FEDERAL AVIATION AGENCY

FLIGHT STANDARDS SERVICE

[14 CFR Part 4b]

[Notice 63-21 ; Docket No. 1797]

REVISION OF THE FLUTTER, DEFORMATION, AND VIBRATION REQUIREMENTS APPLICABLE TO TRANSPORT CATEGORY AIRPLANES

Notice of Proposed Rule Making

Notice is hereby given that there is under consideration a proposal to amend § 4b.308 of Part 4b of the Civil Air Regulations to: (1) require that the dynamic evaluation of the airplane take into account elastic, inertia, and aerodynamic forces associated with rotations and displacements of the plane of the propeller; (2) require that the airplane, under specified conditions, remain free from hazardous flutter, vibration, and divergence after any reasonably probable single structural failure or equipment malfunction; and (3) make related minor revisions, including editorial revisions for clarification. Manufacturers and operators of transport category airplanes may be affected by the proposed amendment.

Interested persons are invited to participate in the making of the proposed rule by submitting such written data, views, or arguments as they may desire. Communications should identify the Notice or Docket number and be submitted in duplicate to the Federal Aviation Agency, Office of the General Counsel: Attention Rules Docket, Room A-103, 1711 New York Avenue, N.W., Washington 25, D.C. All communications received on or before August 19,1963, will be considered by the

Administrator before taking action on the proposed rule. The proposals contained in this notice may be changed in the light of comments received. All comments submitted will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons.

Regulations dealing specifically with flutter, deformation, and vibration on transport category airplanes were first introduced when Part 04 (later designated as Part 4b) became effective on November 9, 1945. These regulations evolved into currently effective § 4b.308 with the adoption of two substantive revisions, as follows: (1) effective March 5, 1952, the requirement that freedom from flutter and divergence be demonstrated at all speeds up to 1.2 V_D was amended to permit this demonstration at speeds up to a value less than 1.2 V_D if the characteristics of the airplane are such that it would be unlikely to attain a speed of 1.2 V_D and if it is shown that a proper margin of damping exists at speed V_D; and (2) effective October 1, 1959, a provision was added requiring that, if control surface flutter dampers are used for flutter prevention, the flutter damper system be of such design that a single failure will not preclude continued safe flight of the airplane at any speed up to V_D.

During the period between 1945 and 1955, § 4b.308 and predecessor regulations were generally effective in insuring freedom from flutter and divergence in transport category airplanes, despite the absence of a provision requiring an investigation of the influence of a single structural failure on flutter stability. A reasonable margin of safety was evidently provided by reason of the required demonstration that the airplane be free from flutter and divergence at speeds up to 1.2 V_D, over the critical ranges of the pertinent parameters.

Subsequently, several reported instances of tab flutter on a transport category airplane led to adoption of the provision in currently effective § 4b.320(a) which, by cross-reference to § 4b.308, requires that tab control systems be free from hazardous flutter after disconnection or failure of any element at speeds up to V_C. This provision became effective on March 13, 1956.

In general, applicants have resorted to analyses in showing compliance with the provisions of § 4b.308 and predecessor regulations, supplemented in some cases by flight flutter tests on the prototype airplane. Such analyses (which have steadily improved in scope and precision with advances in the state of the art) have in the past taken into account, for propeller-driven airplanes, the mass of the engine-propeller combination and the natural frequency of vibration of its suspension, but not the elastic, inertia, and aerodynamic forces associated with the rotations and displacements of the propeller plane. These forces, experts on flutter analysis then agreed, had no significant effect on wing flutter stability.

During 1959 and 1960 two fatal accidents, both involving a civil four-engine turboprop airplane, focused particular attention on the hazards associated with aeroelastic instabilities in transport category airplanes. An exhaustive investigation into the cause of these accidents, and associated engineering studies by both industry and government experts, have indicated that the various forces associated with the rotations and displacements of the plane of the propeller must be considered in evaluating the flutter and divergence stability of transport category airplanes. The oscillatory motion of the plane of the propeller may itself become unstable, or diverge, or may contribute to instability of the wing. For these reasons, it is being proposed to amend § 4b.308(a) by adding a requirement that the dynamic evaluation of the airplane include consideration of the effect of significant elastic, inertia, and aerodynamic forces associated with rotations and displacements of the plane of the propeller.

The provisions of currently effective § 4b.308(a) are limited in scope in that they prescribe freedom from flutter and divergence for wing and tail units only; whereas it is well known that the higher speeds of modern transport category airplanes may introduce flutter or divergence in other portions of the airplane. To insure that tests or analyses take this possibility into account, it is proposed that the wording in § 4b.308(a) be amended to prescribe freedom from flutter and divergence for all portions of the airplane.

