U.S. Department
of Transportation

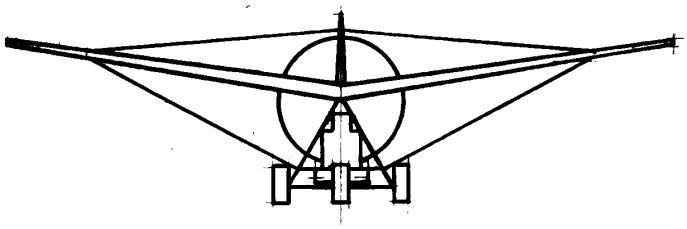
**Federal Aviation
Administration**

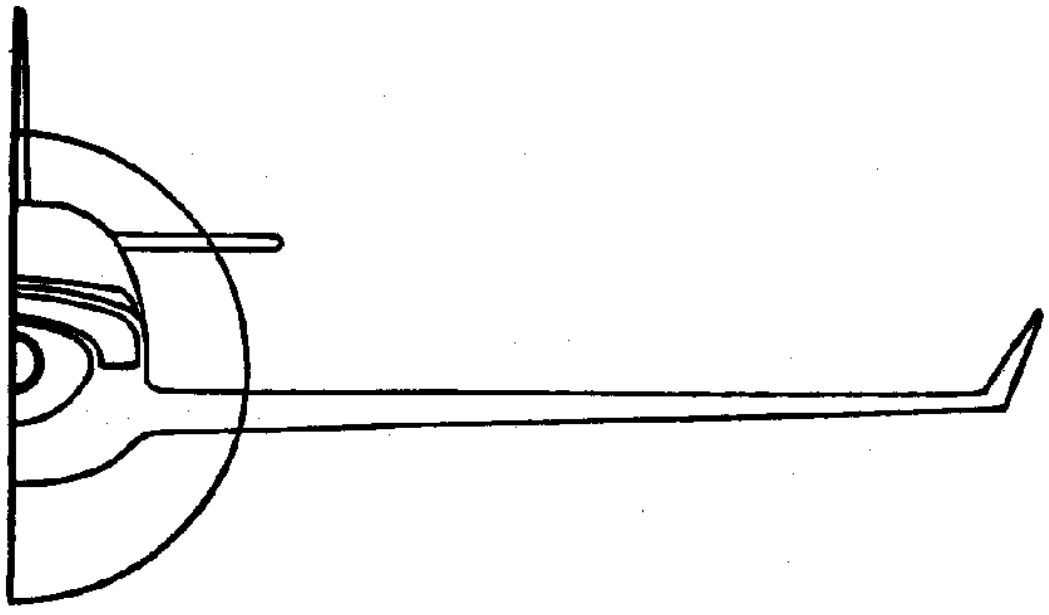
Advisory Circular

DATE: **5/24/95**

AC NO: **90-89A**

AMATEUR-BUILT AIRCRAFT AND ULTRALIGHT FLIGHT TESTING HANDBOOK





Initiated by: AFS-340

U.S. Department
of Transportation

Federal Aviation Administration

Advisory Circular

Subject: **AMATEUR-BUILT AIRCRAFT & ULTRALIGHT FLIGHT TESTING HANDBOOK**

Date: **5/24/95** AC No: **90-89A**
Initiated by: **AFS-340** Change:

1. PURPOSE. This advisory circular (AC) sets forth suggestions and safety related recommendations to assist amateur and ultralight builders in developing individualized aircraft flight test plans.

2. CANCELLATION. AC 90-89, Amateur-Built Aircraft Flight Testing Handbook, dated September 18, 1989, is cancelled.

3. RELATED READING MATERIAL. A list of selected reading material on amateur-built/ ultralight flight testing and first flight experience may be found in appendix 3.

4. BACKGROUND.

a. The Federal Aviation Administration (FAA), 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.

b. The FAA Administrator, T. Allen McArtor, and EAA President, Paul H. Poberezny, signed a Memorandum of Agreement on August 1, 1988, which addressed the need for educational and safety programs to assist amateur-builders in test flying their aircraft. In accordance with that agreement, this AC provides guidelines for flight testing amateur-built aircraft.

c. As part of the FAA's continuing efforts to improve the safety record of all types of general aviation aircraft, this AC has been revised to include flight testing recommendations for canard-type and ultralight aircraft.

