Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Rotorcraft Issue Area
Metallic Rotorcraft Structure Working Group

Task 1 – Harmonize 14 CFR/JAR 27 and 29

Task Assignment

change is consistent with the Act. Persons making written submissions should file six copies thereof with the Secretary, Securities and Exchange Commission, 450 Fifth Street, NW, Washington, DC 20549–0609. Copies of the submission, all subsequent amendments, all written statements with respect to the proposed rule change that are filed with the Commission, and all written communications relating to the proposed rule change between the Commission and any person, other than those that may be withheld from the public in accordance with the provisions of 5 U.S.C. 552, will be available for inspection and copying in the Commission's Public Reference Room, 450 Fifth Street, NW, Washington, DC Copies of such filing will also be available for inspection and copying at the principal office of the Amex. All submissions should refer to File No. SR–Amex–00–06 and should be submitted by April 26, 2000.

For the Commission by the Division of Market Regulation, pursuant to delegated authority.[9]

Margaret H. McFarland,

Deputy Secretary.

[FR Doc. 00–8323 Filed 4–4–00; 8:45 am]

BILLING CODE 8010–01–M

[9] 17 CFR 200.30–3(a)(12).

DEPARTMENT OF TRANSPORTATION

Office of the Secretary

Minority Business Resource Center Advisory Committee; Cancellation of Meeting

Notice is hereby given of the cancellation of the Minority Business Resource Center Advisory Committee meeting for Tuesday, April 18, 2000, at 10:00 a.m. until 12:00 p.m. in Room 4438–4440 at the Department of Transportation, 400 7th Street, SW., Washington, DC 20590. (Originally announced at Vol. 65, No. 53, FR 14640, March 17, 2000.)

Issued in Washington, DC on March 27, 2000.

Luz A. Hopewell,

Director, Office of Small and Disadvantaged Business Utilization.

[FR Doc. 00–8324 Filed 4–4–00; 8:45 am]

BILLING CODE 4910–62–P

DEPARTMENT OF TRANSPORTATION

Coast Guard

[CGD08–00–002]

Lower Mississippi River Waterway Safety Advisory Committee

AGENCY: Coast Guard, DOT.

ACTION: Notice of meeting.

SUMMARY: The Lower Mississippi River Waterway Safety Advisory Committee (LMRWSAC) will meet to discuss various issues relating to navigational safety on the Lower Mississippi River and related waterways. The meeting will be open to the public.

DATES: LMRWSAC will meet on Wednesday, April 26, 2000, from 9:00 a.m. to 12 noon. This meeting may close early if all business is finished. Written material and requests to make oral presentations should reach the Coast Guard on or before April 17, 2000. Requests to have a copy of your material distributed to each member of the committee should reach the Coast Guard on or before April 17, 2000.

ADDRESSES: LMRWSAC will meet in the basement conference room of the Hale Boggs Federal Building, 501 Magazine Street, New Orleans, LA. Send written material and requests to make oral presentations to M.M. Ledet, Committee Administrator, c/o Commander, Eighth Coast Guard District (m), 501 Magazine Street, New Orleans, LA 70130–3396. This notice is available on the Internet at http://dms.dot.gov.

FOR FURTHER INFORMATION CONTACT: For questions on this notice, contact M.M. Ledet, Committee Administrator, telephone (504) 589–6271, Fax (504) 589–4999.

SUPPLEMENTARY INFORMATION: Notice of this meeting is given under the Federal Advisory Committee Act, 5 U.S.C. App. 2.

Agenda of Meeting

Lower Mississippi River Waterway Safety Advisory Committee (LMRWSAC). The agenda includes the following:

(1) Introduction of committee members.

(2) Remarks by RADM P. Pluta, Committee Sponsor.

(3) Approval of the September 8, 1999 minutes.

(4) Old Business:

a. PAWSS update.

b. Soft Dikes Working Group Report.

(5) New Business: Physical Oceanographic Real-Time System (PORTS).

(6) Next meeting.

(7) Adjournment.

Procedural

The meeting is open to the public. Please note that the meeting may close early if all business is finished. At the Chair's discretion, members of the public may make oral presentations during the meeting. If you would like to make an oral presentation at the meeting, please notify the Committee Administrator no later than April 17, 2000. Written material for distribution at the meeting should reach the Coast Guard no later than April 17, 2000. If you would like a copy of your material distributed to each member of the committee or subcommittee in advance of the meeting, please submit 28 copies to the Committee Administrator at the location indicated under Addresses no later than April 17, 2000.

Information on Services for Individuals With Disabilities

For information on facilities or services for individuals with disabilities, or to request special assistance at the meetings, contact the Committee Administrator at the location indicated under Addresses as soon as possible.

Dated: March 13, 2000.

K.J. Eldridge,

Captain, U.S. Coast Guard, Acting Commander, 8th Coast Guard Dist.

[FR Doc. 00–8378 Filed 4–4–00; 8:45 am]

BILLING CODE 4910–15–M

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee Rotorcraft Issues—New Task

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of new task assignments for the Aviation Rulemaking Advisory Committee (ARAC)

SUMMARY: Notice is given of two new tasks assigned to and accepted by the Aviation Rulemaking Advisory Committee (ARAC). This notice informs the public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Mark Shilling, Rotorcraft Standards Staff (ASW—119), Federal Aviation Administration, 2601 Meacham Blvd, Fort Worth, Texas 76137–4298; phone (817) 222–5110; fax (817) 222–5961 email Mark.R.Schilling@faa.gov.

SUPPLEMENTARY INFORMATION:

Background

The FAA has established an Aviation Rulemaking Advisory Committee to provide advice and recommendations to the FAA Administrator, through the Associate Administrator for Regulation and Certification, on the full range of the FAA's rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the FAA's commitment to harmonize the Federal Aviation Regulations (FAR) and practices with its trading partners in Europe and Canada.

The Task

This notice is to inform the public that the FAA has asked ARAC to provide advice and recommendations on the following harmonization tasks:

Task No. 1: Damage Tolerance and Fatigue Evaluation of Metallic Rotorcraft Structure

- The project is to be a harmonized Joint Aviation Regulation (JAR)/FAR 27/29 ARAC program.
- Evaluate: the European Association of Aerospace Industries and the Aerospace Industry Association's White Paper, the recommendations contained in the Technical Oversight Group for Aging Aircraft letters to the FAA, and the ongoing activities and results of rotorcraft damage tolerance research and development.
- Identify the information needed to commence rulemaking and define an acceptable means of compliance.
- Recommend appropriate changes to FAR/JAR 29 regarding damage tolerance and fatigue evaluation of metallic structure, and recommend appropriate changes to FAR/JAR 27 that would allow damage tolerance as an option. Any recommended changes should be practical and appropriate to the unique characteristics of rotorcraft. Where feasible and appropriate, provide consistency with FAR/JAR 23/25.
- Evaluate and revise, as appropriate, the following advisory materials: AC 29–2; AC 27–1; and AC 20–95, Fatigue Evaluation of Rotorcraft Structure; and related guidance.
- The recommendation should be forwarded to the Federal Aviation Administration (FAA) and the Joint Aviation Authorities (JAA) in the format of a proposed rule.

Although this tasking for metallic structure does not depend on the completion of the composite structure project, the Composite Rotorcraft Structure and Metallic Rotorcraft Structure working groups should communicate to avoid possibly conflicting recommendation to amend the same regulatory sections.

The FAA requests that ARAC draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations. If the recommendation results in one or more notice of proposed rulemaking (NPRM) published by the FAA, the FAA may ask ARAC to dispose of any substantive comments the FAA receives.

A progress report should be provided at each Joint Harmonization Working Group meeting. The recommendation should be forwarded to the FAA and the FAA by September 2002.

Task No. 2: Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structure

- The project is to be a harmonized FAR/JAR 29/29 ARAC program.
- Revise current FAR/JAR 27 and 29 to add regulations for composite structure. Consider creating a new FAR/FAR 27/29.573 to address composite structure.
- Evaluate and revise, as appropriate, the regulations and the following advisory materials: AC 20–107A, Composite Aircraft Structure; AC 27–1; AC 29–2; and related guidance to achieve the goal of improved tolerance to flaws and defects in composite structure with methodology and procedures which are practical and appropriate to rotorcraft. Where feasible and appropriate, provide consistency with FAR/JAR 23/25.
- The recommendation should be forwarded to the FAA and JAA in the format of a proposed rule.

Although this tasking for composite structure does not depend on the completion of the metallic structure project, the Composite Rotorcraft Structure and Metallic Rotorcraft Structure working groups should communicate to avoid possibly conflicting recommendations to amend the same regulatory sections.

The FAA requests that ARAC draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations. If the recommendation results in one or more NPRM's published by the FAA, the FAA may ask ARAC to dispose of any substantive comments the FAA receives.

A progress report should be provided at each Joint Harmonization Working Group meeting. The recommendation should be forwarded to the FAA and JAA by November 2002.

ARAC Acceptance of Task

ARAC has accepted the tasks and has chosen to establish two new working groups, the Composite Rotorcraft Structure working group and the Metallic Rotorcraft Structure working group. The working groups will serve as staff to ARAC to assist ARAC in the completion of the assigned tasks. Working group recommendations must be reviewed and approved by ARAC. If ARAC accepted the working groups' recommendations, ARAC will forward them to the FAA as recommendations.

Working Group Activity

The Composite Rotorcraft Structure working group and the Metallic Rotorcraft Structure working group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working groups are expected to:

1. Recommend a work plan for completion of the task, including the rationale supporting such a plan, for consideration at the Rotorcraft Issues ARAC meeting held following publication of this notice.
2. Given a detailed conceptual presentation of the proposed recommendations prior to proceeding with the work stated in item 3 below.
3. Draft appropriate regulatory documents with supporting economic and other required analyses, and/or any other related guidance material or collateral documents the working group determines to be appropriate; or, if new or revised requirements or compliance methods are not recommended, a draft report stating the rationale for not making such recommendations.
4. Provide a status report at each meeting of ARAC held to consider rotorcraft issues.

Participation in the Working Group

The Composite Rotorcraft Structure working group and the Metallic Rotorcraft Structure working group will be composed of technical experts having an interest in the assigned tasks. A working group member need not be a representative of a member of the full committee.

An individual who has expertise in the subject matter and wishes to become a member of the working group should write to the person listed under the caption **FOR FURTHER INFORMATION CONTACT** expressing that desire, describing his or her interest in the task, and stating the expertise he or she would bring to the working group. All requests to participate must be received no later than April 10, 2000. The requests will be reviewed by the assistant chair and the assistant executive director, and the individuals will be advised whether or not the request can be accommodated.

Individuals chosen for membership on the working group will be expected to represent their aviation community segment and participate actively in the working group (*e.g.*, attend all meetings, provide written comments when requested to do so, *etc.*). They also will be expected to devote the resources necessary to ensure the working group meets any assigned deadline(s). Members are expected to keep their management chain advised of working group activities and decisions to ensure that the agreed technical solutions do not conflict with their sponsoring organization's position when the subject is presented to ARAC for a vote.

Once the working group has begun deliberations, members will not be added or substituted without the approval of the assistant chair, the assistant executive director, and the working group chair.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

Meetings of ARAC will be open to the public. Meetings of the working groups will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on March 28, 2000.

Anthony F. Fazio,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 00–8382 Filed 4–4–00; 8:45 am]

BILLING CODE 4910–13–M

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Notice of Availability of Draft Environmental Impact Statement; Piedmont Triad International Airport, Greensboro, NC

SUMMARY: Pursuant to Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969, as amended, as implemented by the Council on Environmental Quality (40 CFR Parts 1500–1508), the Federal Aviation Administration (FAA) will file with the Environmental Protection Agency, and make available to other government and interested private parties, the Draft Environmental Impact Statement (DEIS) for the proposed Runway 5L/23R, a proposed air cargo sorting and distribution facility (FedEx Mid Atlantic Hub), and associated development at Piedmont Triad International Airport, Greensboro, North Carolina. The DEIS will be on file with the EPA and available to the public for review starting April 6, 2000, after 1 p.m. at locations listed under **SUPPLEMENTARY INFORMATION.** A Public Hearing and Information Workshop will be held on May 23, 2000; between the hours of 5:00 p.m. and 8:00 p.m. at the Greensboro Coliseum Exhibit Hall, 1921 W. Lee Street, Greensboro, North Carolina. Written comments on the DEIS will be accepted by the FAA until June 7, 2000, or 45 days after the publication of this Federal Register Notice, whichever is later.

FOR FURTHER INFORMATION CONTACT: Ms. Donna M. Meyer, Environmental Program Specialist, Federal Aviation Administration, Atlanta Airports District Office, 1701 Columbia Avenue, Suite 2–260, College Park, Georgia 30337–2747, Phone (404) 305–7150.

SUPPLEMENTARY INFORMATION: The Piedmont Triad Airport Authority (PTAA), owner and operator of the airport is proposing airside and landside improvements to the Piedmont Triad International Airport. The PTAA's proposed project consists of a new widely spaced Transport Category parallel runway (Runway 5L/23R) that would be 9,000 feet long and 150 feet wide. The runway would be located on the western side of the airport. Other associated projects include the development and operation of an air cargo sorting and distribution facility (FedEx Mid-Atlantic Hub), surface transportation improvements, NAVAIDS for new Runway 5L/23R, property acquisition and relocation of several airport tenant operations. The DEIS has examined the sponsor's proposed project and improvements along with other reasonable alternatives to the proposed project. The Federal Highway Administration (FHWA) is acting as a cooperating agency to the FAA in this DEIS.

A Public Hearing will be held by the FAA to afford interested parties the opportunity to provide their comments on the merits and findings of the DEIS and to consider the economic, social, and environmental effects of PTAA's proposed development and its consistency with the goals and objectives of such urban planning as has been carried out by the community. The Public Hearing will be conducted in conjunction with an informal Information Workshop. During the Information Workshop, participants will be able to view project related materials and speak with representatives of the FAA and the consulting team.

In addition, the public is invited to comment in one of four ways during the Public Hearing/Information Workshop: (1) Written comments may be submitted anytime during the Hearing/Workshop; (2) Pre-addressed written comment forms may be mailed to the Individual listed above, (3) Private oral comments may be given to a certified court reporter anytime during the Hearing/Workshop, and, (4) Oral comments may be made in front of the Hearing Officer who will be present to preside over and conduct the Public Hearing. The FAA encourages interested parties to review the DEIS and provide comments during the public comment period.

For the convenience of interested parties, the DEIS may be reviewed at the following locations:

Greensboro Public Library, 219 No. Church Street, Greensboro
Hege Library of Guilford College, 5800 West Friendly Avenue, Greensboro
High Point Public Library, 901 North Main Street, High Point
Forsyth County Library, 660 West Fifth Street, Winston-Salem
Piedmont Triad International Airport, 6415 Airport Parkway, Greensboro
Federal Aviation Administration, Atlanta District Office, 1701 Columbia Avenue, College Park, Georgia

Dated: Issued in Atlanta, Georgia, March 31, 2000.

Scott L. Seritt,

Manager, Atlanta Airports District Office.

[FR Doc. 00–8383 Filed 4–4–00; 8:45 am]

BILLING CODE 4910–13–M

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

RTCA, Inc.; Free Flight Steering Committee

Revised Agenda

The April 13 RTCA Free Flight Steering Committee Meeting announced in the **Federal Register**, 65 FR 16240 (Monday, March 27, 2000), third column, has been revised.

The revised agenda reads as follows: The agenda will include: (1) Welcome and Opening Remarks: (a) Recognize Departing Members of the Steering Committee; (b) Welcome Incoming Members. (2) Review Summary of the Previous Meeting; (3) Reports from FAA on: (c) Free Flight Phase 1 Baseline Data and Performance Assessments Update; (d) Controller-Pilot Data Link

7313 Janetta Drive
Fort Worth, Texas 76180

September 26, 2005

Mr. Nicholas A. Sabatini
Associate Administrator for Regulation and Certification
FAA National Headquarters, AVR-1
800 Independence Avenue, SW
Washington, D.C. 20591

Dear Mr. Sabatini:

The Aviation Rulemaking Advisory Committee (ARAC) Working Group activity associated with the Fatigue Tolerance Evaluation of Metallic Structure Task has been completed. The ARAC examined the results of the working group's activity in public meetings on February 7, 2005, and September 8, 2005, and approved them.

This task was originally intended to be harmonized with the Joint Aviation Authorities (JAA). European industry personnel participated throughout the development of the package; however, the JAA participated only until they were replaced by the European Aviation Safety Agency (EASA). EASA decided not to continue participation in the completion of the task.

Accordingly, the ARAC hereby submits, without change, the proposed NPRM and associated Advisory Circular package developed by the working group with a recommendation that it be processed for publication.

Very truly yours,

John D. Swihart, Jr.
ARAC Assistant Chair for Rotorcraft Issues

cc: Mr. Ronald Priddy, ARAC Chair
Mr. Craig Bolt, ARAC Vice Chair
Mr. Tony Fazio, ARAC Executive Director
Mr. Mark Schilling, ARAC Assistant Executive Director
Mrs. Sharon Miles, FAA Working Group Representative
Mr. Doug Tritsch, Working Group Chair
Mr. Charles Chung, Helicopter Association International
Mrs. Caren Waddell, FAA, ARM-200
Mrs. Gerri Robinson, FAA, ARM-200
Mrs. Kathy Jones, FAA, ASW-111

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of Rulemaking
800 Independence Ave., SW.
Washington, DC 20591

December 14, 2005

Mr. John Swihart
Aviation Rulemaking Advisory Committee
Assistant Chair, Rotorcraft Issues Group
7313 Janetta Drive
Fort Worth, TX 76180

Dear Mr. Swihart,

This letter acknowledges receipt of your September 26, 2005 letter transmitting the Rotorcraft Issues Group (RIG) recommendation on the fatigue tolerance of rotorcraft metallic structure. The two-part recommendation includes a proposed rulemaking and an advisory circular.

I would like to thank the Aviation Rulemaking Advisory Committee (ARAC), particularly those members associated with the RIG and the Fatigue Tolerance Evaluation of Metallic Structure Harmonization Working Group. I appreciate the work and resources they spent in developing the recommendation.

We consider your submittal of the recommendation as completion of the task. Therefore we have closed the task and have forwarded it to the Rotorcraft Directorate for review and decision. We will continue to keep you apprised of our efforts on the ARAC recommendation at future RIG meetings. Further, if the proposed rule and advisory material generate substantial or controversial comments once they publish in the Federal Register, the FAA may task the RIG to dispose of any comments received in response to the documents.

Sincerely,

Anthony F. Fazio
Executive Director, Aviation Rulemaking Advisory Committee

Recommendation

DRAFT

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 29

[Docket No. FAA-YYYY- ; Notice No.]

RIN 2120-

Title: Fatigue Tolerance Evaluation of Metallic Structures

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This document proposes an amendment to the airworthiness standards for fatigue tolerance evaluation (FTE) of transport category rotorcraft metallic structures. This proposal would revise the FTE safety requirements to address advances in structural fatigue substantiation technology for metallic structures. An increased level of safety would be provided by avoiding or reducing catastrophic fatigue failures of metallic structures. These increased safety requirements would help ensure that should serious accidental damage occur during manufacturing or within the operational life of the rotorcraft, the remaining structure could withstand fatigue loads that are likely to occur, without failure, until the damage is detected or the part is replaced. In addition to the improvement in the safety standards for FTE of all principal structural elements (PSE), the proposed amendment would be harmonized with international standards.

DATES: Send your comments on or before [Insert date 90 days after date of publication in the Federal Register].

ADDRESSES: You may send comments [identified by Docket Number *[Insert docket number, for example, FAA-200X-XXXXX]*] using any of the following methods:

- DOT Docket web site: Go to http://dms.dot.gov and follow the instructions for sending your comments electronically.
- Government-wide rulemaking web site: Go to http://www.regulations.gov and follow the instructions for sending your comments electronically.
- Mail: Docket Management Facility; US Department of Transportation, 400 Seventh Street, S.W., Nassif Building, Room PL-401, Washington, DC 20590-001.
- Fax: 1-202-493-2251.
- Hand Delivery: Room PL-401 on the plaza level of the Nassif Building, 400 Seventh Street, S.W., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

For more information on the rulemaking process, see the SUPPLEMENTARY INFORMATION section of this document.

Privacy: We will post all comments we receive, without change, to http://dms.dot.gov, including any personal information you provide. For more information, see the Privacy Act discussion in the SUPPLEMENTARY INFORMATION section of this document.

Docket: To read background documents or comments received, go to http://dms.dot.gov at any time or to Room PL-401 on the plaza level of the Nassif Building, 400 Seventh Street, S.W., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

FOR FURTHER INFORMATION CONTACT: Sharon Y. Miles, Regulations and Policy Group, Rotorcraft Directorate, ASW-111, Federal Aviation Administration, Fort Worth, Texas 76193-0110, telephone number (817) 222-5122; facsimile (817) 222-5961, e-mail sharon.y.miles@faa.gov.

SUPPLEMENTARY INFORMATION:

Comments Invited

The FAA invites interested persons to participate in this rulemaking by submitting written comments, data, or views. We also invite comments relating to the economic, environmental, energy, or federalism impacts that might result from adopting the proposals in this document. The most helpful comments will reference a specific portion of the proposal, explain the reason for any recommended change, and include supporting data. We ask that you send us two copies of written comments.

We will file in the docket all comments we receive, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking. The docket is available for public inspection before and after the comment closing date. If you wish to review the docket in person, go to the address in the ADDRESSES section of this preamble between 9:00 a.m. and 5:00 p.m., Monday through Friday, except Federal holidays. You may also review the docket using the Internet at the web address in the ADDRESSES section.

Privacy Act:

Using the search function of our docket web site, anyone can find and read the comments received into any of our dockets, including the name of the individual sending the comment (or signing the comment on behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act Statement in the Federal Register published on April 11, 2000 (65 FR 19477-78), or you may visit http://dms.dot.gov.

Before acting on this proposal, we will consider all comments we receive on or before the closing date for comments. We will consider comments filed late if it is possible to do so without incurring additional expense or delay. We may change these proposals based on the comments we receive.

If you want the FAA to acknowledge receipt of your mailed comments on this proposal, include with your comments a pre-addressed, stamped postcard on which the docket number appears. We will stamp the date on the postcard and mail it to you.

Availability of Rulemaking Documents

You can get an electronic copy using the Internet by:

(1) Searching the Department of Transportation's electronic Docket Management System (DMS) web page at http://dms.dot.gov/search;

(2) Visiting the Office of Rulemaking's web page at http://www.faa.gov/avr/arm/index.cfm; or

(3) Accessing the Government Printing Office's web page at http://www.gpoaccess.gov/fr/index.html.

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue S.W, Washington, DC 20591, or by calling (202) 267-9680. Make sure to identify the docket number, notice number, or amendment number of this rulemaking.

Authority for this Rulemaking

The FAA's authority to issue rules regarding aviation safety is found in Title 49 of the United States code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in Subtitle VII, Part A, Subpart III, Section 44701, "General requirements," Section 44702, "Issuance of Certificates," and Section 44704, "Type Certificates, production certificates, and airworthiness certificates." Under Section 44701, the FAA is charged with prescribing regulations and minimum standards for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. Under Section 44702, the FAA may issue various certificates including type certificates, production certificates, air agency certificates, and airworthiness certificates. Under Section 44704, the FAA shall issue type certificates for aircraft, aircraft engines, propellers, and specified appliances when the FAA finds that the product is properly designed and manufactured, performs properly, and meets the regulations and minimum prescribed standards. This regulation is within the scope of these authorities because it would promote safety by updating the existing minimum prescribed standards, used during the type certification process, to address advances in metallic structural fatigue substantiation technology. It would also harmonize this standard with international standards for evaluating the fatigue strength of transport category rotorcraft metallic primary structural elements.

Background

Statement of the Problem

Fatigue of rotorcraft dynamic components was first addressed in the 1950's by means of safe-life methodology. Historically, the application of this methodology, such as that described in AC 27-1B MG 11, has been successful in providing an adequate level of reliability for transport category rotorcraft. In addition, manufacturers currently include in their maintenance program inspections for detecting damage, such as scratches, corrosion, wear, or cracks, in addition to other routine inspections of the rotorcraft. The inspection intervals were not determined by analysis or tests, but were based on previous experience with similar designs, engineering judgment, and good design practices. This helped minimize the effect of damage in service. However, it was recognized in the 1980's that higher levels of reliability might be realized by taking into account the fatigue strength reducing effects of damage that experience has shown can occur during manufacture or in operational service. The introduction of composites led the manufacturers and regulatory authorities to develop a more robust safe-life methodology by considering the specific static and fatigue-strength reduction due to aging, temperature, moisture absorption, impact damage, and other accepted industry practices. Furthermore, where clearly visible damage resulted from impact or other sources, inspection programs were developed to maintain safety. In parallel, crack growth methodology has been successfully used for solving short-term airworthiness problems in metallic structures of rotorcraft and as the certification basis for civil and military transport aircraft applications. These advances in design, analytical methods, and other industry practices made it feasible to address certain types of damage that could result in fatigue failure. Consistent with this, the regulatory requirements of §

29.571 were substantially revised by Amendment 29-28. While many years have passed since its introduction, Amendment 29-28 has not been used often for certification of completely new rotorcraft designs, because there have been only a limited number of new rotorcraft designs since 1989, when that Amendment became effective. However, the general understanding by the rotorcraft community of rotorcraft fatigue tolerance evaluation has developed considerably in the interim. Also, there has been much discussion within the technical community about the meaning of Amendment 29-28 and the merits of the methodologies that are prescribed in it. These methodologies have been the subject of a series of meetings between the FAA, the rotorcraft industry, and the Technical Oversight Group for Aging Aircraft (TOGAA). As a result of these meetings, the industry position was documented in a White Paper entitled “Rotorcraft Fatigue and Damage Tolerance”, and TOGAA made a recommendation to the FAA. TOGAA recommended that current safe-life methods be complemented by damage tolerance assessment methods and that the flaw-tolerant safe-life method, introduced in Amendment 29-28, be removed from the regulations. The rotorcraft industry White Paper, on the other hand, agreed that safe-life methods should be complemented by damage tolerance methods, but recommended retention of the flaw-tolerant safe-life method as an available option. Since both groups recommended changes, the FAA decided to consider revision of the regulations.

History

The FAA requested that the Aviation Rulemaking Advisory Committee (ARAC) study the need to revise the regulations on fatigue evaluation in light of advancements in technology and operational procedures and to develop regulatory recommendations.

The ARAC was established on February 5, 1991 by notice in the Federal Register (56 FR 2190, January 22, 1991), to assist the FAA in the rulemaking process by providing advice from the private sector on major regulatory issues affecting aviation safety. The ARAC includes representatives of manufacturers, air carriers, general aviation, industry associations, labor groups, universities, and the general public. The ARAC's formation has given the FAA additional opportunities to solicit information directly from significantly affected parties who meet and exchange ideas about proposed and existing rules that should be either created, revised, or eliminated.

Following an announcement in the Federal Register (65 FR 17936, April 5, 2000), an ARAC Working Group was chartered to study and make appropriate recommendations concerning whether new or revised airworthiness standards are appropriate regarding fatigue evaluation of transport rotorcraft metallic structures.

The working group, co-chaired by representatives from a U.S. manufacturer and a European manufacturer, included technical specialists knowledgeable in the area of fatigue evaluation of rotorcraft structures. This broad participation is consistent with FAA policy to have all known interested parties involved as early as practicable in the rulemaking process.

The working group evaluated the industry White Paper, TOGAA recommendations, and the continuing activities and results of rotorcraft damage tolerance research and development. As a result, the working group recommended changes to the fatigue evaluation requirements for transport rotorcraft found in 14 CFR § 29.571 to improve currency and understanding. The ARAC accepted those recommendations and presented them to the FAA. This rulemaking proposal is based on those recommendations.

Statement of the Issues

Prior to Amendment 29-28, there were no requirements to consider the impact of damage on the fatigue performance of any rotorcraft structure. The strategy used to manage fatigue was limited to retirement before the probability of crack initiation became significant, and the “safe-life” method was used to establish retirement times.

It was generally agreed, based on in-service experience, that not accounting for damage could be a serious shortcoming. Accordingly, Amendment 29-28 made it a requirement to consider damage when performing fatigue evaluations unless it was demonstrated to be impractical. This amendment also prescribed two methods to account for damage and one method to be used if the use of either of those two methods was shown to be impractical. The two methods that could be used to account for damage are referred to as flaw-tolerant methods. These two methods, the “flaw-tolerant safe-life” method and the “fail-safe” method, are considered equivalent options within the context of the current § 29.571. The “flaw-tolerant safe-life” method is based on crack initiation time in a purposely “flawed” PSE and results in a retirement life. The flaw tolerant “fail-safe” method is based on a crack growth life in a purposely “flawed” PSE and results in inspection requirements. The “safe-life” method is based on a crack initiation time in a “non-flawed” PSE and results in a retirement life. Although the “safe-life” method does not explicitly account for any damage, under current § 29.571, it is the prescribed default fatigue evaluation method if the applicant establishes that neither of the two flaw tolerant methods can be achieved within the limitations of geometry, inspectability, or good design practice.

One of the primary issues addressed by the working group was the equivalency of the two flaw-tolerant methods. While both can be used to address damage, their equivalency, from a technical perspective, is difficult to address without specific factual details.

Two concerns considered by the working group were establishing inspection requirements using the flaw-tolerant safe-life method, and establishing retirement times using the fail-safe method. While both are theoretically possible, an evaluation of the effectiveness is not possible without considering the details of a specific application. Additionally, while using the flaw-tolerant safe-life method for establishing an inspection interval is clearly not within the intent of the Amendment 29-28, the fail-safe method for establishing retirement times has been accepted as meeting its intent.

<u>Reference Material</u>

1. Industry White Paper “Rotorcraft Fatigue and Damage Tolerance”, prepared for the TOGAA, January 1999.

2. TOGAA memo to the FAA, dated 15 March 1999.

General Discussion of Proposals

The proposals would improve the currency and clarify the intent of the rule and thereby facilitate evaluation consistency and result in equal levels of safety among applicants. Some of the more significant revisions to the current rule are summarized below.

We have determined that a descriptive phrase is needed that makes general reference to the entire fatigue process (including crack initiation, crack growth, and final failure) with or without the influence of damage. Consistent with the current rule, the words “fatigue tolerance” are proposed for this purpose. Also, we propose not to use words or phrases that have different meanings depending on their usage context (e.g. flaw-tolerant, fail-safe).

Additionally, we have determined that the current rule is too prescriptive when it directs the applicant to use specific methodologies to meet the objective. Further, we determined that the significance of the basic objective of evaluating fatigue tolerance was de-emphasized in practice because the primary focus is on means of compliance. Consequently, the entire rule has been rewritten to emphasize the basic objective and be less prescriptive as to specific methodologies. Therefore, we propose to delete all reference to specific fatigue tolerance evaluation methods (e.g. safe-life, flaw-tolerant safe-life, and fail-safe).

Further, we have determined that there are various fatigue tolerance evaluation methods used by industry; all of these methods have merit and could potentially be effective, depending on the specifics of the damage being addressed. The proposed rule requires a specific result, but does not specify the method to achieve the result. However, the proposed rule does require that all methods be validated by analysis and test and the methodology used for compliance be approved.

We have determined that, in general, the safest metallic structures use both retirements and inspections together to mitigate the risk of catastrophic failure due to fatigue. Consequently, there is now a requirement proposed in § 29.571(g) to establish inspection and retirement times or approved equivalent means.

Also, we have determined that a key element that had to be included in the evaluation was identification of all threats that needed to be considered so damage could be quantified. Consistent with this, a specific requirement in paragraph (d)(4) is proposed to require a threat assessment.

We have recognized that an inspection approach may not be possible for some kinds of damage so a provision has been included wherein inspections need not be established if they are shown to be impractical, provided other actions are implemented to minimize the probability of the damage occurring or contributing to a catastrophic failure.

Section-by-Section Discussion of the Proposals

This proposal would revise § 29.571 as follows:

The heading of § 29.571 would be revised to read “Fatigue Tolerance Evaluation of Metallic Structures”. This heading emphasizes that it applies to metallic structures.

Paragraph (a) is new and provides a general summary of the requirements. It points out that all principle structural elements (PSE) must be evaluated and, based on the results of the evaluations, appropriate actions must be established to avoid catastrophic failure. It also states that the effects of damage must be considered.

Paragraph (b) is new and requires FAA approval of the compliance methodology.

Paragraph (c) is new and requires identification of all PSE, and includes a definition of PSE.

Paragraph (d) is new and identifies the elements of each evaluation.

Paragraph (e) is new and specifically addresses residual strength assessment load requirements used to support inspection interval requirements.

Paragraph (f) is new and requires that the effect of damage on stiffness, dynamic behavior, loads, and functional performance be considered.

Paragraph (g) is new and requires that applicants for a transport category rotorcraft type certificate address the technical issue of structural metal fatigue by inspections and retirement times or approved equivalent means. It also requires this information to be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness.

Paragraph (h) is new and requires that supplemental procedures must be established if inspections for the critical damage, as determined by a threat assessment, cannot be established within the limitations of geometry, inspectability, or good design practice.

Paperwork Reduction Act

This proposal contains the following new information collection requirements. As required by 44 U.S.C. § 3507(d) of the Paperwork Reduction Act of 1995, the FAA has submitted the information requirements associated with this proposal to the Office of Management and Budget for its review.

Title: Fatigue Tolerance Evaluation of Metallic Structures.

Summary: This proposal would revise the FTE safety requirements to address advances in structural fatigue substantiation technology for metallic structures. An increased level of safety would be provided by avoiding or reducing catastrophic fatigue failures of metallic structures. These increased safety requirements would help ensure that should accidental damage occur during manufacturing or within the operational life of the rotorcraft, the remaining structure could withstand fatigue loads that are likely to occur, without failure, until the damage is detected and repaired or the part is replaced. In addition to the improvement in the safety standards for FTE of all PSE, the proposed amendment would lead to harmonized international standard.

Use of: To obtain type certification of a rotorcraft, an applicant must show that the rotorcraft complies with specific certification requirements. To show compliance, the applicant must submit substantiating data. FAA Engineers and designated engineer representatives from industry would review the required data submittals to determine if the rotorcraft complies with the applicable minimum safety requirements for fatigue critical rotorcraft metallic structures and that the rotorcraft has no unsafe features in the metallic structures.

Respondents (including number of): The likely respondents to this proposed information requirement are applicants for certification of fatigue critical metallic parts for transport category helicopters. A conservative estimate of the number of applicants affected by this rule would average 10 applicants per year.

Frequency: The frequency of collection of this information is not a set time; it is established as needed by the respondent to meet their certification schedule. The respondent must submit the required information prior to type certification, which can span a number of years.

Annual Burden Estimate: It is current practice to submit a compliance methodology to the FAA. Hence, there is little or no additional cost burden in requiring the collection of this information.

The agency is soliciting comments to--

(1) evaluate whether the proposed information requirement is necessary for the proper performance of the functions of the agency, including whether the information will have practical utility;

(2) evaluate the accuracy of the agency's estimate of the burden;

(3) enhance the quality, utility, and clarity of the information to be collected; and

(4) minimize the burden of the collection of information on those who are to respond, including through the use of appropriate automated, electronic, mechanical, or other technological collection techniques or other forms of information technology.

