INTERNATIONAL

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Standard Practice for Simplified Aircraft Loads Determination[1]

This standard is issued under the fixed designation F3409; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—The images in Figs. 1 and 2 were interchanged editorially in October 2022.

1. Scope

1.1 This practice provides an acceptable, and simplified, means of determining certain design loads criteria and conditions for fixed wing aircraft. In particular, the practice provides overall aircraft flight loads and flight conditions as well as control surface loads, wing loads, gust load factors, and gust loads on stabilizing surfaces.

1.2 This practice is intended to be referenced by other standards that define requirements for comprehensive aircraft loads. This practice does not provide all aircraft loads required for structural compliance. In addition, each load or condition determined through this practice has limitations on its use within the relevant section to which it must adhere.

1.3 *Units*—The values given in this standard are in SI units and are to be regarded as standard. Any values given in parentheses are mathematical conversions to inch-pound (or other) units that are provided for information only and are not considered standard. The values stated in each system may not be exact equivalents. Where it may not be clear, some equations provide the units of the result directly following the equation.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2245 Specification for Design and Performance of a Light Sport Airplane

F3060 Terminology for Aircraft

F3116/F3116M Specification for Design Loads and Conditions

3. Terminology

3.1 *Definitions:*

3.1.1 A listing of terms, abbreviations, acronyms, and symbols related to aircraft can be found in Terminology F3060. Items listed in 3.2 are more specific to this standard.

3.2 *Abbreviations:*

n_1 = airplane positive maneuvering limit load factor

n_2 = airplane negative maneuvering limit load factor

n_3 = airplane positive gust limit load factor at V_C

n_4 = airplane negative gust limit load factor at V_C

n_{flap} = airplane positive limit load factor with flaps fully extended at V_F

V_{Fmin} = minimum design flap speed =

$$0.818 = \sqrt{n_1 (W/S)}$$

V_A = design maneuvering speed =

$$V_S \sqrt{n_1} \quad \text{where} \quad V_S = \sqrt{\left(\frac{W}{\left(\frac{1}{2} \rho \, C_{L\max} \, S \right)} \right)}$$

V_{Cmin} = minimum design cruising speed

$$1.27 = \sqrt{n_1 (W/S)}$$

but need not exceed 0.9 V_H

[1] This practice is under the jurisdiction of ASTM Committee F37 on Light Sport Aircraft and is the direct responsibility of Subcommittee F37.20 on Airplane.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

V_{Dmin} = minimum design dive speed

$$1.79 = \sqrt{n_1(W/S)}$$

but need not exceed

$$1.4 \quad V_{C\min}\sqrt{n_1/3.8}$$

See 4.2.5.2.

V_{Csel} = design cruising speed (if greater than V_{Cmin})

4. Simplified Design Load Criteria

4.1 *Limitations:*

4.1.1 Methods provided in this section provide one possible means (but not the only possible means) of compliance. These requirements may be applied to airplanes meeting the following limitations without further justification.

4.1.1.1 A main wing located closer to the airplane's center of gravity than to the aft, fuselage-mounted empennage.

4.1.1.2 A main wing that contains a quarter chord sweep angle of not more than 15° fore or aft.

4.1.1.3 A main wing that is equipped with trailing-edge controls (ailerons or flaps, or both).

4.1.1.4 A main wing aspect ratio not greater than 7.0.

4.1.1.5 A horizontal tail aspect ratio not greater than 4.0.

4.1.1.6 A horizontal tail volume coefficient not less than 0.34.

4.1.1.7 A vertical tail aspect ratio not greater than 2.0.

4.1.1.8 A vertical tail planform area not greater than 10 % of the wing planform area.

4.1.1.9 Horizontal and vertical tail airfoil sections must both be symmetrical.

4.1.1.10 A main wing that does not have winglets, outboard fins, or other wing tip devices.

4.1.2 This section may be used outside of the limitations in 4.1.1 when evidence can be provided that the method provides safe and reliable results.

4.1.3 Airplanes with any of the following design features shall not use this section.

4.1.3.1 Canard, tandem-wing, or tailless arrangements of the lifting surfaces.

4.1.3.2 Biplane or multiplane wing arrangements.

4.1.3.3 V-tail or any tail arrangement where the horizontal stabilizer is supported by the vertical stabilizer (T-tail, cruciform (+), etc.).

