DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. 27358; Amdt. No. 25–96]

RIN 2120–AD42

Fatigue Evaluation of Structure

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This action amends the fatigue requirements for damage-tolerant structure on transport category airplanes to require a demonstration using sufficient full-scale fatigue test evidence that widespread multiple-site damage will not occur within the design service goal of the airplane; and inspection thresholds for certain types of structure based on crack growth from likely initial defects. This change is needed to ensure the continued airworthiness of structures designed to the current damage tolerance requirements, and to ensure that should serious fatigue damage occur within the design service goal of the airplane, the remaining structure can withstand loads that are likely to occur, without failure, until the damage is detected and repaired.

EFFECTIVE DATE: April 30, 1998.

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SUPPLEMENTARY INFORMATION:

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Small Entity Inquiries

The Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA) requires the FAA to report inquiries from small entities concerning information on, and advice about, compliance with statutes and regulations within the FAA's jurisdiction, including interpretation and application of the law to specific sets of facts supplied by a small entity.

If you are a small entity and have a question, contact your local FAA official. If you do not know how to contact your local FAA official, you may contact Charlene Brown, Program Analyst Staff, Office of rulemaking, ARM–27, Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, 1–888–551–1594. Internet users can find additional information on SBREFA in the ''Quick Jump'' section of the FAA's web page at http://www.faa.gov and may send electronic inquiries to the following Internet address: 9–AWA–SBREFA@faa.dot.gov.

Background

This amendment is based on Notice of Proposed Rulemaking (NPRM) 93–9, which was published in the **Federal Register** on July 19, 1993 (58 FR 38642). The notice was issued because of the need: (1) To ensure that widespread, multiple site fatigue cracking will not occur during the period of service for which the airplane is designed to operate; and (2) to prescribe criteria for establishing the thresholds for damage-tolerance based inspections.

In addition three minor changes requested by both U.S. and European manufacturers of transport category airplanes, aimed at harmonizing the U.S. and European certification requirements, were also proposed in this notice.

Section 25.571 of 14 CFR part 25 requires that applicants for an airplane type certificate address the technical issue of structural fatigue (other than sonic fatigue) in one of two ways: (1) A damage-tolerance evaluation of the structure; or (2) a safe-life fatigue evaluation of the structure.

Of the two methods of evaluation, the first is preferred and the second may only be used if the applicant establishes that it is impractical to use a damage-tolerance approach. Even so, several in-service incidents and accidents resulting from structural fatigue failures have demonstrated the need to improve the damage-tolerance evaluation requirements of part 25.

A damage-tolerance evaluation consists of engineering calculations and tests aimed at establishing what kind of inspections are needed, and how often they need to be repeated on an airplane's structure while in service. The inspection frequency is set to assure that, should serious fatigue damage begin to develop before the design service goal of the airplane is reached, it will be found and repaired before it grows to proportions that represent a hazard to the airplane.

This methodology has proven to be successful in many applications and, in fact, is part of the reason for the excellent overall safety record that has been achieved in the U.S. Nevertheless, there are two issues that have been debated within the technical community that are not clearly dealt with by the damage-tolerance methodology:

1. When in an airplane's life should the first inspection in the inspection cycle be conducted (the threshold inspection)?

2. When in an airplane's life can safety no longer be effectively maintained by the damage tolerance inspection program prescribed at the time of certification of the airplane type (the onset of widespread cracking)?

These are complex issues that are discussed at some length in Notice 93–9. This rulemaking attempts to incorporate into part 25 some technical judgments on these issues that offer a high degree of safety to the flying public, without overburdening the air transportation system with unnecessary inspections or tests. To this end, the FAA proposed that § 25.571 of the FAR, ''Damage-tolerance and fatigue evaluation of structure,'' be revised:

1. To require sufficient full-scale fatigue testing to ensure that widespread, multiple-site fatigue damage does not occur within the design service goal of the airplane; and

2. To require that thresholds for inspections be based on anaylses and tests considering the damage-tolerance concept, manufacturing quality, and susceptibility to in-service damage. (The idea of basing the time of the threshold inspection on the time it takes a crack to grow from a manufacturing defect that is likely to escape manufacturing

quality control inspection to the time the crack represents a hazard to the airplane is known as the ''rogue flaw'' concept for establishing inspection thresholds.)

