AIRWORTHINESS REQUIREMENTS FOR GLIDERS AND SAILPLANES.

by L.L.Th. HULS.

INTRODUCTION.

During the previous OSTIV-meeting the author had the privilege to read a paper on some technical aspects of the design of gliders in which he stressed the importance of establishing a set of internationally accepted airworthiness requirements for gliders and sailplanes. The idea was then supported from several sides, but as the organization of OSTIV itself was still in its infancy, no practical steps have been taken so far

It is hoped that during this meeting a small working group can be formed which will prepare a draft for international airworthiness requirements, to be submitted to the member-countries before the next conference. The purpose of this paper is to put forward some general aspects of these requirements to be discussed. As in this gathering scientists, pilots and technicians from nearly all countries concerned are present, it is hoped that comments will be made from several sides in order to provide a basis of opinions on which the working group can start preparing its draft.

GENERAL CONSIDERATIONS.

The basis for airworthiness requirements is the wish to establish a set of conditions to which an aircraft should conform in order to be acceptable as a safe vehicle both for its occupants and for third parties (people and property on the ground and other aircraft). Now safety is a relative condition rather than an absolute one and perhaps one had better say that airworthiness requirements aim at establishing an acceptable degree of unsafety, if this did not sound so unpleasant. Which degree of unsafety can be considered acceptable is, of course, an arbitrary question. Technical development and experience, particularly from accident statistics, are the main factors deciding this degree.

For powered aircraft there is a growing tendency to base the airworthiness requirements on a certain acceptable "accident rate". This requires, of course, the accumulation of as much statistical data on accidents and incidents (if this term be used for the cases that could, under less favourable conditions, have been accidents) as possible As there are much more powered aircraft flying than gliders and sailplanes and the organizations for recording accident data both nationally and internationally, are much more firmly established, it would be unwise to say that at present we should try and establish our requirements for powerless aircraft on the same basis. It is the author's opinion that a determined effort should, however, be made by OSTIV to collect as much data on glider accidents as possible in order to take these into account for future revisions of the requirements.

At present airworthiness requirements for gliders and sailplanes are derived from those for powered aircraft and there is, of course, every reason for this as these two categories of aircraft have very much in common and a number of requirements can be entirely identical. There is a danger, however, in this procedure, which is felt most in smaller countries, where very limited information on the special problems and aspects of glider flight is available, that the requirements for gliders become too complicated and that the paper work concerned with the certification of gliders has to pass through the necessarily more complicated machinery set up for powered aircraft. It is hoped that if we are successful in establishing a set of internationally accepted airworthiness requirements for gliders and sailplanes, based on all available experience, the national authorities will be more willing to accept a simplified procedure for the certification of powerless aircraft.

Before discussing briefly some of the technical details of the airworthiness requirements the author would like to put forward his views on the general outline which in his opinion, the international requirements should have.