4.1.3.4 Wings with delta planforms.

4.1.3.5 Wings with slatted lifting surfaces.

4.1.3.6 Full-flying stabilizing surfaces (horizontal and vertical).

4.2 *Flight Loads:*

4.2.1 Table 1 must be used to determine values of n_1, n_2, n_3, and n_4, corresponding to the maximum design weights.

TABLE 1 Minimum Design Limit Flight Load Factors

Flaps Up	$n_1 = 4.0$
	$n_2 = -0.5n_1$
	n_3 from Fig. 1
	n_4 from Fig. 2
Flaps Down	$n_f = 0.5n_1$
	$n_f = 0^A$

^A Vertical wing load may be assumed equal to zero and only the flap part of the wing need be checked for this condition.

4.2.2 Each flight load may be considered independent of altitude and, except for the local supporting structure for dead weight items, only the maximum design weight conditions must be investigated.

4.2.3 Figs. 1 and 2 must be used to determine values of n_3 and n_4, corresponding to the minimum flying weights, and if these load factors are greater than the load factors at the design weight, the supporting structure for dead weight items must be substantiated for the resulting higher load factors.

4.2.4 Each specified wing and tail loading is independent of the center of gravity range. The applicant, however, must select a CG range, and the basic fuselage structure must be investigated for the most adverse dead weight loading conditions for the CG range selected.

4.2.5 The following loads and loading conditions are the minimums for which strength must be provided in the structure:

4.2.5.1 *Airplane Equilibrium*—The aerodynamic wing loads may be considered to act normal to the relative wind and to have a magnitude of 1.05 times the airplane normal loads (as determined from 4.3.2 and 4.3.3) for the positive flight conditions and magnitude equal to the airplane normal loads for the negative conditions. Each chord-wise and normal component of this wing load must be considered.

4.2.5.2 *Minimum Design Airspeeds*—The minimum design airspeeds may be chosen by the applicant except that they may not be less than the minimum speeds found in 3.2. In addition, V_C min need not exceed values of 0.9 V_H actually obtained at sea level for the lowest design weight category for which certification is desired. In computing these minimum design airspeeds, n_1 may not be less than 4.0.

4.2.5.3 *Flight Load Factor*—The limit flight load factors specified in Table 1 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 flight load factor is an aerodynamic force acting upward, with respect to the airplane.

4.3 *Flight Conditions:*

4.3.1 *General*—Each design condition in 4.3.2 – 4.3.4 must be used to assure sufficient strength for each condition of speed and load factor on or within the boundary of a flight loads envelope diagram for the airplane similar to the diagram in Fig. 3. This diagram must also be used to determine the airplane structural operating limitations.

4.3.2 *Symmetrical Flight Conditions*—The airplane must be designed for symmetrical flight conditions as follows:

4.3.2.1 The airplane must be designed for at least the four basic flight conditions, "A," "D," "E," and "G" as noted on the flight loads envelope of Fig. 3. In addition, the following requirements apply:

(1) The design limit flight load factors corresponding to Conditions "D" and "E" of Fig. 3 must be at least as great as those specified in Table 1, and the design speed for these conditions must be at least equal to the value of V_{Dmin} from 3.2.

(2) For conditions "A" and "G" of Fig. 3, the load factors must correspond to those specified in Table 1, and the design