Individuals and organizations may submit comments on the information collection requirement by *[Insert date 60 days after publication in the Federal Register],* and should direct them to the address listed in the **ADDRESSES** section of this document. Comments also should be submitted to the Office of Information and Regulatory Affairs, OMB, New Executive Building, Room 10202, 725 17th Street, N.W., Washington, DC 20053, Attention: Desk Officer for FAA.

According to the 1995 amendments to the Paperwork Reduction Act (5 CFR 1320.8(b)(3)(vi)), an agency may not collect or sponsor the collection of information, nor may it impose an information collection requirement unless it displays a currently valid OMB control number. The OMB control number for this information collection will be published in the Federal Register, after the Office of Management and Budget approves it.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA determined that ICAO annex 8, part IV, Chapter 3, paragraph 3.8 corresponds to these proposed regulations. The proposed regulations are consistent with the ICAO standards and recommended practices.

Executive Order 12866, DOT Regulatory Policies and Procedures, Economic Assessment, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

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 impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. §§ 2531-2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. And fourth, the Unfunded Mandates Reform Act of 1995 requires agencies to prepare a written assessment of the costs, benefits and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local or tribal governments, in the aggregate, or by the private sector, of $100 million or more, in any one year (adjusted for inflation.)

The FAA has made initial determinations that the least cost alternative to the proposed rule: (1) has benefits which do justify its costs, (2) does not impose costs sufficient to be considered "significant" under the economic standards for significance under Executive Order 12866 or under DOT's Regulatory Policies and Procedures, (3) would not have a significant economic impact on a substantial number of small entities, (4) would not constitute a barrier to international trade, and (5) would not constitute an unfunded mandate. The FAA has placed these analyses in the docket and summarized them below.

The proposed rule would amend Part 29 of Title 14, Code of Federal Regulations (14 CFR) to modify the regulations applicable to transport category rotorcraft structures. This proposed rule would revise the FTE safety requirements to address advances in fatigue substantiation technology for metallic structures. This proposed regulation is the result of information gathered from a review of catastrophic fatigue failures, and it is intended to improve the level of safety. The proposed rule would assure that should serious accidental damage occur during manufacturing or within the operational life of the rotorcraft, the remaining structure could withstand fatigue loads that are likely to occur, without failure, until the damage is detected and repaired or the part is replaced. In addition to improving the level of safety for FTE of all principal structural elements (PSE), the proposed rule would harmonize Federal Aviation Administration (FAA) standards with requirements by the European aviation authorities.

In the absence of a new rule, future rotorcraft metallic fatigue accidents could occur. A key benefit of the proposed rule would be avoidance of these accidents.

Summary of the Cost-Benefit Analysis

Overview of Costs and Benefits

The FAA estimates the present (2003) value of the total quantifiable safety benefits over 20 years to be about $26.4 million. In addition, the cost savings that would accrue due to harmonization of this rule would contribute to a large potential harmonization savings. The total cost over 20 years of the proposed rule is approximately $1.79 million in present or discounted cost. The fleet studied is an assumed fleet of 4 certifications, each with a ten-year production run; as described in this evaluation. Accordingly, if the rule would be more than 6.8% effective (1.79/26.4 = 0.0678), benefits would exceed costs.

The proposed rule would require rotorcraft manufacturers and operators to take additional actions including the following: (1) perform a more thorough threat assessment, (2) submit a compliance methodology report to the FAA for approval, (3) perform a more rigorous residual strength assessment, and (4) conduct inspections. It is current practice for rotorcraft manufacturers to submit voluntarily a compliance methodology report to the FAA for approval. Hence, for those applicants, there are no additional costs associated with this methodology report. The rotorcraft manufacturers currently perform a threat assessment and a residual strength assessment, but those would become more robust under the proposed rule. The current rule mandates that manufacturers establish inspection intervals or retirement times, which are included in the Airworthiness Limitation Section of the Instructions for Continued Airworthiness. The proposed rule mandates that both retirement times and inspection intervals be established and included in the Airworthiness Limitation Section of the Instructions for

Continued Airworthiness. Except for the four items discussed above, the proposed standard would not have a significant effect on U.S. manufacturer's cost compared to the current rule.

Costs

Based on information from industry representatives on the ARAC Working Group, the FAA estimates that the average additional cost to perform a more thorough threat assessment would be $100,000 per certification; the average additional cost to perform the more rigorous residual strength assessment proposed by this rule would be an additional $50,000; and putting both retirement times and inspection intervals in the airworthiness limitation section of the Instructions for Continued Airworthiness would cost on average an additional $54,000. Based on information received from industry representatives, the FAA also estimates that over the next 20 years, Part 29 rotorcraft structures will be comprised of approximately 50% metallic parts and 50% composite parts. Hence, the additional certification cost under this proposed rule would be $50,000 for a threat assessment ($100,000 * 0.5 = $50,000), $25,000 for a residual strength assessment ($50,000 * 0.5 = $25,000), and $27,000 for putting both inspection intervals and retirement times in the airworthiness limitation section ($54,000 * 0.5 = $27,000). Therefore, the FAA estimates that the total certification cost per new type certification would be $102,000 ($50,000 + $25,000 + $27,000 = $102,000). The total certification costs would be $408,000 (4 certifications at $102,000 per certification) over 20 years in undiscounted costs or about $287,573 in discounted costs (assuming a 7% discount rate).

Industry representatives on the ARAC Working Group also estimated that approximately 30 components would require additional inspection as a result of this proposal, and that it would take a mechanic one hour to inspect each component. Hence, an inspection would take 30 man-hours. At the mechanic wage rate of $60 per hour, each inspection would cost $1,800 (30 man-hours * $60 per hour = $1,800). Based on information received from industry representatives, the FAA estimates that inspections would occur on average approximately every 1250 flight hours. From 1998 - 2000, turbine rotorcraft flew an average of 412 flight hours annually. (FAA Aerospace Forecasts, Fiscal Years 2001-2012, p. VI-3; FAA Aerospace Forecasts, Fiscal Years 2002-2013, p. VI-3) Hence, inspections would occur on average about once every 3 years (1250 / 412 = 3.03).

According to the “2003 Aerospace Source Book” by Aviation Week & Space Technology (January 13, 2003), the growth of the civil helicopter market is expected to be flat for the next several years, with perhaps a few percent growth per year. According to the “FAA Aerospace Forecasts: Fiscal Years 2002-2013” (March 2002), the number of turbine powered rotorcraft is expected to total 4570 by 2013—an increase of only 100 rotorcraft over the 2000 level. Hence, the rate of new rotorcraft production is assumed to approximate the rate of rotorcraft attrition.

Representatives from Sikorsky and Bell estimated that there would be one new type certificate every 10 years for each of their respective companies. For cost estimation purposes, the FAA assumes that the new models would be certificated in years 1 and 11 during the 20-year analysis period, and that each future aircraft certification would have a production run of 10 years. The forecasted production rates for a new Sikorsky model is taken from the forecast of units produced of the S-92 in the "World Rotorcraft Overview" (July 2002) by the Teal Group. Based on forecasted production rates for the Bell 230, 430, UH-1, 212, and 214 in the "World Rotorcraft Overview", the FAA assumes that Bell's production rate for a new model would be roughly 1.5 times that of Sikorsky's. The FAA estimates that the total inspections costs over the 20-year analysis period would be $3,825,000 (2,125 inspections at $1,800 per inspection) in undiscounted costs or about $1,507,000 in discounted costs (by applying a 7% discount rate). Therefore, the total costs of this proposed rule over 20 years is estimated to be $4,233,000 in undiscounted costs ($3,825,000 + $408,000 = $4,233,000) or about $1,795,000 in discounted costs ($1,507,165 + $287,573 = $1,794,738).

Benefits

Discounted at 7 percent annually, total potential benefits for significantly reducing the likelihood of fatigue-related accidents for Part 29 rotorcraft metallic structures amount to an estimated $26.4 million over the 20-year analysis period. In the absence of a new rule, it is likely that future fatigue-related accidents will occur on Part 29 rotorcraft in a manner similar to what has happened in the past. A key benefit of the proposed rule would be the avoidance of these accidents.

In the review of the accident and incident history, the FAA only considered accidents that were relevant to metallic rotorcraft structure fatigue problems. In addition, the FAA did not consider events in which externally aggravating circumstances existed, such as operation of the aircraft outside of its weight and balance limitations.

Databases that the FAA examined include the NTSB Aviation Accident Database & SynoPSE and the National Aviation Safety Data Analysis Center (NASDAC) database.

Since 1982, 13 accidents were identified that may have been prevented if this rule had been in effect. These accidents resulted in 12 fatalities, 5 serious injuries and 6 minor injuries. In addition, all of the aircraft involved in the accidents were either destroyed or received substantial damage.

In order to quantify future benefits, the FAA needed to calculate the costs of a future averted accident as a direct result of this proposed rule. The minimum value of a statistical aviation fatality avoided is set at $3.0 million, that of a serious injury (assumed to be the average of a severe, serious, and moderate injury) at $260,500, and that of a minor injury at $6,000. The associated medical and legal costs for a fatality is $132,700, a serious injury (assumed to be the average of a severe, serious, and moderate injury) $46,633.33, and that of a minor injury, $2,500. In addition, the average replacement cost of a destroyed turbine rotorcraft greater than or equal to 7,000 pounds is represented by a value of $1,651,000, and a NTSB accident investigation costs about $26,000. The number of fatalities, serious injuries and minor injuries represents the average number of such casualties in the thirteen accidents. Based on the above information, the FAA estimates the average value of avoiding a fatigue-related metallic rotorcraft accident is $3.8 million.

Given that thirteen accidents have occurred, without preventative action a number of accidents could occur in the future. The Poisson probability distribution provides a good model for estimating the number of “rare events” observed in a given unit of time. Using the Poisson probability distribution, the FAA estimated probabilities associated with the projected number of future accidents (rare events) for the proposed rulemaking. Based on the Cumulative Poisson probability distribution with mean equal to 13, over the next 20 years, there is a probability of approximately 83% that there would be 10 or more accidents, and a probability of over 99% that there would be 5 or more accidents.

The present value benefit estimate assumes that the probability of an accident is equally likely in any year of the 20-year study period. If 13 accidents were avoided over the next 20 years, the present value benefit would be approximately $26.4 million. If 10 accidents were avoided over the next 20 years, the present value benefit would be approximately $20.3 million.

The benefits of the proposed regulation include the acceptance by the European aviation authorities of a harmonized standard. Such acceptance will offer the benefit of improved acceptability in European countries of products that have been certificated. The harmonized standard would increase the current standard of safety for FAA certificated rotorcraft by mandating inspections as well as retirement times. The FAA has not attempted to quantify the cost savings that may accrue due to harmonization of this rule, beyond noting that they contribute to a large potential harmonization savings. Safety under the provisions of this rule would be at least equivalent to operational safety under the previous regulations.

Comparison

The FAA estimates the discounted present value (2003) benefits of the proposed rule to be $26.4 million. In the absence of this proposed rule, it is highly likely that future fatigue-related metallic rotorcraft accidents will occur. The FAA finds that on average 13 accidents within the fleet included in this analysis could be prevented by the enactment of this proposed rule. The benefit of the proposed rule would be the avoidance of these accidents. As previously discussed, the probability of 5 or more accidents occurring in the absence of this rule is 99%. The benefit of avoiding 5 accidents is about $10 million. Accordingly, based on this analysis, there is a 99% probability that the benefits of this proposal will exceed costs by a factor of over 5.5 (10/1.79 = 5.59). These benefits are derived from preventing accidents due to fatigue.

The FAA seeks comments with supportive justification regarding these benefit estimates. It is estimated that the discounted present value (2003) cost of the proposed rule would be $1.79 million. The cost figure above includes the cost of systems design, qualification, certification, equipment purchase and installation, testing, and inspections. The FAA seeks comments with supportive justification on these cost estimates.

The estimated $26.4 million benefits of this proposed rule far exceeds the estimated $1.79 million costs. Thus, the FAA concludes that the benefits of the proposed rule do justify the costs of the proposed 14 CFR Part 29 rule. The $26.4 million in benefits assumes that all future fatigue accidents are prevented within the aircraft produced under the 4 new certifications. Hence, if this rule is more than 6.8% effective (1.79/26.4 = 0.0678), then benefits will exceed costs.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) establishes “as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation." To achieve that principle, the Act requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The Act covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule would have a significant economic impact on a substantial number of small entities. If the determination is that it would, the agency must prepare a regulatory flexibility analysis as described in the Act.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The FAA believes that this proposed rule would not have a significant economic impact on a substantial number of small entities because all United States Part 29 aircraft manufacturers exceed the Small Business Administration small-entity criteria of 1,500 employees for aircraft manufacturers. Currently U.S. manufactured Part 29 aircraft type certificate holders include Sikorsky Aircraft and Bell Helicopters (a subsidiary of Textron Inc.). The operators would bear the costs of inspections. However, it is very difficult to identify who the operators would be. The FAA believes that there would be no significant economic impact on a substantial number of small operators because the operators will purchase the rotorcraft only if the additional costs can be recovered in the marketplace. Given that there are no small entity manufacturers of Part 29 aircraft, the FAA certifies that this proposed rule would not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The Trade Agreement Act of 1979 prohibits Federal agencies from establishing any standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards. The FAA has assessed the potential effect of this proposed rule and determined that it would harmonize the U.S. standards with the international standards thereby lowering the costs of international trade.

Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 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 agency 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. This proposed rule does not contain a Federal intergovernmental or private sector mandate that exceeds $100 million in any year, therefore the requirements of the act do not apply.

Executive Order 13132, Federalism

The FAA has analyzed this proposed rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action would not have a substantial direct effect 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, we determined that this notice of proposed rulemaking would not have federalism implications.

Regulations Affecting Interstate 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 any manner affecting interstate 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 proposed rule would apply to the certification of future designs of transport category rotorcraft and their subsequent operation, it could, if adopted, affect interstate aviation in Alaska. The FAA therefore specifically requests comments on whether there is justification for applying the proposed rule differently in interstate operations in Alaska.

Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this proposed rulemaking action qualifies for the categorical exclusion identified in paragraph 312f and involves no extraordinary circumstances.

Regulations That Significantly Affect Energy Supply, Distribution, or Use

The energy impact of the proposed rule has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Public Law 94-163, as amended (42

U.S.C. 6362) and the Department of Transportation implementing regulations, specifically 14 C.F.R. § 313.4, that defines a "major regulatory action." We have determined that this notice is not a "major regulatory action under the provisions of the EPCA. Additionally, we have analyzed this proposal under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). We have determined that it is not a "significant regulatory action" under Executive Order 12866, and it is not likely to have a significant adverse affect of the supply, distribution, or use of energy.

List of Subjects in 14 CFR Part 29

Air transportation, Aircraft, Aviation safety, Rotorcraft, Safety.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 29 of Title 14, Code of Federal Regulations, as follows:

PART 29 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

1. The authority citation for part 29 continues to read as follows:

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

2. Amend § 29.571 by revising § 29.571 to read as follows:

§ 29.571 Fatigue Tolerance Evaluation of Metallic Structure.

(a) A fatigue tolerance evaluation of the principal structural elements (PSE) defined in paragraph (c) of this section must be performed and appropriate inspections and retirement time or approved equivalent means must be established to avoid catastrophic failure during the operational life of the rotorcraft. A catastrophic failure is an event that could prevent continued safe flight and landing. The fatigue tolerance evaluation must consider the effects of both fatigue and the damage determined in paragraph (d)(4) of this section. Parts to be evaluated include PSE of the rotors, rotor drive systems between the engines and rotor hubs, controls, fuselage, fixed and movable control surfaces, engine and transmission mountings, landing gear, and their related primary attachments.

(b) The compliance methodology must be submitted to the Administrator for approval.

(c) Considering all structure, structural elements, and assemblies, the PSE must be identified. PSE are structural elements that contribute significantly to the carrying of flight or ground loads and the fatigue failure of which could result in catastrophic failure of the rotorcraft.

(d) Each evaluation required by this section must include:

(1) In-flight measurements to determine the fatigue loads or stresses for the PSE identified in paragraph (c) of this section in all critical conditions throughout the range of limitations in § 29.309 (including altitude effects), except that maneuvering load factors need not exceed the maximum values expected in operations.

(2) The loading spectra as severe as those expected in operation based on loads or stresses determined under paragraph (d)(1) of this section, including external load operations, if applicable, and other high-frequency power-cycle operations.

(3) Take-off, landing, and taxi loads when evaluating the landing gear and other affected PSE.

(4) A determination for the PSE identified in paragraph (c) of this section of the probable locations, types, and sizes of damage considering fatigue, environmental effects,

intrinsic and discrete flaws, or accidental damage that may occur during manufacture or operation.

(5) A determination of the fatigue tolerance characteristics for the PSE with the damage identified in paragraph (d)(4) of this section that supports the inspection and retirement times, or other approved equivalent means.

(6) Analyses supported by test evidence and, if available, service experience.

(e) A residual strength determination is required to establish the allowable damage size. For inspection interval determination based on damage growth, the residual strength evaluation must show that the remaining structure after damage growth is able to withstand design limit loads without failure within its operational life.

(f) The effect of damage on stiffness, dynamic behavior, loads and functional performance must be considered.

(g) Based on the requirements of this section, inspections and retirement times or approved equivalent means must be established to avoid catastrophic failure. The inspections and retirement times or approved equivalent means must be included in the Airworthiness Limitation Section of the Instructions for Continued Airworthiness required by Section 29.1529 and Section A29.4 of Appendix A of this part.

(h) If inspections for any of the damage types identified in paragraph (d)(4) of this section cannot be established within the limitations of geometry, inspectability, or good design practice, then supplemental procedures, in conjunction with the retirement time, must be established that will minimize the risk of each of these types of damage being present or leading to a catastrophic failure during the operational life of the rotorcraft.

Issued in Washington, DC, on

[Name of Office Director]

[Title of Office Director]

[Name and title of the individual signing the NPRM. Generally, the OPI director. If the individual signing the NPRM is "acting" for another individual, this must be noted in the signature block.]

AC 29.571B. § 29.571 (Amendment 29-XX) FATIGUE TOLERANCE EVALUATION OF METALLIC STRUCTURE.

a. Purpose. This advisory material provides an acceptable means of compliance with the provisions of § 29.571 Amendment XX of the Federal Aviation Regulations (FAR) dealing with the fatigue tolerance evaluation of transport category rotorcraft metallic structure. This guidance applies to conventional metallic materials. (Corresponding guidance for composite structure can be found in AC 29–2C, MG 8, supplemented by AC 20-107A). The fatigue evaluation procedures outlined in this advisory material are for guidance purposes only and are neither mandatory nor regulatory in nature. Although a uniform approach to fatigue tolerance evaluation is desirable, it is recognized that in such a complex area, new design features and methods of fabrication, new approaches to fatigue tolerance evaluation, and new configurations may require variations and deviations from the procedures described herein. It should be noted that § 29.571 requires that the methodology used by the applicant be approved by the FAA/AUTHORITY to assure compliance with the regulatory requirements.

b. Special Considerations. The unique performance capabilities of rotorcraft and their typical operational environment make fatigue tolerance evaluations both complex and critically important. Due to the many rotating elements inherent in their design, rotorcraft structures are potentially subject to damaging cyclic stresses in practically every regime of flight. The complexity of the fatigue loading is compounded by the fact that rotorcraft are highly maneuverable and are utilized for many widely varying roles. Corrosion and other environmental damages are not uncommon in rotorcraft operations; neither are inadvertent damages from maintenance that is typically frequent and intensive. For these reasons, special attention should be focused on the fatigue tolerance evaluation of rotorcraft structure.

c. Background.

(1) Fatigue of rotorcraft dynamic components was first addressed in the 1950's by means of a Safe-Life methodology. The application of this methodology, as described in AC 27-1B, MG 11, has proven to be successful in providing an adequate level of reliability for transport category rotorcraft. However, it was recognized in the 1980's that higher levels of reliability might be realized by taking into account the fatigue strength-reducing effects of damage that experience has shown can occur in manufacture or in operational service. The introduction of composites led the manufacturers and regulatory authorities to develop a robust Safe-Life methodology by taking into account the specific static and fatigue strength-reducing effects of aging, temperature, moisture absorption, impact damage, and recognition of an accepted industry standard. Furthermore, where clearly visible damages resulted from impact or other sources, inspection programs were developed to maintain safety. In parallel, crack growth methodology has been successfully used for solving short-term airworthiness problems in metallic structures of rotorcraft, and as the certification basis for civil and military transport aircraft applications. These advances in design, analytical

methods, and industry practices made it feasible to address certain types of damage, which could result in fatigue failure. Consistent with this, the regulatory requirements of § 29.571 were substantially revised by Amendment 28. While many years have passed since its introduction, Amendment 28 has had little exposure to use for certification of completely new rotorcraft designs. However, the general understanding of rotorcraft fatigue tolerance evaluation has developed considerably in the interim and an additional amendment was determined to be appropriate. The latest Amendment XX of Part 29 and the associated revisions to advisory material were introduced to improve the currency and understanding of the rule and clarify the differing approaches and methods available for accomplishing fatigue tolerance evaluation of rotorcraft metallic structure.

(2) This guidance provides material with respect to the fatigue tolerance requirements for metallic structure and is supplemented by AC 27-1C, MG 11 for evaluations using the Safe-Life methodology and other general fatigue considerations.

d. Introduction.

(1) Definitions. The following definitions are applicable when used within the context of this guidance material.

(i) As-manufactured structure is a structure that passes the applicable quality control process and has been found to conform to an approved design within the allowable tolerances.

(ii) Catastrophic failure is an event that could prevent continued safe flight and landing.

(iii) Damage is a detrimental change to the condition of the structure or assembly. In the context of this guidance material it is used as a generic term to describe all types of flaws including those caused by environmental effects and accidental damage arising in manufacture, maintenance or operation.

(iv) Flaw is an imperfection, defect, or blemish and may be either discrete or intrinsic.

(v) Discrete flaw is a flaw that is not inherent in the design and is caused by an external action, such as corrosion, scratches, gouges, nicks, fretting, wear, impact, and potentially cracks initiated by fatigue.

(vi) Intrinsic flaw is a flaw that is inherent in the design and manufacture of the part, situated within it or peculiar to it, such as inclusions, cracks, forging laps, or porosity.

(vii) Damage Tolerance is the attribute of the structure that permits it to retain its required residual strength without detrimental structural deformation for a period of un-repaired use after the structure has sustained a given level of fatigue, corrosion, accidental, or discrete source damage.

(viii) Fatigue is a degradation process of a structure subject to repeated loads that may involve four phases (e.g., nucleation of many micro-cracks, coalescence of some micro-cracks to one major macro-crack, stable crack growth, unstable crack growth, and immediate failure). The boundaries between these phases are, in practice, not always easily defined. Crack initiation methods (e.g., using the S-N curve and the Miner's Rule) are generally used to address the first two phases. Linear Fracture Mechanics methods (e.g., using da/dn - ΔK and fracture toughness data) are generally used for the latter two phases.

(ix) Fatigue Loads are repeated loads, which induce a repeated variation of stress versus time in a structure.

(x) Fatigue Tolerance is the ability of a structure, either in an as-manufactured or damaged condition, to tolerate specified operational loading for a given period of use without initiating cracks, and assuming they initiate, tolerate their growth, without failure, under specified residual strength loads.

(xi) Inspection interval is the maximum period of usage allowed for a structure between inspections. At the end of this period, the structure is inspected and if there is no damage detected, the structure may be returned to service for another inspection interval.

(xii) Limit Loads are the maximum loads to be expected in service, as defined in § 29.301(a).

(xiii) Multiple Load Path is identified with a redundant structure of multiple and distinct elements, in which the applied loads would be safely redistributed to other load carrying members after complete failure of one of the elements. These may be Active, where two or more elements are loaded during operation to a similar load spectrum, or Passive, where one or more of elements of the structure are relatively unloaded until failure of the other element(s).

(xiv) Principal Structural Elements (PSE) are structural elements that contribute significantly to the carrying of flight or ground loads and the fatigue failure of which could result in catastrophic failure of the rotorcraft.

(xv) Retirement (Replacement) Time of a component is that number of events such as flight hours or landings at which the part must be removed from service regardless of its condition.

(xvi) Residual Strength is the level of strength retained by a structure with damage present.

(xvii) Barely Detectable Flaw (BDF) is the worst-case flaw that is expected to remain on the structure for its operational life.

(xiii) Clearly Detectable Flaw (CDF) is the worst-case detectable flaw that would not be expected to remain in place for a significant period of time without corrective action.

(xix) Safe-Life is the number of events, such as flight hours or landings, for a structural component during which there is a low probability that the strength will degrade below its design ultimate value due to fatigue damage initiating cracks.

(2) General. The objective of fatigue tolerance evaluation is to prevent catastrophic failure of the structure by mitigation of the effects of damage in combination with fatigue throughout the life of the rotorcraft.

(i) Fatigue tolerant design as substantiated by fatigue tolerance evaluation methods such as those outlined in this guidance is required for all PSE's, unless it entails such complications that an effective structure that is tolerant to damage cannot be achieved within the limitations of geometry, inspectability, or good design practice. In such cases, the particular type of damage at issue must be identified and alternative measures should be taken to minimize both the risk of acquiring that damage and its consequences.

(ii) To perform an evaluation first requires an understanding of the potential threats (resulting in damage) that may modify the fatigue behavior of the component. The principal concerns of this guidance are consideration of all damage sources and of the fatigue loads and rotorcraft usage. Further mitigation of the sources of damage may be achieved by adoption of a critical parts plan to help ensure that the condition of the part remains as envisaged by the designer throughout its life cycle (see § 29.602).

(iii) The need for the use of complex inspection techniques or equipment or highly trained personnel (resources that may not be available to the small operator or in remote areas of operation) should be considered when establishing the methodology. When inspections cannot be relied upon for detection of small cracks or other damage, then retirement times must be established that account for the probable types and locations of the damage, including consideration of cracks.

(iv) A retirement time should be provided for all components, including those subject to inspection, whose fatigue behavior is not reliably established to a point well beyond the life of the rotorcraft. This is intended to prevent the continued use of components beyond the point that ultimate load capability may no longer be assumed to exist in the rotorcraft due to the onset of fatigue cracking. This is particularly important for single load path components or a structure prone to widespread fatigue damage.

(v) Experience with the application of methods of fatigue tolerance evaluation indicates that a relevant test background should exist in order to achieve the design objective. It is general practice within industry to conduct tests to obtain design information and for certification purposes. Damage location, fatigue characteristics, and crack growth data based on test results and service history of similar parts, if available, should be considered when establishing inspections and retirement times. The FAA/AUTHORITY should agree upon the extent of supporting evidence necessary for each phase of the evaluation process outlined below.

(3) Essential Considerations. In order to satisfy the requirements of § 29.571, consideration should be given to the following issues in order to demonstrate compliance.

(i) Selection of PSE. All structure, structural elements, and assemblies, the failure or undetected failure of which could result in catastrophic failure of the rotorcraft, should be identified as PSE [see paragraph f(2)]. To do this, a failure mode and effects analysis or similar method may be used. Specific areas of interest within the PSE that may require particular attention include the following:

(A) Irregularly shaped parts, or those containing numerous or super-imposed fillets, holes, threads, or lugs;

(B) Parts of unique design for which no past service experience is available;

(C) New materials or processes for which there is no previous experience;

(D) Bolted or pinned connections;

(E) Parts subject to fretting;

(F) Complex casting; and

(G) Welded sections.

(ii) In-flight measurement to determine the loads or stresses (steady and oscillatory) for the PSEs in all critical conditions throughout the range of limitations in § 29.309 (including altitude effects), except that maneuvering load factors need not exceed the maximum values expected in operations. See paragraph f(3).

(iii) Loading spectra as severe as those expected in operation including external load operations, if applicable, and other high frequency power cycle operations. See paragraphs f(3) and f(4).

(iv) A threat assessment of probable damage, including a determination of the probable locations, types, and sizes should be performed. In particular, the assessment should include an evaluation of the details of the specific work processes used on each component, operational environment, and maintenance practices to determine the potential for damage. See paragraph f(5).

(v) Inspectability of the rotorcraft, inspection methods, and detectable flaw sizes should be compatible with the chosen fatigue tolerance methods and validated by trials conducted under realistic conditions. See paragraph f(6).

(vi) For each PSE, one or more fatigue tolerance methodologies should be selected to ensure each specific damage resulting from the threat assessment is addressed and to satisfy the requirement for inspections and retirement times as discussed in paragraph e. of this guidance. The fatigue tolerance characteristics (including variability) of the structure and materials therein should be evaluated as necessary to support the evaluation. Generally this will include understanding the fatigue strength, fatigue crack propagation characteristics of the materials used, and of the structure and the residual strength of the damaged structure. See paragraphs e., f(7) and f(8).

(vii) Fatigue Tolerance Results of the evaluation should be used to provide data in the Limitations Section of the Instructions for Continued Airworthiness. See paragraph f(9).

e. <u>Fatigue Tolerance Evaluation</u>. A fatigue tolerance evaluation, by analysis and tests, of the PSE is required to establish inspections and retirement times, or approved equivalent means, to avoid catastrophic failure due to fatigue cracking during the operational life of the rotorcraft. The evaluation should consider the impact of the probable threats identified on the fatigue performance and residual strength of all critical areas of each PSE. A number of different fatigue evaluation methods have evolved over the years. Seven of these methods are recognized and discussed in detail in this guidance. The seven methods are summarized as a table in Figure AC 29.571B-1. Also noted in the table is the safety management strategy the specific method supports, the analysis category in which they belong, and whether the specific method can be used to address the types of damage identified in the threat assessment.

(1) Each approach results in information that can be used to support establishment of retirement times or inspection requirements. Four methods are used to support safety-by-retirement strategies and they result in retirement times. The other three methods are used to support safety-by-inspection strategies and the result is in-service inspection requirements.

(2) In some cases application of one method may be sufficient to achieve acceptable fatigue tolerance. In other cases more than one method may be needed. For example, use of Safe-Life Retirement in combination with Crack Growth Inspections could be an effective way to manage fatigue due to all possible sources.

(3) All the methods listed, with the exception of Safe-Life Retirement, were developed to explicitly address some level of damage. All the methods can theoretically be implemented analytically or by test. However, some of the methods are more practically implemented analytically and some are best implemented by test.

METHOD	PARAGRAPH	STRATEGY	ANALYSIS CATEGORY	THREAT ASSESSMENT RESULTS
Safe-Life Retirement	e.(6)(i)(A)	Retire	Crack Initiation	Not Included
Safe-Life Retirement with BDF(s)	e.(6)(i)(B)	Retire	Crack Initiation	Not Including Cracks
Safe-Life Retirement with CDF(s)	e.(6)(i)(C)	Retire	Crack Initiation	Not Including Cracks
Safe-Life Inspection for CDF(s)	e(6)(i)(D)	Inspect	Crack Initiation	Included
Safe-Life Inspection for a failed element	e.(6)(i)(E)	Inspect	Crack Initiation	Included if Considered for all Elements
Crack Growth Retirement	e.(6)(ii)(A)	Retire	Crack Growth	Included if Crack Bounds Damage
Crack Growth Inspection	e.(6)(ii)(B)	Inspect	Crack Growth	Included

Figure AC 29.571B-1. Seven Fatigue Evaluation Methods discussed in this guidance

(4) From an analytical standpoint these methods fall into one of two categories, crack initiation or crack growth. Each of the seven methods is briefly described below in paragraphs e(6)(i) and e(6)(ii), depending on the category.

(5) In-service experience may be used to support establishing fatigue tolerance characteristics when it is shown on a similar structure.

(6) Fatigue Evaluation Methods.

(i) Crack Initiation Methods. The methods described in this section are categorized as crack initiation methods since they involve quantifying the time it takes for a crack to initiate at a critical area in an as-manufactured part or at a critical area that has sustained some level of damage. Analytically these methods depend on fatigue data (e.g., stress versus number of cycles (S-N) curves) and cumulative fatigue damage algorithms (e.g., Miner's Rule) to establish a high margin retirement time. Testing that supports these methods employs specimens that are as-manufactured or ones that have been preconditioned with damage as identified in the threat assessment.

(A) Safe-Life Retirement. Safe-Life Retirement is a crack initiation method that accounts for damage induced by fatigue loading but does not account for flaws and defects due to manufacturing and in-service conditions. Application of this method results in a replacement time based on the time to initiate a crack in an as-manufactured part. Analysis or tests may be used to determine the crack initiation life. The rationale behind this method is based on part replacement before the probability of initiating a crack becomes significant. This method needs to be supplemented by other methods to account for damage. For compliance details see paragraph f(7)(i).

(B) Safe-Life Retirement with a Barely Detectable Flaw (BDF). Safe-Life Retirement with a BDF is a crack initiation methodology that explicitly addresses the effect of damage that is considered barely detectable and is therefore likely to go unnoticed for the life of the part. Application of this method results in a replacement time based on the time to initiate a crack from a BDF. Analysis or tests may be used to determine the crack initiation life. The rationale behind this method is based on part replacement before the probability of initiating a crack is significant. Damage in excess of the BDF must be addressed using other methods. For compliance details see paragraph f(7)(ii).

(C) Safe-Life Retirement with a Clearly Detectable Flaw (CDF). Safe-Life Retirement with a CDF is a crack initiation methodology that explicitly addresses the effect of damage that is considered clearly detectable but conservatively recognizes that it would remain in place without corrective action prior to the retirement time of the part. Application of this method results in a retirement time based on the time to initiate a crack from a CDF. Analysis or tests may be used to determine the crack initiation life. The rationale behind this method is based on part replacement before the probability of initiating a crack is significant. Use of this method by itself could achieve acceptable fatigue tolerance and may preclude the need for any mandated directed inspections. See paragraph f(7)(iii) for compliance details.

(D) Safe-Life Inspection for a CDF. Safe-Life Inspection for a CDF is a crack initiation method that explicitly addresses the effect of damage that is considered clearly detectable and would therefore not be expected to remain in place without corrective action for any significant period of time. Application of this method results in a directed inspection task with an interval based on the time to initiate a crack from a clearly detectable flaw. Analysis or tests may be used to determine the crack initiation life. The rationale behind this method is based on visual detection and disposition of the flaw before the probability of initiating a crack is significant. Damage that is not detectable must be addressed by other methods and the cumulative effects of fatigue prior to and following the advent of the damage should be considered. For compliance details see paragraph f(8)(i).

(E) Safe-Life Inspection for a failed element. Safe-Life Inspection for a failed element is a crack initiation method. It results in an inspection for a completely failed load path with an interval based on the crack initiation life of the adjacent structure accounting for internal load redistribution due to failure of the load path that is to be inspected. This method can only be applied if the structure is initially designed for limit load capability with the failed element. The rationale behind this method is based on visual detection and disposition of the failed load path before the probability of initiating a crack in the adjacent structure becomes significant. Therefore it may not be appropriate if the damage that has led to the failure of the first load path could similarly affect the remaining path. For compliance details see paragraph f(8)(ii)(B)(3).

