U.S. Department of Transportation
Federal Aviation Administration

Policy Statement

Subject: Certification of Structural Elements in Flight Control Systems

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Initiated By: ANM-115

Summary

This policy statement provides guidance for certifying structural elements in flight control systems. Because of the unique nature of structural elements in systems, which act as both structure and as part of a system, additional guidance is needed on the appropriate application of the fatigue and damage tolerance requirements of Title 14, Code of Federal Regulations (14 CFR) 25.571, and the system safety requirements of §§ 25.671 and 25.1309. This policy provides examples of structural elements that are subject to these regulations and provides guidance on compliance.

Definition of Key Terms

In this policy, the term "element" is synonymous with "component" or "part." The term "system" means a combination of components, parts, and elements that are interconnected to perform one or more functions.

Current Regulatory and Advisory Material

Regulations that apply to structural elements in flight control systems are found throughout part 25, subparts C, D, and F. This policy focuses on compliance with §§ 25.571, 25.671, and 25.1309.

The relevant advisory material includes the following:

- Advisory Circular (AC) 25-22, *Certification of Transport Airplane Mechanical Systems*, dated March 14, 2000. (Relevant guidance is contained within AC 25-14, *High Lift and Drag Devices*, dated May 4, 1988, which was canceled and incorporated in its entirety into AC 25-22.)

- AC 25.571-1D, *Damage Tolerance and Fatigue Evaluation of Structure*, dated January 13, 2011.

- AC 25.629-1A, *Aeroelastic Stability Substantiation of Transport Category Airplanes*, dated July 23, 1998.

- AC 25.1309-1A, *System Design and Analysis*, dated June 21, 1988.

- Policy Statement PS-ANM100-1984-00039, *Failsafe Tab Control Systems, FAR 25.629*, dated August 9, 1984.

- Policy Statement PS-ANM100-1984-00053, *Requirement for Fail-Safe Wing Flap Design*, dated May 15, 1984.

Changes to §§ 25.671 and 25.1309 and the relevant guidance material are planned. Those changes are not expected to affect the guidance provided herein.

Relevant Past Practice

In some past cases, applicants have classified certain structural elements as being either "structures" or "systems." Depending on how they were classified, either structural regulations (such as § 25.571) or system regulations (such as §§ 25.671 and 25.1309) were applied exclusively. However, the FAA has stated that for many structural elements in flight control systems, both sets of regulations apply.

For example, during a certification program, the FAA provided the following guidance regarding an elevator tab assembly: "Section 25.671 requires consideration of any single failure in the flight control system and surfaces. This includes any structural elements within that system. The FAA agrees that § 25.571 and other structures requirements normally govern structural design, but that does not exclude structural elements of the flight control system, including control surfaces, from applicable control system requirements."

Policy Statement PS-ANM100-1984-00053, which addresses flap design, provides another example of the application of both sets of regulations, as follows: "The flap support linkages referred to in this policy statement are hinges, tracks, and support linkages. They are considered part of the flight control system and therefore must meet the single failure condition of [14 CFR] 25.671. These support linkages are also considered primary flight structure and must comply with the damage tolerance requirements of [14 CFR] 25.571."

Policy

1. Applicability of Requirements

Both the fatigue and damage tolerance requirements of § 25.571, and the system safety requirements of §§ 25.671 and 25.1309, apply to structural elements in flight control systems.

Examples of structural elements subject to both § 25.571 and to §§ 25.671 and 25.1309 include the horizontal stabilizer; horizontal stabilizer actuator—or jackscrew assembly; primary control surfaces; high lift devices; tabs and tab mechanisms; control surface and high lift actuators; and any structural elements that transmit or react control surface, system, or pilot loads, such as flap and slat tracks, hinges, fittings, attachments, and feel system elements.

Additional guidance on the applicability of §§ 25.571, 25.671, and 25.1309 is provided in AC 25.571-1D, AC 25-22, AC 25.1309-1A, and in the regulations themselves. Section 25.629 requires consideration of failures considered under §§ 25.571, 25.671, and 25.1309, and AC 25.629-1A provides examples of failures to consider. The attachment to this policy statement includes references to these and other guidance documents that describe the applicability of these regulations.

AC 25-22 states that the control system ends where it attaches to "fixed structure." Examples of fixed structure are the main wing, vertical stabilizer, fuselage and floor structure, pressure bulkheads, and engine mounts. These fixed structures need not be considered part of a system, and they are not subject to § 25.671 or § 25.1309. Some system elements may be fixed, such as attachment fittings and flap tracks. Nevertheless, these types of elements are still part of a system and, therefore, must be evaluated in accordance with §§ 25.671 and 25.1309, as well as § 25.571.

