Designation: F3396/F3396M − 23

Standard Practice for
Aircraft Simplified Loads Criteria[1]

This standard is issued under the fixed designation F3396/F3396M; 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.

1. Scope

1.1 This practice provides an acceptable means of meeting the airworthiness requirements for the flight design loads and conditions of small normal category level 1 and 2 aeroplanes. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on Normal Category aeroplanes. The content may be more broadly applicable; it is the responsibility of the applicant to substantiate broader applicability as a specific means of compliance. The topics covered within this practice are: Simplified Design Load Criteria, Acceptable Methods for Control Surface Loads Calculations, Acceptable Methods for Primary Control System Loads Calculations, and Control Surface Loading (Level 1 Aeroplanes).

1.2 This practice is applicable to normal category, low-speed, level 1 and 2 aeroplanes. Use of the term aeroplane used throughout this practice will mean "normal category, low-speed, level 1 or 2 aeroplane," unless otherwise stated.

1.3 An applicant intending to propose this information as means of compliance for a design approval must seek guidance from their respective oversight authority (for example, published guidance from applicable CAAs) concerning the acceptable use and application thereof. For information on which oversight authorities have accepted this standard (in whole or in part) as an acceptable means of compliance to their regulatory requirements (hereinafter "the Rules"), refer to the ASTM Committee F44 web page (www.astm.org/COMMITTEE/F44.htm).

1.4 This document may present information in either SI units, English Engineering units, or both. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 *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.*

1.6 *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]

F3060 Terminology for Aircraft
F3116/F3116M Specification for Design Loads and Conditions

2.2 *U.S. Code of Federal Regulations:*[3]

14 CFR Part 23 Airworthiness Standards: Normal, Utility, Aerobatic and Commuter Category Airplanes (Amendment 62)

2.3 *European Aviation Safety Agency (EASA) Regulations:*[4]

CS-23, Amendment 4 Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes
CS-VLA, Amendment 1 Certification Specifications for Very Light Aeroplanes

3. Terminology

3.1 A listing of terms, abbreviations, acronyms, and symbols related to aircraft covered by ASTM Committees F37 and F44 airworthiness design standards can be found in Terminology F3060. Items listed below are more specific to this standard.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *chordwise, n*—directed, moving, or placed along the chord of an airfoil section.

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[1] This practice is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.30 on Structures.

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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.

[3] Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

[4] Available from the European Aviation Safety Agency (EASA), Postfach 10 12 53, D-50452 Koeln, Germany, https://www.easa.europa.eu/.

3.2.2 *downwash, n*—the downward deflection of an airstream by an aircraft wing.

3.2.3 *flight envelope, n*—any combination of airspeed and load factor on and within the boundaries of a flight envelope that represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria.

3.2.4 *flight load factor, n*—represents the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the aeroplane) to the weight of the aeroplane. A positive flight load factor is one in which the aerodynamic force acts upward, with respect to the aeroplane.

3.2.5 *propeller slipstream, n*—the airstream pushed back by a revolving aircraft propeller.

3.2.6 *spanwise, n*—directed, moving, or placed along the span of an airfoil.

3.2.7 *winglet, n*—a nearly vertical airfoil at an aeroplane's wingtip.

3.3 *Symbols and Abbreviations:*

3.3.1 C_{NA}—maximum aeroplane normal force coefficient

3.3.2 M_C—design cruising speed (Mach number)

3.3.3 *MCP*—maximum continuous power

3.3.4 n_1—aeroplane positive maneuvering limit load factor

3.3.5 n_2—aeroplane negative maneuvering limit load factor

3.3.6 n_3—aeroplane positive gust limit load factor at V_C

3.3.7 n_4—aeroplane negative gust limit load factor at V_C

3.3.8 n_{flap}—aeroplane positive limit load factor with flaps fully extended at V_F

3.3.9 $V_{A\ min}$—minimum design maneuvering speed = $15.0\sqrt{n_1 W/S}$ knots (however this need not exceed V_C used in design)