(ii) Crack Growth Methods. The methods described in this paragraph are categorized as crack growth methods since they involve quantifying the time it takes a crack at a critical area to grow from some initial size to some final size. Analytically these methods depend on crack growth rate properties (e.g., da/dN vs. ΔK vs. R) and fracture properties (e.g., K_{IC}). Using these properties, Fracture Mechanics based tools are used to predict crack growth and final fracture. Testing that supports these methods employs specimens that contain cracks and involves close monitoring to document actual crack growth and final fracture.

(A) Crack Growth Retirement is a crack growth method that explicitly addresses the largest damage that could occur during manufacture or operation of the rotorcraft. This damage is modeled as a crack with a bounding equivalent crack (BEC) established based on the results of the threat assessment. Application of this method results in a retirement time based on the time for the initial crack to grow large enough to reduce the residual strength to design limit level. Since typical BECs are relatively small and thus difficult to induce in test specimens, this method is typically implemented analytically. The rationale behind this method is based on part retirement before the largest probable damage, modeled as a crack, would reduce the residual strength below design limit. Use of this method by itself could achieve acceptable fatigue tolerance and preclude the need for any mandated inspections provided all threats are accounted for by the BECs. For compliance details see paragraph f(7)(iv)

(B) Crack Growth Inspection is a crack growth method that explicitly addresses damage that could occur during manufacture or operation of the rotorcraft. An in-service inspection method is selected that defines a detectable crack size, which could be as large as a completely failed load path. An inspection interval is established based on the time for the detectable crack to grow to critical size or for the residual strength of the adjacent structure to drop to design limit due to continuing crack growth in it. This method is applicable to single or multiple load path structure and inspection for a completely failed load path or less. This method may be addressed by analysis supported by test depending on the difficulty of introducing into the specimen the inspectable crack or failed load path. The rationale behind this approach is based on detection and disposition of a crack or failed load path before residual strength is reduced below the design limit load. For compliance details see paragraph f(8)(ii).

f. Means of Compliance.

(1) GENERAL. The results of the fatigue tolerance evaluation required by § 29.571 are used to establish operational procedures that are meant to minimize the risk of catastrophic failures during the operational life of the rotorcraft. It is required that the evaluation performed considers the effect of damage that could result from potential threats present during manufacture and operation. An assessment of probable threats is required to identify the damage that must be considered in the fatigue tolerance evaluation.

(i) The fatigue tolerance evaluation should establish both retirement times and inspection intervals, or approved equivalent means, to prevent any catastrophic failures. Retirement times should be set to ensure that baseline ultimate strength capability is not compromised for as-manufactured structures and structures where the damage is likely to be undetected during the operational life. Intervals for inspections for detectable damage must be established so that strength capability will never fall below maximum design limit level. The intent is that if damage does occur, the structure will retain the capability to withstand reasonable loads without catastrophic failure or excessive structural deformation until the damage is detected and the structure is replaced or repaired. If inspections cannot be established within the limitations of geometry, inspectability, or good design practice, then supplemental procedures, when available, should be established that would minimize the risk of damage being present or leading to a catastrophic failure.

(ii) The following considerations will assist the successful design of a fatigue tolerant structure.

(A) Use multiple-element and multiple load path construction with provisions for crack stoppers that can limit (arrest) the growth of cracks while maintaining adequate residual strength.

(B) Select materials and stress levels that preclude crack growth or crack initiation from flaws or that provide a controlled slow rate of crack propagation combined with high residual strength after initiation of cracks. Test data should substantiate material properties.

(C) Design for detection of damage (i.e., cracks and flaws) and retirement or repair.

(D) Provide provisions that limit the occurrence of damage and the probability of concurrent multiple damage, particularly after long service.

(iii) Section 29.571 requires that the applicant's proposed compliance methodology must be submitted to the Administrator in order to obtain their concurrence and approval. Therefore, the applicant should coordinate the involvement of the FAA/AUTHORITY from an early stage. The proposed means of compliance should include the following items.

(A) A list of PSEs to be evaluated.

(B) The results of threat analyses for each PSE including type, location, and size of the damage that will be considered in order to establish retirement times, inspections, or other procedures.

(C) Inspection criteria that includes an estimate of detectability or inspectability, along with any supplemental procedure to minimize the risk of damage.

(D) The analysis methods and supporting test data that will establish retirement times, inspections, or other procedures.

(2) IDENTIFICATION OF PSE. The fatigue tolerance evaluation should first consider all airframe structure and structural elements, and assemblies in order to identify the PSE. The structural elements and assemblies identified as PSE should be formally submitted to the FAA/AUTHORITY with justification based on good design practice, service history with similar structure, drawing reviews, static analysis issues, or other appropriate means.

(i) A Failure Mode and Effects Analysis or similar method may be used to identify structures whose failure due to fatigue can lead to catastrophic failure of the rotorcraft. The need to design PSE for fatigue tolerance when they are supplied by third parties (e.g., actuators) should be clearly identified in the rotorcraft manufacturer’s specification for the part. The list of PSE will likely include structural elements and assemblies that will be subjected to significant fatigue loading expected during the operational life of the rotorcraft. This may include the following rotorcraft parts:

(A) Rotors: blades, hubs, hinges, attachment fittings, vibration dampening devices;

(B) Rotor drive systems (parts connecting rotors to engines): gears, shafts, gear housings, couplings;

(C) Rotor control systems: actuators, pitch control system, swashplate, servo flaps;

(D) Fuselage (airframe): rotor system support structure, landing gear attachment;

(E) Fixed and movable control surfaces: stabilizer;

(F) Engine, transmission or equipment mountings: APU, auxiliary gearbox;

(G) Landing gear;

(H) Folding systems: main blade, tail beam.

(ii) Analyses and fatigue tests on complete structures or representative sub-element structures can determine the locations within PSE that need to be identified for fatigue tolerance evaluation. The following should be considered:

(A) Strain gauge data on undamaged structure that can identify high stress points.

(B) Analysis that shows high stress or small margin of safety values.

(C) Locations where permanent deformation occurred in static tests.

(D) Locations where failure has occurred in as-manufactured structure fatigue tests.

(E) Locations where the potential for fatigue damage has been identified by analysis.

(F) Locations where the maximum allowed stress occurs when an adjacent element fails.

(G) Locations in structure needed to maintain adequate residual strength that has high stress concentration values.

(H) Locations where detection would be difficult.

(I) Locations where service experience with similar components indicates potential for fatigue or other damage (e.g., fretting, corrosion, wear).

(3) FLIGHT LOADS MEASUREMENT PROGRAM. The simulation of expected spectrum loads for each PSE should be based on flight recorded strain gauge data collected as part of a structured flight test program. The PSE spectrum loads include

the steady state, transient, and vibratory loads that are expected in operation. AC 27-1B, MG 11, provides further detail for development and use of flight measured loads as the basis for spectrum loads used in the fatigue tolerant evaluations.

(4) ROTORCRAFT USAGE SPECTRUM.

(i) The usage and loading spectrum should be developed so that it is unlikely that the actual usage and loads will cause fatigue damage or crack growth rates beyond those associated with the defined spectrum used in the fatigue tolerance evaluation. The usage spectrum allocating percentage of time or frequencies of occurrence to flight conditions or maneuvers should be based on the expected usage of the rotorcraft. Considerations should include flight history, recorded flight data, design limitations established in static strength requirements, and recommended operating conditions and limitations specified in the rotorcraft flight manual.

(ii) The fatigue load spectrum developed for fatigue testing and analysis purposes should be representative of the anticipated service usage. Low amplitude load levels that can be shown not to contribute fatigue damage may be omitted (truncated). Simplification of the spectrum loads may also include summing (binding) of percent times or cycles with common steady and vibratory load values.

(iii) The steady state, transient, and vibratory flight load assigned to each regime in the spectrum and utilized in the fatigue tolerance evaluations for each condition should take into account combinations of altitude, center of gravity (CG), gross weight (GW), airspeed, etc., considered to be representative of expected GW/CG mission configurations.

(iv) The usage spectrum should be presented to the FAA/AUTHORITY for their concurrence. It should include normal operation over the range of rotorcraft configurations including a percent time under 'external load' conditions. This spectrum should represent a "composite worst-case" compilation that includes all of the critical conditions that the rotorcraft is expected to experience during performance of the design missions.

(v) AC 27-1B, MG 11, provides further detail for the development of the usage spectrums used in the fatigue tolerance evaluations.

(5) THREAT ASSESSMENT.

(i) A determination should be made of all potential threats that could occur during the manufacturing and service life that may cause damage to each PSE. A threat assessment should be performed for each PSE. To acquire sufficient knowledge of the component and of its global environment, the following items must be identified:

(A) manufacturing process

(B) quality control process

(C) prescribed storage, transport, handling, assembly and maintenance aspects of the component, and of the surrounding components

(D) operational environment

(E) potential for corrosion including that from contamination by corrosive fluids

(F) potential for impact damages from debris, dropped tools, hail, tramping underfoot during maintenance, etc.

(G) potential for wear

(ii) To determine types, locations, and sizes of the probable damages, considering the time and circumstances of their occurrence, the following should be considered:

(A) Intrinsic flaws and other damage that could exist in an as-manufactured structure based on the evaluation of the details and potential sensitivities involved in the specific manufacturing work processes used.

(B) Damage that could be expected to occur during prescribed activities associated with storage, transport, handling, assembly, maintenance, overhaul, repair and operation of the component and of the surrounding components including impacts, scratches, fretting, corrosion, contamination, wear, and loss of bolt torque.

(C) Previous experience and data collected on similar events and on similar components; materials, and processes should be considered in identifying risks and causes of damages and their effects in inducing flaws or cracks.

(D) Metallurgical evaluations, manufacturing records and overhaul and repair reports, field service reports, incident and accident investigations, and engineering judgment may be used as supporting data.

(E) When data are not available, the threat should be experimentally simulated and the effect established through tests and analysis. With agreement of the FAA/AUTHORITY, an upper cut-off value may be established for each class of damage.

(F) Credit may be given to manufacturing, transport, handling, installation, and maintenance instructions finalized to minimize or avoid damages. Examples of these processes or instructions could be: "frozen manufacturing processes," Flight Critical Parts programs, material selection to mitigate intrinsic flaws like inclusions and defects, procedures to reduce deviations from nominal structures, etc.

(G) Credit may be given to protection of structures, such as the use of protective coatings, shielding and plating against corrosion, fretting, and impacts.

(H) Critical areas will be assumed as typical location of the damage, unless proper justification is provided to limit the applicability to specific areas or sections of the part.

(iii) Classification of Damage.

(A) The results of the threat assessment are used to classify the damage used in the fatigue tolerance evaluation. The process employed to classify the damage will depend on the fatigue tolerance evaluation method to be used. Depending on the method, a BDF, a CDF, a BEC, or an initial inspectable crack must be established.

(B) For each damage type identified, the sizes to be considered should be representative of the maximum sizes that might not be detected by the inspection techniques established for the component. Sizes exceeding those that are likely to occur do not need to be considered. Standard sizes of damage or standard level of aggression may be derived from previous experience. Each applicant will be required to present justification for damage and crack sizes to be used in the fatigue tolerance evaluations. Within the operational life, defect sizes that have been found in service should be correlated with the sizes used in the design certification.

(C) Barely Detectable Flaw (BDF). For retirement time analysis, flaw sizes that are "barely detectable" may be used to conservatively represent the worst case of undetectable flaws. Alternatively, when the detectable size is larger than the one identified by the threat assessment, a smaller size, but one not less than the flaw size likely to occur, can be used. Sometimes an "allowable" detectable size is established as acceptable for a specific manufacturing process, such as castings, to remain in place for the life of the structure. When it is impossible to simulate that maximum allowable size in the test specimen, the sizes available in the specimen may be used, provided the subsequent analysis of the test result conservatively accounts for the shortfall in the damage size.

(D) Clearly Detectable Flaw (CDF). For inspection intervals, flaw sizes that are "clearly detectable" may be used. The largest discrete size of a CDF to be considered may be limited to the maximum size of the CDF that is likely to remain in place for a significant period of time and not be detected during routine inspections for general conditions and normal observations by knowledgeable personnel. The damage size used may be limited to the maximum probable size identified in the threat assessment. For multiple load path structure, the number of failed load paths to be considered should be established.

(E) Bounding Equivalent Crack (BEC). A Bounding Equivalent Crack must be defined to determine a retirement time using the Crack Growth Retirement method. The size of the BEC should bound the life reducing effect of damage that could occur as a result of manufacturing, maintenance, or the service environment. The size may be established by analytical back calculations from coupon or service fatigue life data accounting for material variability effects in the data. In any case, there should be no probable damage from any source that would lead to failure of the part in less time that it would take the BEC to reach critical size. Each applicant must justify the BEC sizes used in the analysis; however, there has been some limited experience that indicates that the following BEC sizes could be appropriate.

(1) 0.015 inch or 0.380 mm radius semicircular surface crack for precision-machined mechanical parts

(2) 0.050 inch or 1.270 mm radius quarter-circular corner crack in fastener holes for typical aluminum airframe structure

(F) Initial Inspectable Crack. The size and shape of the initial inspectable crack (a_{DET}) must be established when the Crack Growth Inspection approach is used. The inspection interval is based on the time for the initial inspectable crack to grow to a size (a_{CRIT}) that would result in catastrophic failure of the rotorcraft if limit loads were applied. The initial inspectable crack is a function of the inspection method that is used to detect it. Regardless of the inspection method, the probability of detecting this size crack should be high and it should be substantiated.

(6) INSPECTABILITY AND INSPECTION METHODS. This section provides guidance on selecting and substantiating damage detection methodology for use with the methods of paragraphs f(8) (Inspection Intervals) and f(10) (Approved Equivalent Means). The methods of paragraph f(8) can result in a mandated inspection program that must be included in the Airworthiness Limitations Section (ALS) of the Instructions for Continued Airworthiness in accordance with § 29.1529 of the regulatory requirements. Qualified personnel must conduct these inspections at the specified interval using the approved method or methods. Additionally, § 29.571 allows that substantiation may be accomplished by "Approved Equivalent Means," which is discussed in paragraph f(10). These Approved Equivalent Means may include actions that detect damage or flaws indirectly and are substantiated using the methods of paragraph f(8). These actions should be shown to be reliable and systematically conducted by knowledgeable personnel. The following are considerations for establishing inspections, inspection methods, or indirect damage detection.

(i) Inspectability. The ease of conducting an inspection should be a design goal for principal structural elements. Design features such as open construction, access panels or ports, or other easy access to fatigue critical areas for needed inspections should be considered. A design that requires disassembly in order to conduct a required inspection, other than during a scheduled maintenance disassembly, should be avoided.

(ii) The specific inspection methods that are used to accomplish fatigue substantiation should be:

(A) Compatible with the threats identified in the threat assessment, paragraph f(5) and provide a high probability of detection in the threat assessment and their development under the operational loads and environment.

(B) Consistent with the capabilities, facilities, and resources of the potential operators of the helicopter. The need to conduct complex or difficult field-level inspections should be avoided, especially when the projected usage of the helicopter may include extended periods of operation in remote areas.

(C) Developed and substantiated for each specific application by means of a full-scale test program, or by experience with similar methods in similar applications.

(D) Included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness in accordance with § 29.1529 as required by § 29.571(g).

(iii) Detectable Damage Size Assessment.

(A) In the case where the substantiation is predicated on the detection of a specific flaw or crack size, an assessment should be conducted to assure that the selected inspection method will be highly reliable in detecting that size of damage in service. This assessment may be based on the known capability of currently available inspection methods and equipment, provided that this capability is verified by a full-scale test program or by experience with the method in service for similar structure and damage.

(B) If the current capability of a specific inspection method is in question, or if the capability of a specific method needs to be extended to a smaller damage size, then a systematic assessment and substantiation of the method for the intended purpose is appropriate. This assessment could include the determination of the Probability of Detection (POD) as a function of damage size and should consider the capabilities of the potential operators of the helicopter and the environment in which the inspections will be conducted.

(iv) Indirect Detection of Damage. Several damage detection procedures are available that could be used as "Approved Equivalent Means" to support substantiation of a structure [reference paragraph f(10)]. These procedures, if systematically required and conducted by knowledgeable personnel, can be used in conjunction with the methods presented in paragraph f(8) to achieve the substantiation. Examples of this type of substantiation are:

(A) In-flight damage detectable by vibration, noise, or observing a blade-out-of-track tip path plane. Consideration should be given to the background levels of noise and vibration, as well as whether the indication is of a different character (more detectable) rather than just a change in level (less detectable).

(B) Damage that is obvious in a preflight check or routine visual examination. This could include obvious flaws or cracking, but also could include structure that is found to be loose, broken, or soft when deflected by hand. Other obvious damage detection could include fluid leaks, missing fasteners, structure bent or out of alignment, or jamming of mechanical parts.

(C) Damage that is indicated following flight completion. Spectrographic oil analysis would be an example.

(D) Damage detection by automated means. This includes crack detection by foil, fiber, or wire break, load monitoring (to detect a change in internal load distribution), acoustic emission monitoring, or other on-board sensors that meet the goals of damage detectability and reliability.

(7) RETIREMENT TIMES. Each of the four methods below provides a means to establish a retirement time for each PSE. The determination of the fatigue tolerance characteristics should include an assessment using the conventional Safe-Life methodology. In addition, this serves as a baseline for comparison to retirement times determined with flaws and defects included, and should be used as the structure's retirement time if it is the lowest calculated time.

(i) The conventional Safe-Life methodology accounts for damage induced by fatigue loading but does not account for flaws and defects due to manufacturing and in-service conditions. If the retirement time is established using this method, then the damage identified in paragraph f(5) (as required by § 29.571(d)(iii)) must be addressed by inspections or other equivalent means. Information to guide a fatigue evaluation based on a conventional Safe-Life approach is provided in detail in AC 27–1B MG 11. The method consists of:

(A) Establishing mean fatigue curves (e.g., stress-life or strain-life) based on crack initiation in constant-amplitude or spectrum testing of as-manufactured structure;

(B) Establishing working fatigue curves with strength and life margins; and

(C) Conducting a cumulative damage working life calculation using known flight loads and estimated usage.

(ii) A Safe-Life retirement time substantiation with BDF provides a safe period of operation of a structure with probable flaws that may remain in place without detection for that period. Barely detectable flaws are intended to conservatively represent a worst-case of undetectable flaws. The substantiation is accomplished by testing and analysis employing conventional Safe-Life methodology except that an intrinsic and discrete critical flaw in critical locations on the structure is considered. It should be noted that this method, since it is a Safe-Life (crack initiation) method, is not appropriate for use when the flaw being considered is already a crack.

(A) The types, sizes, and locations of flaws to be considered are determined by the threat assessment (paragraph f(5)). These flaws may be represented by “equivalent flaws” if it is demonstrated that they have the same or a more severe strength-reducing effect than the corresponding representative flaws.

(B) The mean fatigue strength of the structure with flaws may be determined by one of the following three methods:

(1) Testing a full-scale structure with flaws:

(i) Representative flaws as determined by the threat assessment, or equivalent flaws if substantiated, are imposed at the critical locations on the structure where flaws are likely to occur.

(ii) S-N or spectrum safe-life fatigue testing is conducted, see paragraph e of AC 27-1B MG 11.

(iii) A mean S-N curve with flaws is derived directly from this data.

(2) As-manufactured structure strength modified by the effect of flaws.

(i) A mean strength for as-manufactured structure (without flaws) can be determined using full-scale S-N or spectrum safe-life fatigue testing.

(ii) The effect of flaws may be determined by analysis, by similarity to components where the effect of the flaws has previously been determined, or by a specimen test program incorporating the pertinent features of the full-scale component. Consideration should be given to the material form, geometric features, surface finish, and steady and vibratory load levels, in combination with flaws representative of those identified in the threat assessment.

(iii) The effect of the flaws is combined with the fatigue result determined on the as-manufactured structure without flaws.

(3) Analytical mean strength modified by the effect of flaws:

(i) A mean strength for as-manufactured structure (without flaws) can be determined analytically, provided that correlation with a similar design can be accomplished, or if additional conservatism is included in the working curve reductions employed in paragraph f(7)(ii)(D).

(ii) The effect of flaws may be determined by analysis, by similarity to components where the effect of the flaws has previously been determined, or by a specimen test program incorporating the pertinent features of the full-scale component. Consideration should be given to the material form, geometric features, surface finish, and steady and vibratory load levels in combination with flaws representative of those identified in the threat assessment.

(iii) The effect of the flaws is combined with the fatigue result analytically determined for the as-manufactured structure without flaws.

(C) Working Curve Determination. Reduction factors should be applied to the mean curve determined above to derive a working fatigue curve. As outlined in AC 27-1B, MG 11, working curve reduction factors should include consideration of the number of specimens tested, variability (scatter), previous test data on the same materials or similar structures, as well as service experience. Different reduction factors from those used for conventional Safe-Life methodology may be employed if justified to the FAA/AUTHORITY.

(D) Retirement Time Determination. The working fatigue curve, flight loads (paragraph f(3)), and usage spectrum (paragraph f(4)) are used with a cumulative damage analysis such as shown in AC 27-1B, MG 11, to calculate a safe retirement time.

(iii) Safe-Life Retirements with Clearly Detectable Flaws.

(A) A retirement time may also be based on flaws larger than the BDF case, up to the clearly detectable size described in paragraph f(5), if the applicant chooses. This could be the case, for example, if it was desired to allow a specific manufacturing-related flaw of detectable size to remain in place for the life of the structure without further inspection.

(B) The substantiation for this case can be the same as described in paragraph f(7)(ii), except that the larger flaws selected for the replacement time substantiation are used instead of the BDFs.

(iv) Crack Growth Retirement.

(A) General.

(1) This approach depends on retirement rather than inspection to ensure the continued airworthiness of a PSE. The retirement time is established based on consideration of crack growth characteristics. Fatigue with damage is addressed by timely retirement and there are no explicit inspection requirements that are derived from this approach.

(2) This approach requires demonstration either by analysis, testing, or both, that the BEC (a_{BEC}), the most severe crack consistent with manufacturing, maintenance, and service environment, will not grow or will not grow to critical size (a_{CRIT}) under the service loading and environment before the structure is retired. The critical crack size (a_{CRIT}) is established by limit load. The crack should be assumed at the critical location, as defined by the largest stress intensity factor range under the expected service loading range including the ground–air–ground cycle. It is recommended that full scale fatigue testing be undertaken to provide an understanding of the fatigue behavior of the component in support of the chosen methodology. In particular it ensures hot spots are identified, which experience has shown analysis often fails to identify.

(3) A threat assessment (see paragraph f(5)) should be performed to support establishing the BEC size to be used. It is intended that the BEC conservatively bounds the most severe defect resulting from manufacturing, maintenance, or the service environment. That is, there should be no probable defect, from any source, that would lead to failure of the part in less time than it would take the BEC to reach critical size. It should be noted that the resulting crack is a mathematical expedient that may not represent a true physical crack. If the BEC is defined by analytical back calculations from coupon or service fatigue life data, it will be highly dependent on the predictive tool used (i.e., growth algorithm, material data, etc.). Therefore, the same predictive tool must be used to perform the fatigue tolerance evaluation. When the BEC is based upon test or service data, it must account for material variability in initiation and growth.

(4) To determine the retirement, the BEC should be assumed at the critical location and the crack growth characteristics should be determined for the expected load and environment spectrum. There are three different scenarios that could result from a crack growth assessment and be used for establishing a retirement time. These scenarios are illustrated in Figure AC 29.571B-2, Figure AC 29.571B-3, and Figure AC 29.571B-4.

(B) No Growth. The no crack growth scenario is illustrated in Figure AC 29.571B-2. Here the BEC does not grow when using top-of-scatter crack growth rate data. In this case the retirement time should not exceed the design service life (L_{DES}).

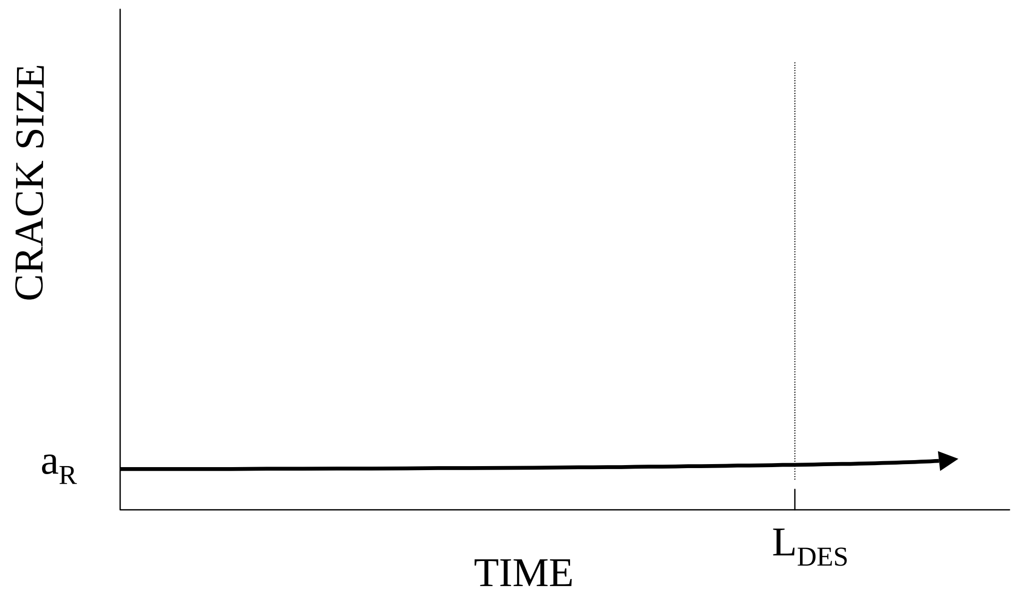

Figure AC 29.571B-2. No Growth

(C) Slow Growth of Undetectable Crack. Figure AC 29.571B-3 illustrates the scenario where the BEC grows relatively slowly but becomes critical prior to becoming detectable (a_{DET}). In this case, the retirement time should be set equal to the total crack growth life (L_T) divided by a factor N.

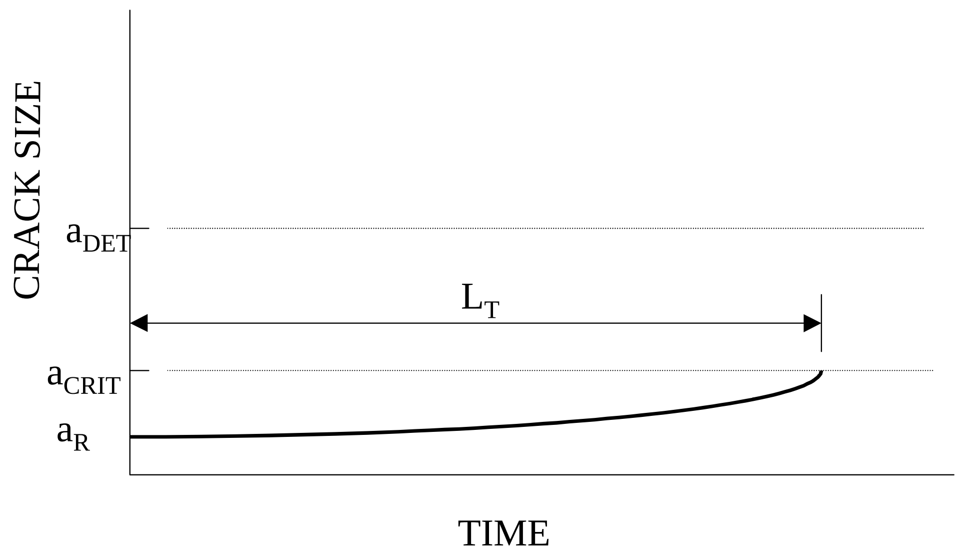

Figure AC 29.571B-3. Slow Growth of Undetectable Crack

(D) Slow Growth of Detectable Crack. Figure AC 29.571B-4 illustrates the scenario where the BEC grows to a detectable size (at L_1) before becoming critical (at L_1+L_2). In this case, the retirement time should be set equal to the total crack growth life (L_1+L_2) divided by a factor N.

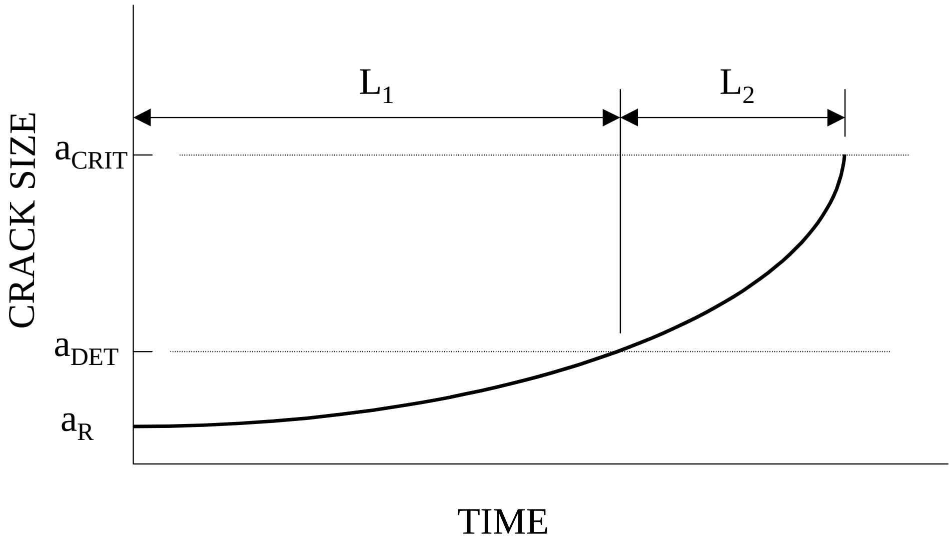

Figure AC29.571B-4. Slow Growth of detectable Crack

(E) Life Factors for Crack Growth Retirement.

(1) In determining the factor of N to be used for determining the retirement time, consideration should be given to the crack growth data used (e.g., top of scatter data versus average data, number of specimens used to generate data, etc.).

(2) The minimum suggested N value should be N=2 in the case where the conservative top-of-scatter crack growth data are used in the crack growth analysis, or N=4 when the average crack growth data are used in the crack growth analysis, or N=4 when the crack growth life is obtained from the crack growth test of one specimen (for two or more full scale specimens, N=3 of the shortest crack growth life can be used).

(3) It should also be noted that with this approach, the validity of the crack growth threshold, ΔK_{th}, is especially important since there is no element of inspection to ensure continued airworthiness. Consistent with this, additional attention may be required for validating the crack growth threshold value(s) used in the analyses. Consideration should be given to the influence of the test procedure used to develop values, microstructure, heat treatment, crack size, loading conditions, environment, grain size and orientation, etc. In general, a coupon-testing program may be necessary

to develop a consistent ΔK_{th} database and the use of published data may require additional conservatism.

(8) INSPECTION INTERVALS. Each of the following three methods provides a means to establish inspection intervals for detectable damage or detectable damage growth. The time of the first inspection should coincide with the repetitive interval established unless the applicant can substantiate an alternate time.

(i) Safe-Life Inspection for a CDF provides a safe interval of operation between repetitive inspections for the presence of probable detectable flaws. The substantiation is accomplished by testing and analysis employing conventional Safe-Life methodology except that intrinsic and discrete critical flaws are considered. The size of flaws considered should be “clearly detectable”, which is intended to be a conservative representation of detectable flaws that could remain in place for the entire interval in spite of routine inspections for general condition. It should be noted that this method, since it is a safe-life (crack initiation) method, is not appropriate for use when the flaw being considered is already a crack.

(A) The method described in paragraph f(7)(iii), Safe-Life Retirements with Clearly Detectable Flaws, may be employed for this case, except that the calculated retirement time is used as a repetitive inspection interval.

(B) The repetitive inspection consists of examination of the structure for the presence of the flaw using the substantiated inspection method. If no flaw is found, the structure may be returned to service for another inspection interval period, up to the established retirement time. If the flaw is found, the structure is retired; or, if a repair procedure for the specific flaw type has been substantiated, the structure is repaired and returned to service for another inspection interval period, up to the established retirement time for the structure.

(C) Substantiation of repairs should include careful consideration as to whether undetectable cracks may now exist and whether the original certification approach is still applicable.

(ii) Crack Growth Inspection. This approach depends on detection of cracks before they become critical to ensure the continued airworthiness of a PSE. While any inspections that are capable of detecting cracks with high reliability may be used with this approach, the criteria stated in paragraph f(6), Inspectability and Inspection Methods, should be considered in making the selection. The inspection method chosen will define the initial inspectable crack that will be used to perform the fatigue tolerance evaluation. Once the initial inspectable crack is defined, crack growth, and residual strength assessments must be performed to determine the time for the initial inspectable crack (a_{DET}) to grow to a size (a_{CRIT}) that would result in a catastrophic failure of the rotorcraft if limit loads were applied. This assessment could be theoretically done analytically or by test; however, in most cases it is performed analytically using fracture mechanics methods. The resulting life for a_{DET} to grow to

a_{CRIT} is used to set the inspection interval. This general process applies to both single and multiple load path structure regardless of the level of inspection (e.g., for complete load path failure or less than load path failure in a multiple load path structure). The details of defining the interval once the crack growth life has been determined are discussed later.

(A) Single Load Path Structure. The time for a detectable crack (a_{DET}) to grow to critical size (a_{CRIT}) in a structure is denoted as L_2 in Figure AC 29.571B-4. If this were a single load path structure, the inspection interval would be established as L_2 divided by N. (See paragraph f(8)(ii)(C) for guidance on values of N.) This interval is valid until the part is retired.

(B) Multiple Element Structure.

(1) Depending on inspectability considerations and residual life characteristics of the structure following a load path failure, it may be beneficial to take advantage of the redundancy of a multiple load path structure. On the other hand, the safety of a multiple load path structure can be managed without taking advantage of its redundancy. In this case, each load path would be considered independently and inspection intervals established for each load path consistent with paragraph f(8)(ii)(A). This may be necessary for similarly stressed load paths when damage according to the threat assessment could occur in each element at the same time.

(2) When considering redundancy in a multiple load path structure, two scenarios might be possible; one where the required inspection is for a completely failed load path and one where the inspection is for less than a load path failure. In either case, the remaining life of the secondary load path after primary load path failure is used to determine the inspection interval. Consistent with this, the resulting intervals are only valid until the cumulative fatigue damage or crack growth in the intact structure is taken into account. This issue is illustrated in a crack growth context in Figure AC 29.571B-5. Crack growth in the secondary load path from an initial crack as detailed in paragraph f(8)(ii)(B)(3)(i) will proceed along curve A-B as long as the primary load path remains intact and load redistribution is negligible. However, at the time of primary load path failure, loading on the secondary load path will increase due to load redistribution and crack growth will be accelerated (e.g., subsequent growth from point 1, 2, or 3 depending on if the failure occurs at time t_1, t_2 or t_3). Note that the residual life, L_r, in the secondary load path is inversely proportional to the time at which primary load path failure occurs. This should be considered whenever L_r is used in establishing repeat inspection intervals.