A revision to companion draft Advisory Circular (AC) 25.571–1A was prepared for the proposed rulemaking, to provide guidance on means that the FAA would accept as showing compliance with the regulation. As with all advisory circulars, this draft was intended only to provide guidance on acceptable means of compliance, without eliminating the flexibility for future applicants to identify other means of compliance with the proposed rule. That draft revision (AC 25.571–1X) was not available at the time that Notice 93–9 was issued and was subsequently made available to the public for comment on October 19, 1993 (58 FR 53987). As a result, the FAA has received two sets of comments from the public, one in response to the draft AC and one in response to the proposed rule. Some of the earlier comments were made without the benefit of the commenter knowing the contents of the draft AC. Because of this, the FAA has considered both sets of comments in preparing the final rule contained herein, and in revising the AC. The announcement of the FAA's issuance of the revised AC will be published in the **Federal Register** once it is available to the public.

Interested persons have been given an opportunity to participate in this rulemaking, and due consideration has been given to all matters presented. Comments received in response to Notice 93–9 are discussed below.

Discussion of Comments

The FAA received many comments in response to Notice 93–9, most of which state support for the added requirement for full-scale fatigue testing of new airplane types. Commenters included airplane manufacturers, the National Transportation Safety Board, the Airline Pilots Association, the Aerospace Industries Association, the General Aviation Manufacturers Association, airplane operators, and others. Only a few commenters state that full-scale fatigue testing should not be required.

One commenter states that full-scale fatigue tests should not be mandated because these tests do not adequately account for actual conditions experienced in service and therefore cannot accurately predict in-service problems. The commenter further states that such tests have never predicted widespread fatigue damage that later became a problem in the fleet. The FAA does not concur with this comment. It is widely recognized in the aviation engineering community that ''scatter factors'' need to be applied to fatigue test results, because such tests cannot account for the individual construction variations and the individual service experience of each airplane. Nevertheless, important results have been, and will continue to be, obtained from such tests, including the prediction of widespread fatigue damage. The FAA, airplane manufacturers, and others have come to recognize that full-scale fatigue testing provides an indispensable, although admittedly incomplete, source of information about what to expect in service from airframe structures. As was pointed out by another commenter who favors the new requirement, full-scale fatigue test evidence must be coupled with prudent exploratory fleet inspections to ensure continued airworthiness.

The FAA received several comments about the full-scale fatigue testing of derivative or modified type designs. These commenters point out that full-scale fatigue test data generated during the original certification of an airplane type, and other data, can sometimes be used to determine when widespread multiple-site fatigue damage will, or will not, occur on the modified designs. These commenters state that additional full-scale fatigue testing would not be necessary in all cases. The FAA concurs with these comments. The working of § 25.571(b) in the final rule has been changed along the lines of one comment that had been jointly developed by the Aerospace Industries Association, the Association Europeenne des Constructeurs de Materiel Aerospatial, and the FAA's Technical Oversight Group for Aging Airplanes. This change uses the words ''sufficient full-scale fatigue test evidence'' in place of ''sufficient full-scale testing.''

The same commenters also state that guidance should be provided in the form of an advisory circular (AC) on the subject of when and how much fatigue testing would be necessary for modification and derivative certification programs. The FAA concurs. In fact, draft AC 25.571–1X does contain some guidance. Based on comments provided to the docket for this rulemaking and in response to the draft AC, the FAA has revised and expanded the guidance regarding the relevant factors in determining whether, and to what extent, fatigue testing may be necessary for derivatives and modifications of type designs. Generally, these factors relate to the applicability and reliability of previously developed test evidence for determining that the airplane will remain free of widespread fatigue damage until its design service goal is reached.

Another commenter points out that two lifetimes of fatigue testing cannot ''ensure'' that widespread multiple-site damage will not occur within the design lifetime of an airplane (since no fatigue test can duplicate the exact configuration and operating history of each airplane). The commenter states that the requirement of the rule should be to ensure hat widespread multiple-site damage will not ''normally'' occur. The FAA agrees that two lifetimes of fatigue testing cannot ensure that widespread fatigue damage will not occur within the design lifetime of an airplane; however, guidance on this statistical fact is best addressed in the AC. Therefore, as a result of this comment, the FAA has revised the AC in this regard.