5. DEFINITIONS. The following terms are defined for use in this AC.

a. Amateur-built aircraft means an aircraft issued an Experimental Airworthiness Certificate under the provisions of Federal Aviation Regulations (FAR) § 21.191 (g).

b. The term ultralight means a vehicle that meets the requirements of FAR § 103.1.

c. The term ultralight in this AC also means a two-place training vehicle of 496 pounds or less, operating under an EAA or USUA exemption to FAR Part 103.

d. For the purpose of this AC, both an amateur-built aircraft and a ultralight vehicle will be referred to as an ''aircraft.''

6. DISCUSSION.

a. This AC's purpose is the following:

(1) To make amateur-built/ultralight aircraft pilots aware that test flying an aircraft is a critical undertaking, which should be approached with thorough planning, skill, and common sense.

(2) To provide recommendations and suggestions that can be combined with other sources on test flying (e.g., the aircraft plan/kit manufacturer's flight testing instructions, other flight testing data). This will assist the amateur/ultralight owner to develop a detailed flight test plan, tailored for their aircraft and resources.

b. 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 should be adhered to 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. The goals, however, should be the same.

c. The two goals for an amateur builder/ ultralight owner should be as follows:

(1) At the end of the aircraft's flight test phase, the aircraft will have been adequately tested and found airworthy and safe to operate within its established operational envelope.

(2) Incorporation of the flight test operational and performance data into the aircraft's flight manual so the pilot can reference the data prior to each flight.

7. REQUEST FOR INFORMATION.

a. This AC is designed as a reference document to assist in preparing a flight test plan for an amateur-built or ultralight aircraft.

(1) The suggestions and recommendations in chapters 1 through 6 are for conventionally-designed aircraft with an air-cooled, 4-cycle, reciprocating engine that develops less than 200 horsepower with a fixed pitch propeller.

(2) Chapter 7 deals with flight testing recommendations for canard aircraft.

(3) Chapters 8 through 10 address flight testing considerations for ultralight vehicles under FAR Part 103 and two-seat ultralight training vehicles of less than 496 pounds empty weight operating under an exemption to FAR Part 103.

b. Because of the large number of existing amateur-built/ultralight aircraft designs and new designs being introduced each year, the FAA encourages 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-340)
800 Independence Ave, SW.
Washington, DC 20591

c. Suggestions also may be sent to AFS-340 by FAX (202) 267-5115.

d. After a review, appropriate comments, suggestions, and information may be included in the next revision of this AC.

8. TO OBTAIN COPIES OF THIS AC. Order AC 90-89A from:

U.S. Department of Transportation
Property Use and Storage
Section, M-45.3
Washington, DC 20590.

William J. White
Deputy Director, Flight Standards Service

THIS PAGE IS INTENTIONALLY LEFT BLANK, SO THAT THE TOC CAN BE ON PAGE iii PER PLACEMENT IN DOCUMENT.

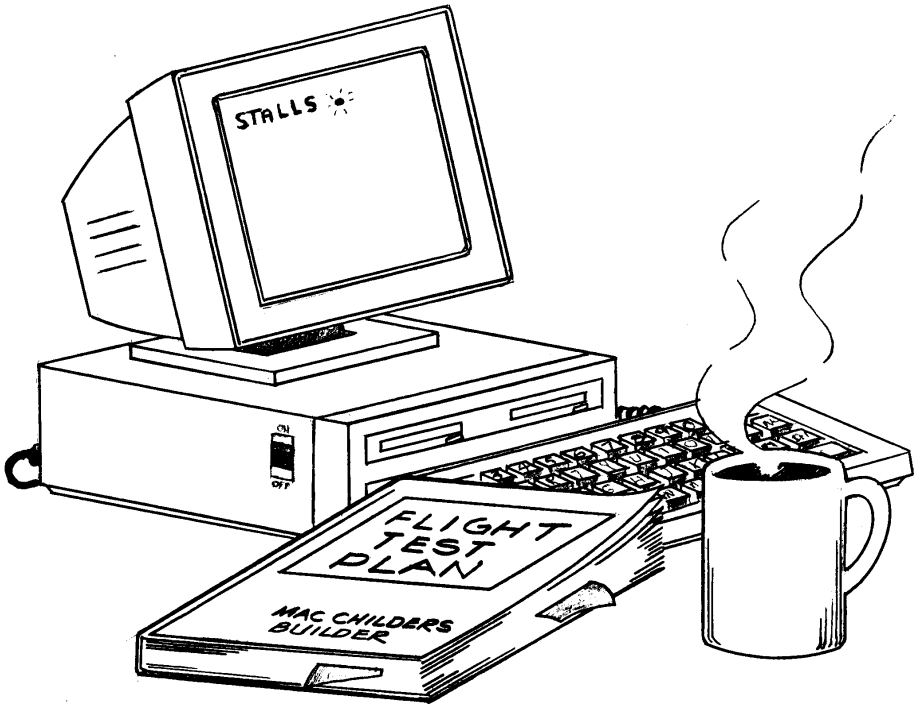
THIS PAGE IS INTENTIONALLY LEFT BLANK, SO THAT THE TOC CAN BE ON PAGE iii PER PLACEMENT IN DOCUMENT.