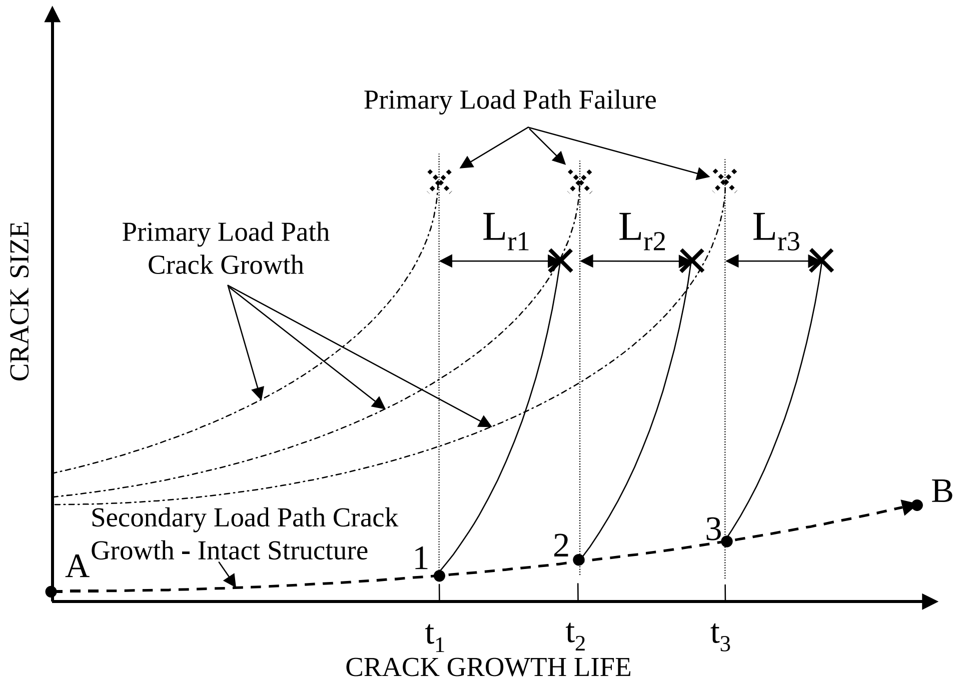

Figure AC 29.571B-5. Decreasing Residual Life in Secondary Load Path for Multiple Element Crack Growth with Inspections.

(3) Inspect for Load Path Failure. If a failed load path is easily detectable and the residual life and strength of the remaining structure is sufficient, this approach may be optimum. Analysis or tests as described in the following paragraphs can determine the inspection interval.

(i) Evaluation by analysis. Figure AC 29.571B-6 illustrates an example of multiple load path structure for which a completely failed load path is easily detectable. The inspection interval is based on the life of the secondary load path (L_r) after primary load path failure at time N_F. Consistent with this, damage accumulated in the secondary load path prior to primary load path failure must be accounted for in the analysis. In order to do this within the context of a crack growth analysis, it is necessary to assume some initial crack, of size a_i, exists in the secondary load path at time zero. This initial crack size should be representative of a normal manufacturing quality unless the threat assessment indicates that larger damage could exist. Crack growth accumulated prior to a load path failure is accounted for by calculating the amount of growth, (Δa_i), between time zero and N_F. Load redistribution that may occur prior to N_F should be considered. The residual life, (L_r), then becomes the time for a crack of size $a_i + \Delta a_i$ to grow to critical size, assuming a complete load path failure has occurred (i.e., “failed” condition loads used). It should be noted that the assumed time of load path failure would also represent an upper limit of validity for any repeat inspection period based on L_r. It is therefore recommended that N_F be assumed equal to the retirement time for the structure being inspected or the rotorcraft design life if the structure has no declared retirement time. Based on the above, (A)Inspection Interval = L_r/N [For N refer to paragraph f(8)(ii)(C)]

(B) Limit of validity = N_F (i.e., repetitive inspection time would not be valid for operation beyond N_F)

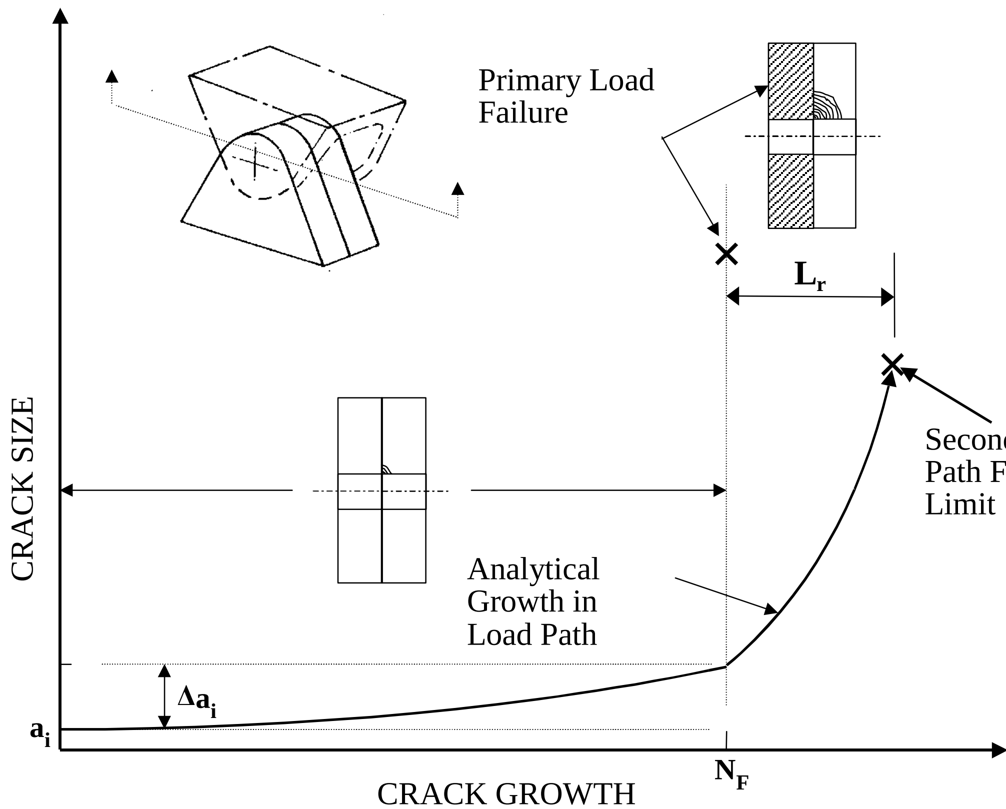

Figure AC 29.571B-6. Multiple Load Path Structure Analytical Evaluation to Support Inspection for a Failed Load Path.

(ii) Evaluation by Test. Figure AC 29.571B-7 illustrates some key points if an inspection for a complete load path failure is to be developed based on testing. The inspection interval is based on the test demonstrated residual life (L_r) subsequent to load path failure. Because the residual life decreases with the time accumulated prior to a load path failure, there will be a limit of validity to the L_r and it will be dependent on the time at which a load path failure is simulated, (N_D).

(A) The test article should consist of as-manufactured production parts. Representative "well" condition loading should be applied for some predetermined period of time, (N_D). It is recommended that the "well" condition loading be of sufficient duration so that N_D/L_{SF} is not less than the retirement time minus one inspection interval for the structure being inspected or the rotorcraft design life if the structure has no declared retirement time. At the end of this period, the load path that is to be inspected for complete failure should be disabled (e.g., saw cutting, attachment(s) removal, member removal) to simulate its failure. The test should then be restarted with a representative “failed” condition loading. (Note that the external loads may be the same as for the “well” condition if the member failure simulation results in the correct “failed” condition internal load redistribution.) The test should continue until the desired residual life has been achieved or to the time at which the secondary load path can no longer support limit loads without failure, whichever is less, (N_0).

(B) In developing the test spectrum, consideration should be given to proper use of representative loads, truncation of non-damaging loads, inclusion of ground-air-ground cycles, clipping of high magnitude loads, and load sequence.

(C) Based on the above,

(a) Demonstrated residual life = $L_r = N_0 - N_D$

(b) Repetitive inspection time = L_r/N [For N refer to paragraph f(8)(ii)(C)]

(c) Limit of validity = N_D/L_{SF}

(d) L_{SF} = 2, Life safety factor

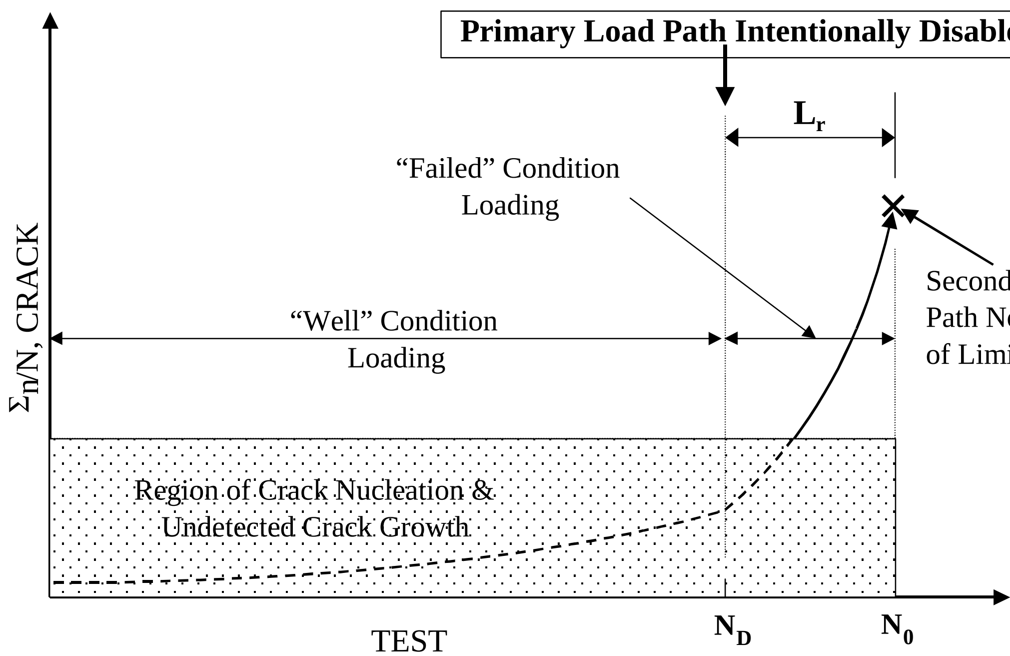

Figure AC 29.571B-7. Multiple Load Path Structure Evaluation by Test to Support Inspection for a Failed Load Path.

(4) Inspect for Less Than a Load Path Failure. Inspection for less than a load path failure may require special non-destructive Inspection (NDI) procedures but will result in longer inspection intervals. Figure AC 29.571B-8 illustrates how inspection

intervals could be established on the basis of crack growth and residual strength evaluation.

(i) In this case the inspection interval is based on the life of the secondary load path (L_r) subsequent to primary load path failure at N_F plus the time (L_P) for a detectable crack (a_{DET}) in the primary load path to grow to critical size under in-service loads. The determination of L_r is the same as discussed in paragraph f(8)(ii)(B)(3)(i).

(ii) Based on the above,

(A) Repetitive Inspection = (L_P + L_r)/N [For N refer to paragraph f(8)(ii)(C)]

(B) Limit of validity = N_F

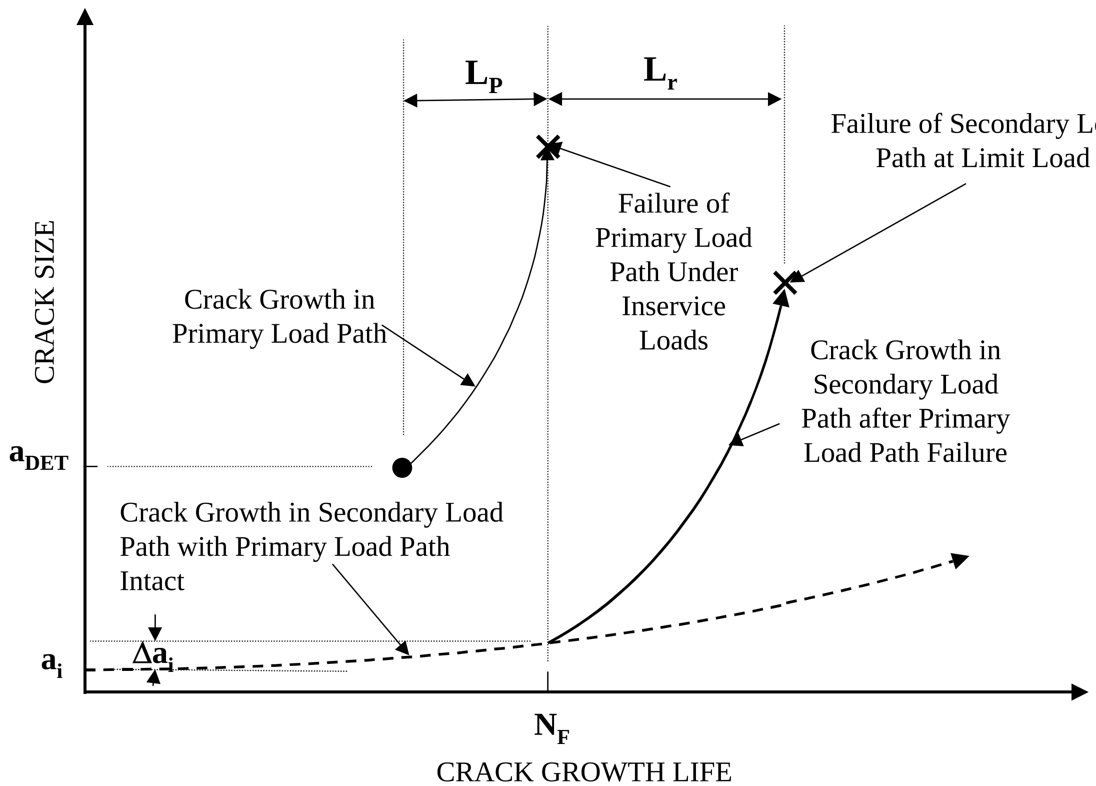

Figure AC 29.571B-8. Multiple Load Path Structure Analytical Evaluation to Support Inspection for Less than a Failed Load Path.

(C) Safety Factors.

(1) In determining the factor of N to be used for determining the inspection time, consideration should be given to the crack growth data used (e.g., top of scatter data versus average data, number of specimens used to generate data, etc.) and the capability of the inspection procedure.

(2) The minimum suggested N value should be N=2 in the case where the conservative top-of-scatter crack growth data are used in the crack growth analysis, or N=4 when the average crack growth data are used in the crack growth analysis, or when the crack growth life is obtained from the crack growth test of one specimen (for two or more full scale specimens, N=3 of the shortest crack growth life can be used).

(iii) Safe-Life Inspection for a Failed Element.

(A) A Safe-Life Inspection substantiation for a Failed Load Path provides a safe interval of operation between repetitive inspections for the failed load path. The substantiation is accomplished by testing and analysis employing conventional safe-life methodology except that the configuration of the structure substantiated is with the critical load path inoperative and appropriate flaws imposed on the remainder of the structure, as determined by the threat assessment.

(B) The method described in paragraph f(8)(i) can be employed for this case with the following differences:

(1) The principal “flaw” considered is failure or loss of the most critical load path. The load path failure can be the result of fatigue cracking, static failure, or a fractured or missing fastener, as determined by the threat assessment, paragraph f(5).

(2) The remainder of the structure may be representative of normal manufacturing quality unless the threat assessment indicates that larger damage should exist.

(3) The mean strength for the substantiation should be based on the number of cycles from the first load path failure to the first initiation of cracking at any other point in the remaining structure. Any applied load changes or load distribution changes that occur as a consequence of the load path failure should also be included (bending due to increased deflection, for example).

(4) When the remaining structure may have some pre-existing fatigue damage at the time the first load path fails (due to both load paths being highly loaded, for example), this should be factored into the analysis.

(5) The remaining structure after first load path failure must be shown to have limit load capability, considered as the ultimate loading, except in some cases where no retirement life is provided and fatigue damage is expected (see paragraph f(10).

(6) The inspection conducted is for the failed or missing load path.

(9) RETIREMENT TIME AND INSPECTION INTERVAL SCHEDULES.

(i) Based on the evaluations required by § 29.571, inspections, retirement times, combinations thereof, or other procedures have been established as necessary to avoid catastrophic failure. These inspections, retirement times, or approved equivalent means must be included in the Airworthiness Limitations Section (ALS) of the Instructions for Continued Airworthiness (ICA) as required by § 29.1529 and Appendix A29.4 of the regulatory requirements. These inspections, retirement times, or a combination of both are normally stated in hours time-in-service, but may be stated in other terms, such as engine starts, landings, external lifts, etc.

(ii) The design service life should be specified in the fatigue evaluation methodology that must be approved by the FAA/AUTHORITY. In any case, routine inspections for wear, fretting, corrosion, cracking, and service damage are appropriate. These routine inspections should be noted in the ICAs (maintenance manual) but are not required to be contained within the ALS of the ICAs unless they are structural inspection intervals or related structural inspection procedures approved under § 29.571.

(10) APPROVED EQUIVALENT MEANS. The requirement includes the possibility that in place of setting retirement times or inspections for damage, some other means may be used. All proposals for 'equivalent means' must be submitted to the FAA/AUTHORITY for approval. Potentially equivalent means to inspection include, but are not limited to:

(i) Indirect detection of damage used to establish a period of safe operation for a structure with the damage present. In this case, the detection is based on the effect of the damage, which may be recognized through:

(A) A warning in flight or during maintenance from a specific feature, sensor, or health monitor, including: oil analysis, chip detector, crack detection wire or foil, health monitoring, fluid leaks or pressure change in a sealed chamber; or by

(B) Pilot sensitivity to a change in the rotorcraft's behavior (such as poor blade tracking, noise generation, vibration generation) provided it is well defined and does not require exceptional piloting skills to recognize these behaviors.

(ii) In all cases, an adequate level of residual strength is demonstrated for the period of operation concerned. Generally, limit load will be considered the minimum residual strength requirement. However, load levels less than the critical limit load conditions may be acceptable for consideration of obvious damage sustained in flight and for the completion of that flight only, provided it allows for continued safe flight and landing.

(iii) Two instances are considered here where it may not be necessary to provide a retirement time in the ALS of the ICAs. However, this does not preclude the investigation of fatigue behavior throughout the life of the rotorcraft or of the part if longer.

(A) When fatigue cracking occurs or is expected to occur for a specific PSE while in service, then the first approach allows the PSE to operate until the damage is found. Therefore, the inspection must find the damage prior to loss of ultimate load capability. This approach may not be appropriate for a single load path structure. For such a process to be safe, the behavior of the part and associated parts that influence its fatigue behavior must be substantiated for as long as they remain in service. All potential failure modes throughout the life of the rotorcraft must be identified and shown to be consistent, repeatable and addressed by the inspection program. In order to meet the intent of the new fatigue tolerance requirements, a high probability of ultimate load capability is required throughout the lifetime of the component. Therefore, for cracks or other damage that are allowed or highly likely to exist, ultimate load capability should be substantiated for that damage and any growth that may occur during the subsequent inspection period.

(B) It may be acceptable that a PSE does not have a specific retirement time when the fatigue tolerance of the part, including any damage not controlled by an acceptable inspection program, has been demonstrated to be in excess of the rotorcraft design life to such an extent that no safety benefit arises from imposing that requirement.

(11) SUPPLEMENTAL PROCEDURES.

(i) The requirement states that if inspections, for any of the damage types identified during the threat assessment, cannot be established within the limitations of geometry, inspectability or good design practice, then supplemental procedures must be established that will minimize the risk of each of these types of damage being present or leading to catastrophic failure. When assessing good design practice, measures such as improved protection against impact, scratches, and corrosion should already have been considered. If the part cannot be redesigned to reduce the acquisition and influence of damage, then supplemental procedures should be introduced.

(ii) Supplemental procedures that should be considered include, but are not limited to:

(A) Specifying shorter than usual calendar inspection intervals to reduce the probability of occurrence and the extent of the damage.

(B) Improving control of maintenance processes associated with the component and damage type, such as by providing specifically designed tooling and requiring additional quality checks after each operation is performed.

(C) Introducing an overhaul program.

(D) Restricting the allowable repair limits for the part.

(E) Modify the PSE design based on service experience if this shows the original design assumptions to be overly conservative with respect to demonstrating impracticality at certification.

(F) Specifying a conservative inspection interval, if the calculated interval cannot be established and there are no other alternatives.

February 24, 2008

Mr. Nicholas A. Sabatini
Associate Administrator for Regulation and Certification
FAA National Headquarters, AVS-1
800 Independence Ave., SW
Washington DC 20591

Dear Mr. Sabatini:

The Aviation Rulemaking Advisory Committee (ARAC) Working Group activity associated with the Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structure Task has been completed. The results of their efforts were submitted to ARAC for review and approval. The ARAC examined the proposed rulemaking submittal in a public meeting on March 1, 2007 in Orlando, FL. The associated advisory circular material was not available at that time, and it was reviewed in a public meeting today in Houston, TX. Both packages were approved by ARAC.

Accordingly, the ARAC hereby submits, without change, the proposed NPRM package and associated advisory circular material developed by the Working Group with a recommendation that it be processed for publication. The advisory circular material is formatted for inclusion in AC 27-1, and AC 29-2.

With this submittal the Rotorcraft Issues Group has completed all of the tasks assigned to it. This seems like a good time for me to step aside. The Helicopter Association International, however, is interested in continuing its role in support of ARAC and, in particular, the Executive Committee. HAI recommends as my replacement Mr. David York, the Helicopter Association International's Vice-President for Regulations and International Affairs. Please contact Mr. York at HAI if you need any further information from him. I appreciate all the good support I received over the last 10-plus years from all of your people.

Very Truly Yours,

John D. Swihart, Jr.
ARAC Assistant Chair for Rotorcraft Issues

Attachments

cc:
Mr. Craig Bolt, ARAC Chair
Mr. Norman Joseph, ARAC Vice Chair
Ms. Pam Hamilton, ARAC Executive Director
Mr. Scott Horn, ARAC Asst. Executive Director
Mr. David York, HAI
Mrs. Gerri Robinson, ARM-200
Mr. Nicanor Davidson, ARM-200 w/attachments
Mr. Ted Jones, ASW-111

U.S. Department
of Transportation
**Federal Aviation
Administration**

MAY 19 2008

Mr. David York
Assistant Chair, Rotorcraft
Issues Group
Helicopter Association International
1635 Prince Street
Alexandria, VA 22314

Dear Mr. York:

This is in reply to Mr. Swihart's February 24, 2008 letter. That letter sent the recommendations from the Aviation Rulemaking Advisory Committee's (ARAC) Working Group activity associated with the Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structure Task. I understand the Rotorcraft Issues Group approved the Working Group's documents during your meeting on February 24, 2008 without dissent.

I wish to thank the Aviation Rulemaking Advisory Committee, the members associated with Rotorcraft Issues and the Composite Rotorcraft Structure Working Group who provided resources to develop the report and recommendation. The report will be placed on the ARAC website at: http://www.faa.gov/regulations_policies/rulemaking/committees/arac/.

We consider your submittal of the Composite Rotorcraft Structure Working Group's report as completion of the original tasking issued on March 28, 2000 (65 FR 17936, April 5, 2000), which asked for an evaluation and revision of parts 27 and 29, and appropriate advisory materials. We understand that this submission completes all outstanding tasks assigned to the Rotorcraft Issues Group.

Sincerely,

Pamela Hamilton-Powell
Director, Office of Rulemaking

AC 29.573. §29.573 (Amendment 29-XX) DAMAGE TOLERANCE AND FATIGUE EVALUATION OF COMPOSITE ROTORCRAFT STRUCTURE

a. Purpose. This advisory material provides an acceptable means of compliance with the provisions of § 29.573, Amendment XX, of the Federal Aviation Regulations (FAR) dealing with the damage tolerance and fatigue evaluation of transport category composite rotorcraft structure. Paragraph f.(6) specifically addresses the advisory guidance applying to damage tolerance and fatigue evaluation as required by §29.573, Amendment 29-XX. Some information contained in AC 29-2C, MG8 (Amendment 29-42) is repeated and updated as appropriate to preserve the "building block" approach for analyses of composite rotorcraft structure for compliance to §29.573, Amendment 29-XX . (Supplemental guidance can be found in AC 20-107A, "Composite Aircraft Structure.") These procedures address the substantiation requirements for composite material system constituents, composite material systems, and composite structures common to rotorcraft. A uniform approach to composite structural substantiation is desirable, but it is recognized that in a continually developing technical area which has diverse industrial roots, both in aerospace and in other industries, variations and deviations from the procedures described here may be necessary. Significant deviations from this advisory material should be coordinated in advance with the Rotorcraft Directorate.

b. Special Considerations. Since rotorcraft structure is configured uniquely and is inherently subjected to severe cyclic stresses, special consideration is required for the substantiation of all rotorcraft structure, including composites. This special consideration is necessary to ensure that the level of safety intended by the current regulations are attained during the type certification process for all structure with special emphasis on composite structure because of its unique structural characteristics, manufacturing quality and operational considerations, and failure mechanisms.

c. Background.

(1) Historically, rotorcraft have required unique, conservative structural substantiation because of unique configuration effects, unique loading considerations, severe fatigue spectrum effects, and the specialized comprehensive fatigue testing required by these effects. Rotorcraft structural static strength substantiation for both metal and composite structure is essentially identical to that for fixed wing structure once basic loads have been determined. However, rotorcraft structural fatigue substantiation for metals is significantly different from fixed wing fatigue substantiation. Since AC 20-107A, as developed, applies to both fixed wing aircraft and rotorcraft, it, of necessity, was finalized in a broad generic form. Accordingly, a need to supplement AC 20-107A for rotorcraft was recognized during type certification programs. One significant difference in traditional rotorcraft fatigue substantiation programs and fixed wing fatigue programs is the use of multiple component fatigue tests for rotorcraft programs rather than just one full-scale test. Also, constant amplitude, accelerated load

tests are typically used rather than spectrum tests because of the high frequency loads common to rotorcraft operations. These rotorcraft fatigue tests have traditionally involved the generation of stress versus life or cycle (S-N) curves for each critical part (most of which are subjected to the cyclic loading of the main or tail rotor system) using a monotonic (sinusoidal) fatigue spectrum based on maximum and minimum service stress values. Unless configuration differences or flight usage data dictate otherwise, the monotonic fatigue spectrum's period is typically based on six ground-air-ground (GAG) cycles for each flight hour of operation. The S-N curves for the substantiation of each detailed part are typically generated by plotting a curved line through three data points (reference AC 29-2C, AC 29 MG 11, "Fatigue Evaluation of Transport Category Rotorcraft Structure (Including Flaw Tolerance)"). The three data points selected are a short specimen life (low-cycle fatigue), an intermediate specimen life and a long specimen life (high-cycle fatigue). Each raw data point is generated by monotonically fatigue testing at least two full-scale parts to failure or run out for each data point on the S-N curve. The raw data point values are then reduced by an acceptable statistical method to a single value for plotting to ensure proper reliability of the associated S-N curve. Order 8110.9, "Handbook on Vibration Substantiation and Fatigue Evaluation of Helicopter and Other Power Transmission Systems" and AC 27-1B, AC 27 MG11, "Fatigue Evaluation of Rotorcraft Structure", contain comprehensive discussions of the S-N curve generation process. The rotorcraft S-N curve process contrasts sharply with the fixed wing process of using a single full-scale fatigue article (usually an entire wing or airframe, which constitutes a single full-scale assembly data point), generic material or full-scale assembly S-N data (e.g., Metallic Materials Properties Development and Standardization (MMPDS) formerly the MIL-HDBK-5 for metals, MIL-HDBK-17 for composites, or AC 23-13, "Fatigue, Fail-Safe, and Damage Tolerance Evaluation of Metallic Structure for Normal, Utility, Acrobatic, and Commuter Airplanes", which replaced AFS-120-73-2 for full-scale assemblies), a non-monotonic spectrum and relatively large scatter factors to verify or determine the design fatigue life of the full-scale airplane.

(2) Also, rotorcraft have employed and mass-produced composite designs in primary structure (typically main and tail rotor blades) since the early 1950's. This was 10 or more years before composites were type certificated for primary fixed-wing structure in either military or civil aircraft applications (with some notable limited production exceptions, such as the Windecker fixed wing aircraft). In any case, the early 1950 period was well before a clear, detailed understanding of composite structural behavior (especially in the areas of macroscopic and microscopic failure mechanisms and modes) was relatively common and readily available in a usable format for the average engineer working in this field. It also predated the initial issuance of AC 20-107. Currently, much composite design information is proprietary, either to government, industry or both, and many data gathering methods have not been completely standardized. Consequently, a significant variation from laboratory to laboratory in material property value determination methods and results can exist. The early rotor blade designs (as well as current designs) are by nature relatively low strain, tension structure designs. Also, by nature, these designs are not damage or flaw critical. Thus by circumstance as much as design, early composite rotor blade and other

composite rotorcraft designs incorporated an acceptable fatigue tolerance level of safety. In the 1980's, more test data, analytical knowledge, and analytical methodology became available to more completely substantiate a composite design. Current 14 CFR parts 27 and 29 contain many sections to be considered in substantiating composite rotorcraft structure. This advisory material provides the current or updated information from AC 29-2C, MG 8, Amendment 29-42 to supplement the general guidance of AC 20-107A and provides compliance guidance for the requirements of §29.573 Amendment 29-XX for rotorcraft composite structure.

d. Definitions. The following basic definitions are provided as a convenient reading reference. MIL-HDBK-17, and other sources, contain more complete glossaries of definitions.

(1) AUTOCLAVE. A closed apparatus usually equipped with variable conditions of vacuum, pressure, and temperature. Used for bonding, compressing or curing materials.

(2) ALLOWABLES. Both A-basis and B-basis values statistically derived and used for a particular composite design.

(3) BALANCED LAMINATE. A composite laminate in which all laminae at angles other than 0° occur only in ± pairs (not necessarily adjacent).

(4) A-BASIS ALLOWABLE. The "A" mechanical property value is the value above which at least 99 percent of the population of values is expected to fall, with a confidence level of 95 percent.

(5) B-BASIS ALLOWABLE. The "B" mechanical property value is the value above which at least 90 percent of the population of values is expected to fall, with a confidence level of 95 percent.

(6) BOND. The adhesion of one surface to another, with or without the use of an adhesive as a bonding agent.

(7) COCURE. The process of curing several different materials in a single step. Examples include the curing of various compatible resin system pre-pregs, using the same cure cycle, to produce hybrid composite structure or the curing of compatible composite materials and structural adhesives, using the same cure cycle, to produce sandwich structure or skins with integrally molded fittings.

(8) CURE. To change the properties of a thermosetting resin irreversibly by chemical reaction; i.e., condensation, ring closure, or addition. Cure may be accomplished by addition of curing (crosslinking) agents, with or without a catalyst, and with or without heat.

(9) DELAMINATION. The separation of the layers of material in a laminate.

(10) DISBOND. A lack of proper adhesion in a bonded joint. This may be isolated or may cover a majority of the bond area. It may occur at any time in the cure or subsequent life of the bond area and may arise from a wide variety of causes.

(11) FIBER. A single homogeneous strand of material, essentially one-dimensional in the macro-behavior sense, used as a principal constituent in advanced composites because of its high axial strength and modulus.

(12) FIBER VOLUME. The volume of fiber present in the composite. This is usually expressed as a percentage volume fraction or weight fraction of the composite.

(13) FILL. The 90° yarns in a fabric, also called the woof or weft.

(14) GLASS TRANSITION. The reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from (or to) a viscous or rubbery condition to (or from) a hard and relatively brittle one.

(15) GLASS TRANSITION TEMPERATURE. The approximate midpoint of the temperature range over which the glass transition takes place.

(16) HYBRID. Any mixture of fiber types (e.g., graphite and glass).

(17) IMPREGNATE. An application of resin onto fibers or fabrics by several processes: hot melt, solution coat, or hand lay-up.

(18) LAMINA. A single ply or layer in a laminate in which all fibers have the same fiber orientation.

(19) LAMINATE. A product made by bonding together two or more layers or laminae of material or materials.

(20) LOW STRAIN LEVEL. As used herein, is defined as a principal, elastic axial gross strain level that for a given composite structure provides for no flaw growth and thus provides damage tolerance of the maximum defects allowed during the certification process using the approved design fatigue spectrum.

(21) MATERIAL SYSTEM CONSTITUENT. A single constituent (ingredient) chosen for a material system (e.g., a fiber, a resin).

(22) MATERIAL SYSTEM. The combination of single constituents chosen (e.g., fiber and resin).

(23) MATRIX. The essentially homogeneous material in which the fibers or filaments of a composite are embedded in resins which are mainly thermoset polymers in aircraft structure.

(24) MAXIMUM STRUCTURAL TEMPERATURE. The temperature of a part, panel or structural element due to service parameters such as incident heat fluxes, temperature, and air flow at the time of occurrence of any critical load case, (i.e., each critical load case has an associated maximum structural temperature). This term is synonymous with the term "maximum panel temperature."

(25) POROSITY. A condition of trapped pockets of air, gas, or void within a solid materials, usually expressed as a percentage of the total nonsolid volume to the total volume (solid + nonsolid) of a unit quantity of material.

(26) PRE-PREG, PREIMPREGNATED. A combination of mat, fabric, nonwoven material, tape, or roving already impregnated with resin, usually partially cured, and ready for manufacturing use in a final product which will involve complete curing. Pre-preg is usually drapable, tacky and can be easily handled.

(27) RESIN. An organic material with indefinite and usually high molecular weight and no sharp melting point.

(28) RESIN CONTENT. The amount of matrix present in a composite either by percent weight or percent volume.

(29) SECONDARY BONDING. The joining together, by the process of adhesive bonding, of two or more already-cured composite parts, during which the only chemical or thermal reaction occurring is the curing of the adhesive itself. The joining together of one already-cured composite part to an uncured composite part, through the curing of the resin of the uncured part, is also considered for the purposes of this advisory circular to be a secondary bonding operation. (See COCURING).

(30) SHELF LIFE. The lengths of time a material, substance, product, or reagent can be stored under specified environmental conditions and continue to meet all applicable specification requirements and remain suitable for its intended function.

(31) STRAIN LEVEL. As used herein, is defined as the principal axial gross strain of a part or component due to the principal load or combinations of loads applied by a critical load case considered in the structural analysis (e.g., tension, bending, bending-tension, etc.). Strain level is generally measured in thousandths of an inch per unit inch of part or microinches/per inch (e.g., .003 in/in equals 3000 microinches/inch).

(32) SYMMETRICAL LAMINATE. A composite laminate in which the ply orientation is symmetrical about the laminate midplane.

(33) TAPE. Hot melt impregnated fibers forming unidirectional pre-preg.

(34) THERMOPLASTIC. A plastic that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristic of the plastic, and when in the softened stage, can be shaped by flow into articles by molding or extrusion.

(35) THERMOSET (OR CHEMSET). A plastic that once set or molded cannot be re-set or remolded because it undergoes a chemical change; (i.e., it is substantially infusible and insoluble after having been cured by heat or other means).

