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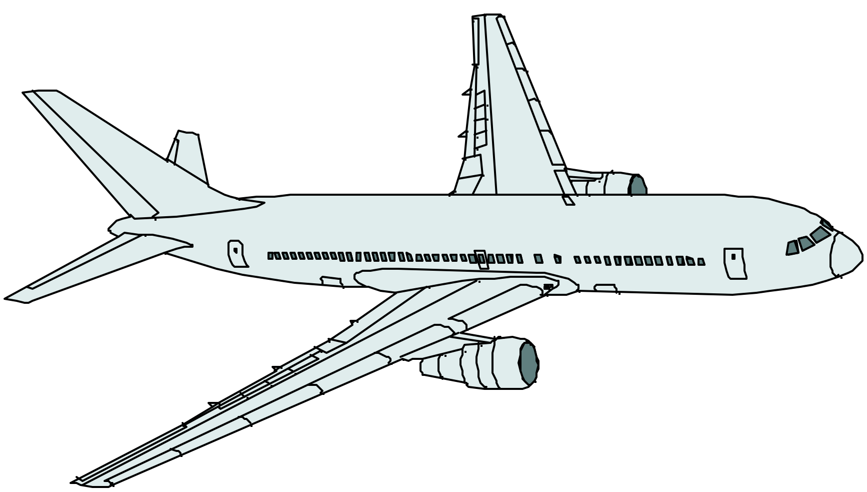
# CERTIFICATION OF TRANSPORT AIRPLANE STRUCTURE



| Paragraph | | CONTENTS | Page Number |
|---|---|---|---|

## CHAPTER 1. STRUCTURE

### Section 1. GENERAL

## Section 2. FLIGHT LOADS



## Section 3. FLIGHT MANEUVER AND GUST CONDITIONS

Section 4. SUPPLEMENTARY CONDITIONS

Section 5. CONTROL SURFACE AND SYSTEM LOADS

Section 6. GROUND LOADS

Section 7. WATER LOADS

## Section 8. EMERGENCY LANDING CONDITIONS

Section 9. FATIGUE EVALUATION



Section 10. LIGHTNING PROTECTION



CHAPTER 2. DESIGN AND CONSTRUCTION

Section 1. GENERAL

Section 2. CONTROL SURFACES

## Section 3. CONTROL SYSTEMS

Section 4. LANDING GEAR

Section 5. FLOATS AND HULLS

Section 6. PERSONNEL AND CARGO ACCOMMODATIONS

Section 7. EMERGENCY PROVISIONS



Section 8. FIRE PROTECTION

Section 9. MISCELLANEOUS



Section 10. FUEL SYSTEM

Section 11. OPERATING LIMITATIONS



APPENDICES

# Chapter 1 - STRUCTURE

## Section 1. GENERAL

1. SECTION 25.301 - LOADS.

a. Rule Text.

*(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.*

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

b. Intent of Rule. The purpose of this rule is to ensure that the loads developed on the airplane are accurately represented and are applied in a realistic manner. This rule also ensures that a margin of safety is provided above the expected loads by applying a factor of safety to the limit loads.

c. Background. This rule was carried forward from § 4b.200 of the Civil Air Regulations (CAR) with minor editorial changes. Amendment 25-23 requires that the methods used to determine load intensities and distributions must be validated by flight load measurements, unless the methods used for determining those loading conditions are shown to be reliable.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970.

e. References. None.

2 - 10. [RESERVED]

11. SECTION 25.303 - FACTOR OF SAFETY.

a. Rule Text.

*Unless otherwise specified, a factor of safety of 1.5 must be applied to the prescribed limit loads 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]*

b. Intent of Rule. The purpose of this rule is to ensure airplane structural integrity by providing a margin of safety above the loads expected in service. This is achieved by application of a factor of safety to the limit loads.

c. Background. This rule was carried forward from § 4b.200 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970.

e. References. None.

12 - 22. [RESERVED]

23. SECTION 25.305 - STRENGTH AND DEFORMATION.

a. Rule Text.

*(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 requirement, 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 $V_C/M_C$.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-54, 45 FR 60172, Sep. 11, 1980; Amdt. 25-77, 57 FR 28949, Jun. 29, 1992; Amdt. 25-86, 61 FR 5220, Feb. 9, 1996]*

b. Intent of Rule. This rule is intended to ensure that the structure is able to withstand loading conditions, including dynamic loading conditions, likely to be encountered in service. This includes loads due to continuous turbulence, buffeting, and vibration. The rule addresses the effects of deformation up to limit loads and up to ultimate loads.

c. Background. This rule was carried forward from § 4b.201 of the Civil Air Regulations (CAR) with some editorial changes. Amendment 25-23 added the requirement to investigate the dynamic response of the airplane to continuous turbulence. Amendment 25-54 added Appendix G (Continuous Gust Design Criteria). Vibration and buffeting were previously covered in § 25.251. Amendment 25-77 transferred the structural requirements of § 25.251 to §§ 25.305(e) and (f). Amendment 25-86 transferred the continuous turbulence requirement of § 25.305(d) to § 25.341(b).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; Amendment 25-54, 45 FR 60172, September 11, 1980; Amendment 25-77, 57 FR 28949, June 29, 1992; and Amendment 25-86, 61 FR 5220, February 9, 1996.

e. References. None.

24 - 34. [RESERVED]

35. SECTION 25.307 - PROOF OF STRUCTURE.

a. Rule Text.

*(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. The Administrator may require ultimate load tests in cases where limit load tests may be inadequate.*
*(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.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-54, 45 FR 60172, Sep. 11, 1980; Amdt. 25-72, 55 FR 29775, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to ensure that flight structures will meet the required strength and deformation levels by analysis and tests. It also requires that appropriate material correction factors be applied to certain test results.

c. Background. Section 25.307 of the FAR was recodified from § 4b.202 of Civil Air Regulations (CAR) in 1964. During recodification, the text was revised for the purpose of technical clarification, but the intent of the requirement remained the same. Prior to adoption of part 4b of the CAR, a similar requirement existed in CAR 04, where § 04.3 required proof of compliance with the strength and deformation requirements of § 04.2.

(1) Amendment 25-23 revised § 25.307 by adding paragraph (d), the requirement for material correction factors which must be used for single load path flight structure substantiated by test only. While there was no corresponding requirement in part 4b of the CAR, § 04.3021 of CAR 04 required the use of material correction factors for all primary structure substantiated by test only. Section 25.307 was further revised by Amendment 25-54 that added the last sentence in § 25.307(a). Amendment 25-72 made further minor revisions, rescinding two redundant sections.

(2) The basic intent of the requirement has remained unchanged since the early 1940's. The regulation required proof of structural compliance with the strength and deformation requirement of Part 25 for each critical loading condition. Structural analysis was allowed only if the structure conformed to that which experience had shown the methods to be reliable.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; Amendment 25-54, 45 FR 60172, September 11, 1980; and Amendment 25-72, 55 FR 29775, July 20, 1990.

e. References. None.

36 - 44. [RESERVED]

## Section 2. FLIGHT LOADS

### 45. SECTION 25.321 - GENERAL.

a. Rule Text.

*(a) Flight load factors represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the airplane) to the weight of the airplane. A positive load factor is one in which the aerodynamic force acts upward with respect to the airplane.*
*(b) Considering compressibility effects at each speed, compliance with the flight loads requirements of this subpart must be shown-*
*(1) At each critical altitude within the range of altitudes selected by the applicant;*
*(2) At each weight from the design minimum weight to the design maximum weight appropriate to each particular flight load condition; and*
*(3) For each required altitude and weight, for any practicable distribution of disposable load within the operating limitations recorded in the Airplane Flight Manual.*
*(c) Enough points on and within the boundaries of the design envelope must be investigated to ensure that the maximum load for each part of the airplane structure is obtained.*
*(d) The significant forces acting on the airplane must be placed in equilibrium in a rational or conservative manner. The linear inertia forces must be considered in equilibrium with the thrust and all aerodynamic loads, while the angular (pitching) inertia forces must be considered in equilibrium with thrust and all aerodynamic moments, including moments due to loads on components such as tail surfaces and nacelles. Critical thrust values in the range from zero to maximum continuous thrust must be considered.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-86, 61 FR 5220, Feb. 9, 1996]*

b. Intent of Rule. The purpose for this rule is to ensure that all flight load conditions required by this subpart accurately account for all critical conditions.

c. Background. This rule was carried forward from § 4b.210 of the Civil Air Regulations (CAR). Amendment 25-23 made minor editorial changes to the rule. Amendment 25-86 added paragraphs (c) and (d) taken from § 25.331 in order to re-organize the presentation accounting for the deletion of the gust envelope by Amendment 25-86.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; and Amendment 25-86, 61 FR 5220, February 9, 1996.

e. References. None.

46 - 54. [RESERVED]

## Section 3. FLIGHT MANEUVER AND GUST CONDITIONS

### 55. SECTION 25.331 - SYMMETRIC MANEUVERING CONDITIONS.

a. Rule Text.

*(a) Procedure. For the analysis of the maneuvering flight conditions specified in paragraphs (b) and (c) of this section, the following provisions apply:*
*(1) Where sudden displacement of a control is specified, the assumed rate of control surface displacement may not be less than the rate that could be applied by the pilot through the control system.*
*(2) In determining elevator angles and chordwise load distribution in the maneuvering conditions of paragraphs (b) and (c) of this section, the effect of corresponding pitching velocities must be taken into account. The in-trim and out-of-trim flight conditions specified in § 25.255 must be considered.*
*(b) Maneuvering balanced conditions. Assuming the airplane to be in equilibrium with zero pitching acceleration, the maneuvering conditions A through I on the maneuvering envelope in § 25.333(b) must be investigated.*
*(c) Pitch maneuver conditions. The conditions specified in paragraphs (c)(1) and (c)(2) of this section must be investigated. The movement of the pitch control surfaces may be adjusted to take into account limitations imposed by the maximum pilot effort specified by § 25.397(b), control system stops and any indirect effect imposed by limitations in the output side of the control system (for example, stalling torque or maximum rate obtainable by a power control system.)*
*(1) Maximum pitch control displacement at $V_A$. The airplane is assumed to be flying in steady level flight (point $A_1$, § 25.333(b)) and the cockpit pitch control is suddenly moved to obtain extreme nose up pitching acceleration. In defining the tail load, the response of the airplane must be taken into account. Airplane loads that occur subsequent to the time when normal acceleration at the c.g. exceeds the positive limit maneuvering load factor (at point $A_2$ in § 25.333(b)), or the resulting tailplane normal load reaches its maximum, whichever occurs first, need not be considered.*
*(2) Specified control displacement. A checked maneuver, based on a rational pitching control motion vs. time profile, must be established in which the design limit load factor specified in § 25.337 will not be exceeded. Unless lesser values cannot be exceeded, the airplane response must result in pitching accelerations not less than the following:*
*(i) A positive pitching acceleration (nose up) is assumed to be reached concurrently with the airplane load factor of 1.0 (points $A_1$ to $D_1$, § 25.333(b)). The positive acceleration must be equal to at least*

$$\frac{39n}{V}(n-1.5),\left(Radians/\sec^2\right)$$

*Where -*

*n is the positive load factor at the speed under consideration, and V is the airplane equivalent speed in knots.*

*(ii) A negative pitching acceleration (nose down) is assumed to be reached concurrently with the positive maneuvering load factor (points $A_2$ to $D_2$, § 25.333(b)). This negative pitching acceleration must be equal to at least*

$$\frac{-26n}{V}(n-1.5),\left(Radians/\sec.^2\right)$$

*Where -*

*n is the positive load factor at the speed under consideration; and V is the airplane equivalent speed in knots.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-46, 43 FR 50594, Oct. 30, 1978; 43 FR 52495, Nov. 13, 1978; 43 FR 54082, Nov. 20, 1978; Amdt. 25-72, 55 FR 29775, Jul. 20, 1990; 55 FR 37607, Amdt. 25-86, 61 FR 5220, Feb. 9, 1996; Amdt. 25-91, 62 FR 40704, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane structure is capable of withstanding maneuvering pitching conditions by requiring investigation of specific maneuvers. It requires the applicant to investigate all significant forces acting on the airplane during pitching maneuvers, including both inertia and aerodynamic forces.

c. Background. This rule was carried forward from § 4b.213 of the Civil Air Regulations (CAR) with minor changes. Amendment 25-23 made changes for clarification. Amendment 25-86 removed all reference to gusts and moved the general requirements to § 25.321. Amendment 25-91 revised the "unchecked" pitch maneuver so that the time history analysis no longer had to be carried out past the point where the maximum tail load was reached.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; Amendment 25-46, 43 FR 50594, October 30, 1978; 43 FR 52495, November 13, 1978; 43 FR 54082, November 20, 1978; Amendment 25-72, 55 FR 29775, July 20, 1990; 55 FR 37607, Amendment 25-86, 61 FR 5220, February 9, 1996; and Amendment 25-91, 62 FR 40704, July 29, 1997.

e. References. None.

56 - 64. [RESERVED]

## 65. SECTION 25.333 - FLIGHT MANEUVERING ENVELOPE.

a. Rule Text.

*(a) General. The strength requirements must be met at each combination of airspeed and load factor on and within the boundaries of the representative maneuvering and gust envelopes (V-n diagram) of paragraph (b) of this section. This envelope must also be used in determining the airplane structural operating limitations as specified in § 25.1501.*
*(b) Maneuvering envelope.*

NOTE: See Title 14, Code of Federal Regulations (14 CFR) for figure following paragraph (b).

*[Amdt. 25-86, 61 FR 5220, Feb. 9, 1996]*

b. Intent of Rule. The purpose of this rule is to provide a structural design envelope that will allow a realistic operating envelope for the airplane.

c. Background. This rule was carried forward from § 4b.211 of the Civil Air Regulations (CAR). Amendment 25-86 revised this section by removing the gust envelope.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-86, 61 FR 5220, February 9, 1996.

e. References. None.

66 - 76. [RESERVED]

## 77. SECTION 25.335 - DESIGN AIRSPEEDS.

a. Rule Text.

*The selected design airspeeds are equivalent airspeeds (EAS). Estimated values of $V_{SO}$ and $V_{S1}$ must be conservative.*
*(a) Design cruising speed, $V_C$. For $V_{C,}$ the following apply:*
*(1) The minimum value of $V_C$ must be sufficiently greater than $V_B$ to provide for inadvertent speed increases likely to occur as a result of severe atmospheric turbulence.*

*(2) Except as provided in § 25.335(d)(2), $V_C$ may not be less than $V_B$+ 1.32 $U_{REF}$ (with $U_{REF}$ as specified in § 25.341(a)(5)(i)). However $V_C$ need not exceed the maximum speed in level flight at maximum continuous power for the corresponding altitude.*
*(3) At altitudes where $V_D$ is limited by Mach number, $V_C$ may be limited to a selected Mach number.*
*(b) Design dive speed, $V_D$. $V_D$ must be selected so that $V_C/M_C$ is not greater than 0.8 $V_D/M_D$, or so that the minimum speed margin between $V_C/M_C$ and $V_D/M_D$ is the greater of the following values:*
*(1) From an initial condition of stabilized flight at $V_C/M_C$, the airplane is upset, flown for 20 seconds along a flight path 7.5º below the initial path, and then pulled up at a load factor of 1.5g (0.5g acceleration increment). The speed increase occurring in this maneuver may be calculated if reliable or conservative aerodynamic data is used. Power as specified in § 25.175(b)(1)(iv) is assumed until the pull-up is initiated, at which time power reduction and the use of pilot controlled drag devices may be assumed;*
*(2) The minimum speed margin must be enough to provide for atmospheric variations (such as horizontal gusts, and penetration of jet streams and cold fronts) and for instrument errors and airframe production variations. These factors may be considered on a probability basis. The margin at altitude where $M_C$ is limited by compressibility effects must not be less than 0.07M unless a lower margin is determined using a rational analysis that includes the effects of any automatic systems. In any case, the margin may not be reduced to less than 0.05M.*
*(c) Design maneuvering speed $V_A$. For $V_A$, the following apply:*
*(1) $V_A$ may not be less than $V_{S1}$ Ön where -*
*(i) n is the limit positive maneuvering load factor at $V_C$; and*
*(ii) $V_{S1}$ is the stalling speed with flaps retracted.*
*(2) $V_A$ and $V_S$ must be evaluated at the design weight and altitude under consideration.*
*(3) $V_A$ need not be more than $V_C$ or the speed at which the positive $C_{N\,MAX}$ curve intersects the positive maneuver load factor line, whichever is less.*
*(d) Design speed for maximum gust intensity, $V_B$.*
*(1) $V_B$ may not be less than*

$$V_{S1}\left[1+\frac{K_g U_{ref} V_C a}{498w}\right]^{1/2}$$

*where—*

*$V_{S1}$ = the 1-g stalling speed based on $C_{NAMAX}$ with the flaps retracted at the particular weight under consideration;*

$V_C$ = *design cruise speed (knots equivalent airspeed);*
$U_{ref}$ = *the reference gust velocity (feet per second equivalent airspeed) from § 25.341(a)(5)(i);*

*w* = *average wing loading (pounds per square foot) at the particular weight under consideration.*

$$K_g = \frac{.88m}{5.3+m}$$

$$m = \frac{2\,w}{r\,cag}$$

*r* = *density of air (slugs/ft*$^3$*);*

*c* = *mean geometric chord of the wing (feet);*

*g* = *acceleration due to gravity (ft/sec*$^2$*);*

*a* = *slope of the airplane normal force coefficient curve,* $C_{NA}$ *per radian;*

*(2) At altitudes where* $V_C$ *is limited by Mach number—*

*(i)* $V_B$ *may be chosen to provide an optimum margin between low and high speed buffet boundaries; and,*

*(ii)* $V_B$ *need not be greater than* $V_C$.

*(e) Design flap speeds,* $V_F$. *For* $V_F$*, the following apply:*

*(1) The design flap speed for each flap position (established in accordance with § 25.697(a)) must be sufficiently greater than the operating speed recommended for the corresponding stage of flight (including balked landings) to allow for probable variations in control of airspeed and for transition from one flap position to another.*

*(2) If an automatic flap positioning or load limiting device is used, the speeds and corresponding flap positions programmed or allowed by the device may be used.*

*(3)* $V_F$ *may not be less than-*

*(i) 1.6* $V_{S1}$ *with the flaps in takeoff position at maximum takeoff weight;*

*(ii) 1.8* $V_{S1}$ *with the flaps in approach position at maximum landing weight; and*

*(iii) 1.8* $V_{SO}$ *with the flaps in landing position at maximum landing weight.*

*(f) Design drag device speeds,* $V_{DD}$. *The selected design speed for each drag device must be sufficiently greater than the speed recommended for the operation of the device to allow for probable variations in speed control. For drag devices intended for use in high speed descents,* $V_{DD}$ *may not be less than* $V_D$. *When an automatic drag device positioning or load limiting means is used, the speeds and corresponding drag device positions programmed or allowed by the automatic means must be used for design.*

*[Amdt. 25-23, 35 FR 5672, April 8, 1970; Amdt. 25-86, 61 FR 5220, February 9, 1996; Amdt. 25-91, 62 FR 40702, July 29, 1997]*

b. Intent of Rule. This rule establishes the airspeeds used for structural design of the airframe. Structural design speeds are based on the structural design stall speed for the airplane as indicated in 25.333(b). These structural design airspeeds are selected to provide a margin above the likely operating speeds, including overspeed due to inadvertent upsets. Approved operating airspeeds must not exceed the approved structural design airspeeds.

c. Background. This rule was carried forward from §§ 4b.210 and 4b.711 of the Civil Air Regulations (CAR). Prior to Amendment 25-23, the design dive speed ($V_D/M_D$) was defined in the operating limitations section of the airworthiness standards as a margin above $V_{MO}/M_{MO}$. $V_D/M_D$ was selected to provide a speed margin above $V_{MO}/M_{MO}$ sufficient to make it highly improbable that $V_D/M_D$ would be inadvertently exceeded in operation. Since $V_D/M_D$ is a structural design speed, Amendment 25-23 brought the definition of $V_D/M_D$ forward to the structures section of the airworthiness standards and redefined it as the speed margin above $V_C/M_C$. The speed margins were not changed. Amendment 25-23 also addressed the design drag device speeds ($V_{DD}$). Amendment 25-86 redefined the design speed for maximum gust intensity to be consistent with the tuned gust methodology adopted in that amendment. Amendment 25-91 provided a redefinition of the minimum speed margin for $V_C$ based on the gust intensities that had been revised by Amendment 25-86. Amendment 25-91 also clarified the meaning of § 25.335(b)(2) to require a rational analysis. Advisory Circular (AC) 25.335-1, or latest revision, was provided for that purpose. In lieu of a rational analysis, a minimum margin of Mach 0.07 can be used.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; Amendment 25-86, 61 FR 5220, February 9, 1996; and Amendment 25-91, 62 FR 40702, July 29, 1997. Advisory Circular 25.335-1, or latest revision, provides guidance information for paragraph (b)(2) for showing compliance with airspeeds used for structural design of the airframe.

e. References. Advisory Circular 25.335-1, or latest revision, Design Dive Speed.

78 - 86. [RESERVED]

## 87. SECTION 25.337 - LIMIT MANEUVERING LOAD FACTORS.

a. Rule Text.

*(a) Except where limited by maximum (static) lift coefficients, the airplane is assumed to be subjected to symmetrical maneuvers resulting in the limit maneuvering load factors prescribed in this section. Pitching velocities appropriate to the corresponding pull-up and steady turn maneuvers must be taken into account.*

*(b) The positive limit maneuvering load factor "n" for any speed up to Vn may not be less than 2.1 + 24,000/(W+10,000), except that "n" may not be less than 2.5 and need not be greater than 3.8-- where "W" is the maximum design takeoff weight.*

*(c) The negative limit maneuvering load factor-*

*(1) May not be less than -1.0 at speeds up to $V_C$; and*

*(2) Must vary linearly with speed from the value at $V_C$ to zero at $V_D$.*

*(d) Maneuvering load factors lower than those specified in this section may be used if the airplane has design features that make it impossible to exceed these values in flight.*

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

b. Intent of Rule. The purpose for establishing minimum maneuvering load factors is to ensure that the airplane is able to withstand any likely maneuver experienced in service without structural damage to the airplane.

c. Background. This rule was carried forward from § 4b.211 of the Civil Air Regulations (CAR). Prior to Amendment 25-23 to this rule, the positive limit maneuvering load factor, *n,* was selected by the applicant, except that it could not be less than 2.5. Amendment 25-23 redefined the positive limit maneuvering load factor as a function of design maximum takeoff weight. It was allowed to range between 2.5 and 3.8. This resulted in a positive limit load factor greater than 2.5 for airplanes with less than 50,000 lb. design maximum takeoff weight. The negative limit maneuvering load factor remained unchanged.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970.

e. References. None.

88 -96. [RESERVED]

97. SECTION 25.341 - GUST AND TURBULENCE LOADS.

a. Rule Text.

*(a) Discrete Gust Design Criteria. The airplane is assumed to be subjected to symmetrical vertical and lateral gusts in level flight. Limit gust loads must be determined in accordance with the following provisions:*
*(1) Loads on each part of the structure must be determined by dynamic analysis. The analysis must take into account unsteady aerodynamic characteristics and all significant structural degrees of freedom including rigid body motions.*

*(2) The shape of the gust must be:*

$$U = \frac{U_{ds}}{2}\left[1 - \mathrm{Cos}\left(\frac{ps}{H}\right)\right]$$

*for 0 ≤ s ≤ 2H*

*where—*

*s = distance penetrated into the gust (feet);*

$U_{ds}$ = *the design gust velocity in equivalent airspeed specified in paragraph (a)(4) of this section; and*

*H = the gust gradient which is the distance (feet) parallel to the airplane's flight path for the gust to reach its peak velocity.*

*(3) A sufficient number of gust gradient distances in the range 30 feet to 350 feet must be investigated to find the critical response for each load quantity.*

*(4) The design gust velocity must be:*

$$U_{ds} = U_{ref} F_g \left(H/350\right)^{1/6}$$

*where—*

$U_{ref}$ = *the reference gust velocity in equivalent airspeed defined in paragraph (a)(5) of this section.*

$F_g$ *= the flight profile alleviation factor defined in paragraph (a)(6) of this section.*

*(5) The following reference gust velocities apply:*

*(i) At the airplane design speed $V_C$: Positive and negative gusts with reference gust velocities of 56.0 ft/sec EAS must be considered at sea level. The reference gust velocity may be reduced linearly from 56.0 ft/sec EAS at sea level to 44.0 ft/sec EAS at 15000 feet. The reference gust velocity may be further reduced linearly from 44.0 ft/sec EAS at 15000 feet to 26.0 ft/sec EAS at 50000 feet.*

*(ii) At the airplane design speed $V_D$: The reference gust velocity must be 0.5 times the value obtained under § 25.341(a)(5)(i).*

*(6) The flight profile alleviation factor, $F_g$, must be increased linearly from the sea level value to a value of 1.0 at the maximum operating altitude defined in § 25.1527. At sea level, the flight profile alleviation factor is determined by the following equation:*

$$F_g = 0.5\left(F_{gz} + F_{gm}\right)$$

*where—*

$$F_{gz} = 1 - \frac{Z_{mo}}{250000};$$

$$F_{gm} = \sqrt{R_2 \operatorname{Tan}\left(\pi R_1 / 4\right)};$$

$$R_1 = \frac{\text{Maximum Landing Weight}}{\text{Maximum Take-off Weight}};$$

$$R_2 = \frac{\text{Maximum Zero Fuel Weight}}{\text{Maximum Take-off Weight}};$$

$Z_{mo}$ = *Maximum operating altitude defined in § 25.1527.*

*(7) When a stability augmentation system is included in the analysis, the effect of any significant system nonlinearities should be accounted for when deriving limit loads from limit gust conditions.*

*(b) Continuous Gust Design Criteria. The dynamic response of the airplane to vertical and lateral continuous turbulence must be taken into account. The continuous gust design criteria of Appendix G of this part must be used to establish the dynamic response unless more rational criteria are shown.*

*[Amdt. 25-72, 55 FR 37607, Sep. 12, 1990; Amdt. 25-86, 61 FR 5220, Feb. 9, 1996, correction published in 61 FR 9533, on Mar. 3, 1996]*

b. Intent of Rule. The purpose of this rule is to define dynamic discrete gust load conditions and continuous turbulence conditions that the airplane is likely to experience during its lifetime. The airplane structure must be designed to withstand these loads.

c. Background. Amendment 25-86 reorganized the gust requirement of the Federal Aviation Regulations (FAR) to bring all gust requirements under section 25.341. The previous static discrete gust criterion was replaced by a dynamic “tuned” discrete gust criterion. In addition, the design gust velocities were revised based on more recent measurements of gusts. The continuous turbulence requirements were brought from § 25.305(d) to § 25.341(b) without change.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-72, 55 FR 37607, September 12, 1990; and Amendment 25-86, 61 FR 5220, February 9, 1996, correction published in 61 FR 9533, on March 3, 1996.

e. References. None.