The FAA also received comments that full-scale fatigue testing represents a prohibitive expense for small entities that perform modifications of type designs produced by others and would put them out of business. These commenters note that the FAA has certificated airplane modifications for damage tolerance in the past, relying on analytical methods that are based upon test data and using conservative assumptions, but without full-scale fatigue testing. They state that they are small entities that the FAA did not consider.

As discussed previously, the objective of this rulemaking is to ensure that transport category airplanes will remain free of widespread fatigue damage within their design service goals. For reasons discussed below, the FAA considers that most modifications can be found to meet this objective without additional full-scale testing. However, it is true that in some cases involving extensive structural modification (such as a cargo conversion project) it may be necessary for the FAA to require a modifier to conduct full-scale fatigue testing to demonstrate freedom from widespread fatigue damage within the design service goal of an airplane type. The FAA acknowledges that such testing may be expensive. In these cases, the FAA has determined that the safety interests of the flying public must take precedence over the economic interests of airplane modifiers. This final rule does not preclude modifiers from conducting such projects, but, if they cannot otherwise meet the objectives of this rule, they will need to consider the costs of full-scale fatigue testing along with the other compliance costs when they evaluate the economic viability of a particular modification project.

The FAA does not, however, concur that the overall economic impact of this final rule on these small entities is significant. First, as discussed in the preceding paragraphs, the full-scale fatigue testing requirement of the proposed rule has been revised such that it is not always necessary to conduct one for a modification project, and most modifications would not necessitate one. The companion AC to the rule has been expanded to provide guidance on acceptable means of showing compliance for modifications. This guidance discusses how small, simple design changes, using a design comparable to the original structure, could be analytically determined to be equivalent to the original structure in their propensity for widespread fatigue damage (e.g., modification of the fuselage structure for mounting an antenna using a design that is similar to the original airplane in that area). In addition, the amendment will not impose any additional costs on these small entities on projects for which they have already applied for supplemental type certificates; nor will it impose any additional costs on projects for which they would apply for supplemental type certificates in the near future, since the designs that would be affected by this amendment would probably not enter service until at least 5 to 10 years after its adoption. This is because, in general, in accordance with § 21.101 of 14 CFR part 21, modifiers of type designs need only comply with the regulations that were used to certificate the original model.

One other commenter states that the rule could be interpreted to require full-scale fatigue testing of modifications specified in service bulletins, which would actually impede safety by delaying the issuance of needed service bulletins. The FAA does not concur with this comment. Service bulletin modifications are in the same general category as other modifications, and most would not necessitate full-scale fatigue testing. Further, if circumstances necessitate airworthiness directive (AD) action to mandate a modification specified in a manufacturer's service bulletin before fatigue testing of the modification is complete, there is nothing in the rule that prevents the FAA from doing so.

One commenter also suggested replacing the sentence in current § 25.571(b) that states, ''Damage at multiple sites due to prior fatigue exposure must also be included where the design is such that this type of damage is expected to occur,'' with the following sentence: ''Special consideration for WFD must be included where the design is such that this type of damage could occur.'' Although the commenter provided no explanation of this suggestion, the FAA considers that it has merit. The FAA concurs that requiring ''special consideration for WFD'' emphasizes that, in addition to demonstrating that WFD will not occur within the design service goal, the applicant for type certificate must also consider ways to prevent or control the effects of WFD that may occur beyond the design service goal. This is necessary to fulfill the objective of § 25.571(a) to avoid catastrophic failure due to fatigue throughout the operational life of the airplane.

Many commenters object to basing all inspection thresholds on the so-called ''rogue flaw'' concept, as would be required by the proposed amendment to § 25.571(a)(3). These commenters state that indiscriminately applying this approach to all airplane structures would result in an exorbitant increase in airplane inspection costs, because it would necessitate detailed inspections earlier in an airplane's life and would not significantly enhance safety. Although most of these commenters aknowledge the necessity of using the ''rogue flaw'' concept to establish inspection thresholds for certain types of airframe design details, it was argued that the current industry practice for establishing the inspection thresholds (consisting of predicting the onset of cracking from fatigue testing and service experience) is adequate for most commonly used airframe designs. Some commenters endorsed a proposal that had previously been jointly submitted by the Aerospace Industries Association, the Association Europeene des Constructeurs De Material Aerospatial (AECMA), and the Technical Oversight Group for Aging Airplanes (hereinafter referred to as the AIA/AECMA/TOGAA comment). This group proposed that rogue flaw based inspection thresholds be limited to single load path structure, or other structure where it cannot be demonstrated that load path failure, partial failure, or crack arrest will be detected and repaired prior to failure of the remaining structure. The FAA concurs with these comments. These criteria have been incorporated into the final rule, and will ensure that the rogue flaw method of establishing inspection thresholds is not applied indiscriminately, but will be applied where necessary.