In the course of past application of the term "proper margin of damping" in currently effective § 4b.308(a), the Agency has indicated that the margin is acceptable if a satisfactory damping coefficient exists for all potential flutter modes at all speeds up to V_D, and if no large and rapid reduction in damping with increased speed is indicated upon approaching V_D. In this regard, it is proposed to amend § 4b.308(a) to clearly state what is meant by the term "proper margin of damping."

The previously mentioned government-industry studies have also disclosed that severe degradation of the wing's aeroelastic properties could result from failure of a structural member (including those which form part of the engine itself in the case of turboprop engines) which supports the engine-propeller combination, or from failure of the propeller control system such that overspeeding of the propeller occurs.

In view of these findings, and in view of past findings indicating that failures in tab and damper control elements may result in flutter, the Agency believes there is a need for a comprehensive set of requirements dealing with the effect of probable failures on flutter stability. The Agency has noted, for example, that hazardous flutter may be induced by any failure reducing the rigidity of irreversible main control systems which are fitted with power boost; by a failure in the power boost itself; by a failure or malfunction of an automatic flight control system; or by failure or partial failure of single principal structural elements. It is therefore proposed to add a new paragraph (d) to § 4b.308 to require that the airplane be free of flutter, after specified failures or malfunctions, at all speeds up to V_D.

This proposal is subject to the FAA Recodification Program. The final rule, if adopted, may be in a recodified form; however, the recodification itself will not alter the substantive contents proposed herein.

In consideration of the foregoing, it is proposed to amend Part 4b of the Civil Air Regulations as hereinafter set forth:

1. By amending § 4b.308(a) to read as follows:

4b.308 Flutter, deformation, and vibration. * * *

(a) Flutter and divergence prevention. The airplane shall be designed to be free from flutter and divergence (i.e., unstable structural distortion due to aerodynamic loading) at all speeds up to 1.2 V_D. A smaller margin above V_D shall be acceptable if the characteristics of the airplane (including the effects of compressibility) render a speed of 1.2 V_D unlikely to be achieved, and if it is shown that a satisfactory damping coefficient exists at all speeds up to V_D and that there is no large and rapid reduction in damping as V_D is approached. In the absence of more accurate data, the terminal velocity in a dive of 30 degrees to the horizontal shall be acceptable as the maximum speed likely to be achieved. If concentrated balance weights are used on control surfaces, their effectiveness and strength, including supporting structure, shall be substantiated. The dynamic evaluation of the airplane shall include an investigation of the significant elastic, inertia, and aerodynamic forces associated with the rotations and displacements of the plane of the propeller.

2. By amending § 4b.308 by adding a new paragraph (d) to read as follows:

4b.308 Flutter, deformation, and vibration. * * *

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(d) Fail safe criteria. It shall be shown, by analysis or tests, that the airplane will remain free from such flutter, divergence, or vibrations as would preclude safe flight, at all speeds up to V_D, after each of the failures, malfunctions, and adverse conditions stated in subparagraphs (1) through (7) of this paragraph, and after any other reasonably probable single failure, malfunction, or adverse condition affecting flutter, divergence, or vibration; except that, if the failure, malfunction, or adverse condition is simulated during flight tests to show compliance with this paragraph, the maximum speed investigated need not exceed V_{FC} when it is shown, by correlation of the flight test data with other test data or analysis, that hazardous flutter, divergence, or vibration will not occur at all speeds up to V_D. The structural failures described in subparagraphs (1) and (2) of this paragraph need not be considered in showing compliance with this paragraph if engineering data verifies that the probability of their occurrence is negligible. Such engineering data shall substantiate, by test or analysis, that the structural element is designed with conservative static strength margins for all ground and flight loading conditions specified in this part, and with fatigue strength sufficient for the loading spectrum expected in service.

(1) Failure of any single element of the structure supporting any engine, independently mounted propeller shaft, large auxiliary power unit, or large externally-mounted aerodynamic body such as an external fuel tank.

(2) Any single failure of the engine structure on turboprop airplanes.

(3) Any single propeller feathered.

(4) Each of the failures described in subparagraphs (1) and (2) of this paragraph, paired with the feathering of any single propeller.

(5) Any single propeller rotating at the highest likely overspeed.

(6) Failure of each principal structural element for which compliance with the provisions of § 4b.270(b) is required.

(7) Failure, malfunction, or disconnection of any single element in the main flight control system (including automatic flight control systems, if installed), in any tab control system, or in any flutter damper connected to a control surface or tab. (See also § 4b.612(d)(4).)

These regulations are proposed under the authority of sections 313(a), 601, and 603 of the Federal Aviation Act of 1958 (72 Stat. 752, 775, 776; 49 U.S.C. 1354, 1421, 1423).

GS Moore
Director,
Flight Standards Service

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