(36) WARP. Yarns extended along the length of the fabric (in the 0° direction) and being crossed by the fill yarns (90° fibers).

(37) WORK LIFE. The period during which a compound, after mixing with a catalyst, solvent, or other compounding constituents, remains suitable for its intended use.

(38) Damage Tolerance. The attribute of the structure that permits it to retain its required residual strength for a period of use after the structure has sustained a given level of fatigue, corrosion, accidental or discrete source damage.

(39) Catastrophic Failure. An event that could prevent continued safe flight and landing.

(40) Damage. A generic term for structural anomalies caused by manufacturing (processing, fabrication, assembly or handling) or service usage. Trimming, fastener installation, or foreign object impact are potential sources of damage, along with fatigue and environmental effects.

(41) Damage Tolerant Safe Life. Capability of structure with damage present to survive expected repeated loads of variable magnitude without detectable damage growth and to maintain ultimate load capability throughout service life of the rotorcraft.

(42) Damage Tolerant Fail-Safe. The capability of structure remaining after a partial failure to withstand design limit loads without catastrophic failure within an inspection period.

(43) Multiple Load Path. Structure providing two or more separate and distinct paths of structure that will carry limit load after complete failure of one of the members.

(44) Active Multiple Load Path. Structure providing two or more load paths that are all loaded during operation to a similar load spectrum.

(45) Passive Multiple Load Path. Structure providing load paths with one or more of the members (or areas of a member) relatively unloaded until failure of the other member or members.

(46) Accidental Damage. Discrete damage which may occur in service use or in manufacturing due to impacts or collisions, such as dents, scratches, gouges, abrasions, disbonds, splintering, and delaminations.

(47) Intrinsic or discrete manufacturing defects. Intrinsic or discrete imperfections or flaws related to manufacturing operations, processing or assembly such as voids, gaps, porosity, inclusions, fiber dislocation, disbonds, and delaminations.

(48) Fatigue or Environmental Damage. Structural damage related to fatigue or environmental effects such as delaminations, disbonds, splintering, or cracking.

(49) Design Limit Loads. The maximum loads to be expected in service, as defined by § 29.301(a).

(50) As-Manufactured. Product or component that has passed the applicable quality control process and has been found to conform to the approved design within the allowable tolerances.

(51) Residual Strength. The strength retained for some period of unrepaired use after a failure or partial failure due to fatigue, accidental, or discrete source of damage.

(52) Principal Structural Element (PSE). A structural element that contributes significantly to the carrying of flight or ground loads and whose failure can lead to catastrophic failure of the rotorcraft.

(53) Coupon. A small test specimen (e.g., usually a flat laminate) for evaluation of basic lamina or laminate properties or properties of generic structural features (e.g., bonded or mechanically fastened joints).

(54) Point Design. An element or detail of a specific design which is not considered generically applicable to other structure for the purpose of substantiation (e.g., lugs and major joints). Such a design element or detail can be qualified by test or by a combination of test and analysis.

(55) Element. A generic element of a more complex structural member (e.g., skin, stringers, shear panels, sandwich panels, joints, or splices).

(56) Detail. A non-generic structural element of a more complex structural member (e.g., specific design configured joints, splices, stringers, stringer runouts, or major access holes).

(57) Subcomponent. A major three-dimensional structure which can provide complete structural representation of a section of the full structure (e.g., stub box, section of a spar, wing panel, wing rib, body panel, or frames).

(58) Component. A major section of the airframe structure (e.g., wing, fin, body, horizontal stabilizer) which can be tested as a complete unit to qualify the structure.

(59) Environment. External, non accidental conditions (excluding mechanical loading), separately or in combination, that can be expected in service and which may affect the structure (e.g., temperature, moisture, UV radiation, and fuel).

e. Related Regulatory and Guidance Material.

Document	Title
FAA Order 8110.9	Handbook on Vibration Substantiation and Fatigue Evaluation of Helicopter and other Power Transmission Systems
AC 27-1B, MG 11	"Fatigue Evaluation of Rotorcraft Structure"
AC 20-107A	"Composite Aircraft Structure"
AC 21-26	"Quality Control for the Manufacture of Composite Materials"
MIL-HDBK-17	"Composite Material Handbooks"
AC 29-2C, MG 11	"Fatigue Tolerance Evaluation of Transport Category Rotorcraft Metallic Structure"
DOT/FAA/CT-86/39	Whitehead, R.S., Kan, H.P., Cordero, R., and Seather, R., "Certification Testing Methodology for Composite Structures", October 1986.

f. Procedures for Substantiation of Rotorcraft Composite Structure. The composite structures evaluation has been divided into eight basic regulatory areas to provide focus on relevant regulatory requirements. These eight areas are: (1) fabrication requirements; (2) basic constituent, pre-preg and laminate material acceptance requirements and material property determination requirements; (3) protection of structure; (4) lightning protection; (5) static strength evaluation; (6) damage tolerance and fatigue evaluation; (7) dynamic loading and response evaluation; and (8) special repair and continued airworthiness requirements. Original as well as alternate or substitute material system constituents (e.g., fibers, resins, etc.), material systems (combinations of constituents and adhesives), and composite designs (laminates, co-cured assemblies, bonded assemblies, etc.) should be qualified in accordance with the methodology presented in the following paragraphs. Each regulatory area will be addressed in turn. It is important to remember that proper certification of a composite structure is an incremental, building block process which involves phased FAA/AUTHORITY involvement and incremental approval in each of the various areas outlined herein. It is recommended that a FAA/AUTHORITY certification team approach be used for composite structural substantiation. The team should consist of FAA/AUTHORITY engineering and cognizant aircraft evaluation group inspector(s), the manufacturing inspector(s), the associated Designated Engineering Representatives (DER's), the associated Designated Manufacturing Inspection Representatives (DMIR's), and cognizant members of the applicant's organization. Personnel who are composites specialists (or are otherwise knowledgeable in the subject) should be primary team member candidates.

Once selected, it is recommended that team meetings be held periodically (possibly in conjunction with type boards) during certification to ensure the building block certification process is accomplished as intended. The team should assure that permanent documentation in the form of reports or other Authority-acceptable documents are included in the certification data package. The documentation includes but is not limited to the structural substantiation reports (both analysis and test), manufacturing processes and quality control, and Instructions for Continued Airworthiness (maintenance, overhaul, and repair manuals). The Airworthiness Limitations Section of the Instructions for Continued Airworthiness is approved by FAA/AUTHORITY engineering. Engineering practices for many of the areas identified below are available in Mil-HDBK-17.

(1) The <u>first</u> area is the <u>fabrication requirements</u> of § 29.605:

(i) The quality control system should be developed considering the critical engineering, manufacturing, and quality requirements and a guidance standard such as AC 21-26, "Quality Control for the Manufacture of Composite Materials." This ensures that all special engineering, or manufacturing quality instructions for composites are presented, evaluated, documented, and approved, using drawings, process and manufacturing specifications, standards, or other equivalent means. This should be one of the early phases of a composite structure certification program, since this represents a major building block for sequential substantiation work. Some important concepts of AC 21-26 are included below.

(ii) Specific allowable defect limits on, for example, fiber waviness, warp defects, fill defects, porosity, hole edge effects, edge defects, resin content, large area debonds, and delaminations, etc., for a particular material system component, laminate design, detailed part, or assembly should be jointly established by engineering, manufacturing, and quality and the associated inspection programs for defect detection created, validated, and approved. Each critical engineering design should consider the variability of the manufacturing process to determine the worse case effects (maximum waviness, disbonds, delaminations, and other critical defects) allowed by the reliability limitations of the approved inspection program.

(iii) If bonds or bond lines such as those typical of rotorcraft rotor blade structure are used, special inspection methods, special fabrication methods or other approved verification methods (e.g., engineering proof tests, reference paragraph g(5)) should be provided to detect and limit disbonds or understrength bonds.

(iv) Structurally critical composite construction fabrication process and procurement specifications, for fabricating reproducible and reliable structure, must be provided and FAA/AUTHORITY approved early during the certification process and should, as a minimum, cover the following:

(A) Vendor and Qualified Parts List (QPL) Control. Applicants should be able to demonstrate to FAA/AUTHORITY certification team members (both the manufacturing inspection district office (MIDO) and FAA/AUTHORITY engineering) at any time, that their quality control systems ensure on a continuous basis, that only qualified suppliers provide the basic material constituents or material systems (e.g., pre-pregs) that meet approved material specifications. Recommended guidelines for qualification of alternate material systems and suppliers are contained in MIL-HDBK-17. These methods can also be used, periodically for qualification status renewals of existing material systems and suppliers.

(B) Receiving Inspection and In-Process Inspection. Applicants should be able to demonstrate to FAA/AUTHORITY certification team members (both MIDO and engineering), at any time, that their receiving and in-process quality control systems provide products which continuously meet approved material and process specifications. Quality systems should be designed with appropriate checks and balances, so that the necessary statistical reliability and confidence levels for the items being inspected (that are specified by engineering) are continuously maintained. This will require periodic standard inspections and engineering characterization tests on basic constituent and material system samples which should be conducted, as a minimum, on a batch-to-batch basis. The periodic testing necessary to maintain the quality standard should be conducted by the applicants on conformed samples and should be FAA/AUTHORITY witnessed.

(C) Material System Component Storage and Handling. Applicants should be able to demonstrate to FAA/AUTHORITY certification team members (both MIDO and engineering), at any time, that their composite material system (or constituent) storage and handling procedures and specifications provide products which continuously meet approved material and process specifications. Quality systems should be designed with appropriate checks and balances, so that the necessary statistical reliability and confidence levels for the items being inspected (which are specified by engineering) are continuously maintained. This should require, as a minimum, periodic inspections to ensure that proper records are kept on critical parameters (e.g., room temperature "bench" exposure, shelf life, etc.) and that periodic basic constituent and material system characterization tests are conducted, on a batch-to-batch basis. The periodic testing necessary to maintain the quality standard should be conducted by the applicants on conformed samples and should be FAA/AUTHORITY witnessed.

(D) Statistical Validation Level. It is necessary to maintain the minimum required statistical validation level of the quality control system (which should be specified for each critical item or constituent by the approved quality and engineering specifications). The statistical validation level should be defined and approved early in certification. Also, approval and proper usage should be continuously maintained during the entire procurement and manufacturing cycles.

(v) Alternate fabrication and process techniques should be approved and must comply with § 29.605. Any alternate techniques should provide at least the same level of quality and safety as the original technique. Any changes should be presented for FAA/AUTHORITY approval well in advance of the change's production effectivity.

(2) The second area is the basic raw constituent, pre-preg, and laminate material acceptance requirements and material property determination requirements of §§ 29.603 and 29.613. These criteria require application of the critical environmental limits such as temperature, humidity, and exposure to aircraft fluids (such as fuel, oils, and hydraulic fluids), to determine their effect on the performance of each composite material system. Temperature and humidity effects are commonly considered by coupon and component tests utilizing preconditioned test specimens for each material system selected. Material "A" and "B" basis allowable strength values and other basic material properties (based on MIL-HDBK-17 or equivalent procedures) are typically determined by small scale tests, such as coupon tests, for use in certification work. In the case of composites, determination of these basic constituent and material system properties will almost invariably involve the submittal, acceptance, and use of company standards. This is currently necessary because the FAA (new managers of MIL-HDBK-17) has not completed development of "B" basis allowables for inclusion in the handbook. Also, test methods vary somewhat from manufacturer to manufacturer; therefore, individual company results will exhibit some scatter in final material property values. Any company standard that is used should meet or exceed related MIL-HDBK-17 requirements. Material structural acceptance criteria and property determination should, as a minimum, include the following:

(i) Property characterization requirements of all material systems (e.g., pre-pregs, adhesives, etc.) and constituents (e.g., fibers, resins, etc.) should be identified, documented, and approved. These requirements, once approved, should be placed in all appropriate procedures and specifications such as those in paragraph f.(1).

(ii) Moisture conditioning of test coupons, parts, subassemblies, or assemblies should be accomplished in accordance with MIL-HDBK-17, other similar approved methods or per FAA/AUTHORITY approved programs.

(iii) The maximum and minimum temperatures expected in service (as derived from test measurements, thermal analyses on panels and other parts, experience, or a combination) should be determined and accounted for in static and fatigue strength (including damage tolerance) substantiation programs considering associated humidity-induced effects.

(iv) The wet glass transition temperature, Tg, is an important characteristic parameter of amorphous polymers, such as epoxies. It is the temperature below which the polymer behaves like a "glassy" solid and above which it behaves like a "rubbery" solid, i.e., it is the temperature at which there is a very rapid change in physical properties. The change from a hard polymeric material to a rubbery material takes place over a narrow temperature range. A composite material will experience a drastic reduction in matrix-controlled mechanical material properties when loaded in this temperature range. Since the resin is the critical structural constituent in a composite matrix and since Tg exceedance is critical to structural integrity; Tg determination is necessary. The Tg margin methodology of MIL-HDBK-17 should be implemented, i.e., the wet glass transition temperature (Tg) should be 50° F higher than the maximum structural temperature (see definition). For any type of resin or adhesive, an acceptable temperature margin using MIL-HDBK-17 techniques (e.g., consideration of limited high temperature excursions) or equivalent methodologies based on tests or experience, or both should be established and approved early in the certification process.

(v) Local design values should be established by analysis and characterization tests and approved for specific structural configurations (point designs) which include the effects of stress risers (e.g., holes, notches, etc.) and structural discontinuities (e.g., joints, splices, etc.). Proper determination of these values for full-scale design and test should be considered one of the most critical building blocks in substantiating and evaluating a composite structure. These transitional load transfer areas typically produce the highest stresses (and strains) and serve as the initiation sites for many of the failures (including those due to the relatively low interlaminar strength of composites) that occur in service in a full-scale part or assembly. Small scales tests (such as coupon, element, and subcomponent tests), or equivalent approved testing programs, and analytical techniques should be carefully designed, prepared, and approved to evaluate potential "hot spots" and provide accurate simulations and representations of full-scale article stresses and strains in the critical transition areas. Proper certification work in this area will ensure initial safety and continued airworthiness in full-scale production articles.

(vi) The design strain level for each major component and material system should be established so that specified impact damage considerations are defined and properly limited. The effects of the strain levels may be established for each composite material using small-scale characterization tests and then the results should be used to establish or verify the maximum allowable design strain level for each full-scale article. The maximum allowable design strain values selected should also take into account the reliability and confidence levels established for the relevant portions of the quality control system. This methodology is necessary because the amount and size of flaws in the production article may restrict the allowable level of design strain. In a no-flaw-growth design, the maximum specified impact damage and manufacturing flaw size at the most critical location on the part will be a major factor in determining the maximum allowable elastic strain. This design approach is currently selected for nearly all civil and most military applications; since, under normal conditions, only visual inspections are required in the field (unless unusual external damage circumstances such as a hail storm occur) to maintain the initial level of airworthiness (safety). However, many military applications, because of their demanding missions, employ scheduled field non-destructive inspection (NDI) maintenance, (such as comparative ultrasonics) to ensure that flaw growth either does not occur, is controlled by approved structural repair, or by replacement of affected parts. To date, civil applications have not been presented that desire a flaw growth, phased NDI approach. Therefore, selection of the full-scale article's design strain limit based on small-scale tests for a no flaw growth design is extremely important.

(vii) Composite and adhesive properties should be determined so that detrimental structural creep does not occur under the sustained loads and environments expected in service. Small-scale characterization tests (such as coupon, element, and subcomponent tests) and analysis, which verify and establish the full-scale design criteria and parameters necessary to ensure that detrimental structural creep in full-scale structure does not occur in service, should be conducted early in certification and should be FAA/AUTHORITY-approved.

(viii) Material allowable strength values for full-scale design and testing should be developed using the coupon procedures presented in MIL-HDBK-17 or equivalent. The intent is to represent the material variability including the effects that can occur in multiple batches of material and process runs. At least three batches of material samples should be used in material allowable strength testing. Company standards should be prepared, evaluated and FAA/AUTHORITY-approved early in certification (as part of the building block process), that reflect the material property determination considerations recommended in MIL-HDBK-17 on an equal to or better than basis.

(3) The <u>third</u> area is the <u>protection of structure</u> as required by § 29.609. Protection against thermal and humidity effects and other environmental effects (e.g., weathering, abrasion, fretting, hail, ultraviolet radiation, chemical effects, accidental damage, etc.) should be provided, or the structural substantiation should consider the results of those effects for which total protection is impractical. Determination and approval of worst-case or most conservative operating limits, and damage scenarios should be accomplished. Appropriate flammability and fire-resistance requirements should also be considered in selecting and protecting composite structure. Usually a threat analysis is conducted early in the certification process that identifies the various threats and threat levels for which protection must be provided. This data is then used to construct and submit for approval the methods-of-compliance necessary to provide proper structural protection.

(4) The <u>fourth</u> area is the <u>lightning protection</u> requirements of § 29.610. Protection should be provided and substantiated in accordance with analysis and with tests such as those of AC 20-53B, "Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Caused by Lightning" and FAA Report DOT/FAA/CT-86/8. For composite structure projects involving rotorcraft certificated to earlier certification bases (which do not automatically include the lightning protection requirements of § 29.610), these requirements should be imposed as special conditions. The design should be reviewed early in the certification process to ensure proper protection is present. The substantiation test program should also be established, reviewed and approved early to ensure proper substantiation.

(5) The <u>fifth</u> area is the <u>static strength evaluation</u> requirements of §§ 29.305 and 29.307 for composite structure. Structural static strength substantiation of a composite design should consider all critical load cases and associated failure modes, including effects of environment, material and process variability, and defects or service damage that are not detectable or allowed by the quality control, manufacturing acceptance criteria, or maintenance documents of the end product. The static strength demonstration should include a program of component ultimate load tests, unless experience exists to demonstrate the adequacy of the analysis, supported by subcomponent tests or component tests to accepted lower load levels. The necessary experience to validate an analysis should include previous component ultimate load tests with similar designs, material systems, and load cases.

(i) The effects of repeated loading and environmental exposure, both of which may result in material property degradation, should be addressed in the static strength evaluation. This can be shown by analysis supported by test evidence, by tests at the coupon, element or subcomponent levels, or alternatively by existing data. Earlier discussions in this AC address the effects of environment on material properties (reference paragraphs f. (2)) and protection of structure (reference paragraphs f.(3)). Static strength tests should be conducted for substantiation of new structure. For the critical loading conditions, two approaches to account for prior repeated loading or environmental exposure for structural substantiation exist.

- In the first approach, the large-scale static test should be conducted on structure with prior repeated loading and conditioned to simulate the environmental exposure and then tested in that environment.

- The second approach relies upon coupon, element, and sub-component test data to assess the possible degradation of static strength after application of repeated loading and environmental exposure. The degradation characterized by these tests should then be accounted for in the static strength demonstration test (e.g., load enhancement), or in the analysis of these results (e.g., showing a positive margin of safety with allowables that include the degrading effects of environment and repeated load).

In practice, the two approaches may be combined to get the desired result (e.g., a large-scale static test may be performed at a temperature with a load enhancement factor to account for moisture absorbed over the aircraft structure's life).

(ii) The strength of the composite structure should be statistically established, incrementally, through a program of analysis and tests at the coupon, element, subcomponent, or component levels. As part of the evaluation, building block tests and analyses at the coupon, element, or subcomponent levels can be used to address the issues of variability, environment, structural discontinuity (e.g., joints, cut-outs or other stress risers), damage, manufacturing defects, and design or process-specific details. Figure AC 29.573-1 provides a conceptual schematic of tests included in the building block approach. The material stress-strain curve should be clearly established, at least through the ultimate design load, for each composite design. As shown in Figure AC 29.573-1, the large quantity of tests needed to provide a statistical basis comes from the lowest levels (coupons and elements) and the performance of structural details are validated in a lesser number of sub-component and component tests. The static strength substantiation program should also consider all critical loading conditions for all critical structure including residual strength and stiffness requirements after a predetermined length of service, e.g., end of life (EOL) (which takes into account damage and other degradation due to the service period).

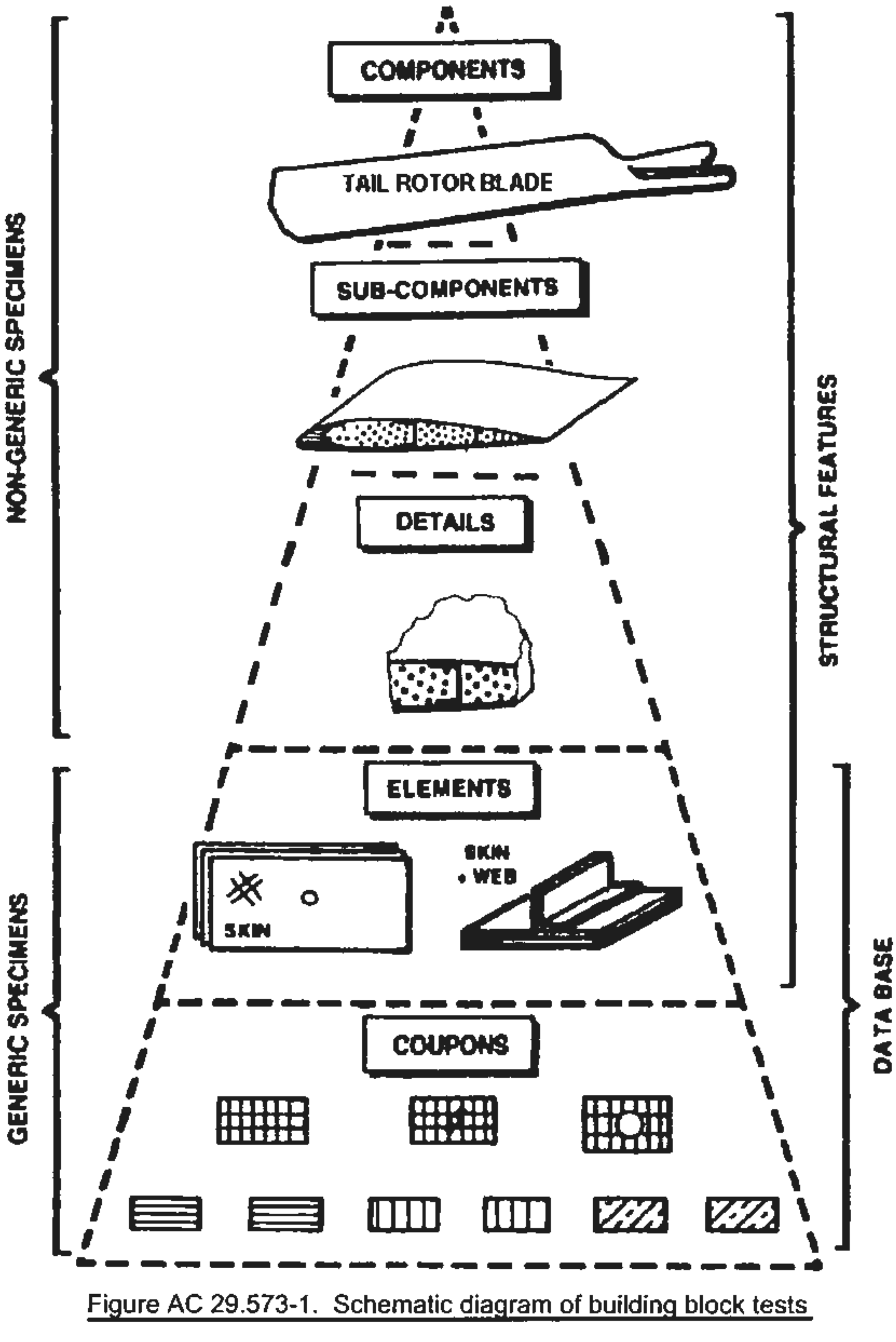

Figure AC 29.573-1. Schematic diagram of building block tests

(iii) Allowables should be evaluated and used as specified in § 29.613. These allowables may be generated at the lamina, laminate, or specific design feature level (e.g. filled hole, lap joint, stringer run-out, etc.), provided they accurately reflect the actual value and variability of the structural strength for the critical failure modes being considered, at each point design where margins need to be established.

(iv) The static test articles should be fabricated and assembled in accordance with production specifications and processes so that they are representative of production structure including defects consistent with the limits established by manufacturing acceptance criteria.

(v) The material and processing variability of the composite structure should be considered in the static strength substantiation. This can be achieved by establishing sufficient process and quality controls to manufacture structure and reliably substantiate the required strength in tests and analyses, which support a building block approach. If sufficient process and quality controls cannot be achieved, it may be necessary to account for greater variability with special factors (§ 29.619) applied to the design. Such factors should be accounted for in the component static tests or analysis.

(vi) It should be shown that impact damage (or other minor discrete source damage) that can be realistically expected from manufacturing and service, but not more than the established threshold of detectability for the selected inspection procedure, will not reduce the structural strength below ultimate load capability. This static strength capability can be shown by analysis supported by test evidence, or by a combination of tests at the coupon, element, subcomponent, and component levels. Later discussions in this AC address the issues associated with damage in excess of that considered in f(5) and drops in residual strength below ultimate load capability (reference paragraph f(6)) below.

(6) The sixth area is the damage tolerance and fatigue evaluation requirements of § 29.573.

(i) BACKGROUND. The static strength determination required by §§ 29.305 and 29.307 establishes the ultimate load capability for composite structures that are manufactured, operated, and maintained with established procedures and conditions. The damage tolerance and fatigue evaluation required by § 29.573 mandates procedures that allow the composite structure to retain the intended ultimate load capability when subjected to expected fatigue loads and conditions during its operational life. The requirements established for the damage tolerance and fatigue evaluation include component replacement times, inspection intervals, or other procedures as necessary to avoid catastrophic failure. These evaluations assume that the baseline ultimate strength capability might be compromised by damage caused by fatigue, environmental effects, intrinsic or discrete flaws, or accidental damage. This damage includes flaws or defects which may occur in manufacturing or maintenance and which are used to set the ultimate strength capability and establish the manufacturing acceptance criteria. The damage tolerance assessment establishes standards that allow the static strength capability to degrade below the ultimate strength capability assuming such damage occurs within the operational life of the structure. However, when this damage occurs, the remaining structure must withstand expected loads without failure or excessive structural deformations until the damage is detected and the component is either repaired to restore ultimate strength capability or retired.

(ii) GENERAL - The nature and extent of the required analysis or tests on complete structures and portions of the primary structure can be based on applicable previous fatigue or damage tolerant designs, construction, tests, and service experience on similar structures. In the absence of experience with similar designs, Airworthiness Authorities-approved structural development tests of components, subcomponents, and elements should be performed. The following considerations are unique to the use of composite material systems and should be observed for the method of substantiation selected by the applicant.

Rotorcraft structure provides a broad range of composite applications that are quite different in terms of functionality, geometry and inspectability. These include the rotors, the drive shafts, the fuselage, control system components (e.g. push-pull rods), and the control surfaces. When selecting the approach, attention should be given to the composite application under evaluation, the type of potential damage and degradation of the structural design details, the materials used and margin over flight loads. Whatever the approach that may be selected, the following considerations will apply for tests and analysis:

(A) The test articles should be fabricated and assembled in accordance with production specifications and processes so that the test articles are representative of production structure.

(B) The test articles should include material imperfections whose extent is not less than the limits established under the inspection and acceptance criteria used during the manufacturing process and consistent with the inspection techniques used in service (e.g. visual, ultrasonic, X-ray). The initial extent of these imperfections should be discussed and agreed with the FAA/AUTHORITY, taking into account experience in manufacturing and routine in-service inspections. Typical defects to be considered include but are not limited to the following:

(1) Disbonds and weak bonds (considered as disbonds)
(2) Delaminations, fiber waviness, porosity, voids
(3) Scratches, gouges, and penetrations
(4) Impact damage

All of the damages identified in the preceding paragraph (B) above should be derived from the threat assessment described in the following paragraph (C).

(C) Threat Assessment. For each PSE, a threat assessment must be made of the probable locations, types, and sizes of damage considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage. This determination must be submitted with accompanying rationale to the certifying authority for approval. This rationale may include experience with similar materials, designs, processes (manufacturing, maintenance, and overhaul), structural details, or structure, and may also include service failure evaluations, manufacturing records, overhauls and repair reports, field service reports, incident and accident investigations, service impact surveys, inspectability surveys, and engineering judgment.

Consideration should also be given to factors that:

- Reduce scatter and deviations from nominal structures, such as "frozen processes", Flight Critical Parts programs, and materials and manufacturing processes to mitigate intrinsic flaws (inclusions and defects).
- Preclude a type of damage by use of a specific design feature (material selection, surface treatment, protective coating, or shielding), a specific stress level (for fatigue damage), or a specific manufacturing inspection process (if it can be shown to be highly reliable, well-controlled and documented, and systematically required).

The assessment should include:

- A systematic evaluation of all the location, types, and sizes of damage and their estimated probability of occurrence.
- A selection or elimination of this damage based on the above estimate
- A verification that the inspection method selected is capable of detecting the damage at the size and location determined.

The types of damage to consider include:

(1) Intrinsic Flaws (imperfections) which are probable to exist in an as-manufactured structure based on the evaluation of the details and potential sensitivities of the specific manufacturing work processes used. The types of flaws to be considered include voids, disbonds, inclusions, foreign objects, resin-rich and resin-starved areas, and improper ply orientation or ply ending. The sizes of the intrinsic flaws considered should be based on the limits established under the manufacturing inspection and acceptance criteria and are expected to remain in service for the life of the structure.

(2) Impact Damage which may occur during manufacturing and in service based on an evaluation of the threats by means of an impact survey and/or service experiences. This type of damage can include dents, penetrations, gouges, abrasions, and scratches. A threat assessment is needed to identify impact damage severity and detectability for design and maintenance. A threat assessment usually includes damage data collected from service plus an impact survey. An impact survey consists of impact tests performed with configured structure, which is subjected to boundary conditions characteristic of the real structure. Many different impact scenarios and locations are typically considered in the survey, which has a goal

of identifying the most critical impacts (i.e., those causing the most serious damage but are least detectable). When simulating accidental impact damage, blunt or sharp impactors should be selected to represent the maximum criticality versus detectability, according to the load conditions (e.g., tension, compression or shear). Until sufficient service experience exists to make good engineering judgments on energy and impactor variables, impact surveys should consider a wide range of conceivable impacts, including runway or ground debris, hail, tool drops, and vehicle collisions. Service data collected over time, can better define impact surveys and design criteria for subsequent products, as well as establish more rational inspection intervals and maintenance practice. Refer to paragraph f(6)(ii)(H) for various combinations of detectability and energy levels to be considered in the damage tolerance and fatigue evaluation.

(3) Discrete Source Damage. The structure should be able to withstand limit static loads (considered as ultimate loads) and fatigue loads which are reasonably expected during a completion of a flight on which damage resulting from obvious discrete source occurs (e.g., hail damage, bird strike, uncontained engine failure, and uncontained high energy rotating machinery failure). The extent of damage should be based on a rational assessment of service mission and potential damage relating to each discrete source.

(D) The use of composite secondary bonding in manufacturing or maintenance requires strict process and quality controls to achieve the reliability needed to use such technology in critical structures (reference AC 21-26). Assuming good process and quality controls, service history has shown that additional damage tolerant design considerations are also needed to ensure the safety of structure with secondary bonds (i.e., random, but an unacceptable number of weak bonds discovered in service). Unless the ultimate strength of each critical bonded joint can be reliably substantiated in production by NDI techniques (or other equivalent, approved techniques), then the limit load capability should be ensured by any or a combination of the following:

(1) Consider isolated disbonds and weak bonds (represented by zero bond strength) in structural elements that use secondary bonding for primary load transfer. The associated disbond size should be up to the limitations provided by redundant design features (i.e., mechanical fasteners or a separate bonding detail). The structure containing such damage should be shown to carry limit load by tests, analyses, or some combination of both. For purposes of test or analysis demonstration, each disbond should be considered separately as a random occurrence (i.e., it is not necessary to demonstrate residual strength with all structural elements disbonded simultaneously).

(2) Each critical bonded joint on each production article should be proof-tested to the critical limit load.

(3) Critical bonded joints that have high static margins of safety (e.g., some rotor blades) may be accepted based on satisfactory service history of like or similar components.

(E) The fatigue load spectrum developed for fatigue testing and analysis purposes should be representative of the anticipated service usage. Low amplitude load levels that can be shown not to contribute to fatigue damage may be omitted (truncated). Reducing maximum load levels (clipping) is generally not accepted.

(F) Environmental effects (temperature and humidity representative of the expected service usage) on the static and fatigue behavior and damage growth should be considered. Unless tested in the environment, appropriate environmental knock down factors for the static and the fatigue test articles should be derived and applied in the evaluation.

(G) Variability in fatigue behavior should be covered by appropriate load or life scatter factors and these factors should take into account the number of specimens tested.

(H) The following Figure AC 29.573-2 illustrates the extent of the impact damage that needs to be considered in the damage tolerance and fatigue evaluation.

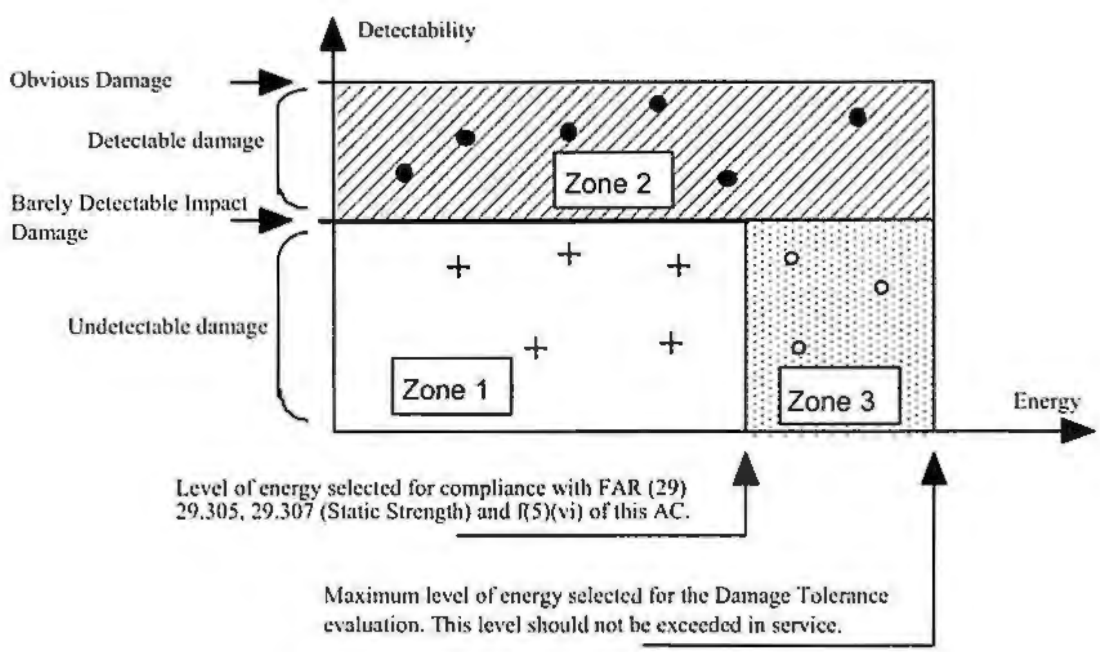

Figure AC 29.573-2. Characterization of Impact Damage

<u>(1)</u> Both the energy level associated with the static strength demonstration and the maximum energy level associated with the damage tolerance evaluation (depicted in Figure AC 29.573-2) are dependent on the part of the structure under evaluation and a threat assessment.