CONTENTS

CONTENTS—Continued

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)

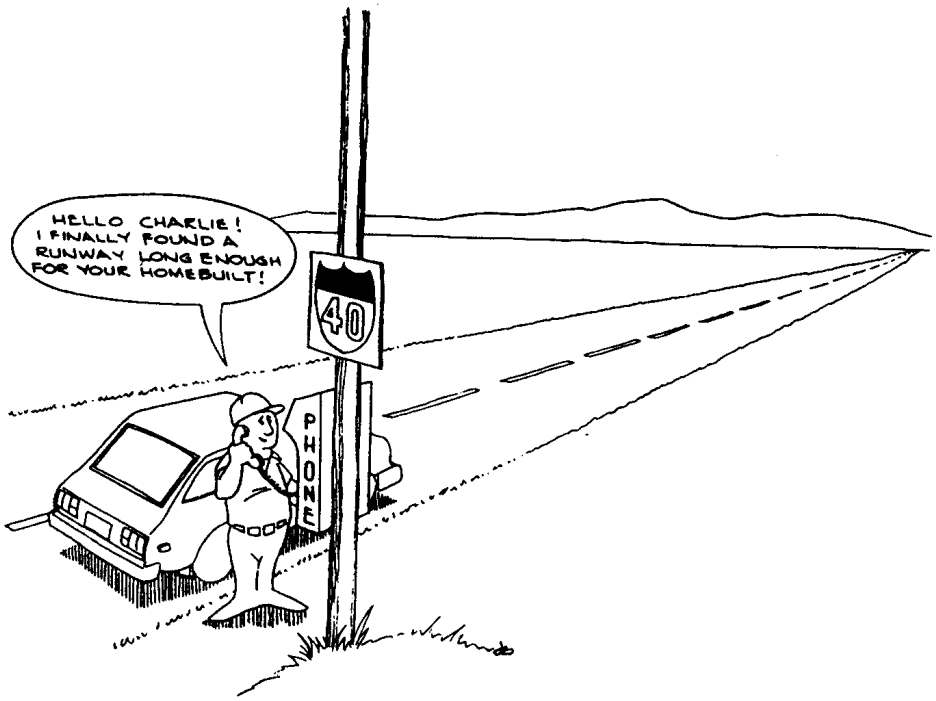
1. OBJECTIVE. A planned approach to flight testing.

a. The most important task for an amateur-builder is to develop a comprehensive FLIGHT TEST PLAN. This PLAN should be individually tailored to define the aircraft's specific level of performance. It is therefore important that the entire flight test plan be developed and completed BEFORE the aircraft's first flight.

b. 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. This data should be used in developing a FLIGHT MANUAL that specifies the aircraft's performance and defines its operating envelope.

