Title 14 —Aeronautics and Space
Chapter I —Federal Aviation Administration, Department of Transportation
Subchapter C —Aircraft
Part 25 —Airworthiness Standards: Transport Category Airplanes
Subpart C —Structure

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Source: Docket No. 5066, 29 FR 18291, Dec. 24, 1964, unless otherwise noted.

General

GENERAL

§ 25.301 Loads.

(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the airplane. These loads must be distributed to conservatively approximate or closely represent actual conditions. Methods used to determine load intensities and distribution must be validated by flight load measurement unless the methods used for determining those loading conditions are shown to be reliable.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-23, 35 FR 5672, Apr. 8, 1970]

§ 25.302 Interaction of systems and structures.

For airplanes equipped with systems that affect structural performance, either directly or as a result of a failure or malfunction, the influence of these systems and their failure conditions must be taken into account when showing compliance with the requirements of subparts C and D of this part. These criteria are only applicable to structure whose failure could prevent continued safe flight and landing.

(a) ***General.*** The applicant must use the following criteria in determining the influence of a system and its failure conditions on the airplane structure.

(b) ***System fully operative.*** With the system fully operative, the following criteria apply:

(1) The applicant must derive limit loads for the limit conditions specified in subpart C of this part, taking into account the behavior of the system up to the limit loads. System nonlinearities must be taken into account.

(2) The applicant must show that the airplane meets the strength requirements of subparts C and D of this part, using the appropriate factor of safety to derive ultimate loads from the limit loads defined in paragraph (b)(1) of this section. The effect of nonlinearities must be investigated sufficiently beyond limit conditions to ensure the behavior of the system presents no detrimental effects compared to the behavior below limit conditions. However, conditions beyond limit conditions need not be considered when it can be shown that the airplane has design features that will not allow it to exceed those limit conditions.

(3) [Reserved]

(c) ***System in the failure condition.*** For any system failure condition not shown to be extremely improbable or that results from a single failure, the following criteria apply:

(1) ***At the time of occurrence.*** The applicant must establish a realistic scenario, starting from 1g level flight conditions, and including pilot corrective actions, to determine the loads occurring at the time of failure and immediately after failure.

(i) For static strength substantiation, the airplane must be able to withstand the ultimate loads determined by multiplying the loads in paragraph (c)(1) of this section by a factor of safety that is related to the probability of occurrence of the failure. The factor of safety (F.S.) is defined in Figure 1.

Figure 1 to paragraph (c)(1)(i)