Following close of the comment period, and after the FAA had reviewed these comments and decided to incorporate the language proposed by AIA/AECMA/TOGAA into the final rule, Boeing, which had participated in the development of the AIA/AECMA/TOGAA comment, became aware of the FAA's decision. (This resulted from a series of communications between Boeing and the FAA regarding an ongoing program to determine the appropriate criteria for establishing fatigue inspection thresholds for the Model 757 and 767 airplanes; the communications were otherwise unrelated to this rulemaking.) At Boeing's request, AIA filed an additional comment, objecting to inclusion of this language in the final rule, and recommending instead that it be incorporated into AC 25.571–1X. AIA stated that the FAA's decision was in conflict with the AIA/AECMA/TOGAA comments, which had been based on the commenters' conclusion that the general requirement of § 25.571(a)(3) that inspections be established ''as necessary to prevent catastrophic failure'' was sufficient to ensure that rogue flaws would be considered appropriately, as described in their proposed revision to the AC.

Although the FAA concurs with the commenter's position that rogue flaws in certain types of structure must be considered, the FAA does not concur that revising the AC alone, and relying on the general language of § 25.571(a)(3), is sufficient to ensure adequate consideration. Advisory circulars are not mandatory and explicitly describe ''one means, but not the only means,'' of complying with the relevant regulations. Therefore, because the FAA considers it essential that rogue flaws be considered, the final rule has been amended, as described previously.

One commenter states that the sentence added to § 25.571(a)(3) should be revised to state that thresholds for inspection should also be based on service experience and fatigue testing, followed by a ''tear-down'' examination of the test article. Although the FAA agrees that there may be important factors, it is more appropriate to discuss them as acceptable means of compliance in the companion advisory circular, and not in the rule itself. This will provide maximum flexibility for future applicants to identify means of fulfilling the rule's objectives.

One manufacturer asks for confirmation that its particular method of establishing thresholds for inspection be allowed under the current rulemaking. The FAA considers it inappropriate, in the context of this rulemaking, to evaluate any one manufacturer's particular methodology. Such an evaluation would normally be

accomplished during the certification process for an airplane type.

One commenter states that the proposed rule implies that simulated manufacturing defects must be inflicted on the full-scale fatigue test from the start. The FAA disagrees. As proposed, the purpose of the full-scale fatigue test requirement is to establish that the structure will be substantially free from widespread fatigue damage at least until its design service goal is reached. In contrast, the purpose for the consideration of manufacturing defects is to establish thresholds for inspection (or other procedures) for certain types of structure. Although the latter could involve full-scale fatigue testing in which the test article is inflicted with simulated manufacturing defects, and, in fact, the FAA's certification evaluation of a model type design may reveal that this is the necessary way of establishing a threshold in exceptional cases, it is not the FAA's intent to require this in general.

One commenter states that it is not normally possible to complete a full-scale fatigue test prior to issuance of a type certificate. The commenter recommends that AC 25.571–1A be revised to allow completion of the full-scale fatigue test after type certification. The FAA agrees with this comment. As noted by the commenter, taken literally, the proposed rule would have required that the testing be completed prior to issuance of a type certificate. However, as reflected in the preamble of the NPRM, the FAA recognized that this may not be realistic and would have allowed completion of testing after issuance of the type certificate. In light of the comment, the FAA has reconsidered this issue and determined that the rule must be revised to address this potential conflict. As revised, the rule allows testing to be completed after issuance of the type certificate, provided:

1. Before issuance of the type certificate the Administrator has approved a plan for completing the required tests, and

2. The Type Certificate contains an airworthiness limitation in the airworthiness limitations section of the instructions for continued airworthiness required by § 25.1529 that no airplane may be operated beyond a number of cycles equal to one-half the number of cycles accumulated on the fatigue test article, until such testing is completed.