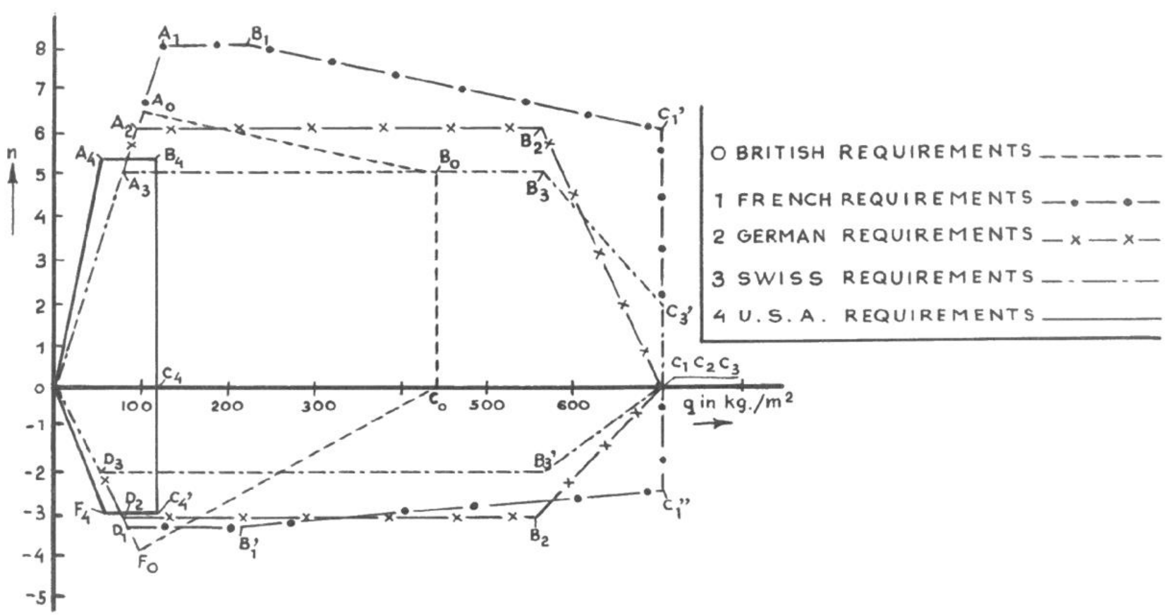
The requirements should be kept as simple as possible in order to keep the amount of work to be done in the design stage, to prove that the aircraft will meet the requirements, to an acceptable minimum. This may mean that in some cases the simple requirements will have to be on the safe side to cover all possible combinations of design parameters. In such cases, more detailed requirements would lead to more refined and a little lighter constructions, but at the expense of more design work. It is the author's opinion, however, that requirements which would necessitate a considerable amount of calculations, etc could hamper the development of new gliders by small groups of enthusiasts, who cannot afford to set up a complete design office to prove compliance with the requirements. It should be left to the individual designer to decide whether he will accept the weight penalty of designing his aircraft to meet the simplified - but somewhat conservative - requirements or whether he will go into the trouble to make more eleborate calculations and tests to prove that his design, though not fully complying with the requirements as they are expressed in simple terms, still achieves the same level of safety.

In this connexion it is also important to keep the number of different categories for gliders and sailplanes as low as possible, although the extending field of operation of sailplanes (high-altitude flying) may lead to the opposite tendency.

Coming to the technical points one of the most important parts of the airworthiness requirements is that concerned with:

STRUCTURAL STRENGTH.

As an example of the large differences occuring in this respect between the requirements of various countries, the flight envelope for a conventional sailplane has been calculated according to the British, French, German, Swiss and U.S. airworthiness requirements. The accompanying figure shows the results and it clearly reveals the necessity of trying to create a set of internationally accepted requirements. The design manoevring load factors differ from 5 in the Swiss requirements to 8 in the French ones, the design diving speed



Flight envelope for a sailplane according to various requirements.

from 4 to 1 times the terminal velocity in a vertical dive (U.S. vs French, German and Swiss requirements).

It is not intended to discuss in detail the differences between these flight envelopes of various nationality, but a few principal points should be mentioned. Firstly the design diving speed. Basing the requirements on the terminal velocity in a vertical dive with dive brakes inoperative may lead to undue weight penalties. It is the author's opinion that the design diving speed should be based on the terminal dive velocity with extended dive brakes, keeping a margin of say 25% over this value to cater for cases in which the pilot exceeds the limiting speed before opening the dive brakes. For the aircraft under review the dynamic pressure corresponding with this proposed design diving speed would be about 450 kg/m2, coinciding with the value derived from the British requirements.

An interesting deviation in the U.S. requirements is that a $C_{1\ max}$ of 2 is specified independent of the airfoil characteristics. This high value should include the effects of dynamic loadings in pulling up. Although these loadings do occur the question arises whether they should be taken as a basis for the flight envelope and whether not the load reducing effects of wing bending in pull-up cancel out these effects.