98 -108. [RESERVED]

109. SECTION 25.343 - DESIGN FUEL AND OIL LOADS.

a. Rule Text.

*(a) The disposable load combinations must include each fuel and oil load in the range from zero fuel and oil to the selected maximum fuel and oil load. A structural reserve fuel condition, not exceeding 45 minutes of fuel under the operating conditions in § 25.1001(e) and (f), as applicable, may be selected.*
*(b) If a structural reserve fuel condition is selected, it must be used as the minimum fuel weight condition for showing compliance with the flight load requirements as prescribed in this subpart. In addition -*
*(1) The structure must be designed for a condition of zero fuel and oil in the wing at limit loads corresponding to -*
*(i) A maneuvering load factor of +2.25; and*
*(ii) The gust conditions of § 25.341(a) but assuming 85% of the design velocities prescribed in § 25.341(a)(4); and*
*(2) Fatigue evaluation of the structure must account for any increase in operating stresses resulting from the design condition of paragraph (b)(1) of this section; and*
*(3) The flutter, deformation, and vibration requirements must also be met with zero fuel.*

*[Amdt. 25-18, 33 FR 12226, Aug. 30,1968; Amdt. 25-72, 55 FR 37607, Sep. 12, 1990; Amdt. 25-86, 61 FR 5221, Feb. 9, 1996]*

b. Intent of Rule. The purpose of this rule is to ensure that the inertia effects of fuel and oil are accounted for in calculating loads on the airframe. It is also intended to require that the airplane meet the flutter, deformation, and vibration requirements for the full range of fuel and oil loading conditions.

c. Background. This rule was carried forward from § 4b.210(c) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-18, 33 FR 12226, August 30,1968; Amendment 25-72, 55 FR 37607, September 12, 1990; and Amendment 25-86, 61 FR 5221, February 9, 1996.

e. References. None.

110 - 118. [RESERVED]

## 119. SECTION 25.345 - HIGH LIFT DEVICES.

a. Rule Text.

*(a) If wing flaps are to be used during takeoff, approach, or landing, at the design flap speeds established for these stages of flight under § 25.335(e) and with the wing flaps in the corresponding positions, the airplane is assumed to be subjected to symmetrical maneuvers and gusts. The resulting limit loads must correspond to the conditions determined as follows:*

*(1) Maneuvering to a positive limit load factor of 2.0; and*

*(2) Positive and negative gusts of 25 ft/sec EAS acting normal to the flight path in level flight. Gust loads resulting on each part of the structure must be determined by rational analysis. The analysis must take into account the unsteady aerodynamic characteristics and rigid body motions of the aircraft. The shape of the gust must be as described in § 25.341(a)(2) except that -*

*$U_{ds}$ = 25 ft/sec EAS;*

*$H$ = 12.5 c; and*

*$c$ = mean geometric chord of the wing (feet).*

*(b) The airplane must be designed for the conditions prescribed in paragraph (a) of this section, except that the airplane load factor need not exceed 1.0, taking into account, as separate conditions, the effects of -*

*(1) Propeller slipstream corresponding to maximum continuous power at the design flap speeds $V_F$, and with takeoff power at not less than 1.4 times the stalling speed for the particular flap position and associated maximum weight; and*

*(2) A head on gust of 25 feet per second velocity (EAS).*

*(c) If flaps or other high lift devices are to be used in en route conditions, and with flaps in the appropriate position at speeds up to the flap design speed chosen for these conditions, the airplane is assumed to be subjected to symmetrical maneuvers and gusts within the range determined by -*

*(1) Maneuvering to a positive limit load factor as prescribed in § 25.337(b); and*

*(2) The discrete vertical gust criteria in § 25.341(a).*
*(d) The airplane must be designed for a maneuvering load factor of 1.5 g at the maximum take-off weight with the wing-flaps and similar high lift devices in the landing configurations.*

*[Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 37607, Sep. 17, 1990; Amdt. 25-86, 61 FR 5221, Feb. 9, 1996; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure adequate strength in the airframe to carry loads that are likely to develop while operating with flaps or similar high lift devices extended. The referenced stalling speeds are 1g structural design stalling speeds.

c. Background. This rule was carried forward from § 4b.212 of the Civil Air Regulations (CAR). Amendment 25-46 added subparagraph (d) that prescribed a load factor of 1.5 when landing at maximum takeoff weight with the flaps in the landing configuration. Amendment 25-72 amended subparagraph (c)(1) by changing the maneuver load factor of 2.5 to the load factor prescribed in 25.337(b).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-46, 43 FR 50595, October 30, 1978; Amendment 25-72, 55 FR 37607, September 17, 1990; Amendment 25-86, 61 FR 5221, February 9, 1996; and Amendment 25-91, 62 FR 40702, July 29, 1997. Advisory Circular (AC) 25-14, or latest revision, provides guidance information for showing compliance with structural and functional safety standards for high lift and drag devices and their operating systems.

e. References. Advisory Circular 25-14, or latest revision, High Lift and Drag Devices.

120 - 128. [RESERVED]

## 129. SECTION 25.349 - ROLLING CONDITIONS.

a. Rule Text.

*The airplane must be designed for loads resulting from the rolling conditions specified in paragraphs (a) and (b) of this section. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner, considering the principal masses furnishing the reacting inertia forces.*
*(a) Maneuvering. The following conditions, speeds, and aileron deflections (except as the deflections may be limited by pilot effort) must be considered in combination with an airplane load factor of zero and of two-thirds of the positive maneuvering factor used in design. In determining the required aileron*

*deflections, the torsional flexibility of the wing must be considered in accordance with § 25.301(b):*
*(1) Conditions corresponding to steady rolling velocities must be investigated. In addition, conditions corresponding to maximum angular acceleration must be investigated for airplanes with engines or other weight concentrations outboard of the fuselage. For angular acceleration conditions, zero rolling velocity may be assumed in the absence of a rational time history investigation of the maneuver.*
*(2) At $V_A$, a sudden deflection of the aileron to the stop is assumed.*
*(3) At $V_C$, the aileron deflection must be that required to produce a rate of roll not less than that obtained in paragraph (a)(2) of this section.*
*(4) At $V_D$, the aileron deflection must be that required to produce a rate of roll not less than one-third of that in paragraph (a)(2) of this section.*
*(b) Unsymmetrical gusts. The airplane is assumed to be subjected to unsymmetrical vertical gusts in level flight. The resulting limit loads must be determined from either the wing maximum airload derived directly from § 25.341(a), or the wing maximum airload derived indirectly from the vertical load factor calculated from § 25.341(a). It must be assumed that 100 percent of the wing air load acts on one side of the airplane and 80 percent of the wing air load acts on the other side.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-86, 61 FR 5222, Feb. 9, 1996]*

b. Intent of Rule. The purpose of this rule is to ensure that the airframe is designed to withstand any likely airplane rolling maneuver condition or unsymmetrical gust condition expected in service.

c. Background. The loading condition rule was carried forward from § 4b.214 of the Civil Air Regulations (CAR). Amendment 25-86 completely revised the unsymetrical gust requirement since it previously depended on the static discrete gust criteria and also on the gust envelope that were eliminated by Amendment 25-86. the new paragraph prescribes a simplified method for the unsymmetical gusts based on the dynamic discrete gust criteria of the revised § 25.341(a).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; and Amendment 25-86, 61 FR 5222, February 9, 1996.

e. References. None.

130 - 137. [RESERVED]

## 138. SECTION 25.351 - YAW MANEUVER CONDITIONS.

a. Rule Text.

*The airplane must be designed for loads resulting from the yaw maneuver conditions specified in paragraphs (a) through (d) of this section at speeds from $V_{MC}$ to $V_D$. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner considering the airplane inertia forces. In computing the tail loads the yawing velocity may be assumed to be zero.*
*(a) With the airplane in unaccelerated flight at zero yaw, it is assumed that the cockpit rudder control is suddenly displaced to achieve the resulting rudder deflection, as limited by:*
*(1) the control system on control surface stops; or*
*(2) a limit pilot force of 300 pounds from $V_{MC}$ to $V_A$ and 200 pounds from $V_C/M_C$ to $V_D/M_D$, with a linear variation between $V_A$ and $V_C/M_C$.*
*(b) With the cockpit rudder control deflected so as always to maintain the maximum rudder deflection available within the limitations specified in paragraph (a) of this section, it is assumed that the airplane yaws to the overswing sideslip angle.*
*(c) With the airplane yawed to the static equilibrium sideslip angle, it is assumed that the cockpit rudder control is held so as to achieve the maximum rudder deflection available within the limitations specified in paragraph (a) of this section.*
*(d) With the airplane yawed to the static equilibrium sideslip angle of paragraph (c) of this section, it is assumed that the cockpit rudder control is suddenly returned to neutral.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 29775, Jul. 20, 1990; 55 FR 37607, Sept. 12, 1990; 55 FR 41415, Oct. 11, 1990; Amdt. 25-86, 61 FR 5222, Feb. 9, 1996; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the airframe is capable of withstanding any yawing maneuvers that are likely to occur in service.

c. Background. This rule was carried forward from part 4b of the Civil Air Regulations (CAR). Amendment 25-23 added the requirement to deflect the rudder by a 300 pound rudder pedal force, from $V_{MC}$ to $V_A$. Amendment 25-46 expanded this condition to include full deflection up to $V_D$. Gust requirements were removed in Amendment 25-86. In Amendment 25-91 the rule was revised to reflect the policy letter of December 8, 1992, by stating that the yawing response of the airplane was to take place with a constant pedal force, not necessarily a constant rudder deflection.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; Amendment 25-46, 43 FR 50595, October 30, 1978; Amendment 25-72, 55 FR 29775, July 20, 1990; 55 FR 37607, September 12, 1990; 55 FR 41415, October 11, 1990; Amendment 25-86, 61 FR 5222, February 9, 1996; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

139 - 147. [RESERVED]

## Section 4. SUPPLEMENTARY CONDITIONS

### 148. SECTION 25.361 - ENGINE TORQUE.

a. Rule Text.

*(a) Each engine mount and its supporting structure must be designed for the effects of -*
*(1) A limit engine torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads from flight condition A of § 25.333(b);*
*(2) A limit torque corresponding to the maximum continuous power and propeller speed, acting simultaneously with the limit loads from flight condition A of § 25.333(b); and*
*(3) For turbopropeller installations, in addition to the conditions specified in paragraphs (a)(1) and (2) of this section, a limit engine torque corresponding to takeoff power and propeller speed, multiplied by a factor accounting for propeller control system malfunction, including quick feathering, acting simultaneously with 1g level flight loads. In the absence of a rational analysis, a factor of 1.6 must be used.*
*(b) For turbine engine installations, the engine mounts and supporting structure must be designed to withstand each of the following:*
*(1) A limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).*
*(2) A limit engine torque load imposed by the maximum acceleration of the engine.*
*(c) The limit engine torque to be considered under paragraph (a) of this section must be obtained by multiplying mean torque for the specified power and speed by a factor of -*
*(1) 1.25 for turbopropeller installations;*
*(2) 1.33 for reciprocating engines with five or more cylinders; or*
*(3) Two, three, or four, for engines with four, three, or two cylinders, respectively.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to ensure the engine mounts and supporting structures are capable of withstanding any likely engine torque loads expected in service.

c. Background. This rule remains basically unchanged since it was adopted in part 4b of the Civil Air Regulations (CAR). Amendment 25-23 allowed a rational analysis to be used instead of the fixed factor of 1.6 specified in paragraph (a)(3) for propeller malfunction. If the fixed 1.6 factor is used, the 1.25 factor for limit torque is intended to be combined with the fixed factor to get the limit propeller malfunction torque factor of 2.0. Additional editorial changes have been made to this regulation by Amendment 25-72 to make the latter point clear.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; Amendment 25-46, 43 FR 50595, October 30, 1978; and Amendment 25-72, 55 FR 29776, July 20, 1990.

e. References. None.

149 - 157. [RESERVED]

## 158. SECTION 25.363 - SIDE LOAD ON ENGINE AND AUXILIARY POWER UNIT MOUNTS.

a. Rule Text.

> *(a) Each engine and auxiliary power unit mount and its supporting structure must be designed for a limit load factor in a lateral direction, for the side load on the engine and auxiliary power unit mount, at least equal to the maximum load factor obtained in the yawing conditions but not less than -*
> *(1) 1.33; or*
> *(2) one-third of the limit load factor for flight condition A as prescribed in § 25.333(b).*
>
> *[Amdt. 25-23, 35 FR 5672, Apr. 8,1970; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the engine mount and its supporting structure are able to withstand any likely side load developed while operating anywhere within the design maneuvering envelope.

c. Background. This rule was carried forward from § 4b.216(b) of the Civil Air Regulations (CAR) with only minor editorial changes. Amendment 25-91 clarified the intent to include auxiliary power unit mounts.

d. Acceptable Compliance Methods. For guidance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8,1970; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

159 - 168. [RESERVED]

## 169. SECTION 25.365 - PRESSURIZED COMPARTMENT LOADS.

a. Rule Text.

*For airplanes with one or more pressurized compartments the following apply:*
*(a) The airplane structure must be strong enough to withstand the flight loads combined with pressure differential loads from zero up to the maximum relief valve setting.*
*(b) The external pressure distribution in flight, and stress concentrations and fatigue effects must be accounted for.*
*(c) If landings may be made with the compartment pressurized, landing loads must be combined with pressure differential loads from zero up to the maximum allowed during landing.*
*(d) The airplane structure must be designed to be able to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33 for airplanes to be approved for operation to 45,000 feet or by a factor of 1.67 for airplanes to be approved for operation above 45,000 feet, omitting other loads.*
*(e) Any structure, component or part, inside or outside a pressurized compartment, the failure of which could interfere with continued safe flight and landing, must be designed to withstand the effects of a sudden release of pressure through an opening in any compartment at any operating altitude resulting from each of the following conditions:*
*(1) The penetration of the compartment by a portion of an engine following an engine disintegration;*
*(2) Any opening in any pressurized compartment up to the size* $H_o$ *in square feet; however, small compartments may be combined with an adjacent pressurized compartment and both considered as a single compartment for openings that*

*cannot reasonably be expected to be confined to the small compartment. The size* $H_O$ *must be computed by the following formula:*

$H_O = PA_S$

*Where -*

$H_O$ *= Maximum opening in square feet, need not exceed 20 square feet.*

$$P = \frac{A_s}{6240} + .024$$

$A_S$ *= Maximum cross-sectional area of the pressurized shell normal to the longitudinal axis, in square feet; and*

*(3) The maximum opening caused by airplane or equipment failures not shown to be extremely improbable.*

*(f) In complying with paragraph (e) of this section, the fail-safe features of the design may be considered in determining the probability of failure or penetration and probable size of openings, provided that possible improper operation of closure devices and inadvertent door openings are also considered. Furthermore, the resulting differential pressure loads must be combined in a rational and conservative manner with 1-g level flight loads and any loads arising from emergency depressurization conditions. These loads may be considered as ultimate conditions; however, any deformations associated with these conditions must not interfere with continued safe flight and landing. The pressure relief provided by intercompartment venting may also be considered.*

*(g) Bulkheads, floors, and partitions in pressurized compartments for occupants must be designed to withstand the conditions specified in paragraph (e) of this section. In addition, reasonable design precautions must be taken to minimize the probability of parts becoming detached and injuring occupants while in their seats.*

*[Amdt. 25-54, 45 FR 60172, Sep. 11, 1980; Amdt. 25-71, 55 FR 13477, Apr. 10, 1990; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990; Amdt. 25-87, 61 FR 28695, Jun 5, 1996]*

b. Intent of Rule. The purpose of this rule is to ensure structural integrity of the fuselage pressure vessel for all operating conditions, and to ensure that the airplane will survive after experiencing sudden loss of cabin pressure in any compartment within or outside the pressure vessel.

c. Background. The basic requirement to consider pressure differential loads in combination with flight loads and external aerodynamic loads was contained in § 4b.216(c) of the Civil Air Regulations (CAR). The basic rule was expanded by Amendment 25-54 to include a requirement to consider the pressure differential loads resulting from a specified hole size in passenger and cargo compartments. The rule was further amended by Amendment 25-71 to require a specified hole size in any compartment and to require that structures outside pressurized areas are also designed to withstand depressurization loads if their failure could interfere with continued safe flight and landing. Amendment 25-87 provided a higher pressure cabin design load factor for high altitude airplanes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-54, 45 FR 60172, September 11, 1980; Amendment 25-71, 55 FR 13477, April 10, 1990; Amendment 25-72, 55 FR 29776, July 20, 1990; and Amendment 25-87, 61 FR 28695, June 5, 1996.

e. References. None.

170 - 177. [RESERVED]

178. SECTION 25.367 - UNSYMMETRICAL LOADS DUE TO ENGINE FAILURE.

a. Rule Text.

*The airplane must be designed for the unsymmetrical loads resulting from the failure of the critical engine. Turbopropeller airplanes must be designed for the following conditions in combination with a single malfunction of the propeller drag limiting system, considering the probable pilot corrective action on the fight controls:*

*(1) At speeds between $V_{MC}$ and $V_D$, the loads resulting from power failure because of fuel flow interruption are considered to be limit loads.*

*(2) At speeds between $V_{MC}$ and $V_C$, the loads resulting from the disconnection of the engine compressor from the turbine or from loss of the turbine blades are considered to be ultimate loads.*

*(3) The time history of the thrust decay and drag build-up occurring as a result of the prescribed engine failures must be substantiated by test or other data applicable to the particular engine-propeller combinations.*

*(4) The timing and magnitude of the probable pilot corrective action must be conservatively estimated, considering the characteristics of the particular engine-propeller-airplane combination.*

*(b) Pilot corrective action may be assumed to be initiated at the time maximum yawing velocity is reached, but not earlier than two seconds after the engine failure. The magnitude of the corrective action may be based on the control forces specified in § 25.397(b) except that lower forces may be assumed where it*

*is shown by analysis or test that these forces can control the yaw and roll resulting from the prescribed engine failure conditions.*

b. Intent of Rule. This rule defines a limit load condition after loss of power in the most critical engine.

c. Background. This rule was carried forward from § 4b.216(d) of the Civil Air Regulations (CAR). Propeller driven airplanes experience a high drag load on the propeller when the engine fails. For wing mounted engines, this propeller drag load produces high yawing moments on the airplane with the associated high loads on the engine supporting structure and on the vertical tail.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

179 - 187. [RESERVED]

188. SECTION 25.371 - GYROSCOPIC LOADS.

a. Rule Text.

*The structure supporting any engine or auxiliary power unit must be designed for the loads including the gyroscopic loads arising from the conditions specified in §§ 25.331, 25.341(a), 25.349, 25.351, 25.473, 25.479, and 25.481, with the engine or auxiliary power unit at the maximum rpm appropriate to the condition. For the purposes of compliance with this section, the pitch maneuver in § 25.331(c)(1) must be carried out until the positive limit maneuvering load factor (point* $A_2$ *in § 25.333(b)) is reached.*

*[Amdt. 25-86, 61 FR 5220, Feb. 9, 1996; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the airframe structure will support any likely loads developed from a combination of flight loads and gyroscopic loads while operating at maximum engine speed.

c. Background. This rule was carried forward from § 4b.216(e) of the Civil Air Regulations (CAR). Gyroscopic loads developed from engines and propellers have always been a concern for airplane structural design. Amendment 25-91 added the landing conditions (including dynamic landing). The rule was also revised to ensure that, notwithstanding the revised 25.331(c)(1) of Amendment 25-91, the gyroscopic forces from the revised “unchecked” pitching maneuver would continue to be developed considering a maneuver time history up to the point the normal load factor was developed on the airplane.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-86, 61 FR 5220, February 9, 1996; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

189 - 199. [RESERVED]

## 200. SECTION 25.373 - SPEED CONTROL DEVICES.

a. Rule Text.

*If speed control devices (such as spoilers and drag flaps) are installed for use in en route conditions-*
*(a) The airplane must be designed for the symmetrical maneuvers prescribed in § 25.333 and § 25.337, the yawing maneuvers prescribed in § 25.351, and the vertical and lateral gust conditions prescribed in § 25.341(a), at each setting and the maximum speed associated with that setting; and*
*(b) If the device has automatic operating or load limiting features, the airplane must be designed for the maneuver and gusts conditions prescribed in paragraph (a) of this section, at the speeds and corresponding device positions that the mechanism allows.*

*[Amdt. 25-72, 55 FR 29776, Jul. 20, 1990; Amdt. 25-86, 61 FR 5222, Feb. 9, 1996]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane structure is capable of withstanding the loads imposed when the speed control devices are deployed in any approved flight regime.

c. Background. The speed control device rule remains basically unchanged from the requirement of § 4b.217 of the Civil Air Regulations (CAR). Amendments 25-72 and 25-86 made editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-72, 55 FR 29776, July 20, 1990; and Amendment 25-86, 61 FR 5222, February 9, 1996.

e References. None.

201 - 208. [RESERVED]

## Section 5. CONTROL SURFACE AND SYSTEM LOADS

### 209. SECTION 25.391 - CONTROL SURFACE LOADS: GENERAL.

a. Rule Text.

*The control surfaces must be designed for the limit loads resulting from the flight conditions in §§ 25.331, 25.341(a), 25.349 and 25.351 and the ground gust conditions in § 25.415, considering the requirements for -*
*(a) Loads parallel to hinge line, in § 25.393;*
*(b) Pilot effort effects, in § 25.397*
*(c) Trim tab effects, in § 25.407;*
*(d) Unsymmetrical loads, § 25.427; and*
*(e) Auxiliary aerodynamic surfaces, in § 25.445.*

[Amdt. 25-86, 61 FR 5222, Feb. 9, 1996]

b. Intent of Rule. The purpose of this rule is to ensure static strength in the control surfaces sufficient to withstand any likely loads developed either in flight or from ground gust conditions.

c. Background. This rule remains basically unchanged from the requirements of § 4b.220 of the Civil Air Regulations (CAR). Only minor conforming references were changed by Amendment 25-86.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-86, 61 FR 5222, February 9, 1996.

e. References. None.

210 - 217. [RESERVED]

### 218. SECTION 25.393 - LOADS PARALLEL TO HINGE LINE.

a. Rule Text.

*(a) Control surfaces and supporting hinge brackets must be designed for inertia loads acting parallel to the hinge line.*
*(b) In the absence of more rational data, the inertia loads may be assumed to be equal to KW, where -*

*(1) K=24 for vertical surfaces;*
*(2) K=12 for horizontal surfaces; and*
*(3) W= weight of the movable surfaces.*

b. Intent of Rule. This rule is intended to ensure adequate strength in the control surfaces and supporting brackets to withstand any likely loading conditions parallel to the control surface hinge line.

c. Background. This rule was carried forward from § 4b.220(e) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

219 - 227. [RESERVED]

228. SECTION 25.395 - CONTROL SYSTEM.

a. Rule Text.

*(a) Longitudinal, lateral, directional, and drag control system and their supporting structures must be designed for loads corresponding to 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in § 25.391.*
*(b) The system limit loads, except the loads resulting from ground gusts, need not exceed the loads that can be produced by the pilot (or pilots) and by automatic or power devices operating the controls.*
*(c) The loads must not be less than those resulting from application of the minimum forces prescribed in § 25.397(c).*

*[Amdt. 25-23, 35 FR 5672, Apr. 8,1970; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

b. Intent of Rule. The intent of this rule is to provide design loads for the control system that are sufficient to provide a rugged system for service use, including consideration of jams, ground gusts, taxiing with tailwind, control inertia, and friction.

c. Background. The provisions of the current rule were essentially contained in § 4b.224 of the Civil Air Regulations (CAR). Control systems have remained basically the same, with minor changes for the addition of automatic and power operated flight controls.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8,1970; and Amendment 25-72, 55 FR 29776, July 20, 1990.

e. References. None.

229 - 238. [RESERVED]

## 239. SECTION 25.397 - CONTROL SYSTEM LOADS.

a. Rule Text.

*(a) General. The maximum and minimum pilot forces, specified in paragraph (c) of this section, are assumed to act at the appropriate control grips or pads (in a manner simulating flight conditions) and to be reacted at the attachment of the control system to the control surface horn.*
*(b) Pilot effort effects. In the control surface flight loading condition, the air loads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any pilot force within the ranges specified in paragraph (c) of this section. Two-thirds of the maximum values specified for the aileron and elevator may be used if control surface hinge moments are based on reliable data. In applying this criterion, the effects of servo mechanisms, tabs, and automatic pilot systems, must be considered.*
*(c) Limit pilot forces and torques. The limit pilot forces and torques are as follows*

| *Control* | *Maximum forces or torques* | *Minimum forces or torques* |
|---|---|---|
| *Aileron:* | | |
| *Stick* | *100 lbs.* | *40 lbs.* |
| *Wheel*[1] | *80 D in-lbs.*[2] | *40 D in-lbs.* |
| *Elevator:* | | |
| *Stick* | *250 lbs.* | *100 lbs.* |
| *Wheel(symmetrical)* | *300 lbs.* | *100 lbs.* |
| *Wheel (unsymmetrical)*[3] | | *100 lbs.* |
| *Rudder* | *300 lbs.* | *130 lbs.* |

[1] *The critical parts of the aileron control system must be designed for a single tangential force with a limit value equal to 1.25 times the couple force determined from these criteria.*

*[2] D = wheel diameter (inches).*
*[3] The unsymmetrical forces must be applied at one of the normal handgrip points on the periphery of the control wheel.*

*[Amdt. 25-38, 41 FR 55466, Dec. 20, 1976; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to establish the maximum and minimum design values for the pilot forces to be used in design of the control systems. Special conditions have been issued for novel designs such as side stick controllers.

c. Background. The limit pilot force and torque requirements were carried forward from § 4b.227 of the Civil Air Regulations (CAR) with minor changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-38, 41 FR 55466, December 20, 1976; and Amendment 25-72, 55 FR 29776, July 20, 1990.

e. References. A320 Special Conditions for side stick controllers, 54 FR 3986, January 27, 1989.

240 - 249. [RESERVED]

250. SECTION 25.399 - DUAL CONTROL SYSTEM.

a. Rule Text.

*(a) Each dual control system must be designed for the pilots operating in opposition, using individual pilot forces not less than -*
*(1) 0.75 times those obtained under § 25.395; or*
*(2) The minimum forces specified in § 25.397(c).*
*(b) The control system must be designed for pilot forces applied in the same direction, using individual pilot forces not less than 0.75 times those obtained under § 25.395.*

b. Intent of Rule. The purpose of this rule is to ensure that the control system is sufficiently robust to withstand any likely pilot forces that could be applied when two pilots are acting in unison and in opposition.

c. Background. This rule remains basically unchanged from § 4b.225 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

251 - 259. [RESERVED]

260. SECTION 25.405 - SECONDARY CONTROL SYSTEM.

a. Rule Text.