The FAA considers that the first condition is necessary to ensure that, at the time of type certification, the TC holder has at least identified an acceptable method of complying with this rule's requirements. The FAA considers that the second condition is necessary to ensure that, following type certification, the testing proceeds so that the affected airplanes receive the safety benefits that this rule is intended to provide. Although these conditions were not specified in the NPRM, the final rule actually provides relief from the literal requirement of the NPRM to complete testing prior to issuance of a TC. It is also a logical outgrowth of the proposal in that it resolves the conflict between the proposed rule language and the preamble discussion in a way that ensures that the rule's objectives are fulfilled.

Several commenters recommend that the words ''within the design lifetime of the airplane,'' used in the sentence added to § 25.571(b), be changed to ''within the design service goal of the airplane.'' It was pointed out that it is difficult for manufacturers to know at the time an airplane is first certificated exactly how long it will be used. The expected service period is set as a goal for fatigue design at that time; therefore, the words ''design service goal'' are more appropriate. Furthermore, it was pointed out that the term ''lifetime'' implies a fixed service period for an airplane, after which it would be retired. These commenters state that this does not represent the intent of the proposed rule. The FAA concurs with this comment, and the words ''design service goal'' have been substituted for ''design lifetime.''

Several commenters state that the proposed requirements for operating past the original design service goal are not clear. They note that an industry team, the Structural Audit Evaluation Task Group (SAETG) of the Airworthiness Assurance Working Group (AAWG), conducted an extensive activity to determine possible actions for airplane models that reach that point. (The SAETG and AAWG are subgroups of the Aviation Rulemaking Advisory Committee (ARAC), which submits rulemaking recommendations to the FAA). The commenters state that the recommendations of the SAETG should be addressed concurrently with the present change to § 25.571. The FAA does not agree with this comment. Although the FAA is addressing the recommendations of the SAETG at this time, that action covers only 11 specific models of airplanes whose fleet leaders have already exceeded their design service goal. These recommendations consist of suggested actions on how to implement the guidance material they generated. Although the FAA agrees that additional guidance may be appropriate for airplanes affected by the present rulemaking on the subject considered by the SAETG, the urgency of that action is not great because the design service goal of these airplanes would not be reached for at least another 20 years. Furthermore, one of the SAETG recommendations is that their guidance should not be extended beyond the 11 specific models it covers until it has actually been tried. To attempt to establish guidance for airplanes affected by the present rulemaking based on the SAETG recommendations at this time would only serve to delay the issuance of the present rulemaking. Therefore, the most expeditious manner of obtaining the benefits of the proposed refinement for the damage-tolerance evaluations is to adopt the present rule change and to continue discussions with the ARAC and others on how best to address the SAETG recommendations.

One commenter states support for the new requirement for full-scale testing, provided the companion Advisory Circular (AC 25.571–1X) follows the Certification Maintenance Requirements (CMR) guidelines (AC 25–19 dated 11/28/94). The CMR guidelines referred to by this commenter are guidelines on how inspection programs for airplane systems should be established at the time of certification. The FAA does not agree with this comment. There are presently fundamental differences in methodology between the way inspection programs are established for airplane systems and airplane structures. Attempts at resolving those differences have not been fruitful in the past, and there is no guarantee that they will be any more fruitful in the future. Therefore, evaluation of the appropriateness of using the CMR guidelines to establish structural inspection programs as part of the present rulemaking would result in a delay that the FAA considers unacceptable.

Several commenters state that the rule should specify the size of the initial manufacturing flaw or fatigue scatter factor criteria, either in the rule itself or in the accompanying AC. Although the FAA does not concur that an absolute size should be specified for the initial manufacturing flaw, guidance on acceptable means of compliance has been provided in the revised version of the AC on both subjects.

Regulatory Evaluation

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the

intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) will generate benefits that justify its costs as defined in the Executive Order; (2) is significant as defined in DOT's Regulatory Policies and Procedures; (3) will not have a significant impact on a substantial number of small entities; and (4) could affect international trade. These analyses, available in the docket, are summarized below.