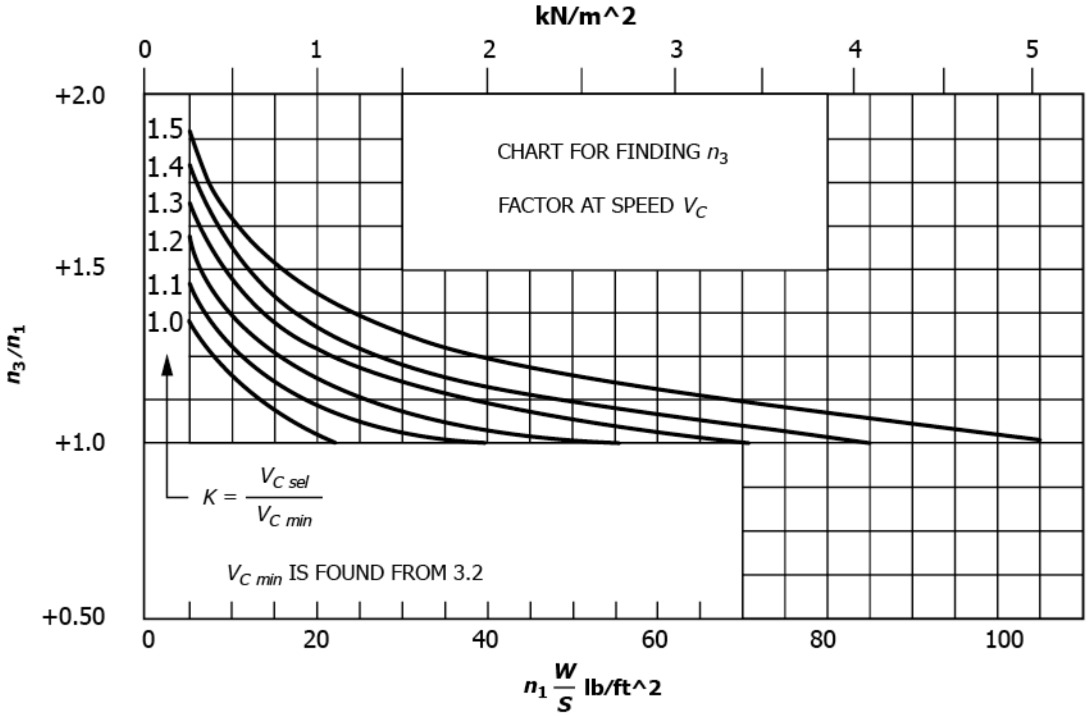

FIG. 1 Chart for Finding n_3 Factor at Speed V_C

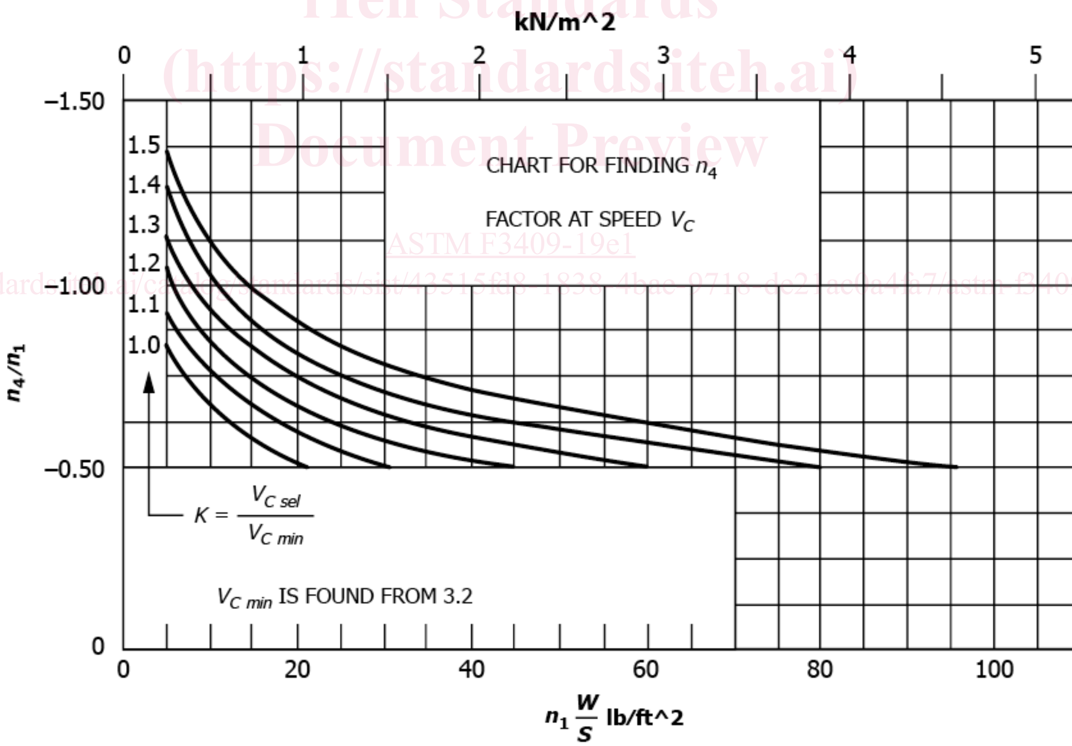

FIG. 2 Chart for Finding n_4 Factor at Speed V_C

speeds must be computed using these load factors with the maximum static lift coefficient C_{NA} determined by the applicant.

(3) Conditions "C" and "F" of Fig. 3 need only be investigated when n_3W/S or n_4W/S is greater than n_1W/S and n_2W/S, respectively.

4.3.2.2 If the flaps or other high-lift devices intended for use at the relatively low airspeed of approach, landing, and takeoff are installed, the airplane must be designed for the two flight conditions corresponding to the values of limit flap-down factors specified in Table 1 with the flaps fully extended at not less than the design flap speed V_{Fmin} from 3.2.