*Secondary controls, such as wheel brake, spoiler, and trim tab controls, must be designed for the maximum forces that a pilot is likely to apply to those controls. The following values may be used:*

*PILOT CONTROL FORCE LIMITS (SECONDARY CONTROLS)*

| *Control* | *Limit pilot forces* |
|---|---|
| *Miscellaneous:* | $\left(\frac{1+R}{3}\right)x50$ *in. lbs., but not less than* |
| **Crank, wheel, or lever.* | *50 lbs. nor more than 150 lbs. (R=radius). (Applicable to any angle within 20$^{o}$ of plane of control).* |
| *Twist* | *133 in.-lbs.* |
| *Push-pull* | *To be chosen by applicant.* |

**Limited to flap, tab, stabilizer, spoiler, and landing gear operation controls.*

b. Intent of Rule. The purpose of this rule is to ensure that secondary control systems are designed to withstand the maximum forces that a pilot is likely to apply to these controls.

c. Background. This rule was carried forward from § 4b.227 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

261 - 268. [RESERVED]

269. SECTION 25.407 - TRIM TAB EFFECTS.

a. Rule Text.

*The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction that would assist the pilot, and the deflections are -*
*(a) For elevator trim tabs, those required to trim the airplane at any point within the positive portion of the pertinent flight envelope in § 25.333(b), except as limited by the stops; and*
*(b) For aileron and rudder trim tabs, those required to trim the airplane in the critical unsymmetrical power and loading conditions, with appropriate allowance for rigging tolerances.*

b. Intent of Rule. The purpose of this rule is to ensure that the additional loads produced by the trim tab deflections are accounted for in the structural design loads.

c. Background. This rule was carried forward from § 4b.220(b) of the Civil Air Regulations (CAR) with only minor editorial changes.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

270 - 275. [RESERVED]

276. SECTION 25.409 - TABS.

a. Rule Text.

*(a) Trim tabs. Trim tabs must be designed to withstand loads arising from all likely combinations of tab setting, primary control position, and airplane speed (obtainable without exceeding the flight load conditions prescribed for the airplane as a whole), when the effect of the tab is opposed by pilot effort forces up to those specified in § 25.397(b).*
*(b) Balancing tabs. Balancing tabs must be designed for deflections consistent with the primary control surface loading conditions.*
*(c) Servo tabs. Servo tabs must be designed for deflections consistent with the primary control surface loading conditions obtainable within the pilot maneuvering effort, considering possible opposition from the trim tabs.*

b. Intent of Rule. The purpose of this rule is to ensure that control surface tabs will withstand any likely loading conditions experienced in service.

c. Background. This rule was carried forward from § 4b.222 of the Civil Air Regulations (CAR) with minor editorial changes.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. Reference. None.

277 - 286. [RESERVED]

287. SECTION 25.415 - GROUND GUST CONDITIONS.

a. Rule Text.

*(a) The control system must be designed as follows for control surface loads due to ground gusts and taxiing downwind:*
*(1) The control system between the stops nearest the surfaces and the cockpit controls must be designed for loads corresponding to the limit hinge moments H of paragraph (a)(2) of this section. These loads need not exceed -*
*(i) The loads corresponding to the maximum pilot loads in § 25.397(c) for each pilot alone; or*
*(ii) 0.75 times these maximum loads for each pilot when the pilot forces are applied in the same direction.*
*(2) The control system stops nearest the surfaces, the control system locks, and the parts of the systems (if any) between these stops and locks and the control surface horns, must be designed for limit hinge moments H, in foot pounds, obtained from the formula,*
$H = .0034KV^2cS$, *where -*
$V$ = *65 (wind speed in knots)*
$K$ = *limit hinge moment factor for ground gusts derived in paragraph (b) of this section.*
$c$ = *mean chord of the control surface aft of the hinge line (ft);*
$S$ = *area of the control surface aft of the hinge line (sq.ft);*

*(b) The limit hinge moment factor K for ground gusts must be derived as follows:*

| *Surface* | *K* | *Position of controls* |
|---|---|---|
| *(a) Aileron* | *0.75* | *Control column locked or lashed in mid-position.* |
| *(b) Aileron* | [1]*± 0.50* | *Ailerons at full throw.* |
| *(c) Elevator* | [1]*±0.75* | *(c) Elevator full down.* |
| *(d) Elevator* | [1]*±0.75* | *(d) Elevator full up.* |
| *(e) Rudder* | *0.75* | *(e) Rudder in neutral.* |
| *(f) Rudder* | *0.75* | *(f) Rudder at full throw.* |

[1]*A positive value of K indicates a moment tending to depress the surface, while a negative value of K indicates a moment tending to raise the surface.*

*[Amdt. 25-72, 55 FR 29776, Jul. 20, 1990; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the control systems and surfaces will not be damaged by likely ground gust conditions.

c. Background. This rule was carried forward from § 4b.226 of the Civil Air Regulations (CAR) with minor editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-72, 55 FR 29776, July 20, 1990; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

288 - 297. [RESERVED]

## 298. SECTION 25.427 - UNSYMMETRICAL LOADS.

a. Rule Text.

*(a) In designing the airplane for lateral gust, yaw maneuver and roll maneuver conditions, account must be taken of unsymmetrical loads on the empennage arising from effects such as slipstream and aerodynamic interference with the wing, vertical fin and other aerodynamic surfaces.*
*(b) The horizontal tail must be assumed to be subjected to unsymmetrical loading conditions determined as follows:*
*(1) 100 percent of the maximum loading from the symmetrical maneuver conditions of § 25.331 and the vertical gust conditions of § 25.341(a) acting separately on the surface on one side of the plane of symmetry; and*
*(2) 80 percent of these loadings acting on the other side.*
*(c) For empennage arrangements where the horizontal tail surfaces have dihedral angles greater than plus or minus 10 degrees, or are supported by the vertical tail surfaces, the surfaces and the supporting structure must be designed for gust velocities specified in § 25.341(a) acting in any orientation at right angles to the flight path.*
*(d) Unsymmetrical loading on the empennage arising from buffet conditions of § 25.305(e) must be taken into account.*

*[Amdt. 25-23, 35 FR 5672, Apr. 8, 1970; Amdt. 25-86, 61 FR 5220, Feb. 9, 1996]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane is able to withstand any likely maneuver or gust condition that imposes unsymmetrical loads on these surfaces. The rule is intended to provide for round the clock gusts for geometries where directions other than vertical and lateral could be more critical. The rule is intended to account for unsymmetrical buffet loads on the horizontal tail, including those arising from stalls.

c. Background. This rule was carried forward from § 4b.220(c) of the Civil Air Regulations (CAR) with minor editorial changes in Amendment 25-23. Amendment 25-86 provided the round the clock gust criterion and required the consideration of buffet conditions on the horizontal tail.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5672, April 8, 1970; and Amendment 25-86, 61 FR 5220, February 9, 1996.

e. References. None.

## 299 - 307. [RESERVED]

308. SECTION 25.445 - AUXILIARY AERODYNAMIC SURFACES.

a. Rule Text.

*(a) When significant, the aerodynamic influence between auxiliary aerodynamic surfaces, such as outboard fins and winglets, and their supporting aerodynamic surfaces, must be taken into account for all loading conditions including pitch, roll, and yaw maneuvers, and gusts as specified in § 25.341(a) acting at any orientation at right angles to the flight path.*
*(b) To provide for unsymmetrical loading when outboard fins extend above and below the horizontal surface, the critical vertical surface loading (load per unit area) determined under § 25.391 must also be applied as follows:*
*(1) 100 percent to the area of the vertical surfaces above (or below) the horizontal surface.*
*(2) 80 percent to the area below (or above) the horizontal surface.*

*[Amdt. 25-86, 61 FR 5222, Feb. 9, 1996*

b. Intent of Rule. The purpose of this rule is to account for the redistribution of loads due to the interaction of intersecting aerodynamic surfaces.

c. Background. This requirement was carried forward from § 4b.220(d) of the Civil Air Regulations (CAR). In Amendment 25-86 the title was changed from "Outboard fins" to "Auxiliary Aerodynamic Surfaces" and the intent was extended to cover auxiliary aerodynamic surfaces such as winglets.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-86, 61 FR 5222, February 9, 1996.

e. References. None.

309 - 318. [RESERVED]

319. SECTION 25.457 - WING FLAPS.

a. Rule Text.

*Wing flaps, their operating mechanisms, and their supporting structures must be designed for critical loads occurring in the conditions prescribed in § 25.345, accounting for the loads occurring during transition from one flap position and airspeed to another.*

b. Intent of Rule. The purpose of this rule is to ensure that the wing flaps and their supporting structures are able to withstand any loading condition likely to occur in service.

c. Background. This rule was carried forward from § 4b.221 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Advisory Circular (AC) 25-14, or latest revision, provides guidance for showing compliance with structural and functional safety standards for high lift and drag devices and their operating systems.

e. References. Advisory Circular 25-14, or latest revision, High Lift and Drag Devices.

320 - 328. [RESERVED]

329. SECTION 25.459 - SPECIAL DEVICES.

a. Rule Text.

*The loading for special devices using aerodynamic surfaces (such as slots, slats and spoilers) must be determined from test data.*

*[Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to ensure the loads used for design of these systems and surfaces are verified by test evidence.

c. Background. This rule was carried forward from § 4b.223 of the Civil Air Regulations (CAR). Amendment 25-72 added slats to the list of items to which this rule applies.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-72, 55 FR 29776, July 20, 1990. Advisory Circular (AC) 25-14, or latest revision, provides guidance information for showing compliance.

e. References. Advisory Circular 25-14, or latest revision, High Lift and Drag Devices.

330 - 339. [RESERVED]

## Section 6. GROUND LOADS.

### 340. SECTION 25.471 - GENERAL.

a. Rule Text.

*(a) Loads and equilibrium. For limit ground loads -*
*(1) Limit ground loads obtained under this subpart are considered to be external forces applied to the airplane structure; and*
*(2) In each specified ground load condition, the external loads must be placed in equilibrium with the linear and angular inertia loads in a rational or conservative manner.*
*(b) Critical centers of gravity. The critical centers of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element. Fore and aft, vertical, and lateral airplane centers of gravity must be considered. Lateral displacements of the c.g. from the airplane centerline which would result in main gear loads not greater than 103 percent of the critical design load for symmetrical loading conditions may be selected without considering the effects of these lateral c.g. displacements on the loading of the main gear elements, or on the airplane structure provided-*
*(1) The lateral displacement of the c.g. results from random passenger or cargo disposition within the fuselage or from random unsymmetrical fuel loading or fuel usage; and*
*(2) Appropriate loading instructions for random disposable loads are included under the provisions of § 25.1583(c)(1) to ensure that the lateral displacement of the center of gravity is maintained within these limits.*
*(c) Landing gear dimension data. Figure 1 of Appendix A contains the basic landing gear dimension data.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.230 of the Civil Air Regulations (CAR). Amendment 25-23 added the requirement to account for lateral c.g. locations on ground loads.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

341 - 349. [RESERVED]

## 350. SECTION 25.473 - LANDING LOAD CONDITIONS AND ASSUMPTIONS.

a. Rule Text.

*(a) For the landing conditions specified in §§ 25.479 to 25.485 the airplane is assumed to contact the ground -*
*(1) In the attitudes defined in § 25.479 and § 25.481;*
*(2) With a limit descent velocity of 10 fps at the design landing weight (the maximum weight for landing conditions at maximum descent velocity); and*
*(3) With a limit descent velocity of 6 fps at the design take-off weight (the maximum weight for landing conditions at a reduced descent velocity).*
*(4) The prescribed descent velocities may be modified if it is shown that the airplane has design features that make it impossible to develop these velocities.*
*(b) Airplane lift, not exceeding airplane weight, may be assumed unless the presence of systems or procedures significantly affects the lift.*
*(c) The method of analysis of airplane and landing gear loads must take into account at least the following elements:*
*(1) Landing gear dynamic characteristics.*
*(2) Spin-up and springback.*
*(3) Rigid body response.*
*(4) Structural dynamic response of the airframe, if significant.*
*(d) The limit inertia load factors corresponding to the required limit descent velocities must be validated by tests as defined in § 25.723(a).*
*(e) The coefficient of friction between the tires and the ground may be established by considering the effects of skidding velocity and tire pressure. However, this coefficient of friction need not be more than 0.8.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.230(b) of the Civil Air Regulations (CAR) with minor changes. Amendment 25-23 made additional minor changes, but the basic requirements remain the same. Amendment 25-91 made some editorial conforming changes related to dynamic landing conditions and lateral drift.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

351 - 361. [RESERVED]

362. SECTION 25.477 - LANDING GEAR ARRANGEMENT.

a. Rule Text.

*Sections 25.479 through 25.485 apply to airplanes with conventional arrangements of main and nose gears, or main and tail gears, when normal operating techniques are used.*

b. Intent of Rule. This rule identifies the landing gear configurations for which these rules apply. It acknowledges that there may be nonconventional arrangements of landing gears.

c. Background. This rule was carried forward from § 4b.230(b)(3) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. Special Conditions (SC) have been issued for non-conventional landing gear arrangements. Reference SC 25-77-NW-4 for the Boeing 747 and reference SC 25-18-WE-7 for the DC-10.

363 - 369. [RESERVED]

370. SECTION 25.479 - LEVEL LANDING CONDITIONS.

a. Rule Text.

*(a) In the level attitude, the airplane is assumed to contact the ground at forward velocity components, ranging from $V_{L1}$ to 1.25 $V_{L2}$ parallel to the ground under the conditions prescribed in § 25.473 with -*

*(1) $V_{L1}$ equal to $V_{S0}$ (TAS) at the appropriate landing weight and in standard sea level conditions; and*

*(2) $V_{L2}$ equal to $V_{S0}$ (TAS) at the appropriate landing weight and altitudes in a hot day temperature of 41 degrees F. above standard.*

*(3) The effects of increased contact speed must be investigated if approval of downwind landings exceeding 10 knots is requested.*

*(b) For the level landing attitude for airplanes with tail wheels, the conditions specified in this section must be investigated with the airplane horizontal reference line horizontal in accordance with Figure 2 of Appendix A of this part.*

*(c) For the level landing attitude for airplanes with nose wheels, shown in Figure 2 of Appendix A of this part, the conditions specified in this section must be investigated assuming the following attitudes:*

*(1) An attitude in which the main wheels are assumed to contact the ground with the nose wheel just clear of the ground; and*

*(2) If reasonably attainable at the specified descent and forward velocities, an attitude in which the nose and main wheels are assumed to contact the ground simultaneously.*

*(d) In addition to the loading conditions prescribed in paragraph (a) of this section, but with maximum vertical ground reactions calculated from paragraph (a), the following apply:*

*(1) The landing gear and directly affected attaching structure must be designed for the maximum vertical ground reaction combined with an aft acting drag component of not less than 25% of this maximum vertical ground reaction.*

*(2) The most severe combination of loads that are likely to arise during a lateral drift landing must be taken into account. In absence of a more rational analysis of this condition, the following must be investigated:*

*(i) A vertical load equal to 75% of the maximum ground reaction of § 25.473 must be considered in combination with a drag and side load of 40% and 35% respectively of that vertical load.*

*(ii) The shock absorber and tire deflections must be assumed to be 75% of the deflection corresponding to the maximum ground reaction of § 25.25.473(a)(2). This load case need not be considered in combination with flat tires.*

*(3) The combination of vertical and drag components is considered to be acting at the wheel axle centerline.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.231 of the Civil Air Regulations (CAR) with minor editorial changes. A minor editorial change was also made by Amendment 25-23. Amendment 25-91 made some editorial conforming changes related to dynamic landing conditions and lateral drift.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

371 - 380. [RESERVED]

## 381. SECTION 25.481 - TAIL DOWN LANDING CONDITIONS.

a. Rule Text.

*(a) In the tail-down attitude, the airplane is assumed to contact the ground at forward velocity components, ranging from $V_{L1}$ to $V_{L2}$ parallel to the ground under the conditions prescribed in § 25.473 with -*
*(1) $V_{L1}$ equal to $V_{SO}$ (TAS) at the appropriate landing weight and in standard sea level conditions; and*
*(2) $V_{L2}$ equal to $V_{SO}$ (TAS) at the appropriate landing weight and altitudes in a hot day temperature of 41 degrees F. above standard.*
*The combination of vertical and drag components specified in § 25.479(c)(1) and (3) is considered to be acting at the main wheel axle centerline.*
*(3) The combination of vertical and drag components is considered to be acting at the main wheel axle centerline.*
*(b) For the tail-down landing condition for airplanes with tail wheels, the main and tail wheels are assumed to contact the ground simultaneously, in accordance with figure 3 of Appendix A. Ground reaction conditions on the tail wheel are assumed to act -*

*(1) Vertically; and*

*(2) Up and aft through the axle at 45 degrees to the ground line.*

*(c) For the tail down landing condition for airplanes with nose wheels, the airplane is assumed to be at an attitude corresponding to either the stalling angle or the maximum angle allowing clearance with the ground by each part of the airplane other than the main wheels, in accordance with figure 3 of Appendix A, whichever is less.*

*[Amdt. 25-91, 62 FR 40705, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.232 of the Civil Air Regulations (CAR) with only editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-91, 62 FR 40705, July 29, 1997.

e. References. None.

382 - 389. [RESERVED]

390. SECTION 25.483 - ONE GEAR LANDING CONDITIONS.

a. Rule Text.

*For the one-gear landing conditions, the airplane is assumed to be in the level attitude and to contact the ground on one main landing gear, in accordance with Figure 4 of Appendix A of this part. In this attitude -*

*(a) The ground reactions must be the same as those obtained on that side under § 25.479(d)(1), and*

*(b) Each unbalanced external load must be reacted by airplane inertia in a rational or conservative manner.*

*[Amdt. 25-91, 62 FR 40705, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.233 of the Civil Air Regulations (CAR). The title was changed from "One-wheel landing conditions" to "One-gear landing conditions" in Amendment 25-91.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-91, 62 FR 40705, July 29, 1997.

e. References. None.

391 - 398. [RESERVED]

## 399. SECTION 25.485 - SIDE LOAD CONDITIONS.

a. Rule Text.

*In addition to § 25.479(d)(2) the following conditions must be considered:*
*(a) For the side load condition, the airplane is assumed to be in the level attitude with only the main wheels contacting the ground, in accordance with figure 5 of Appendix A.*
*(b) Side loads of 0.8 of the vertical reaction (on one side) acting inward and 0.6 of the vertical reaction (on the other side) acting outward must be combined with one-half of the maximum vertical ground reactions obtained in the level landing conditions. These loads are assumed to be applied at the ground contact point and to be resisted by the inertia of the airplane. The drag loads may be assumed to be zero.*

*[Amdt. 25-91, 62 FR 40705, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.234 of the Civil Air Regulations (CAR) unchanged, except for the title. Amendment 25-91 added the requirement for the lateral drift in determining the side loads.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-91, 62 FR 40705, July 29, 1997.

e. References. None.

400 - 409. [RESERVED]

410. SECTION 25.487 - REBOUND LANDING CONDITION.

a. Rule Text.

*(a) The landing gear and its supporting structure must be investigated for the loads occurring during rebound of the airplane from the landing surface.*
*(b) With the landing gear fully extended and not in contact with the ground, a load factor of 20.0 must act on the unsprung weights of the landing gear. This load factor must act in the direction of motion of the unsprung weights as they reach their limiting positions in extending with relation to the sprung parts of the landing gear.*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear and its supporting structure are capable of withstanding the loads exerted as the unsprung mass of the gear extends to the limits of its stroke during airplane rebound conditions.

c. Background. This rule was carried forward from § 4b.234A of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

411 -420. [RESERVED]

421. SECTION 25.489 - GROUND HANDLING CONDITIONS.

a. Rule Text.

*Unless otherwise prescribed, the landing gear and airplane structure must be investigated for the conditions in §§ 25.491 through 25.509 with the airplane at the design ramp weight (the maximum weight for ground handling conditions). No wing lift may be considered. The shock absorbers and tires may be assumed to be in their static position.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b Intent of Rule. The purpose of this rule is to establish the conditions under which ground handling conditions are to be evaluated.

c. Background. This rule was carried forward from § 4b.235 of the Civil Air Regulations (CAR). Amendment 25-23 changed "design takeoff weight" to "design ramp weight."

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

422 - 434. [RESERVED]

435. SECTION 25.491 - TAXI, TAKEOFF, AND LANDING ROLL.

a. Rule Text.

*Within the range of appropriate ground speeds and approved weights, the airplane structure and landing gear are assumed to be subjected to loads not less than those obtained when the aircraft is operating over the roughest ground that may reasonably be expected in normal operation.*

*[Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear and airplane structure will not be damaged during operations on any rough surfaces (e.g., ramps, taxiways, runways) likely to be encountered in service.

c. Background. This rule was carried forward from § 4b.235(a) of the Civil Air Regulations (CAR). Amendment 25-91 clarified the title and intent to include the taxi and landing roll as well as the takeoff run.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

436 - 446. [RESERVED]

## 447. SECTION 25.493 - BRAKED ROLL CONDITIONS.

a. Rule Text.

*(a) An airplane with a tail wheel is assumed to be in the level attitude with the load on the main wheels, in accordance with figure 6 of Appendix A. The limit vertical load factor is 1.2 at the design landing weight and 1.0 at the design ramp weight. A drag reaction equal to the vertical reaction multiplied by a coefficient of friction of 0.8, must be combined with the vertical ground reaction and applied at the ground contact point.*
*(b) For an airplane with a nose wheel the limit vertical load factor is 1.2 at the design landing weight, and 1.0 at the design ramp weight. A drag reaction equal to the vertical reaction, multiplied by a coefficient of friction of 0.8, must be combined with the vertical reaction and applied at the ground contact point of each wheel with brakes. The following two attitudes, in accordance with figure 6 of Appendix A, must be considered:*
*(1) The level attitude with the wheels contacting the ground and the loads distributed between the main and nose gear. Zero pitching acceleration is assumed.*
*(2) The level attitude with only the main gear contacting the ground and with the pitching moment resisted by angular acceleration.*
*(c) A drag reaction lower than that prescribed in this section may be used if it is substantiated that an effective drag force of 0.8 times the vertical reaction cannot be attained under any likely loading condition.*
*(d) An airplane equipped with a nose gear must be designed to withstand the loads arising from the dynamic pitching motion of the airplane due to sudden application of maximum braking force. The airplane is considered to be at design takeoff weight with the nose and main gears in contact with the ground, and with a steady-statevertical load factor of 1.0. The steady-state nose gear reaction must be combined with the maximum incremental nose gear vertical reaction caused by the sudden application of maximum braking force as described in paragraphs (b) and (c) of this section.*

*(e) In the absence of a more rational analysis, the nose gear vertical reaction prescribed in paragraph (d) of this section must be calculated according to the following formula:*

$$V_N = \frac{W_T}{A+B}\left[B + \frac{fmAE}{A+B+mE}\right]$$

*Where:*

*$V_N$ = Nose gear vertical reaction.*
*$W_T$ = Design takeoff weight.*
*A = Horizontal distance between the c.g of the airplane and the nose wheel.*
*B = Horizontal distance between the c.g. of the airplane and the line joining the centers of the main wheels.*
*E = Vertical height of the c.g. of the airplane above the ground in the 1.0 g. static condition.*
*μ = Coefficient of friction of 0.80.*
*f = Dynamic response factor; 2.0 is to be used unless a lower factor is substantiated. In the absence of other information, the dynamic response factor f may be defined by the equation:*

$$f = 1 + \exp\left(\frac{-px}{\sqrt{1-x^2}}\right)$$

*Where:*

*? is the effective critical damping ratio of the rigid body pitching mode about the main landing gear effective ground contact point.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970; Amdt. 25-91, 61 FR 40712, Aug. 5, 1996]*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear and airplane structure are able to withstand any braked roll conditions likely to occur in service.

c. Background. This rule was carried forward from § 4b.235(b) of the Civil Air Regulations (CAR). Amendment 25-23 changed "design takeoff weight" to "design ramp weight."

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

448 - 458. [RESERVED]

## 459. SECTION 25.495 - TURNING.

a. Rule Text.

*In the static position, in accordance with figure 7 of Appendix A, the airplane is assumed to execute a steady turn by nose gear steering, or by application of sufficient differential power, so that the limit load factors applied at the center of gravity are 1.0 vertically and 0.5 laterally. The side ground reaction of each wheel must be 0.5 of the vertical reaction.*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear and supporting structure are able to withstand any likely turning conditions.

c. Background. This rule was carried forward from § 4b.235(c) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

460 - 468. [RESERVED]

## 469. SECTION 25.497 - TAIL-WHEEL YAWING.

a. Rule Text.

*(a) A vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude, is assumed.*
*(b) If there is a swivel, the tail wheel is assumed to be swiveled 90$^{o}$ to the airplane longitudinal axis with the resultant load passing through the axle.*

*(c) If there is a lock, steering device, or shimmy damper, the tail wheel is also assumed to be in the trailing position with the side load acting at the ground contact point.*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, the tail wheel, and its supporting structure are able to withstand any load likely to be encountered in service.

c. Background. This rule was carried forward from § 4b.235(f) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

470 - 477. [RESERVED]

478. SECTION 25. 499 - NOSE-WHEEL YAW AND STEERING.

a. Rule Text.

*(a) A vertical load factor of 1.0 at the airplane center of gravity, and a side component at the nose wheel ground contact equal to 0.8 of the vertical ground reaction at that point are assumed.*
*(b) With the airplane assumed to be in static equilibrium with the loads resulting from the use of brakes on one side of the main landing gear, the nose gear, its attaching structure, and the fuselage structure forward of the center of gravity must be designed for the following loads:*
*(1) A vertical load factor at the center of gravity of 1.0.*
*(2) A forward acting load at the airplane center of gravity of 0.8 times the vertical load on one main gear.*
*(3) Side and vertical loads at the ground contact point on the nose gear that are required for static equilibrium.*
*(4) A side load factor at the airplane center of gravity of zero.*
*(c) If the loads prescribed in paragraph (b) of this section result in a nose gear side load higher than 0.8 times the vertical nose gear load, the design nose gear side load may be limited to 0.8 times the vertical load, with unbalanced yawing moments assumed to be resisted by airplane inertia forces.*
*(d) For other than the nose gear, its attaching structure, and the forward fuselage structure, the loading conditions are those prescribed in paragraph (b) of this section, except that -*

*(1) A lower drag reaction may be used if an effective drag force of 0.8 times the vertical reaction cannot be reached under any likely loading condition; and*
*(2) The forward acting load at the center of gravity need not exceed the maximum drag reaction on one main gear, determined in accordance with § 25.493(b).*
*(e) With the airplane at design ramp weight, and the nose gear in any steerable position, the combined application of full normal steering torque and vertical force equal to 1.33 times the maximum static reaction on the nose gear must be considered in designing the nose gear, its attaching structure, and the forward fuselage structure.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, the nose gear, and its supporting structure, and the forward fuselage, are able to withstand any load likely to be encountered in service.

c. Background. The basic rule was carried forward from § 4b.235(e) of the Civil Air Regulations (CAR) with some editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970; Amendment 25-46, 43 FR 50595, October 30, 1978; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

479 - 482. [RESERVED]

## 483. SECTION 25.503 - PIVOTING.

a. Rule Text.

