stick/yoke force: it should increase.

(9) Note control reversal: abort if evident.

(10) Note speed of pre-stall buffet.

(11) Recover, climb to starting altitude, and continue series until complete.

(12) At stall, note indicated airspeed, pitch changes, roll direction, and amount.

(13) Recover, climb to starting altitude, and continue series until complete

(14) You should have a detailed description of the expected behavior in an accelerated stall available (either from the kit manufacturer or through design analysis) prior to beginning the test. The objective is to verify (or not) that the behavior of your aircraft matches the expected behavior.

d. Make separate test flights to evaluate the airplane's performance at different weights and CG locations. Start with lighter gross weight and forward CG locations. Each test series includes six runs, left and right coordinated turns with the indicated flap settings. If your airplane has retractable gear, run the series with the gear up and down.

(1) For each stall test fly the aircraft at a safe altitude (8,000 feet AGL or as appropriate for aircraft type, in smooth air), trim the airplane to 1.5 times the predicted stall speed and set the flaps as required for the test (this should be slower than VFE).

(2) Apply carburetor heat (if required), pull the power to idle, and establish a coordinated turn in a 30-degree bank; ensure the slip/skid ball is centered. Reduce speed to 10 knots/mph above the straight and level stall speed for that flap setting. Then decelerate at 1 knot/mph per second.

(a) As the airplane slows, make sure it requires an increasingly greater stick/yoke pull force. If the force lightens or changes to a push force—abort the test. This may indicate an aft CG location or insufficient elevator authority. Either of these may cause the nose to pitch up at stall.

(b) As the airplane slows, normal control inputs should maintain the 30-degree bank attitude and nose position. When you feel the pre-stall buffet, note the speed, roll level, and recover to straight and level flight.

NOTE: Stalling the airplane is a personal decision that should be based on the wing drop it exhibited in your wings-level stall tests. Accelerated stalls usually exacerbate this roll, especially when you're turning to the direction the wing drops. Even a properly rigged airplane may roll up to 60 degrees into the turn, or up to 30 degrees in the opposite direction. If the possibility of a roll to 60 degrees is deemed unsafe—do not perform this test.

CHAPTER 6. PUTTING IT ALL TOGETHER: 36 HOURS TO ————?

"Beware of false knowledge; it is more dangerous than ignorance." George Bernard Shaw

SECTION 1. MAXIMUM GROSS WEIGHT TESTS

6-1. OBJECTIVE. To develop aircraft performance data across the weight and CG ranges.

a. Up until this point, all tests have been performed well below the test aircraft's maximum gross weight, with the possible exception of single seat aircraft designs. A complete series of flight tests at **maximum gross weight** from stalls, rates of climb, angles of climb, stability, retraction tests, slow flight, through accelerated stalls should be investigated.

b. These tests should demonstrate that the aircraft has been successfully flown throughout the CG range, and will operate in and at the full range of aircraft weights from minimum to full gross weight. The findings should be documented in the aircraft's flight manual.

c. Each phase of the testing should be done slowly, incrementally, with the same careful attention to detail that should characterize all the flight testing.

d. Increases in the aircraft weight should be done in a series of steps. Usually, 20 percent increments of the maximum payload (e.g., sandbags, lead shot) are added in the aircraft to simulate passengers or baggage weight. The pilot should carefully weigh and secure the ballast. A new weight and balance and CG location must be worked for each new increase in weight. Stop testing when the aircraft's maximum gross weight is reached.

e. The testing up to this point has been done at, or near, the forward CG limit. During these tests, the CG should be slowly, but progressively, moved aft between each test flight. Limit the change to the CG range to about 20 percent of the range. Again, the pilot should weigh the ballast and work a new weight and balance for each flight. With each CG change, the aircraft longitudinal static stability and stall characteristics should be carefully evaluated by using the same technique discussed earlier. Stop testing when the designer's or kit manufacturer's aft CG limit is reached.

f. If the aircraft develops either a neutral or negative longitudinal stability problem, or the aircraft displays unsatisfactory stall characteristics at any CG location being tested, STOP FURTHER TESTING!

g. These tests should confirm the designer's aft CG limit or establish the last satisfactory aft CG location. If the aft CG range is not satisfactory, consult with the kit manufacturer, aircraft designer, or a flight-test engineering consultant.

h. The pilot should avoid the temptation to take a live ballast weight up for a ride for three reasons:

(1) The aircraft has not been proven safe for the higher gross weights.

(2) The pilot and passenger are at great risk. It is a sure sign the pilot has become complacent and sloppy in his flight-test program.

(3) In most cases unless otherwise approved by the FAA the pilot will be in violation of the Operating Limitations for Phase I flight testing that if discovered will result in an enforcement action.

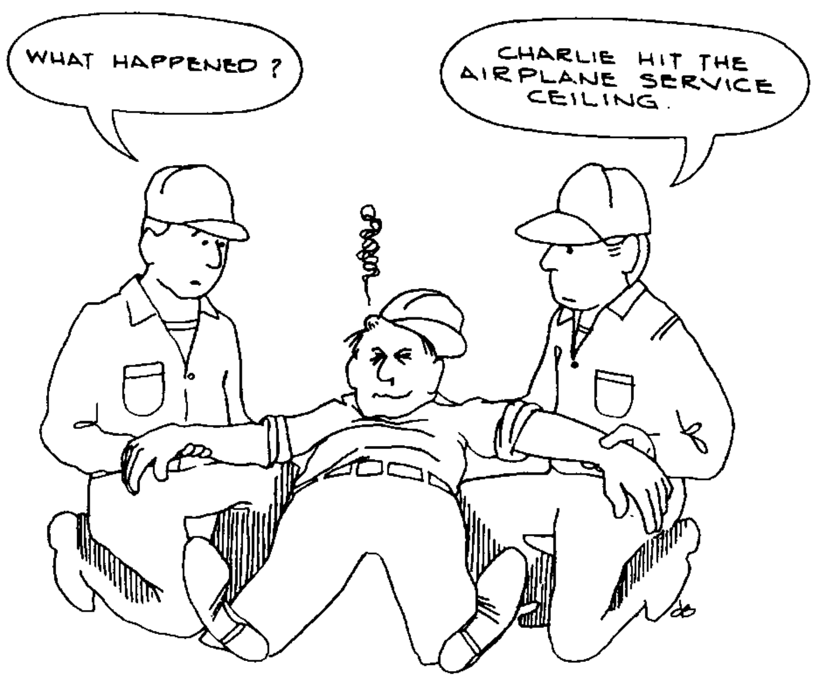
i. Pilots should ensure that the added ballast weight in the cockpit is secured. A seat belt over some sand bags will not stop the weight from shifting and getting loose in a cockpit. The last thing a test pilot needs is a 20-pound lead-shot bag free in the cockpit during a climb test, a landing, or a spin. Tie each weight down individually, and cover all the weights with a cargo net.

j. Ensure the ropes/nets and airframe attach points are strong enough to take the added load. Make sure the passenger seat can take that much localized weight safely.

k. The maximum gross weight test results should be recorded in the flight manual. If there are any changes to the stall speed initially marked on the airspeed indicator, it should be changed to reflect the aircraft stall speed at maximum gross weight.

SECTION 2. SERVICE CEILING TESTS

"Man is made for error; it enters his mind naturally and he discovers a few truths only with the greatest effort." Frederick the Great



6-2. OBJECTIVE. To determine the highest altitude at which an aircraft can continue to climb at 100 feet per minute (service ceiling).

a. Pilots who wish to determine the actual service ceiling of their aircraft are offered the following suggestions:

(1) Ask the local FSDO to amend the Operating Limitations to permit a climb to the aircraft's service ceiling, if that altitude is above 18,000 feet.

(2) Contact the local Flight Service Station (FSS) or ATC facility, and reserve a time and airspace to make the test.

(3) Install a transponder (refer to part 91, § 91.215) or get a waiver.

(4) Install a portable oxygen bottle, if plans are to go above 12,000 feet. (Recommend the pilot becomes familiar with the symptoms and cures of hypoxia and hyperventilation.)

(5) Review the engine manufacturer's mixture leaning procedures.

(6) Maintain communications with an air traffic facility at all times.

b. The climb to the aircraft service ceiling should be made in a series of step climbs during which engine performance, temperatures and pressures are recorded. At the slightest indication of engine performance or aircraft control problems, the pilot should terminate the test and return to the airport.

SECTION 3. NAVIGATION, FUEL CONSUMPTION, AND NIGHT FLYING

"That's one small step for a man, one giant leap for mankind." Neil Armstrong

6-3. OBJECTIVES. To ensure all the small but important aspects of flight have been tested and found reliable.

a. The Magnetic Compass. The magnetic compass should have been checked for accuracy prior to the first flight. However, the addition and removal of equipment, changing of wire bundle routing, and other airframe modifications may have affected the accuracy of the instrument. The following recommendations are offered:

(1) The magnetic compass can be checked for accuracy by using a compass rose located on an airport, or using a hand held "master compass." The master compass is a reverse reading compass with a gun-sight mounted on the top of it. With the aircraft facing north and the pilot running the engine at 1,000 rpm, a second individual standing 30 feet away facing due south "shoots," or aligns, the master compass with the aircraft's centerline. Using hand signals, the pilot aligns the aircraft with the master compass. The pilot then runs the aircraft engine up to approximately 1,700 rpm to duplicate the aircraft's magnetic field and reads the compass.