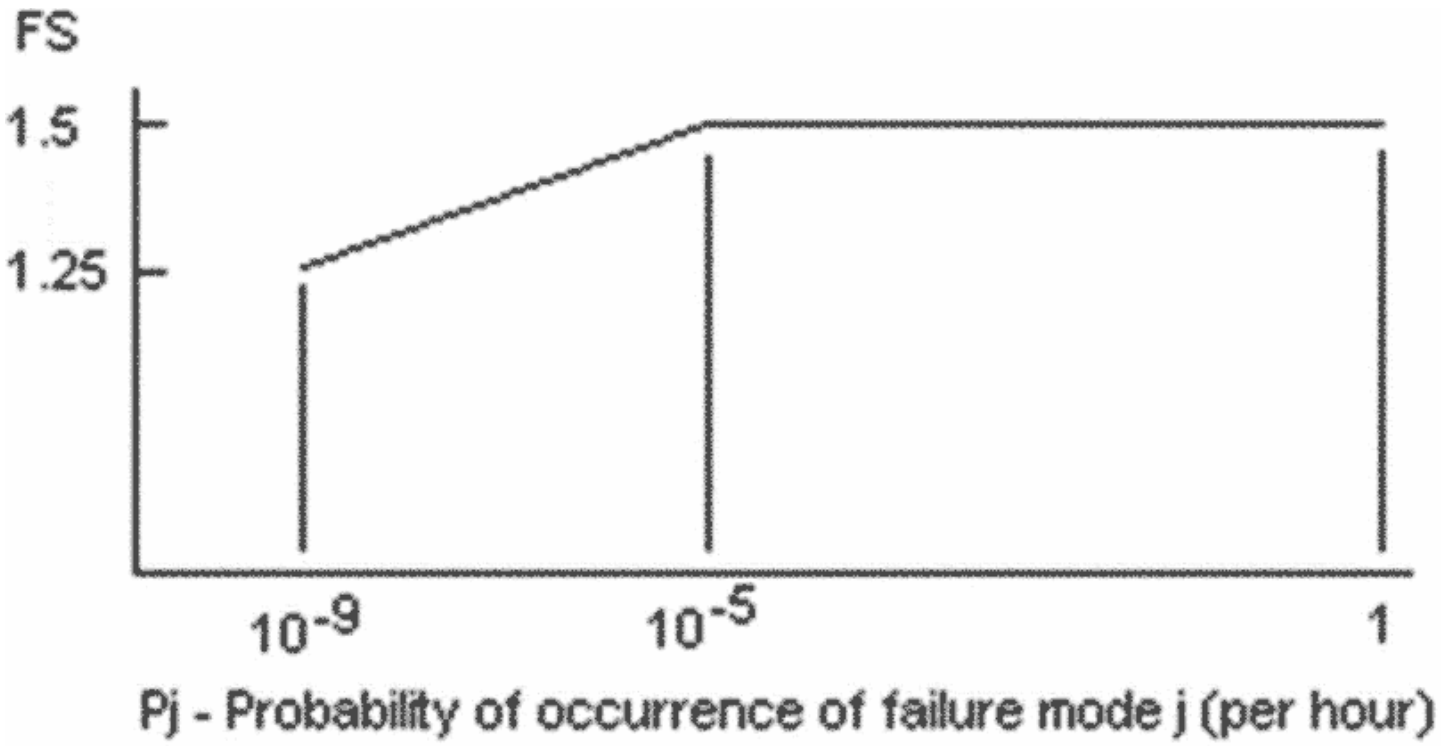

Figure 1 Factor of safety at the time of occurrence

(ii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in paragraph (c)(1)(i) of this section. For pressurized cabins, these loads must be combined with the normal operating differential pressure.

(iii) [Reserved]

(iv) 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.

(2) ***For the continuation of the flight.*** For the airplane, in the system failed state and considering any appropriate reconfiguration and flight limitations, the following apply:

(i) The loads derived from 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:

(A) the limit symmetrical maneuvering conditions specified in §§ 25.331 and 25.345,

(B) the limit gust and turbulence conditions specified in §§ 25.341 and 25.345,

(C) the limit rolling conditions specified in § 25.349 and the limit unsymmetrical conditions specified in §§ 25.367 and 25.427(b) and (c),

(D) the limit yaw maneuvering conditions specified in § 25.351,

(E) the limit ground loading conditions specified in §§ 25.473 and 25.491, and

(F) any other subpart C of this part load condition for which a system is specifically installed or tailored to reduce the loads of that condition.

(ii) For static strength substantiation, each part of the structure must be able to withstand the loads in paragraph (c)(2)(i) of this section multiplied by a factor of safety that depends on the probability of being in this failure condition. The factor of safety is defined in Figure 2.

Figure 2 to paragraph (c)(2)(ii)