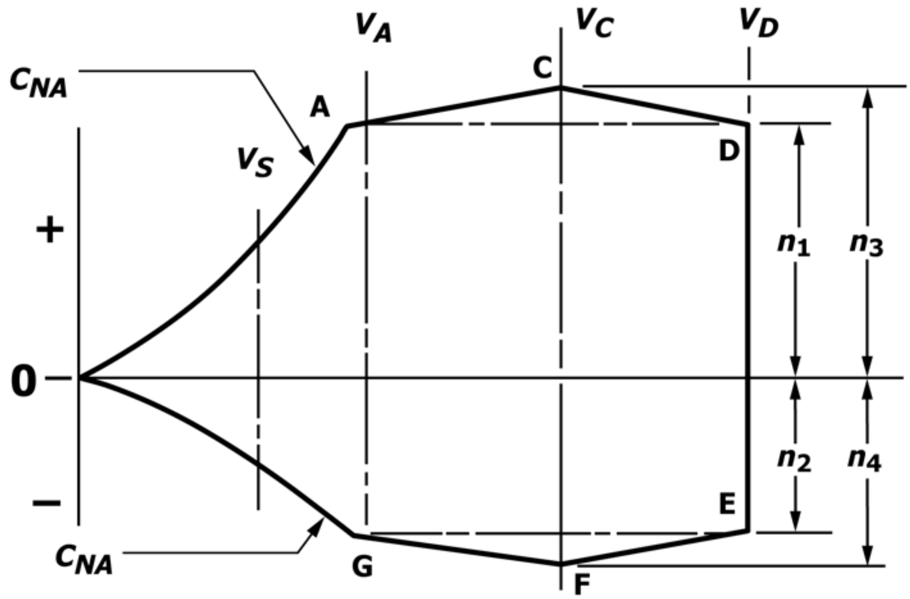

FIG. 3 Generalized Flight Loads Envelope

4.3.3 *Unsymmetrical Flight Conditions*—Each affected structure must be designed for unsymmetrical loadings as follows:

4.3.3.1 The aft fuselage-to-wing attachment must be designed for the critical vertical surface load determined in accordance with 5.2.3.

4.3.3.2 The wing and wing carry-through structures must be designed for 100 % of Condition "A" loading on one side of the airplane's plane of symmetry and 70 % on the opposite side.

4.3.3.3 The wing and wing carry-through structures must be designed for the loads resulting from a combination 75 % of the positive maneuvering wing loading on both sides of the plane of symmetry and the maximum wing torsion resulting from aileron displacement. The effect of aileron displacement on wing torsion at V_C or V_A using the basic airfoil moment coefficient modified over the aileron portion of the span, must be computed as follows:

(1) $C_m = C_m + 0.01\ \delta_u$ (up aileron side) wing basic airfoil.

(2) $C_m = C_m - 0.01\ \delta_d$ (down aileron side) wing basic airfoil, where δ_u is the up aileron deflection of δ_d is the down aileron deflection.

4.3.3.4 $\Delta_{critical}$, which is the sum of $\delta_u + \delta_d$, must be computed as follows:

(1) Compute Δ_a and Δ_b from Eq 1 and 2:

$$\Delta_a = V_A/V_C \times \Delta_p, \quad \text{and} \tag{1}$$

$$\Delta_b = 0.5 \times V_A/V_D \times \Delta_p \tag{2}$$

where:

Δ_p = maximum total deflection (sum of both aileron deflections) at V_A with V_A, V_C, and V_D described in 4.2.5.2.

(2) Compute K from Eq 3:

$$K = \frac{(C_m - 0.01\ \delta_b)V_D^2}{(C_m - 0.01\ \delta_a)V_C^2} \tag{3}$$

where:

δ_a = down aileron deflection corresponding to Δ_a, and
δ_b = down aileron deflection corresponding to Δ_b as computed in 4.3.3.4(1).

(3) If K is less than 1.0, Δ_a is $\Delta_{critical}$ and must be used to determine δ_u and δ_d. In this case, V_C is the critical speed that must be used in computing the wing torsion loads over the aileron span.

(4) If K is equal to or greater than 1.0, Δ_b is $\Delta_{critical}$ and must be used to determine $\delta_u + \delta_d$. In this case, V_D is the critical speed that must be used in computing the wing torsion loads over the aileron span.

4.3.4 *Supplementary Conditions, Rear Lift Truss, Engine Torque, Side Load on Engine Mount*—Each of the following supplementary conditions must be investigated:

4.3.4.1 In designing the rear lift truss, the following special condition may be investigated instead of Condition "G" of Fig. 3. The rear lift truss must be deigned for conditions of reversed airflow at a design speed of V = 20 m/s (39 kts). Either aerodynamic data for a particular wing section used, or a value of C_L equaling –0.8 with a chord-wise distribution that is triangular between a peak at the trailing edge and zero at the leading edge, must be used.

4.3.4.2 Each engine mount and its supporting structures must be designed for the maximum limit torque corresponding to maximum expected takeoff power and propeller speed acting simultaneously with the limit loads resulting from the maximum positive maneuvering flight load factor n_1. The limit torque must be obtained from 5.2.9 of Specification F2245.