3.3.10 $V_{C\ min}$—minimum design cruising speed = $17.0\sqrt{n_1 W/S}$ knots (however this need not exceed $0.9V_H$, see 5.2.5.2)

3.3.11 $V_{D\ min}$—minimum design dive speed = $24.0\sqrt{n_1 W/S}$ knots (however this need not exceed $1.4V_{C\min}\sqrt{n_1/3.8}$)

3.3.12 V_E—design dive speed at zero or negative load factor

3.3.13 $V_{F\ min}$—minimum design flap speed = $11.0\sqrt{n_1 W/S}$ knots

3.3.14 V_{SF}—stalling speed with flaps fully extended

4. Significance and Use

4.1 This practice provides one means for determining the aeroplane structural loads for flight, control surfaces, and control systems. This practice satisfies the simplified loads requirements set forth in Specification F3116/F3116M for Normal Category Aeroplanes.

5. Simplified Design Load Criteria

5.1 *Limitations:*

5.1.1 The methods provided in this section provide one possible means (but not the only possible means) of compliance and can only be applied to Normal Category, low-speed, level 1 and level 2 aeroplanes.

5.1.2 These methods may be applied to aeroplanes meeting the following limitations without further justification:

5.1.2.1 A single engine excluding turbine powerplants.

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

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

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

5.1.2.5 A main wing aspect ratio not greater than 7.0.

5.1.2.6 A main wing that does not have winglets, outboard fins, or other wingtip devices.

5.1.2.7 A horizontal tail aspect ratio not greater than 4.0.

5.1.2.8 A horizontal tail volume coefficient not less than 0.34.

5.1.2.9 A vertical tail aspect ratio not greater than 2.0.

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

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

5.1.3 This section may be used outside of the limitations in 5.1.2 when evidence can be provided that the method provides safe and reliable results.

5.1.4 Aeroplanes with any of the following design features shall not use this section:

5.1.4.1 Canard, tandem-wing, close-coupled, or tailless arrangements of the lifting surfaces;

5.1.4.2 Biplane or multiplane wing arrangements;

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

5.1.4.4 Wings with slatted lifting surfaces; and

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

5.2 *Flight Loads:*

5.2.1 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.

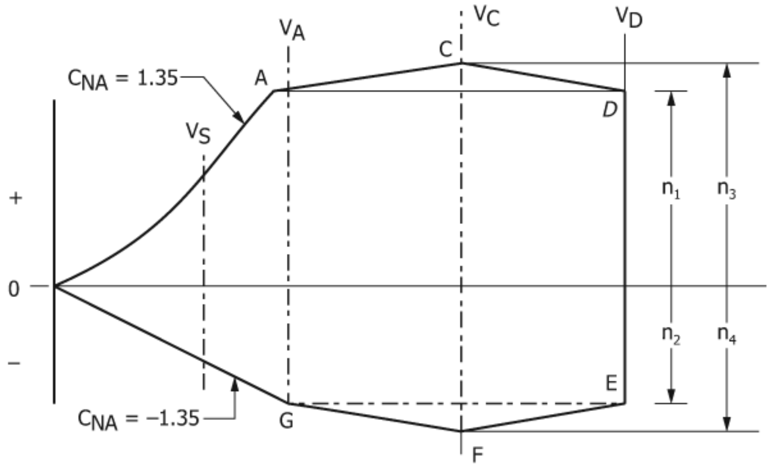
5.2.2 Table 1 must be used to determine values of n_1, n_2, n_3, and n_4, corresponding to the maximum design weights. Fig. 1 presents a generalized flight envelope.