NOTE: Conventional gear aircraft builders will have to position the magnetic compass in a straight and level position for this test. Raise the tail or mount the compass level with the horizon.

(2) If the aircraft compass is not in alignment with the master compass (start at north), correct the error by adjusting the north/south brass adjustment screw with a non-metallic screwdriver (can be made out of stainless steel welding rod, brass stock, or plastic) until the compass reads correctly. Go to the reciprocal heading (south) and remove half the error. On the east/west headings, use the other brass adjustment screw to make the corrections using the same procedures that was used to correct the north/south errors.

(3) Check again for errors at each cardinal heading. Record the last readings and prepare a compass correction card. The maximum deviation (positive or negative) is 10 degrees on any one heading.

(4) If the compass cannot be adjusted to meet this requirement, install another one. If the new compass is not available, try a different location in the cockpit, away from all ferrous metals and electrical bundles.

NOTE: A common error that affects the compass's accuracy is the mounting of magnetic compass on/in the instrument panel with steel machine screws and nuts rather than brass.

(5) If the aircraft has an electrical system it is recommended that two complete compass checks be made, one with all electrical accessories on (e.g., radios/navigation lights), and one with all electrical accessories off. If the deviation in level flight is more than 10 degrees on any heading with the accessories on, make up a separate compass correction card that shows the magnetic heading with the equipment on.

(6) Record the findings in the aircraft's flight manual and create a compass correction card, mounting it near the magnetic compass in the cockpit. Make two cards; one with radios on and one with radios and non-essential electrical accessories off.

b. Very High Frequency (VHF) Omni-directional Radio Range (VOR) Check. The best guide to check the accuracy of the VOR on board equipment is the VOR Receiver Check found in the Airman's Information Manual (AIM), available online at: http://www.faa.gov/air_traffic/publications/ATpubs/AIM/index.htm. The following is an abbreviated summary of the VOR procedure in the AIM.

(1) For a ground test of the VOR, you must use a VOR test facility (VOT). To use the VOT service, tune the VOR receiver to the VOT frequency, normally 108 MHz. With the course deviation indicator centered, the omni bearing selector should read 0 degrees with the To/From indicator showing "from," or the omni-bearing selector should read 180 degrees with the To/From indicator showing "to." The maximum bearing error should never be more than four degrees.

NOTE: You can find the VOT facilities closest to the flight-test location in the FAA's Airport/Facility Directory publication, available in digital format for a charge from the FAA at http://www.faa.gov/air_traffic/flight_info/aeronav/productcatalog/digitalproducts/dafd/, or by contacting a FSS.

(2) For the airborne test, select a prominent ground point along the selected radial, preferably more than 20 miles from the VOR. Maneuver the aircraft directly over the point at a reasonably low altitude.

(a) Note the VOR bearing indicated by the receiver when over the ground point. The maximum permissible variation between the published radial and the indicated bearing is six degrees.

(b) If the aircraft has dual VORs, the maximum permissible variation between the two receivers is 4 degrees.

c. Fuel Consumption. The amount of fuel consumed is a good indication of how much the engine is working for each rpm produced. For a new or recently overhauled engine, the fuel consumption should improve each flight hour until the engine finishes its break-in period (i.e., after approximately 100 hours of operation).

(1) To determine the aircraft fuel consumption, lay out a racetrack course with 8- to 10-mile legs. If the aircraft has one fuel tank or cannot switch tanks, do the following: Determine the approximate fuel burn to reach 1,000, 3,000, 5,000, 7,000, and 9,000 feet of altitude. With full tanks, climb to 3,000 feet and run the racetrack course for half an hour at 55 percent power.

(2) Land and measure the fuel used by dipping the tanks with a calibrated fuel stick, or by adding measured amounts of fuel to the tank until the tank is full. Subtract the approximate fuel burn to altitude, and multiply the remainder by two to get the fuel burn per hour.

(3) The tests are much easier and the results more accurate if the aircraft has two independent fuel tanks. Take-off on one tank and switch to the opposite tank at the test altitude. At the completion of the test, switch back to the first tank; land and measure the amount of fuel added in both tanks and multiply the quantity by two to get the amount of fuel used per hour.

(4) Run the same test at 65 percent and 75 percent power at the same altitude, using the same procedures. Move up to the next altitude and run the same tests.

d. Night Operations. You should conduct night operations during Phase II using the aircraft's FAA operating limitations and limiting operations to normal climbs and descents, such as rates of 500 feet per minute, pitch angles of less than 5 degrees, straight and level flight, and coordinated turns of no more than 20 degrees of bank angle. However during Phase I there are some checks you should perform prior to accomplishing night operations in Phase II.

(1) Some night testing requirements should be determined on the ground during Phase I. For example:

(a) The electrical load review of lights, pumps, instrumentation, and avionics did not exceed 80 percent of the aircraft's charging system capacity.

(b) The cockpit instrumentation lighting is adequate and was tested for reliability of operation during daytime flights.

(c) The pilot has at least 30 minutes of night-time practice taxiing the aircraft. The pilot needs this practice to familiarize the pilot with a different operating environment. Do not exceed engine operating temperatures during taxiing.

(d) The position and brightness of instrument panel lights, anti-collision strobe lights, and rotating beacons will not adversely affect the pilot's night vision.

(2) Once Phase I flight testing is complete the main concern for initial night testing during Phase II should be the availability of a horizontal reference, such as a bright moon or artificial horizon.

(3) Before every night flight, place a reliable flashlight with fresh batteries and a set of flight-test plan procedures on board.

(4) The first actual night flight should be conducted with a single pilot and no passengers on board.

(5) A suggested night flight-test plan is a series of takeoffs and landings and traffic pattern entries and exits. The tests should begin while there is still enough light to read a newspaper and transition to true night flying. The actual night flight will consist of an evaluation of the effectiveness of the taxi/landing light system during taxi, takeoff, and landing. The pilot should note any glare on the windshield or light flicker on the instrument panel.

CHAPTER 7. THOUGHTS ON TESTING CANARD TYPE AMATEUR-BUILT AIRCRAFT

"FLY." Jonathan Livingston Seagull

SECTION 1. CANARDS

7-1. OBJECTIVE. To discuss canard flight characteristics.

a. Canard configured aircraft generally fall into two categories: the LongEze design (pusher prop, tandem seats) and the Quickie (Q2) design (tractor prop, side-by-side seats). Canard configured aircraft do not "stall" in the conventional sense. All successful "loaded canard" designs have the angle of incidence (AOI) of the canard set higher than the main (rear) wing.

b. As the airplane's angle of attack (AOA) increases, the canard should stall first, lowering the AOA of the main (rear) wing. Since the rear wing doesn't stall, a characteristic "buck" or "nod" takes place. Full aft stick results in the canard alternately stalling and flying, while the rear wing never reaches its critical AOA and continues to fly. This self-limiting stall characteristic prevents spins in a properly designed and built canard aircraft. You should note that the accident rate for canard designs are about the same as conventional designed amateur built aircraft because of the following:

(1) During takeoff, the transition from ground roll to flight can be a more critical procedure in some canards as compared to more conventional designs.

(2) Some canards with combinations of CG and pitch control sensitivity will be more likely to over rotate at lift-off.

(3) Some canards have less visible airframe structure in front of the pilot and in his peripheral vision. Others have more than enough. These differences in design can produce a different reference frame for pilots with many hours of conventional aircraft time and may cause initial errors in pitch attitude, such as the nose too high on takeoff and landings.

(4) In addition, canard aircraft by design have very different takeoff characteristics than conventional configured aircraft. Canard aircraft with pusher propellers need a substantially higher rotation speed on takeoff.

(5) To rotate a conventional design aircraft, all that is required is enough airspeed to provide sufficient control to attain a positive angle of attack due to the long moment arm from the main gear (the axis of rotation) to the tail, a relatively small amount of lift is required. This lift, generated at a relatively low airspeed, makes it possible to rotate the aircraft into the takeoff position slightly below flying speed. Allow the aircraft to accelerate to flying speed and lift off.

(6) In contrast, the canard nose wheel will stay firmly on the ground until an airspeed is reached at which the canard, with full up elevator, can generate enough lift to equal the following:

(a) The load carried by the nose wheel, plus

(b) The nose down moment caused by the friction of the nose and main gear tires with the surface, and the down-thrust vector provided by the propeller during the takeoff roll.

(7) Since the main wing may reach flying speed before the canard, the nose wheel will stay firmly on the runway until takeoff speed is reached. Rotation will then occur, and the aircraft will literally jump off the ground.

(8) Canards with a thrust line above the CG will have appreciable pitch trim change with power. Forward stick motion is required when power is reduced. While this may not be of any consequence to an experienced pilot, it can be a serious surprise to an unwary and inexperienced pilot. This unfamiliar flight characteristic might cause pilot-induced pitch oscillations with disturbing consequences under some conditions (e.g., an aborted takeoff).

(9) Due to its unique design, the canard aircraft needs a higher nose up attitude when landing compared to conventional configured aircraft. Many canard pilots are reluctant to raise the nose high on landing due to the limited forward visibility while the nose is up. Consequently, many canard pilots tend to make their approach angle shallow. This shallow angle results in approach speeds quite a few knots faster than what is necessary. For pilots who prefer visibility to shorter runways, it is recommended that canard designed aircraft be tested on runways a minimum of 1,000 feet longer than what would be used for a conventional aircraft of the same HP and performance capability. Longer runways should be used until the pilot becomes more experienced with the landing characteristics of the aircraft.

