Designation: F3254 – 22

Standard Specification for Aircraft Interaction of Systems and Structures[1]

This standard is issued under the fixed designation F3254; 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 specification covers the airworthiness requirements that address the interaction of systems and structures. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on 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 Authority (CAAs)) concerning the acceptable use and application thereof. For information on which oversight authorities have accepted this specification (in 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). Annex A1 maps the Means of Compliance of the ASTM Standards to EASA CS-23, amendment 5, or later, and FAA 14 CFR Part 23, amendment 64, or later.

1.3 *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.*

1.4 *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

F3093/F3093M Specification for Aeroelasticity Requirements

F3115/F3115M Specification for Structural Durability for Small Aeroplanes

F3116/F3116M Specification for Design Loads and Conditions

F3230 Practice for Safety Assessment of Systems and Equipment in Small Aircraft

2.2 *EASA Standard:*[3]

CS-23 Normal, Utility, Aerobatic and Commuter Aeroplanes

2.3 *FAA Standard:*[4]

14 CFR Part 23 Airworthiness Standards: Normal Category Airplanes

3. Terminology

3.1 A listing of terms, abbreviations, acronyms, and symbols related to aircraft covered by ASTM Committees F37 and F44 airworthiness design standards can be found in F3060 Terminology for Aircraft. Items listed here are more specific to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *extremely improbable*—the allowable quantitative probability based on the assessment level and catastrophic failure condition classification.

3.2.1.1 *Discussion*—The term extremely improbable is defined in Practice F3230. As used in this specification, it represents the allowable quantitative probability to be used in this specification based on the assessment level and catastrophic failure condition classification found in Practice F3230.

[1] This specification 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.

3.2.2 *failure condition*—structural system failure condition that affects the structural performance of the aeroplane.

3.2.2.1 *Discussion*—The term failure condition in this specification applies only to structural system failure conditions that affect the structural performance of the aeroplane (for example, system failure conditions that induce loads, change the response of the aeroplane to inputs such as gusts or pilot actions, or lower flutter margins).

3.2.3 *flight limitation*—limitations that can be applied to the aeroplane flight conditions following an in-flight occurrence.

3.2.3.1 *Discussion*—Example flight limitations include speed limitations and avoidance of severe weather. These limitations are included in the flight manual.

3.2.4 *operational limitation*—limitations, including flight limitations, that can be applied to the aeroplane operating conditions before flight.

3.2.4.1 *Discussion*—Example operational limitations include fuel, payload, and Master Minimum Equipment List limitations.

3.2.5 *probable*—the allowable quantitative probability based on the assessment level and minor failure condition classification.

3.2.5.1 *Discussion*—The term probable is defined in Practice F3230. As used in this specification, it represents the allowable quantitative probability to be used in this specification based on the assessment level and minor failure condition classification found in Practice F3230.

3.2.6 *remote*—the allowable quantitative probability based on the assessment level and major failure condition classification.

3.2.6.1 *Discussion*—The term remote is defined in Practice F3230. As used in this specification, it represents the allowable quantitative probability to be used in this specification based on the assessment level and major failure condition classification found in Practice F3230.

3.2.7 *structural performance*—capability of the aeroplane to meet the applicable structural requirements.

3.2.8 *structural system*—system where the intended function is to alter an aeroplane's structural design envelope or where failure or malfunction adversely affects structural performance.

3.2.8.1 *Discussion*—Example structural systems include, but are not limited to, active flight control systems, stability augmentation systems, load alleviation systems, flutter control systems, flight-envelope protection systems, control surface limiting systems, rudder bias systems, autopilot systems, and fuel management systems.

3.3 *Symbols:*

P_j = probability of occurrence of failure mode j (per hour)
Q_j = probability of being in failure condition j
T_j = average time spent in failure condition j (in hours)
V' = clearance speed as defined by Specification F3093/F3093M, requiring freedom from flutter, control reversal, and divergence up to V_D/M_D after the specified system failure.
V'' = clearance speed as defined by Specification F3093/F3093M, requiring freedom from flutter, control reversal, and divergence for any condition of operation within the limit V-n envelope and at all speeds up to 1.2 V_D/1.2 M_D, limited to Mach 1.0 for subsonic aeroplanes.