5.2.3 Fig. 2 and Fig. 3 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

TABLE 1 Minimum Design Limit Flight Load Factors

<table>
<tr><th colspan="2">Flight Load Factors</th><th>Not Approved for Aerobatics</th><th>Approved for Aerobatics</th></tr>
<tr><td>Flaps Up</td><td>n_1</td><td>3.8</td><td>6.0</td></tr>
<tr><td></td><td>n_2</td><td colspan="2">–0.5 n_1</td></tr>
<tr><td></td><td>n_3</td><td colspan="2">Find from Fig. 2</td></tr>
<tr><td></td><td>n_4</td><td colspan="2">Find from Fig. 3</td></tr>
<tr><td>Flaps Down</td><td>n_{flap}</td><td colspan="2">0.5 n_1</td></tr>
<tr><td></td><td>n_{flap}</td><td colspan="2">Zero[A]</td></tr>
</table>

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



NOTE 1—Conditions “C” and “F” of Fig. 1 need only be investigated when n_3W/S or n_4W/S are greater than n_1W/S and n_2W/S, respectively.

NOTE 2—Condition “G” need not be investigated when the supplementary condition specified for a rear lift truss is investigated.

FIG. 1 Generalized Flight Envelope

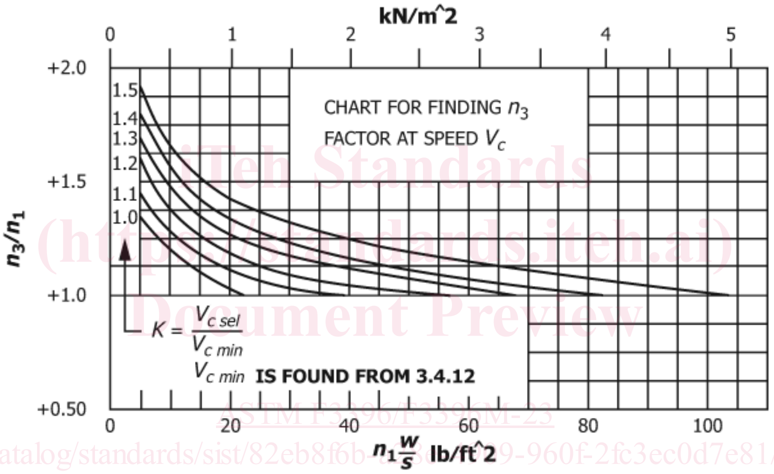


FIG. 2 Chart for Finding n_3 Factor at Speed V_C

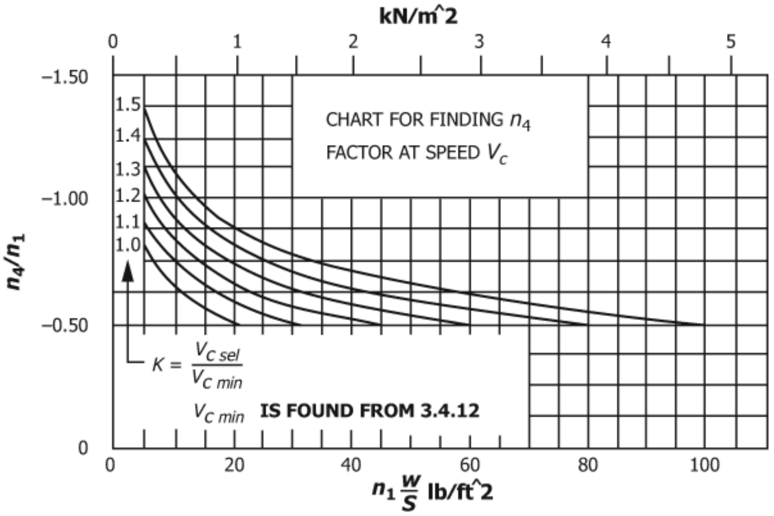


FIG. 3 Chart for Finding n_4 Factor at Speed V_C

design weight, the supporting structure for dead weight items must be substantiated for the resulting higher load factors.

5.2.4 Each specified wing and tail loading is independent of the center of gravity range. However, a center of gravity (c.g.) range must be selected for the aeroplane and the basic fuselage structure must be investigated for the most adverse dead weight loading conditions for the c.g. range selected.