(10) If the nose is held at a too high an angle on landing, the canard will stall while the main wing is still generating lift. The stalled canard will drop the nose rapidly onto the runway with enough force to damage the nose gear.

(11) Quickie (tractor engine designs) configured canard designs have a limited ability to rotate nose up while on the ground. This tends to increase takeoff speeds because the canard and the main wing angle of attack are limited while the aircraft is on the ground. That is why this design appears to “levitate” off the ground without much apparent pitch change.

(12) Some canard designs are very sensitive to rain or other types of contamination on the leading edge and/or top of the airfoil. Contamination in the form of water droplets, frost, crushed insects, or even poorly applied paint will disturb the laminar flow over the canard and lift is lost. When decreasing lift over drag (L/D) performance, the chances for an accident increase.

SECTION 2. FLIGHT TEST CONSIDERATIONS.

7-2. GENERAL. Technically, a canard type aircraft cannot stall, or at least it will not stall in the normal fashion. A pilot testing the aircraft for stability characteristics should approach such testing with caution in mind.

a. Under certain conditions, usually consisting of aft CG problems, the main wing may stall before the canard surface. In this case, extreme pitch-up can occur until the canard surface or strakes stall. The aircraft would then pitch down to a near-level attitude, however the airspeed would be approaching zero and the angle of attack could approach or exceed 45 degrees. This condition (high-alpha) could be so stabilized, with the aircraft in a deep stall, that recovery might not be possible.

b. Testing for pitch stability in a new design or a just-completed aircraft built from a kit or from plans is a requirement the pilot needs to consider prior to carrying passengers. Pitch stability tests are conducted to ensure that the aircraft does not exhibit any dangerous flight characteristics but must be approached and conducted in a logical and sensible manner.

(1) Positive pitch stability is exhibited when the aircraft trimmed for hands off level flight, returns to that state when a control force is applied and released.

(2) Neutral pitch stability is achieved when the aircraft remains in the pitch attitude attained when a control force is applied.

(3) Negative pitch stability is demonstrated when the aircraft departs from the pitch attitude attained when a control force is applied and continues to increase in amplitude.

c. The aircraft should be weighed and the CG carefully calculated. At the same time, determine the weight needed and the moment calculated to load the aircraft at the most forward and aft CG limits recommended by the designer. Beginning at the most forward CG, trim the aircraft to a hands off condition and slowly reduce the power, maintaining altitude by increasing pitch attitude. When the stick reaches the full aft position, momentarily release the back pressure followed by full aft stick. The aircraft, in demonstrating positive stability, should return to its original pitch attitude and remain there. The aircraft should display positive stability characteristics.

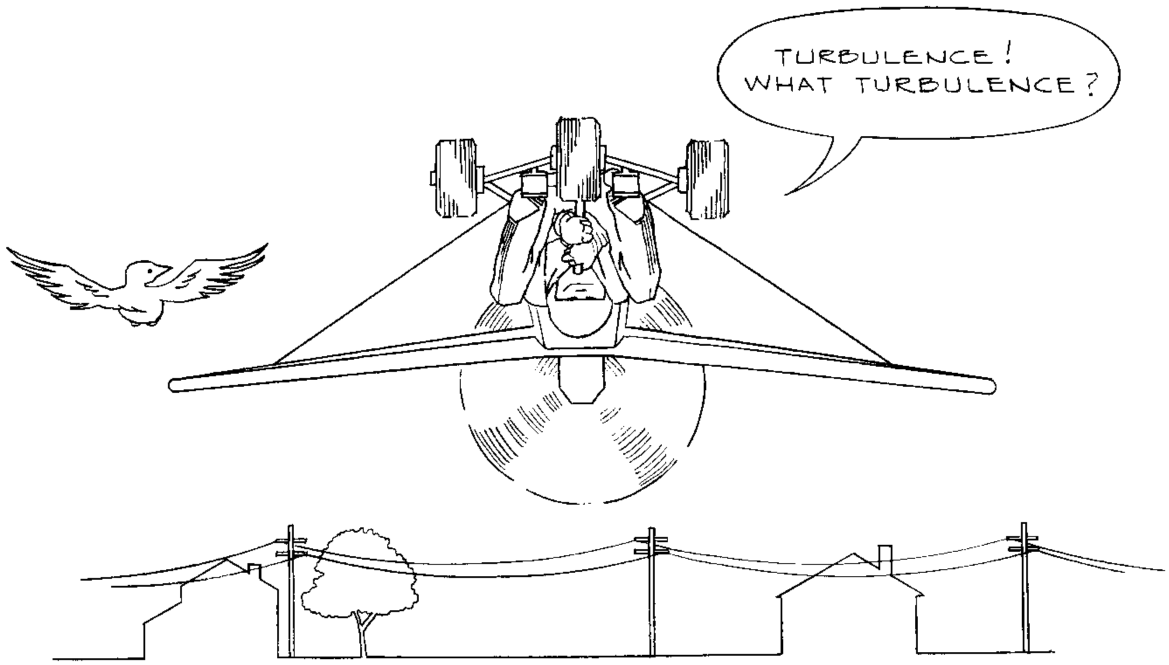
d. Other tests may be conducted by adjusting the CG further aft and observing the tendency of the aircraft. At some point near the aft CG limit, you may experience neutral stability, or the point where the aircraft no longer recovers by itself from the upset. Moving further aft in the CG range from this point will cause the aircraft to diverge from the trim path in the direction of the upset (neutral stability).

e. Some designers and builders have installed adjustable, moveable ballast containers in the aircraft to allow the CG to be adjusted forward or aft during flight. If testing is to be accomplished outside the recommended range, it is advisable to consider the installation of a ballistic recovery system or spin parachute system. In addition, the pilot should make a decision about leaving the aircraft if the test becomes unmanageable.

CHAPTER 8. ULTRALIGHT AIRFRAME INSPECTION

"You can learn 10 things by learning one." Japanese proverb

SECTION 1. DIFFERENCES



8-1. OBJECTIVES. To serve as additional resource for ultralight test pilots and to help the new owner develop a flight-test plan for the ultralight.

8-2. DEFINITION. The term "ultralight" means a fixed wing vehicle powered by a conventional 2- or 4-cycle, gasoline-powered engine, and is operated under 14 CFR part 103. It has one seat and does not exceed 254 pounds, excluding floats and safety devices. In addition, the ultralight can be unpowered, in which case the weight is restricted to 155 pounds. The powered ultralight's fuel capacity can't be more than five U.S. gallons. The vehicle should not be able to exceed 55 knots calibrated airspeed at full power and level flight and can't exceed a power-off stall speed of 24 knots calibrated airspeed.

a. Many in the general aviation community view amateur-built and ultralights as one and the same design category, therefore all flight testing procedures should be identical. While in many cases this assumption is true, there are several major differences between the two designs.

(1) Most ultralights are assembled from complete kits, unlike amateur-built aircraft of which the major portion (51 percent) of the aircraft and its component parts are manufactured by the builder. Most of the kit/ultralight manufacturer's pilot operating handbooks/flight manuals are usually accurate and address the majority of the information covered in the first eight chapters of this AC. The FAA recommends the POH always be consulted by the new owner prior to flight.

(2) The changes in ultralight ownership are more frequent than amateur-built and general aviation aircraft ownership. Although the ultralight is "used," the new owner is usually unfamiliar with its operating characteristics. A comprehensive flight testing/training program should be a high priority safety consideration of the new owner.

(3) New flying skills should be developed. Each ultralight pilot/owner should address the effects smaller size, lighter wing-loading, lower weight, and higher drag designs have on low-speed flight.

b. Due to these differences, the FAA recommends that each new ultralight owner design a FLIGHT-TEST PLAN regardless if the ultralight was bought used, and/or the ultralight has a Flight Manual supplied by the manufacturer. The ultralight FLIGHT-TEST PLAN does not have to be as extensive as the one recommended for amateur-built aircraft but should address all flight conditions and emergencies called out in the ultralight's flight manual.

c. With these differences in mind, the next three chapters will address problems associated with both NEW and USED ultralight flight testing. Chapter 8 will address pre-test flight inspection, Chapter 9 will cover engine and fuel system operation and inspection, and Chapter 10 will cover ultralight flight testing.

d. In keeping with that professional approach towards flight testing, it is suggested that a FLIGHT-TEST PLAN and other relevant safety recommendations found in chapters 1 through 7 be adopted by the ultralight owner/operator prior to test flying a new or used ultralight.

SECTION 2. THE TEST PILOT

"There is always a harder way to flight test an aircraft,
but that path does not need to be followed. "
George Kaseote, FAA Test Pilot

8-3. GENERAL. Whether the ultralight is brand new or used, you should properly evaluate it. A new owner should enlist the services of an experienced ultralight flight instructor.

a. The instructor should test fly the ultralight only after it has been properly assembled, inspected, engine run-in, and taxi tests have been performed. It is not recommended that a "new" pilot and a new/used ultralight "learn" to fly together.

b. The test pilot should be experienced and competent. He/she should have made a minimum of 100 solo flights in similar make, model, and type of ultralight and must follow the FLIGHT-TEST PLAN exactly. The FLIGHT-TEST PLAN should examine the ultralight and its performance capability, beginning with the pre-flight inspection and ending only after the test pilot has explored the ultralight's published flight envelope as described in the flight manual.