<u>(2)</u> Obvious impact damage is used to define the threshold from which damage is readily detectable and appropriate actions may be taken before the next flight.

<u>(3)</u> Barely Detectable Impact Damage is the state of damage at the threshold of detectability for the approved inspection procedure. Barely Visible Impact Damage (BVID) is that threshold of visually detectable damage associated with a detailed visual inspection procedure.

<u>(4)</u> Detectable Damage is the state of damage that can be reliably detected at scheduled inspection intervals. Visible Impact Damage (VID) is that threshold associated with the type of damage that should be detectable during a detailed visual inspection.

<u>(5)</u> Three Zones are depicted by this figure:

Zone 1: Since the damage is not detectable, Ultimate Load capability is required. The provisions of paragraph f(5) provide a means of compliance.

Zone 2: Since the damage can be detected at a scheduled inspection, Limit Load (considered as Ultimate load) capability is the minimum requirement for this damage.

Zone 3: Since the damage is not detectable with the proposed in-service inspection procedures, ultimate load capability is required, unless an alternate procedure can show an equivalent level of safety. For example, residual strength lower than ultimate may be used in association with improved inspection procedures or with a probabilistic approach showing that the occurrence of energy levels is low enough so that an acceptable level of safety can be achieved.

Of the three zones, only Zone 3 may have a residual strength requirement that can vary with alternate procedures or the probability of damage occurrence or both. In either case, any compromise for residual strength requirements less than the ultimate load requirement should only be considered when pursuing one of the options under the damage tolerant fail-safe means of compliance, as described in the following section, f(6)(iii)(B).

One example of the use of alternate procedures is for the rare damage threat from a high energy, blunt impact (e.g., service vehicle collision). Depending on the selected maintenance inspection scheme, such damage may fall under Zone 3. When considering such damage in the design of a part, it may be shown to be damage tolerant fail safe, even though the damage is not detectable, based on a very low probability of occurrence. As a result, the design may have sufficiently high residual strength (e.g., below Ultimate, but well above limit load capability to ensure safety without detection for long periods of time). If it is further determined that such impact events usually occur with the knowledge of maintenance or aircraft service personnel, then the alternate procedures may be added to the Instructions for Continued Airworthiness. For example, advanced inspection methods, which can detect damage from high-energy blunt impacts, may be used as alternate procedures to minimize the risk of catastrophic failure for such Zone 3 damage.

(iii) MEANS OF COMPLIANCE - For each PSE, inspections, replacement times, or other procedures must be established as necessary to avoid catastrophic failure. Compliance with the requirements of § 29.573(e) and (f) should be shown by one, or a combination of, the methods described subsequently. Generally, replacement times are established using Damage Tolerance Safe Life Evaluations and Inspection Intervals are established using Fail Safe Evaluations. From current state-of-the-art rotorcraft applications, it is widely accepted that composite materials have good flaw and damage tolerance capabilities and therefore the supplemental procedures may only be rarely necessary. Damage tolerance evaluations are best suited for composite structures, particularly those with structural redundancy and inherent resistance to damage growth. Damage resulting from anomalous or accidental events must be considered in the damage tolerant evaluations. The damage tolerant evaluation for replacement times and inspection intervals is to be used unless shown that neither can be achieved within the limitations of geometry, inspectability, or good design practice. In that case, supplemental procedures must be established and submitted to the FAA/AUTHORITY for approval. In any case, the FAA/AUTHORITY must approve the methodology used for compliance to § 29.573.

The substantiation method(s) should be chosen so that the structure is protected against catastrophic failure from each of the threats identified in paragraph f(6)(ii)(C) of this AC by a specific procedure (inspection, replacement time, or other procedure). For example, a manufacturing-related void of a specific allowable size could be substantiated by means of a replacement time method with no scheduled inspection. An accidental impact in the same area could be substantiated by an inspection method with no specific replacement time. The result could be one structure with several different inspection requirements (location, method, and interval) and a fixed replacement time as well. This combination of procedures assures that each threat is covered.

The fatigue substantiation should include sufficient coupon, element, sub-element, or component tests to establish the fatigue scatter, curve shapes, and the environmental effects. The substantiation should include full-scale, component, or sub-component fatigue testing but also may be accomplished by analysis supported by test evidence. When spectrum testing is used, the lowest load levels can be eliminated from the spectrum if they can be shown to be non-damaging. The substantiation should include a static strength evaluation to show that the required residual strength and adequate stiffness, accounting for the effects of environment, are retained for the life of the structure or the appropriate inspection interval. Damage as determined in paragraph f(6)(ii) of this AC for the specific structure being substantiated should be imposed at each critical area of the structure.

(A) Damage Tolerant Safe-Life Evaluation. This is a "No-Growth" method in which the structure, with damage present, is able to withstand repeated loads of variable magnitude without detectable damage growth for the life of the rotorcraft or within a specified replacement time. This evaluation may be used to substantiate any type of damage that will remain in-service for the life of the part.

No specific inspection requirements are generated from the test program in this method. However, compliance with routine inspections for cracking, delaminations, and service damage and other limitations prescribed in accordance with § 29.1529 are always required. Compliance using full-scale, component, or sub-component fatigue testing can be accomplished by either of the following methods:

(1) S-N Method. This method is based on determining the point where initiation of growth occurs for the damage present at critical locations in the structure. AC 27-1B, Change 1, AC 27 MG-11, provides guidance that may be appropriate for this method. The method utilizes one or more full-scale, component, or sub-component test specimens subjected to constant-amplitude or spectrum loading applied in a distribution on the structure that is representative of critical flight conditions. Any indication of growth of the imposed damage and defects, or structurally significant cracking, disbonding, splintering, or delaminating of the composite, defines the fatigue initiation characteristic of the structure in terms of applied load and cycles. Working S-N curves are established from the mean curve using strength or cycle reductions or both to account for fatigue scatter and environmental effects. Flight loads are compared to this working curve, and if any intercepts occur, a cumulative damage calculation is conducted to establish the component retirement time. Compliance with the ultimate load requirements should be demonstrated at the completion of the fatigue test.

(2) Life-Test Method. This method uses spectrum fatigue testing to verify the absence of damage growth over a large number of cycles that are equivalent to a lifetime of expected usage. The method uses one or more full-scale, component, or sub-component test specimens subjected to spectrum fatigue loading applied in a representative distribution of flight loads, including Ground-Air-Ground (GAG) loads. Fatigue test loads should be increased by factors for environment and fatigue strength scatter. The load may also be increased using an S-N curve approach to reduce the duration of the test. Any significant growth of the imposed damage, or structurally significant cracking, disbonding, splintering, or delamination of the composite during the test constitutes failure to achieve the desired lifetime. However, the equivalent life demonstrated at the time of inception of damage growth or cracking can be used as a retirement time for the component. Compliance with the ultimate load requirements should be demonstrated at the completion of the fatigue test.

(B) Damage Tolerant Fail-Safe (Residual Strength with Detectable Damage) Evaluation. This method establishes inspection intervals to ensure that the structure remaining after a partial failure is able to withstand design limit loads without failure or excessive structural deformations within a specified inspection interval. If the damage is detected in an inspection, the structure should be either replaced or repaired to restore ultimate load capability. Evaluation of Zone 3 damage should have sufficiently high residual strength and, if necessary, supplemental procedures should be established to minimize the risk of catastrophic failure. Full-scale, component, or sub-component testing should be accomplished using one or more specimens subjected to constant amplitude or spectrum loading applied in a manner representative of flight load conditions. The test loads should be increased by factors that account for environment and fatigue strength scatter. The results of the testing can be used to manage the structure in one or a combination of the three methods described subsequently.

(1) No Growth Evaluation. This approach is appropriate for inspectable in-service damage which does not grow in service. See Figure AC 29.573-3. (Damage growth should be substantiated using either method described in f(6)(iii)(B)(2) or f(6)(iii)(B)(3)). Structural details, elements, sub-components, and components of critical structural areas, or full-scale structures, should be tested under repeated loads for validating a no-growth approach to the damage tolerance requirements. The number of cycles applied to validate a no-growth concept should be statistically significant, and may be determined by load or life considerations or both. Residual strength testing or evaluations should be performed after repeated load cycling demonstrating that the residual strength of the structure is equal to or greater than limit load considered as ultimate. Moreover, it should be shown that stiffness properties have not changed beyond acceptable levels. Inspection intervals should be established, considering the residual strength capability associated with the assumed damage. The intent of this is to assure that structure is not exposed to an excessive period of time with static margins less than ultimate, providing a lower safety level than in the typical slow growth situation, as illustrated by the Figure AC 29.573-3. Once the damage is detected, the component is either repaired to restore ultimate load capability or replaced.

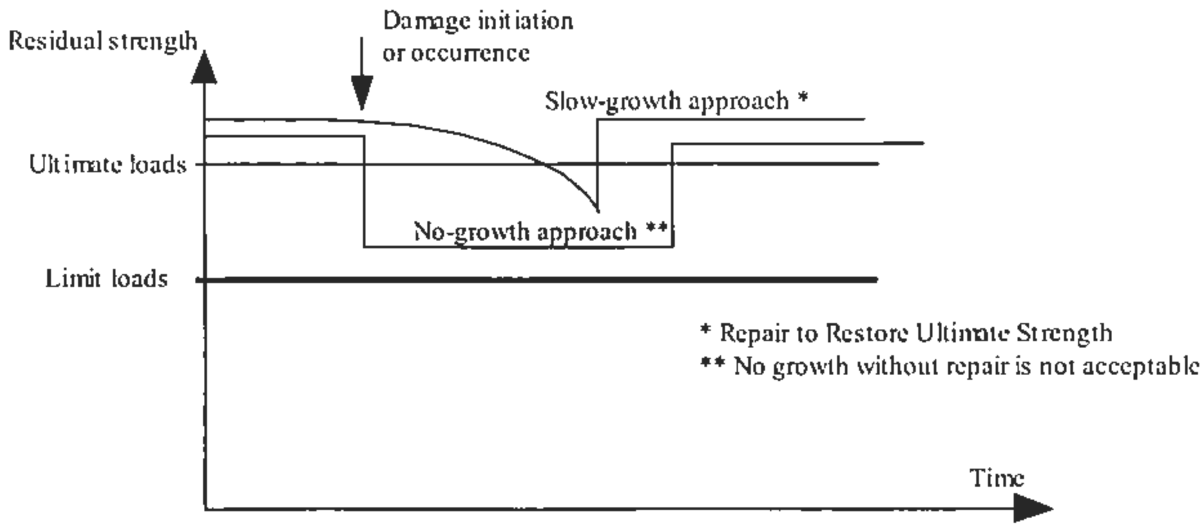

Figure AC 29.573-3. Residual Strength vs. Time

The lower the residual strength of a structure after an accidental damage event, the shorter the inspection interval should be. Considerations of both inspectability and impact surveys (including probability of occurrence) for specific structure may be used to isolate the most critical threats to consider in setting a maintenance inspection interval. Knowledge of the residual strength for a given critical damage is also needed for such an evaluation. If it is known that the design is capable of handling large and clearly detectable damage, while maintaining a residual strength well above limit load, a less rigorous engineering approach may be applied in establishing the inspection interval.

(2) Slow Growth Evaluation. This method is applicable when the damage grows in the test and the growth rate is shown to be slow, stable, and predictable, as illustrated in Figure AC 29.573-4. An inspection program should be developed consisting of the frequency, extent, and methods of inspection for inclusion in the maintenance plan. Inspection intervals should be established so that the damage will have a very high probability of detection between the time it becomes initially inspectable and the time at which the extent of the damage reduces the residual static strength to limit load (considered as ultimate), including the effects of environment. For any damage size that reduces the load capability below ultimate, the component is either repaired to restore ultimate load capability or replaced. Should functional impairment (such as unacceptable loss of stiffness) occur before the damage becomes otherwise critical, this should be accounted for in the development of the inspection program.

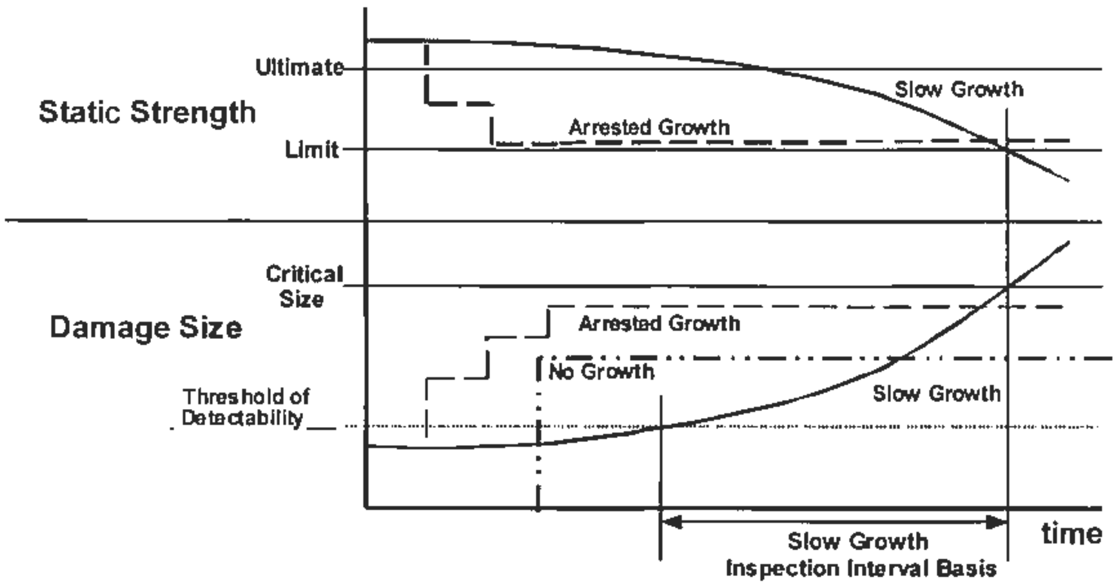

Figure AC 29.573-4. Illustration of Residual Strength and Damage Size Relationships for Fail-Safe Substantiation

(3) Arrested Growth Evaluation. This method is applicable when the damage grows, but the growth is mechanically arrested or terminated before becoming critical (residual static strength reduced to limit load), as illustrated in Figure AC 29.573-4. Arrested Growth may occur due to design features such as a geometry change, reinforcement, thickness change, or a structural joint. This approach is appropriate for inspectable arrested growth damage. Structural details, elements, and sub-components of critical structural areas, or full-scale structures, should be tested under repeated loads for validating an arrested growth approach to the flaw tolerance requirements. The number of cycles applied to validate an arrested growth concept should be statistically significant, and may be determined by load or life considerations or both. Residual strength testing or evaluation should be performed after repeated load cycling and a demonstration that the residual strength of the structure is equal to or greater than limit load considered as ultimate. Moreover, it should be shown that stiffness properties have not changed beyond acceptable levels. Inspection intervals should be established, considering the residual strength capability associated with the arrested growth damage. The intent of this is to assure that structure is not exposed to an excessive period of time with static margins less than ultimate, providing a lower safety level than in the typical slow growth situation, as illustrated by Figure AC 29.573-3. For any damage size that reduces the load capability below ultimate, the component is either repaired to restore ultimate load capability or replaced.

The lower the residual strength of a structure after an arrested growth event, the shorter the inspection interval should be. Considerations of both inspectability and impact surveys (including probability of occurrence) for specific structure may be used to isolate the most critical threats to consider in setting a maintenance inspection interval.

Knowledge of the residual strength for a given critical damage is also needed for such an evaluation. If it is known that the design is capable of handling large and clearly detectable damage, while maintaining a residual strength well above limit load, a less rigorous engineering approach may be applied in establishing the inspection interval.

(C) Combination of Damage Tolerant Safe Life and Fail Safe Evaluations. Generally, it may be appropriate to establish both a replacement time and an inspection program for a given structure as calculated by the Damage Tolerant Safe Life and Fail Safe Evaluations.

(D) Other Procedures. Other procedures are allowed according to paragraph 29.573(d). Such alternative procedures must still provide the same degree of damage tolerance to the same identified threats as the replacement time or inspection interval methods.

One possible alternate approach is the use of indirect damage detection methods instead of the specific mandated inspection procedures that are determined in the Fail Safe Evaluations of f(6)(iii)(B). These indirect detection methods should be documented and shown to have the same degree of reliability, repeatability, and margin provided by a conventional inspection approach. These methods could include: (1) establishing measurable vibration or blade out-of-track conditions and limits, (2) defining indirect inspections which would detect damage, and (3) in-flight detecting of damage by means of monitoring and warning devices.

(E) Supplemental Procedures. If the damage tolerant evaluations as described previously cannot be achieved within the limitations of geometry, inspectability, or good design practice, a fatigue evaluation using supplemental procedures may be proposed to the certifying authority per § 29.573(h). A rationale must be provided as to why the damage tolerance criteria cannot be satisfied for the specific PSE, locations, and threats considered. In addition, the types of damage considered in the evaluations must be identified. Finally, supplemental procedures must be established to minimize the risk of catastrophic failure with the damages considered.

(iv) Additional Considerations for DAMAGE TOLERANCE AND FATIGUE Evaluations.

(A) Experience with the application of methods of fatigue and damage tolerance evaluations indicates that a relevant test background should exist in order to achieve the design objective. It is the general practice within industry to conduct damage tolerance tests for design information and guidance purposes. It is crucial that the critical structure be identified and tested to the proper flight and ground loads. In the fatigue and flaw tolerance evaluation, the following items must be considered:

(B) Identification of the structure to be considered in each evaluation (a failure mode and effects analysis or similar method should be used).

(1) Identification of Principal Structural Elements. Principal structural elements are those that contribute significantly to carrying flight and ground loads and whose failure could result in catastrophic failure of the rotorcraft. Typical examples of such elements are:

(i) Rotor blades and attachment fittings.

(ii) Rotor heads, including hubs, hinges, and some main rotor dampers.

(iii) Control system components subject to repeated loading, including control rods, servo structure, and swashplates.

(iv) Rotor supporting structure (lift path from airframe to rotorhead).

(v) Fuselage, including stabilizers and auxiliary lifting surfaces, airframe provisions for engine and transmission mountings.

(vi) Main fixed or retractable landing gear and fuselage attachment structure.

(2) Identification of Locations Within Principal Structural Elements to be Evaluated. The locations of damage to structure for damage tolerance evaluation can be determined by analysis or by fatigue test on complete structures or subcomponents. However, tests will be necessary when the basis for analytical prediction is not reliable, such as for complex components. If less than the complete structure is tested, care should be taken to ensure that the internal loads and boundary conditions are valid. The following should be considered:

(i) Strain gauge data on undamaged structure to establish points of high stress concentration as well as the magnitude of the concentration;

(ii) Locations where analysis shows high stress or low margins of safety;

(iii) Locations where permanent deformation occurred in static tests;

(iv) Locations of potential fatigue damage identified by fatigue analysis;

(v) Locations where the stresses in adjacent elements will be at a maximum with an element in the location failed;

(vi) Partial fracture locations in an element where high stress concentrations are present in the residual structure;

(vii) Locations where detection would be difficult;

(viii) Design details that service experience of similarly designed components indicates are prone to fatigue or other damage.

(3) In addition, the areas of probable damage from sources such as a severe corrosive or fretting environment, a wear or galling environment, or a high maintenance environment should be determined from a review of the design and past service experience.

(C) The stresses and strains (steady and oscillatory) associated with all representative steady and maneuvering operating conditions expected in service.

(D) The frequency of occurrences of various flight conditions and the corresponding spectrum of loadings and stresses.

(E) The fatigue strength, fatigue crack propagation characteristics of the materials used and of the structure, and the residual strength of the damaged structure.

(F) Inspectability, inspection methods, and detectable flaw sizes.

(G) Variability of the measured stresses of paragraph f(6)(iv)(C), the actual flight condition occurrences of paragraph f(6)(iv)(D), and the fatigue strength material properties of paragraph f(6)(iv)(E).

(v) FLIGHT STRAIN MEASUREMENT PROGRAM.

(A) General. Subsequent to design analysis, in which aircraft loads and associated stresses are derived, the stress level or loads are to be verified by a carefully controlled flight strain measurement program. (This guidance is similar to that of AC 27-1B, MG 11.)

(B) Instrumentation.

(1) The instrumentation system used in the flight strain measurement program should accurately measure and record the critical strains under test conditions associated with normal operation and specific maneuvers. The location

and distribution of the strain gauges should be based on a rational evaluation of the critical stress areas. This may be accomplished by appropriate analytical means supplemented, when deemed necessary, by strain sensitive coatings or photoelastic methods. The distribution and number of strain gauges should cover the load spectrum adequately for each part essential to the safe operation of the rotorcraft as identified in § 29.573(c)(1). Other devices such as accelerometers may be used as appropriate.

(2) The corresponding flight parameters (airspeed, rotor RPM, center-of-gravity accelerations, etc.) should also be recorded simultaneously by appropriate methods. This is necessary to correlate the loads and stresses with the maneuver or operating conditions at which they occurred.

(3) The instrumentation system should be adequately calibrated and checked periodically throughout the flight strain measurement program to ensure consistent and accurate results.

(C) Parts to be Strain-Gauged. Fatigue critical portions of the rotor systems, control systems, landing gear, fuselage, and supporting structure for rotors, transmissions, and engine are to be strain-gauged. For rotorcraft of unusual or unique design, special consideration might be necessary to ensure that all the essential parts are evaluated.

(D) Flight Regimes and Conditions to be investigated.

(1) Typical flight and ground conditions to be investigated in the flight strain measurement program are given in paragraphs c. and d. of AC 27-1B, MG 11.

(2) The determination of flight conditions to be investigated in the flight strain measurement program should be based on the anticipated use of the rotorcraft and, if available, on past service records for similar designs. In any event, the flight conditions considered appropriate for the design and application should be representative of the actual operation in accordance with the rotorcraft flight manual. In the case of multiengine rotorcraft, the flight conditions concerning partial engine-out operation should be considered in addition to complete power-off operation. The flight conditions to be investigated should be submitted in connection with the flight evaluation program.

(3) The severity of the maneuvers investigated during the flight strain survey should be at least as severe as the maneuvers likely to occur in service.

(4) All flight conditions considered appropriate for the particular design are to be investigated over the complete rotor speed, airspeed, center of gravity, altitude, and weight ranges to determine the most critical stress levels associated with each flight condition. The temperature effects on loads as affected by

elastomeric components are to be investigated. To account for data scatter and to determine the stress levels present, a sufficient amount of data points should be obtained at each flight condition. Consideration can be given to the use of scatter factors in determining the sufficiency of data points. In some instances, the critical weight, center of gravity, and altitude ranges for the various maneuvers can be based on past experience with similar design. This procedure is acceptable where adequate flight tests are performed to substantiate such selections. The combinations of flight parameters that produce the most critical stress levels should be used in the evaluation.

(vi) FREQUENCY OF LOADING.

(A) Types of Operation.

(1) The probable types of operation (transport, utility, etc.) for the rotorcraft should be established. The type of operation can have a major influence on the loading environment. In the past, rotorcrafts have been substantiated for the most critical general types of operation with some consideration of special, occasional types of operation. To assure that the most critical types of operation are considered, each major rotorcraft structural component should be substantiated for the most critical types of operation as established by the manufacturer. The types of operation shown below should be considered and, if applicable, used in the substantiation:

(i) Long flights to remote sites (low ground-air-ground cycles but high cruising speeds).

(ii) Typical, general types of operation.

(iii) Short flights as used in logging operations.

(2) One means is to substantiate for the most severe type of operation; however, this method is not always economically feasible.

(3) A second means is to quantify the influence of mission type on fatigue damage by adding to or replacing hour limitations by flight cycle limitations (if properly defined and easily identifiable by the crew, for example: one landing, one load transportation). A special type of flight hour limitation replacement using factorization of flight hours for multiple types of operations may be feasible if continuing manufacturers' technical support is provided and documented; i.e., the manufacturer either provides the factorization analyses or checks them on a continuing basis for each type of rotorcraft operation.

(4) Where one or more operations are not among the general uses intended for the rotorcraft, the rotorcraft flight manual should state in the limitations section that the intended use of the rotorcraft does not include certain missions or repeated maneuvers (i.e., logging with its high number of takeoffs and

landings per hour). A note to this effect should also appear in the rotorcraft airworthiness limitations section of the maintenance manual prepared in accordance with §§ 29.573 and 29.1529.

(5) Should subsequent usage of the rotorcraft encompass a mission for which the original structural substantiation did not account, the effects of this new mission environment on the frequency of loading and structural substantiation should be addressed and where practicable, in the interest of safety, a reassessment made. If this reassessment indicates the necessity for revised retirement times, those new times may be limited to aircraft involved in the added mission provided:

(i) Changes are adopted through the airworthiness directives process, and;

(ii) Proper part re-identification is established;

(iii) A Rotorcraft Flight Manual (RFM) supplement outlining the limitations is approved;

(iv) An airworthiness limitations section (ALS) supplement is approved; or

(v) An appropriate combination of part re-identification, RFM supplement, or airworthiness limitation section supplement is approved.

(B) Loading Spectrum. The spectrum allocating percentage of time or frequencies of occurrence to flight conditions or maneuvers is to be based on the expected usage of the rotorcraft. This spectrum is to be established so that it is unlikely that actual usage will subject the structure to damage beyond that associated with the spectrum. Considerations to be included in developing this spectrum should include prior knowledge based on flight history recorder data, design limitations established in compliance with § 29.309, and recommended operating conditions and limitations specified in the rotorcraft flight manual or instructions for continued airworthiness (ICA). The distribution of times at various forward flight speeds should reflect not only the relation of these speeds to V_{NE} but also the recommended operating conditions in the rotorcraft flight manual or ICA that govern V_c or cruise speed. It is desirable to conduct the flight strain-gauge program by simulating the usage as determined previously, with continuous recording of stresses and loads, thus obtaining directly the stress or load spectra for structural elements.

(7) The seventh major area is the dynamic loading and response requirements of § 29.241, § 29.251, and § 29.629 for vibration and resonance frequency determination and separation for aeroelastic stability and stability margin determination for dynamically critical flight structure. Critical parts, locations, excitation modes, and separations should be identified and substantiated. This substantiation

should consist of analysis supported by tests and tests that account for repeated loading effects and environment exposure effects on critical properties, such as stiffness, mass, and damping. This must be accomplished to assure that the initial stiffness, residual stiffness, proper critical frequency design, and structural damping are provided as necessary to prevent vibration, resonance, and flutter problems.

(A) All vibration and resonance critical composite PSE must be identified and properly evaluated.

(B) All flutter-critical composite PSE must be identified and properly evaluated. This structure must be shown by analysis to be flutter free to 1.1 V_{NE} (or any other critical operating limit, such as V_D, for a VSTOL aircraft) with the extent of damage for which residual strength and stiffness are demonstrated.

(C) Where appropriate, crash impact dynamics considerations should be taken into account to ensure proper crash resistance and a proper level of occupant safety for an otherwise survivable impact.

(8) The eighth area is the special repair and continued airworthiness requirements of §§ 29.611, 29.1529, and 14 CFR part 29 Appendix A, for composite structures. When repair and continued airworthiness procedures are provided in service documents (including approved sections of the maintenance manual or instructions for continued airworthiness), the resulting repairs and maintenance provisions should be shown to provide structure which continually meets the guidance of paragraphs (1) through (7) of this AC. All certification-based repair and continued airworthiness standards, limits, and inspections must be clearly stated and their provisions and limitations clearly documented to ensure continued airworthiness. No composite structural repair should be attempted that is beyond the scope of the applicable approved Structural Repair Manual (SRM) without an engineering design approval by a qualified FAA/AUTHORITY designated representative.

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 27 and 29

[Docket No. FAA-YYYY- ; Notice No.]

RIN 2120- [If a RIN has been assigned to the project it can be found in the Semiannual Regulatory Agenda. However, if a RIN has not been assigned, the ARM analyst obtains the RIN from AGC–200 six months prior to publication.

Title: Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structure

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This document proposes to add type certification requirements for both normal and transport category rotorcraft to 14 CFR parts 27 and 29. This proposal would add airworthiness standards to evaluate the fatigue strength of composite rotorcraft structure using a damage tolerance philosophy. The current regulations were written for metallic structure and do not provide adequate certification standards for composite materials and structures. This proposal would add safety requirements for composite rotorcraft structure to address advances in composite structures technology. This proposal would provide increased safety by establishing internationally harmonized procedures to evaluate the fatigue strength of composite rotorcraft structure.

DATES: Send your comments on or before [Insert date 90 days after date of publication in the Federal Register].

ADDRESSES: Address your comments to the Docket Management System, U.S. Department of Transportation, Room Plaza 401, 400 Seventh Street, SW., Washington, DC 20590-0001. You must identify the docket number FAA-YYYY-XXXXX at the beginning of your comments, and you should submit two copies of your comments. If you wish to receive confirmation that FAA received your comments, include a self-addressed, stamped postcard.

You may also submit comments through the Internet to http://dms.dot.gov. You may review the public docket containing comments to these proposed regulations in person in the Dockets Office between 9:00 a.m. and 5:00 p.m., Monday through Friday, except Federal holidays. The Dockets Office is on the plaza level of the NASSIF Building at the Department of Transportation at the above address. Also, you may review public dockets on the Internet at http://dms.dot.gov.

FOR FURTHER INFORMATION CONTACT: Richard A. Monschke, Rotorcraft Directorate, Aircraft Certification Service, Rotorcraft Standards Staff, ASW-110, Federal Aviation Administration, Fort Worth, Texas, 76193-0110; telephone (817) 222-5116; facsimile (817) 222-5961; e-mail richard.a.monschke@ faa.gov.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to participate in the making of the proposed action by submitting such written data, views, or arguments, as they may desire.

Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this document also are invited. Substantive comments should be accompanied by cost estimates. Comments must identify the regulatory docket or notice number and be submitted in duplicate to the DOT Rules Docket address specified above.

All comments received, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking, will be filed in the docket. The docket is available for public inspection before and after the comment closing date.

All comments received, on or before the closing date, will be considered by the Administrator before taking action on this proposed rulemaking. Comments filed late will be considered as far as possible without incurring expense or delay. The proposals in this document may be changed in light of the comments received.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this document must include a pre-addressed, stamped postcard with those comments on which the following statement is made: "Comments to Docket No. FAA-YYYY-XXXX." The postcard will be date stamped and mailed to the commenter.

Availability of Rulemaking Documents

You can get an electronic copy using the Internet by taking the following steps:

(1) Go to the search function of the Department of Transportation's

electronic Docket Management System (DMS) web page (http://dms.dot.gov/search).

(2) On the search page type in the last four digits of the Docket number shown at the beginning of this notice. Click on "search."

(3) On the next page, which contains the Docket summary information for the Docket you selected, click on the document number of the item you wish to view.

You can also get an electronic copy using the Internet through the Office of Rulemaking's web page at http://www.faa.gov/avr/armhome.htm or the Federal Register's web page at http://www.access.gpo.gov/su_docs/aces/aces140.html.

You can also get a copy by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW, Washington, DC 20591, or by calling (202) 267-9680. Make sure to identify the docket number, notice number, or amendment number of this rulemaking.

Background

Statement of the Problem

The current FAR/JAR 27/29 regulations do not provide adequate certification standards for composite materials and structures. Certification has been based on advisory material and a very broad interpretation of the fatigue substantiation and the design and construction airworthiness standards. Some European authorities have issued special conditions because the advisory material is not supported by an adequate airworthiness standard. Industry and national regulatory authorities need to address these issues as related to the regulations and supporting advisory materials. There are also limitations in the current FAR/JAR 27/29 regulations for metallic structure. Although they differ from the concerns for composite structures, the solutions sought for composite and metal structures need to be compatible to avoid using conflicting recommendations to amend the same regulatory sections.

History

Certification and service experiences for composite rotorcraft structure over the last twenty-five years have suggested a need to reconsider the current FAR/JAR 27/29.571 regulations for damage tolerance and fatigue evaluation. To this end, an Aviation Rulemaking Advisory Committee (ARAC) working group (WG) was chartered to study the problems and make appropriate recommendations.

The international ARAC WG that assembled in 2000 consisted of industry practitioners, regulatory officials, and technical specialists, each with unique experiences from composite applications. The two co-chairmen, one from a U.S. manufacturer and the other from a European manufacturer, each had many years of rotorcraft industry experience with composite structures. The team included members familiar with the different rotorcraft structures, including airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, and transmission mountings. Such a balanced team was needed to develop recommendations that consider the unique technical issues and design characteristics for composites used in the different rotorcraft structures. Both Parts 27- and 29-category rotorcraft had industry representatives on the team.

The ARAC WG considered alternatives and determined that rulemaking action was required. It was felt that taking no action would result in continued confusion among and within manufacturers and authorities. Relying on advisory material only, as in the past, did not always alleviate the need for special conditions, and such material was not enforceable. The ARAC WG's effort resulted in recommendations for a standardized means of compliance that allowed for innovation and changes in technology. To accomplish the recommendations, the WG proposed new regulations, FAR/JAR 27.573 and 29.573, specific to composite structure. Advisory material to support the new regulations was developed concurrently. The above actions are responsive to the Terms of Reference (TOR).

The ARAC WG developed a two-year plan ending in 2002, which included producing a Notice of Proposed Rulemaking (NPRM) for each proposed rule and an Advisory Circular (AC) describing a means, but not the only means, of compliance for each rule. The following approach was used. First, rotorcraft industry applications and service histories, as well as the related certification experiences in composite damage tolerance and fatigue evaluation, were shared within the WG. Next, an initial concept for the new composite rule was developed and agreed to by all WG members. At the same time, the composite structures AC for the existing rule was updated to represent relevant WG experiences. Finally, the new rule and a new AC were proposed.

In reviewing composite structures experiences, it became evident that different safety concerns existed depending on the specific rotorcraft application. Many of the differences related to fatigue and accidental damage threats, design detail, and critical load cases. For example, rotor blades, which are dynamically loaded by predominately centrifugal forces, have different concerns than an airframe structure with significant compressive loads. As a result, the ARAC WG had to derive a general rule that was comprehensive for all types of rotorcraft structures. In addition, the AC needed to consider critical technical details and safety concerns of relevance to each specific composite application.

Statement of Issues

A number of issues justified work to develop a new rule and AC for damage tolerance and fatigue evaluation of composite rotorcraft structure. These included:

1) Existing regulations, FAR/JAR 27.571 and 29.571, do not clearly or completely describe the fatigue certification requirements for rotorcraft composite structure. The available advisory circulars also lack definitive guidance for the unique applications of composites to rotorcraft structure. The lack of regulatory requirements and lack of comprehensive advisory material has given rise to inconsistent interpretations from one rotorcraft certification project to another, resulting in different burdens upon industry to substantiate their composite structure. As discussed above, some authorities have found it necessary to issue special conditions to assure the certification requirements are met.

