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TRANSPORT CATEGORY AIRPLANES

Fatigue Regulatory Review Program Amendments

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Title 14—Aeronautics and Space

CHAPTER I—FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

[Docket No. 16280; Amdt. No. 25-45]

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

Fatigue Regulatory Review Program Amendments

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: The purpose of these amendments is to improve and update the airworthiness standards applicable to the type certification of transport category airplanes by revising the structural fatigue evaluation requirements. These revisions take into account state-of-the-art developments and accumulated service experience.

DATES: Effective date—December 1, 1978.

FOR FURTHER INFORMATION CONTACT:

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SUPPLEMENTARY INFORMATION: During recent years, there have been significant state-of-the-art and industry-practice developments in the area of structural fatigue and fail-safe-strength evaluation of transport category airplanes. Recognizing that these developments could warrant some revision of existing fatigue requirements contained in §§ 25.571 and 25.573 of part 25 of the Federal aviation regulations, the FAA, on November 18, 1976, gave notice of its transport category airplane fatigue regulatory review program and invited interested persons to submit proposals to amend those requirements (see 41 FR 50956). Subsequently, the FAA convened a Transport Category Airplane Fatigue Regulatory Review Conference during March 15-17, 1977, in Arlington, Va., to obtain the views of all concerned on the proposals submitted for the review.

Participants in the Review Conference discussed the proposals submitted for the review. Those proposals and the related discussions formed the basis for the FAA's belief that a comprehensive revision of the structural fatigue evaluation standards of §§ 25.571 and 25.573 was warranted. To that end, on August 9, 1977, the FAA issued notice 77-15 (42 FR 41236; Aug. 15, 1977) which proposed regulatory changes directed at upgrading and improving those standards. These amendments are based on that notice.

Interested persons have been afforded an opportunity to participate in the making of these amendments and due consideration has been given to all matters presented. The more significant comments received in response to notice 77-15 are discussed below. A number of substantive, editorial, and clarifying changes have been made to the proposed rules based on relevant comments received and on further review within the FAA. Except for minor editorial and clarifying changes and the changes discussed below, these amendments and the reasons for their adoption are the same as those contained in notice 77-15.

DISCUSSION OF GENERAL COMMENTS

Sixteen comments were received in response to notice 77-15. Several of the commenters were associations that presented the views of manufacturers and air carriers. In general the commenters concerned themselves with those areas of the proposal they believed could be improved and they raised no objection to the basic concept of the proposal.

Two commenters recommended that full-scale fatigue tests of the whole airplane structure be required, so as to insure reliable identification of those locations and detail design points at which a fatigue failure, if not detected in time, could cause catastrophic failure of the airplane. The FAA disagrees. Although full-scale testing can be useful in predicting possible locations of fatigue failures, the test results do not always correlate with service experience because of differences in the loading spectrum, varying environmental conditions, scatter in the test data, and unpredictable operational effects. Under the rules being adopted the manufacturer is required to: (1) Determine the probable locations and modes of damage due to fatigue, corrosion, and accidental damage; (2) support that determination by tests on either the whole structure or components of the structure and by reference (as applicable) to previous operational experience; and (3) establish a related inspection program. This practice has been used successfully in the past.

A commenter recommended that the applicant be required to determine the "time to first failure" of critical structural components, and to establish information on the frequency, extent, and methods of inspection, by repeating the fatigue test program on an appropriate number of identical samples of those components and by employing probabilistic evaluation and risk analysis. The FAA recognizes that this procedure may be necessary for some critical safe-life components but not for those evaluated by means of the damage-tolerance approach covered in this amendment. Damage-tolerance (fail-safe) evaluations take into account the possibility that structural damage can occur due to causes other than classical fatigue (for example: Corrosion, foreign-object impact, and maintenance errors) and recognizes that this damage can be detected before catastrophic failure by an adequate inspection procedure. The frequency, extent, and methods of inspection are determined by repeated load analyses and tests (including a statistical approach where necessary), by fracture mechanics analyses and tests, and by reference to service experience.

