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Experimental Aircraft Association EAA 21 Evansville, Indiana

EAA Chapter 21 Logbook

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No October Chapter Meeting: There will be no regular monthly Chapter meeting this month. We will have already had two events this month; the Young Eagles rally at Marion, KY on October 2, and the EAA 21 Club fly-in at Henderson on October 9. We will resume our normal meeting schedule in November.

Experimental Aircraft Association EAA 21 Evansville, Indiana **Club**
GOURMET BURGERS, BRATS and DOGS

Thank you for making our EAA 21 Club Fly-Ins such a success this year. We have been preparing Hamburgers, Brats and Hot Dogs for all that fly-in. Just as New York's 21 Club was known as the *HAPPENING PLACE* to be and be seen, you have made EAA 21 Club the place to be.

Don't miss our last EAA 21 Club Fly-In of the year. We should have the best fly-in weather of the summer so plan on joining us and enjoy some of our gourmet burgers, dogs and brats. PLUS this month we have added Gourmet Chili made from a secret family recipe we bought from a talking dog named Duke.

When: October 9th
10:00 AM till 2:00 PM Central time

Where: Henderson Kentucky City-County Airport (KEHR)

We had 40 planes and a bunch of drive-ins last month. We should have some of the best weather of the Summer this Saturday so fly-in; the two tier observation deck always has a nice breeze and the FBO lounge is AIR CONDITIONED.

Steve Eberhart
Program Chairman
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EAA™ THE SPIRIT OF AVIATION

This article comes from the September 1959 issue of Sport Aviation

Flying Qualities Requirements for Personal Airplanes

By William H. Phillips

EDITOR'S NOTE: This article is reproduced from the series of papers presented at the NACA-Industry Conference on Personal Aircraft held at the Langley Memorial Aeronautical Laboratory, Langley Field, Va., in September, 1946.

A great deal of research work has been conducted during the war years to determine requirements for satisfactory flying qualities of airplanes. While previously there was considerable speculation as to the flying characteristics desired in an airplane, it is now possible to specify in quantitative terms the minimum requirements that an airplane must meet in order to be considered satisfactory from the pilot's standpoint. These requirements were set up as a result of experience gained in testing all types of airplanes, including five light airplanes. The requirements may therefore be used with confidence by the designer of personal airplanes to arrive at a design with satisfactory stability and control characteristics.

The requirements may be listed under the general headings of longitudinal stability and control characteristics, lateral stability and control characteristics, and stalling characteristics. Table 1 presents a list of the factors considered in the requirements for longitudinal stability and control characteristics. I would like to point out how NACA research has contributed to the knowledge of some of these topics.

Table I — OUTLINE OF FLYING QUALITIES REQUIREMENTS

I. Requirements for Longitudinal Stability and Control:

- **A. Elevator control in takeoff**
- **B. Elevator control in steady flight**
- **C. Longitudinal trimming device**
- **D. Elevator control in accelerated flight**
- **E. Uncontrolled longitudinal motion**
- **F. Limits of trim change due to power and flaps**
- **G. Elevator control in landing**

II. Requirements for Lateral Stability and Control

- **A. Aileron-control characteristics**
- **B. Yaw due to ailerons**
- **C. Rudder and aileron trimming devices**
- **D. Limits of rolling moment due to sideslip**
- **E. Rudder-control characteristics**
- **F. Yawing moment due to sideslip**
- **G. Crosswind force characteristics**
- **H. Pitching moment due to sideslip**
- **I. Uncontrolled lateral and directional motion**

III. Stalling Characteristics

First are listed the requirements for the elevator control in take-off. Tests of numerous wind-tunnel models have been made with a ground-board in place in the tunnel to determine the ability of airplanes of various designs to meet this requirement.

Next are the requirements for elevator control in steady flight. As a result of an analysis that has been made of the flight tests of numerous airplanes (reference 1), it is now possible to predict from the airplane's dimensions the power-off static longitudinal stability of an airplane, and hence the basic elevator control characteristics in steady flight, with the same degree of accuracy that it may be measured in flight or in the wind tunnel. In addition, a great deal of data have been accumulated on the effects of power on stability, both from flight and wind-tunnel tests. Flight-test data are summarized in reference 2. The control forces required to fly steadily at various speeds may also be predicted as a result of extensive NACA research on control-surface hinge moments and aerodynamic balances. (For example, see references 3 and 4.)