2) Some applicants have complained that the lack of an independent, rotorcraft composite structure rule has resulted in confusion because the links

between the current FAR/JAR 27.571 and 29.571 rules and the various advisory materials are not clear. The hierarchy among the existing rules, AC 20-107A, AC 29-2C, AC 27-1B, AC 27/29.571, AC 27/29 MG 8, and AC 27/29 MG 11 is convoluted and tortuous. New rules and AC material should alleviate this problem.

3) The new rules and advisory materials will integrate and reflect the different original equipment manufacturers' experiences wherein advantage can be taken of past service history and the lessons learned.

4) There have been significant changes in composite technology since the original advisory material was written. In recent years, there have been changes in design, analysis, testing, manufacturing, maintenance techniques, and maintenance procedures. The new regulations and advisory materials will take these changes into account.

The WG identified all relevant technical issues and narrowed the scope of the effort to only those concerns that need be addressed in the recommended rulemaking. Of special note, the WG recognizes the safety concerns relating to the sensitivity of composite structure to defects and service damage. As a result, the WG recommends that the new FAR/JAR 27.573 and 29.573 allow only a damage tolerance evaluation or a damage/flaw tolerant (safe-life) evaluation. Conventional (unflawed) safe-life evaluation will not be considered an option for composites.

Several other key technical issues were important points of discussion for the WG in their rulemaking efforts. A thorough damage threat assessment was believed crucial to defining the damage tolerance and fatigue evaluation for each principal structural element (PSE) of the rotorcraft. This was particularly of concern for composite structure where the primary threats relate to accidental damage events (e.g., impact) and anomalous manufacturing flaws. Clarity in describing the requirements that define inspection intervals and replacement times was also sought in order to give applicants some freedom in the approach taken for damage tolerance and fatigue evaluation of a given PSE. Finally, numerous details associated with different means of compliance were addressed in updating the AC for the existing rule and then drafting an AC for the new rule. Much of this effort relied on previous experiences from certification and good service histories.

Proper training of the engineering workforce on the issues of damage tolerance and fatigue evaluation of composite rotorcraft structures is also important. To this end, a joint FAA/JAA/industry workshop on the subject may be appropriate after the new rule and AC material complete the approval process. The ARAC WG members who support Mil Handbook 17 will also pursue an update to the handbook's detailed background on damage tolerance and fatigue of composite aircraft structures.

Reference Material

The following material was researched by the ARAC WG and contributed significantly to formulating these proposals. Copies may be found in Rules Docket No. XXXXX.

1. 14 CFR 27.571, Amdt. 27-26, March 6, 1990.

2. 14 CFR 29.571, Amdt. 29-28, October 27,1989.

3. AC 20-95, "Fatigue Evaluation of Rotorcraft Structure", May 18, 1976 .

4. AC 20-107A, "Composite Aircraft Structure", April 25, 1984.

5. AC 21-26, "Quality Control for the Manufacture of Composite Materials", June 26, 1989.

6. Proceedings, 42nd Mil-HDBK-17 Coordination Group Meeting, Addendum to Polymer Matrix Composites Coordination Group, "Chapter 5.

Damage Resistance and Damage Tolerance-new", 20-23 February 2001, Clearwater, Florida.

7. AC 29-2C, "Certification of Transport Category Rotorcraft", paragraphs AC 29 MG 8, "Substantiation of Composite Rotorcraft Structure", and AC 29 MG 11, "Fatigue Evaluation of Transport Category Rotorcraft Structure (including Flaw Tolerance)", September 30, 1999.

8. Rouchon, J. "Effects of Low Velocity Impact Damage on Primary Composite Aircraft Structures: The Certification Issue", Note 07/SP1/99, dated August 24, 1999.

9. Rauch, P. and Charreyre, A. "Damage-Tolerant Tail Rotor Blade for AS 332 L2 Super Puma Helicopter".

10. Adams, D.O., Chairman, The Fatigue Methodology Committee of the Aerospace Industries Association "Composites Qualification Criteria", dated 1995.

11. Dickson, B., Roesch, J., Adams, D.O., and Krasnowski, B. "Rotorcraft Fatigue and Damage Tolerance", prepared for the Technical Oversight Group on Aging Aircraft (TOGAA), January 1999.

12. Bansemir, H., Besson, J.-M., and Pfeifer, K. "Development and Substantiation of Composite Structures with Regard to Damage Tolerance", presented at the 27th European Rotorcraft Forum, September 11-14, 2001, Moscow, Russia.

13. Bansemir, H. and Muller, R. "The EC135 – Applied Advanced Technology", presented at the American Helicopter Society 53rd Annual Forum, April 29-May 1, 1997, Virginia Beach, Virginia.

14. Reddy, D.J. "Qualification Program of the Composite Main Rotor Blade for the Model 214B Helicopter", presented at the 35th Annual National Forum of the American Helicopter Society, May 1979, Washington, D.C.

15. Guzzetti, G., Mariani, U., and Oggioni, F. "Certification of the EH-101 Composite Components: A Comprehensive Approach", presented at the American Helicopter Society 51st Annual Forum, May 9-11,1995, Fort Worth, Texas.

The above materials, which were reviewed by the WG, provided state-of-the-art substantiation for current rotorcraft composite structures manufactured in both the United States and European industries. The certification of these structures, some of which are highly dynamically loaded, is based on the above references. Some national authorities issued special rules for composite structure substantiation such as the "Special Condition for Primary Structures Designed with Composite Material" issued by the Luftfarht-Bundesamt (LBA), the Federal Republic of Germany airworthiness authority. This special condition contained increased safety demands required by the LBA.

Special features addressed in the special condition are:

- An investigation of the structural components to determine which are suitable or unsuitable for a damage-tolerance evaluation and the related inspection procedures for those components.
- An investigation of the growth rate of damage, under repeated loads expected in service, that may occur from fatigue, corrosion, intrinsic flaws, manufacturing defects, and discrete source impact damage.
- Consideration of the effects of material variability.
- Consideration of the effects of environmental conditions such as the degradation of strength in composite structure due to heat and humidity over time.
- Residual strength requirements including consideration of manufacturing and impact damage.
- Substantiation of bonded joints.

WG review of the referenced material and industry experiences in both the United States and Europe indicate that proposed rulemaking is necessary for standardization within and between each of the airworthiness authorities, and also for the inclusion of increased safety standards offered by advances in technology.

Related Activity

A separate rotorcraft ARAC WG developed a damage tolerance rulemaking proposal for metallic structure. In order to ensure two rules were necessary and that the wording used in both was consistent, several of the same people served on both WG's. This also ensured that recommendations to amend the same regulatory sections were compatible. The need for separate composite and metal rules is discussed later in this document.

The evolution of composite technology used in rotorcraft structure is currently occurring at a fast pace. Such change suggests a need to periodically review the associated rules and AC's for composite damage tolerance and fatigue evaluation in the future. It is anticipated that new applications, service databases, and progress in research over the next five years will require that another ARAC WG be assembled to assess additional needs and updates in this area by 2007.

Current Requirements

Current practice has mainly relied upon the application of the requirements specified in advisory materials. The advisory materials are loosely related to §§ 27.571 and 29.571. The specific advisory materials are AC 20-107A, "Composite Aircraft Structure"; AC 27-1B, "Certification of Normal Category Rotorcraft", paragraph AC 27 MG 8, Substantiation of Composite Rotorcraft Structure; and AC 29-2C, "Certification of Transport Category Rotorcraft", paragraph AC 29 MG 8, Substantiation of Composite Rotorcraft Structure. There is no difference in the advisory material between AC 27 MG 8 and AC 29 MG 8. For the many reasons discussed above, the current practice is inadequate.

General Discussion of the Proposals

The need for a new rule was identified from the start of the ARAC WG efforts. Previous discussions provide the justification. Within the first year, a draft of §§ 27.573/29.573 was completed. Several refinements to the initial draft occurred as teammates proposed changes for clarity (see discussions below). The new rule that was eventually accepted by all teammates did not contain a traditional safe-life option. Specific references to discrete source damage conditions, such as those included in § 25.571, paragraph (e), were also not included because they were thought to be adequately covered by other Part 29 rules. After the draft proposals for composite and metal rules from each ARAC WG were completed, a comparison was made to determine whether they could be combined into one. A decision was made to maintain two separate rules based on the comparison (see discussions below).

Consideration of 23.573

The only other rule for damage tolerance and fatigue evaluation of structure that has special considerations for composite materials is paragraph (a) of §§ 23.573. Much of this Part 23 rule had details for composite airframe structures subjected to relatively low numbers of fatigue cycles. As a result, the ARAC WG felt it didn't contain the generality sought in a rule for the complete range of composite rotorcraft structures. In addition, any details from § 23.573, which have relevance to rotorcraft, can be found in the existing AC's (AC 27-1B and 29-2C). Note that these two AC's were updated by the ARAC WG to add details important to dynamic rotorcraft components.

Rationale for Separate Metal and Composite Rules

A number of reasons led to separate rules for the damage tolerance and fatigue evaluation of metal and composite structures. The primary reason was a need to emphasize different aspects of the evaluation as related to the most critical issues for each class of materials. Some unique material behaviors and sensitivities to different damage and loading conditions drive these issues. For example, the proposed title for the composite rule gives special attention to damage tolerance because fatigue is only one of several mechanisms that can reduce strength. In composites, low fatigue sensitivity often yields no growth behavior, whereas accidental damage from impact can immediately reduce residual strength. In metals, all critical damage types have sensitivities to fatigue loads; hence, the emphasis on fatigue tolerance in the proposed title for the metal rule, § 29.571.

Several other issues are emphasized in the composite rule. These include material and process variability and environmental effects. A requirement for ultimate loads is also applied for maximum acceptable manufacturing defects and service damage to provide an option for some rotorcraft structures and damage scenarios that justify an approach based on retirement times instead of inspection intervals. Finally, the proposed rule for composite structure is somewhat longer than the rule for metallic structure in order to provide more clarity on issues such as the threat assessment, which is closely associated with service history for composite structure.

Section-by-Section Discussion of the Proposals

Proposed §§ 27.573 and 29.573

There is no difference in the requirements between the proposed § 27.573 and § 29.573 for normal and transport category type certification of composite rotorcraft structure. Unless other procedures are approved, each section requires composite rotorcraft structure to be substantiated by a damage tolerance evaluation. The evaluation must show that catastrophic failure of such structure will be avoided throughout the operational life of the rotorcraft by establishing component replacement times or by establishing prescribed inspection intervals for those components that will detect any damage growth before the required residual strength is exceeded.

Key Language in the New Rule

The existing rule, § 29.571, provided a starting point for all work in drafting a separate composite rule. As a result, some details were retained as important to the new proposal. These included several steps in the evaluation, such as identification of PSE, in-flight measurements of loads, and definition of the loading spectra as severe as expected in operations. Other details were explained in greater detail for clarification purposes. The details that were eliminated related to a specific means of compliance. For example, the reference to flaw tolerance/safe-life and fail-safe evaluations were removed from the rule because it was realized that there were more general ways of describing the essence of each approach under damage tolerance. As mentioned earlier, the traditional safe-life option was removed because composites have sensitivities to defects and damage that must be considered in design and certification testing.

Several iterations in the proposed new rule occurred as the efforts of the ARAC WG progressed. Initially, all members desired an improved description of the requirements for defining the inspection intervals and retirement times. The discussion was expanded and given greater emphasis because inspection intervals and retirement times were believed to be important deliverables from a damage tolerance and fatigue evaluation.

The minimum residual strength requirement for any damage or defects that could be found by inspection was always tied to limit loads. Wording was added to also link the required residual strength to considerations of the probability of a given damage type, inspection interval, and damage detectability. This covered two purposes for composite structures. First, it was realized that one of the more critical threats--impact damage--could immediately lower residual strength well below ultimate loads when it occurs. The intent of the added words was to ensure that the lower the residual strength, the sooner that damage would be detected and repaired. The idea is that the inspection will catch any damage or defect growth so that the rotorcraft is exposed to a minimum time operating at less than an ultimate loads capability. Another purpose for the expanded wording was to address very rare damage (such as high-energy, blunt impacts) that could not be detected with the selected inspection schemes. Although the occurrence of such damage may have a very low probability, the expanded wording was intended to ensure that sufficient residual strength existed to ensure safety for such cases. Additional discussions were added to the AC, including illustrations, to help explain both of these cases.

There were numerous discussions on the load requirement for damage threats to structure, which were linked to retirement times. It was decided that the residual strength requirement for any damage not subjected to maintenance inspection should be linked to ultimate loads. A desire to establish a retirement time may occur either because the damage could not be found by inspection or the applicant elected not to burden the rotorcraft owners with repeated inspections. The rule was worded so that some damage scenarios for a given PSE could be covered by a retirement time (an ultimate load requirement), while others could be detected by inspection (a limit load requirement) and repaired to restore ultimate strength.

The new rule rearranged the location of several key points for purposes of clarity and emphasis. For all PSE, assessments of the damage threats and the residual strength and fatigue characteristics were moved to the list of requirements needed to ensure sufficient inspection intervals and/or replacement times. A paragraph on the need to consider the effects of damage on stiffness, dynamic behavior, loads, and functional performance was given more emphasis. In the existing rule, such words were limited in scope and only appeared under fail-safe evaluations. Some mechanisms of fatigue damage growth in rotorcraft composite structures can affect stiffness, dynamic behavior, and functional performance, without being a serious threat to residual strength.

The final section, paragraph (h), was added for special cases that were not completely covered by other discussions in the proposed rule. A rationale is required to deviate from the damage tolerance and fatigue evaluations described in paragraphs (c) through (g). Since it was believed that not all damage scenarios for PSE were likely to fall under the category of a special case, the specific types of damages must be defined and included in the rationale. Finally, supplemental procedures, added to the Instructions for Continued Airworthiness (§§ 27.1529 and 29.1529 and Sections A27.4 and A29.4 of Appendix A of Part 27 and 29, respectively), were required to minimize the risk of catastrophic failure due to such damage. An example of such a case discussed by the ARAC WG was that very rare damages such as high-energy, blunt impacts could not be found with the base field inspections used at scheduled maintenance inspections. As discussed previously, assuring sufficient residual strength can attain a sufficient level of safety for such damages. In addition, supplemental procedures may be defined to ensure maintenance organizations use more advanced field inspections or contact the manufacturer when a rare impact event is known to occur, regardless of the indications of damage when using the base inspection techniques. The WG decided to address such details in the AC.

Appendix A To Parts 27 and 29 – Airworthiness Limitations section

The second sentence in paragraphs A27.4 and A29.4, Airworthiness Limitations section, would be revised to read, "This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure approved under §§ 27.571 and 27.573 and "§§ 29.571 and 29.573, respectively."

These revisions would ensure that the replacement times, inspection intervals, and related structural inspection procedures generated by the requirements of the new §§ 27.573 and 29.573 are included in the Airworthiness Limitations section of the maintenance manual.

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. We have determined that there are no new information collection requirements associated with this proposed rule.

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA determined that there are no ICAO Standards and Recommended Practices that correspond to these proposed regulations.

Economic Evaluation, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

[Insert summary of the economic evaluation prepared by APO.] Economic Evaluation, Regulatory Flexibility Determination, Trade Impact Assessment, and Unfunded Mandates Assessment [APO is responsible for drafting the Regulatory Evaluation Summary. This section should contain a brief summary of the full regulatory evaluation or analysis being placed in the docket. It should not restate background information because this information is found elsewhere in the document. Subheadings such as "Benefits," "Costs," and "Benefit/Cost Comparison" may be used, as appropriate, after the introductory language.]

Proposed changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency propose or adopt a regulation only upon a determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. section 2531-2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act also requires agencies to consider international standards and, where appropriate, use them as the basis of U.S. standards. And fourth, the Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by private sector, of $100 million or more annually (adjusted for inflation).

In conducting these analyses, FAA has determined this rule (1) [has/does not have benefits which [do] justify its costs, [is/is not] a "significant regulatory action" as defined in section 3(f) of Executive Order 12866 and [is/is not] "significant" as defined in DOT's Regulatory Policies and Procedures; (2) [will/will not] have a significant impact on a substantial number of small entities; (3)

[will/will not] reduce barriers to international trade; and (4) [does/does not] impose an unfunded mandate on state, local, or tribal governments, or on the private sector. These analyses, available in the docket, are summarized below.

The purpose of this [proposal/rule] is to . . .[summarize what rule does economically].

Regulatory Flexibility Act [APO provides the following paragraph.]

The Regulatory Flexibility Act (RFA) of 1980, 5 U.S.C. 601–612, directs the FAA to fit regulatory requirements to the scale of the business, organizations, and governmental jurisdictions subject to the regulation. We are required to determine whether a proposed or final action will have a "significant economic impact on a substantial number of small entities" as defined in the Act. If we find that the action will have a significant impact, we must do a "regulatory flexibility analysis."

This [proposed/final] rule [say what rule does]. ..... Therefore, we certify that this action [will/will not} have a significant economic impact on a substantial number of small entities.

Trade Impact Assessment [APO is responsible for drafting this statement, which should contain a brief summary of the international trade impact statement contained in the full economic evaluation as placed in the docket.]

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards or related activity that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In addition, consistent with the Administration's belief in the general superiority and desirability of free trade, it is the policy of the Administration to remove or diminish, to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and barriers affecting the import of foreign goods and services to into the U.S.

In accordance with the above statute and policy, the FAA has assessed the potential effect of this rulemaking and has determined that it will [Choose from choices below to finish sentence.]

1) have only a domestic impact and therefore no effect on any trade-sensitive activity.

OR

2) impose the same costs on domestic and international entities and thus has a neutral trade impact.

OR

3) accept European standards as the basis for U.S. regulations and supports the Administration's policy on free trade.

OR

4) reduce trade barriers by narrowing the difference between the U.S. and ________________ regulations.

OR

5) have some potential effect on trade sensitive activities as discussed

below.

Unfunded Mandates Assessment [APO is responsible for developing this analysis. The following language may need to be revised based on the proposed rule.]

The Unfunded Mandates Reform Act of 1995 (the Act), enacted as Public Law 104-4 on March 22, 1995, is intended, among other things, to curb the practice of imposing unfunded Federal mandates on State, local, and tribal governments. Title II of the Act requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in a $100 million or more expenditure (adjusted annually for inflation) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a "significant regulatory action."

This notice does not contain such a mandate. Therefore, the requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply.

Executive Order 13132, Federalism [Provided by AGC]

The FAA has analyzed this proposed rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action would not have a substantial direct effect 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, we determined that this notice of proposed rulemaking would not have federalism implications.

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental impact statement. In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), this proposed rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the notice has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Public Law 94-163, as amended (42 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the notice is not a major regulatory action under the provisions of the EPCA.

List of Subjects

14 CFR Parts 27 and 29

Air transportation, Aircraft, Aviation safety, Rotorcraft, Safety.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend Chapter I of Title 14, Code of Federal Regulations, as follows:

PART27-AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

1. The authority citation for part 27 is revised to read as follows:

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

2. Add a new § 27.573 to read as follows:

* * * * *

§ 27.573 Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structure

(a) Composite rotorcraft structure must be evaluated under the damage tolerance paragraphs (b) through (g) of this section unless shown to be impractical within the limitations of geometry, inspectability, and good design practice. If the applicant establishes that the full damage tolerance criterion is impractical for a particular structure, that structure must be evaluated in accordance with requirements of paragraph (h) of this section.

(b) The compliance methodology must be submitted to the regulatory authority for approval.

(c) Damage tolerance evaluations of the strength of principal composite structural elements or components, detail design points, and fabrication techniques must show that catastrophic failure due to static and fatigue load requirements, considering the intrinsic/discrete manufacturing defects or accidental damage, will be avoided throughout the operational life or prescribed inspection intervals of the rotorcraft. The effects of material and process variability along with environmental conditions must be accounted for in the strength and fatigue evaluations. Parts to be evaluated must include, but are not limited to, principal structural elements of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, and transmission mountings. Each evaluation required by this section must include:

(1) The identification of principal structural elements (PSE), the failure of which could result in catastrophic failure of the rotorcraft.

(2) In-flight measurements in determining the loads or stresses for items identified in paragraph (c)(1) of this section for all critical conditions throughout the range of limitations in § 27.309 including altitude effects, except that maneuvering load factors need not exceed the maximum values expected in operations.

(3) Loading spectra as severe as those expected in operation based on loads or stresses determined under paragraph (c)(2) of this section, including external load operations, if applicable, and other operations including high-torque events.

(4) A threat assessment for the PSE identified in paragraph (c)(1) of this section that determines the probable locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic/discrete flaws, and impact or other accidental damage (including discrete source) that may occur during manufacture or operation.

(5) An assessment of the residual strength and fatigue characteristics of the PSE as needed to support compliance with paragraphs (e) and (f) of this section.

(d) For each element identified in paragraph (c)(1) of this section, inspections, replacement times, or other procedures must be established as necessary to avoid catastrophic failure. These inspections, replacement times, or other procedures must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 27.1529 and section A27.4 of Appendix A of this part.

(e) Replacement times must be demonstrated by tests or by analysis supported by tests, to ensure that the structure is able to withstand the repeated loads of variable magnitude expected in service. In establishing these replacement times, the following items must be considered:

(1) Damage identified by the threats in paragraph (c)(4) of this section.

(2) Maximum acceptable manufacturing defects and service damage (i.e., those that do not lower the residual strength below ultimate design loads and those that can be repaired to restore ultimate strength).

(3) Ultimate load strength capability must be shown after application of repeated loads.

(f) Inspection intervals must be established to ensure that any damage identified in paragraph (c)(4) of this section that may occur from fatigue and/or other in-service causes will be detected before it has grown to the extent that the required residual strength capability cannot be achieved. In establishing these inspection intervals the following items must be considered:

(1) The growth rate or no-growth of the damage under the repeated loads expected in-service must be determined by test or analysis supported by test.

(2) The required residual strength for the assumed damage must be

established considering the damage type, inspection interval, detectability of damage, and the techniques adopted for damage detection. The minimum required residual strength is limit load.

(3) The initial inspection and the repetitive inspection intervals must be established to ensure that the damage growth is detected and residual strength restored to ultimate load capability or the component must be replaced.

(g) The effect of damage on stiffness, dynamic behavior, loads, and functional performance must be considered in establishing the allowable damage size and inspection interval.

(h) If the damage tolerance evaluations described above cannot be achieved within the limitations of geometry, inspectability, or good design practice,a fatigue evaluation usingthe following procedures must be performed:

(1) A rationale must be provided to demonstrate that the damage tolerance criteria prescribed by paragraphs (c) through (g) of this section cannot be satisfied.

(2) The types of damage considered in this evaluation must be defined.

(3) Supplemental procedures must be established to minimize the risk of catastrophic failure associated with the damages identified in paragraph h(2) of this section.

(4) These supplemental procedures must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 27.1529 and section A27.4 of Appendix A of this part.

* * * * *

3. APPENDIX A TO PART 27-INSTRUCTIONS FOR CONTINUED AIRWORTHINESS is amended by revising the second sentence of section A.27.4, *Airworthiness Limitations section,* to read as follows:

* * * * *

"This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure approved under §§ 27.571 and 27.573."

* * * * *

PART 29-AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

4. The authority citation for part 29 continues to read as follows:

Authority: 49U.S.C49 U.S.C. 106(g) 40113, 44701 – 44702, 44704

5. Add a new § 29.573 to read as follows:

* * * * *

§ 29.573 Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structure

(a) Composite rotorcraft structure must be evaluated under the damage tolerance paragraphs (b) through (g) of this section unless shown to be impractical within the limitations of geometry, inspectability, and good design practice. If the applicant establishes that the full damage tolerance criterion is impractical for a particular structure, that structure must be evaluated in accordance with requirements of paragraph (h) of this section.

(b) The compliance methodology must be submitted to the regulatory authority for approval.

(c) Damage tolerance evaluations of the strength of principal composite structural elements or components, detail design points, and fabrication techniques must show that catastrophic failure due to static and fatigue load requirements, considering the intrinsic/discrete manufacturing defects or accidental damage, will be avoided throughout the operational life or prescribed inspection intervals of the rotorcraft. The effects of material and process variability along with environmental conditions must be accounted for in the strength and fatigue evaluations. Parts to be evaluated must include, but are not limited to, principal structural elements (PSE) of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, and transmission mountings. Each evaluation required by this section must include:

(1) The identification of principal structural elements, the failure of which could result in catastrophic failure of the rotorcraft.

(2) In-flight measurements in determining the loads or stresses for items identified in paragraph (c)(1) of this section for all critical conditions throughout the range of limitations in § 29.309 including altitude effects, except that maneuvering load factors need not exceed the maximum values expected in operations.

(3) Loading spectra as severe as those expected in operation based on loads or stresses determined under paragraph (c)(2) of this section, including external load operations, if applicable, and other operations including high-torque

events.

(4) A threat assessment for the PSE identified in paragraph (c)(1) of this section that determines the probable locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic/discrete flaws, and impact or other accidental damage (including discrete source) that may occur during manufacture or operation.

(5) An assessment of the residual strength and fatigue characteristics of the PSE as needed to support compliance with paragraphs (e) and (f) of this section.

(d) For each element identified in paragraph (c)(1) of this section, inspections, replacement times, or other procedures must be established as necessary to avoid catastrophic failure. These inspections, replacement times, or other procedures must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 29.1529 and section A29.4 of Appendix A of this part.

(e) Replacement times must be demonstrated by tests or by analysis supported by tests, to ensure that the structure is able to withstand the repeated loads of variable magnitude expected in service. In establishing these replacement times, the following items must be considered:

(1) Damage identified by the threats in paragraph (c)(4) of this section.

(2) Maximum acceptable manufacturing defects and service damage (i.e., those that do not lower the residual strength below ultimate design loads and those that can be repaired to restore ultimate strength).

(3) Ultimate load strength capability must be shown after application of repeated loads.

(f) Inspection intervals must be established to ensure that any damage identified in paragraph (c)(4) of this section that may occur from fatigue and/or other in-service causes will be detected before it has grown to the extent that the required residual strength capability cannot be achieved. In establishing these inspection intervals the following items must be considered:

(1) The growth rate or no-growth of the damage under the repeated loads expected in-service must be determined by test or analysis supported by test.

(2) The required residual strength for the assumed damage must be established considering the damage type, inspection interval, detectability of damage, and the techniques adopted for damage detection. The minimum required residual strength is limit load.

(3) The initial inspection and the repetitive inspection intervals must be established to ensure that the damage growth is detected and residual strength restored to ultimate load capability or the component must be replaced.

(g) The effect of damage on stiffness, dynamic behavior, loads, and functional performance must be considered in establishing the allowable damage size and inspection interval.

(h) If the damage tolerance evaluations, as described above, cannot be achieved within the limitations of geometry, inspectability, or good design practice,a fatigue evaluation usingthe following procedures must be performed:

(1) A rationale must be provided to demonstrate that the damage

tolerance criteria prescribed by paragraphs (c) through (g) of this section cannot be satisfied.

(2) The types of damage considered in this evaluation must be defined.

(3) Supplemental procedures must be established to minimize the risk of catastrophic failure associated with the damages identified in paragraph (h)(2) of this section.

(4) These supplemental procedures must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 29.1529 and section A29.4 of Appendix A of this part.

* * * * *

6. APPENDIX A TO PART 29-INSTRUCTIONS FOR CONTINUED AIRWORTHINESS is amended by revising the second sentence of section A.29.4, *Airworthiness Limitations section,* to read as follows:

* * * * *

"This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure approved under §§ 29.571 and 29.573."

* * * * *

Issued in Washington, DC, on .

[The date of issuance is the signature date.]

[Name of Office Director]

[Title of Office Director]

[Name and title of the individual signing the NPRM. Generally, the OPI director. If the individual signing the NPRM is "acting" for another individual, this must be noted in the signature block.]

§ 25.253 High-speed characteristics.

(a) * * *

(4) Adequate roll capability to assure a prompt recovery from a lateral upset condition must be available at any speed up to V_{DF}/M_{DF}.

(5) With the airplane trimmed at V_{MO}/M_{MO}, extension of the speedbrakes over the available range of movements of the pilot's control, at all speeds above V_{MO}/M_{MO}, but not so high that V_{DF}/M_{DF} would be exceeded during the maneuver, must not result in:

(i) An excessive positive load factor when the pilot does not take action to counteract the effects of extension;

(ii) Buffeting that would impair the pilot's ability to read the instruments or control the airplane for recovery; or

(iii) A nose down pitching moment, unless it is small.

(b) *Maximum speed for stability characteristics, V_{FC}/M_{FC}.* V_{FC}/M_{FC} is the maximum speed at which the requirements of §§ 25.143(g), 25.147(f), 25.175(b)(1), 25.177(a) through (c), and 25.181 must be met with flaps and landing gear retracted. Except as noted in § 25.253(c), V_{FC}/M_{FC} may not be less than a speed midway between V_{MO}/M_{MO} and V_{DF}/M_{DF}, except that, for altitudes where Mach number is the limiting factor, M_{FC} need not exceed the Mach number at which effective speed warning occurs.

(c) *Maximum speed for stability characteristics in icing conditions.* The maximum speed for stability characteristics with the ice accretions defined in appendix C, at which the requirements of §§ 25.143(g), 25.147(f), 25.175(b)(1), 25.177(a) through (c), and 25.181 must be met, is the lower of:

* * * * *

Issued in Washington, DC, on November 1, 2011.

J. Randolph Babbitt,

Administrator.

[FR Doc. 2011–30954 Filed 11–30–11; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 27 and 29

[Docket No.: FAA–2009–0660; Amdt. Nos. 27–47, 29–54]

RIN 2120–AJ52

Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This rule revises airworthiness standards for type certification requirements of normal and transport category rotorcraft. The amendment requires evaluation of fatigue and residual static strength of composite rotorcraft structures using a damage tolerance evaluation, or a fatigue evaluation if the applicant establishes that a damage tolerance evaluation is impractical. The amendment addresses advances in composite structures technology and provides internationally harmonized standards.

DATES: Effective January 30, 2012.

ADDRESSES: For information on where to obtain copies of rulemaking documents and other information related to this final rule, see "How To Obtain Additional Information" at the end of the **SUPPLEMENTARY INFORMATION** section of this document.

FOR FURTHER INFORMATION CONTACT: For technical questions concerning this action, contact Sharon Y. Miles, Regulations and Policy Group, Rotorcraft Directorate, ASW–111, Federal Aviation Administration, 2601 Meacham Boulevard Fort Worth, Texas 76137–0111; telephone (817) 222–5122; facsimile (817) 222–5961; email *sharon.y.miles@faa.gov.* For legal questions concerning this action, contact Steve C. Harold, Directorate Counsel, ASW–7G1, Federal Aviation Administration, 2601 Meacham Boulevard Fort Worth, Texas 76137–0007, telephone (817) 222–5099; facsimile (817) 222–5945, email *steve.c.harold@faa.gov.*

SUPPLEMENTARY INFORMATION:

Authority for This Rulemaking

The FAA's authority to issue rules on aviation safety is found in Title 49 of the United States Code. Subtitle I, section 106, describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in subtitle VII, part A, subpart III, section 44701, "General Requirements," Section 44702, "Issuance of Certificates," and Section 44704, "Type Certificates, Production Certificates, and Airworthiness Certificates." Under Section 44701, the FAA is charged with prescribing regulations and minimum standards for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. Under Section 44702, the Administrator may issue various certificates including type certificates, production certificates, air agency certificates, and airworthiness certificates. Under Section 44704, the Administrator must issue type certificates for aircraft, aircraft engines, propellers, and specified appliances when the Administrator finds the product is properly designed and manufactured, performs properly, and meets the regulations and minimum standards prescribed under section 44701(a). This regulation is within the scope of these authorities because it will promote safety of composite structures by updating the existing minimum prescribed standards, used during the type certification process, to address advances in composite structural fatigue substantiation technology. It will also harmonize this standard with international standards for evaluating the fatigue strength of normal and transport category rotorcraft composite primary structural elements.

I. Overview of Final Rule

Composite structures present unique material behaviors and react differently from metallic structures to damage and loading conditions. This rule addresses the unique characteristics of composite materials and requires applicants to evaluate these materials in a different manner from traditional metallic materials. This rulemaking addresses the type certification requirements for substantiating and certifying composite rotorcraft structures, including different aspects of the evaluation for the most critical issues for each class of materials.

This rule changes the certification standards in areas of frequent non-standardization and misinterpretation by applicants for certification of rotorcraft composite structures. This rule is intended to require damage tolerance and fatigue evaluation of composite structures in order to prevent reduction of structural strength of rotorcraft. In composite structures, low cycle fatigue often yields minimal damage growth, whereas accidental damage from impact can immediately reduce residual structural strength. This is different in metals, where any critical damage to the structure is sensitive to cyclic fatigue loads.

These rule changes also address material and process variability and environmental effects. A strength requirement for ultimate loads will be applied when maximum acceptable manufacturing defects and service damage are present. However, these rule changes provide an exception to the requirement for a damage tolerance evaluation if the applicant can establish that the damage tolerance evaluation is impractical within the limits of geometry, inspectability, and good design practice. In that instance, the applicant may be allowed to perform a fatigue evaluation for some rotorcraft structures and damage scenarios based on supplemental procedures, such as establishing a retirement time. Under this exception, an applicant could demonstrate that certain damage will not grow or does not grow beyond a certain threshold or size, and that the damaged structure could still carry ultimate loads. In this case, an inspection may not be necessary and the structure could be assigned a retirement life instead of a required inspection program. Further, this rule will require an applicant to conduct a threat assessment, which is associated with the service history of composite structures.

The rule requires that applicants consider varying types of damage, loading conditions, threat assessments, manufacturing defects, and the residual strength associated with composite structures. In developing these requirements, the FAA recognized that it may be impractical within the limits of geometry, inspectability, or good design practice to evaluate all the composite structures of a rotorcraft using a damage tolerance evaluation. Therefore, the rule allows for a fatigue evaluation of particular rotorcraft composite structures under §§ 27.573(e) and 29.573(e), where appropriate, if the applicant can establish that performing a damage tolerance evaluation is impractical within the limits of geometry, inspectability, and good design practice for those principal structural elements (PSEs). As part of the approval process for fatigue evaluation of a particular rotorcraft composite structure, the applicant will be required to identify the PSEs and the types of damage considered, establish supplemental procedures to minimize the risk of catastrophic failure associated with those types of damage, and include procedures in the Airworthiness Limitation section of the Instructions for Continued Airworthiness. These requirements minimize the risk of catastrophic failure of composite structures used on rotorcraft certificated in accordance with part 27 and part 29 standards.

A. Key Provisions in the New Rule

Some of the requirements for evaluating composite structures came from the current § 29.571 standards. These requirements in the evaluation process include certain steps, such as identification of the PSEs, the in-flight measurements of loads, and the use of loading spectra, as severe as those expected in-service. These rule changes add more detailed steps and do not refer to the current flaw tolerant safe-life and fail-safe evaluations because there are more suitable ways of describing each approach under damage tolerance. Further, this rule does not refer to the traditional safe-life method because composites have sensitivities to defects and damage that must be considered in design and certification testing that makes the traditional safe-life method inappropriate.