The same commenter, referring to damage-tolerance evaluation tests, suggested that such tests should be carried out to final failure to demonstrate the residual strength of the remaining structure and that the loading conditions for this purpose should take into account the effects of structural flexibility, the rate of loading, and the most unfavorable expected temperature in heavy gusts. This commenter also contended that simulation of cracks artificially should not be allowed since this method would predetermine the location of failure and would in many cases indicate a greater residual strength than a genuine fatigue crack. The FAA does not agree with these comments. The nature and extent of tests on complete structure, or on portions of the primary structure, will depend upon applicable previous design, construction, tests, and service experience. If previous experience with similar structure is available, an analytical approach rather than tests may be sufficient to show adequate residual strength. The applicant is required in either event to take into account the factors mentioned by the commenter. For example, § 25.571(a)(1)(i) of this amendment requires that each evaluation include the "typical loading spectra, temperatures, and humidities expected in service." And § 25.571(b) of this amendment requires that "if significant changes in structural stiffness or geometry, or both, follow from a structural failure, the effect on damage-tolerance must be further investigated." Concerning the matter of simulating cracks artificially, the FAA has found from past experience that it may not be practical to produce actual fatigue cracks. Artificial crack simulation has proven satisfactory in the past.

In addition, the commenter, referring to the proposed requirements for damage-tolerance (fail-safe) evalua-

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tion, contended that the pilot should be instantaneously warned of the occurrence of a failure of a single principal structural element, because no hidden strength reserves are required. The FAA questions whether the crack detection and monitoring system that would be needed for this purpose could be relied upon to detect all critical damage. In any event, the FAA believes such a warning system is unnecessary, for the following reasons. This amendment specifies a residual static strength level of 100 percent of limit load (up from the previously prescribed 80 percent) and requires residual repeated load strength consistent with crack growth analysis and with the anticipated inspection program, thereby raising the level of safety for structure in a "damaged" condition. Structure designed to these requirements remains capable of supporting static limit loads after partial failure until the failure is detected, since those loads are the maximum loads expected to occur in service. In addition, to account for the fatigue spectrum, the damage-tolerance evaluation must incorporate repeated load and static analyses supported by test evidence. On the basis of past experience, the FAA believes that these requirements provide an adequate level of safety when combined with a sound inspection program that insures detection of damage before catastrophic failure occurs.

Several commenters objected to the use of mandatory language in proposed appendix H contending that it was inconsistent with statements in the notice preamble, and in proposed § H25.1 of the appendix, that the appendix contained guidance material and that deviations from this guidance material may be necessary to take into account new design features and methods of fabrication, new evaluation approaches, and new configurations. The FAA agrees in principle with these comments. However, with the removal of the mandatory language objected to by the commenters, the proposed appendix would not be regulatory in nature. Placement in the Federal aviation regulations would therefore not be appropriate. In this connection, the FAA's advisory circular system is an effective vehicle for providing guidance information to the public relating to regulatory matters. Accordingly, proposed appendix H, with mandatory language removed and with additional changes as discussed below, is being issued concurrently with this amendment in the form of a new advisory circular. A reference to the new advisory circular is included in § 25.571(a), as adopted, and copies of the advisory circular may be obtained from U.S. Department of Transportation, Publications Section M443.1, Washington, D.C. 20590.

Discussion of Specific Comments

§ 25.571(a)

Several commenters objected to the wording of the first sentence of proposed § 25.571(a), contending that it would impose an absolute requirement that would be impossible to comply with. The purpose of the proposal was to establish an evaluation requirement rather than an absolute requirement for the strength, detail design, and fabrication of the airframe structure. Based on the comments, the first and second sentences of proposed § 25.571(a), as adopted, are revised to make this clear.

A commenter suggested that the term "engine mounting" be added to the examples of structure listed (in parentheses) in the second sentence of proposed § 25.571(a) since it is an important structural element that should be considered. The FAA agrees, and this change is incorporated in the adopted rule. In addition, the word "including" inside the parentheses is changed to "such as" to make it clearer that the structural elements listed are examples only.