*(a) The airplane is assumed to pivot about one side of the main gear with the brakes on that side locked. The limit vertical load factor must be 1.0 and the coefficient of friction 0.8.*
*(b) The airplane is assumed to be in static equilibrium, with the loads being applied at the ground contact points, in accordance with figure 8 of Appendix A.*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.235(d) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

484 - 488. [RESERVED]

489. SECTION 25.507 - REVERSED BRAKING.

a. Rule Text.

*(a) The airplane must be in a three point static ground attitude. Horizontal reactions parallel to the ground and directed forward must be applied at the ground contact point of each wheel with brakes. The limit loads must be equal to 0.55 times the vertical load at each wheel or to the load developed by 1.2 times the nominal maximum static brake torque, whichever is less.*
*(b) For airplanes with nose wheels, the pitching moment must be balanced by rotational inertia.*
*(c) For airplanes with tail wheels, the resultant of the ground reactions must pass through the center of gravity of the airplane.*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.235(g) of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

490 - 495. [RESERVED]

496. SECTION 25.509 - TOWING LOADS.

a. Rule Text.

*(a) The towing loads specified in paragraph (d) of this section must be considered separately. These loads must be applied at the towing fittings and must act parallel to the ground. In addition -*

*(1) A vertical load factor equal to 1.0 must be considered acting at the center of gravity;*

*(2) The shock struts and tires must be in their static positions; and*

*(3) With $W_T$ as the design ramp weight, the towing load, $F_{TOW}$, is -*

*(i) 0.3 $W_T$ for $W_T$ less than 30,000 pounds;*

*(ii) $(6W_T+450,000)/7$ for $W_T$ between 30,000 and 100,000 pounds; and*

NOTE: The denumerator of 7 is incorrect in the CFR, it was published correctly in the Federal Register as 70.

*(iii) 0.15 $W_T$ for $W_T$ over 100,000 pounds.*

*(b) For towing points not on the landing gear but near the plane of symmetry of the airplane, the drag and side tow load components specified for the auxiliary gear apply. For towing points located outboard of the main gear, the drag and side tow load components specified for the main gear apply. Where the specified angle of swivel cannot be reached, the maximum obtainable angle must be used.*

*(c) The towing loads specified in paragraph (d) of this section must be reacted as follows:*

*(1) The side component of the towing load at the main gear must be reacted by a side force at the static ground line of the wheel to which the load is applied.*

*(2) The towing loads at the auxiliary gear and the drag components of the towing loads at the main gear must be reacted as follows:*

*(i) A reaction with a maximum value equal to the vertical reaction must be applied at the axle of the wheel to which the load is applied. Enough airplane inertia to achieve equilibrium must be applied.*

*(ii) The loads must be reacted by airplane inertia.*

*(d) The prescribed towing loads are as follows:*

| Tow point | Position | Magnitude | Load No. | Direction |
|---|---|---|---|---|
| Main gear | | 0.75 Ftow per main gear unit | 1 | Forward, parallel to drag axis. |
| | | | 2 | Forward, at 30$^{o}$ to drag axis. |
| | | | 3 | Aft, parallel to drag axis. |
| | | | 4 | Aft, at 30$^{o}$ to drag axis. |
| Auxiliary gear | Swiveled forward | 1.0 $F_{TOW}$ | 5 | Forward. |
| | | | 6 | Aft. |
| | Swiveled aft | 1.0 $F_{TOW}$ | 7 | Forward. |
| | | | 8 | Aft. |
| | Swiveled 45$^{o}$ from forward | 0.5 $F_{TOW}$ | 9 | Forward, in plane of wheel. |
| | | | 10 | Aft, in plane of wheel |
| | Swivel 45$^{o}$ from aft | 0.5 $Ft_{OW}$ | 11 | Forward, in plane of wheel. |
| | | | 12 | Aft, in plane of wheel. |

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, towing fittings and supporting structure are able to withstand any likely towing loads developed in service.

c. Background. This rule was carried forward from § 4b.235(h) of the Civil Air Regulations (CAR). Amendment 25-23 redefined $W_T$ as the design ramp weight.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

NOTE: In paragraph a.(ii), the denominator of 7 is an error and should be 70.

e. References. None.

497 - 508. [RESERVED]

## 509. SECTION 25.511 - GROUND LOAD: UNSYMMETRICAL LOADS ON MULTIPLE-WHEEL UNITS.

a. Rule Text.

*(a) General. Multiple-wheel landing gear units are assumed to be subjected to the limit ground loads prescribed in this subpart under paragraphs (b) through (f) of this section. In addition -*
*(1) A tandem strut gear arrangement is a multiple-wheel unit; and*
*(2) In determining the total load on a gear unit with respect to the provisions of paragraphs (b) through (f) of this section, the transverse shift in the load centroid, due to unsymmetrical load distribution on the wheels, may be neglected.*
*(b) Distribution of limit loads to wheels; tires inflated. The distribution of the limit loads among the wheels of the landing gear must be established for each landing, taxiing, and ground handling condition, taking into account the effects of the following factors:*
*(1) The number of wheels and their physical arrangements. For truck type landing gear units, the effects of any seesaw motion of the truck during the landing impact must be considered in determining the maximum design loads for the fore and aft wheel pairs.*
*(2) Any differentials in tire diameters resulting from a combination of manufacturing tolerances, tire growth, and tire wear. A maximum tire-diameter differential equal to 2/3 of the most unfavorable combination of diameter*

*variations that is obtained when taking into account manufacturing tolerances, tire growth, and tire wear, may be assumed.*

*(3) Any unequal tire inflation pressure, assuming the maximum variation to be ±5 percent of the nominal tire inflation pressure.*

*(4) A runway crown of zero and a runway crown having a convex upward shape that may be approximated by a slope of 1½ percent with the horizontal. Runway crown effects must be considered with the nose gear unit on either slope of the crown.*

*(5) The airplane attitude.*

*(6) Any structural deflections.*

*(c) Deflated tires. The effects of deflated tires on the structure must be considered with respect to the loading conditions specified in paragraphs (d) through (f) of this section, taking into account the physical arrangement of the gear components. In addition-*

*(1) The deflation of any one tire for each multiple wheel landing gear unit, and the deflation of any two critical tires for each landing gear unit using four or more wheels per unit, must be considered; and*

*(2) The ground reactions must be applied to the wheels with inflated tires except that, for multiple-wheel gear units with more than one shock strut, a rational distribution of the ground reactions between the deflated and inflated tires, accounting for the differences in shock strut extensions resulting from a deflated tire, may be used.*

*(d) Landing conditions. For one and for two deflated tires, the applied load to each gear unit is assumed to be 60 percent and 50 percent, respectively, of the limit load applied to each gear for each of the prescribed landing conditions. However, for the drift landing condition of § 25.485, 100 percent of the vertical load must be applied.*

*(e) Taxiing and ground handling conditions. For one and for two deflated tires -*

*(1) The applied side or drag load factor, or both factors, at the center of gravity must be the most critical value up to 50 percent and 40 percent respectively, of the limit side or drag load factors, or both factors, corresponding to the most severe condition resulting from consideration of the prescribed taxiing and ground handling conditions;*

*(2) For the braked roll conditions of § 25.493(a) and (b)(2), the drag loads on each inflated tire may not be less than those at each tire for the symmetrical load distribution with no deflated tires;*

*(3) The vertical load factor at the center of gravity must be 60 percent and 50 percent, respectively, of the factor with no deflated tires, except that it may not be less than 1g; and*

*(4) Pivoting need not be considered.*

*(f) Towing conditions. For one and for two deflated tires, the towing load,* $F_{TOW}$, *must be 60 percent and 50 percent, respectively, of the load prescribed.*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane, landing gear and its supporting structure are able to withstand any load distributions likely to occur in service.

c. Background. This rule was carried forward from § 4b.236 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

510 - 519. [RESERVED]

520. SECTION 25.519 - JACKING AND TIE-DOWN PROVISIONS.

a. Rule Text.

*(a) General. The airplane must be designed to withstand the limit load conditions resulting from the static ground load conditions of paragraph (b) of this section and, if applicable, paragraph (c) of this section at the most critical combinations of airplane weight and center of gravity. The maximum allowable [limit] load at each jack pad must be specified.*

*(b) Jacking. The airplane must have provisions for jacking and must withstand the following limit loads when the airplane is supported on jacks -*

*(1) For jacking by the landing gear at the maximum ramp weight of the airplane, the airplane structure must be designed for a vertical load of 1.33 times the vertical static reaction at each jacking point acting singly and in combination with a horizontal load of 0.33 times the vertical static reaction applied in any direction.*

*(2) For jacking by other airplane structure at maximum approved jacking weight:*

*(i) The airplane structure must be designed for a vertical load of 1.33 times the vertical reaction at each jacking point acting singly and in combination with a horizontal load of 0.33 times the vertical static reaction applied in any direction.*

*(ii) The jacking pads and local structure must be designed for a vertical load of 2.0 times the vertical static reaction at each jacking point, acting singly and in combination with a horizontal load of 0.33 times the vertical static reaction applied in any direction.*

*(c) Tie-down. If tie-down points are provided, the main tie-down points and local structure must withstand the limit loads resulting from a 65-knot horizontal wind from any direction.*

*[Amdt. 25-81, 59 FR 22102, Apr. 28, 1994]*

b. Intent of Rule. The purpose of this rule is to provide minimum design requirements for jacking and tie-down.

c. Background. This rule was incorporated into part 25 by Amendment 25-81.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-81, 59 FR 22102, April 28, 1994.

e. References. None.

521 - 528. [RESERVED]

## Section 7. WATER LOADS.

### 529. SECTION 25.521 - GENERAL.

a. Rule Text.

*(a) Seaplanes must be designed for the water loads developed during takeoff and landing, with the seaplane in any attitude likely to occur in normal operation, and at the appropriate forward and sinking velocities under the most severe sea conditions likely to be encountered.*
*(b) Unless a more rational analysis of the water loads is made, or the standards in ANC-3 are used, §§ 25.523 through 25.537 apply.*
*(c) The requirements of this section and §§ 25.523 through 25.537 apply also to amphibians.*

b. Intent of Rule. This rule provides the general requirements for developing water loads on seaplanes.

c. Background. This rule was carried forward from § 4b.250 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

530 - 540. [RESERVED]

### 541. SECTION 25.523 - DESIGN WEIGHTS AND CENTER OF GRAVITY POSITIONS.

a. Rule Text.

*(a) Design weights. The water load requirements must be met at each operating weight up to the design landing weight except that, for the takeoff condition prescribed in § 25.531, the design water takeoff weight ( the maximum weight for water taxi and takeoff run) must be used.*
*(b) Center of gravity positions. The critical centers of gravity within the limits for which certification is requested must be considered to reach maximum design loads for each part of the seaplane structure.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to account for all operating gross weights and c.g. locations.

c. Background. This rule was carried forward from § 4b.251 of the Civil Air Regulations (CAR). Amendment 25-23 added editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

542 - 548. [RESERVED]

## 549. SECTION 25.525 - APPLICATION OF LOADS.

a. Rule Text.

*(a) Unless otherwise prescribed, the seaplane as a whole is assumed to be subjected to the loads corresponding to the load factors specified in § 25.527.*
*(b) In applying the loads resulting from the load factors prescribed in § 25.527, the loads may be distributed over the hull or main float bottom (in order to avoid excessive local shear loads and bending moments at the location of water load application) using pressures not less than those prescribed in § 25.533(b).*
*(c) For twin float seaplanes, each float must be treated as an equivalent hull on a fictitious seaplane with a weight equal to one-half the weight of the twin float seaplane.*
*(d) Except in the takeoff condition of § 25.531, the aerodynamic lift on the seaplane during the impact is assumed to be 2/3 of the weight of the seaplane.*

b. Intent of Rule. The purpose of this rule is to provide criteria to be used in developing the waterloads on the seaplane.

c. Background. This rule was carried forward from § 4b.252 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

550 - 559. [RESERVED]

560. SECTION 25.527 - HULL AND MAIN FLOAT LOAD FACTORS.

a. Rule Text.

*(a) Water reaction load factors $n_W$ must be computed in the following manner:*
*(1) For the step landing case*

$$n_w = \frac{C_1 V_{so}^{\ 2}}{\left(\mathrm{T}an^{2/3}\boldsymbol{b}\right)W^{1/3}}$$

*(2) For the bow and stern landing cases*

$$n_w = \frac{C_1 V_{so}^{\ 2}}{\left(\mathrm{T}an^{2/3}\boldsymbol{b}\right)W^{1/3}} x \frac{K_1}{\left(1+r_x^{\ 2}\right)^{2/3}} \ ;$$

*(b) The following values are used:*
*(1) $n_W$ = water reaction load factor (that is, the water reaction divided by seaplane weight).*
*(2) $C_1$ = empirical seaplane operations factor equal to 0.012 (except that this factor may not be less than that necessary to obtain the minimum value of step load factor of 2.33).*
*(3) $V_{SO}$ = seaplane stalling speed in knots with flaps extended in the appropriate landing position and with no slipstream effects.*
*(4) β = angle of dead rise at the longitudinal station at which the load factor is being determined, in accordance with Figure 1 of Appendix B.*
*(5) W = seaplane design landing weight in pounds.*
*(6) $K_1$ = empirical hull station weighing factor, in accordance with Figure 2 of Appendix B.*
*(7) $r_x$ = ratio of distance, measured parallel to hull reference axis, from the center of gravity of the seaplane to the hull longitudinal station at which the load factor is being computed to the radius of gyration in pitch of the seaplane, the hull reference axis being a straight line, in the plane of symmetry, tangential to the keel at the main step.*
*(c) For a twin float seaplane, because of the effect of flexibility of the attachment of the floats to the seaplane, the factor $K_1$ may be reduced at the bow and stern to 0.8 of the value shown in Figure 2 of Appendix B. This reduction applies only to the design of the carry-through and seaplane structure.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to provide a method for calculating the water reaction load factor distribution for use in calculating hull loads.

c. Background. This rule was carried forward from § 4b.253 of the Civil Air Regulations (CAR). Amendment 25-23 made minor editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

561 - 568. [RESERVED]

569. SECTION 25.529 - HULL AND MAIN FLOAT LANDING CONDITIONS.

a. Rule Text.

*(a) Symmetrical step, bow, and stern landing. For symmetrical step, bow, and stern landings, the limit water reaction load factors are those computed under § 25.527. In addition -*
*(1) For symmetrical step landings, the resultant water load must be applied at the keel, through the center of gravity, and must be directed perpendicularly to the keel line;*
*(2) For symmetrical bow landings, the resultant water load must be applied at the keel, one-fifth of the longitudinal distance from the bow to the step, and must be directed perpendicularly to the keel line; and*
*(3) For symmetrical stern landings, the resultant water load must be applied at the keel, at a point 85 percent of the longitudinal distance from the step to the stern post, and must be directed perpendicularly to the keel line.*
*(b) Unsymmetrical landing for hull and single float seaplanes. Unsymmetrical step, bow, and stern landing conditions must be investigated. In addition -*
*(1) The loading for each condition consists of an upward component and a side component equal, respectively, to 0.75 and 0.25 tan ß times the resultant load in the corresponding symmetrical landing condition; and*
*(2) The point of application and direction of the upward component of the load is the same as that in the symmetrical condition, and the point of application of the side component is at the same longitudinal station as the upward component but is directed inward perpendicularly to the plane of symmetry at a point midway between the keel and chine lines.*
*(c) Unsymmetrical landing; twin float seaplanes. The unsymmetrical loading consists of an upward load at the step of each float of 0.75 and a side load of 0.25*

*tan ß at one float times the step landing load reached under § 25.527. The side load is directed inboard, perpendicularly to the plane of symmetry midway between the keel and chine lines of the float, at the same longitudinal station as the upward load.*

b. Intent of Rule. The purpose of this rule is to define the types of landing conditions to be considered for structural design.

c. Background. This rule was carried forward from § 4b.254 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

570 - 575. [RESERVED]

576. SECTION 25.531 - HULL AND MAIN FLOAT TAKEOFF CONDITION.

a. Rule Text.

*For the wing and its attachment to the hull or main float -*
*(a) The aerodynamic wing lift is assumed to be zero; and*
*(b) A downward inertia load, corresponding to a load factor computed from the following formula, must be applied:*

$$n = \frac{C_{TO} V_{SI}^2}{\left(\tan^{2/3} b\right) W^{1/3}}$$

*where -*
*n* = *inertia load factor;*
$C_{TO}$ = *empirical seaplane operations factor equal to 0.004;*
$V_{SI}$ = *seaplane stalling speed (knots) at the design takeoff weight with the flaps extended in the appropriate takeoff position;*
β = *angle of dead rise at the main step (degrees); and*
W = *design water takeoff weight in pounds.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the wing and its attachment to the hull or main float are able to withstand the inertia loads likely to be encountered in service.

c. Background. This rule was carried forward from § 4b.255 of the Civil Air Regulations (CAR). Amendment 25-23 made only minor editorial changes.

d. Acceptable Compliance Methods. For guidance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

577 - 583. [RESERVED]

## 584. SECTION 25.533 - HULL AND MAIN FLOAT BOTTOM PRESSURES.

a. Rule Text.

*(a) General. The hull and main float structure, including frames and bulkheads, stringers, and bottom plating, must be designed under this section.*
*(b) Local pressures. For the design of the bottom plating and stringers and their attachments to the supporting structure, the following pressure distributions must be applied:*
*(1) For an unflared bottom, the pressure at the chine is 0.75 times the pressure at the keel, and the pressures between the keel and chine vary linearly, in accordance with figure 3 of Appendix B. The pressure at the keel (psi) is computed as follows:*

$$P_k = C_2 \frac{K_2 V_{SI}^2}{\tan \beta_k}$$

*where -*
*$P_k$ = pressure (psi) at the keel;*
*$C_2$ = 0.00213;*
*$K_2$ = hull station weighing factor, in accordance with figure 2 of Appendix B;*
*$V_{SI}$ = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and*
*$\beta_k$ = angle of dead rise at keel, in accordance with figure 1 of Appendix B.*
*(2) For a flared bottom, the pressure at the beginning of the flare is the same as that for an unflared bottom, and the pressure between the chine and the beginning of the flare varies linearly, in accordance with figure 3 of Appendix B. The pressure distribution is the same as that prescribed in paragraph (b)(1) of this*

*section for an unflared bottom except that the pressure at the chine is computed as follows:*

$$P_{ch} = C_3 \frac{K_2 V_{SI}^{2}}{\tan \beta}$$

*where -*

$P_{ch}$ *= pressure (psi) at the chine;*

$C_3$ *= 0.0016;*

$K_2$ *= hull station weighing factor, in accordance with figure 2 of Appendix B;*

$V_{S\,I}$ *= seaplane stalling speed at the design water takeoff weight with flaps extended in the appropriate takeoff position; and*

$\beta$ *= angle of dead rise at appropriate station.*

*The area over which these pressures are applied must simulate pressures occurring during high localized impacts on the hull or float, but need not extend over an area that would induce critical stresses in the frames or in the overall structure.*

*(c) Distributed pressures. For the design of the frames, keel, and chine structure, the following pressure distributions apply:*

*(1) Symmetrical pressures are computed as follows:*

$$P = C_4 \frac{K_2 V_{SO}^{2}}{\tan \beta}$$

*where -*

$P$ *= pressure (psi);*

$C_4$ *= 0.078* $C_1$ *(with* $C_1$ *computed under § 25.527);*

$K_2$ *= hull station weighing factor, determined in accordance with figure 2 of Appendix B;*

$V_{so}$ *= seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect; and*

$\beta$ *= angle of dead rise at appropriate station.*

*(2) The unsymmetrical pressure distribution consists of the pressures prescribed in paragraph (c)(1) of this section on one side of the hull or main float centerline and one-half of that pressure on the other side of the hull or main float centerline, in accordance with figure 3 of Appendix B.*

*These pressures are uniform and must be applied simultaneously over the entire hull or main float bottom. The loads obtained must be carried into the sidewall structure of the hull proper, but need not be transmitted in a fore and aft direction as shear and bending loads.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the bottom structures of the hull and floats are able to withstand likely pressure loads developed during takeoff and landing.

c. Background. This rule was carried forward § 4b.256 of the Civil Air Regulations (CAR). Amendment 25-23 made minor editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

e. References. None.

585 - 589. [RESERVED]

590. SECTION 25.535 - AUXILIARY FLOAT LOADS.

a. Rule Text.

*(a) General. Auxiliary floats and their attachments and supporting structures must be designed for the conditions prescribed in this section. In the cases specified in paragraphs (b) through (e) of this section, the prescribed water loads may be distributed over the float bottom to avoid excessive local loads, using bottom pressures not less than those prescribed in paragraph (g) of this section.*
*(b) Step loading. The resultant water load must be applied in the plane of symmetry of the float at a point three-fourths of the distance from the bow to the step and must be perpendicular to the keel. The resultant limit load is computed as follows, except that the value of L need not exceed three times the weight of the displaced water when the float is completely submerged:*

$$L = C_5 \frac{V_{SO}{}^2 W^{2/3}}{\tan^{2/3} \beta_s \left(1 + r_y{}^2\right)^{2/3}}$$

*where -*
*L = limit load (lbs.);*
*$C_5$ = 0.0053;*
$V_{So}$ = *seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect;*
*W = seaplane design landing weight in pounds;*
$\beta_s$ = *angle of dead rise at a station 3/4 of the distance from the bow to the step, but need not be less than 15 degrees; and*

$r_y$ = *ratio of the lateral distance between the center of gravity and the plane of symmetry of the float to the radius of gyration in roll.*

*(c) Bow loading. The resultant limit load must be applied in the plane of symmetry of the float at a point one-fourth of the distance from the bow to the step and must be perpendicular to the tangent to the keel line at that point. The magnitude of the resultant load is that specified in paragraph (b) of this section.*

*(d) Unsymmetrical step loading. The resultant water load consists of a component equal to 0.75 times the load specified in paragraph (a) of this section and a side component equal to 3.25 tan ß times the load specified in paragraph (b) of this section. The side load must be applied perpendicularly to the plane of symmetry of the float at a point midway between the keel and the chine.*

NOTE: The 3.25 factor is an error, it should be 0.25.

*(e) Unsymmetrical bow loading. The resultant water load consists of a component equal to 0.75 times the load specified in paragraph (b) of this section and a side component equal to 0.25 tan ß times the load specified in paragraph (c) of this section. The side load must be applied perpendicularly to the plane of symmetry at a point midway between the keel and the chine.*

*(f) Immersed float condition. The resultant load must be applied at the centroid of the cross section of the float at a point one-third of the distance from the bow to the step. The limit load components are as follows:*

$$\textit{vertical} = \rho g V$$

$$\textit{aft} = C_x \frac{r}{2} V^{2/3} \left(KV_{SO}\right)^2$$

$$\textit{side} = C_y \frac{r}{2} V^{2/3} \left(KV_{SO}^2\right)$$

*where -*

$\rho$ = *mass density of water (slugs/ft.)$^2$;*

*V = volume of float (ft.)$^2$;*

$C_x$ = *coefficient of drag force, equal to 0.133;*

$C_y$ = *coefficient of side force, equal to 0.106;*

*K = 0.8, except that lower values may be used if it is shown that the floats are incapable of submerging at a speed of 0.8 $V_{SO}$ in normal operations;*

$V_{So}$ = *seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect; and*

*g = acceleration due to gravity (ft/sec$^2$)*

*(g) Float bottom pressures. The float bottom pressures must be established under § 25.533, except that the value of $K_2$ in the formulae may be taken as 1.0. The angle of dead rise to be used in determining the float bottom pressures is set forth in paragraph (b) of this section.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to establish structural design requirements for auxiliary floats and their attachments.

c. Background. This rule was carried forward from § 4b.257 of the Civil Air Regulations (CAR). Amendment 25-23 made minor editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970.

NOTE: In paragraph (d), the 3.25 factor is an error and should be 0.25. The error was corrected by FAA policy letter dated September 23, 1993.

e. References. None.

591 - 597. [RESERVED]

598. SECTION 25.537 - SEAWING LOADS.

a. Rule Text.

*Seawing design loads must be based on applicable test data.*

NOTE: This rule also applies to hydrofoils.

b. Intent of Rule. The purpose of this rule is to ensure that seawings and hydrofoils are able to withstand any likely loads encountered in service.

c. Background. This rule was carried forward from § 4b.537 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

599 - 602. [RESERVED]

# Section 8. EMERGENCY LANDING CONDITIONS

## 603. SECTION 25.561.- GENERAL.

a. Rule Text.

*(a) The airplane, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this section to protect each occupant under those conditions.*
*(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a minor crash landing when -*
*(1) Proper use is made of seats, belts, and all other safety design provisions;*
*(2) The wheels are retracted (where applicable); and*
*(3) The occupant experiences the following ultimate inertia forces acting separately relative to the surrounding structure:*
*(i) upward, 3.0g*
*(ii) Forward, 9.0g*
*(iii) Sideward, 3.0g on the airframe; and 4.0g on the seats and their attachments.*
*(iv) Downward, 6.0g*
*(v) Rearward, 1.5g*
*(c) For equipment, cargo in the passenger compartments and any other large masses, the following apply:*
*(1) Except as provided in paragraph (c)(2) of this section, these items must be positioned so that if they break loose they will be unlikely to*
*(i) Cause direct injury to occupants;*
*(ii) Penetrate fuel tanks or lines or cause fire or explosion hazard by damage to adjacent systems; or*
*(iii) Nullify any of the escape facilities provided for use after an emergency landing.*
*(2) When such positioning is not practical (e.g. fuselage mounted engines or auxiliary power units) each such item of mass shall be restrained under all loads up to those specified in paragraph (b)(3) of this section. The local attachments for these items should be designed to withstand 1.33 times the specified loads if these items are subject to severe wear and tear through frequent removal (e.g. quick change interior items).*
*(d) Seats and items of mass (and their supporting structure) must not deform under any loads up to those specified in paragraph (b)(3) of this section in any manner that would impede subsequent rapid evacuation of occupants.*

*[Amdt. 25-23, 35 FR 5673, Apr. 8, 1970; Amdt. 25-64, 53 FR 17646, May 17, 1988; Amdt. 25-91, 62 FR 40702, Jul. 29, 1997]*

b. Intent of Rule. The purpose of this rule is to ensure that occupants will have a reasonable chance of escaping serious injury after an emergency landing on either land or water.

c. Background. This rule was carried forward from § 4b.260 of the Civil Air Regulations (CAR). Amendment 25-23 made minor editorial changes for clarification. Amendment 25-64 increased the inertia load factors in the upward, sideward, and downward directions and added a rearward load factor. Amendment 25-64 also removed the reference to the five f.p.s. ultimate descent velocity. Amendment 25-91 provided a factor of 1.33 for frequently removed items.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5673, April 8, 1970; Amendment 25-64, 53 FR 17646, May 17, 1988; and Amendment 25-91, 62 FR 40702, July 29, 1997.

e. References. None.

