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

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

where—

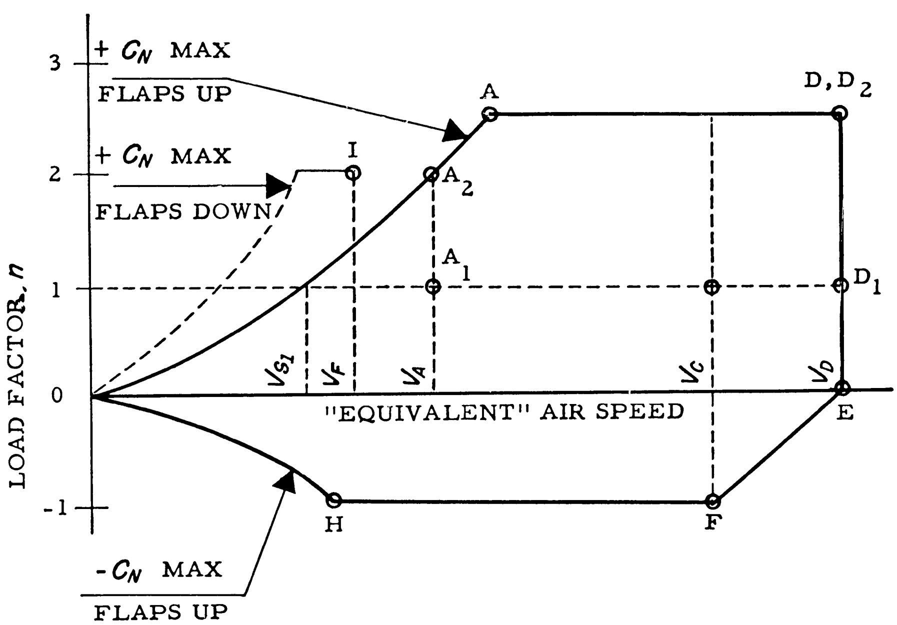
n is the positive load factor at the speed under consideration; and V is the airplane equivalent speed in knots.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by 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, July 20, 1990; 55 FR 37607, Sept. 12, 1990; Amdt. 25–86, 61 FR 5220, Feb. 9, 1996; Amdt. 25–91, 62 FR 40704, July 29, 1997]

§ 25.333 Flight maneuvering envelope.

(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 envelope (*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.*



[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25–86, 61 FR 5220, Feb. 9, 1996]

§ 25.335 Design airspeeds.

The selected design airspeeds are equivalent airspeeds (EAS). Estimated values of V_{S0} 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 7.5° below the initial path, and then pulled up at a load factor of 1.5*g* (0.5*g* 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 pullup 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 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 $V_{S1}\sqrt{n}$ 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.

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

$$\mu=\frac{2w}{\rho cag}$$

ρ=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_{S0} 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.

[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25–23, 35 FR 5672, Apr. 8, 1970; Amdt. 25–86, 61 FR 5220, Feb. 9, 1996; Amdt. 25–91, 62 FR 40704, July 29, 1997]

§25.337 Limit maneuvering load factors.

(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 V_n 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 design maximum 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.

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

§25.341 Gust and turbulence loads.

(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 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:

$$U = \frac{U_{ds}}{2}\left[1 - \cos\left(\frac{\pi s}{H}\right)\right]$$

for $0 \le s \le 2H$

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