A commenter objected to the sonic fatigue evaluation requirement in the third sentence of proposed § 25.571(a), contending that while such an evaluation is necessary for turojet-powered airplanes there has been no service experience indicating that it is also necessary for turbopropeller-powered airplanes. The FAA agrees. Based on a reevaluation of the information available to the FAA, the term "turbine-engine-powered" in the third sentence of proposed § 25.571 (fourth sentence as adopted) is changed to "turbojet-powered."

Several commenters objected to proposed § 25.571(a)(3) on the grounds that: (1) The required inspection or other procedures to prevent catastrophic failure are best developed after type certification by the combined efforts of the FAA, the manufacturers, and the operators, using the Maintenance Review Board (MRB) process described in advisory circular AC 121-22; and (2) if the inspection and other procedures were to be established as a certification requirement, operators would find it burdensome to have them adjusted in the light of operational experience after an airplane enters service. The FAA firmly believes that in this critical safety area (involving measures to prevent catastrophic failure) the initial set of inspection and other procedures must be established by the manufacturer under a type certification requirement. Since the manufacturer conducts the evaluation tests and analyses upon which those procedures must be based, it is appropriate that he take prime responsibility for establishing them. However, there is nothng in proposed § 25.571(a)(3) that would prevent later adjustments of the established inspection, or other procedures, based on operational experience after type certification. See also the related discussion under proposed appendix § H25.2(h). Accordingly, proposed § 25.571(a)(3) is adopted without change.

§ 25.571(b)

A commenter noted that the parenthetical term "(fail-safe)" in the title of proposed § 25.571(b) is not a synonym for "damage-tolerance." The FAA used the term "(fail-safe)" in the title merely to indicate that this was the previously accepted evaluation method. Some fail-safe design features may still be incorporated in a damage-tolerance approach. The term "(fail-safe)" is therefore retained in the title.

The same commenter recommended that the phrase "test evidence and service experience" in the second sentence of proposed § 25.571(b) be changed to "test evidence or service experience," contending that the proposed language would prevent designers from doing anything new. The FAA's intent is to require that the analysis be supported by test evidence in every instance and (if available) by service experience. To make this intent clear, the parenthetical phrase "(if available)" is inserted before the term "service experience" in the adopted rule.

The commenter also objected to the third sentence of proposed § 25.571(b) on the ground that it limits the concern to prior fatigue exposure only. No change to the proposal is being made based on this comment since the FAA believes the proposed language adequately reflects the intent.

In addition, the commenter contended that the fourth and fifth sentences of proposed § 25.571(b) were not sufficiently specific and suggested a general revision of the proposed language. The FAA does not agree. The FAA believes that the proposed language is clear and expresses the intent accurately.

Another commenter suggested that the words "at V_C" in proposed § 25.571(b)(1) be changed to "up to V_C", contending that maneuvers at speeds lower than V_C should also be covered. The FAA believes that the words "at V_C" provide for a realistic and adequate condition for residual strength evaluation that is consistent with a similar loading condition applied under the rule being amended.

This commenter also suggested that proposed § 25.571(b)(2) be revised to

insure that dynamic effects are covered for gust conditions. The FAA believes that the gust conditions in proposed § 25.571(b)(2), which are similar to those applied under the rule being amended, are adequate for residual strength evaluations.

In addition, the commenter noted that § 25.351(a), which is referenced in proposed § 25.571(b)(4), does not specify yaw maneuvers at speeds above V_A and suggested a revision to specify such maneuvers. The FAA, in airworthiness review notice No. 75-26 (40 FR 24802, June 10, 1975) has proposed changing the V_A in current § 25.351(a) to V_D. This issue will be considered as part of the airworthiness review program.

A commenter suggested that the term "normal operating pressure" used in proposed §§ 25.571(b)(5) (i) and (ii) be changed to "normal operating differential pressure" because it is more precise and is used elsewhere in part 25. The FAA agrees, and this change is incorporated in §§ 25.571(b)(5) (i) and (ii) as adopted.

A commenter recommended that the 1.1 factor in proposed § 25.571(b)(5)(ii) be changed to 1.15 to be consistent with existing design practice based on the present Federal Aviation regulations, and to cover variations in strength due to material properties and undetected corrosion. The FAA disagrees. The only purpose of the 1.1 factor is to take into account pressure relief valve tolerances. Material variations are covered elsewhere in the regulations. The FAA does not believe an increase to 1.15 is justifiable.