2. Compliance with the Requirements

a. Compliance with § 25.571

As noted in paragraph 1b of the attachment, the structural elements of certain mechanical systems must be considered "principal structural elements" and evaluated in accordance with § 25.571.

AC 25.571-1D includes the following guidance regarding application of § 25.571 to structural elements in systems: "Normally, the damage tolerance assessment consists of a deterministic evaluation …. In certain specific instances, however, damage-tolerant design might be more realistically assessed by a probabilistic evaluation employing methods such as risk analysis. Risk analyses are routinely employed in fail-safe evaluations of airplane systems and have occasionally been used where structure and systems are interrelated."

This does not mean that risk analysis must be used for all structural elements in systems, but that it may be used where considered appropriate as described in AC 25.571-1D.

Policy Statement PS-ANM100-1984-00039, *Failsafe Tab Control Systems, FAR 25.629*, dated August 9, 1984, also provides guidance on compliance with § 25.571 for control systems.

b. Compliance with §§ 25.671 and 25.1309

When assessing structural elements in flight control systems, single failures must be considered in accordance with §§ 25.671 and 25.1309. As noted in the referenced advisory and regulatory material, the single failure requirement does apply to certain structural elements that in the past may have been evaluated only as "structure." Examples are flap tracks, hinges, and attachment fittings.

For compliance with §§ 25.671 and 25.1309, single failures should be evaluated as described in AC 25.1309-1A, or later approved revision. The AC states, "In general, a failure condition resulting from a single failure mode of a device cannot be accepted as being extremely improbable. In very unusual cases, however, experienced engineering judgment may enable an assessment that such a failure mode is not a practical possibility." Such cases are rare and should be presented to the FAA for evaluation and acceptance.

On April 28, 2003, the FAA issued a "Notice of Availability" of Aviation Rulemaking Advisory Committee (ARAC) recommended changes to AC 25.1309-1A. The FAA did not adopt the ARAC-recommended AC, but accepted its use until later rulemaking could be completed. The AC indicates that single failure of certain structural elements need not be assumed if they are shown to meet the damage tolerance requirements of § 25.571. Upon further review, the FAA determined that, with the exception of the main structural elements in landing gear, the horizontal stabilizer, and other control surfaces, meeting the damage tolerance requirement of § 25.571 by itself is <u>not</u> sufficient to justify the assumption that a single failure will not occur. This is because single failure of structural elements can occur due to causes other than those addressed by § 25.571.

For the main structural elements in landing gear, the horizontal stabilizer, and other control surfaces (excluding attachment structure and actuators), compliance with § 25.571 <u>is</u> sufficient to meet the single failure requirement of §§ 25.671 and 25.1309 because the only anticipated failure modes of these elements are fully addressed by § 25.571. Therefore, if these structural elements meet the fatigue and damage-tolerance requirements of § 25.571, as well as other relevant structural requirements, then it can be concluded that complete failure of these structural elements will not occur for the purposes of finding compliance with the single failure requirements of §§ 25.671 and 25.1309.

In addition to single failures, §§ 25.671 and 25.1309 also require the assessment of combinations of failures that involve structural elements in flight control systems. As

with all systems, the safety assessment required by §§ 25.671 and 25.1309 may be qualitative, rather than quantitative, as described in AC 25.1309-1A.

Effect of Policy

The general policy stated in this document does not constitute a new regulation. Agency employees and their designees and delegations must not depart from this policy without appropriate justification and concurrence from the FAA management that issued this policy statement.

Whenever a proposed method of compliance is outside this established policy, the project aircraft certification office has to coordinate it with the policy issuing office using an issue paper. Similarly, if the project aircraft certification office becomes aware of reasons that an applicant's proposal that meets this policy should not be approved, the office must coordinate its response with the policy issuing office. Applicants should expect that certificating officials would consider this information when making findings of compliance relevant to new certificate actions. In addition, as with all advisory material, this policy statement identifies one means, but not the only means, of compliance.

Implementation

This policy discusses compliance methods that should be applied to type certificate, amended type certificate, supplemental type certificate, and amended supplemental type certification programs. The compliance methods apply to those programs with an application date that is on or after the effective date of the final policy. If the date of application precedes the effective date of the final policy, and the methods of compliance have already been coordinated with and approved by the FAA or its designee, the applicant may choose to either follow the previously acceptable methods of compliance or follow the guidance contained in this policy.