604 - 610. [RESERVED]

611. SECTION 25.562 - EMERGENCY LANDING DYNAMIC CONDITIONS.

a. Rule Text.

*(a) The seat and restraint system in the airplane must be designed as prescribed in this section to protect each occupant during an emergency landing condition when -*
*(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design; and*
*(2) The occupant is exposed to loads resulting from the conditions prescribed in this section.*
*(b) Each seat type design approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat, in accordance with each of the following emergency landing conditions. The tests must be conducted with an occupant simulated by a 170-pound anthropomorphic test dummy, as defined by 49 CFR Part 572, Subpart B, or its equivalent, sitting in the normal upright position.*
*(1) A change in downward vertical velocity ($\Delta V$) of not less than 35 feet per second, with the airplane's longitudinal axis canted downward 30 degrees with respect to the horizontal plane and with the wings level. Peak floor deceleration must occur in not more than 0.08 seconds after impact and must reach a minimum of 14g.*
*(2) A change in forward longitudinal velocity ($\Delta V$) of not less than 44 feet per second, with the airplane's longitudinal axis horizontal and yawed 10 degrees*

*either right or left, whichever would cause the greatest likelihood of the upper torso restraint system (where installed) moving off the occupant's shoulder, and with the wings level. Peak floor deceleration must occur in not more than 0.09 seconds after impact and must reach a minimum of 16g. Where floor rails or floor fittings are used to attach the seating devices to the test fixture, the rails or fittings must be misaligned with respect to the adjacent set of rails or fittings by at least 10 degrees vertically (i.e., out of Parallel) with one rolled 10 degrees.*
*(c) The following performance measures must not be exceeded during the dynamic tests conducted in accordance with paragraph (b) of this section:*
*(1) Where upper torso straps are used for crewmembers, tension loads in individual straps must not exceed 1,750 pounds. If dual straps are used for restraining the upper torso, the total strap tension loads must not exceed 2,000 pounds.*
*(2) The maximum compressive load measured between the pelvis and the lumbar column of the anthropomorphic dummy must not exceed 1,500 pounds.*
*(3) The upper torso restraint straps (where installed) must remain on the occupant's shoulder during the impact.*
*(4) The lap safety belt must remain on the occupant's pelvis during the impact.*
*(5) Each occupant must be protected from serious head injury under the conditions prescribed in paragraph (b) of this section. Where head contact with seats or other structure can occur, protection must be provided so that the head impact does not exceed a Head Injury Criterion (HIC) of 1,000 units. The level of HIC is defined by the equation:*

$$HIC = \left\{ (t_2 - t_1) \left[ \frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a(t)\,dt \right]^{2.5} \right\}_{MAX}$$

*where:*
*$t_1$ is the initial integration time,*
*$t_2$ is the final integration time, and*
*a(t) is the total acceleration vs. time curve for the head strike, and where*
*(t) is in seconds, and (a) is in units of gravity (g).*
*(6) Where leg injuries may result from contact with seats or other structure, protection must be provided to prevent axially compressive loads exceeding 2,250 pounds in each femur.*
*(7) The seat must remain attached at all points of attachment, although the structure may have yielded.*
*(8) Seats must not yield under the tests specified in paragraphs (b)(1) and (b)(2) of this section to the extent they would impede rapid evacuation of the airplane occupants.*

*[Amdt. 25-64, 53 FR 17646, May 17, 1988]*

b. Intent of Rule. The purpose of this rule is to provide protection for each occupant during emergency landing conditions.

c. Background. This rule was made effective by Amendment 25-64 on May 17, 1988. Prior to this amendment, there was no requirement to dynamically test seats or restraint systems.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-64, 53 FR 17646, May 17, 1988. Advisory Circular (AC) 25.562-1A, or latest revision, provides guidance information regarding compliance with the provisions of part 25 applicable to dynamic testing of seats intended for use in transport category airplanes.

e. References. Advisory Circular 25.562-1A, or latest revision, Dynamic Evaluation of Seat Restraint Systems & Occupant Protection on Transport Airplanes.

612 - 620. [RESERVED]

## 621. SECTION 25.563 - STRUCTURAL DITCHING PROVISIONS.

a. Rule Text.

*Structural strength considerations of ditching provisions must be in accordance with § 25.801(e).*

b. Intent of Rule. The purpose of this rule is to ensure that for aircraft certificated for ditching, the structural integrity of doors and windows will be maintained during ditching.

c. Background. This rule was brought forward from § 4b.261 of the Civil Air Regulations (CAR) with a minor editorial change.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

622 - 628. [RESERVED]

## Section 9. FATIGUE EVALUATION

### 629. SECTION 25.571 - DAMAGE-TOLERANCE AND FATIGUE EVALUATION OF STRUCTURE.

a. Rule Text.

*(a) General. 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 evaluation must be conducted in accordance with the provisions of paragraphs (b) and (e) of this section, except as specified in paragraph(c) of this section, for each part of the structure which 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). For turbojet powered airplanes, those parts that could contribute to a catastrophic failure must also be evaluated under paragraph (d) of this section. In addition, the following apply:*
*(1) Each evaluation required by this section must include -*
*(i) The typical loading spectra, temperatures, and humidities expected in service;*
*(ii) The identification of principal structural elements and detail design points, the failure of which could cause catastrophic failure of the airplane; and*
*(iii) An analysis, supported by test evidence, of the principal structural elements and detail design points identified in paragraph (a)(1)(ii) of this section.*
*(2) The service history of airplanes of similar structural design, taking due account of differences in operating conditions and procedures, may be used in the evaluations required by this section.*
*(3) Based on the evaluations required by this section, inspections or other procedures must be established as necessary to prevent catastrophic failure, and must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by § 25.1529. Inspection thresholds for the following types of structure must be established based on crack growth analyses and/or tests, assuming the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage:*
*(i) Single load path structure, and*
*(ii) Multiple load path "fail-safe" structure and crack arrest "fail-safe" structure, where it cannot be demonstrated that load path failure, partial failure, or crack arrest will be detected and repaired during normal maintenance, inspection, or operation of an airplane prior to failure of the remaining structure.*

*(b) Damage-tolerance evaluation. The evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. Repeated load and static analyses supported by test evidence and (if available) service experience must also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. It must be demonstrated with sufficient full-scale fatigue test evidence that widespread fatigue damage will not occur within the design service goal of the airplane. The type certificate may be issued prior to completion of full-scale fatigue testing, provided the Administrator has approved a plan for completing the required tests, and the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by § 25.1529 of this part specifies that no airplane may be operated beyond a number of cycles equal to 1/2 the number of cycles accumulated on the fatigue test article, until such testing is completed.. The extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand loads (considered as static ultimate loads) corresponding to the following conditions:*

*(1) The limit symmetrical maneuvering conditions specified in § 25.337 at all speeds up to* $V_C$ *and in § 25.345.*

*(2) The limit gust conditions specified in § 25.341 at speeds up to* $V_C$*, and in § 25.345.*

*(3) The limit rolling conditions specified in § 25.349 and the limit unsymmetrical conditions specified in §§ 25.367 and 25.427(a) through (c), at speeds up to* $V_C$*.*

*(4) The limit yaw maneuvering conditions specified in § 25.351(a) at the specified speeds up to* $V_C$*.*

*(5) For pressurized cabins, the following conditions:*

*(i) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in paragraphs (b)(1) through (4) of this section, if they have a significant effect.*

*(ii) The maximum value of normal operating differential pressure (including the expected external aerodynamic pressures during 1g level flight) multiplied by a factor of 1.15, omitting other loads.*

*(6) For landing gear and directly-affected airframe structure, the limit ground loading conditions specified in §§ 25.473, 25.491, and 25.493.*

*If significant changes in structural stiffness or geometry, or both, follow from a structural failure, or partial failure, the effect on damage tolerance must be further investigated.*

*(c) Fatigue (safe-life) evaluation. Compliance with the damage-tolerance requirements of paragraph (b) of this section is not required if the applicant establishes that their application for particular structure is impractical. This*

*structure must be shown by analysis, supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected during its service life without detectable cracks. Appropriate safe-life scatter factors must be applied.*
*(d) Sonic fatigue strength. It must be shown by analysis, supported by test evidence, or by the service history of airplanes of similar structural design and sonic excitation environment, that -*
*(1) Sonic fatigue cracks are not probable in any part of the flight structure subject to sonic excitation; or*
*(2) Catastrophic failure caused by sonic cracks is not probable assuming that the loads prescribed in paragraph (b) of this section are applied to all areas affected by those cracks.*
*(e) Damage-tolerance (discrete source) evaluation. The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of -*
*(1) Impact with a 4-pound bird when the velocity of the airplane relative to the bird along the airplane's flight path is equal to $V_C$ at sea level or $0.85V_C$ at 8,000 feet, whichever is more critical;*
*(2) Uncontained fan blade impact;*
*(3) Uncontained engine failure; or*
*(4) Uncontained high energy rotating machinery failure.*

*The damaged structure must be able to withstand the static loads (considered as ultimate loads) which are reasonably expected to occur on the flight. Dynamic effects on these static loads need not be considered. Corrective action to be taken by the pilot following the incident, such as limiting maneuvers, avoiding turbulence, and reducing speed, must be considered. If significant changes in structural stiffness or geometry, or both, follow from a structural failure or partial failure, the effect on damage tolerance must be further investigated.*

*[Amdt. 25-45, 43 FR 46242, Oct. 5, 1978; Amdt. 25-54, 45 FR 60173, Sep. 11, 1980; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990; Amdt. 25-86, 61 FR 5222, Feb. 9, 1996; Amdt. 25-96, 63 FR 15708, Mar. 31, 1998]*

b. Intent of Rule. The purpose of this rule is to ensure that fatigue, or corrosion, or accidental damage will be detected and repaired before it becomes catastrophic. This is achieved by adhering to damage tolerant design practices and by prescribing inspections that will detect any such damage before it becomes critical.

c. Background. This rule was carried forward from § 4b.270 of the Civil Air Regulations (CAR), Fatigue Evaluation. The fatigue evaluation provided an option of fatigue strength (safe life) or fail safe strength for flight critical structures. Amendment 25-45 to part 25 introduced the new damage-tolerance rule and mandated an inspection program that is based on the damage tolerance evaluation required by this section. It also required a damage-tolerance (discrete source) evaluation to cover accidental damage. Amendment 25-54 requires that inspections or other procedures must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 25.1529. Amendment 25-72 removes the requirement to consider propeller blade impact and to define the likely operating speed to consider for the 4-pound bird impact. Editorial changes were made in Amendment 25-86 to conform to changes in the gust load requirements. Amendment 25-96 added requirements for fatigue tests and inspection thresholds. It also corrected an editorial error in paragraph (e)(1) that reduced the birdstrike speed to 0.85 $V_C$ at 8,000 feet, and revised the residual strength cabin pressure loads.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-45, 43 FR 46242, October 5, 1978; Amendment 25-54, 45 FR 60173, September 11, 1980; Amendment 25-72, 55 FR 29776, July 20, 1990; and Amendment 25-86, 61 FR 5222, February 9, 1996. Advisory Circular (AC) 25.571-1B, or latest revision, provides an acceptable means of compliance with this regulation.

e. References. Advisory Circular 25.571-1B, or latest revision, Damage-Tolerance and Fatigue Evaluation of Structure; and AC 20-107A, or latest revision, Composite Aircraft Structures.

630 - 638. [RESERVED]

## Section 10. LIGHTNING PROTECTION

### 639. SECTION 25.581 - LIGHTNING PROTECTION.

a. Rule Text.

*(a) The airplane must be protected against catastrophic effects from lightning.*
*(b) For metallic components, compliance with paragraph (a) of this section may be shown by--*
*(1) Bonding the components properly to the airframe; or*
*(2) Designing the components so that a strike will not endanger the airplane.*
*(c) For nonmetallic components, compliance with paragraph (a) of this section may be shown by--*
*(1) Designing the components to minimize the effects of a strike; or*
*(2) Incorporating acceptable means of diverting the resulting electrical current so as not to endanger the airplane.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane is able to withstand any likely lightning strike and continue safe flight and landing.

c. Background. This rule was adopted by Amendment 25-23 on April 8, 1970.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970. Advisory Circular (AC) 20-136, or latest revision, provides guidance information concerning an acceptable means, but not the only means, of compliance for preventing hazardous effects, due to lightning, from occurring to electrical/electronic systems performing critical essential functions. Advisory Circular 20-53A, or latest revision, provides guidance information applicable to preventing ignition of fuel vapors due to lightning.

e. References. Advisory Circular 20-53A, or latest revision, Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition due to Lightning, AC 20-107A, or latest revision, Composite Aircraft Structure; and AC 20-136, or latest revision, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning.

### 640 - 650. [RESERVED]

# Chapter 2 - DESIGN AND CONSTRUCTION

## Section 1. GENERAL

### 651. SECTION 25.601 - GENERAL.

a. Rule Text.

*The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.*

b. Intent of Rule. The purpose of this rule is to prohibit approval of any design that service experience has shown to be unsafe. This includes materials that experience has shown to be unsuitable for aircraft use.

c. Background. This rule was carried forward from § 4b.300 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by service experience review.

e. References. None.

### 652 - 658. [RESERVED]

### 659. SECTION 25.603 - MATERIALS.

a. Rule Text.

*The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must -*
*(a) Be established on the basis of experience or tests;*
*(b) Conform to approved specifications (such as industry or military specifications, or Technical Standard Orders) that ensure their having the strength and other properties assumed in the design data; and*

*(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.*

*[Amdt. 25-38, 41 FR 55466, Dec. 20, 1976; Amdt.. 25-46, 43 FR 50595, Oct. 30, 1978]*

b. Intent of Rule. The purpose of this rule is to ensure that materials used in the design of airplane parts are suitable for their intended purpose.

c. Background. This rule was carried forward from § 4b.301 of the Civil Air Regulations (CAR), along with the § 4b.301-1 Civil Aeronautics Manual (CAM) material. Amendment 25-38 made minor editorial changes, and Amendment 25-46 added the requirement to account for environmental effects.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-38, 41 FR 55466, December 20, 1976; and Amendment 25-46, 43 FR 50595, October 30, 1978.

e. References. None.

660 - 668. [RESERVED]

669. SECTION 25.605 - FABRICATION METHODS.

a. Rule Text.

*(a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process (such as gluing, spot welding, or heat treating) requires close control to reach this objective, the process must be performed under an approved process specification.*
*(b) Each new aircraft fabrication method must be substantiated by a test program.*

*[Amdt. 25-46, 43 FR 50595, Oct. 30, 1978]*

b. Intent of Rule. The purpose of this rule is to ensure a consistent design that will meet the strength and other properties assumed in the design data.

c. Background. This rule was carried forward from § 4b.302 of the Civil Air Regulations (CAR). Amendment 25-46 required that each new fabrication method be substantiated by a test program.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-46, 43 FR 50595, October 30, 1978.

e. References. None.

670 - 675. [RESERVED]

676. SECTION 25.607 - FASTENERS.

a. Rule Text.

*(a) Each removable bolt, screw, nut, pin, or other removable fastener must incorporate two separate locking devices if -*
*(1) Its loss could preclude continued flight and landing within the design limitations of the airplane using normal pilot skill and strength; or*
*(2) Its loss could result in reduction in pitch, yaw, or roll control capability or response below that required by Subpart B of this chapter.*
*(b) The fasteners specified in paragraph (a) of this section and their locking devices may not be adversely affected by the environmental conditions associated with the particular installation.*
*(c) No self-locking nut may be used on any bolt subject to rotation in operation, unless a non-friction locking device is used in addition to the self-locking device.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that removable fasteners used in critical locations will not be lost due to failure of any single retention device.

c. Background. This rule was carried forward from § 4b.303 of the Civil Air Regulations (CAR) with considerable revision. Amendment 25-23 added the requirement for dual locking devices on fasteners in critical locations.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970, and Advisory Circular (AC) 20-71, or latest revision.

e. References. Advisory Circular 20-71, or latest revision, Dual Locking Devices on Fasteners.

677 - 683. [RESERVED]

684. SECTION 25.609 - PROTECTION OF STRUCTURE.

a. Rule Text.

*Each part of the structure must -*
*(a) Be suitably protected against deterioration or loss of strength in service due to any cause, including -*
*(1) Weathering;*
*(2) Corrosion; and*
*(3) Abrasion; and*
*(b) Have provisions for ventilation and drainage where necessary for protection.*

b. Intent of Rule. The purpose of this rule is to ensure that the structure is adequately protected to provide resistance to deterioration in service.

c. Background. This rule was carried forward from § 4b.304 of the CAR with editorial changes.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by review of drawings and by inspection of aircraft.

e. References. None.

685 - 692. [RESERVED]

693. SECTION 25.611 - ACCESSIBILITY PROVISIONS.

a. Rule Text.

*Means must be provided to allow inspection (including inspection of principal structural elements and control systems), replacement of parts normally requiring replacement, adjustment, and lubrication as necessary for continued airworthiness. The inspection means for each item must be practicable for the inspection interval for the item. Nondestructive inspection aids may be used to inspect structural elements where it is impracticable to provide means for direct visual inspection if it is shown that the inspection is effective and the inspection procedures are specified in the maintenance manual required in § 25.1529.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to make it possible to replace parts when needed and to inspect critical structures. Continued safe operation depends on the ability to evaluate critical systems and structures and to replace or repair as necessary.

c. Background. This rule was carried forward from § 4b.305 of the Civil Air Regulations (CAR) and was revised by Amendment 25-23.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble to Amendment 25-23, 35 FR 5674, April 8, 1970. Compliance may be shown by review of drawings or by inspection of aircraft.

e. References. None.

694 - 698. [RESERVED]

699. SECTION 25.613 - MATERIAL STRENGTH PROPERTIES AND DESIGN VALUES.

a. Rule Text.

*(a) Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis.*
*(b) Design values must be chosen to minimize the probability of structural failures due to material variability. Except as provided in paragraph (e) of this section, compliance with this paragraph must be shown by selecting design values which assure material strength with the following probability:*
*(1) Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component, 99 percent probability with 95 percent confidence.*
*(2) For redundant structure, in which the failure of individual elements would result in applied loads being safely distributed to other load carrying members, 90 percent probability with 95 percent confidence.*
*(c) The effects of temperature on allowable stresses used for design in an essential component or structure must be considered where thermal effects are significant under normal operating conditions.*
*(d) The strength, detail design, and fabrication of the structure must minimize the probability of disastrous fatigue failure, particularly at points of stress concentration.*
*(e) Greater design values may be used if a "premium selection" of the material is made in which a specimen of each individual item is tested before use to*

*determine that the actual strength properties of that particular item will equal or exceed those used in design.*

*[Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to ensure that design values are based on enough tests of material meeting an approved specification to minimize the probability of structural failures due to material variability.

c. Background. This rule was carried forward from § 4b.306 of the Civil Air Regulations (CAR) with editorial changes. Amendment 25-46 permitted the Administrator to approve other design values. Amendment 25-72 combined the requirements of § 25.613 with § 25.615, and removed the reference to the military handbooks (MIL-HDBK's). This was done, in part, to harmonize with the Joint Aviation Requirements (JAR).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-46, 43 FR 50595, October 30, 1978; and Amendment 25-72, 55 FR 29776, July 20, 1990.

e. References. Military handbook (MIL-HDBK)-5, Metallic Materials and Elements for Flight Vehicle Structure; MIL-HDBK-17, Plastics for Flight Vehicles Composite Construction for Flight Vehicles.

700 - 707. [RESERVED]

708. SECTION 25.615 [Removed].

NOTE: In Amendment 25-72, Sections 25.613 and 25.615 were revised and consolidated into a single rule in Section 25.613.

*[Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

709. SECTION 25.619 - SPECIAL FACTORS.

a. Rule Text.

*The factor of safety prescribed in § 25.303 must be multiplied by the highest pertinent special factor of safety prescribed in §§ 25.621 through 25.625 for each part of the structure whose strength is -*

*(a) Uncertain;*
*(b) Likely to deteriorate in service before normal replacement; or*
*(c) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to account for uncertainties in structural strength, likely deterioration in service, and appreciable variability in manufacturing. This is necessary to ensure that the probability of failure of the part being under strength from these causes is extremely remote.

c. Background. This rule was carried forward from § 4b.307 of the Civil Air Regulations (CAR). Amendment 25-23 revised this rule for clarification of the applicability of the appropriate special factors. The revised rule makes it clear that the safety factor prescribed in § 25.303 is to be multiplied by the highest pertinent special factor prescribed in §§ 25.621 through 25.625. These special factors are not to be compounded.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970.

e. References. None.

710 - 718. [RESERVED]

## 719. SECTION 25.621 - CASTING FACTORS.

a. Rule Text.

*(a) General. The factors, tests, and inspections specified in paragraphs (b) through (d) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.*
*(b) Bearing stresses and surfaces. The casting factors specified in paragraphs (c) and (d) of this section -*
*(1) Need not exceed 1.25 with respect to bearing stresses regardless of the method of inspection used; and*
*(2) Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.*

*(c) Critical castings. For each casting whose failure would preclude continued safe flight and landing of the airplane or result in serious injury to occupants, the following apply:*

*(1) Each critical casting must -*

*(I) Have a casting factor of not less than 1.25; and*

*(ii) Receive 100 percent inspection by visual, radiographic, and magnetic particle or penetrant inspection methods or approved equivalent nondestructive inspection methods.*

*(2) For each critical casting with a casting factor less than 1.50, three sample castings must be static tested and shown to meet -*

*(i) The strength requirements of § 25.305 at an ultimate load corresponding to a casting factor of 1.25; and*

*(ii) The deformation requirements of § 25.305 at a load of 1.15 times the limit load.*

*(3) Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, and fuel and oil tank supports and attachments, and cabin pressure valves.*

*(d) Noncritical castings. For each casting other than those specified in paragraph (c) of this section, the following apply:*

*(1) Except as provided in paragraphs (d) (2) and (3) of this section, the casting factors and corresponding inspections must meet the following table:*

| *Casting factor* | *Inspection* |
|---|---|
| *2.0 or more* | *100 percent visual.* |
| *Less than 2.0 but more than 1.5* | *100 percent visual, and magnetic particle or penetrant or equivalent nondestructive inspection methods.* |
| *1.25 through 1.50* | *100 percent visual, magnetic particle or penetrant, and radiographic, or approved equivalent nondestructive inspection methods.* |

*(2) The percentage of castings inspected by nonvisual methods may be reduced below that specified in paragraph (d)(1) of this section when an approved quality control procedure is established.*

*(3) For castings procured to a specification that guarantees the mechanical properties of the material in the casting and provides for demonstration of these properties by test of coupons cut from the castings on a sampling basis--*

*(i) A casting factor of 1.0 may be used; and*

*(ii) The castings must be inspected as provided in paragraph (d)(1) of this section for casting factors of "1.25 through 1.50" and tested under paragraph (c)(2) of this section.*

b. Intent of Rule. The purpose of this rule is to account for variability in strength due to uncertainties in manufacturing processes and inspection methods. These uncertainties are usually the result of porosity or inclusions in the castings.

c. Background. This rule was carried forward § 4b.307 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

720 - 728. [RESERVED]

## 729. SECTION 25.623 - BEARING FACTORS.

a. Rule Text.

*(a) Except as provided in paragraph (b) of this section, each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.*
*(b) No bearing factor need be used for a part for which any larger special factor is prescribed.*

b. Intent of Rule. The purpose for this rule is to provide for normal relative motion in parts subject to pounding or vibration.

c. Background. The basis for this rule was carried forward from § 4b.307 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

730 - 738. [RESERVED]

739. SECTION 25.625 - FITTING FACTORS.

a. Rule Text.

*For each fitting (a part or terminal used to join one structural member to another), the following apply:*
*(a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1.15 must be applied to each part of -*
*(1) The fitting;*
*(2) The means of attachment; and*
*(3) The bearing on the joined members.*
*(b) No fitting factor need be used -*
*(1) For joints made under approved practices and based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood); or*
*(2) With respect to any bearing surface for which a larger special factor is used.*
*(c) For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member.*
*(d) For each seat, berth, safety belt, and harness, the fitting factor specified in § 25.785(f)(3) applies.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to ensure that fittings will not be under strength because of the inability to predict the stress conditions in the part.

c. Background. This rule was carried forward from § 4b.307 of the Civil Air Regulations (CAR). Amendment 25-23 added the reference to § 25.785 for seats, berths, safety belts, and harnesses. Amendment 25-72 made minor editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970; and Amendment 25-72, 55 FR 29776, July 20, 1990.

e. References. None.

740 - 745. [RESERVED]

746. SECTION 25.629 - AEROELASTIC STABILITY REQUIREMENTS.

a. Rule Text.