Two commenters suggested revisions to the flush paragraph at the end of proposed § 25.571(b) to make clear which effects are to be considered. The FAA believes that the proposed language adequately covers the range of effects to be considered.

§ 25.571(c)

Several commenters noted the typographical error in the title of proposed § 25.571(c). The parenthetical term "(safe-fail)" should be "(safe-life)." This error is corrected in the final rule.

A commenter objected to proposed § 25.571(c) on the ground that it would give the FAA new powers to overrule the manufacturer's judgement as to whether it would be impractical, for a given structure, to comply with the damage-tolerance requirements of proposed § 25.571(b). Under the rules being amended, the commenter noted, the manufacturer has the option of selecting either the "safe-life" or "fail-safe" approach. The FAA has considered this comment; however, service experience has shown conclusively that the damage-tolerance (fail-safe) approach is more reliable than the safe-life approach, particularly since the safe-life approach does not take into account the probability of damage due to foreign-object impact, corrosion, or improper maintenance. The FAA firmly believes that safety is best served by requiring the manufacturer to use the damage-tolerance approach unless he shows to the FAA's satisfaction that it would be impractical to do so.

Several commenters pointed out that the third sentence of proposed § 25.571(c) would improperly allow cracking to occur. The FAA agrees. As noted by the commenters, the intent of the proposal was to require that the structure be able to withstand the repeated loads of variable magnitude expected during its service life without detectable cracks. Accordingly, in the adopted rule, the third sentence of proposed § 25.571(c) is deleted, and the words "without detectable cracks" are added to its second sentence for clarification. One of these commenters suggested that the last sentence of proposed § 25.571(c) also be deleted since it is covered in the proposed appendix. The FAA believes that this sentence is necessary in the basic rule as well as in associated guidance material.

A commenter contended that proposed § 25.571(c) omitted a key requirement—that no reduction in strength be allowed. The FAA disagrees. Experience with transport airplane structure and materials has shown that there is no significant reduction in ultimate strength due to repeated load application unless detectable cracks have developed. Therefore, if it is shown that no detectable cracks will be initiated during the service life of the structure, the FAA considers that no reduction in ultimate strength will occur.

§ 25.571(d)

No adverse comments were received concerning proposed § 25.571(d). Accordingly, § 25.571(d) is adopted as proposed.

§ 25.571(e)

A commenter objected to proposed § 25.571(e), contending that it would be impossible to obtain a type certificate for a propeller-driven airplane under its provisions. This commenter stated that it is difficult to imagine designing airplanes strong enough to withstand a 200- to 300-pound propeller, or even a single propeller blade, coming loose and crashing through the fuselage. The FAA believes that a transport category airplane making use of structural design features such as slow crack growth, crack arrestment, and multiple-load-path construction, can be designed for discrete source damage, including propeller impact damage. This would require that the structure withstand the static loads expected during completion of the flight (on which the impact damage occurred). The extent of the damage would be determined on the basis of a rational assessment of operational experience and potential damage. The FAA has no reason to believe that designers of propeller-driven airplanes would not be able to comply with proposed § 25.571(e), as adopted.

Another commenter expressed concern lest interpretation of proposed § 25.571(e), insofar as it would apply to structural damage caused by propeller blade impact, might discourage the development of new advanced turboprop airplanes and, therefore, would not be in the public interest. The FAA anticipates no interpretation problem in administering § 25.571(e), as adopted, and has no reason to believe that designers of turboprop airplanes would not be able to comply with its provisions.

A commenter recommended that proposed § 25.571(e) be deleted on the ground that each of the items listed in subparagraphs (1) through (4) necessitates special consideration of the circumstances under which the event arises and that they therefore warrant separate treatment in the regulations, as is done currently in part 25. Moreover, this commenter contended, no detailed justification has been provided for proposed § 25.571(e), which in general represents an increase in severity over current regulations. The FAA believes that it is appropriate to consider the items in subparagraphs (1) through (4) together since the concern in each instance is the probability of structural damage. The need for these requirements is dictated by service experience. Modern damage-tolerance (fail-safe) techniques, such as slow crack growth, crack arrestment, and multiple-load-path construction, make it possible to provide a capability of surviving discrete source damage.