Conclusion

This policy provides guidance for certifying structural elements in flight control systems. Because of the unique nature of structural elements in systems, which act as both structure and as part of a system, additional guidance is needed on the appropriate application of the fatigue and damage tolerance requirements of § 25.571, and the system safety requirements of §§ 25.671 and 25.1309. The FAA has determined that for many structural elements in flight control systems, both sets of regulations apply. This policy provides examples of structural elements that are subject to these regulations and provides guidance on compliance.

Michael Kaszycki
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Attachment
Current Guidance on Applicability of Requirements

Current Guidance on Applicability of Requirements

1. Applicability of Fatigue and Damage-Tolerance Requirements

a. Section 25.571, Damage-Tolerance and Fatigue Evaluation of Structure. Section 25.571(a) states: "An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane." This regulation applies to "each part of the structure that could contribute to a catastrophic failure (such as wing, empennage, control surfaces and their systems, the fuselage, engine mounting, landing gear, and their related primary attachments)."

b. AC 25.571-1D, Damage Tolerance and Fatigue Evaluation of Structure. AC 25.571-1D defines a principal structural element (PSE) as an element of structure that contributes significantly to the carrying of flight, ground, or pressurization loads, and whose integrity is essential in maintaining the overall structural integrity of the airplane. Examples of PSEs in the wing and empennage include: "Control surfaces, slats, flaps, and their mechanical systems and attachments (hinges, tracks, and fittings)." Therefore, these elements are subject to the requirements of § 25.571.

c. AC 25-22, Certification of Transport Airplane Mechanical Systems. This AC includes the following guidance: "STRUCTURAL REQUIREMENTS. The structure of high lift and drag devices must be designed to comply with the damage tolerance requirements of § 25.571, Amendment 25-45, of the [14 CFR] (or later amendment). The design should incorporate features that would provide a high probability of detection of any damage, before the damage causes loss of the surface from the airplane. High lift and drag components to be evaluated under the requirements of § 25.571 typically include all structure that contributes significantly in reacting applied flight and actuation loads. Examples of such structure are the flap or slat surfaces, support linkages or tracks, hinges, fittings, and attachments."

2. Applicability of System Safety Requirements

a. Section 25.671, Control Systems—General; and Section 25.1309, Equipment, Systems, and Installations. Sections 25.671 and 25.1309 require that the airplane be shown to be capable of continued safe flight and landing after certain failures—including structural failures—in the flight control system. Any combination of failures not shown to be extremely improbable must be considered. Also, any single failure must be considered, which may include, for example, disconnection or failure of mechanical elements, or structural failure of hydraulic components.

b. AC 25-22, Certification of Transport Airplane Mechanical Systems. This AC includes the following guidance: "CONTROL SYSTEM REQUIREMENTS. The control system for high lift and drag devices must be designed to comply with the requirements of § 25.671. For the purpose of compliance with § 25.671, the control system ends where the control surface attaches to fixed structure such as the wing or fuselage. Examples of elements to be evaluated under the requirements of § 25.671

are linkages, hinges, cables, pulleys, quadrants, valves, actuator components, track rollers, movable tracks, bearings, and hydraulic or electrical systems. In accordance with § 25.671, the airplane must be shown to be capable of continued safe flight and landing without requiring exceptional pilot skill or strength following the failure of any single mechanical element or any combination of failures not shown to be extremely improbable, excluding jamming."

c. Policy Statement PS-ANM100-1984-00053, Requirement for Fail-Safe Wing Flap Design. This policy addresses flap design and includes the following guidance: "The flap support linkages referred to in this policy statement are hinges, tracks, and support linkages. They are considered part of the flight control system and therefore must meet the single failure condition of [14 CFR] 25.671. These support linkages are also considered primary flight structure and must comply with the damage tolerance requirements of [14 CFR] 25.571."

3. Applicability of Aeroelastic Stability Requirements

a. Section 25.629, Aeroelastic Stability Requirements. Section 25.629(d) requires consideration of failures, malfunctions, and adverse conditions. These include: "Any damage or failure condition, required or selected for investigation by Sec. 25.571" and "Any damage, failure, or malfunction considered under Secs. 25.631, 25.671, 25.672, and 25.1309." Therefore, both structures and systems regulations must be considered when showing compliance with § 25.629(d).

b. AC 25.629-1A, Aeroelastic Stability Substantiation of Transport Category Airplanes. AC 25.629-1A includes the following guidance regarding failure conditions: "Control surfaces, including tabs, should be investigated for nominal conditions and for failure modes that include single structural failures (such as actuator disconnects, hinge failures, or, in the case of aerodynamic balance panels, failed seals), single and dual hydraulic system failures, and any other combination of failures not shown to be extremely improbable. Where other structural components contribute to the aeroelastic stability of the system, failures of those components should be considered for possible adverse effects."