The requirements for the longitudinal trimming device are next on the list. A report is available which summarizes the results of many wind-tunnel and flight tests on the effectiveness of trimming tabs. This report (reference 5) will allow an accurate estimation of the tab sizes to meet this requirement.

The elevator control characteristics in accelerated flight have been found to be very important in determining the pilot's opinion of an airplane. Quantitative limits for the control motions and force gradients necessary on airplanes of many different types have been determined from flight measurements. A new airplane may be designed to incorporate these characteristics by the methods described previously.

The characteristics of the uncontrolled longitudinal motion are considered next. It may be of interest to mention in passing that the characteristics of the long-period, or phugoid oscillation of an airplane have been found to be relatively unimportant. The extensive theoretical work conducted on this subject in the past therefore has little bearing on the subject of flying qualities. Sometimes the short-period oscillation characteristics of an airplane may fail to meet the requirements, however. Recent reports are available which describe flight experiences with unsatisfactory characteristics (reference 6), as well as theoretical analyses to show how to avoid the undesirable characteristics (reference7).

Trim changes due to power and flaps are limited to definite quantitative values in the requirements. The light airplane manufacturer should be encouraged to note that in the case of several fighter-type airplanes, where the problems of reducing the control force changes due to flaps and power are much more difficult than for a smaller airplane, designs with very small trim changes have been developed as a result of wind-tunnel and flight tests. The problem of reducing the trim changes in the case of a light airplane should therefore be fairly easy.

The elevator control characteristics in landing are specified in the final longitudinal requirement. A report is available which presents a method for calculating the elevator angle required to land (reference 8). This method has been developed from an analysis of the results of flight tests of numerous airplanes. Extensive wind-tunnel data are also available on this subject. The elevator angle required to land is of importance because this is frequently the most critical requirement for elevator effectiveness.

Table 1 also shows the requirements for lateral stability and control. The requirements for aileron control characteristics are expressed quantitatively in terms of the minimum value of the helix angle generated by the wing tip in a roll. This requirement was set up before the war, and numerous subsequent tests have confirmed its validity. A summary report on NACA lateral-control research has been prepared (reference 9). This report contains sufficient data to allow the design of satisfactory ailerons for any type of airplane.

The yaw due to ailerons should not exceed a certain maximum value. This requirement has been found to be a critical one from the standpoint of directional stability. Ordinarily changing the aileron design does not greatly reduce the adverse yawing moments at high lift coefficients.

The rudder and aileron trimming devices may be designed to meet the requirements in the same manner as the longitudinal trimming devices.

The next requirements specify the limits of rolling moment due to sideslip, ordinarily known as dihedral effect. Several flight investigations made with airplanes of various plan forms and different amounts of geometric dihedral have shown the allowable limits of dihedral effect for satisfactory flying qualities.

The rudder control characteristics are considered next in the list of requirements. The rudder must perform many functions besides simply providing directional trim in the various flight conditions. These functions include offsetting the adverse aileron yawing moments, providing satisfactory control in sideslips, providing adequate spin recovery, providing satisfactory control during takeoff and landing, and offsetting the yawing moment due to asymmetric power on a multiengine airplane. A great deal of research has been done to determine the rudder configurations required to satisfy these requirements and in later lectures the design criterion for spin recovery will be discussed in more detail. It has been shown by flight tests that the rudder effectiveness required for takeoff and landing is determined by many factors other than the design of the rudder.