A commenter suggested that proposed § 25.571(e) be transferred to subpart D of part 25 since it covers more than structural implications. The FAA disagrees. The intent is to cover only the structural implications of the listed impacts and failures, as the proposed language makes clear. The FAA is concerned here only with structural damage.

A commenter considered that the word "likely" in the lead-in of proposed § 25.571(e) was not necessary. The FAA disagrees. The word "likely" has a substantive probability connotation in this context.

Two commenters noted that the bird strike condition in proposed § 25.571(e)(1) is different from those in current §§ 25.631 and 25.775, and one commenter suggested they be made

consistent. The FAA believes there may be merit in this suggestion but does not have sufficient information, at this time, on which to base any revision of current §§ 25.631 and 25.775. The FAA believes, however, that proposed § 25.571(e)(1) is a realistic condition for structural damage assessment in general.

A commenter suggested that the sources of structural damage listed in proposed § 25.571(e) include "faulty maintenance" and "faulty operation." The FAA disagrees. Likely sources of this kind are considered during damage-tolerance (fail-safe) evaluation.

A commenter suggested that the word "static" in the first sentence of the flush paragraph at the end of proposed § 25.571(e) is unnecessary and should be deleted. The FAA disagrees, since the word "static" is necessary to describe the internal ultimate design loads expected to occur.

Several commenters objected to the third sentence of the flush paragraph at the end of proposed § 25.571(e), contending that dynamic effects are adequately taken into account when determining the likely structural damage caused by the listed discrete-source impacts and failures and the magnitude of the static loads that would subsequently occur in flight. The FAA agrees, and the flush paragraph in the adopted rule is revised to make this point clear.

Two commenters suggested revisions to the last sentence of the flush paragraph at the end of proposed § 25.571(e) to make clear which effects are to be considered. The FAA believes the proposed language adequately covers the range of effects to be considered.

§ 25.573

There were no adverse comments on the proposal to delete § 25.573. Accordingly, § 25.573 is deleted.

§ 25.629(d)(4)(v)

A commenter, noting that the proposed amendment to § 25.629(d)(4)(v) referred only to proposed § 25.571(b), suggested that it also refer to proposed § 25.571(e), which could have an effect not only on flutter but also on handling characteristics. The FAA disagrees. The intent of proposed § 25.571(e) is to insure that the airplane, after receiving discrete-source damage, has sufficient residual static strength capability to successfully complete the flight. Evaluating flutter and handling characteristics goes beyond that intent.

APPENDIX H

As discussed previously, proposed appendix H is being adopted in the form of a new advisory circular. In addition to removing the inappropriate mandatory language proposed in the appendix, a number of changes have been incorporated based on the comments received and further review. Those comments and changes are discussed below.

APPENDIX H, § H25.1

A commenter suggested that the first sentence of the second lead-in paragraph of proposed § H25.1 be revised to allow the consideration of "good design practice" in determining whether an effective damage-tolerant structure can be achieved. The FAA agrees and the suggested change is incorporated in the new advisory circular.

A commenter suggested that "engine mounts" be added to the examples given in the last sentence of the second lead-in paragraph of proposed § H25.1 since it is not only in the attachments of these structures that difficulties may be experienced in achieving damage-tolerant designs. The FAA agrees, and this change is incorporated in the new advisory circular.

A commenter objected to the phrase "at critical regions in" as used in the first sentence of proposed § H25.1(c) because if stresses are of low order, the regions could hardly be called "critical." The FAA agrees, and in the new advisory circular the phrase "in specific regions of" is substituted for "at critical regions in".

A commenter objected to the reference to "probability" in the first sentence of proposed § H25.1(c), contending that it has an unfavorable connotation. The FAA disagrees. The use of probability terminology is appropriate in this context. However, the language in this sentence is editorially revised in the new advisory circular without substantive change.