Estimated Costs and Benefits

Based on the opinions of industry and agency experts, the FAA estimates that development and certification costs associated with the requirement for an inspection threshold based on initial manufacturing defects will be negligible. However, this provision could affect operating costs, depending on the degree to which it impinges on the timing of initial inspections. This evaluation conservatively estimates that an additional 500,000 work hours will be required to inspect a fleet of 1,000 airplanes as result of the requirement to base inspection thresholds on assumed manufacturing defects. Assuming a fully burdened compensation rate of $65 per hour, this provision will increase operating costs by approximately $32.5 million over the life of a 1,000 airplane fleet.

The cost of a full-scale fatigue test for a representative transport category airplane design is statistically estimated using a sample of four different airplane models, ranging from a 45-seat airplane to a large widebody transport. In its comments on NPRM 93–9, the Aerospace Industries Association (AIA) notes that certification requirements could double the number of work hours for such testing. To account for this, full-scale fatigue test costs for each airplane model were inflated by multiplying the labor cost component by a factor of two. The relationship between these adjusted fatigue test costs and airplane size—measured by the number of seats—was then estimated using ordinary least squares. This yields a cost estimate of $540,000 for each seat in a proposed model. The cost of a full-scale fatigue test for a 162-seat airplane design, for example, would be approximately 162 times $540,000 or $87.5 million. for a 1,000 airplane fleet, this would equal $87,500 per airplane.

Total costs are estimated for a representative type certification using the following assumptions: (1) The hypothetical airplane model is assumed to have 162 seats; (2) 50 percent of testing costs are incurred in the year 2000, one-third of the remaining costs are incurred in each of the years 2001, 2002, and 2003; (3) production commences in the year 2002; (4) 100 airplanes are produced per year for 10 years; (5) the first airplanes enter service in 2002; (6) for each airplane, inspection costs related to the ''rogue flaw'' requirement are uniformly distributed in the interval bounded by one-fourth and one-half the design service goal (i.e., between the 5th and 9th years of operation); (7) total burdened cost per work hour is $65; (8) the discount rate is 7 percent; and (9) each airplane is retired at the end of its 20-year design service goal.

Under these assumptions, undiscounted fleet certification and operating costs—including the costs of a full-scale fatigue test and the inspection threshold provision—equal $120.0 million or $120,000 per airplane. On a discounted (1997 dollar) basis, fleet costs equal $78.6 million or $78,600 per airplane.

The benefits of the rule depend on the inherent variability of structural fatigue analysis and on the efficacy of actions taken in response to the results of such analysis. For example, the ''rogue-flaw'' inspection threshold requirement will prevent an accident only if: (1) The threshold occurs before an accident would otherwise occur; and (2) the resulting inspection identifies the damaged structure. Nevertheless, based on the accident history and the likelihood of ancillary benefits, the FAA finds that the benefits of the rule justify its costs.

An examination of the service history identified 39 domestic accidents or incidents involving structural fatigue during the period 1974–1990. The National Transportation Safety Board (NTSB) identified improper maintenance and/or corrosion as important contributing factors in 17 of the events. Of the remaining 22 events, 12 involved the landing gear and 10 involved the wing, fuselage, or other structure.

Although only two of these 10 events resulted in fatalities, several other events had catastrophic potential (in one case a wing spar failed, and in five other cases passenger cabin decompression occurred). In at least one case, the NTSB concluded that the accident was the probable result of a manufacturing defect.

During the same period, air carriers accumulated approximately 148 million flight hours. Thus, between 1974 and 1990, the overall event rate was (10/148)=0.0676 per million flight hours. The historical fatal accident rate was (2/148)=0.014.

Assuming that the average air carrier airplane has 162 seats, 69 percent of which are occupied; the airplane replacement cost is $30 million; and the value of an averted fatality is $2.7 million; then the economic value of one accident in which an airplane is destroyed and there are no survivors is approximately $345.9 million. If the rule prevents one such accident, its undiscounted benefits will exceed its undiscounted costs by a ratio of $345.9 million/$120.0 million or 2.88. Assuming that the probability of an avoided accident is proportional to the size of the complying fleet in any given year, then the expected discounted benefits of such an avoided accident will exceed discounted costs by a ratio of approximately 1.34.