These rule changes revise the standards for determining inspection intervals and retirement times based on results of damage tolerance and fatigue evaluation. Currently, the minimum residual structural strength requirement for any damage or defect that can be found by inspection is tied to limit loads (maximum loads to be expected in service). These rule changes link the required residual structural strength to the probability of a given damage type, inspection interval, and damage detectability. This link is necessary for at least two reasons. First, one of the more critical threats—impact damage—could immediately lower residual structural strength to well below ultimate loads (limit loads multiplied by prescribed factors of safety) if it occurs. These requirements will help ensure that, as the residual structural strength is lowered, the earlier damage will be detected and repaired. Inspections will be required that will be frequent and comprehensive enough to reveal any damage or defect growth to minimize the time that the rotorcraft might be operated at less than an ultimate load capability. Second, the requirements address rare damage (such as a high-energy, blunt impact) that is not detectable with the currently prescribed inspection schemes for aircraft in operational service. Although such damage may have a low probability of occurring, the rules require that sufficient residual structural strength exists to compensate for such damage.

These rule changes require that all PSEs, the failure of which could result in catastrophic failure of the rotorcraft, meet ultimate load residual structural strength requirements or require a retirement time if there could be any damage that may not be found by a maintenance inspection. Under this rule, an applicant will establish a retirement time to address the damage that may not be found by inspection or to eliminate the burden of the repeated inspection by the rotorcraft owners. For damage detectable by inspection, the rule establishes a limit load requirement to repair and restore the structure to its ultimate strength capability.

These rule changes add all PSE assessments for damage threats, residual strength, and fatigue characteristics to the list of requirements for inspection intervals or require replacement times as stated in §§ 27.573(d)(2) and 29.573(d)(2). The fatigue evaluation will include the PSEs of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, engine and transmission mountings, landing gear, and other parts. In addition, performing damage tolerance evaluations of the strength of composite detail design points and fabrication techniques is considered critical by the FAA to avoid catastrophic failure due to static or fatigue loads.

The rule requires consideration of the effects of fatigue damage on stiffness, dynamic behavior, loads, and functional performance of composite structures. These characteristics are not considered to be a serious threat to residual structural strength. Currently, such requirements are limited to fail-safe evaluations.

The FAA recognizes there may be limited cases in which a damage tolerance evaluation may be impractical. In these rare cases, the applicant is required to identify the nature of the evaluation and provide a justification to the FAA for the impracticality determination. The justification must support the specific types of damage to the PSE to qualify for a fatigue evaluation. Finally, the rule requires the applicant to establish replacement times, structural inspection intervals, and related structural inspection procedures to minimize the risk of catastrophic failure because of PSE damage. The required replacement times, inspection intervals, and structural inspections will be included in the Instructions for Continued Airworthiness as required by §§ 27.1529 and 29.1529.

Additionally, the FAA recognizes that rare types of damage, such as high-energy, blunt impacts may not be uncovered as part of a base field inspection during scheduled maintenance inspection intervals. Therefore, this rule requires that the applicant substantiate sufficient residual structural strength to maintain an adequate level of safety in the event of an occurrence of rare damage. Supplemental procedures may be required to adequately address rare impact damage.

B. Airworthiness Limitations Section (Appendix A to Parts 27 and 29)

These sections require the mandatory replacement times, structural inspection intervals, and related structural inspection procedures produced under the requirements of §§ 27.571 and 29.571, the new §§ 27.573 and 29.573, and any other similar requirement for type certification be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness.

C. Benefit-Cost Comparison

This final rule adopts as regulatory requirements past FAA and industry practice regarding the use of composites on rotorcraft, including special conditions and advisory circulars. Although we anticipate both cost savings and improved safety as a consequence of the requirement for testing, inspection, and replacement schedules, we are unable to quantify these benefits. Nevertheless, based on industry-provided data, we believe that this final rule will yield benefits exceeding the estimated costs.

II. Background and Statement of the Issues

The evolution of composite technology used in rotorcraft structures is advancing rapidly. These rapid changes, along with the increased use of composites in rotorcraft structures, issues discovered during certification of composite structures, and service experiences of composite rotorcraft structures over the last 25 years, have caused us to reconsider the current regulations and guidance materials for damage tolerance and fatigue evaluation and to address the state of technology in composite structures. The current certification process is based on a broad interpretation of metallic fatigue substantiation and the design and construction airworthiness standards. However, composite and metal structures are different. Composites are complex materials that have unique advantages in fatigue strength, weight, and tolerance to damage. The methodologies for evaluating metallic structures are not necessarily suitable for composite structures. Because composite structures differ from metallic structures, the current regulations, §§ 27.571 and 29.571, do not adequately provide the fatigue certification requirements for composite rotorcraft structures.

This may lead to inconsistent interpretations from one rotorcraft certification project to another, resulting in different burdens on applicants to substantiate their composite rotorcraft structures. It has also caused confusion for some certification applicants. These applicants state there is no clear, complete guidance for certification of composite rotorcraft structures.

To address these concerns, the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC) [1] through its Composite Rotorcraft Structure working group to provide advice and recommendations as follows:

- Recommend revisions to FAA Regulations/Joint Aviation Regulations (JAR) parts 27 and 29 for composite structures that are harmonized.
- Evaluate and recommend, as appropriate, regulations, advisory material, and related guidance to achieve the goal of improved tolerance to flaws and defects in composite structure with methodology and procedures that are practical and appropriate to rotorcraft.

This rule is based on ARAC's recommendations to the FAA. The recommendations have been placed in the docket for this rulemaking.

A. Related Activity

At the same time ARAC was tasked with providing advice and recommendations for composite rotorcraft structures, they were also tasked with providing advice and recommendations for metallic rotorcraft structures. However, because of the unique characteristics and structural capabilities of composite structures, the FAA established a separate rule for the damage tolerance and fatigue evaluations of rotorcraft composite structures. In response to the ARAC recommendations for improved standards for metallic structures, the FAA has developed a separate rule entitled ''Fatigue Tolerance Evaluation of Metallic Structures.''

B. Summary of the NPRM

The FAA published the NPRM for this composite structures rule in the **Federal Register** on January 6, 2010 (75 FR 793). The comment period for the NPRM closed on April 6, 2010. However, in response to a European Aviation Safety Agency (EASA) request, the FAA subsequently reopened the comment period to July 16, 2010 (published in the **Federal Register** on May 5, 2010, 75 FR 24502). The FAA received 12 comments to the docket on the NPRM. Commenters included two manufacturers, a government agency, and an engineering company.

C. General Overview of Comments

The FAA received various comments from four commenters—Adhesion Associates, Eurocopter France, Sikorsky Aircraft, and Transport Canada. All of the commenters generally supported the proposed changes; however, some suggested changes and clarifications to the rule, as discussed more fully in the next section of this document. The FAA received comments on the following general areas of the proposal.

- Definition of the term ''composites.''
- Reconciling differences related to compliance methodology approval authority between § 29.571 (metallics) and § 29.573 (composites).
- Reevaluating the economic impact of the rule.
- The manner of the application of ''safe life evaluation'' as established in the Advisory Circular (AC) 27–1B or 29–2C, Miscellaneous Guidance-08 and its relationship to these new rule changes.
- Rewording To clarify that the application of the changes to the Appendix A required by this rule applies to structures only.
- Requesting further rulemaking to address the potential for subsequent service adhesion failures and the effect of micro-voiding on bonding strength.

III. Discussion of Public Comments and Final Rule

Definition of the Term ''Composites''

Sikorsky Aircraft recommended a further definition of ''composites,'' beyond that contained in Advisory Circular (AC) 21–26, because it believes this is a necessary part of compliance for determining, for a given structure, whether to use § 29.571 or § 29.573.

The term ''composites'' is widely understood throughout the aviation industry to be different materials that are bonded or composed to create a structural component material. It has been defined in AC 21–26 as a material containing two or more distinct materials (fillers, reinforcing materials, and compatible plastic resin) designed to exhibit specific performance properties. A further definition is unnecessary. This definition is consistent with the FAA intent when it uses the term ''composites'' in both §§ 27.573 and 29.573. Therefore, the FAA is adopting the rule as proposed.

Reconciling Difference Between This Rule and the § 29.571 (Metallics) Rule, in the Approval Authority of Compliance Methodology and Methodology Results

Sikorsky Aircraft identified the difference between §§ 27.573 and 29.573, which refer to FAA approval, and § 29.571 (metallics), which refers to the Administrator's approval. It states that the language used in the approval process should be similar for § 29.571 (metallics) and § 29.573 (composites).

[1] Published in the **Federal Register**, April 5, 2000 (65 FR 17936).

The FAA agrees that this could cause confusion. The wording is changed in this rule to make it consistent with the wording in § 29.571 (metallics). The intent of §§ 29.571, 27.573, and 29.573 is that the approval of the methodology for the evaluation remains with the FAA (Administrator).

Re-Wording To Clarify That Changes to the Appendix Apply to Structures Only

Eurocopter France recommended rewording the proposed amended language to part 29, Appendix A, from ''required for type certification'' to ''required for type certification of structures'' to eliminate addressing non-structural elements. It further recommended implementation of the policy statement ASW–100–09–003 (Subj: Policy Statement Concerning Life Limits and Instructions for Continued Airworthiness for Rotorcraft), and for the FAA to address mandatory Instruction for Continued Airworthiness (ICA) for non-structural elements through a new rulemaking task, in coordination with the European Aviation Safety Agency (EASA).

The intent of the policy statement and this rule is to require that any life limit or required inspection interval for type certification is included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness. This is the same wording used in the current 14 CFR part 23, Appendix G23.4. This is also consistent with the intent of the airworthiness limitations section of the Appendix to highlight certification limitations regardless of whether they are structural or non-structural.

The FAA does not anticipate further rulemaking to implement the policy statement because it does not differentiate between structural or non-structural elements. Therefore, the FAA is adopting the provision as proposed.

Cost Estimates to the Economic Impact of the Rules

Sikorsky Aircraft believes the cost estimates for this rule should be calculated based on 12,000 hours per certification project.

Based on this commenter's cost estimate of 12,000 hours, at $86 per hour, the total nominal dollar estimate will be $1,032,000 ($567,000 in present value). The original hours provided in the ARAC recommendation were 8290 hours at $86 per hour. Taking into account the intervening 27 years, the present value difference between these estimates is $175,000. Based on this information, we estimate the nominal total compliance costs of this final rule to be between our original estimate of $713,000 and the commenter based estimate of $1,032,000.

Acceptability of ''Traditional Safe Life'' Approach in the Context of Flaw Tolerance Requirements, and the Application of ACs 27–1B and 29–2C, Miscellaneous Guidance (MG) 8, Paragraph g(6)(iii)(C)) (Safe Life Evaluation)

Transport Canada requested confirmation of the FAA's position concerning the acceptability of the ''traditional safe life'' approach for flaw tolerance requirements, and asks that the FAA consider amending MG 8 to clarify that the ''traditional safe life'' is not appropriate for composites, if that is the case. Transport Canada further suggested that the FAA amend §§ 27.573 and 29.573 to include clarification to this effect, since the flaw tolerance concept is applicable to both static and fatigue strength, and to consider incorporating into the new rule requirements for environmental conditions, maximum manufacturing defects and service damages, and the effect of repeat loading (after fatigue).

Intentionally, the proposed rule did not address flaw tolerance or safe life. This was only addressed in MG 8 based on the requirements of the current § 29.571. The requirement is for evaluating damage tolerance as addressed in paragraphs (d) of §§ 27.573 and 29.573. If impractical, paragraph (e) will require a fatigue evaluation. The proposed rule did not specifically address static requirements because they are covered in the current requirements of §§ 27.305 and 29.305. The draft AC for this rule is similar in format to the current MG 8, but has been updated to address the damage tolerance fatigue requirements of composite structures. All of these damage tolerance concerns must be considered under the requirements of paragraphs (d) and (e) of this rule. The miscellaneous guidance referred to in the comment is the applicable guidance for compliance until §§ 27.573 and 29.573 become effective; it is not the guidance for this new rule. Therefore, the FAA is adopting the rule as proposed.

Request for Further Rulemaking To Address Subsequent Service Adhesion Failures

Adhesion Associates Proprietary, Limited, recommended that the FAA address the in-service degradation of the chemical bonds in a new regulation (§ 2x.605 for parts 27 and 29); and that information on the significance, causes, and management procedures for micro-voids be incorporated into AC 20–107B.

The recommendation for a new regulation is beyond the scope of this rulemaking. However, it will be considered in future rulemaking. Likewise, the recommended changes to AC 20–107B will be considered in future AC revisions.

Differences Between the NPRM and the Final Rule

Sections §§ 27.573(b) and 29.573(b) are reworded to be consistent with the wording in § 29.571 for metallic structures.

IV. Regulatory Notices and Analyses

A. Regulatory Evaluation

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 and Executive Order 13563 direct 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 (Pub. L. 96–354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96–39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation with base year of 1995). This portion of the preamble summarizes the FAA's analysis of the economic impacts of this proposed rule. We suggest readers seeking greater detail read the full regulatory evaluation, a copy of which we have placed in the docket for this rulemaking.

In conducting these analyses, FAA has determined that this final rule:

(1) Has benefits that justify its costs;

(2) Is not an economically ''significant regulatory action'' as defined in section 3(f) of Executive Order 12866;

(3) Is ''non-significant'' as defined in DOT's Regulatory Policies and Procedures;

(4) Would not have a significant economic impact on a substantial number of small entities;

(5) Would not have a significant effect on international trade; and

(6) Would not impose an unfunded mandate on state, local, or tribal governments, or on the private sector by exceeding the monetary threshold identified.

These analyses are summarized below.

Total Benefits and Costs of This Rulemaking

The estimated total cost of this final rule is between $713,000 ($392,000 in present value at 7%) and $1,032,000 ($567,000 in present value at 7%). The final rule systematizes past FAA and industry practice regarding the use of composites on rotorcraft, including special conditions and advisory circulars. Although we anticipate both cost savings and improved safety as a result of required inspection and replacement schedules, we are unable to quantify these benefits. Nevertheless, we believe that the qualitatively estimated benefits are real and significant and exceed the final rule's costs.

Who is Potentially Affected by this Rulemaking?

- Manufacturers of U.S.-registered part 27 and part 29 rotorcraft.

Our Cost Assumptions and Sources of Information.

- Discount rate—7%.
- Period of analysis of 27 years equals the 27 years of National Transportation Safety Board accident history. During this period, manufacturers will seek new certifications for 10.5 part 27 rotorcraft and six part 29 rotorcraft.

Benefits of This Rule

The final rule adopts as regulatory requirements past FAA and industry practice regarding the use of composites on rotorcraft, including special conditions and advisory circulars. Although we anticipate both cost savings and improved safety as a result of required inspection and replacement schedules, we are unable to quantify these benefits. Nevertheless, we believe that the qualitatively estimated benefits are real and significant and exceed the final rule's costs. We did not receive any comments regarding our conclusion that the benefits exceed the costs.

Cost of This Rule

Based upon the ARAC recommendation, we estimated the costs of this final rule to be about $713,000 ($392,000 in present value) over the 27-year analysis period. Manufacturers of 14 CFR part 27 rotorcraft would incur costs of about $101,000 ($55,000 in present value) and manufacturers of 14 CFR part 29 helicopters would incur costs of about $612,000 ($337,000 in present value).

One commenter provided a cost estimate of 12,000 hours as the cost of the rule. Converting the hours to dollars results in a nominal cost of $1,032,000 ($567,000 in present value); therefore, we estimate that the nominal cost of the final rule will have a range of $713,000 to $1,032,000.

B. Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation.'' To achieve that principle, the RFA requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The RFA covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the RFA.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

This final rule directly affects rotorcraft manufacturers.

Part 27 Helicopter Manufacturers

Size Standards

Size standards for small entities are published by the Small Business Administration (SBA) on their Web site at *http://www.sba.gov/size*. The size standards used herein are from ''SBA U.S. Small Business Administration, Table of Small Business Size Standards, Matched to North American Industry Classification System Codes.'' The table is effective August 22, 2008 and uses the NAICS 2007 NAICS codes.

Helicopter manufacturers are listed in the referenced table under Sector 31–33—Manufacturing; Subsector 336—Transportation Equipment Manufacturing; NAICS Code 336411—Aircraft Manufacturing. The small entity size standard is 1,500 employees.

Table R1 shows there are six U.S. part 27 helicopter manufacturers that produce composite helicopters. MD Helicopters, with 400 employees, is the only part 27 helicopter manufacturer to qualify as a small entity. It is estimated that MD Helicopters has annual revenues of $175,000,000. The cost of this rule for one part 27 helicopter certification for a part 27 manufacturer is estimated to be $9,600. This is less than 0.01 percent of MD Helicopters annual revenue. We do not believe that is a significant cost. Therefore, it is not anticipated that this final rule would have a significant economic impact on a substantial number of part 27 helicopter manufacturers.

Table R1

U.S. Part 27 Helicopter Manufacturers

Manufacturer					Annual		
No.	**Name**	**Ultimate Owner**	**Employees**	**Small Entity**	**Revenues (AR)**	**Proposal Costs (PC)**	**% PC of AR**
1	Agusta (A)	Finmeccanica	73,000	No	€ 15,037,000	N.A.	N.A.
2	Bell Helicopter (B)	Textron	42,000	No	$ 14,200,000,000	N.A.	N.A.
3	Eurocopter (C)	EADS	118,000	No	€ 43,300,000,000	N.A.	N.A.
4	Kaman Aerospace (D)	Kaman Corp.	4,000	No	$ 1,200,000,000	N.A.	N.A.
5	**MD Helicopters (E)(F)**	**None**	**400**	**Yes**	**$ 175,000,000**	**$ 9,600**	**0.01%**
6	Sikorsky (G)	UTC	223,100	No	$ 58,700,000,000	N.A.	N.A.
7	Robinson Helicopters (H)						

Notes:

(A)	http://www.finmeccanica.com
(B)	http://www.Textron.com/about/company
(C)	http://www.eads.com
(D)	http://www.kaman.com
(E)	http://www.linkedin.com
(F)	http://www.jigsaw.com/id55718/md_helicopters_company.xhtml (Average of range of $100-$250 million)
	Cost is based on one helicopter certification during the analysis period.
(G)	http://www.utc.com/about_utc/fast_facts.lhtml
(H)	Robinson Helicopters is not included because it produces only metallic helicopters and is not expected to produce composite helicopters in the future.

8/10/2009

Part 29 Helicopter Manufacturers

Size Standards

Size standards for part 29 manufacturers are the same as the size standards for part 27 manufacturers.

Table R2 shows there are four U.S. part 29 helicopter manufacturers currently producing helicopters. None of these manufacturers qualify as a small entity. Therefore, this final rule will not have a significant economic impact on a substantial number of part 29 helicopter manufacturers.

Table R2

U.S. Part 29 Helicopter Manufacturers

Manufacturer					Annual		
No.	Name	Ultimate Owner	Employees	Small Entity	Revenues (AR)	Proposal Costs (PC)	% PC of AR
1	Agusta (A)	Finmeccanica	73,000	No	€ 15,037,000	N.A.	N.A.
2	Bell Helicopter (B)	Textron	42,000	No	$ 14,200,000,000	N.A.	N.A.
3	Eurocopter (C)	EADS	118,000	No	€ 43,300,000,000	N.A.	N.A.
4	Sikorsky (D)	UTC	223,100	No	$ 58,700,000,000	N.A.	N.A.
5	Erickson Air Crane (E)						

Notes:

(A) http://www.finmeccanica.com
(B) http://www.Textron.com/about/company
(C) http://www.eads.com
(D) http://www.utc.com/about_utc/fast_facts.lhtml
(E) Erickson Air Crane is not included because it produces only one metallic helicopter, the S-64, and is not expected to produce composite helicopters in the future.

6/29/2011

For the initial regulatory flexibility analysis we made the same determination that this rule would not have a significant economic impact on a substantial number of small entities and we did not receive any comments regarding our analysis or determination regarding small entities. Consequently, the FAA Administrator certifies that this final rule will not have a significant economic impact on a substantial number of part 27 or part 29 rotorcraft manufacturers.

C. International Trade Impact Assessment

The Trade Agreements Act of 1979 (Pub. L. 96–39), as amended by the Uruguay Round Agreements Act (Pub. L. 103–465), prohibits Federal agencies from establishing standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to these Acts, establishing standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such as the protection of safety, and does not operate in a manner that excludes imports that meet this objective. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards.

The FAA has assessed the potential effect of this proposed rule and determined that it would impose the same costs on domestic and international entities and thus has a neutral trade impact.

D. Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (adjusted annually for inflation) in any 1 year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a ''significant regulatory action.'' The FAA currently uses an inflation-adjusted value of $140.8 million in lieu of $100 million. This proposed rule does not contain such a mandate.

E. Paperwork Reduction Act

The Paperwork Reduction Act of 1995 requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. According to the 1995 amendments to the Paperwork Reduction Act (5 CFR 1320.8(b)(2)(vi)), an agency may not collect or sponsor the collection of information, nor may it impose any information collection requirement unless it displays a currently valid Office of Management and Budget (OMB) control number.

This final rule will impose the following new information collection requirements. As required by 44 U.S.C. 3507(d) of the Paperwork Reduction Act of 1995, the FAA has submitted requirements associated with this rule to OMB for its review. Notice of OMB approval for this information collection will be published in a future **Federal Register** document.

Summary: This rule adds new certification standards for normal and transport category rotorcraft to address advances in structural damage tolerance and fatigue substantiation technology for composite rotorcraft structures. The rule increases the current minimum safety standards to require compliance with certain current industry practices and FAA policies that would result in higher safety standards, and result in harmonized international standards. The rule helps ensure that if damage occurs to composite structures during manufacturing or within the operational life of the rotorcraft, the remaining structure can withstand fatigue loads that are likely to occur, without failure, until the damage is detected. The damaged structure must be repaired or the part must be replaced to restore ultimate load capability. Sections 27.573 and 29.573 require that applicants get FAA approval of their proposed methods for complying with the certification requirements for damage tolerance and fatigue evaluation of composite structures.

Public comments: No public comments were received on the information collection requirements discussed in the NPRM.

Use: The required damage tolerance and fatigue evaluation information will be determined for principal composite structural elements or components, detail design points, and fabrication techniques and will be collected from rotorcraft certification applicants. The FAA will use the approval process for the applicant's submitted compliance methodology to determine whether the proposed methods are sufficient to comply with the certification requirements for damage tolerance and fatigue evaluation of composite structures. The FAA also will use the approval process for the applicant's submitted compliance methodology to determine if the rotorcraft has any unsafe features in the composite structures.

Respondents (including number of): The likely respondents to this damage tolerance and fatigue evaluation information are applicants requesting type certification of composite structures. We anticipate about 16.5 normal and transport category rotorcraft certification applicants (including supplemental type certificate applicants) over the 27 year analysis period or about 0.6 per year.

Frequency: The frequency of determining the damage tolerance and fatigue evaluation methodologies will depend on how often an applicant seeks certification of a composite structure. This compliance methodology will be provided during each certification. We anticipate 16.5 certifications over the 27 year analysis period or about 0.6 per year.

Annual Burden Estimate: The compliance methodology will be required to be submitted and approved during each certification of a composite rotorcraft structure. We anticipate there will be 0.6 certifications each year and it will take 182 hours to submit and approve the compliance methodology for each certification, for a total annual time burden of 109 hours. We anticipate that submitting and approving the compliance methodology for each certification will cost $100 per hour. Therefore, the estimated total annual cost burden will be $10,900.

F. International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to conform our regulations to International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has reviewed the corresponding ICAO Standards and Recommended Practices and has identified no ''differences'' with these regulations.

G. Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 312f and involves no extraordinary circumstances.

H. Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the FAA, when modifying its regulations 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 appropriate regulatory distinctions. In the NPRM, the FAA requested comments on whether the proposed rule should apply differently to intrastate operations in Alaska. The agency did not receive any comments, and has determined, based on the administrative record of this rulemaking, that there is no need to make any regulatory distinctions applicable to intrastate aviation in Alaska.

V. Executive Order Determinations

A. Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. The agency determined that this action will not have a substantial direct effect on the States, or the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, does not have Federalism implications.

B. Executive Order 13211, Regulations That Significantly Affect Energy Supply, Distribution, or Use

The FAA analyzed this final rule under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). The agency has determined that it is not a ''significant energy action'' under the executive order and it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

VI. How To Obtain Additional Information

A. Rulemaking Documents

An electronic copy of a rulemaking document may be obtained by using the Internet—

1. Search the Federal Docket Management System (*http://www.regulations.gov*);
2. Visit the FAA's Regulations and Policies Web page at *http://www.faa.gov/regulations_policies/*; or
3. Access the Government Printing Office's Web page at *http://www.gpoaccess.gov/fr/index.html*.

Copies may also be obtained by sending a request (identified by notice, amendment, or docket number of this rulemaking) to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680.

B. Comments Submitted to the Docket

Comments received may be viewed by going to *http://www.regulations.gov* and following the online instructions to search the docket number for this action. Anyone is able to search the electronic form of all comments received into any of the FAA's dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.).

C. Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. A small entity with questions regarding this document, may contact its local FAA official, or the person listed under the **FOR FURTHER INFORMATION CONTACT** heading at the beginning of the preamble. To find out more about SBREFA on the Internet, visit *http://www.faa.gov/regulations_policies/rulemaking/sbre_act/*.

List of Subjects

14 CFR Part 27

Aircraft, Aviation safety.

14 CFR Part 29

Aircraft, Aviation safety.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends chapter I, parts 27 and 29 of Title 14, Code of Federal Regulations as follows:

PART 27—AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT

■ 1. The authority citation for part 27 continues to read as follows:

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

■ 2. Add § 27.573 to read as follows:

§ 27.573 Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures.

(a) Each applicant must evaluate the composite rotorcraft structure under the damage tolerance standards of paragraph (d) of this section unless the applicant establishes that a damage tolerance evaluation is impractical within the limits of geometry, inspectability, and good design practice. If an applicant establishes that it is impractical within the limits of geometry, inspectability, and good design practice, the applicant must do a fatigue evaluation in accordance with paragraph (e) of this section.

(b) The methodology used to establish compliance with this section must be submitted to and approved by the Administrator.

(c) Definitions:

(1) *Catastrophic failure* is an event that could prevent continued safe flight and landing.

(2) *Principal Structural Elements (PSEs)* are structural elements that contribute significantly to the carrying of flight or ground loads, the failure of which could result in catastrophic failure of the rotorcraft.

(3) *Threat Assessment* is an assessment that specifies the locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage (including the discrete source of the accidental damage) that may occur during manufacture or operation.

(d) Damage Tolerance Evaluation:

(1) Each applicant must show that catastrophic failure due to static and fatigue loads, considering the intrinsic or discrete manufacturing defects or accidental damage, is avoided throughout the operational life or prescribed inspection intervals of the rotorcraft by performing damage tolerance evaluations of the strength of composite PSEs and other parts, detail design points, and fabrication techniques. Each applicant must account for the effects of material and process variability along with environmental conditions in the strength and fatigue evaluations. Each applicant must evaluate parts that include PSEs of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, engine and transmission mountings, landing gear, other parts, detail design points, and fabrication techniques deemed critical by the FAA. Each damage tolerance evaluation must include:

(i) The identification of all PSEs;

(ii) In-flight and ground measurements for determining the loads or stresses for all PSEs for all critical conditions throughout the range of limits in § 27.309 (including altitude effects), except that maneuvering load factors need not exceed the maximum values expected in service;

(iii) The loading spectra as severe as those expected in service based on loads or stresses determined under paragraph (d)(1)(ii) of this section, including external load operations, if applicable, and other operations including high-torque events;

(iv) A threat assessment for all PSEs that specifies the locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage (including the discrete source of the accidental damage) that may occur during manufacture or operation; and

(v) An assessment of the residual strength and fatigue characteristics of all PSEs that supports the replacement times and inspection intervals established under paragraph (d)(2) of this section.

(2) Each applicant must establish replacement times, inspections, or other procedures for all PSEs to require the repair or replacement of damaged parts before a catastrophic failure. These replacement times, inspections, or other procedures must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by § 27.1529.

(i) Replacement times for PSEs must be determined by tests, or by analysis supported by tests, and must show that the structure is able to withstand the repeated loads of variable magnitude expected in-service. In establishing these replacement times, the following items must be considered:

(A) Damage identified in the threat assessment required by paragraph (d)(1)(iv) of this section;

(B) Maximum acceptable manufacturing defects and in-service damage (i.e., those that do not lower the residual strength below ultimate design loads and those that can be repaired to restore ultimate strength); and

(C) Ultimate load strength capability after applying repeated loads.

(ii) Inspection intervals for PSEs must be established to reveal any damage identified in the threat assessment required by paragraph (d)(1)(iv) of this section that may occur from fatigue or other in-service causes before such damage has grown to the extent that the component cannot sustain the required residual strength capability. In establishing these inspection intervals, the following items must be considered:

(A) The growth rate, including no-growth, of the damage under the repeated loads expected in-service determined by tests or analysis supported by tests;

(B) The required residual strength for the assumed damage established after considering the damage type, inspection interval, detectability of damage, and the techniques adopted for damage detection. The minimum required residual strength is limit load; and

(C) Whether the inspection will detect the damage growth before the minimum residual strength is reached and restored to ultimate load capability, or whether the component will require replacement.

(3) Each applicant must consider the effects of damage on stiffness, dynamic behavior, loads, and functional performance on all PSEs when substantiating the maximum assumed damage size and inspection interval.

(e) Fatigue Evaluation: If an applicant establishes that the damage tolerance evaluation described in paragraph (d) of this section is impractical within the limits of geometry, inspectability, or good design practice, the applicant must do a fatigue evaluation of the particular composite rotorcraft structure and:

(1) Identify all PSEs considered in the fatigue evaluation;

(2) Identify the types of damage for all PSEs considered in the fatigue evaluation;

(3) Establish supplemental procedures to minimize the risk of catastrophic failure associated with the damages identified in paragraph (d) of this section; and

(4) Include these supplemental procedures in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 27.1529.

Appendix A to Part 27 [Amended]

■ 3. Amend the second sentence of section A.27.4 of Appendix A to Part 27 by removing the phrase ''approved under § 27.571'' and adding the phrase ''required for type certification'' in its place.

PART 29—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT

■ 4. The authority citation for part 29 continues to read as follows:

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

■ 5. Add § 29.573 to read as follows:

§ 29.573 Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures.

(a) Each applicant must evaluate the composite rotorcraft structure under the damage tolerance standards of paragraph (d) of this section unless the applicant establishes that a damage tolerance evaluation is impractical within the limits of geometry, inspectability, and good design practice. If an applicant establishes that it is impractical within the limits of geometry, inspectability, and good design practice, the applicant must do a fatigue evaluation in accordance with paragraph (e) of this section.

(b) The methodology used to establish compliance with this section must be submitted to and approved by the Administrator.

(c) Definitions:

(1) *Catastrophic failure* is an event that could prevent continued safe flight and landing.

(2) *Principal Structural Elements (PSEs)* are structural elements that contribute significantly to the carrying of flight or ground loads, the failure of which could result in catastrophic failure of the rotorcraft.

(3) *Threat Assessment* is an assessment that specifies the locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage (including the discrete source of the accidental damage) that may occur during manufacture or operation.

(d) Damage Tolerance Evaluation:

(1) Each applicant must show that catastrophic failure due to static and fatigue loads, considering the intrinsic or discrete manufacturing defects or accidental damage, is avoided throughout the operational life or prescribed inspection intervals of the rotorcraft by performing damage tolerance evaluations of the strength of composite PSEs and other parts, detail design points, and fabrication techniques. Each applicant must account for the effects of material and process variability along with environmental conditions in the strength and fatigue evaluations. Each applicant must evaluate parts that include PSEs of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, engine and transmission mountings, landing gear, other parts, detail design points, and fabrication techniques deemed critical by the FAA. Each damage tolerance evaluation must include:

(i) The identification of all PSEs;

(ii) In-flight and ground measurements for determining the loads or stresses for all PSEs for all critical conditions throughout the range of limits in § 29.309 (including altitude effects), except that maneuvering load factors need not exceed the maximum values expected in service;

(iii) The loading spectra as severe as those expected in service based on loads or stresses determined under paragraph (d)(1)(ii) of this section, including external load operations, if applicable, and other operations including high-torque events;

(iv) A threat assessment for all PSEs that specifies the locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage (including the discrete source of the accidental damage) that may occur during manufacture or operation; and

(v) An assessment of the residual strength and fatigue characteristics of all PSEs that supports the replacement times and inspection intervals established under paragraph (d)(2) of this section.

(2) Each applicant must establish replacement times, inspections, or other procedures for all PSEs to require the repair or replacement of damaged parts before a catastrophic failure. These replacement times, inspections, or other procedures must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by § 29.1529.

(i) Replacement times for PSEs must be determined by tests, or by analysis supported by tests, and must show that the structure is able to withstand the repeated loads of variable magnitude expected in-service. In establishing these replacement times, the following items must be considered:

(A) Damage identified in the threat assessment required by paragraph (d)(1)(iv) of this section;

(B) Maximum acceptable manufacturing defects and in-service damage (i.e., those that do not lower the residual strength below ultimate design loads and those that can be repaired to restore ultimate strength); and

(C) Ultimate load strength capability after applying repeated loads.

(ii) Inspection intervals for PSEs must be established to reveal any damage identified in the threat assessment required by paragraph (d)(1)(iv) of this section that may occur from fatigue or other in-service causes before such damage has grown to the extent that the component cannot sustain the required residual strength capability. In establishing these inspection intervals, the following items must be considered:

(A) The growth rate, including no-growth, of the damage under the repeated loads expected in-service determined by tests or analysis supported by tests;

(B) The required residual strength for the assumed damage established after considering the damage type, inspection interval, detectability of damage, and the techniques adopted for damage detection. The minimum required residual strength is limit load; and

(C) Whether the inspection will detect the damage growth before the minimum residual strength is reached and restored to ultimate load capability, or whether the component will require replacement.

(3) Each applicant must consider the effects of damage on stiffness, dynamic behavior, loads, and functional performance on all PSEs when substantiating the maximum assumed damage size and inspection interval.

(e) Fatigue Evaluation: If an applicant establishes that the damage tolerance evaluation described in paragraph (d) of this section is impractical within the limits of geometry, inspectability, or good design practice, the applicant must do a fatigue evaluation of the particular composite rotorcraft structure and:

(1) Identify all PSEs considered in the fatigue evaluation;

(2) Identify the types of damage for all PSEs considered in the fatigue evaluation;

(3) Establish supplemental procedures to minimize the risk of catastrophic failure associated with the damages identified in paragraph (d) of this section; and

(4) Include these supplemental procedures in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 29.1529.

Appendix A to Part 29 [Amended]

■ 6. Amend the second sentence of section A.29.4 of Appendix A to Part 29 by removing the phrase ''approved under § 29.571'' and adding the phrase ''required for type certification'' in its place.

Issued in Washington, DC, on October 4, 2011.

J. Randolph Babbitt,

Administrator.

[FR Doc. 2011–30945 Filed 11–30–11; 8:45 am]

BILLING CODE 4910–13–P