*(a) General. The aeroelastic stability evaluations required under this section include flutter, divergence, control reversal and any undue loss of stability and control as a result of structural deformation. The aeroelastic evaluation must include whirl modes associated with any propeller or rotating device that contributes significant dynamic forces. Compliance with this section must be shown by analyses, wind tunnel tests, ground vibration tests, flight tests, or other means found necessary by the Administrator.*
*(b) Aeroelastic stability envelopes. The airplane must be designed to be free from aeroelastic instability for all configurations and design conditions within the aeroelastic stability envelopes as follows:*
*(1) For normal conditions without failures, malfunctions, or adverse conditions, all combinations of altitudes and speeds encompassed by the $V_D/M_D$ versus altitude envelope enlarged at all points by an increase of 15 percent in equivalent airspeed at both constant Mach number and constant altitude. In addition, a proper margin of stability must exist at all speeds up to $V_D/M_D$, and there must be no large and rapid reduction in stability as $V_D/M_D$ is approached. The enlarged envelope may be limited to Mach 1.0 when $M_D$ is less than 1.0 at all design altitudes, and*
*(2) For the conditions described in § 25.659(d) below, for all approved altitudes, any airspeed up to the greater airspeed defined by;*
*(i) The $V_D/M_D$ envelope determined by § 25.335(b); or,*
*(ii) An altitude-airspeed envelope defined by a 15 percent increase in equivalent airspeed above $V_C$ at constant altitude, from sea level to the altitude of the intersection of 1.15 $V_C$ with the extension of the constant cruise Mach number line, $M_C$, then a linear variation in equivalent airspeed to $M_C$ + .05 at the altitude of the lowest $V_C/M_C$ intersection; then, at higher altitudes, up to the maximum flight altitude, the boundary defined by a .05 Mach increase in $M_C$ at constant altitude.*
*(c) Balance weights. If concentrated balance weights are used, their effectiveness and strength, including supporting structure, must be substantiated.*
*(d) Failures, malfunctions, and adverse conditions. The failures, malfunctions, and adverse conditions which must be considered in showing compliance with this section are:*
*(1) Any critical fuel loading conditions, not shown to be extremely improbable, which may result from mismanagement of fuel.*
*(2) Any single failure in any flutter damper system.*
*(3) For airplanes not approved for operation in icing conditions, the maximum likely ice accumulation expected as a result of an inadvertent encounter.*

*(4) Failure of any single element of the structure supporting any engine, independently mounted propeller shaft, large auxiliary power unit, or large externally mounted aerodynamic body (such as an external fuel tank).*
*(5) For airplanes with engines that have propellers or large rotating devices capable of significant dynamic forces, any single failure of the engine structure that would reduce the rigidity of the rotational axis.*
*(6) The absence of aerodynamic or gyroscopic forces resulting from the most adverse combination of feathered propellers or other rotating devices capable of significant dynamic forces. In addition, the effect of a single feathered propeller or rotating device must be coupled with the failures of paragraphs (d)(4) and (d)(5) of this section.*
*(7) Any single propeller or rotating device capable of significant dynamic forces rotating at the highest likely overspeed.*
*(8) Any damage or failure condition, required or selected for investigation by § 25.571. The single structural failures described in paragraphs (d)(4) and (d)(5) of this section need not be considered in showing compliance with this section if:*
*(I) the structural element could not fail due to discrete source damage resulting from the conditions described in § 25.571(e), and;*
*(ii) A damage tolerance investigation in accordance with § 25.571(b) shows that the maximum extent of damage assumed for the purpose of residual strength evaluation does not involve complete failure of the structural element.*
*(9) Any damage, failure, or malfunction considered under §§ 25.631, 25.671, 25.672, and 25.1309.*
*(10) Any other combination of failures, malfunctions, or adverse conditions not shown to be extremely improbable.*
*(e) Flight flutter testing. Full scale flight flutter tests at speeds up to $V_{DF}/M_{DF}$ must be conducted for new type designs and for modifications to a type design unless the modifications have been shown to have an insignificant effect on the aeroelastic stability. These tests must demonstrate that the airplane has a proper margin of damping at all speeds up to $V_{DF}/M_{DF}$, and that there is no large and rapid reduction in damping as $V_{DF}/M_{DF}$ is approached. If a failure, malfunction, or adverse condition is simulated during flight test in showing compliance with paragraph (d) of this section, the maximum speed investigated need not exceed $V_{FC}/M_{FC}$ if it is shown, by correlation of the flight test data with other test data or analyses, that the airplane is free from any aeroelastic instability at all speeds within the altitude-airspeed envelope described in paragraph (b)(2) of this section.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8,1970; Amdt. 25-46, 43 FR 50595, Oct. 30,1978; Amdt. 25-72, 55 FR 29776, Jul. 20, 1990; Amdt. 25-77, 57 FR 28949, Jun. 29,1992]*

b. Intent of Rule. The purpose of this rule is to ensure that the airplane will be free from any aeroelastic instabilities including flutter, divergence, control reversal, and any undue loss of stability and control as a result of structural deformation or failure. Amendment 25-77 recognized the improved substantiation capability of modern methods and revised the safety margins from 20 percent to 15 percent for flutter substantiation.

c. Background. This rule was carried forward from § 4b.307 of the Civil Air Regulations (CAR). Amendment 25-23 made extensive changes to the rule.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8,1970; Amendment 25-46, 43 FR 50595, October 30,1978; Amendment 25-72, 55 FR 29776, July 20, 1990; and Amendment 25-77, 57 FR 28949, June 29,1992. Advisory Circular (AC) 25.629-1, or latest revision, provides guidance information for demonstrating compliance with the design requirements for transport category airplanes to preclude flutter and other aeroelastic phenomena.

e. References. Advisory Circular 25.629-1, or latest revision, Flutter Substantiation of Transport Category Airplanes.

747 - 759. [RESERVED]

## 760. SECTION 25.631 - BIRD STRIKE DAMAGE.

a. Rule Text.

*The empennage structure must be designed to assure capability of continued safe flight and landing of the airplane after impact with an 8-pound bird when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to $V_C$ at sea level, selected under § 25.335(a). Compliance with this section by provision of redundant structure and protected location of control system elements or protective devices such as splitter plates or energy absorbing material is acceptable. Where compliance is shown by analysis, tests, or both, use of data on airplanes having similar structural design is acceptable.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the empennage structure is able to withstand impacts with birds likely to be encountered in service.

c. Background. This rule was introduced by Amendment 25-23.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970.

e. References. None.

761 - 769. [RESERVED]

## Section 2. CONTROL SURFACES

### 770. SECTION 25.651 - PROOF OF STRENGTH.

a. Rule Text.

*(a) Limit load tests of control surfaces are required. These tests must include the horn or fitting to which the control system is attached.*
*(b) Compliance with the special factors requirements of §§ 25.619 through 25.625 and 25.657 for control surface hinges must be shown by analysis or individual load tests.*

b. Intent of Rule. The purpose of this rule is to ensure that the control surfaces and their attachments are able to withstand the design loads.

c. Background. This rule was carried forward from § 4b.311 of the Civil Air Regulations (CAR) with editorial changes.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

771 - 778. [RESERVED]

### 779. SECTION 25.655 - INSTALLATION.

a. Rule Text.

*(a) Movable tail surfaces must be installed so that there is no interference between any surfaces when one is held in its extreme position and the others are operated through their full angular movement.*
*(b) If an adjustable stabilizer is used, it must have stops that will limit its range of travel to the maximum for which the airplane is shown to meet the trim requirements of § 25.161.*

b. Intent of Rule. The purpose of this rule is to ensure that control surfaces will not interfere with each other in any possible condition of deflection. It also requires that the stabilizer trim is physically limited by stops so that the airplane can meet minimum control requirements in the most adverse trim positions. This is intended to limit the effects of trim system failures.

c. Background. This rule was carried forward basically unchanged from § 4b.312 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

780 - 787. [RESERVED]

788. SECTION 25.657 - HINGES.

a. Rule Text.

*(a) For control surface hinges, including ball, roller, and self-lubricated bearing hinges, the approved rating of the bearing may not be exceeded. For nonstandard bearing hinge configurations, the rating must be established on the basis of experience or tests and, in the absence of a rational investigation, a factor of safety of not less than 6.67 must be used with respect to the ultimate bearing strength of the softest material used as a bearing.*
*(b) Hinges must have enough strength and rigidity for loads parallel to the hinge line.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that control surface hinges do not fail due to any flight or ground loading conditions.

c. Background. This rule was carried forward from § 4b.313 of the Civil Air Regulations (CAR). Amendment 25-23 added self-lubricated bearings to the list of bearings that may not exceed their rated capacity.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970.

e. References. None.

789 -793. [RESERVED]

## Section 3. CONTROL SYSTEMS

### 794. SECTION 25.671 - GENERAL.

a. Rule Text.

*(a) Each control and control system must operate with the ease, smoothness, and positiveness appropriate to its function.*
*(b) Each element of each flight control system must be designed, or distinctively and permanently marked, to minimize the probability of incorrect assembly that could result in the malfunctioning of the system.*
*(c) The airplane must be shown by analysis, tests, or both, to be capable of continued safe flight and landing after any of the following failures or jamming in the flight control system and surfaces (including trim, lift, drag, and feel systems) within the normal flight envelope, without requiring exceptional piloting skill or strength. Probable malfunctions must have only minor effects on control system operation and must be capable of being readily counteracted by the pilot.*
*(1) Any single failure, excluding jamming (for example, disconnection or failure of mechanical elements, or structural failure of hydraulic components, such as actuators, control spool housing, and valves).*
*(2) Any combination of failures not shown to be extremely improbable, excluding jamming (for example, dual electrical or hydraulic system failures, or any single failure in combination with any probable hydraulic or electrical failure).*
*(3) Any jam in a control position normally encountered during takeoff, climb, cruise, normal turns, descent, and landing unless the jam is shown to be extremely improbable, or can be alleviated. A runaway of a flight control to an adverse position and jam must be accounted for if such runaway and subsequent jamming is not extremely improbable.*
*(d) The airplane must be designed so that it is controllable if all engines fail. Compliance with this requirement may be shown by analysis where that method has been shown to be reliable.*

*[Amdt. 25-23, 35 FR 5674, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that failures in the flight control systems will not result in catastrophic loss of the airplane.

c. Background. This rule was carried forward from § 4b.320 of the Civil Air Regulations (CAR). Amendment 25-23 made major changes to this rule by addressing combinations of failure conditions.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5674, April 8, 1970. Advisory Circular (AC) 25-14, or latest revision, provides guidance information for showing compliance with the requirements for structural and functional safety standards for high lift and drag devices and their operating systems. Advisory Circular 25.672-1, or latest revision, provides guidance information for showing an equivalent means of compliance by setting forth procedures applying to load alleviation systems (SAS), and flutter suppression systems (FSS).

e. References. Advisory Circular 25-14, or latest revision, High Lift and Drag Devices; and AC 25.672-1, or latest revision, Active Flight Controls.

795 - 800. [RESERVED]

## 801. SECTION 25.672 - STABILITY AUGMENTATION AND AUTOMATIC AND POWER-OPERATED SYSTEMS.

a. Rule Text.

*If the functioning of stability augmentation or other automatic or power-operated systems is necessary to show compliance with the flight characteristics requirements of this part, such systems must comply with § 25.671 and the following:*

*(a) A warning which is clearly distinguishable to the pilot under expected flight conditions without requiring his attention must be provided for any failure in the stability augmentation system or in any other automatic or power-operated system which could result in an unsafe condition if the pilot were not aware of the failure. Warning systems must not activate the control systems.*

*(b) The design of the stability augmentation system or of any other automatic or power-operated system must permit initial counteraction of failures of the type specified in § 25.671(c) without requiring exceptional pilot skill or strength, by either the deactivation of the system, or a failed portion thereof, or by overriding the failure by movement of the flight controls in the normal sense.*

*(c) It must be shown that after any single failure of the stability augmentation system or any other automatic or power-operated system-*

*(1) The airplane is safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations that is critical for the type of failure being considered;*

*(2) The controllability and maneuverability requirements of this part are met within a practical operational flight envelope (for example, speed, altitude, normal acceleration, and airplane configurations) which is described in the Airplane Flight Manual; and*

*(3) The trim, stability, and stall characteristics are not impaired below a level needed to permit continued safe flight and landing.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that failures in automatic and power operated systems will not be a hazard to the airplane.

c. Background. This fundamental rule was carried forward from § 4b.320 of the Civil Air Regulations (CAR). The rule was substantially revised by Amendment 25-23 to raise the level of safety.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970. Advisory Circular (AC) 25.672-1, or latest revision, provides guidance information for showing an equivalent means of compliance by setting forth procedures applying to load alleviation systems (SAS), and flutter suppression systems (FSS). Advisory Circular 25.1309-1A, or latest revision, describes various acceptable means of compliance to provide guidance for the engineering and operational judgment that form the basis for compliance findings.

e. References. Advisory Circular 25.672-1, or latest revision, Active Flight Controls; AC 25.1309-1A, or latest revision, System Design Analysis; AC 25.1329-1A, or latest revision, Automatic Pilot Systems Approval; and Special Conditions (SC) issued against fly-by-wire airplanes. Reference SC 25-ANM-23 for the A320, and reference SC 25-ANM-78 for the Boeing Model 777.

802 - 810. [RESERVED]

## 811. SECTION 25.673 - Two-Control Airplanes. [Removed]

NOTE: This rule was removed because it is obsolete in regard to transport category airplanes.

*[Amdt. 25-72, 55 FR 29776, Jul. 20, 1990]*

## 812. SECTION 25.675 - STOPS.

a. Rule Text.

*(a) Each control system must have stops that positively limit the range of motion of each movable aerodynamic surface controlled by the system.*

*(b) Each stop must be located so that wear, slackness, or take-up adjustments will not adversely affect the control characteristics of the airplane because of a change in the range of surface travel.*
*(c) Each stop must be able to withstand any loads corresponding to the design conditions for the control system.*

*[Amdt. 25-38, 41 FR 55466, Dec. 20, 1976]*

b. Intent of Rule. The purpose of this rule is to provide a positive means of limiting the movement of the control surfaces. It also requires that the stops be designed to withstand the design loads on the control system.

c. Background. This rule was carried forward from § 4b.325 of the Civil Air Regulations (CAR). Amendment 25-38 made editorial changes to paragraph (a).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-38, 41 FR 55466, December 20, 1976.

e. References. None.

813 - 818. [RESERVED]

819. SECTION 25.677 - TRIM SYSTEMS.

a. Rule Text.

*(a) Trim controls must be designed to prevent inadvertent or abrupt operation and to operate in the plane, and with the sense of motion, of the airplane.*
*(b) There must be means adjacent to the trim control to indicate the direction of the control movement relative to the airplane motion. In addition, there must be clearly visible means to indicate the position of the trim device with respect to the range of adjustment.*
*(c) Trim control systems must be designed to prevent creeping in flight. Trim tab controls must be irreversible unless the tab is appropriately balanced and shown to be free from flutter.*
*(d) If an irreversible tab control system is used, the part from the tab to the attachment of the irreversible unit to the airplane structure must consist of a rigid connection.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the trim system is designed to preclude inadvertent out of trim conditions and flutter problems.

c. Background. This rule was carried forward from § 4b.322 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970.

e. References. Advisory Circular (AC) 25.629-1, or latest revision, Flutter Substantiation of Transport Category Airplanes.

820 - 827. [RESERVED]

828. SECTION 25.679 - CONTROL SYSTEM GUST LOCKS.

a. Rule Text.

*(a) There must be a device to prevent damage to the control surfaces (including tabs), and to the control system, from gusts striking the airplane while it is on the ground or water. If the device, when engaged, prevents normal operation of the control surfaces by the pilot, it must -*
*(1) Automatically disengage when the pilot operates the primary flight controls in a normal manner; or*
*(2) Limit the operation of the airplane so that the pilot receives unmistakable warning at the start of takeoff.*
*(b) The device must have means to preclude the possibility of it becoming inadvertently engaged in flight.*

b. Intent of Rule. The purpose of this rule is to protect the flight controls from ground gust conditions and to prevent the gust lock system from interfering with the normal operation of the airplane.

c. Background. This rule was carried forward from § 4b.326 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. None.

829 - 835. [RESERVED]

836. SECTION 25.681 - LIMIT LOAD STATIC TESTS.

a. Rule Text.

*(a) Compliance with the limit load requirements of this part must be shown by tests in which -*
*(1) The direction of the test loads produces the most severe loading in the control system; and*
*(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included.*
*(b) Compliance must be shown (by analysis or individual load tests) with the special factor requirements for control system joints subject to angular motion.*

b. Intent of Rule. The purpose of this rule is to ensure that the control systems are able to withstand any loads that are likely to occur in service, and to validate that deformations will not be hazardous.

c. Background. This rule was carried forward from § 4b.327 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by tests(s).

e. References. None.

837 - 844. [RESERVED]

845. SECTION 25.683 - OPERATION TESTS.

a. Rule Text.

*It must be shown by operation tests that when portions of the control system subject to pilot effort loads are loaded to 80 percent of the limit load specified for the system and the powered portions of the control system are loaded to the maximum load expected in normal operation, the system is free from -*
*(a) Jamming;*
*(b) Excessive friction; and*
*(c) Excessive deflection.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the control systems are free from jamming, excessive friction, and excessive deflections under likely operating loads.

c. Background. This rule was carried forward from § 4b.328 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. For guidance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970.

e. References. None.

846 - 851. [RESERVED]

852. SECTION 25.685 - CONTROL SYSTEM DETAILS.

a. Rule Text.

*(a) Each detail of each control system must be designed and installed to prevent jamming, chafing, and interference from cargo, passengers, loose objects, or the freezing of moisture.*
*(b) There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam the system.*
*(c) There must be means to prevent the slapping of cables or tubes against other parts.*
*(d) Sections 25.689 and 25.693 apply to cable systems and joints.*

*[Amdt. 25-38, 41 FR 55466, Dec. 20, 1976]*

b. Intent of Rule. The purpose of this rule is to ensure that the control systems will not become jammed due to foreign objects or ice formation.

c. Background. This rule was carried forward from § 4b.329 of the Civil Air Regulations (CAR).

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-38, 41 FR 55466, December 20, 1976.

e. References. None.

853 - 860. [RESERVED]

861. <u>SECTION 25.689 - CABLE SYSTEMS</u>.

a. <u>Rule Text</u>.

*(a) Each cable, cable fitting, turnbuckle, splice, and pulley must be approved. In addition-*
*(1) No cable smaller than 1/8 inch in diameter may be used in the aileron, elevator, or rudder systems; and*
*(2) Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations.*
*(b) Each kind and size of pulley must correspond to the cable with which it is used. Pulleys and sprockets must have closely fitted guards to prevent the cables and chains from being displaced or fouled. Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.*
*(c) Fairleads must be installed so that they do not cause a change in cable direction of more than three degrees.*
*(d) Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system.*
*(e) Turnbuckles must be attached to parts having angular motion in a manner that will positively prevent binding throughout the range of travel.*
*(f) There must be provisions for visual inspection of fairleads, pulleys, terminals, and turnbuckles.*

b. <u>Intent of Rule</u>. The purpose of this rule is to prevent damage to control cable runs due to wear, fatigue, fire, lightning, and accidental damage.

c. <u>Background</u>. This rule was carried forward from § 4b.329 of the Civil Air Regulations (CAR).

d. <u>Acceptable Compliance Methods</u>. Compliance with this requirement may be shown by design review.

e. <u>References</u>. None.

862 - 867. [RESERVED]

868. SECTION 25.693 - JOINTS.

a. Rule Text.

*Control system joints (in push-pull systems) that are subject to angular motion, except those in ball and roller bearing systems, must have a special factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball or roller bearings, the approved ratings may not be exceeded.*

*[Amdt. 25-72, 55 FR 29777, Jul. 20, 1990]*

b. Intent of Rule. This rule is intended to account for wear, abuse, and shock loading in the bearing.

c. Background. This rule was carried forward from § 4b.329 of the Civil Air Regulations (CAR). Amendment 25-72 removed the reference to MIL-HDBK-5.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-72, 55 FR 29777, July 20, 1990.

e. References. None.

869 - 875. [RESERVED]

876. SECTION 25.695 - POWER-BOOST AND POWER-OPERATED CONTROL SYSTEM. [Removed]

NOTE: This section was removed since it became extraneous and superseded by the proposed general requirements under 25.671(c) and (d). Certification basis earlier than Amendment 25-23 should include § 25.695.

a. Rule Text.

*(a) If a power-boost or power-operated control system is used, an alternate system must be immediately available to allow continued safe flight and landing in the event of a single failure in the power portion.*
*(b) Each alternate system may be a duplicate power portion or a manually operated mechanical system. The power portion includes the power source, such as hydraulic pumps, and such items as valves, lines, and actuators.*

*(c) The failure of mechanical parts (such as piston rods and links) and the jamming of power cylinders must be considered unless they are extremely remote.*
*(d) Both the primary and alternate systems must be operable if any engine fails. For airplanes with more than two engines, at least one system must be operable if any two engines fail. It must be shown by analysis that the airplane is controllable if all engines fail.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

877. SECTION 25.697 - LIFT AND DRAG DEVICES, CONTROLS.

a. Rule Text.

*(a) Each lift device control must be designed so that the pilots can place the device in any takeoff, en route, approach, or landing position established under § 25.101(d). Lift and drag devices must maintain the selected positions, except for movement produced by an automatic positioning or load limiting device, without further attention by the pilots.*
*(b) Each lift and drag device control must be designed and located to make inadvertent operation improbable. Lift and drag devices intended for ground operation only must have means to prevent the inadvertent operation of their controls in flight if that operation could be hazardous.*
*(c) The rate of motion of the surfaces in response to the operation of the control and the characteristics of the automatic positioning or load limiting device must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power, and airplane altitude.*
*(d) The lift device control must be designed to retract the surfaces from the fully extended position, during steady flight at maximum continuous engine power at any speed below* $V_F$*+9.0 (knots).*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-57, 49 FR 6848, Feb. 23, 1984]*

b. Intent of Rule. This rule is intended to ensure safe operation of the lift and drag devices under all operating conditions expected in service.

c. Background. This rule was carried forward from § 4b.323 of the Civil Air Regulations (CAR). Amendment 25-23 made a major editorial change to the rule. Amendments 25-46 and 25-57 made additional editorial changes.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970; Amendment 25-46, 43 FR 50595, October 30, 1978; and Amendment 25-57, 49 FR 6848, February 23, 1984.

e. References. None.

878 - 886. [RESERVED]

887. SECTION 25.699 - LIFT AND DRAG DEVICE INDICATOR.

a. Rule Text.

*(a) There must be means to indicate to the pilots the position of each lift or drag device having a separate control in the cockpit to adjust its position. In addition, an indication of unsymmetrical operation or other malfunction in the lift or drag device systems must be provided when such indication is necessary to enable the pilots to prevent or counteract an unsafe flight or ground condition, considering the effects on flight characteristics and performance.*
*(b) There must be means to indicate to the pilots the takeoff, en route, approach, and landing lift device positions.*
*(c) If any extension of the lift and drag devices beyond the landing position is possible, the controls must be clearly marked to identify this range of extension.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

NOTE: Refer to Advisory Circular (AC) 25-XX, Mechanical Systems Handbook, for guidance.

888. SECTION 25.701 - FLAP AND SLAT INTERCONNECTION.

a. Rule Text.

*(a) Unless the airplane has safe flight characteristics with the flaps or slats retracted on one side and extended on the other, the motion of flaps or slats on opposite sides of the plane of symmetry must be synchronized by a mechanical interconnection or approved equivalent means.*
*(b) If a wing flap or slat interconnection or equivalent means is used, it must be designed to account for the applicable unsymmetrical loads, including those resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at takeoff power.*

*(c) For airplanes with flaps or slats that are not subjected to slipstream conditions, the structure must be designed for the loads imposed when the wing flaps or slats on one side are carrying the most severe load occurring in the prescribed symmetrical conditions and those on the other side are carrying not more than 80 percent of that load.*
*(d) The interconnection must be designed for the loads resulting when interconnected flap or slat surfaces on one side of the plane of symmetry are jammed and immovable while the surfaces on the other side are free to move and the full power of the surface actuating system is applied.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 29777, Jul. 20, 1990]*

b. Intent of Rule. The purpose of this rule is to require the installation of interconnection systems unless the airplane has safe flight capability with a full asymmetric deployment of the flaps or slats, and to establish design load conditions for the interconnection system.

c. Background. This rule was carried forward from § 4b.324 of the Civil Air Regulations (CAR). Amendment 25-23 added the requirement to consider flap jam loads on the interconnection.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970; Amendment 25-46, 43 FR 50595, October 30, 1978; and Amendment 25-72, 55 FR 29777, July 20, 1990. Advisory Circular (AC) 25-14, or latest revision, provides guidance information for showing compliance with the requirements for structural and functional safety standards for high lift and drag devices and their operating systems.

e. References. Advisory Circular 25-14, or latest revision, High Lift and Drag Devices; and Advisory Circular 25.1309-1A, or latest revision, System Design Analysis.

889 - 896. [RESERVED]

## Section 4. LANDING GEAR

### 897. SECTION 25.721 - GENERAL.

a. Rule Text.

*(a) The main landing gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause-*
*(1) For airplanes that have a passenger seating configuration, excluding pilots seats, of nine seats or less, the spillage of enough fuel from any fuel system in the fuselage to constitute a fire hazard; and*
*(2) For airplanes that have a passenger seating configuration, excluding pilots seats, of 10 seats or more, the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.*
*(b) Each airplane that has a passenger seating configuration excluding pilots seats, of 10 seats or more must be designed so that with the airplane under control it can be landed on a paved runway with any one or more landing gear legs not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard.*
*(c) Compliance with the provisions of this section may be shown by analysis or tests, or both.*

*[Amdt. 25-15, 32 FR 13262, Sep. 20, 1967; Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-32, 37 FR 3969, Feb. 24, 1972]*

b. Intent of Rule. The purpose of this rule is to ensure that if the landing gear fails due to overloads during takeoff and landing, the failure itself will not cause the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.

c. Background. This rule was added by Amendment 25-15 (Sept. 20, 1967). Amendments 25-23 and 25-32 extended the application of the rule to include all fuel systems.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-15, 32 FR 13262, September 20, 1967; Amendment 25-23, 35 FR 5676, April 8, 1970; and Amendment 25-32, 37 FR 3969, February 24, 1972.

e. References. None.

898 - 907. [RESERVED]

## 908. SECTION 25.723 - SHOCK ABSORPTION TESTS.

a. Rule Text.

*(a) It must he shown that the limit load factors selected for design in accordance with § 25.473 for takeoff and landing weights, respectively, will not be exceeded. This must be shown by energy absorption tests except that analyses based on earlier tests conducted on the same basic landing gear system which has similar energy absorption characteristics may be used for increases in previously approved takeoff and landing weights.*
*(b) The landing gear may not fail in a test, demonstrating its reserve energy absorption capacity, simulating a descent velocity of 12 f.p.s. at design landing weight, assuming airplane lift not greater than the airplane weight acting during the landing impact.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 29777, July 20, 1990]*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear has sufficient strength and energy absorption capability to withstand any landing conditions likely to be encountered in service. The rule also ensures that the airplane limit load factors will not be exceeded.

c. Background. This rule was carried forward from §§ 4b.330, 4b.331, and 4b.332 of the Civil Air Regulations (CAR). Amendment 25-72 changed the rule to allow analysis for gross weight increases even when some modifications to the basic landing gear were required. In addition to the changes in air and oil charges, these modifications might include changes in the metering pins and orifice plates.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970; Amendment 25-46, 43 FR 50595, October 30, 1978; and Amendment 25-72, 55 FR 29777, July 20, 1990.

e. References. None.

## 909 - 913. [RESERVED]

914. SECTION 25.725 - LIMIT DROP TESTS.

a. Rule Text.