Prevented accidents, however, do not exhaust the benefits of this rule. Full-scale fatigue testing is already industry practice. This reflects, in part, benefits such as timely correction of deficiencies to prevent early cracking, and verification of inspection and maintenance procedures. In addition to obvious safety implications, early identification of premature cracking will allow repairs to be accomplished during scheduled maintenance visits, thus lessening the economic impact of withdrawing an airplane from revenue service. While it is difficult to account for these ancillary benefits, the accident history gives some indication of their potential.

A review of records on accidents that occurred between 1974 and 1989 shows that at least five fleetwide inspections involving approximately 900 airplanes were ordered as a result of accidents involving failure of airplane structure. During these inspections, at least 72 airplanes were found to have fatigue cracks. Cost information specifically related to these inspections is unavailable. However, a review of some recent Airworthiness Directives (AD) and Service Bulletin data indicates that a minimum of 20 work hours (10 hours elapsed time) are necessary to carry out the required inspections. Minimum out-of-service time is 15–20 hours—approximately one day. If the cracking is predicted by full-scale fatigue testing and planned for in normal maintenance, unscheduled downtime may be averted. The number of required work hours (and downtime) would be much greater of the examination reveals extensive

cracking since this finding would necessitate additional inspections and structural repair. If cracking is predicted from a full-scale fatigue test, it can be detected at an earlier stage of development in the operating airplanes, resulting in less costly repairs, requiring less downtime to accomplish.

The cost of the unscheduled downtime for a fleetwide inspection, in which each airplane is withdrawn from revenue service for one day, can be estimated using the same production, operating history, and discount rate assumptions listed above. Assuming that the probability of an unscheduled inspection is uniformly distributed over each airplane's service life and that the revenue lost per airplane per day out of service is $40,000, the FAA estimates that the expected discounted savings from averting an average of one unscheduled inspection/repair day per airplane (over the service life of the fleet) is approximately $12.1 million. Thus, regardless of the number of accidents avoided, if the rule averts an average of 6.5 days of downtime per airplane over the life of the fleet, the expected discounted benefits of the rule will equal the discounted costs.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires agencies to review rules which may have a ''significant economic impact on a substantial number of small entities.'' Entities potentially affected by the rule include manufacturers of transport category airplanes and aircraft modification firms.

While manufacturers of transport category airplanes generally support full scale fatigue testing, some aircraft modifiers—including some small firms—object to this requirement on the grounds that it constitutes and excessive burden. As noted previously, however, the final rule may require full-scale fatigue testing—covering, when applicable, modifications to future transport airplane designs—for four reasons.

First, the rule will not affect existing airplane types. The amendment will not impose additional costs on existing applications for supplemental type certification, nor will it affect applications made in the near future. The airplanes that would be affected by this amendment would not enter service for at least 5 to 10 years after its adoption.

Second, in the case of future type designs, it is difficult to predict whether anyone would seek approval for subsequent modifications, and, if so, how extensive the modifications would be and whether full-scale testing would be necessary for them (based on experience, the FAA concludes that most modifications of future designs will not require full-scale fatigue testing). Thus, it is impossible to conclude that there will be a significant effect on a substantial number of small entities.

Third, even assuming that small entities would propose such modifications, the FAA has determined that the safety interests of the flying public take precedence over the economic interests of airplane modifiers. The FAA finds, that, under the circumstances where existing test evidence is insufficient to meet the objectives of this rule, there are no alternatives to full-scale testing that would enable small entities to meet these objectives.

Fourth, the FAA remains open to considering technical innovations that provide alternatives to full scale testing. Such innovations could form the basis for finding that sufficient full-scale test evidence exists based on testing performed during initial type certification.

International Trade Impact Assessment

The Office of Management and Budget directs Federal Agencies to assess whether or not a rule or regulation will affect any trade-sensitive activity. The FAA has assessed the potential for this rule to affect domestic transport category airplane manufacturers, aircraft modification firms, and air carriers.

The FAA determines that the rule will have little or no effect on trade for either U.S. firms marketing transport category airplanes in foreign markets or foreign firms marketing transport category airplanes in the U.S. This follows since full scale fatigue testing for such airplanes is already industry practice, both domestically and abroad. Also, domestic and foreign manufactured airplanes would both be subject to the inspection threshold provision of the rule if they are certificated in the U.S.

Similarly, the FAA determines that the rule will have little or no effect on foreign firms competing for U.S. aircraft modification work, or U.S. firms competing for foreign aircraft modification work.