SECTION 3. PRE-FLIGHT AIRFRAME INSPECTION

8-4. GENERAL.

a. Ultralight owners should remember that the lightweight, thin wall tubing design of an ultralight fuselage/wing structure is particularly susceptible to metal fatigue. When aluminum tubing has been stressed beyond its elastic limit, it takes on a chalky white appearance (corrosion) at the point of highest stress. Warpage and deformation are other signs of high stress points and once discovered, the ultralight should be grounded until the damaged is repaired.

b. The tolerance limit of a tube or fitting can be significantly lowered by over-torqueing a bolt. If a bent or damaged support tube or structure is not repaired, the bend or dent will become a crack, and ultimately the crack will become a structural failure.

NOTE: If a used ultralight has been purchased, it is highly recommended that the owner perform a detailed acceptance inspection on the aircraft assisted by an experienced individual who is familiar with the make and model aircraft. It is also recommended that all existing hardware (e.g., nuts, bolts, springs) be replaced with new aviation quality hardware.

c. If possible, remove the fabric envelope and check the airframe structure underneath for dents, cracks, and corrosion. Check the top and bottom of the spars for compression (wrinkled metal) damage. Double check all wings, landing gear, strut, engine, and tail surface attach points for wear, elongated holes, or damage.

d. If any previous repairs are found, check with the manufacturer to see if damage in that area can be repaired and if the repair that was made is airworthy.

8-5. CHECKLIST. Each ultralight FLIGHT-TEST PLAN should include a pre-flight inspection CHECKLIST. The CHECKLIST should include a step-by-step approach to inspection that covers all the manufacturer inspection items as well as the following suggested items starting at the landing gear.

a. Landing Gear. The landing gear is the last part of the lightweight aircraft to leave the earth and the first part to arrive. Since the majority of these aircraft fly from unimproved strips, the stress on the gear is high. The checklist should include inspection items recommended by the manufacturer and inspection for the following:

(1) The condition of the landing gear attach points, and alignment of the landing gear and wheels to the longitudinal axis of the fuselage. If the attach points are misaligned, the landing gear will not track in a straight line and this will affect takeoffs and landings.

(2) Elongated bolt holes, loose Army/Navy (AN) hardware, bent tubing, condition and attachment of wheels, wheel bearings, tire inflation, tire condition and brakes.

(3) Brake condition and operation, including chafing of brake lines/cables against the gear struts.

(4) Condition and operation of the steerable nose gear, if applicable.

(5) Condition and attachment of the tailwheel/skid, if applicable.

b. Wing Assembly. The vast majority of ultralight aircraft use a man-made sailcloth material stretched over a tubular frame. This type of fabric is susceptible to ultra-violet radiation from the sun. If left unprotected, it can become unairworthy in less than 6 months. The checklist should include the following inspection items:

(1) Ensure the sailcloth has not suffered any tears, or abrasion, due to wear or foreign object damage.

(2) Check the sailcloth for obvious ultraviolet (UV) degrading of fabric strength by examining the condition of the fabric on top of the wing. Compare it to the fabric on the bottom of the wing. If the top wing fabric shows a significant difference in color (faded), the fabric should be tested for strength with a fabric tester (Maule or Quicksilver) to see if it tests within the manufacturer's serviceable limits. If no minimum service limits are listed, the fabric should test out at 46 pounds, or 70 percent or more, of its original tensile strength, whichever is greater, to be considered airworthy. If the fabric fails the tests, it must be replaced before further flight.

(3) Flying and landing support cables should be checked for tension, routing, attach points, and condition. Scrutinize the swaged cable ends. It is recommended that a red reference mark (nail polish works fine) be painted on each of the cables abutting the swaged end. If the cable is growing (i.e., a gap forming between the swaged end and the painted referenced mark), there is an impending failure of the swaged terminal. Do not fly the aircraft until the cable is replaced.

(4) Flight control cables should be checked for frayed wires and proper routing. Run a rag over all of the flying and landing wires and control cables (wings and tail). If the cloth snags, this may indicate a frayed wire which demands further inspection. If possible, bend the cable to form a "U" and inspect for internal broken wires. Also, check the cable pulleys for wear and operation. Extreme wear patterns on pulleys indicate misrouting and must be corrected prior to flight.

(5) Check wing leading/trailing edge, wing struts, aileron, flaps, spoiler hinges and attach points for loose rivets, cracks, elongation, and wear. Ensure that all hardware (nuts and bolts) is of aviation quality.

(6) Ensure that the bungee, or return springs for wing spoilers (if applicable), are serviceable, and will keep the spoiler down flat against the top of the wing when not being deployed.

(7) Check the aircraft's flight controls rigging every time the aircraft is re-assembled. It is recommended that the cables/rigging for easier assembly be color-coded (e.g., red to red, blue to blue).

(8) Check for corrosion on all metal surfaces. Corrosion on aluminum usually appears as a white powder, rough to the touch. On steel parts, corrosion takes the common form of rust.

Dissimilar metal corrosion occurs when two different types of metal make surface contact. To obtain additional information on corrosion and treating it, refer to the current edition of AC 43-4, Corrosion Control for Aircraft.

(9) Make sure the leading edge of the wing and tail surfaces are clean and free of insects, grass, or mud prior to flight.

c. Fuselage Assembly. The fuselage is the backbone of the lightweight aircraft. All the flight and ground operating stresses encountered by the wings, tail, landing gear, and engine are transferred to the fuselage at the attach points. Exercise extra care when examining these high stress areas because failure of any of these attach points and associated hardware will cause catastrophic structural failure.

(1) Flight controls should be checked for proper operation, travel, and condition of the stops. There should not be any sharp bends in the flight control cables.

(2) Check engine controls for proper operation; they should be free of bends and properly secured. Ensure that all control cables are securely clamped to the fuselage to prevent the cable from slipping, hence not transferring the desired movement to the engine control.

(3) Check the instrument panel for security and instruments for attachment, proper operation, and range/limit markings.

(4) Inspect for bent or damaged structural tubing. If a tube is bent, it must be properly repaired or replaced. Straightening out a bend will only work-harden the tube in the damaged area and hasten the time of failure.

(5) Fiberglass structures should be checked for cracks, delaminations, and holes—especially on the bottom of the fuselage.

(6) Examine the following for security and condition.

- Seat, seat brackets, and seat belt/shoulder harness;
- Attach points, clips/rings, brackets or tangs and other hardware; and
- Safety fasteners such as cotter pins or safety wire.

(7) Check the shoulder/seat belt harness for condition and proper operation.

(8) Check the ballistic parachute hardware and mounting assembly (review information in Chapter 1, Section 3).

d. Tail Surfaces. The tail, or empennage group, contains two of the ultralight's three primary control surfaces: the rudder (yaw control) and the elevator (pitch control). In two-axis ultralights, the elevators are the only flight controls on the tail. Special attention must be given to the attach points, hardware, and proper operation for both control systems.

(1) Ensure that the primary controls and trim systems, if applicable, have the proper travel, that control cables are properly tensioned, and that all turnbuckles are safetied.

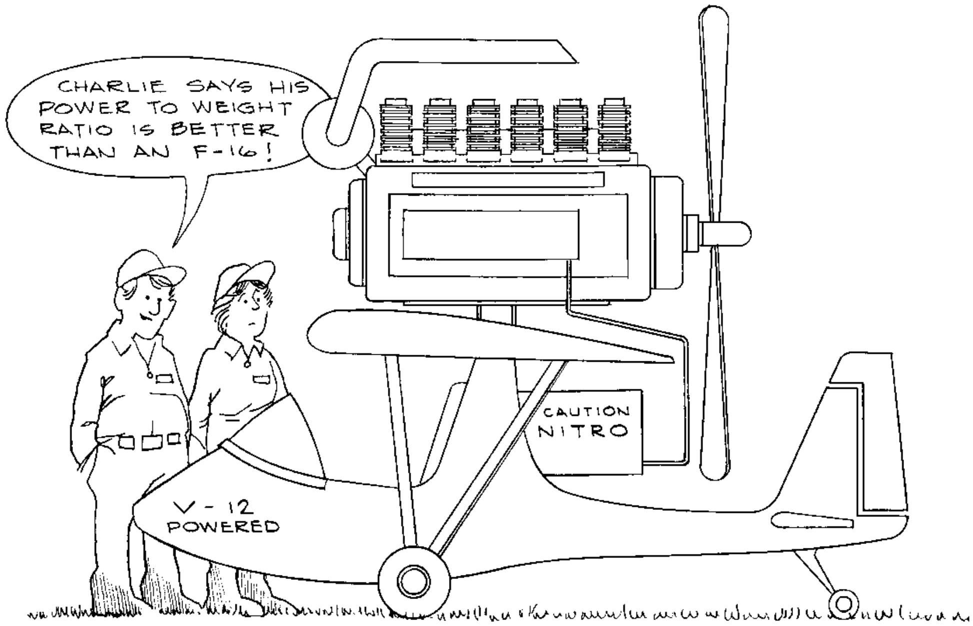
(2) Examine the control hinges and attach points on the elevator and rudder horn for wear, cracking, and elongation of bolt holes, and security of the rudder and elevator stops.

(3) Check the leading and trailing edges of the flight controls for damage.

(4) Check for wear/UV deterioration to the fabric cover.