*(a) If compliance with § 25.723(a) is shown by free drop tests, these tests must be made on the complete airplane, or on units consisting of a wheel, tire, and shock absorber, in their proper positions, from free drop heights not less than -*
*(1) 18.7 inches for the design landing weight conditions; and*
*(2) 6.7 inches for the design takeoff weight conditions.*
*(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced mass, the landing gear must be dropped with an effective mass equal to*

$$W_e = W\left[\frac{h+(1-L)d}{h+d}\right]$$

*where -*
*$W_e$ = the effective weight to be used in the drop test (lbs.);*
*$h$ = specified free drop height (inches);*
*$d$ = deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (inches);*
*$W = W_M$ for main gear units (lbs.), equal to the static weight on that unit with the airplane in the level attitude (with the nose wheel clear in the case of nose wheel type airplanes);*
*$W = W_T$ for tail gear units (lbs.), equal to the static weight on the tail unit with the airplane in the tail-down attitude;*
*$W = W_N$ for nose wheel units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0g downward and 0.25g forward; and*
*$L$ = ratio of the assumed airplane lift to the airplane weight, but not more than 1.0*
*(c) The drop test attitude of the landing gear unit and the application of appropriate drag loads during the test must simulate the airplane landing conditions in a manner consistent with the development of a rational or conservative limit load factor value.*
*(d) The value of d used in the computation of $W_e$ in paragraph (b) of this section may not exceed the value actually obtained in the drop test.*
*(e) The limit inertia load factor n must be determined from the free drop test in paragraph (b) of this section according to the following formula:*

$$n = n_j \left[ \frac{W_e}{W} \right] + L$$

*where -*

*$n_J$ = the load factor developed in the drop test (that is, the acceleration of dv/dt in g`s recorded in the drop test) plus 1.0; and*
*$W_e$, W, and L are the same as in the drop test computation.*

*(f) The value of n determined in paragraph (e) of this section may not be more than the limit inertia load factor used in the landing conditions in § 25.473.*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear will absorb the landing impact energy without exceeding the limit loads in the landing gear and without exceeding the design load factors specified in the airplane design.

c. Background. This rule was carried forward from § 4b.332 of the Civil Air Regulations (CAR). Amendment 25-23 made clarifying changes to the rule.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970. Compliance may be shown by drop tests. Drop tests are required on all newly type certificated airplanes and on amended type certificated airplanes with new landing gear configurations.

e. References. None.

915 - 921. [RESERVED]

922. SECTION 25.727 - RESERVE ENERGY ABSORPTION DROP TESTS.

a. Rule Text.

*(a) If compliance with the reserve energy absorption condition specified in § 25.723(b) is shown by free drop tests, the drop height may not be less than 27 inches.*

*(b) If airplane lift is simulated by air cylinders or by other mechanical means, the weight used for the drop must be equal to W. If the effect of airplane lift is represented in free drop tests by an equivalent reduced mass, the landing gear must be dropped with an effective mass,*

$$W_e = \frac{Wh}{h+d}$$

*where the symbols and other details are the same as in § 25.725(b).*

*[Amdt. 25-23, 35 FR 5675, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear has sufficient reserve energy capability to withstand landing conditions outside the normal design limit envelope without complete failure.

c. Background. This rule was carried forward from § 4b.332 of the Civil Air Regulations (CAR). Amendment 25-23 provided some clarification of the rule.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5675, April 8, 1970. Drop tests are required on all newly type certificated airplanes and on amended type certificated airplanes with new landing gear configurations

e. References. None.

923 - 928. [RESERVED]

929. SECTION 25.729 - RETRACTING MECHANISM.

a. Rule Text.

*(a) General. For airplanes with retractable landing gear, the following apply:*
*(1) The landing gear retracting mechanism, wheel well doors, and supporting structure, must be designed for -*
*(i) The loads occurring in the flight conditions when the gear is in the retracted position,*
*(ii) The combination of friction loads, inertia loads, brake torque loads, air loads, and gyroscopic loads resulting from the wheels rotating at a peripheral speed equal to 1.3 $V_S$ (with the flaps in takeoff position at design takeoff weight),*

*occurring during retraction and extension at any airspeed up to 1.6 $V_{S1}$ (with the flaps in the approach position at design landing weight), and*

*(iii) Any load factor up to those specified in § 25.345(a) for the flaps extended condition.*

*(2) Unless there are other means to decelerate the airplane in flight at this speed, the landing gear, the retracting mechanism, and the airplane structure (including wheel well doors) must be designed to withstand the flight loads occurring with the landing gear in the extended position at any speed up to 0.67 $V_C$.*

*(3) Landing gear doors, their operating mechanism, and their supporting structures must be designed for the yawing maneuvers prescribed for the airplane in addition to the conditions of airspeed and load factor prescribed in paragraphs (a)(1) and (2) of this section.*

*(b) Landing gear lock. There must be positive means to keep the landing gear extended, in flight and on the ground.*

*(c) Emergency operation. There must be an emergency means for extending the landing gear in the event of* **-**

*(1) Any reasonably probable failure in the normal retraction system; or*

*(2) The failure of any single source of hydraulic, electric, or equivalent energy supply.*

*(d) Operation test. The proper functioning of the retracting mechanism must be shown by operation tests.*

*(e) Position indicator and warning device. If a retractable landing gear is used, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that the gear is secured in the extended (or retracted) position. This means must be designed as follows:*

*(1) If switches are used, they must be located and coupled to the landing gear mechanical systems in a manner that prevents an erroneous indication of "down and locked" if the landing gear is not in a fully extended position, or of "up and locked" if the landing gear is not in the fully retracted position. The switches may be located where they are operated by the actual landing gear locking latch or device.*

*(2) The flightcrew must be given an aural warning that functions continuously, or is periodically repeated, if a landing is attempted when the landing gear is not locked down.*

*3) The warning must be given in sufficient time to allow the landing gear to be locked down or a go-around to be made.*

*(4) There must not be a manual shut-off means readily available to the flightcrew for the warning required by paragraph (e)(2) of this section such that it could be operated instinctively, inadvertently, or by habitual reflexive action.*

*(5) The system used to generate the aural warning must be designed to eliminate false or inappropriate alerts.*

*(6) Failures of systems used to inhibit the landing gear aural warning, that would prevent the warning system from operating, must be improbable.*
*(f) Protection of equipment in wheel wells. Equipment that is essential to safe operation of the airplane and that is located in wheel wells must be protected from the damaging effects of -*
*(1) A bursting tire, unless it is shown that a tire cannot burst from overheat; and*
*(2) A loose tire tread, unless it is shown that a loose tire tread cannot cause damage.*

*[Amdt. 25-23, 35 FR 5676, Apr., 1970; Amdt. 25-42, 43 FR 2323, Jan. 16, 1978; Amdt. 25-72, 55 FR 29777, Jul. 20, 1990; Amdt. 25-75, 56 FR 63762, Dec. 5, 1991]*

b. Intent of Rule. The purpose of this rule is to ensure that the landing gear and its supporting structure, including up-locks, down-locks, and landing gear doors, are able to withstand all loads imposed anywhere within the approved operating envelope. The rule also requires a position indicator and aural warning to prevent inadvertent landing if the landing gear is not down and locked.

c. Background. This regulation was carried forward from § 4b.334 of the Civil Air Regulations (CAR). Amendment 25-23 added the requirement to consider gyroscopic loads resulting from wheel rotation. Amendment 25-42 revised the aural warning requirements. Amendment 25-75 allowed a manual means of shutting off the aural warning system.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5676, April 8, 1970; Amendment 25-42, 43 FR 2323, January 16, 1978; Amendment 25-72, 55 FR 29777, July 20, 1990; and Amendment 25-75, 56 FR 63762, December 5, 1991.

e. References. Advisory Circular (AC) 25-XX, Mechanical Systems Handbook.

930 - 938. [RESERVED]

## 939. SECTION 25.731 WHEELS.

a. Rule Text.

*(a) Each main and nose wheel must be approved.*
*(b) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with -*
*(1) Design maximum weight; and*
*(2) Critical center of gravity.*

*(c) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.*

*[Amdt. 25-72, 55 FR 29777, Jul. 20, 1990]*

NOTE: Refer to Advisory Circular (AC) 25-XX, Mechanical Systems Handbook, for guidance.

940 - 946. [RESERVED]

947. SECTION 25.733 TIRES.

a. Rule Text.

*(a) When a landing gear axle is fitted with a single wheel and tire assembly, the wheel must be fitted with a suitable tire of proper fit with a speed rating approved by the Administrator that is not exceeded under critical conditions and with a load rating approved by the Administrator that is not exceeded under -*
*(1) The loads on the main wheel tire, corresponding to the most critical combination of airplane weight (up to maximum weight) and center of gravity position, and*
*(2) The loads corresponding to the ground reactions in paragraph (b) of this section, on the nose wheel tire, except as provided in paragraphs (b)(2) and (b)(3) of this section.*
*(b) The applicable ground reactions for nose wheel tires are as follows:*
*(1) The static ground reaction for the tire corresponding to the most critical combination of airplane weight (up to maximum ramp weight) and center of gravity position with a force of 1.0g acting downward at the center of gravity. This load may not exceed the load rating of the tire.*
*(2) The ground reaction of the tire corresponding to the most critical combination of airplane weight (up to maximum landing weight) and center of gravity position combined with forces of 1.0g downward and 0.31g forward acting at the center of gravity. The reactions in this case must be distributed to the nose and main wheels by the principles of statics with a drag reaction equal to 0.31 times the vertical load at each wheel with brakes capable of producing this ground reaction. This nose tire load may not exceed 1.5 times the load rating of the tire.*
*(3) The ground reaction of the tire corresponding to the most critical combination of airplane weight (up to maximum ramp weight) and center of gravity position combined with forces of 1.0g downward and 0.20g forward*

*acting at the center of gravity. The reactions in this case must be distributed to the nose and main wheels by the principles of statics with a drag reaction equal to 0.20 times the vertical load at each wheel with brakes capable of producing this ground reaction. This nose tire load may not exceed 1.5 times the load rating of the tire.*
*(c) When a landing gear axle is fitted with more than one wheel and tire assembly, such as dual or dual-tandem, each wheel must be fitted with a suitable tire of proper fit with a speed rating approved by the Administrator that is not exceeded under critical conditions, and with a load rating approved by the Administrator that is not exceeded by -*
*(1) The loads on each main wheel tire, corresponding to the most critical combination of airplane weight (up to maximum weight) and center of gravity position, when multiplied by a factor of 1.07; and*
*(2) Loads specified in paragraphs (a)(2), (b)(1), (b)(2), and (b)(3) of this section on each nose wheel tire.*
*(d) Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent unintended contact between the tire and any part of the structure or systems.*
*(e) For an airplane with a maximum certificated takeoff weight of more than 75,000 pounds, tires mounted on braked wheels must be inflated with dry nitrogen or other gases shown to be inert so that the gas mixture in the tire does not contain oxygen in excess of 5 percent by volume, unless it can be shown that the tire liner material will not produce a volatile gas when heated or that means are provided to prevent tire temperatures from reaching unsafe levels.*

*[Amdt. 25-48, 44 FR 68752, Nov. 29, 1979; Amdt. 25-72, 55 FR 29777, Jul. 20, 1990, as amended by Amdt. 25-78, 58 FR 11781, Feb. 26, 1993]*

NOTE: Refer to Advisory Circular (AC) 25-XX, Mechanical Systems Handbook, for guidance.

948 - 954. [RESERVED]

## 955. SECTION 25.735 BRAKES.

a. Rule Text.

*(a) Each brake must be approved.*
*(b) The brake system and associated systems must be designed and constructed so that if any electrical, pneumatic, hydraulic, or mechanical connecting or*

*transmitting element (excluding the operating pedal or handle) fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest under conditions specified in § 25.125, with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section. Subcomponents within the brake assembly, such as brake drum, shoes, and actuators (or their equivalents), shall be considered as connecting or transmitting elements, unless it is shown that leakage of hydraulic fluid resulting from failure of the sealing elements in these subcomponents within the brake assembly would not reduce the braking effectiveness below that specified in this paragraph.*

*(c) Brake controls may not require excessive control force in their operation.*

*(d) The airplane must have a parking control that, when set by the pilot, will without further attention, prevent the airplane from rolling on a paved, level runway with takeoff power on the critical engine.*

*(e) If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane.*

*(f) The design landing brake kinetic energy capacity rating of each main wheel-brake assembly shall be used during qualification testing of the brake to the applicable Technical Standard Order (TSO) or an acceptable equivalent. This kinetic energy rating may not be less than the kinetic energy absorption requirements determined under either of the following methods:*

*(1) The brake kinetic energy absorption requirements must be based on a rational analysis of the sequence of events expected during operational landings at maximum landing weight. This analysis must include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or power-plant forward thrust, and (if more critical) the most adverse single engine or propeller malfunction.*

*(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheelbrake assembly may be derived from the following formula, which must be modified in cases of designed unequal braking distributions.*

$$KE = \frac{0.0443\, WV^2}{N}$$

*Where -*

*KE = Kinetic energy per wheel (ft.-lb.);*

*W = Design landing weight (lb.);*

*V = Airplane speed in knots. V must be not less than $V_{SO}$, the poweroff stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and*

*N = Number of main wheels with brakes.*

*The formula must be modified in cases of unequal braking distribution.*
*(g) The minimum stalling speed rating of each main wheel-brake assembly (that is, the initial speed used in the dynamometer tests) may not be more than the V used in the determination of kinetic energy in accordance with paragraph (f) of this section, assuming that the test procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy, the rate of energy absorption (the power absorbing ability of the brake) varies inversely with the initial speed.*
*(h) The rejected takeoff brake kinetic energy capacity rating of each main wheel-brake assembly that is at the fully worn limit of its allowable wear range shall be used during qualification testing of the brake to the applicable Technical Standard Order (TSO) or an acceptable equivalent. This kinetic energy rating may not be less than the kinetic energy absorption requirements determined under either of the following methods:*
*(1) The brake kinetic energy absorption requirements must be based on a rational analysis of the sequence of events expected during an accelerate-stop maneuver. This analysis must include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or powerplant forward thrust, and (if more critical) the most adverse single engine or propeller malfunction.*
*(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula, which must be modified in cases of designed unequal braking distributions:*

$$KE = \frac{0.0443WV^2}{N}$$

*Where -*
*KE = Kinetic energy per wheel (ft.-lb.);*
*W = Airplane weight (lb.);*
*V = Airplane speed (knots)*
*N = Number of main wheels with brakes; and*
*W and V are the most critical combination of takeoff weight and ground speed obtained in a rejected takeoff.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-48, 44 FR 68742, Nov. 29, 1979; Amdt. 25-72, 55 FR 29777, Jul. 20, 1990; Amdt. 25-92, 63 FR 8298; Feb. 18, 1998]*

NOTE: Refer to Advisory Circular (AC) 25-XX, Mechanical Systems Handbook, for guidance.

956 - 960. [RESERVED]

961. SECTION 25.737 - SKIS.

a. Rule Text.

*Each ski must be approved. The maximum limit load rating of each ski must equal or exceed the maximum limit load determined under the applicable ground load requirements of this part.*

NOTE: No guidance is currently available on this subject.

962 - 966. [RESERVED]

# Section 5. FLOATS AND HULLS

## 967. SECTION 25.751 - MAIN FLOAT BUOYANCY.

a. Rule Text.

*Each main float must have -*
*(a) A buoyancy of 80 percent in excess of that required to support the maximum weight of the seaplane or amphibian in fresh water; and*
*(b) Not less than five watertight compartments approximately equal in volume.*

NOTE: There is no guidance currently available on this subject.

968 - 973. [RESERVED]

## 974. SECTION 25.753 MAIN FLOAT DESIGN.

a. Rule Text.

*Each main float must be approved and must meet the requirements of § 25.521.*

NOTE: There is no guidance currently available on this subject.

975 - 977. [RESERVED]

## 978. SECTION 25.755 - HULLS.

a. Rule Text.

*(a) Each hull must have enough watertight compartments so that, with any two adjacent compartments flooded, the buoyancy of the hull and auxiliary floats (and wheel tires, if used) provides a margin of positive stability great enough to minimize the probability of capsizing in rough, fresh water.*
*(b) Bulkheads with watertight doors may be used for communication between compartments.*

NOTE: There is no guidance currently available on this subject.

979 - 981. [RESERVED]

## Section 6. PERSONNEL AND CARGO ACCOMMODATIONS

### 982. SECTION 25.771 - PILOT COMPARTMENT.

a. Rule Text.

*(a) Each pilot compartment and its equipment must allow the minimum flight crew (established under § 25.1523) to perform their duties without unreasonable concentration or fatigue.*
*(b) The primary controls listed in § 25.779(a), excluding cables and control rods, must be located with respect to the propellers so that no member of the minimum flight crew (established under § 25.1523), or part of the controls, lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub making an angle of five degrees forward or aft of the plane of rotation of the propeller.*
*(c) If provision is made for a second pilot, the airplane must be controllable with equal safety from either pilot seat.*
*(d) The pilot compartment must be constructed so that, when flying in rain or snow, it will not leak in a manner that will distract the crew or harm the structure.*
*(e) Vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the airplane.*

*[Amdt. 25-4, 30 FR 6113, Apr. 30, 1965]*

NOTE: There is no guidance currently available on this subject.

### 983 - 988. [RESERVED]

### 989. SECTION 25.772 - PILOT COMPARTMENT DOORS.

a. Rule Text.

*For an airplane that has a maximum passenger seating configuration of more than 20 seats and that has a lockable door installed between the pilot compartment and the passenger compartment:*
*(a) The emergency exit configuration must be designed so that neither crewmembers nor passengers need use that door in order to reach the emergency exits provided for them; and*

*b) Means must be provided to enable flight crewmembers to directly enter the passenger compartment from the pilot compartment if the cockpit door becomes jammed.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-47, 44 FR 61325, Oct. 25, 1979; Amdt. 25-72, 55 FR 29782, July 20, 1990]*

NOTE: Refer to Advisory Circular (AC) 25-17, Transport Airplane Cabin Interiors Crashworthiness Handbook, for guidance information for showing compliance with the crashworthiness requirements of part 25 for transport category airplanes.

990 - 996. [RESERVED]

## 997. SECTION 25.773 - PILOT COMPARTMENT VIEW.

a. Rule Text.

*(a) Nonprecipitation conditions. For nonprecipitation conditions, the following apply:*
*(1) Each pilot compartment must be arranged to give the pilots a sufficiently extensive, clear, and undistorted view, to enable them to safely perform any maneuvers within the operating limitations of the airplane, including taxiing, takeoff, approach, and landing.*
*(2) Each pilot compartment must be free of glare and reflection that could interfere with the normal duties of the minimum flight crew (established under § 25.1523). This must be shown in day and night flight tests under nonprecipitation conditions.*
*(b) Precipitation conditions. For precipitation conditions, the following apply:*
*(1) The airplane must have a means to maintain a clear portion of the windshield, during precipitation conditions, sufficient for both pilots to have a sufficiently extensive view along the flight path in normal flight attitudes of the airplane. This means must be designed to function, without continuous attention on the part of the crew, in -*
*(i) Heavy rain at speeds up to 1.6 $V_{S1}$ with lift and drag devices retracted; and*
*(ii) The icing conditions specified in § 25.1419 if certification with ice protection provisions is requested.*
*(2) The first pilot must have -*
*(i) A window that is openable under the conditions prescribed in paragraph (b)(1) of this section when the cabin is not pressurized, provides the view specified in that paragraph, and gives sufficient protection from the elements against impairment of the pilot's vision; or*

*(ii) An alternate means to maintain a clear view under the conditions specified in paragraph (b)(1) of this section, considering the probable damage due to a severe hail encounter.*
*(c) Internal windshield and window fogging. The airplane must have a means to prevent fogging of the internal portions of the windshield and window panels over an area which would provide the visibility specified in paragraph (a) of this section under all internal and external ambient conditions, including precipitation conditions, in which the airplane is intended to be operated.*
*(d) Fixed markers or other guides must be installed at each pilot station to enable the pilots to position themselves in their seats for an optimum combination of outside visibility and instrument scan. If lighted markers or guides are used they must comply with the requirements specified in § 25.1381.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-46, 43 FR 50595, Oct. 30, 1978; Amdt. 25-72, 55 FR 29778, Jul. 20, 1990]*

NOTE: Refer to Advisory Circular (AC) 25-7A, Flight Test Guide for Certification of Transport Category Airplanes, for guidance.

998 - 1003. [RESERVED]

1004. SECTION 25.775 - WINDSHIELDS AND WINDOWS.

a. Rule Text.

*(a) Internal panes must be made of nonsplintering material.*
*(b) Windshield panes directly in front of the pilots in the normal conduct of their duties, and the supporting structures for these panes, must withstand, without penetration, the impact of a four-pound bird when the velocity of the airplane (relative to the bird along the airplane's flight path) is equal to the value of $V_C$, at sea level, selected under § 25.335(a).*
*(c) Unless it can be shown by analysis or tests that the probability of occurrence of a critical windshield fragmentation condition is of a low order, the airplane must have a means to minimize the danger to the pilots from flying windshield fragments due to bird impact. This must be shown for each transparent pane in the cockpit that -*
*(1) Appears in the front view of the airplane;*
*(2) Is inclined 15 degrees or more to the longitudinal axis of the airplane; and*
*(3) Has any part of the pane located where its fragmentation will constitute a hazard to the pilots.*

*(d) The design of windshields and windows in pressurized airplanes must be based on factors peculiar to high altitude operation, including the effects of continuous and cyclic pressurization loadings, the inherent characteristics of the material used, and the effects of temperatures and temperature differentials. The windshield and window panels must be capable of withstanding the maximum cabin pressure differential loads combined with critical aerodynamic pressure and temperature effects after any single failure in the installation or associated systems. It may be assumed that, after a single failure that is obvious to the flight crew (established under § 25.1523), the cabin pressure differential is reduced from the maximum, in accordance with appropriate operating limitations, to allow continued safe flight of the airplane with a cabin pressure altitude of not more than 15,000 feet.*
*(e) The windshield panels in front of the pilots must be arranged so that, assuming the loss of vision through any one panel, one or more panels remain available for use by a pilot seated at a pilot station to permit continued safe flight and landing.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-38, 41 FR 55466, Dec. 20. 1976]*

b. Intent of Rule. The purpose of this rule is to ensure structural integrity of the windshield under all likely operating conditions, and to minimize the hazard to the pilots from glass fragments due to bird impact.

c. Background. This rule was carried forward from § 4b.352 of the Civil Air Regulations (CAR). The requirement to consider the loss of vision through any one panel in front of the pilots was added by Amendment. 25-38.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-23, 35 FR 5676, April 8, 1970; and Amendment 25-38, 41 FR 55466, December 20, 1976. Compliance with this requirement may be shown by test(s) such as: (1) bird impact tests with the windshield installed in a representative windshield support frame, and (2) fail-safe pressure testing on the windshield.

e. References. None.

1005 - 1015. [RESERVED]

1016. SECTION 25.777 - COCKPIT CONTROLS.

a. Rule Text.

*(a) Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation.*
*(b) The direction of movement of cockpit controls must meet the requirements of § 25.779. Wherever practicable, the sense of motion involved in the operation of other controls must correspond to the sense of the effect of the operation upon the airplane or upon the part operated. Controls of a variable nature using a rotary motion must move clockwise from the off position, through an increasing range, to the full on position.*
*(c) The controls must be located and arranged, with respect to the pilots' seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flight crew (established under § 25.1523) when any member of this flight crew, from 5'2" to 6'3" in height, is seated with the seat belt and shoulder harness (if provided) fastened.*
*(d) Identical powerplant controls for each engine must be located to prevent confusion as to the engines they control.*
*(e) Wing flap controls and other auxiliary lift device controls must be located on top of the pedestal, aft of the throttles, centrally or to the right of the pedestal centerline, and not less than 10 inches aft of the landing gear control.*
*(f) The landing gear control must be located forward of the throttles and must be operable by each pilot when seated with seat belt and shoulder harness (if provided) fastened.*
*(g) Control knobs must be shaped in accordance with § 25.781. In addition, the knobs must be of the same color, and this color must contrast with the color of control knobs for other purposes and the surrounding cockpit.*
*(h) If a flight engineer is required as part of the minimum flight crew (established under § 25.1523), the airplane must have a flight engineer station located and arranged so that the flight crewmembers can perform their functions efficiently and without interfering with each other.*

*[Amdt. 25-46, 43 FR 50596, Oct. 30, 1978]*

NOTE: There is no guidance currently available on this subject.

1017 - 1022. [RESERVED]

1023. SECTION 25.779 - MOTION AND EFFECT OF COCKPIT CONTROLS.

a. Rule Text.

*Cockpit controls must be designed so that they operate in accordance with the following movement and actuation:*

*(a) Aerodynamic controls:*

*(1) Primary.*

| *Controls* | *Motion and effect* |
|---|---|
| *Aileron* | *Right (clockwise) for right wing down.* |
| *Elevator* | *Rearward for nose up.* |
| *Rudder* | *Right pedal forward for nose right.* |

*(2) Secondary.*

| *Controls* | *Motion and effect* |
|---|---|
| *Flaps (or auxiliary lift devices)* | *Forward for flaps up; rearward for for flaps down.* |
| *Trim tabs (or equivalent)* | *Rotate to produce similar rotation of the airplane about an axis parallel to the axis of the control.* |

*(b) Powerplant and auxiliary controls:*

*(1) Powerplant.*

| *Controls* | *Motion and effect* |
|---|---|
| *Power or thrust* | *Forward to increase forward thrust and rearward to increase rearward thrust.* |
| *Propellers* | *Forward to increase rpm.* |
| *Mixture* | *Forward or upward for rich.* |
| *Carburetor air heat* | *Forward or upward for cold.* |
| *Supercharger* | *Forward or upward for low blower. For turbosuperchargers, forward, upward, or clockwise, to increase pressure.* |

*(2) Auxiliary.*

| *Controls* | *Motion and effect* |
|---|---|
| *Landing gear* | *Down to extend.* |

*[Amdt. 25-72, 55 FR 29778, Jul. 20, 1990]*

NOTE: There is no guidance currently available on this subject.

1024 - 1029. [RESERVED]

1030. SECTION 25.781 COCKPIT CONTROL KNOB SHAPE.

a. Rule Text.

*Cockpit control knobs must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure:*

(See the published Code of Federal Regulations (CFR) rules for drawings of cockpit control knobs.)

*[Amdt. 25-72, 55 FR 29779, July 20, 1990]*

NOTE: There is no guidance currently available on this subject.

1031 - 1037. [RESERVED]

1038. SECTION 25.783 - DOORS.

a. Rule Text.