A commenter noted that the words "tensile area" (modifying "cutouts") in the second sentence of proposed § H25.1(c) tend to restrict attention inappropriately since cutouts in shear and compression areas also warrant attention. The FAA agrees, and the words "tensile area" are deleted in the new advisory circular.

Two commenters contended that it was not always possible to complete the repeated load tests necessary to show compliance with the damage-tolerance evaluation requirements in proposed § 25.571(b) within a reasonable time. This would lead, it was asserted, to a burdensome and costly delay in obtaining type certificates for airplanes. One of these commenters suggested that proposed § H25.1(c) be revised so that an applicant can obtain the type certificate without having completed those tests if the applicant substantiates at least 1 year of safe operation. The other commenter suggested that a somewhat similar provision be added to proposed § H25.2(g). The FAA believes that the circumstances described by these commenters will occur only rarely and that the need for the suggested relief (and the proper extent of that relief) can only be judged on the merits of each individual case. For these reasons, the FAA believes that it would be inappropriate to incorporate the revision suggested. Instead, the FAA will consider requests for relief on an individual basis.

APPENDIX H, §§ H25.2 (a), (b), AND (c)

A commenter asserted that proposed §§ H25.2(a) (1), (2), and (3) were essentially variations of the same proposal and should be combined in a single general statement. The FAA agrees, and proposed §§ H25.2(a) (1), (2), and (3) are revised accordingly and appear in a combined form in the new advisory circular.

A commenter stated that, in the lead-in sentence of proposed § H25.2(a)(6), the phrase "due to fatigue" rules out concern for corrosion damage, and the phrase "high life conditions" is not a useful concept. This commenter suggested that the lead-in be revised to read: "Provision to limit the probability of concurrent multiple damage, particularly after long service, which could conceivably contribute to a common fracture path. Examples of such multiple damage are;". The FAA agrees and proposed § H25(a)(6), as contained in the new advisory circular, incorporates this change.

A commenter objected to proposed § H25.2(a)(6)(i), contending that the word "initial" implies the cracks were present when the structure was built, and that the phrase "each of which being less than the minimum detectable length" was unnecessarily restrictive, since cracks that small are not likely to cause major concern. The commenter suggested that proposed § H25.2(a)(6)(i) be revised to read "A number of small cracks which might coalesce to form a single long crack." The FAA believes the suggested language clarifies the intent. The new advisory circular incorporates this language.

The same commenter objected to proposed § H25.2(a)(6)(ii), contending that the word "initial" here implies the failure was built in and that the phrases "following an initial failure" and "due to redistribution of loading" should be in reverse order to avoid confusion. The commenter suggested that proposed § H25.2(a)(6)(ii), be revised to read "Failures, or partial failures, in adjacent areas due to the redistribution of loading following a failure of a single element." The FAA

agrees, and this language is used in the new advisory circular.

This commenter also objected to proposed § H25.2(c), contending that it deals with several reasonably simple concepts in a complex, obscure way. A specific revision was suggested. The FAA believes that the intent of this paragraph is clear as proposed.

APPENDIX H, §§ H25.2 (d), (e), AND (f)

A commenter suggested that the last sentence of proposed § H25.2(d) be placed at the beginning of the paragraph and revised (to emphasize the preference for damage-tolerance evaluation to read: "Every reasonable effort should be made to ensure inspectability of all structural parts, and to qualify them under the damage-tolerance provisions." The FAA agrees, and the suggestion has been followed in the new advisory circular. This change also responds to another commenter who suggested several changes to proposed § H25.2(d) which were aimed at emphasizing the preferability of avoiding completely uninspectable areas.

A commenter noted that in proposed § H25.2(e) the words "damage" and "failure," which were apparently intended to be synonymous, convey separate concepts. The FAA agrees, and in the new advisory circular the sentence is clarified.