The FAA recognizes that the rule could affect the competition for international air travel by imposing more conservative inspection requirements on U.S. carriers. However, it is unlikely that, in validating the FAA's certification of a future airplane design, another civil aviation authority would escalate the inspection threshold required by this rule. Nevertheless, if a foreign civil aviation authority determines that the inspection threshold is too conservative and, thus, chooses not to impose this requirement, U.S. carriers operating future airplane models subject to this rule could incur larger inspection costs relative to foreign carriers operating foreign registered airplanes of the same models. The FAA estimates that the discounted 20-year cost of the inspection threshold provision is approximately $12,000 per airplane. Under the average passenger capacity and load factor assumptions described above, and assuming an average of 1,600 departures per airplane per year, this equals approximately $0.003 per enplaned passenger.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this rule will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

International Civil Aviation Organization (ICAO) and Joint Aviation Regulations

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with ICAO Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that this rule does not conflict with any international agreement of the United States.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), there are no reporting or recordkeeping requirements associated with this rule.

Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in Title 14 of the CFR in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such

regulatory distinctions as he or she considers appropriate. Because this final rule applies to the certification of future designs of transport category airplanes and their subsequent operation, it could affect intrastate aviation in Alaska. The Administrator has considered the extent to which Alaska is not served by transportation modes other than aviation, and how the final rule could have been applied differently to intrastate operations in Alaska. However, the Administrator has determined that airplanes operated solely in Alaska would present the same safety concerns as all other affected airplanes; therefore, it would be inappropriate to establish a regulatory distinction for the intrastate operation of affected airplanes in Alaska.

Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Public Law 104–4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed ''significant intergovernmental mandate.'' A ''significant intergovernmental mandate'' under the Act is any provision in a Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

This rule does not contain a Federal intergovernmental or private sector mandate meeting that criterion, therefore the requirements of the Act do not apply.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

Adoption of the Amendment

In consideration of the foregoing, the Federal Aviation Administration (FAA) amends 14 CFR part 25 of the Federal Aviation Regulations (FAR) as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701–44702, 44704.

2. Section 25.571 is amended by revising the introductory text of paragraph (a), and paragraph (a)(3), the introductory text of paragraph (b), and paragraphs (b)(1), (b)(5)(ii), and (e)(1) to read as follows:

§ 25.571 Damage-tolerance and fatigue evaluation of structure.

(a) *General.* An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, 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 that 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). For turbojet powered airplanes, those parts that could contribute to a catastrophic failure must also be evaluated under paragraph (d) of this section. In addition, the following apply:

* * * * *

(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 Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by § 25.1529. Inspection thresholds for the following types of structure must be established based on crack growth analyses and/or tests, assuming the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage:

(i) Single load path structure, and

(ii) Multiple load path ''fail-safe'' structure and crack arrest ''fail-safe'' structure, where it cannot be demonstrated that load path failure, partial failure, or crack arrest will be detected and repaired during normal maintenance, inspection, or operation of an airplane prior to failure of the remaining structure.

(b) *Damage-tolerance evaluation.* The evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. Repeated load and static analyses supported by test evidence and (if available) service experience must also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. It must be demonstrated with sufficient full-scale fatigue test evidence that widespread fatigue damage will not occur within the design service goal of the airplane. The type certificate may be issued prior to completion of full-scale fatigue testing, provided the Administrator has approved a plan for competing the required tests, and the airworthiness limitations section of the instructions for continued airworthiness required by § 25.1529 of this part specifies that no airplane may be operated beyond a number of cycles equal to ½ the number of cycles accumulated on the fatigue test article, until such testing is completed. The extent of damage for residual strength evaluation at any time within the operational life of the airplane 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 all speeds up to V_c and in § 25.345.

* * * * *

(5) * * *

(ii) The maximum value of normal operating differential pressure (including the expected external aerodynamic pressures during 1 g level flight) multiplied by a factor of 1.15, omitting other loads.

* * * * *

(e) * * *

(1) Impact with a 4-pound bird when the velocity of the airplane relative to the bird along the airplane's flight path is equal to V_c at sea level or $0.85V_c$ at 8,000 feet, whichever is more critical;

* * * * *

Issued in Washington, D.C. on March 26, 1998.

Jane F. Garvey,

Administrator.

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