*(a) Each cabin must have at least one easily accessible external door.*
*(b) There must be a means to lock and safeguard each external door against opening in flight (either inadvertently by persons or as a result of mechanical failure or failure of a single structural element either during or after closure). Each external door must be openable from both the inside and the outside, even though persons may be crowded against the door on the inside of the airplane. Inward opening doors may be used if there are means to prevent occupants from crowding against the door to an extent that would interfere with the opening of the door. The means of opening must be simple and obvious and must be arranged and marked so that it can be readily located and operated, even in darkness. Auxiliary locking devices may be used.*
*(c) Each external door must be reasonably free from jamming as a result of fuselage deformation in a minor crash.*
*(d) Each external door must be located where persons using them will not be endangered by the propellers when appropriate operating procedures are used.*
*(e) There must be a provision for direct visual inspection of the locking mechanism to determine if external doors, for which the initial opening movement is not inward (including passenger, crew, service, and cargo doors), are fully closed and locked. The provision must be discernible under operational lighting conditions by appropriate crewmembers using a flashlight or equivalent lighting source. In addition, there must be a visual warning means to signal the appropriate flight crewmembers if any external door is not fully closed and*

*locked. The means must be designed such that any failure or combination of failures that would result in an erroneous closed and locked indication is improbable for doors for which the initial opening movement is not inward.*
*(f) External doors must have provisions to prevent the initiation of pressurization of the airplane to an unsafe level if the door is not fully closed and locked. In addition, it must be shown by safety analysis that inadvertent opening is extremely improbable.*
*(g) Cargo and service doors not suitable for use as emergency exits need only meet paragraphs (e) and (f) of this section and be safeguarded against opening in flight as a result of mechanical failure or failure of a single structural element.*
*(h) Each passenger entry door in the side of the fuselage must meet the applicable requirements of §§ 25.807 through 25.813 for a Type II or larger passenger emergency exit.*
*(i) If an integral stair is installed in a passenger entry door that is qualified as a passenger emergency exit, the stair must be designed so that under the following conditions the effectiveness of passenger emergency egress will not be impaired:*
*(1) The door, integral stair, and operating mechanism have been subjected to the inertia forces specified in § 25.561 (b)(3), acting separately relative to the surrounding structure.*
*(2) The airplane is in the normal ground attitude and in each of the attitudes corresponding to collapse of one or more legs of the landing gear.*
*(j) All lavatory doors must be designed to preclude anyone from becoming trapped inside the lavatory, and if a locking mechanism is installed, it be capable of being unlocked from the outside without the aid of special tools.*

*[Amdt. 25-15, 32 FR 13262, Sep. 20, 1967; Amdt. 25-23, 35 FR 5676, Apr. 8, 1970; Amdt. 25-54, 45 FR 60173, Sep. 11, 1980; Amdt. 25-72, 55 FR 29780, Jul. 20, 1990; Amdt. 25-88, 61 FR 57956, Nov. 8, 1996]*

b. Intent of Rule. The intent of this rule is to ensure that external doors will not open in flight, either inadvertently by persons as a result of mechanical failure, or failure of a single structural element. Failures in the door that would cause the door to open in flight must be extremely improbable.

c. Background. This rule was carried forward from § 4b.356 of the Civil Air Regulations (CAR). The rule was amended to include consideration of failure of a single structural element (Amendment 25-23). Amendment 25-54 made a significant change to the rule by requiring a means of preventing pressurization unless the door was fully closed and locked. It also specified a minimum reliability for the door warning system.

d. Acceptable Compliance Methods. For guidance on compliance with this requirement, refer to the preamble of Amendment 25-15, 32 FR 13262, September 20, 1967; Amendment 25-23, 35 FR 5676, April 8, 1970; Amendment 25-54, 45 FR 60173, September 11, 1980; Amendment 25-72, 55 FR 29780, July 20, 1990; and Amendment 25-88, 61 FR 57956, November 8, 1996. Advisory Circular (AC) 25.783-1, or latest revision, provides guidance information for showing compliance with structural and functional safety standards for doors and their operating systems. For the purpose of showing compliance with § 25.783, hatches and exits are also considered to be doors.

e. References. Advisory Circular 25.783-1, or latest revision, Fuselage Doors, Hatches, and Exits.

1039 - 1049. [RESERVED]

1050. SECTION 25.785 - SEATS, BERTHS, SAFETY BELTS, AND HARNESSES.

a. Rule Text.

*(a) A seat (or berth for a nonambulant person) must be provided for each occupant who has reached his or her second birthday.*
*(b) Each seat, berth, safety belt, harness, and adjacent part of the airplane at each station designated as occupiable during takeoff and landing must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in §§ 25.561 and 25.562.*
*(c) Each seat or berth must be approved.*
*(d) Each occupant of a seat that makes more than an 18-degree angle with the vertical plane containing the airplane centerline must be protected from head injury by a safety belt and an energy absorbing rest that will support the arms, shoulders, head, and spine, or by a safety belt and shoulder harness that will prevent the head from contacting any injurious object. Each occupant of any other seat must be protected from head injury by a safety belt and, as appropriate to the type, location, and angle of facing of each seat, by one or more of the following:*
*(1) A shoulder harness that will prevent the head from contacting any injurious object.*
*(2) The elimination of any injurious object within striking radius of the head.*
*(3) An energy absorbing rest that will support the arms, shoulders, head, and spine.*
*(e) Each berth must be designed so that the forward part has a padded end board, canvas diaphragm, or equivalent means, that can withstand the static load reaction of the occupant when subjected to the forward inertia force specified in § 25.561. Berths must be free from corners and protuberances likely to cause injury to a person occupying the berth during emergency conditions.*
*(f) Each seat or berth, and its supporting structure, and each safety belt or harness and its anchorage must be designed for an occupant weight of 170*

*pounds, considering the maximum load factors, inertia forces, and reactions among the occupant, seat, safety belt, and harness for each relevant flight and ground load condition (including the emergency landing conditions prescribed in § 25.561). In addition -*

*(1) The structural analysis and testing of the seats, berths, and their supporting structures may be determined by assuming that the critical load in the forward, sideward, downward, upward, and rearward directions (as determined from the prescribed flight, ground, and emergency landing conditions) acts separately or using selected combinations of loads if the required strength in each specified direction is substantiated. The forward load factor need not be applied to safety belts for berths.*

*(2) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in § 25.395.*

*(3) The inertia forces specified in § 25.561 must be multiplied by a factor of 1.33 (instead of the fitting factor prescribed in § 25.625) in determining the strength of the attachment of each seat to the structure and each belt or harness to the seat or structure.*

*(g) Each seat at a flight deck station must have a restraint system consisting of a combined safety belt and shoulder harness with a single-point release that permits the flight deck occupant, when seated with the restraint system fastened, to perform all of the occupant's necessary flight deck functions. There must be a means to secure each combined restraint system when not in use to prevent interference with the operation of the airplane and with rapid egress in an emergency.*

*(h) Each seat located in the passenger compartment and designated for use during takeoff and landing by a flight attendant required by the operating rules of this chapter must be:*

*(1) Near a required floor level emergency exit, except that another location is acceptable if the emergency egress of passengers would be enhanced with that location. A flight attendant seat must be located adjacent to each Type A or B emergency exit. Other flight attendant seats must be evenly distributed among the required floor level emergency exits to the extent feasible.*

*(2) To the extent possible, without compromising proximity to a required floor level emergency exit, located to provide a direct view of the cabin area for which the flight attendant is responsible.*

*(3) Positioned so that the seat will not interfere with the use of a passageway or exit when the seat is not in use.*

*(4) Located to minimize the probability that occupants would suffer injury by being struck by items dislodged from service areas, stowage compartments, or service equipment.*

*(5) Either forward or rearward facing with an energy absorbing rest that is designed to support the arms, shoulders, head, and spine.*

*(6) Equipped with a restraint system consisting of a combined safety belt and shoulder harness unit with a single point release. There must be means to secure each restraint system when not in use to prevent interference with rapid egress in an emergency.*
*(i) Each safety belt must be equipped with a metal to metal latching device.*
*(j) If the seat backs do not provide a firm handhold, there must be a handgrip or rail along each aisle to enable persons to steady themselves while using the aisles in moderately rough air.*
*(k) Each projecting object that would injure persons seated or moving about the airplane in normal flight must be padded.*
*(l) Each forward observer's seat required by the operating rules must be shown to be suitable for use in conducting the necessary enroute inspection.*

*[Amdt. 25-15, 32 FR 13262, Sep. 20, 1967; Amdt. 25-20, 34 FR 5544, Apr. 23, 1969; Amdt. 25-32, May 1, 1974; Amdt. 25-51, 45 FR 7755, Mar. 6, 1980; Amdt. 25-64, 53 FR 17647, June 16, 1988; Amdt. 25-72, 55 FR 29780, July 20, 1990; Amdt. 25-88, 61 FR 57956, Nov. 8, 1996]*

NOTE: Refer to Advisory Circular (AC) 25-17, or latest revision, Transport Airplane Cabin Interiors Crashworthiness Handbook, for guidance.

1051 - 1054. [RESERVED]

1055. SECTION 25.787 - STOWAGE COMPARTMENTS.

a. Rule Text.

*(a) Each compartment for the stowage of cargo, baggage, carry-on articles, and equipment (such as life rafts), and any other stowage compartment must be designed for its placarded maximum weight of contents and for the critical load distribution at the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of § 25.561(b), except that the forces specified in the emergency landing conditions need not be applied to compartments located below, or forward, of all occupants in the airplane. If the airplane has a passenger seating configuration, excluding pilots seats, of 10 seats or more, each stowage compartment in the passenger cabin, except for underseat and overhead compartments for passenger convenience, must be completely enclosed.*
*(b) There must be a means to prevent the contents in the compartments from becoming a hazard by shifting, under the loads specified in paragraph (a) of this section. For stowage compartments in the passenger and crew cabin, if the*

*means used is a latched door, the design must take into consideration the wear and deterioration expected in service.*

*(c) If cargo compartment lamps are installed, each lamp must be installed so as to prevent contact between lamp bulb and cargo.*

*[Amdt. 25-32, 37 FR 3969, Feb. 24, 1972; Amdt. 25-38, 41 FR 55466, Dec. 20, 1976; Amdt. 25-51, 45 FR 7755, Feb. 4, 1980]*

NOTE: Refer to Advisory Circular (AC) 25-17, or latest revision, Transport Airplane Cabin Interiors Crashworthiness Handbook, for guidance.

1056 - 1059. [RESERVED]

1060. SECTION 25.789 - RETENTION OF ITEMS OF MASS IN PASSENGER AND CREW COMPARTMENTS AND GALLEYS.

a. Rule Text.

*(a) Means must be provided to prevent each item of mass (that is part of the airplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of § 25.561(b).*
*(b) Each interphone restraint system must be designed so that when subjected to the load factors specified in § 25.561(b)(3), the interphone will remain in its stowed position.*

*[Amdt. 25-32, 37 FR 3969, Feb. 24, 1972; Amdt. 25-46, 43 FR 50596, Oct. 30, 1978]*

b. Intent of Rule. The purpose of this rule is to protect passengers and crewmembers from loose objects that could become a safety hazard by shifting under flight, ground, and emergency landing loads.

c. Background. This rule was introduced by Amendment 25-32. The requirement to retain the interphone in its stowed position was introduced by Amendment 25-46.

d. Acceptable Compliance Methods. Retention of each of item of mass within the cabin can be shown by analysis for the flight and ground load factors.

e. References. Advisory Circular (AC) 25.562-1A, or latest revision, Dynamic Evaluation of Seat Restraint Systems & Occupant Protection on Transport Airplanes; and AC 25-17, or latest revision, Transport Airplane Cabin Interiors Crashworthiness Handbook.

1061 - 1068. [RESERVED]

1069. SECTION 25.791 - PASSENGER INFORMATION SIGNS AND PLACARDS.

a. Rule Text.

*(a) If smoking is to be prohibited, there must be at least one placard so stating that is legible to each person seated in the cabin. If smoking is to be allowed, and if the crew compartment is separated from the passenger compartment, there must be at least one sign notifying when smoking is prohibited. Signs which notify when smoking is prohibited must be operable by a member of the flightcrew and, when illuminated, must be legible under all probable conditions of cabin illumination to each person seated in the cabin.*
*(b) Signs that notify when seat belts should be fastened and that are installed to comply with the operating rules of this chapter must be operable by a member of the flightcrew and, when illuminated, must be legible under all probable conditions of cabin illumination to each person seated in the cabin.*
*(c) A placard must be located on or adjacent to the door of each receptacle used for the disposal of flammable waste materials to indicate that use of the receptacle for disposal of cigarettes, etc., is prohibited,*
*(d) Lavatories must have "No Smoking" or "No Smoking in Lavatory" placards conspicuously located on or adjacent to each side of the entry door.*
*(e) Symbols that clearly express the intent of the sign or placard may be used in lieu of letters.*

*[Amdt. 25-72, 55 FR 29780, Jul. 20, 1990]*

NOTE: Refer to Advisory Circular (AC) 25-17, or latest revision Transport Airplane Cabin Interiors Crashworthiness Handbook, for guidance.

1070 - 1072. [RESERVED]

1073. SECTION 25.793 - FLOOR SURFACES.

a. Rule Text.

*The floor surface of all areas which are likely to become wet in service must have slip resistant properties.*

*[Amdt. 25-51, 45 FR 7755, Feb. 4, 1980]*

NOTE: Refer to Advisory Circular (AC) 25-17, or latest revision, Transport Airplane Cabin Interiors Crashworthiness Handbook, for guidance.

1074 - 1075. [RESERVED]

## Section 7. EMERGENCY PROVISIONS

### 1076. SECTION 25.801 - DITCHING.

a. Rule Text.

*(a) If certification with ditching provisions is requested, the airplane must meet the requirements of this section and §§ 25.807(e), 25.1411, and 25.1415(a).*
*(b) Each practicable design measure, compatible with the general characteristics of the airplane, must be taken to minimize the probability that in an emergency landing on water, the behavior of the airplane would cause immediate injury to the occupants or would make it impossible for them to escape.*
*(c) The probable behavior of the airplane in a water landing must be investigated by model tests or by comparison with airplanes of similar configuration for which the ditching characteristics are known. Scoops, flaps, projections, and any other factor likely to affect the hydrodynamic characteristics of the airplane, must be considered.*
*(d) It must be shown that, under reasonably probable water conditions, the flotation time and trim of the airplane will allow the occupants to leave the airplane and enter the life-rafts required by § 25.1415. If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. If the airplane has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume.*
*(e) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behavior of the airplane in a water landing (as prescribed in paragraphs (c) and (d) of this section), the external doors and windows must be designed to withstand the probable maximum local pressures.*

*[Amdt. 25-72, 55 FR 29781, Jul. 20,1990]*

b. Intent of Rule. The purpose of this rule is to require protection of the occupants in the event of an emergency landing on water.

c. Background. This rule was carried forward from § 4b.361 of the Civil Air Regulations (CAR). Editorial changes were introduced by Amendment 25-72.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. Refer to Advisory Circular (AC) 25-17, or latest revision, Transport Airplane Cabin Interiors Crashworthiness Handbook, for guidance on emergency evacuation following ditching.

1077 - 1085. [RESERVED]

## Section 8. FIRE PROTECTION

### 1086. SECTION 25.865 - FIRE PROTECTION OF FLIGHT CONTROLS, ENGINE MOUNTS, AND OTHER FLIGHT STRUCTURE.

a. Rule Text.

*Essential flight controls, engine mounts, and other flight structures located in designated fire zones or in adjacent areas which would be subjected to the effects of fire in the fire zone must be constructed of fireproof material or shielded so that they are capable of withstanding the effects of fire.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to protect the flight controls and other primary structures form the effects of fires in fire zones.

c. Background. This regulation was created by Amendment 25-23.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. Advisory Circular (AC) 25-XX, Transport Airplane Propulsion, Engine, and Auxiliary Power Unit (APU) Certification Handbook.

### 1087 - 1095. [RESERVED]

### 1096. SECTION 25.867 - FIRE PROTECTION: OTHER COMPONENTS.

a. Rule Text.

*(a) Surfaces to the rear of the nacelles, within one nacelle diameter of the nacelle centerline, must be at least fire-resistant.*
*(b) Paragraph (a) of this section does not apply to tail surfaces to the rear of the nacelle that could not be readily affected by heat, flames, or sparks coming from a designated fire zone or engine compartment of any nacelle.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure that structure located aft of any likely fire is at least fire resistant.

c. Background. This rule was created by Amendment 25-23.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. Advisory Circular (AC) 25-XX, Transport Airplane Propulsion, Engine, and APU Certification Handbook.

1097 - 1105. [RESERVED]

## Section 9. MISCELLANEOUS

### 1106. SECTION 25.871 - LEVELING MEANS.

a. Rule Text.

*There must be means for determining when the airplane is in a level position on the ground.*

*[Amdt. 25-23, 35 FR 5676, Apr. 8, 1970]*

b. Intent of Rule. The purpose of this rule is to ensure there will be a means for determining when the airplane is level.

c. Background. This rule was created by Amendment 25-23.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by drawing review.

e. References. None.

### 1107 - 1112. [RESERVED]

# Section 10. FUEL SYSTEM

## 1113. SECTION 25.963 - FUEL TANKS: GENERAL.

a. Rule Text.

*a. Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads that it may be subjected to in operation.*
*b. Flexible fuel tank liners must be approved or must be shown to be suitable for the particular application.*
*c. Integral fuel tanks must have facilities for interior inspection and repair.*
*d. Fuel tanks within the fuselage contour must be able to resist rupture and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in § 25.561. In addition, these tanks must be in a protected position so that exposure of the tanks to scraping action with the ground is unlikely.*
*e. Fuel tank access covers must comply with the following criteria in order to avoid loss of hazardous quantities of fuel:*
*(1) All covers located in an area where experience or analysis indicates a strike is likely must be shown by analysis or tests to minimize penetration and deformation by tire fragments, low energy engine debris, or other likely debris.*
*(2) All covers must be fire resistant as defined in part 1 of this chapter.*
*(f) For pressurized fuel tanks, a means with fail-safe features must be provided to prevent the buildup of an excessive pressure difference between the inside and the outside of the tank.*

*[Amdt. 25-40, 42 FR 15043, Mar. 17, 1977; Amdt. 25-69, 54 FR 40354, Sep. 29, 1989]*

b. Intent of Rule. The purpose of this rule is to ensure structural integrity of the fuel tanks under all likely operating conditions, including emergency landing conditions.

c. Background. This rule was carried forward from § 4b.420 of the Civil Air Regulations (CAR). Amendment 25-40 removed the requirements pertaining to the augmentation liquid tank capacity. Amendment 25-69 added the requirements pertaining to fuel tank access covers.

d. Acceptable Compliance Methods. Advisory Circular (AC) 25-963-1, or latest revision, provides guidance information for showing compliance with the impact and fire resistance requirements of 25.963(e). Fuel tank access covers must be fire resistant and meet the impact criteria specified in

Advisory Circular 25.963-1, or latest revision. Compliance with this requirement may be shown by test(s) and/or analysis.

e. References. Advisory Circular 25.963-1, or latest revision, Fuel Tank Access Covers, and AC 25-XX, Transport Airplane Propulsion, Engine, and APU Certification Handbook.

1114 - 1122. [RESERVED]

## Section 11. OPERATING LIMITATIONS

### 1123. SECTION 25.1517 - Rough Air Speed, $V_{RA}$.

a. Rule Text.

*A rough air speed, $V_{RA}$, for use as the recommended turbulence penetration airspeed in § 25.1585(a)(8), must be established, which -*
*(1) is not greater than the design airspeed for maximum gust intensity, selected for $V_B$; and*
*(2) is not less than the minimum value of $V_B$ specified in § 25.335(d); and*
*(3) is sufficiently less than $V_{MO}$ to ensure that likely speed variation during rough air encounters will not cause the overspeed warning to operate too frequently. In the absence of a rational investigation substantiating the use of other values, $V_{RA}$ must be less than $V_{MO}$ - 35 knots (TAS).*

*[Amdt. 25-86; 61 FR 5222, Feb. 9, 1996]*

b. Intent of Rule. The purpose of this rule is to provide a means of determining the recommended speeds that must be established under § 25.1585(a)(8).

c. Background. This rule was established consistent with the incorporation of the tuned gust criteria of Amendment 25-91.

d. Acceptable Compliance Methods. Compliance with this requirement may be shown by analysis.

e. References. None.

### 1124 - 1129. [RESERVED]

1130. SECTION 25.1529/APPENDIX H - INSTRUCTIONS FOR CONTINUED AIRWORTHINESS.

a. Rule Text.

*The applicant must prepare Instructions for Continued Airworthiness in accordance with Appendix H to this part that are acceptable to the Administrator. The instructions may be incomplete at type certification if a program exists to ensure their completion prior to delivery of the first airplane for issuance of a standard certificate of airworthiness, whichever occurs later.*

*[Amdt. 25-54, 45 FR 60173, Sep. 11, 1980]*

*H25.4 Airworthiness Limitations section.*
*The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedures approved under § 25.571. If the Instructions for Continued Airworthiness consist of multiple documents, the section required by this paragraph must be included in the principal manual. This section must contain a legible statement in a prominent location that reads: "The Airworthiness Limitations section is FAA approved and specifies maintenance required under §§ 43.16 and 91.403 of the Federal Aviation Regulations unless an alternative program has been FAA approved."*

*[Amdt. 25-54, 45 FR 60177, Sep. 11, 1980; Amdt. 25-68, 54 FR 34329, Aug. 18, 1989]*

b. Intent of Rule. The purpose of this rule is to ensure continued airworthiness of the airplane by requiring that inspections, checks, and replacement of parts are performed in accordance with the requirements established for type certification.

c. Background. This rule, along with Appendix H, was created by Amendment 25-54.

d. Acceptable Compliance Methods. Review of airworthiness limitations document and applicable damage tolerance analyses and tests.

e. References. Advisory Circular (AC) 25.571-1, or latest revision, Damage Tolerance & Fatigue Evaluation of Structure.

1130 - 1140. [RESERVED]

## APPENDIX 1. GLOSSARY OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AC | Advisory Circular |
| ACO | Aircraft Certification Office |
| Admt. | Amendment |
| APU | Auxiliary Power Unit |
| CAM | Civil Aeronautics Manual |
| CAR | Civil Air Regulations (predecessor of FAR) |
| CFR | Code of Federal Regulations |
| EAS | Equivalent Airspeeds |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulations |
| FR | Federal Register |
| FSS | Flutter Suppression Systems |
| JAR | Joint Aviation Requirements |
| MIL HDBK | Military Handbook |
| SAS | Load Alleviation Systems |
| SC | Special Condition |
| TSO | Technical Standard Order |

## APPENDIX 2. INDEX OF INCORPORATED GUIDANCE MATERIAL AND REFERENCES

1. Advisory Circulars.

The advisory circulars (AC) listed below contain information relevant to the approval of airframe systems on transport category airplanes. The latest revisions of the AC's can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785, USA.

| AC No. | Title | Section Reference |
|---|---|---|
| | | |
| AC 20-53A | Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning, dated 4/12/85 | 25.581 |
| | | |
| AC 20-71 | Dual Locking Devices on Fasteners, dated 12/8/70 | 25.607 |
| | | |
| AC 20-107A | Composite Aircraft Structure, dated 4/25/84 | 25.571, 25.581 |
| | | |
| AC 20-136 | Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning, dated 3/5/90 | 25.581 |
| | | |
| AC 25-7A | Flight Test Guide for Certification of Transport Category Airplanes Handbook, dated 3/31/98 | 25.773 |
| | | |
| AC 25-14 | High Lift and Drag Devices, dated 5/4/88 | 25.457, 25.459, 25.671, 25.701 |
| | | |
| AC 25-17 | Transport Airplane Cabin Interiors Crashworthiness Handbook, dated 7/15/91 | 25.772, 25.785, 25.787, 25.789, 25.791, 25.793, 25.801 |
| | | |
| AC 25-335-1 | Design Dive Speed, dated 10/20/97 | 25.335 |
| | | |
| AC 25-562-1A | Dynamic Evaluation of Seat Restraint Systems & Occupant Protection on Transport Category Airplanes, dated 1/19/96 | 25.562, 25.789 |
| | | |

| AC No. | Title | Section Reference |
|---|---|---|
| | | |
| AC 25.571-1C | Damage-Tolerance and Fatigue Evaluation of Structure, dated 4/29/98 | 25.571, 25.1529 |
| | | |
| AC 25.629-1A | Aeroelastic Stability Substantiation of Transport Category Airplanes, dated 7/23/98 | 25.629, 25.677 |
| | | |
| 25.672-1 | Active Flight Controls, dated 11/15/83 | 25.671, 25.672 |
| | | |
| AC 25.783-1A | Fuselage Doors, Hatches, and Exits, dated 12/10/86 | 25.783 |
| | | |
| AC 25.963-1 | Fuel Tank Access Covers, dated 7/29/92 | 25.963 |
| | | |
| AC 25.1309-1A | System Design and Analysis, dated 6/21/88 | 25.672, 25.701 |
| AC 25.1329-1A | Automatic Pilot Systems Approval, dated 7/8/68 | 25.672 |
| | | |

| AC No. | Advisory Circulars To Be Issued | Section Reference |
|---|---|---|
| | | |
| AC 25-XX | Transport Airplane Cabin Interiors Crashworthiness Handbook | 25.772, 25.785, 25.787, 25.789, 25.791, 25.793, 25.801 |
| | | |
| AC 25-XX | Certification of Transport Airplane Electrical Equipment Installations | All sections |
| | | |
| AC 25-XX | Certification of Transport Airplane Mechanical Systems | 25.699, 25.729, 25.731, 25.733, 25.735 |
| AC 25-XX | Certification of Transport Airplane Propulsion, Engine, and APU | 25.865, 25.867, 25.963 |
| | | |

2. Special Conditions.

The special conditions (SC) listed below contain information relevant to the approval of airframe systems on transport category airplanes.

| SC No. | Title | Section Reference |
|---|---|---|
| | | |
| SC 25-ANM-23 | Special Conditions issued against fly-by-wire airplanes, for Side Stick Controllers on the Airbus A320 (54 FR 3986) January 27, 1989 | 25.397, 25.672 |
| | | |
| SC 25-77-NW-4 | Special Conditions for Boeing Model 747 Series Airplanes, issued June 27, 1977 (Non-conventional Landing Gear Arrangements) | 25.477 |
| | | |
| SC 25-18-WE-7 | Special Conditions for the DC-10, issued January 7, 1970 (Non-conventional Landing Gear Arrangements) | 25.477 |
| | | |
| SC 25-ANM-78 | Special Conditions Issued Against Fly-By-Wire Airplanes, for the Boeing Model 777 (58 FR 59646) November 10, 1993 | 25.672 |
| | | |

3. Miscellaneous Documents Referenced in this Advisory Circular.

| Number | Title | Section Reference |
|---|---|---|
| | | |
| MIL-HDBK-5 | Metallic Materials and Elements for Flight Vehicle Structure | 25.613, 25.693 |
| | | |
| MIL-HDBK-17 | Plastics for Flight Vehicles, Composite Construction for Flight Vehicles | 25.613 |
| | | |