CHAPTER 9. ULTRALIGHT ENGINE/FUEL SYSTEM INSPECTION

"Do not let ego overcome reason." Al Hodges, Ultralight pilot, Homestead, FL (1994)



SECTION 1. ENGINE INSPECTION

9-1. OBJECTIVE. To provide the amateur builder/ultralight pilot with a suggested engine and fuel system inspection program in addition to the manufacturer's checklist items.

a. Engine.

(1) Check the engine mount, vibration isolation mounts, and attach points before each flight.

NOTE: If slippage marks are painted across the bolt heads, engine mount, and fuselage at the time the mount bolts are torqued, a break in the paint will give advance warning the mount is coming loose. (Again, red nail polish works adequately.)

(2) Check all hose clamps for tightness.

(3) Check for fuel and oil leaks.

(4) Check air filter for condition and attachment

(5) Ensure that all spark plugs are the correct ones, properly torqued. Check that the ignition wires, caps, and plug cap restraints on inverted engines are secured and safetied. Ensure that the kill switch, if applicable, is within easy reach and works as advertised.

(6) Check that the carburetor and the throttle cable are secured and both operate freely from idle stop to full power stop.

(7) Check carburetor boots for cracks that will suck air and may create a lean mixture, high CHT and EGT, and possible engine failure.

(8) Check the fuel on/off valve, fuel filter, and crossover valve for proper operation and position.

(9) Drain the fuel system of water and sediment.

(10) Ensure that the fuel tank is secured, full, and if applicable, contains the proper mix (ratio) of fuel and oil.

b. Exhaust System.

(1) On most 2-cycle engines, the exhaust system is tuned to the engine in order to have the proper amount of back pressure. Sometimes, due to installation demands, the exhaust system must be modified. If modifications are necessary, contact the engine manufacturer before incorporating any exhaust systems changes.

(2) The exhaust system should be mounted on vibration-damping elements and be safety wired. The exhaust system ball-joints should not be mounted under a tension load and they should be lubricated with an anti-seize, heat resistant grease to allow the ball joints to move freely. Some exhaust systems use springs to keep pressure (compression) on the ball-joints. If the engine is so equipped, run a piece of safety wire through the spring and secure it to the exhaust system. This would prevent a broken spring from coming loose and hitting the propeller in a pusher configuration or hitting the top of the wing or tail in a tractor design.

(3) Another approach to prevent propeller damage from broken springs is to lay a bead of high temperature silicon length-wise across the spring. If a spring does break during flight, the silicon bead will hold some or all of the broken pieces of spring material in place until the aircraft lands.

c. Fan Cooling.

(1) It is particularly important that installations of fan cooled engines with enclosed cowlings are designed so that the hot cooling air exits the cowl and cannot recirculate back into the cooling fan intake. If there are any doubts, tests should be carried out by measuring the temperature of the air entering the cooling fan.

(2) In most cases, it is unlikely there will be a problem with cooling belt tension on a new engine. On older engines, however, the belt may have bedded down in the V of the pulley causing a significant reduction in belt tension. If corrosion is present on a pulley, the belt wear rate will be rapid. During the visual inspection of the fan cooling belt and pulley, look for evidence of wear and corrosion on the pulleys.

d. Reduction Drive.

(1) A large percentage of engines used on lightweight aircraft are 2-cycle air cooled engines fitted with an rpm reduction drive. The reduction drive is usually a bolt-on unit which drops the high 2-cycle engine rpm down to a propeller rpm that is more efficient.

(2) To check tension on most V belts on the reduction drive, grab the belt and twist. The belt should allow no more than a half a turn.

(3) Ensure that the reduction gearbox is filled with oil to the proper level in accordance with the manufacturer's instructions and drain plug/filter is safetied.

(4) Grasp the propeller (switch off and spark plugs disconnected) approximately half way down each blade. Try first to move the prop in an up and down motion. Pull away from the aircraft and then push in the opposite direction. No appreciable bearing slop should be detected in the reduction gear bearings.

(5) Eccentricity of the driving or driven pulley will cause variations of belt tension with rotation, possibly leading to rapid failure of the belt and engine or propeller shaft bearings. Remove the spark plugs and rotate the engine slowly by hand for several turns in small steps (approximately 45 degrees of engine rotation per step). There should be no noticeable change in belt tension at any position. Any noticeable change must be investigated further (e.g., by measuring the run out of the engine pulley and propeller shaft pulley with a dial indicator).

SECTION 2. FUEL SYSTEMS

9-2. GENERAL. Many problems with lightweight aircraft engines can be directly traced to the type of fuel used. Many states allow automotive fuels to be sold containing 10 percent alcohol without requiring a label stating so. Alcohol can cause serious problems in aircraft engines so first ensure that the fuel source is a reliable one.

a. Test for Alcohol in Automotive Fuel. Take a thin glass jar, mark it one inch from the bottom of the jar with tape or indelible ink, and fill the jar with water up to that mark. Fill the jar to the top with a sample of the fuel to be tested. There is a clear separation between the water and the fuel. Put the lid on the jar and shake. Let it settle for about a minute and check. If the water line is now above the first mark, the fuel has alcohol in it. Try another source for fuel and do another test.

b. Fuel Primer System. Perform a careful inspection of fuel primer bulbs fitted in suction lines because they deteriorate over time and are a possible source of air leaks, resulting in a lean mixture. Primer bulbs with plastic one-way valves have been known to break loose and completely block the fuel in the fuel line. Positioning the fuel line so the fuel flows upward through the primer bulb will help minimize the possibility of this problem occurring. A permanently fitted fuel pressure gage is recommended because it can check fuel system operation during engine break-in and fuel flow during extreme angles of attack.

c. Filters, Fuel Lines, and Throttles.

(1) Finger screens in fuel tanks should be checked every 10 hours for debris or varnish build up from fuel. Nylon mesh fuel filters are preferred with 2-cycle engines. Paper element filters should be avoided because they may severely and invisibly restrict the fuel flow. This is due to a reaction between water and oil detergents. The fuel filter should be distinctly located, between the fuel pump and the carburetors, to facilitate pre-flight inspection and avoid the possibility of air leaks on the suction side.

(2) Check plastic fuel lines for age hardness, discoloration, and over all condition. Fuel line attach points should be checked before each flight. Always clamp a fuel line at the inlet and outlet. A slip-on line might slip off in flight. Leave a little slack in the fuel lines to minimize cracking from vibration.

(3) If the 2-cycle engine has two carburetors, make sure the throttles are exactly synchronized. If not, one carburetor will run rich while the other runs lean, causing cylinder overheating and a possibility of the piston seizing or being holed.

d. Causes of High Fuel Consumption.

(1) Dirty air filter causes a rich mixture.

(2) Propeller is not matched to the engine.

(3) Carburetor float improperly adjusted.

(4) Fuel pressure set too high.

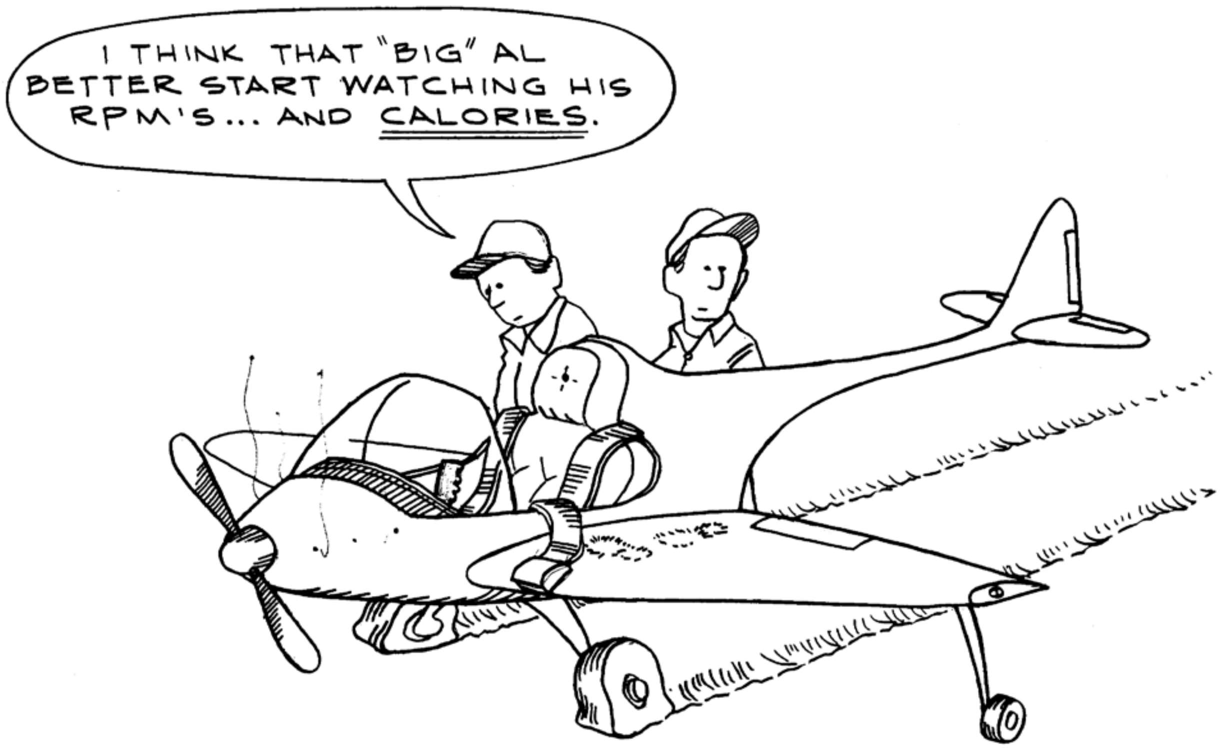
(5) Wrong carburetor jets installed.