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)

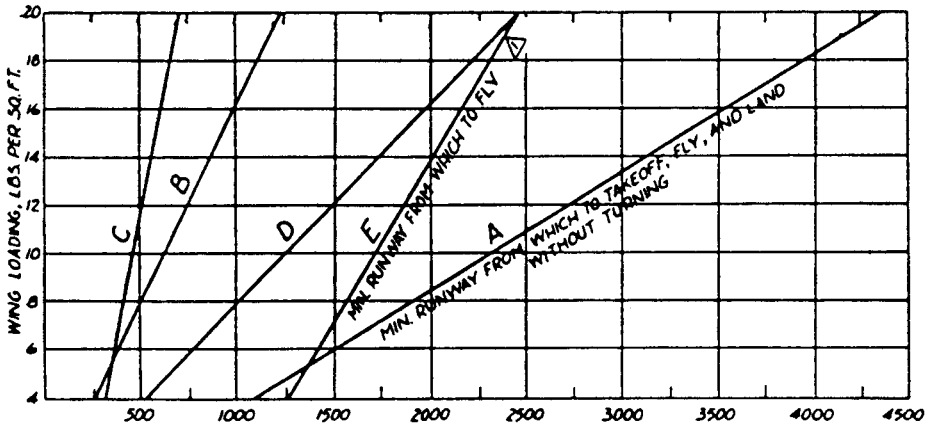


1. OBJECTIVE. To select an airport to test fly the aircraft.

a. 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. To determine an appropriate runway, use the chart in figure 1 (sea-level elevation), or the following rule-of-thumb:

c. The ideal runway at sea-level elevation should be at least 4,000 feet long and 100 feet wide. For each 1,000 feet 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 to allow a wider margin of safety. Other considerations, such as power to weight ratio, wing design, and density altitude, also should be factored into the equation for picking the best runway for the initial flight testing.



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.

Take-off Distance in Feet

FIGURE 1. Runway Length Chart

d. 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.

e. It is advisable to perform flight tests from an airport with an active unicom or tower, even if the aircraft does not have an electrical system or is not equipped with a radio. Even at an uncontrolled field, a communications base should be improvised. For both situations, a hand held radio with aviation frequencies and a headset with a mike and a push-to-talk switch on the stick/yoke is recommended. Good radio communications improves the overall level of safety and reduces cockpit workload.

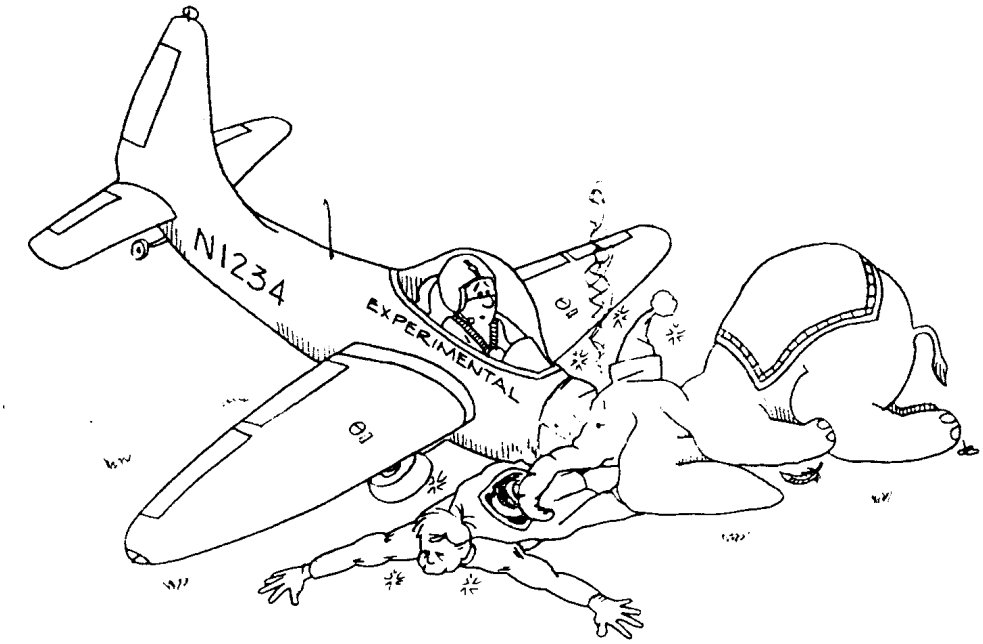
f. The FAA recommends airport selection criteria include the availability of hangar space and ramp areas. These facilities will provide protection from inclement weather and vandalism while the aircraft is being tested, maintained, and inspected.