The yawing moment due to sideslip or directional stability must be sufficient to meet certain requirements for providing satisfactory sideslip characteristics, limiting the sideslip in rolls due to aileron yawing moments, and providing adequate stability for flight with asymmetric power. A large amount of directional stability has never failed to be beneficial to the handling characteristics of an airplane. Design data are available to allow estimation of the tail size required to provide adequate directional stability, as will be discussed in a later paper. The crosswind force characteristics and the pitching moment due to sideslip, both of which are characteristics measured in steady sideslips, form the subject of the next requirement. The pitching moment due to sideslip should be small as this factor may lead to inadvertent stalling. Typical flight measurements of satisfactory sideslip characteristics are shown in Fig. 1. The final requirement for lateral stability and control is concerned with the uncontrolled lateral and directional motion. The results of flight tests have been used to establish these requirements and a great deal of theoretical work performed by the NACA is available to enable the designer to predict these characteristics (reference 10).

Time does not permit a detailed discussion of all the requirements. The characteristics of a personal airplane should, in general, be superior to the minimum requirements for satisfactory flying qualities. Some of the characteristics that are believed very desirable in a light airplane as a result of NACA research are as follows: the static longitudinal stability in all flight conditions should be large, so that the pilot will be warned of the approach to the stall by the rearward position of the stick at low flight speeds. The stick-force gradients in straight flight should be stable and should be sufficiently large compared to the control friction so that the stick will have a definite centering tendency. The force variation with acceleration in accelerated flight should be between 7 and 10 pounds per g. The trim changes due to changing flap or power condition should be very small.

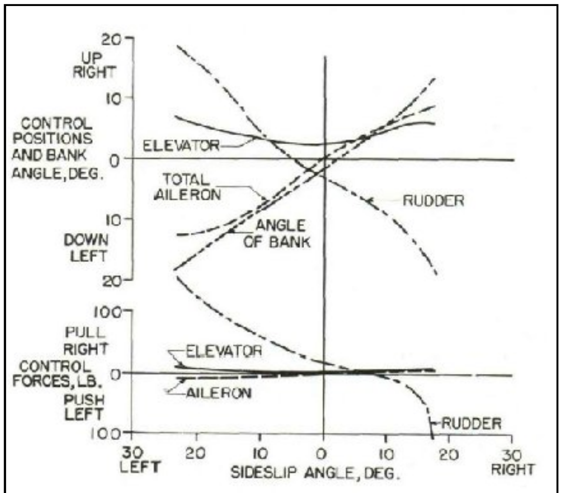

Figure 1.- Steady sideslip characteristics.

The aileron control effectiveness should be sufficient to provide a helix angle of the wing tip of greater than 0.07 radian. The aileron forces should be light, but sufficiently large compared to the friction to give the control stick a definite centering tendency. The directional stability should be large. The rudder control should be sufficiently powerful to overcome aileron yaw.

The stalling characteristics of a personal-type airplane are very important. The stall should be preceded by adequate warning in the form of buffeting of the airplane and by a marked increase in rearward motion in the stick and pull force as the stall is approached. When the airplane is stalled, there should be no rolling instability in any flight condition, even with the stick held full back. This characteristic was obtained by relatively minor modifications to a typical light airplane at the NACA (reference 11).

In conclusion it may be pointed out that a large amount of information has been accumulated both on the requirements for satisfactory flying qualities and on the means for designing an airplane to incorporate these flying qualities. As a result, it is believed possible to design an airplane of the personal-airplane category with the assurance that its flying qualities will be satisfactory.

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Upcoming Chapter 21 Events

No October Chapter Meeting: There will be no regular monthly Chapter meeting this month. We will have already had two events this month; the Young Eagles rally at Marion, KY on October 2, and the EAA 21 Club fly-in at Henderson on October 9. We will resume our normal meeting schedule in November.

Don't miss our last EAA 21 Club Fly-In of the year. In anticipation of a great Fall flying season we are adding our special Chili, made from a secret family recipe that we bought from Duke.

When: October 9th, 10:00 AM till 2:00 PM Central time

Where: Henderson Kentucky City-County Airport (KEHR)

Hancock County Airport Day (KY8, Ron Lewis Field, Lewisport, Kentucky, near Tell City, Indiana)

Our new Airport will be dedicated on Saturday, Nov, 6, 2010. It will follow with an Open House. We are trying to make this something that the pilots and our community will look forward to on an annual basis.

Jim Fallin
Chairman
Hancock County Airport Board