APPENDIX H, §§ H25.2 (g) AND (h)

A commenter recommended a general revision of the lead-in paragraph of proposed § H25.2 (g), contending that: (1) The phrase "damage extent for residual strength" should convey a different idea than it does in proposed § H25.2(c); (2) the phrase "the time at which the damage becomes initially detectable" is not quite accurate since "initially detectable" implies a much smaller dimension than is likely to be appropriate; and (3) the second sentence appears to be a rather academic requirement. The FAA disagrees. The intent of proposed § H25.2(g) is to identify damage-tolerance criteria (analytical and test) with respect to residual strength, damage growth rate, inspection programs, repeated loads, damage-tolerance characteristics, and discrete source damage. The FAA believes this intent is clear in the language proposed. However, based in part on a comment concerning proposed §§ H25.2(g) (1), (2), and (3), the FAA believes that proposed § H25.2(g) (2) would be clearer if it read "By demonstrating that the damage would be detected before it reaches the value for residual strength evaluation." In addition, based on a review of proposed § H25.2(g)(3), the FAA believes that the previously verified design should also have a similar configuration. These changes are incorporated in the new advisory circular.

Two commenters suggested a revision to make it clear that the applicant can use any one of the methods listed in §§ H25.2(g) (1), (2), and (3) for showing damage-tolerance characteristics. The FAA agrees, and appropriate changes are incorporated in the new advisory circular.

A commenter suggested that a provision be added to proposed § H25.2(g) to enable an applicant to obtain a type certificate without having completed the repeated load tests necessary to support damage-tolerance evaluation (where practical) of structure. For a discussion of this and a similar suggestion submitted by another commenter, see the preamble discussicn for proposed § H25.1.

A commenter agreed with proposed § H25.2(h), but suggested that it should contain a factor on inspection intervals to allow for scatter in structural behavior, operational usage, and inspection reliability. The FAA recognizes that the inspection interval should be conservative, but believes that it would be inappropriate to prescribe a specific factor. It is preferable that the factor be established by the manufacturer after all contributing parameters have been considered. Final approval would be by the FAA.

Several commenters objected to the last sentence of proposed § H25.2(h), contending that it should mention (as an example of a document that provides for revision as a result of operational experience) the operator's FAA-approved structural inspection program developed through the Maintenance Review Board (MRB) procedures for part 121 operators. The FAA agrees, and the new advisory circular references the MRB-generated programs. In addition, a reference to § 25.571(a)(3) is also added.

APPENDIX H, § H25.3

A commenter objected to the reference to "probability" in the first sentence, contending that it has an unfavorable connotation. The FAA disagrees. The use of probability terminology is appropriate in this context. However, the language in this sentence is editorially revised in the new advisory circular, without substantive change, for consistency with similar provisions elsewhere.

A commenter suggested that the words "consideration of" in the third sentence of proposed § H25.3(a) should be deleted. With the elimination of the mandatory language from the proposed appendix, these words are superfluous. They do not appear in the new advisory circular.

Three commenters objected to the phrase "to prevent catastrophic failure" in proposed § H25.3(a)(5). The FAA believes that the intent of proposed § H25.3(a) is adequately expressed in general terms in the first sentence of proposed § H25.3(a), and that this intent need not be repeated in § H25.3(a)(5). An appropriate revision is contained in the new advisory circular.

A commenter, referring to proposed § H25.3(c)(5), suggested that FAA specify approved methods and procedures (for rework or repair of the structure) that might gain further life. The FAA disagrees, since this suggestion, if adopted, would tend to unnecessarily dictate design.

ADOPTION OF THE AMENDMENT

Accordingly, part 25 of the Federal Aviation regulations (14 CFR Part 25) is amended as follows, effective December 1, 1978:

1. By revising § 25.571 to read as follows:

§ 25.571 Damage tolerance and fatique evaluation of structure.

(a) *General.* An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, or accidental damage, will be avoided throughout the operational life of the airplane. This evaluation must be conducted in accordance with the provisions of paragraphs (b) and (e) of this section, except as specified in paragraph (c) of this section, for each part of the structure which could contribute to a catastrophic failure (such as wing, empennage, control surfaces and their systems, the fuselage, engine mounting, landing gear, and their related primary attachments). Advisory Circular AC No. 25.571-1 contains guidance information relating to the requirements of this section (copies of the advisory circular may be obtained from U.S. Department of Transportation, Publications Section M443.1, Washington, D.C. 20590). For turbojet-powered airplanes, those parts which could contribute to a catastrophic failure must also be evaluated under paragraph (d) of this section. In addition, the following apply:

(1) Each evaluation required by this section must include—

(i) The typical loading spectra, temperatures, and humidities expected in service;

(ii) The identification of principal structural elements and detail design points, the failure of which could cause catastrophic failure of the airplane; and

(iii) An analysis, supported by test evidence, of the principal structural elements and detail design points identified in paragraph (a)(1)(ii) of this section.