g. The airport should have a telephone and fire fighting equipment, the latter being in compliance with relevant municipal codes (e.g., fire codes).

h. Explain the Flight Test Program and EMERGENCY PLANS to the airport manager or owner. They may be able to assist the amateur-builder in obtaining temporary hangar space, providing ground/air communications, and supplying 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



1. OBJECTIVE. To develop a FLIGHT TEST PLAN which contain two sets of emergency plans; one for IN-FLIGHT emergencies and another for GROUND emergencies.

a. The IN-FLIGHT emergency plan should address the following:

(1) Complete engine failure or partial failure, especially after take off

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

(3) Fire in the engine compartment or cockpit

b. The GROUND EMERGENCY plan should be developed to train the ground crew and/or the airport fire department crash crew on the following:

(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 and magneto/ignition switch location and **OFF** position

(5) Engine cowling removal procedures to gain access to the battery location or for fire fighting

(6) The battery location and disconnect procedures

(7) Fire extinguisher application and use

(8) How to secure the ballistic parachute system

c. Ground Crew. Every test of an amateur-built aircraft should be supported by a minimum ground crew of two experienced individuals. The ground crew's function is two-fold:

(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, it is suggested the ground crew have a four wheel drive vehicle equipped with a portable radio, first aid kit, metal-cutting tools, and a fire extinguisher. A minimum of one person should be trained in first-aid.

(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) *Suggestion.* For a small donation, some local volunteer fire and rescue companies will provide the amateur-builder with a 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, a medical alert bracelet or card should be carried or worn to alert medical personnel of the condition.

f. Fire Extinguisher. Fire extinguisher's 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 positioned 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 being tested. Some aircraft have forward hinged canopies that are not equipped with quick release pins or have pusher propellers which increase the chance of injury to the pilot while exiting the aircraft. Other aircraft designs may pose no exit problems. If the decision is made to wear a parachute, check that it has been recently packed (within 120 days) by a qualified parachute rigger. Ensure that the chute 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 Chutes. Ballistic chutes are the latest development in dealing with in-flight emergencies. A ballistic chute is attached to the aircraft and when activated, lowers the whole aircraft and the pilot to the ground at the rate of descent of approximately 20 feet per second.

(1) Deployment Scenarios:

(i) structural failure

(ii) mid-air collision

(iii) stall/spin

(iv) loss of control/icing

(v) engine failure over bad terrain

(vi) pilot incapacitation

(2) Installation Considerations: The builder should consider the following when installing a ballistic chute:

(i) Matching the chute with the aircraft's size, weight, and V_{ne} speed (check with the chute manufacturer)

(ii) How the chute will be positioned and mounted

(iii) The chute's effect on the aircraft's weight and balance before deployment and aircraft's touchdown attitude after deployment

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

(v) The routing of the bridle and harness

(vi) The routing of the activating housing

(vii) The placement of the activating handle in the cockpit

(viii) Incorporation of chute deployment procedures in the in-flight emergency plan and emergency check list

(ix) The deployment time, from activation to full chute opening

(3) If a ballistic chute is installed, the builder **should add the appropriate ballistic chute inspection items to the aircraft's pre-flight inspection check list.** The builder also should add the ballistic chute manufacturer's repack/refitting schedule and maintenance inspections to the flight manual and the conditional annual inspection check list.

SECTION 4. TEST PILOT

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

1. OBJECTIVE. To select a qualified individual to be the test pilot.

2. GENERAL. The test pilot should be competent in an aircraft of similar configuration, size, weight, and performance as the aircraft to be tested. If the aircraft's builder is the test pilot, the costs involved in maintaining pilot competence should be budgeted with the same level of commitment and priority that is assigned to plans and materials to complete the project.

3. TEST PILOT REQUIREMENTS.

a. 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. The following suggested number of flight hours are only an indication of pilot skill, not an indicator of pilot competence. Each test pilot must assess if their level of competence is adequate or if additional flight training is necessary. If an individual determines they are not qualified to flight test an unproven aircraft, someone who is qualified must be found.