(6) Defective float valve.

(7) Extreme vibration (propeller/engine) that keeps float valve open.

CHAPTER 10. ULTRALIGHT TEST FLYING RECOMMENDATIONS

"Hurrying is a visible sign of worry." Arnold H. Glascow



SECTION 1. THREE RECOMMENDATIONS

10-1. OBJECTIVE. To list additional items applicable to ultralights that will need to be addressed in the FLIGHT-TEST PLAN

10-2. RECOMMENDATIONS.

a. Even if the builder/owner or pilot is a B747 airline captain with 20,000 hours in type, the pilot should NOT climb into an ultralight without first receiving flight instruction from a ultralight flight instructor. This sometimes can be done in a two-seat aircraft that is of similar design as the single seat ultralight. The two-seat aircraft will be registered as either special light sport aircraft (SLSA) or an experimental light sport aircraft (ELSA). The ELSA will need a Letter of Deviation Authority (LODA) to be used for flight training. Both SLSA and ELSA will require a properly rated CFI to give the flight training. Ultralights by their very nature are highly susceptible to winds above 15 mph. All ultralight aircraft test flights should be conducted in light or no-wind conditions.

b. Even more so than America's top fighter pilots, ultralight pilots must manage airspeed. Due to its small speed range between stall and full power; high drag and low weight, airspeed should become the single most important concern of the ultralight pilot.

SECTION 2. AIRPORT SELECTION

10-3. OBJECTIVE. To choose an airport to test fly the ultralight.

a. Most ultralights are flown out of unimproved grass strips. Before test flying the ultralight from one of these locations ensure that a windsock or even a flag is installed nearby to give some indication of the wind direction and speed.

b. Carefully examine each airstrip. Note and record in the FLIGHT-TEST PLAN the surrounding terrain, man-made structures, power lines, phone wires, and trees. Record the probability of these factors contributing toward or causing mechanical turbulence during certain times of the day, or presenting a hazard to flight in other ways.

c. Make sure that the strip is orientated towards the prevailing winds. Before selecting a strip, make certain emergency strips are located close-by in case of engine failure.

SECTION 3. TAXIING

10-4. GENERAL. As explained in Chapter 2, taxiing should be designed and conducted to achieve the FLIGHT-TEST PLAN goals. In addition to identifying the ultralight's ground handling characteristics at low and high taxi speeds, braking, monitoring engine operation, and developing pilot proficiency, the FLIGHT-TEST PLAN should consider developing the following:

a. Cross-wind handling characteristics during taxi.

b. Addressing the ultralight's response to rapid changes in power (tractor design versus pusher).

c. Practice the procedures for starting and stopping the engine.

NOTE: When taxiing a nose-gear ultralight, the input response on the rudder bar will be positive, similar to a car. If operating a tail dragger design, anticipate an initially larger input with a decreasing amount of pressure upon entering the turn. If the pilot is slow in getting the pressure off, the larger moment arm-main gear to the tail versus main gear to the nose wheel-will set the ultralight up for a ground loop.

SECTION 4. FIRST FLIGHT DIFFERENCES

"Fly as if angels are watching you and taking notes."
Dr. Anthony Romanazzi, DMD and Ultralight pilot (1994)

10-5. USE OF POWER. One of the biggest differences between a general aviation aircraft and an ultralight is the effect very quick changes in power can have on aircraft speed. In a lightweight aircraft, it is possible to go from cruise speed to a stall in less than 4 seconds. This is due to the low-mass, high-drag configuration, and smaller speed range characteristic of the majority of ultralights. To avoid unplanned stalls, make small power reductions over a longer time period while always monitoring the airspeed.

10-6. CONTROL FEEL. Due to the slow cruise speed and lower weight of ultralights, their flight controls feel light or sensitive. Once the flight control input has been made, however, the rate of response tends to be slower than inputs on faster and heavier aircraft.

10-7. STALLS. Because of their high angle of dihedral, most ultralight stalls tend to be straight forward, particularly during a power-off stall. These ultralights experience little airframe buffeting. The only stall indications the pilot may recognize are the ultralight's slowed forward movement, a rapid decrease in altitude, and controls that are suddenly mushy and mostly ineffective.

10-8. STEEP TURNS. When performing steep turns in an ultralight, the increasing weight (G load) and high drag tends to bleed off energy very quickly. The pilot must monitor the airspeed to avoid inadvertently setting up a stall/spin scenario.

SECTION 5. EMERGENCY PROCEDURES

10-9. ENGINE FAILURES. The single most common emergency in ultralight and amateur-built aircraft is engine failure. When an engine fails, FLY THE ULTRALIGHT! Push the nose down to maintain airspeed, pick the landing field, and try to land into the wind.

a. If the pilot knows the cause of the engine failure (e.g., failure to change tanks) and can easily fix it in flight, they should do so. Do not focus all attention on restarting the engine. If preoccupied with the restart, the pilot may be distracted from flying the ultralight, inadvertently allowing the airspeed to bleed off, and setting the ultralight up for a stall/spin.

b. The best way to prepare for an engine out procedure is to practice, practice, and practice until the real thing is a non-event.

10-10. LOSS OF CONTROL. Another emergency procedure the FLIGHT-TEST PLAN should address is sudden loss of a control function such as ailerons/spoilers (roll), rudder (yaw), or elevator (pitch). In all emergency situations, all corrective control movements should be small and slowly initiated.

a. Loss of rudder authority or a jammed rudder can usually be overcome with opposite aileron. Be advised this is a cross control situation. Large or rapid control inputs could initiate a stall/spin maneuver, especially when the ultralight is in a landing configuration and/or operating at a low airspeed.

b. Loss of ailerons authority usually can be overcome with rudder. The turns should be shallow while avoiding rudder inputs that would generate large yawing movements.

c. Loss of the elevator is the most serious loss of control function a pilot can experience. If the elevator is jammed in one position, or remains in a trail position behind the horizontal stabilizer, the pilot must experiment with engine power to determine whether an increase in power will raise or lower the nose.

10-11. CATASTROPHIC FAILURE.

a. The chance of loss of life or personal injury due to a catastrophic failure of the ultralight can be reduced with a ballistic recovery system (see Chapter 1, Section 3). If control of the ultralight cannot be regained, and the ultralight is equipped with a ballistic parachute, deploy the parachute before running out of time and altitude.

b. The pilot must be sure that activation of the parachute is a better choice than any other options available. Once the canopy is deployed, the pilot becomes a passenger.

c. Even with a canopy deployed, however, the pilot must remain alert to the danger of power lines, trees, rocks, water, and highways below which may obstruct his/her attempt to safely land.

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION

AIRCRAFT IDENTIFICATION:

TYPE/SN.			
ENGINE MODEL/SN.		N NUMBER	
PROPELLER MODEL/SN.		PROPELLER TOTAL TIME	
A/F TOTAL TIME		ENGINE TOTAL TIME	
OWNER			

GENERAL:

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
REGISTRATION/AIRWORTHINESS/OPERATION LIMITATIONS				
AIRCRAFT IDENTIFICATION PLATES INSTALLED				
EXPERIMENTAL PLACARD INSTALLED				
WEIGHT AND BALANCE/EQUIPMENT LIST (updated for each flight)				
RADIO LICENSE				
WINGS: REMOVE INSPECTION PLATES/FAIRINGS				
GENERAL INSPECTION OF THE EXTERIOR/INTERIOR WING				
FLIGHT CONTROL BALANCE WEIGHTS FOR SECURITY				
FLIGHT CONTROL PROPER ATTACHMENT (NO SLOP)				
FLIGHT CONTROL HINGES/ROD END BEARINGS				
FLIGHT CONTROLS PROPERLY RIGGED/PROPER TENSION				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
INSPECT ALL CONTROL STOPS FOR SECURITY				
TRIM CONTROL PROPERLY RIGGED				
TRIM CONTROL SURFACES/HINGES/ROD END BEARINGS				
FRAYED CABLES OR CRACKED/FROZEN/RATCHETING PULLEYS				
SKIN PANELS DELAMINATE/VOIDS (COIN TEST)				
POPPED RIVETS/CRACKED/DEFORMED SKIN				
FABRIC/RIB STITCHING/TAPE CONDITION				
LUBRICATION				
WING ATTACH POINTS				
FLYING/LANDING WIRES/STRUTS FOR SECURITY				
CORROSION				
FOR U/L AIRCRAFT CHECK				
FLIGHT CONTROL BOLTS/PINS FOR SAFETY AND				
WING/STRUT/CABLE ATTACHMENTS AND HARDWARE FOR SAFETY AND CONDITION				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
FUEL SYSTEM: CORROSION				
FUEL LINES FOR CHAFING/LEAKS/SECURITY/CONDITION				
SUMP ALL FUEL TANKS FOR WATER OR DEBRIS				
FUEL CAPS FOR SECURITY				
FUEL PLACARD				
FUEL VALVE/CROSS FEED/FOR OPERATION AND SECURITY				
CLEAN FUEL FILTERS/GASCOLATOR/FLUSH SYSTEM				
INSPECT FUEL TANK VENT SYSTEM				
LANDING GEAR:				
INSPECT STRUTS/TORQUE LINKS FOR ATTACHMENT				
INSPECT STRUTS FOR PROPER EXTENSION				
INSPECT FOR HYDRAULIC LEAKS				
CHECK ALL BUSHINGS FOR WEAR/FREE PLAY				
CHECK LUBRICATION				
INSPECT WHEELS FOR ALIGNMENT				
WHEEL/TIRES FOR CRACKS AND SERVICEABILITY				
WHEEL BEARINGS FOR LUBRICATION				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
INSPECT FOR CORROSION				
INSPECT NOSE GEAR FOR CRACKS AND TRAVEL				
INSPECT TAIL WHEEL FOR CRACKS AND TRAVEL				
PERFORM GEAR RETRACTION TEST/CHECK INDICATOR LIGHTS				
EMERGENCY GEAR RETRACTION SYSTEM				
CHECK TIRE PRESSURE				
BRAKE LINING WITHIN LIMITS				
BRAKE DISKS FOR CRACKS, WEAR, AND DEFORMITY				
BRAKE HYDRAULIC LINES FOR LEAKS AND SECURITY				
FUSELAGE: REMOVE INSPECTION PLATES AND PANELS				
INSPECT BULKHEADS AND STRINGERS FOR POPPED RIVETS				
INSPECT FOR DELAMINATED SKIN/VOIDS (COIN TEST)				
INSPECT THE SECURITY OF ALL INTERNAL LINES				
INSPECT WINDOWS/CANOPY FOR CRACKS AND FIT				
INSPECT DOOR OR CANOPY LATCHING MECHANISM				
INSPECT FIRE WALL FOR DISTORTION AND CRACKS				
INSPECT RUDDER PEDALS AND BRAKES FOR OPERATION AND SECURITY				
INSPECT BEHIND FIREWALL FOR LOOSE WIRES AND				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
CHECK CONTROL STICK/YOKE FOR FREEDOM OF				
CHECK FLAP CONTROL OPERATION				
CHECK CABLE AND PULLEYS FOR ATTACHMENT AND OPERATION				
PERFORM FLOODLIGHT CARBON MONOXIDE TEST				
ENSURE THE COCKPIT INSTRUMENTS ARE PROPERLY MARKED				
INSPECT INSTRUMENTS, LINES, FOR SECURITY				
CHECK/CLEAN/REPLACE INSTRUMENT FILTER				
INSPECT COCKPIT FRESH AIR VENTS/HEATER VENTS FOR OPERATION AND SECURITY				
INSPECT SEATS, SEAT BELTS/SHOULDER HARNESS FOR SECURITY AND ATTACHMENT				
CORROSION				
CHECK BALLISTIC PARACHUTE INSTALLATION PER MANUFACTURER				
RECOMMENDATIONS				
EMPENNAGE/CANARD				
REMOVE INSPECTION PLATES AND FAIRINGS				
INSPECT CANARD ATTACH POINTS FOR SECURITY				
INSPECT VERTICAL FIN ATTACH POINTS				
INSPECT ELEVATOR/STABILIZER ATTACH POINTS				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
INSPECT HINGES/TRIM TABS/ROD ENDS FOR ATTACHMENT				
INSPECT EMPENNAGE/CANARD SKIN FOR				
INSPECT ALL CONTROL CABLES, HINGES AND PULLEYS				
INSPECT ALL CONTROL STOPS				
FOR ULTRALIGHT: CHECK ALL ATTACHMENT POINTS AND CONTROL FOR SAFETY CONDITION				
ENGINE: PERFORM COMPRESSION TEST #1 ___ #2 ___ #3 #4 #5 #6				
CHANGE OIL AND FILTER (CHECK FOR METAL)				
INSPECT IGNITION HARNESS FOR CONDITION AND				
CHECK IGNITION LEAD CIGARETTES FOR				
CLEAN AND GAP SPARK PLUGS				
CHECK MAGNETO TIMING/POINTS/OIL SEAL/DISTRIBUTOR				
INSPECT ENGINE MOUNT/BUSHINGS				
INSPECT ENGINE MOUNT ATTACHMENT BOLT TORQUE				
INSPECT ALTERNATOR/GENERATOR ATTACHMENT				
CHECK ALTERNATOR/GENERATOR BELT CONDITION				
INSPECT CYLINDERS FOR CRACKS/BROKEN FINS/EXHAUST				
INSPECT ENGINE BAFFLES FOR CRACKS/CONDITION				
CHECK FOR OIL LEAKS INSPECT VACUUM PUMP AND LINES				
INSPECT OIL VENT LINES				
INSPECT ALL CABIN HEAT/CARB HEAT/DEFROSTER DUCTS				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
INSPECT CARBURETOR FOR SECURITY & CLEAN INLET				
INSPECT INTAKE HOSES/SEALS FOR SECURITY/LEAKS				
INSPECT THROTTLE/MIXTURE/CARB HEAT/CONTROL FOR PROPER TRAVEL AND SECURITY				
INSPECT CARB HEAT AIR BOX FOR CRACKS/OPERATION				
INSPECT CONDITION OF FLEXIBLE FUEL AND OIL LINES				
INSPECT OIL COOLER FOR LEAKS AND CONDITION				
CHECK EXHAUST SYSTEM FOR ATTACHMENT & CONDITION				
CHECK MUFFLER/INTERNAL BAFFLE/FOR SECURITY				
CHECK EXHAUST PIPES/FLANGES FOR SECURITY &				
REPACK EXHAUST GASKETS AS REQUIRED				
CHECK COWLING FOR CRACKS AND SECURITY				
FOR ULTRALIGHT: CHECK CARB BOOTS ON 2-CYCLE ENGINES FOR CRACKS				
CHECK SAFETIES ON EXHAUST SPRINGS				
PERFORM 2-CYCLE COMPRESSION TEST TO CHECK SEALS				
ENSURE SPARK PLUG CAPS ARE SAFETIED ON INVERTED				
PROPELLER: CHECK SPINNER AND BACK PLATE FOR CRACKS				
INSPECT FOR CRACKS/STONE DAMAGE/NICKS				
CHECK FOR DELAMINATION (WOOD/COMPOSITE BLADES)				
CHECK PROP BOLTS TORQUE/SAFETY WIRE				
CHECK FOR OIL LEAKS (CRANKCASE NOSE SEAL)				
GREASE LEAKS (CONSTANT SPEED PROP)				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
CHECK PROPELLER GOVERNOR FOR LEAKS AND				
CHECK PROP TRACK				
CHECK PROP BALANCE (WOOD PROP)				
ELECTRICAL				
SPARE FUSES AVAILABLE				
BATTERY SERVICED AND FREE FROM CORROSION				
BATTERY BOX FREE FROM CORROSION				
ELT BATTERY FREE FROM CORROSION AND CURRENT				
CHECK LANDING LIGHT OPERATION				
CHECK POSITION LIGHTS OPERATION				
CHECK ANTI COLLISION LIGHT FOR OPERATION				
INSPECT ALL ANTENNA MOUNTS AND WIRING FOR				
CHECK ALL GROUNDING WIRES (ENGINE TO AIRFRAME, WING TO AILERON/FLAP, ETC.)				
INSPECT RADIOS/LEADS/WIRES FOR ATTACHMENT & SECURITY				
INSPECT CIRCUIT BREAKERS/FUSES PANELS FOR				
OPERATIONAL INSPECTION: VISUAL INSPECTION OF THE ENGINE/PROPELLER				
ALL INSPECTION PANELS AND FAIRINGS SECURE				
PERSONNEL WITH FIRE BOTTLE STANDING BY				
BRAKE SYSTEM CHECK				
PROPER FUEL IN TANKS				
ENGINE START PROCEDURES				

APPENDIX 1. SAMPLE CHECKLIST FOR A CONDITION INSPECTION (Continued)

S = SATISFACTORY U = UNSATISFACTORY (correct all unsatisfactory items prior to flight)	Builder/Inspector			
	S	U	S	U
OIL PRESSURE/OIL TEMPERATURE WITHIN LIMITS				
VACUUM GAUGE CHECK				
MAGNETO CHECK/HOT MAG CHECK				
IDLE RPM/MIXTURE CHECK				
STATIC RPM CHECK				
ELECTRICAL SYSTEM CHECK				
COOL DOWN PERIOD/ENGINE SHUT DOWN				
PERFORM OIL, HYDRAULIC, AND FUEL LEAK CHECK				
PAPERWORK: AIRWORTHINESS DIRECTIVES				
RECORD FINDINGS AND SIGN OFF INSPECTION AND				
MAINTENANCE IN AIRCRAFT LOG BOOKS				

APPENDIX 2. SOURCES FOR ACCIDENT/INCIDENT INFORMATION

Accident/incident reports for all U.S.-registered make and model aircraft are available from the following sources:

Federal Aviation Administration (FAA):

http://www.faa.gov/data_research/accident_incident.

National Transportation Safety Board (NTSB):

https://www.ntsb.gov/investigations/reports_aviation.html.

APPENDIX 3. ADDITIONAL REFERENCES ON FLIGHT TESTING

The following references comprise selected additional information sources on flight testing and first flight experiences for amateur-built and ultralight aircraft. This list of informational material may help amateur builders in preparing the FLIGHT-TEST PLAN for their aircraft.

EAA publications are available in the EAA archives, a benefit available to EAA members. Non-members can obtain copies, for a fee, by calling 1-800-564-6322.

Some of these publications are out of print but may be available on auction sites such as eBay.