4. Interaction of Systems and Structure

4.1 *Applicability*—For aeroplanes equipped with structural systems, the influence and failure of these systems must be taken into account. Fig. 1 provides an assessment of the applicability of this specification to a specific system, along with the depth of analysis required to show compliance.

4.2 *General*—The criteria in this specification address the structural performance of aeroplanes equipped with structural systems.

4.2.1 The criteria defined herein only address the direct structural consequences of the system responses and performances and cannot be considered in isolation but must be included in the overall safety evaluation of the aeroplane. These criteria are only applicable to structure whose failure could prevent continued safe flight and landing. Specific criteria that define acceptable limits on handling characteristics or stability requirements when operating in the system degraded or inoperative mode are not provided in this specification.

4.2.2 Depending upon the specific characteristics of the aeroplane, additional studies may be required that go beyond the criteria provided in this specification in order to demonstrate the capability of the aeroplane to meet other realistic conditions such as alternative gust or maneuver descriptions for an aeroplane equipped with a load alleviation system.

4.3 *System Fully Operative*—With the structural system fully operative, the following apply:

4.3.1 Limit loads must be derived in all normal operating configurations of the system from all the limit conditions specified in Specification F3116/F3116M (or used instead of those specified in Specification F3116/F3116M), taking into account any special behavior of such a system or associated functions or any effect on the structural performance of the aeroplane up to limit loads. In particular, any significant nonlinearity (rate of displacement of control surface, thresholds, or any other system nonlinearities) must be accounted for in a realistic or conservative way when deriving limit loads from limit conditions.

4.3.2 The aeroplane must meet the applicable static strength requirements using the specified factors to derive ultimate loads from the limit loads defined in 4.3.1. The effect of nonlinearities must be investigated beyond limit conditions to ensure the behavior of the system presents no anomaly compared to the behavior below limit conditions. However, conditions beyond limit conditions need not be considered when it can be shown that the aeroplane has design features that will not allow it to exceed those limit conditions.