(1) 100 hours solo time before flight testing a kit plane or an aircraft built from a time-proven set of plans

(2) 200 hours solo time before flight testing for a ''one of a kind'' or a high performance aircraft

(3) A minimum of 50 recent takeoffs and landings in a conventional (tail wheel aircraft) if the aircraft to be tested is a tail dragger

c. The test pilot should:

(1) Be familiar with the airport and the emergency fields in the area

(2) Talk with and, if possible, fly with a pilot in the same kind of aircraft to be tested

(3) Take additional instruction in similar type certificated aircraft. For example, if the aircraft to be tested is a tail dragger, a Bellanca Citabria or Super Cub is appropriate for training. For testing an aircraft with a short wing span, the Grumman American Yankee or Globe Swift is suitable for training.

(4) Be considered competent when they have demonstrated a high level of skill in all planned flight test maneuvers in an aircraft with performance characteristics similar to the test aircraft

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

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

(7) If appropriate, have logged a minimum of 10 tail wheel take-off and landings within the past 30 days

(8) 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.

(9) 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).

(10) 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.

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, contact a local EAA Chapter or EAA Headquarters, (414) 426-4800.

SECTION 5. MEDICAL FACTS FOR PILOTS

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

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

a. Alcohol. FAR Part 91, ''General Operating and Flight Rules,'' § 91.17 requires that 8 hours must elapse from the last drink to the first flight. Test flying an aircraft, however, places additional mental and physical demands on the pilot. 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 judgement, reaction time, and decrease a pilot's tolerance to hypoxia.

b. Anesthetics. Local and dental anesthetic can affect a pilots performance in many adverse ways. It is recommended that a minimum of 48 hours elapse from the time of anesthesia to the time the pilot climbs into the cockpit.

c. Blood Donations. Do not fly for 3 weeks after donating blood. The body needs approximately three weeks for a complete physiological recovery. Although the physical affects 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. Carbon monoxide prevents oxygen absorption by the blood, and exposure to the gas creates vision problems, headaches, disorientation, and blurred thinking (see chapter 1, section 7, paragraph 3 (g) for testing the aircraft for CO contamination).

e. Drugs. Similar to alcohol, drugs will reduce or impair judgement and affect reflexes and hand/ eye coordination. It is a given that the use/abuse of illegal drugs is dangerous and against the law. Prescription drugs and over-the-counter remedies, however, also may be dangerous when combined with flying. The FAA recommends all pilots who must take medication consult with an Aviation Medical Examiner (AME) to understand the medication's affects 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. The 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 can be effective: pinch the nose, close the mouth, and try to force air through the nostrils.

(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, allowing 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, try wetting paper towels with hot water, put the towels in the bottom of a plastic or dixie cup and then 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 Aviation Medical Examiner to understand the affects 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, 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.

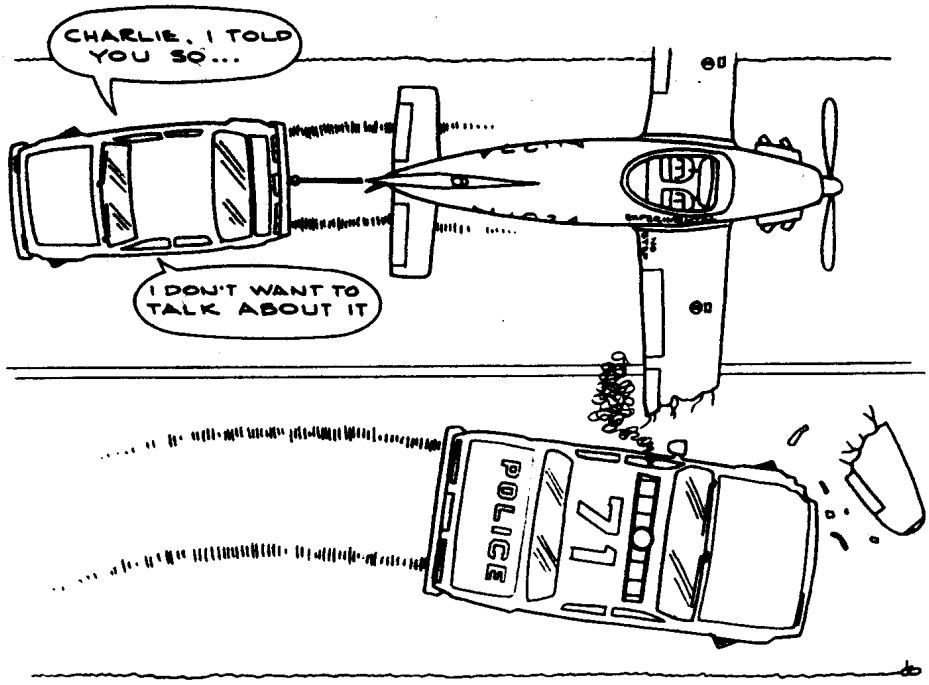
h. Flicker Vertigo. Light, when flashing at a frequency between 4 to 29 cycles per second, can cause a dangerous physiological condition in some people called flicker vertigo. These conditions range from nausea and dizziness to unconsciousness, or even reactions similar to an epileptic fit. When heading 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 ''be done by date.'' Stress also may impair judgement, 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. OBJECTIVE. To reduce damaging the aircraft in transit. The following suggestions may prevent this from happening:

a. Use a truck or flat bed truck/trailer large enough to accommodate 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, 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.

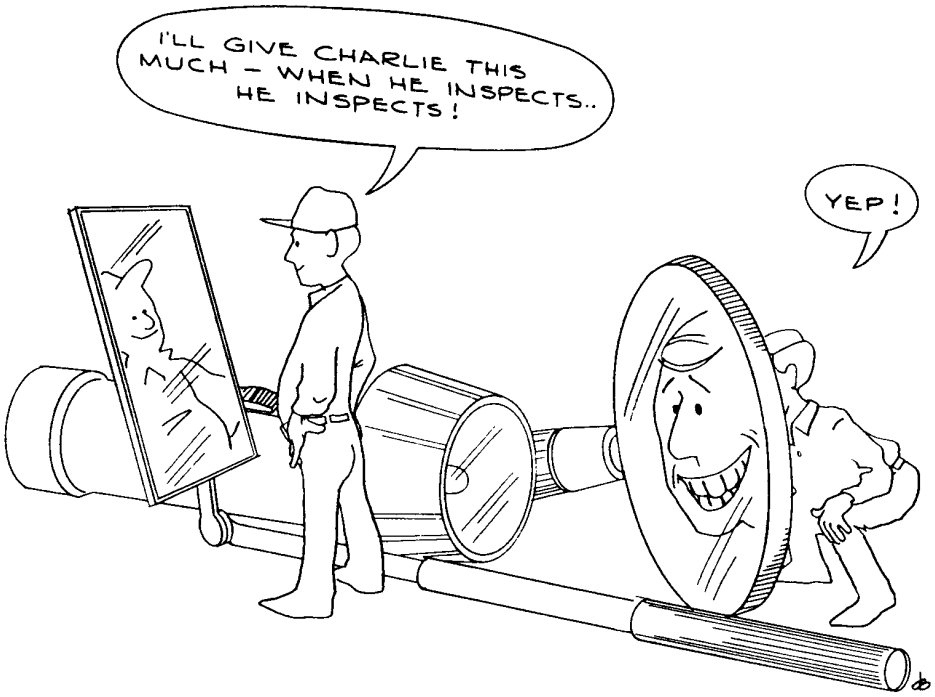
f. During the planning stage, obtain applicable permits and follow the local ordinances for transporting an oversized load. Ask the local police if they can provide an escort to the airport.

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. OBJECTIVE. To determine the airworthiness of the aircraft and its systems.

2. GENERAL.

a. If the aircraft must be reassembled after being moved to the airport -- **take time to do so carefully.** This is a critical event because mistakes can easily be made 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 check list specifically designed as part of the FLIGHT TEST PLAN. At the completion of each major operation, have another expert check the work.

b. When the aircraft is reassembled, perform a pre-flight ''fitness inspection.'' This inspection should be similar in scope and detail to an annual inspection. The fitness inspection should be accomplished even if the aircraft has just been issued a special airworthiness certificate by the FAA. 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.

3. FITNESS INSPECTION - AIRFRAME. The following additional safety check list items may not be applicable to all amateur-built make and model aircraft, but are presented 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.