The requirements under review differ not only in manoevring load factors, gust loads are also differently specified. Vertical gusts speeds differ from 5.6 to 10 m/sec (German and Swiss requirements). These gust loads are most important for the negative load factors as illustrated in the figure, where negative load factors, ranging from -2 to -3.9 are shown. With the growing intensity of soaring in standing waves, where large vertical wind speeds can occur, the need for specifying special gust loading cases for these conditions should be considered.

Requirements for loading cases relating to the launching of gliders and sailplanes are still very incomplete. Of the 5 sets of requirements under review only the British and French requirements specify a loading case for aeroplane-tow while a winch-launching case is specified in the British requirements only. The British and French loading cases for aeroplane-tow have much in common. An interesting difference is that the French take the axis of the cone inside which the direction of the tow force can vary as inclined downwards (11.5°) while the British specify this axis as being horizontal. Although in most cases the sailplanes flies a little higher than the tug it is questionable whether this should be taken into account in a case like this.

AEROELASTICITY.

In most requirements little or no attention has so far been paid to flutter prevention and structural stiffness. Cases of gliders accidents due to flutter have been relatively few but recent experience has shown that it is desirable to investigate the flutter characteristics, especially for high performance sailplanes having slender and relatively thin wings and tailplanes.

A difficult question is, however, how requirements for flutter prevention could be stated in simple terms. A very simple requirement would be that the aircraft be free from flutter under all operating conditions, but the question arises how to prove compliance with this requirement in the design stage. The carrying out of a detailed flutter analysis involves such an enormous amount of work that only in exceptional cases both funds and staff will be available for this task.

A solution to this problem can perhaps be found in formulating stiffness criteria for the various parts of the aircraft, compliance with which will ensure that flutter and similar vibrations of a dangerous nature will not occur and that structural distortion in flight will be within limits which will not seriously affect the control and stability of the aircraft. For powered aircraft of conventional design such criteria have been given, e.g. in the British Civil Airworthiness Requirements. The question arises whether these criteria should also be applied to gliders and sailplanes. There is a chance that for this category of aircraft compliance with these criteria, which necessarily should be on the conservative side, would require unacceptable weight sacrifices. It is proposed that this problem be further investigated in the near future.

HANDLING QUALITIES.

The differences between the various sets of requirements relating to handling characteristics mainly lie in the degree to which they have been detailed. The question arises how far one should go in expressing the desired characteristics quantitatively. With the increasing knowledge of this subject it has become possible to describe desired flying qualities for powered aircraft by a number of parameters (stability and manoevring margins stick force per g). It may be attractive to try and do this for gliders also but then good care should be taken not to follow the requirements for powered aircraft too closely.

As far as longitudinal stability is concerned, for powered aircraft, especially for transport aircraft, there is, for instance, a tendency to accept slight static instability as a compromise with other considerations. For a sailplane there is no need for such a compromise and it is the author's opinion that positive static longitudinal stability should be specified.

One important problem affecting the requirements for handling characteristics should be mentioned here. In some countries - including Holland - gliding and soaring is being used as part of the training of pilots for powered aircraft. Government support is based on this aspect and I am afraid little gliding would be done in Holland if we had to do without this support. Those who wish to look at soaring purely as a sport sometimes consider this aspect of pilot training as a nuisance. In our discussions on handling characteristics this point has also been mentioned. For gliders to be used in the training of pilots for powered aircraft it would be a good thing to have control forces and harmonization as much alike those for powered aircraft as possible. This may involve, however, larger tail surfaces etc. than necessary for stability reasons and would, therefore, involve a slight sacrifice in performance. The question is whether a seperate category for gliders to be used for training purposes should be included or whether all gliders and sailplanes should comply with the more strict requirements and the slight performance sacrifice be accepted.

In the foregoing point several questions have been raised relating to the airworthiness requirements for gliders and sailplanes. It is hoped that comments will be made from several sides in order to provide a basis on which we can start trying to answer those questions.