4.3.3 The aeroplane must meet the aeroelastic stability requirements of Specification F3093/F3093M.

4.3.4 The aeroplane must meet the structural durability requirements of Specification F3115/F3115M.

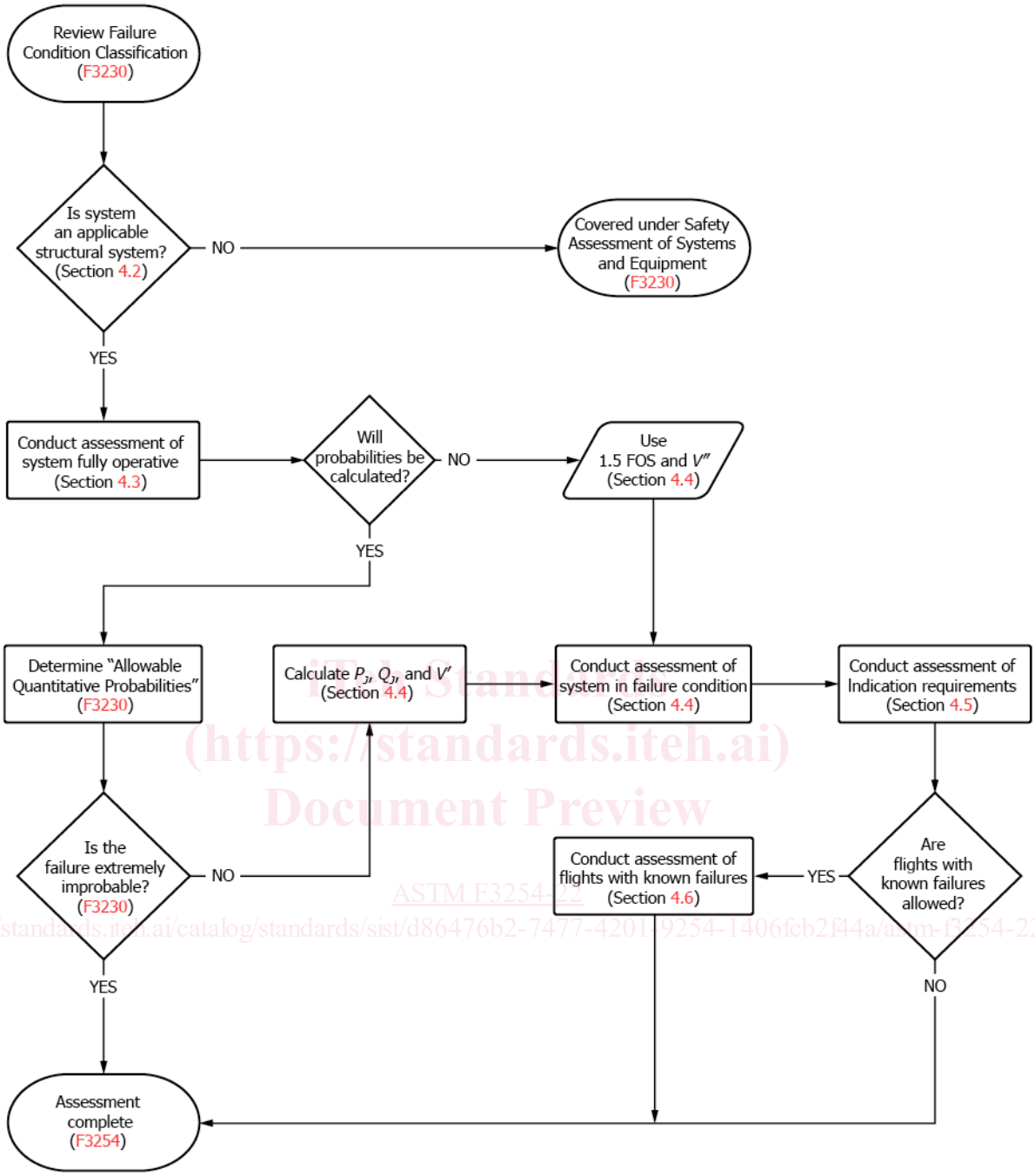

FIG. 1 Depth of Analysis Flowchart

4.4 *System in Failure Condition*—For any structural system failure condition not shown to be extremely improbable, the following apply:

4.4.1 *At Time of Occurrence*—Starting from 1-g level flight conditions, a realistic scenario, including pilot corrective actions, must be established to determine the loads occurring at the time of failure and immediately after failure.

4.4.1.1 For static strength substantiation, these loads multiplied by an appropriate factor of safety that is related to the probability of occurrence of the failure are ultimate loads to be considered for design. The factor of safety (FOS) is defined in Fig. 2. If P_j is not calculated, a 1.5 factor of safety must be applied.

4.4.1.2 For structural durability substantiation, the aeroplane must be able to withstand two-thirds of the ultimate loads defined in 4.4.1.1. For pressurized cabins, these loads must be combined with the normal operating differential pressure.