(2) The service history of airplanes of similar structural design, taking due

account of differences in operating conditions and procedures, may be used in the evaluations required by this section.

(3) Based on the evaluations required by this section, inspections or other procedures must be established as necessary to prevent catastrophic failure, and must be included in the maintenance manual required by § 25.1529.

(b) *Damage-tolerance (fail-safe) evaluation.* The evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. The determination must be by analysis supported by test evidence and (if available) service experience. Damage at multiple sites due to prior fatigue exposure must be included where the design is such that this type of damage can be expected to occur. The evaluation must incorporate repeated load and static analyses supported by test evidence. The extent of damage for residual strength evaluation at any time within the operational life must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand loads (considered as static ultimate loads) corresponding to the following conditions:

(1) The limit symmetrical maneuvering conditions specified in § 25.337 at V_C and in § 25.345.

(2) The limit gust conditions specified in §§ 25.341 and 25.351(b) at the specified speeds up to V_C, and in § 25.345.

(3) The limit rolling conditions specified in § 25.349 and the limit unsymmetrical conditions specified in §§ 25.367 and 25.427, at speeds up to V_C.

(4) The limit yaw maneuvering conditions specified in § 25.351(a) at the specified speeds up to V_C.

(5) For pressurized cabins, the following conditions:

(i) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in paragraphs (b) (1) through (4) of this section, if they have a significant effect.

(ii) The expected external aerodynamic pressures in 1 g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load.

(6) For landing gear and directly-affected airframe structure, the limit ground loading conditions specified in §§ 25.473, 25.491, and 25.493.

If significant changes in structural stiffness or geometry, or both, follow from a structural failure, or partial failure, the effect on damage tolerance must be further investigated.

(c) *Fatigue (safe-life) evaluation.* Compliance with the damage-tolerance requirements of paragraph (b) of this section is not required if the applicant establishes that their application for particular structure is impractical. This structure must be shown by analysis, supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected during its service life without detectable cracks. Appropriate safe-life scatter factors must be applied.

(d) *Sonic fatigue strength.* It must be shown by analysis, supported by test evidence, or by the service history of airplanes of similar structural design and sonic excitation environment, that—

(1) Sonic fatigue cracks are not probable in any part of the flight structure subject to sonic excitation; or

(2) Catastrophic failure caused by sonic cracks is not probable assuming that the loads prescribed in paragraph (b) of this section are applied to all areas affected by those cracks.

(e) *Damage-tolerance (discrete source) evaluation.* The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of—

(1) Impact with a 4-pound bird at likely operational speeds at altitudes up to 8,000 feet;

(2) Propeller and uncontained fan blade impact;

(3) Uncontained engine failure; or

(4) Uncontained high energy rotating machinery failure.

The damaged structure must be able to withstand the static loads (considered as ultimate loads) which are reasonably expected to occur on the flight. Dynamic effects on these static loads need not be considered. Corrective action to be taken by the pilot following the incident, such as limiting maneuvers, avoiding turbulence, and reducing speed, must be considered. If signficant changes in structural stiffness or geometry, or both, follow from a structural failure or partial failure, the effect on damage tolerance must be further investigated.

§ 25.573 [Reserved]

2. By deleting § 25.573 and marking it "[Reserved]."

§ 25.629 [Amended]

3. By amending § 25.629(d)(4)(v) by deleting "§ 25.571(c)" and inserting in its place "§ 25.571(b)."

(Secs. 313(a), 601, and 603, Federal Aviation Act of 1958, as amended (49 U.S.C. 1354(a), 1421, and 1423); sec. 6(c), Department of Transportation Act (49 U.S.C. 1655(c)).)

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LANGHORNE BOND,
Administrator.

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