Designation: F3651/F3651M – 23

Standard Practice for Determining Safe-Life, Inspection Threshold and Recurring Inspection Intervals[1]

This standard is issued under the fixed designation F3651/F3651M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides guidance to determine scatter factors to establish either the safe-life, or inspection threshold, and inspection intervals to be published in the Airworthiness Limitation section of the maintenance manual in order to maintain continued airworthiness. The guidance materials presented herein for a means of compliance based on cyclic testing, damage tolerance testing, fatigue analysis, or damage tolerance analysis, or combinations thereof. The material was developed through open consensus of international experts in general aviation. The information was created by focusing on Levels 1, 2, 3 and 4 Normal Category aeroplanes. The content may be more broadly applicable; it is the responsibility of the applicant to substantiate broader applicability as a specific means of compliance.

1.2 An applicant intending to propose this information as Means of Compliance for a design approval must seek guidance from their respective oversight authority (for example, published guidance from applicable civil aviation authorities, or CAAs) concerning the acceptable use and application thereof. For information on which oversight authorities have accepted this standard (whole or in part) as an acceptable Means of Compliance to their regulatory requirements (hereinafter "the Rules"), refer to the ASTM Committee F44 web page (www.astm.org/COMMITTEE/F44.htm).

1.3 *Units*—This document may present information in either SI units, English Engineering units, or both; the values stated in each system may not be exact equivalents. Each system shall be used independently of the other; combining values from the two systems may result in nonconformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3115/F3115M Specification for Structural Durability for Small Aeroplanes

F3498 Practice for Developing Simplified Fatigue Load Spectra

2.2 *EASA Documents:*[3]

CS-23 Certification Specifications for Normal-Category Aeroplanes

AMC 20-29 Composite Aircraft Structure

2.3 *FAA Documents:*[4]

AC 20-107B Composite Aircraft Structure

AC 23-13A Fatigue, Fail-Safe, and Damage Tolerance Evaluation of Metallic Structure for Normal, Utility, Acrobatic, and Commuter Category Airplanes

DOT/FAA/AR-10/6 Determining the Fatigue Life of Composite Aircraft Structures Using Life and Load Enhancement Factors

AC 25.571-1C Damage Tolerance and Fatigue Evaluation of Structure

2.4 *Federal Standards:*[5]

14 CFR Part 23 Airworthiness Standards: Normal Category Airplanes

[1] This practice is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.30 on Structures.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from European Union Aviation Safety Agency (EASA), Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, https://www.easa.europa.eu.

[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

[5] Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

3. Terminology

3.1 The following are a selection of terms relevant to this practice taken directly from Terminology F3060, Specification F3115/F3115M, and AC 25.571-1C. Refer to these documents for the up-to-date definitions, also for additional definitions and abbreviations.

3.2 *Definitions:*

3.2.1 *airworthiness limitation, n*—limitation applicable to an aircraft or article installed on an aircraft in the form of a life limit or a maintenance task that is mandatory to maintain the aircraft in airworthy condition.

3.2.2 *continuing airworthiness, n*—set of processes by which an aircraft, engine, propeller, or part complies with the applicable airworthiness requirements and remains in a condition for safe operation throughout its operating life.

3.2.3 *fatigue, n*—the process of progressive localized permanent structural change occurring in a material subjected to conditions that produce fluctuating stresses and strains at some point or points, which may result in damage or complete fracture after a sufficient number of fluctuations.

3.2.4 *multiple load path, adj—applies to structure*, the applied loads of which are distributed through redundant structural members, so that the failure of a single structural member does not result in the loss of structural capability to carry applied load.

3.2.5 *safe-life, n—of a structure*, that number of events, such as flights, landings, or flight hours, during which there is a low probability that the strength will degrade below its design ultimate value due to fatigue-induced damage.

3.2.6 *scatter factor, n*—statistically derived divisor applied to fatigue test results to account for the variation in fatigue performance of built-up or monolithic structures and usage variability; a scatter factor can also be used in a fatigue analysis to address the uncertainties inherent in a fatigue analysis; also called "life reduction factor."

3.2.7 *single load path, adj—applies to structure*, the applied loads of which are eventually distributed through a single structural member, the failure of which would result in the loss of the structural capability to carry applied load.

4. Significance and Use

4.1 This practice provides one means for determining the scatter factors to establish either the safe-life, or inspection threshold, or recurring inspection intervals, or combinations thereof, as a result of aeroplane durability and damage tolerance assessments. This information can be used in conjunction with Specification F3115/F3115M.

4.1.1 This practice defines scatter factors or factors to be used on the unfactored test or analytical mean lives, or both, for determining factored lives (that is, safe-life, inspection threshold, or recurring inspection intervals, or combinations thereof). These factors may be related to but are different from other factors such as load enhancement factor, and life factor that are used to compensate for long test duration. For guidance on life and load enhancement factors, refer to DOT/FAA/AR-10/6 or from relevant CAAs.

4.1.2 The unfactored test or analytical mean life, or both, must be determined prior to the usage of this standard practice (see 4.5.1).

4.2 The material presented herein is derived from the references listed in Section 2.

4.3 Either the safe-life or inspection thresholds can be determined for the entire aeroplane or separately for components such as wing, empennage, landing gear, control surfaces, etc. Such determinations are based on test(s), similarity to previous test(s), or analysis supported by tests. Recurring inspection intervals are typically determined on the same basis but may also be supported by in-service data.

4.4 The scatter factors described in this practice are applicable to cyclic test data that meets the following criteria:

4.4.1 The cyclic test article must be representative of the production article. Careful consideration must be given for any modifications or alterations, or both, made to the test article prior to or during testing, or both, for metallic structures.

4.4.2 At the completion of full-scale or component fatigue/cyclic tests (excluding landing gear), the residual strength capability must be demonstrated before determining either the safe-life, or inspection threshold.

4.5 The following are not within the scope of this standard:

4.5.1 Methodologies of durability, damage tolerance analysis, or test, or combinations thereof.

4.5.2 Structures which use novel fabrication methods such as friction stir welding, additive manufacturing, and thermoplastic welding.

4.5.3 Structural bonding (except already proven metal-to-metal bonding, etc.); for guidance on structural bonding refer to AC 20-107B (or AMC 20-29).

4.6 The Finite Element Model (FEM) used for analysis must be validated with test data, or other independent analysis methods in accordance with relevant CAA requirements.

4.7 The inspection intervals determined using this practice are independent of other inspection intervals that are defined by other process, such as Maintenance Steering Group (MSG).

5. Procedure

5.1 The mechanics, modes of failure, and structural assessment methods associated with fatigue and damage growth are different for metals compared to the non-metallic (that is, composites). A consequence of this is that the methods to define damage inspection techniques and intervals are also different. Therefore, the derivations of either the safe-life or inspection intervals are segregated into two different methods—metallic and non-metallic.

5.2 Table 1 summarizes the means for determining either the safe-life, inspection threshold, or recurring inspection intervals, or combinations thereof.

5.3 *Safe-Life Determination:*

5.3.1 The safe-life or life limit, for metallic structures, can be determined based on a full-scale fatigue test (FSFT). After completion of FSFT, and demonstration of required residual strength capability, or, fail-safe capability per the guidance