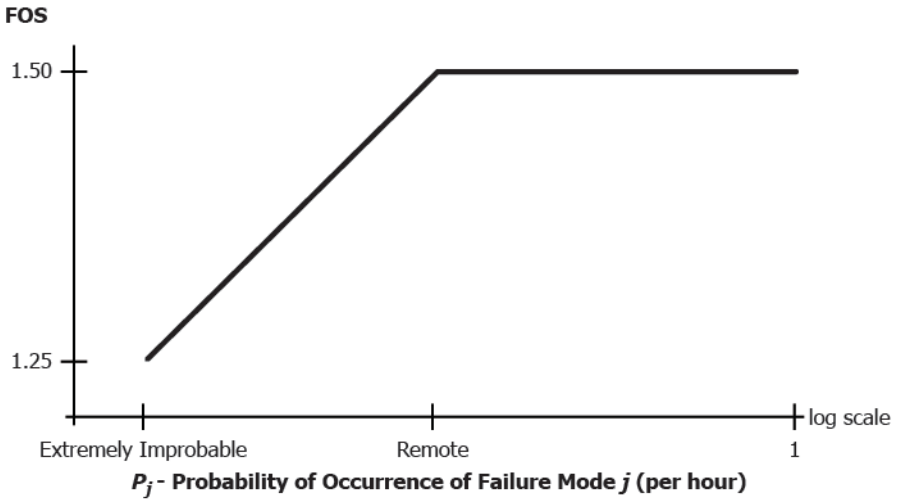

FIG. 2 Factor of Safety at Time of Occurrence

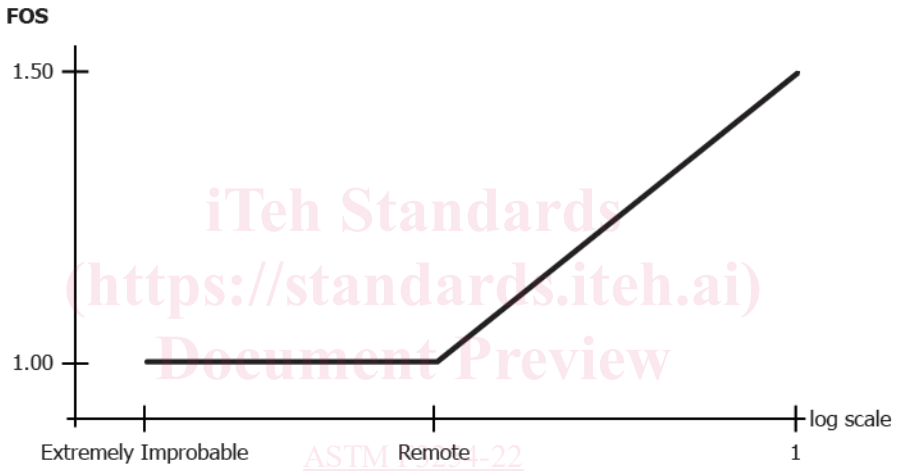

FIG. 3 Factor of Safety for Continuation of Flight

4.4.1.3 Freedom from aeroelastic instability must be shown up to the speeds defined in Specification F3093/F3093M, requiring freedom from flutter, control reversal, and divergence up to V_D/M_D. For failure conditions that result in speed increases beyond V_D/M_D, freedom from aeroelastic instability must be shown to increased speeds, so that the margins intended by Specification F3093/F3093M are maintained.

4.4.1.4 Failures of the system that result in forced structural vibrations (oscillatory failures) must not produce loads that could result in detrimental deformation of primary structure.

4.4.2 *For Continuation of Flight*—For the aeroplane, in the system failed state and considering any appropriate reconfiguration and flight limitations, the following apply:

4.4.2.1 The loads derived from the following conditions, as applicable (or used instead of the following conditions), at speeds up to V_C/M_C, or the speed limitation prescribed for the remainder of the flight, must be determined:

(1) The limit symmetrical maneuvering conditions specified in Specification F3116/F3116M as "Symmetrical Flight Conditions," "Flight Envelope," "High Lift Devices," "Maneuvering Loads for Horizontal Surfaces," and "Outboard Fins or Winglets."

(2) The limit gust and turbulence conditions specified in Specification F3116/F3116M as "Gust Load Factors," "High Lift Devices," "Gust Loads for Horizontal Surfaces," "Gust Loads for Vertical Surfaces," and "Outboard Fins or Winglets."

(3) The limit rolling and unsymmetrical conditions specified in Specification F3116/F3116M as "Rolling Conditions," "Unsymmetrical Loads," and "Outboard Fins or Winglets."

(4) The limit yaw maneuvering conditions specified in Specification F3116/F3116M as "Yawing Conditions" and "Outboard Fins or Winglets."

(5) The limit ground loading conditions specified in Specification F3116/F3116M as "Ground Load Conditions and Assumptions."

4.4.2.2 For static strength substantiation, each part of the structure must be able to withstand the loads in 4.4.2.1 multiplied by a factor of safety depending on the probability of