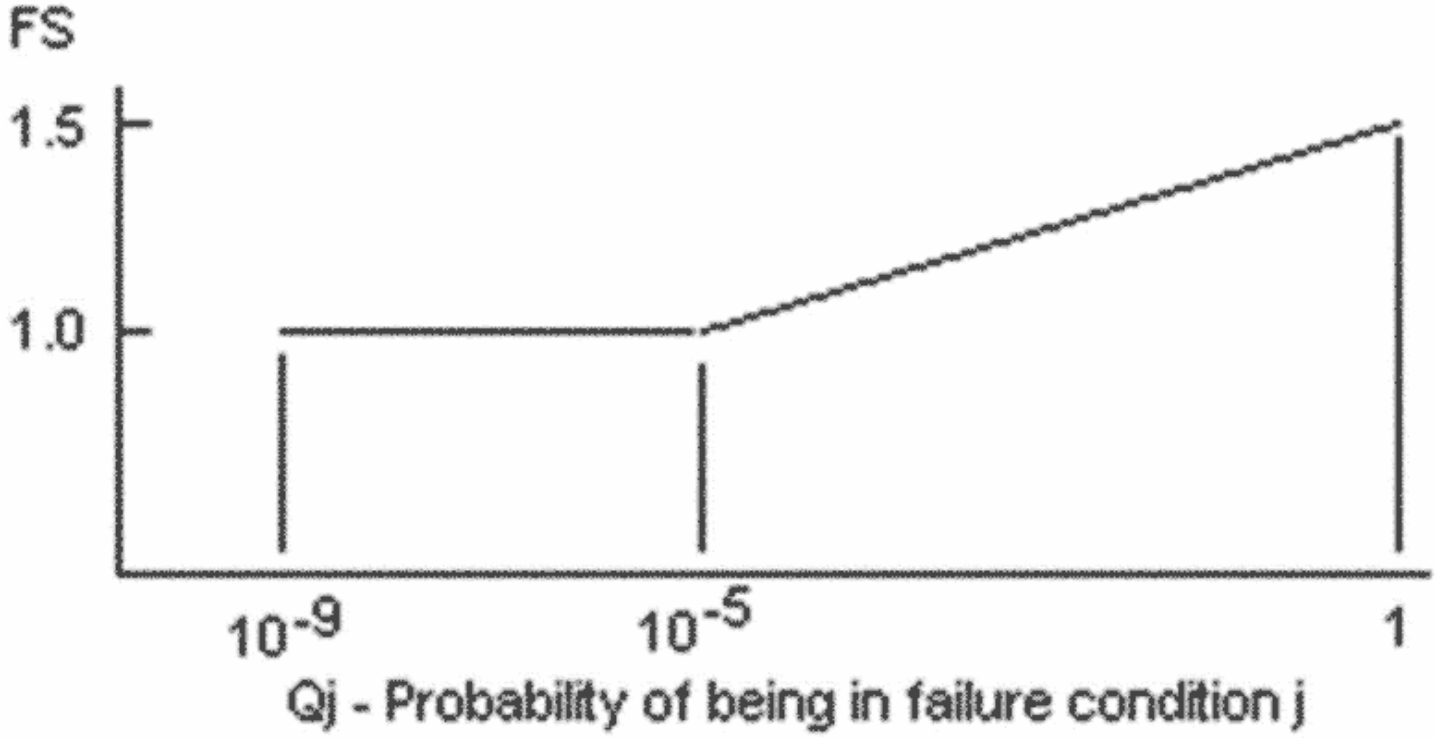

Figure 2 Factor of safety for continuation of flight

Qj = (Tj)(Pj) where:

Tj = Average time spent in failure condition j (in hours)

Pj = Probability of occurrence of failure mode j (per hour)

If Pj is greater than 10^{-3} per flight hour, then a 1.5 factor of safety must be applied in lieu of the factor of safety defined in Figure 2.

(iii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in paragraph (c)(2)(ii) of this section. For pressurized cabins, these loads must be combined with the normal operating differential pressure.

(iv) If the loads induced by the failure condition have a significant effect on fatigue or damage tolerance then their effects must be taken into account.

(v)-(vi) [Reserved]

(3) [Reserved]

(d) ***Failure indications.*** For system failure detection and indication, the following apply:

(1) The system must be checked for failure conditions evaluated under paragraph (c) of this section that degrade the structural capability below the level required by subparts C (excluding § 25.302) and D of this part or that reduce the reliability of the remaining system. As far as practicable, these failures must be indicated to the flightcrew before flight.

(2) The existence of any failure condition evaluated under paragraph (c) of this section that results in a factor of safety between the airplane strength and the loads of subpart C of this part below 1.25 must be indicated to the flightcrew.

(e) Dispatch with known failure conditions. If the airplane is to be dispatched in a known system failure condition that affects structural performance or affects the reliability of the remaining system to maintain structural performance, then the Master Minimum Equipment List must ensure the provisions of § 25.302 are met for the dispatched condition and for any subsequent failures. Flight limitations and operational limitations may be taken into account in establishing Qj as the combined probability of being in the dispatched failure condition and the subsequent failure condition for the safety margins in Figure 2. No reduction in these safety margins is allowed if the subsequent system failure rate is greater than 10^{-3} per flight hour.

[Doc. No. FAA-2022-1544, 89 FR 68732, Aug. 27, 2024]

§ 25.303 Factor of safety.

Unless otherwise specified, a factor of safety of 1.5 must be applied to the prescribed limit load which are considered external loads on the structure. When a loading condition is prescribed in terms of ultimate loads, a factor of safety need not be applied unless otherwise specified.

[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970]

§ 25.305 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure for at least 3 seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the 3-second limit does not apply. Static tests conducted to ultimate load must include the ultimate deflections and ultimate deformation induced by the loading. When analytical methods are used to show compliance with the ultimate load strength requirements, it must be shown that—

(1) The effects of deformation are not significant;

(2) The deformations involved are fully accounted for in the analysis; or

(3) The methods and assumptions used are sufficient to cover the effects of these deformations.

(c) Where structural flexibility is such that any rate of load application likely to occur in the operating conditions might produce transient stresses appreciably higher than those corresponding to static loads, the effects of this rate of application must be considered.

(d) [Reserved]

(e) The airplane must be designed to withstand any vibration and buffeting that might occur in any likely operating condition up to V_D/M_D, including stall and probable inadvertent excursions beyond the boundaries of the buffet onset envelope. This must be shown by analysis, flight tests, or other tests found necessary by the Administrator.

(f) Unless shown to be extremely improbable, the airplane must be designed to withstand any forced structural vibration resulting from any failure, malfunction or adverse condition in the flight control system. These must be considered limit loads and must be investigated at airspeeds up to V_C/M_C.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-54, 45 FR 60172, Sept. 11, 1980; Amdt. 25-77, 57 FR 28949, June 29, 1992; Amdt. 25-86, 61 FR 5220, Feb. 9, 1996]

§ 25.307 Proof of structure.

(a) Compliance with the strength and deformation requirements of this subpart must be shown for each critical loading condition. Structural analysis may be used only if the structure conforms to that for which experience has shown this method to be reliable. In other cases, substantiating tests must be made to load levels that are sufficient to verify structural behavior up to loads specified in § 25.305.

(b)-(c) [Reserved]

(d) When static or dynamic tests are used to show compliance with the requirements of § 25.305(b) for flight structures, appropriate material correction factors must be applied to the test results, unless the structure, or part thereof, being tested has features such that a number of elements contribute to the total strength of the structure and the failure of one element results in the redistribution of the load through alternate load paths.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-54, 45 FR 60172, Sept. 11, 1980; Amdt. 25-72, 55 FR 29775, July 20, 1990; Amdt. 25-139, 79 FR 59429, Oct. 2, 2014]