INDUSTRY PUBLICATIONS: Amateur-Built

Askue, Vaughan, Flight Testing Homebuilt Aircraft, (Ames, IA: State University Press, 1992).

Ariosto, James, "A Two Minute Test-Hop Reveals All Wrongs," Sport Aviation, (May 1970), pp. 29-30.

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____ "After the First Test Flight," Sport Aviation, (April 1988), pp. 27-30.

____ "Flight Testing Homebuilts-Stage One: Making Preparations for Flight Testing," Sport Aviation, (January 1989), pp. 27-30.

____ "Flight Testing Homebuilts-Stage Two: Making the Initial Flight Test," Sport Aviation, (February 1989), pp. 27-30.

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Dwiggins, Don, "Flight Testing Your Homebuilt," Homebuilt Aircraft, (July 1985), pp. 40-43.

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Experimental Aircraft Association, Pilot Reports and Flight Testing, V. 1, pg. 72 (1977). Selected first flight reports and flight testing procedures.

Friedman, Peter, "High Tech-First flight," Sport Pilot, (February 1989), pp. 16, 17, 72, 73.
Goyar, Norman, "Free Insurance and How to Get It," Sport Pilot, j. 5, No. 3 (1989), pp. 44-49.

Heintz, Chris, "The First Flight of Your Aircraft," EAA Light Plane World, (May 1986), pp. 7-9.

____ "Performance Testing Your Aircraft," EAA Light Plane World, (July 1986), pp. 13-15.

Hurt, H. H., Jr., Aerodynamics for Naval Aviators, (California: University of Southern California, 1960 [revised 1965]). NAVAIR 00-80T-80. Issued by the Office of the Chief of Naval Operations, Aviation Training Division.

Jacquemin, G., "Flight-testing for the Amateur," Sport Aviation, (April 1965), pg. 4.

Kerley, Jim, "Thoughts on Test Flying," Sport Aviation, (March 1970), pp. 34-35.

Ladd, Robert W., "The Test Flight of Chihuahua," Sport Aviation, (February 1968), pg. 4.

Macq, Harvey, "Test Flight," Sport Aviation, (March 1960), pg. 3.

Mason, Sammy, Stalls, Spins, and Safety, (New York: Macmillan Publishing Company, 1985).

Mitchell, C.G.B., "Design of the 'Kittiwake' Family of Light Aircraft," (Part 2) Sport Aviation, (March 1969), pp. 36-37.

Rhodes, Mike, "First Flight—Trial by Fire," (Part 1) Sport Aviation, (August 1988), pp. 26, 27, 29.

Smith, Hubert, Performance Flight Testing, (Blue Ridge Summit: Tab Books, Inc. [Modern Aviation Series], 1982), pg. 131.

Sport Aviation, "Pointers on Test Flying Complied by Chapter 32, St. Louis, MO," Sport Aviation, (December 1960), pg. 3.

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Taylor, M. B., "Testing your Homebuilt," Sport Aviation, (January 1977), pg. 24-27.

Tausworthe, Jim, "The Brotherhood of Flight," Sport Aviation, (August 1969), pg. 22.

Thorp, J. W., "Structural Flight Testing," Sport Aviation, (November 1961), pg. 2.

Wendt, H. O., "Designing, Building, and Flight Testing of the Wendt Wh-1 Traveler," Sport Aviation, (March 1973), pg. 10-15.

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Wood, Karl D., Technical Aerodynamics, (New York: McGraw Hill, 1947).

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Cannon, Mike, "Learning to Fly—Again," Ultralight Flying, (June 1988), pp. 5.

____ "Keeping Cool in the Summer Time," Ultralight Flying, (August 1988), pp. 16-17.

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Chapman, John, and Smith, Clark, "Preparing for the In-Flight Emergency," Ultralight Flying, (March 1989), pp. 32.

Demeter, Dennis, "Risk Management," Ultralight Flying, (July 1993), pp. 48-49.

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Grunnarson, Tom, "Getting into Ultralight Float Flying," Ultralight Flying, (April 1989), pp. 27-29.

Johnson, Don, "Getting the Most out of Flight Reviews," Ultralight Flying, (March 1989), pp. 20-23.

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Peghiny, Tom, "Effects of Sunlight on Polyester Sail Cloth," Ultralight Foundation, Volume 2, Number 1, pp. 49-50, (1986).

GOVERNMENT PUBLICATIONS:

FAA Advisory Circulars are available at:
http://www.faa.gov/regulations_policies/advisory_circulars.

AC 20-32, Carbon Monoxide (CO) Contamination in Aircraft—Detection and Prevention.

AC 20-34, Prevention of Retractable Landing Gear Failures.

AC 20-35, Tiedown Sense.

AC 20-37, Aircraft Metal Propeller Maintenance.

AC 20-42, Hand Fire Extinguishers for Use in Aircraft.

AC 20-103, Aircraft Engine Crankshaft Failure.

AC 20-105, Reciprocating Engine Power-Loss Accident Prevention and Trend Monitoring.

AC 20-125, Water in Aviation Fuels.

AC 23-8, Flight Test Guide for Certification of Part 23 Airplanes.

AC 23-16**,** Powerplant Guide for Certification of Part 23 Airplanes and Airships.

AC 90-109, Airmen Transition to Experimental or Unfamiliar Airplanes.

AC 90-116, Additional Pilot Program for Phase I Flight Test.

AC 91-61, A Hazard in Aerobatics: Effects or G-Forces of Pilots.

AC 103-6, Ultralight Vehicle Operations-Airports, Air Traffic Control (ATC), and Weather.

AC 103-7, The Ultralight Vehicle.

FAA Handbooks (current editions) are available at:

http://www.faa.gov/regulations_policies/handbooks_manuals.

Airman's Information Manual (AIM): Official Guide to Basic Flight Information and ATC Procedures.

FAA-H-8083, Airplane Flying Handbook.

FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge.

FAA-H-8083-1 Aircraft Weight and Balance Handbook.

APPENDIX 4. ADMINISTRATIVE INFORMATION

1. CANCELLATION. AC 90-89A, Amateur-Built Aircraft Flight Testing Handbook, dated May 24, 1995, is cancelled.

2. BACKGROUND. We, The Federal Aviation Administration (FAA), along with the Experimental Aircraft Association (EAA), and the United States Ultralight Association (USUA), are concerned and committed to improving the safety record of amateur-built and ultralight aircraft. Past FAA Administrator, T. Allen McArtor, and past EAA President, Paul H. Poberezny, signed a Memorandum of Agreement (MOA) on August 1, 1988, addressing the need for educational and safety programs to help amateur builders test fly their aircraft. This AC lists guidelines for flight testing amateur-built aircraft, using suggestions in the MOA. We have revised this AC to include flight testing recommendations for canard type and ultralight aircraft as part of our continuing efforts to improve the safety record of all types of general aviation aircraft. In 2012 the first Loss of Control Working Group (LOCWG) investigated the causal factors behind fatal accidents arising from a loss of control (LOC) during the approach and landing phases of flight. Loss of Control is the leading cause of fatal accidents in general aviation. From study of a random sample of 90 fatal accidents fitting this profile over the past decade the Working Group recommended 27 safety enhancements (SE), 23 of which were approved. SE-23 is implemented into this AC. As a result of SE-23, there are two major additions to this AC.

- The Type Club Coalition (TCC) coordinated by the EAA developed a best practices guide for when flight tests should be done following a modification to an amateur-built aircraft.
- Testing for center-of-gravity (CG) limits, including lateral, was added to this Advisory Circular.

Two informational FAA updates were added.

- Light Sport Aircraft (LSA) flight testing after a modification is mentioned where appropriate within this AC.
- All references to two seat ultralights have been removed.

3. DEFINITIONS. The following terms are defined for use in this AC.

- **Aircraft.** In this AC, is an amateur built aircraft, SLSA, ELSA, or an ultralight vehicle.
- **Amateur-Built Aircraft.** An aircraft issued an Experimental Airworthiness Certificate under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) part 21, § 21.191(g).
- **Experimental Light Sport Aircraft (ELSA).** An aircraft issued an Experimental Airworthiness Certificate under the provisions of § 21.191(i).
- **Special Light Sport Aircraft (SLSA).** An aircraft issued a Special Airworthiness Certificate in the light-sport category under the provisions of part 21, § 21.190.
- **Ultralight.** A vehicle that meets the requirements of 14 CFR part 103, § 103.1.

4. REQUEST FOR INFORMATION. We have designed this AC as a reference document to help prepare a flight-test plan for an amateur-built or ultralight aircraft. The suggestions and recommendations in Chapters 1 through 6 are for conventionally-designed aircraft with an air-cooled, 4-cycle, reciprocating engine developing less than 200 HP and with a fixed pitch propeller.

- Chapter 7 deals with flight testing recommendations for canard aircraft.
- Chapters 8 through 10 address flight testing considerations for ultralight vehicles under 14 CFR part 103.

Because of many existing amateur-built/ultralight aircraft designs and new designs being introduced each year, we encourage public participation in updating this document. Send comments, suggestions, or information about this AC to the following address:

U.S. Department of Transportation
Federal Aviation Administration
Flight Standards Service (AFS-350)
800 Independence Avenue
Washington, DC 20591

After a review, appropriate comments, suggestions, and information may be included in the next revision of this AC.

5. COPIES OF THIS AC. You can access this AC online at www.faa.gov/regulations_policies/advisory_circulars.