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

5.2.5.1 *Aeroplane 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 aeroplane normal loads (as determined from 5.3.2 and 5.3.3) for the positive flight conditions and a magnitude equal to the aeroplane normal loads for the negative conditions. Each chordwise and normal component of this wing load must be considered.

5.2.5.2 *Minimum Design Airspeeds*—The minimum design airspeeds may not be less than the minimum speeds found in 3.3. In addition, $V_{C\ min}$ need not exceed values of $0.9V_H$ actually obtained at sea level for the lowest design weight for which certification is desired. In computing these minimum design airspeeds, n_1 may not be less than 3.8.

5.2.5.3 *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 aeroplane) to the weight of the aeroplane. A positive flight load factor is an aerodynamic force acting upward, with respect to the aeroplane.

5.3 *Flight Conditions:*

5.3.1 *General*—Each design condition in 5.3.2 and 5.3.3 must be used to assure sufficient strength for each condition of speed and load factor on or within the boundary of a *V-n* diagram for the aeroplane similar to the diagram in Fig. 1. This diagram must also be used to determine the aeroplane structural operating limitations as specified in 14 CFR Part 23, Sec. 23.1501 (c) through 23.1513 and 23.1519.

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

5.3.2.1 The aeroplane must be designed for at least the four basic flight conditions, "A," "D," "E," and "G" as noted on the flight envelope of Fig. 1. In addition, the following requirements apply:

(1) The design limit flight load factors corresponding to conditions "D" and "E" of Fig. 1 must be at least as great as those specified in Table 1 and Fig. 1, and the design speed for these conditions must be at least equal to the value of $V_{D\ min}$ from 3.3.

(2) For conditions "A" and "G" of Fig. 1, the load factors must correspond to those specified in Table 1, and the design speeds must be computed using these load factors with the maximum static lift coefficient C_{NA} determined by the applicant. However, in the absence of more precise computations, these latter conditions may be based on a value of $C_{NA} = \pm 1.35$ and the design speed for condition "A" may be less than $V_{A\ min}$.

(3) Conditions "C" and "F" of Fig. 1 need only be investigated when n_3W/S or n_4W/S are greater than n_1W/S or n_2W/S, respectively.

5.3.2.2 If flaps or other high lift devices intended for use at the relatively low airspeed of approach, landing, and takeoff, are installed, the aeroplane 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 $V_{F\ min}$ from 3.3.

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

5.3.3.1 The aft fuselage-to-wing attachment must be designed for the critical vertical surface load determined in accordance with 6.2.3.1 and 6.2.3.2.

5.3.3.2 The wing and wing carry-through structures must be designed for 100 % of condition "A" loading on one side of the plane of symmetry and 70 % on the opposite side, or 60 % on the opposite side for aeroplanes approved for aerobatics.

5.3.3.3 The wing and wing carry-through structures must be designed for the loads resulting from a combination of 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, C_{mo}, modified over the aileron portion of the span, must be computed as follows:

(1) $C_m = C_{mo} \pm 0.01\ \delta_u$ (up aileron side) wing basic airfoil.

(2) $C_m = C_{mo} \pm 0.01\ \delta_d$ (down aileron side) wing basic airfoil, where δ_u is the up aileron deflection and δ_d is the down aileron deflection.

5.3.3.4 $\Delta_{critical}$, which is the sum of $\delta_u + \delta_d$, must be computed as follows:

(1) Compute Δ_a and Δ_b from the formulas:

$$\Delta_a = \frac{V_A}{V_C} \times \Delta_P \tag{1}$$

$$\Delta_b = 0.5\frac{V_A}{V_D} \times \Delta_P \tag{2}$$

where:

Δ_p = the maximum total deflection (sum of both aileron deflections) at V_A with V_A, V_C, and V_D described in 5.2.5.2.

(2) Compute K from the formula:

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

where:

δ_a = the down aileron deflection corresponding to Δ_a, and

δ_b = the down aileron deflection corresponding to Δ_b as computed in 5.3.3.4*(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 which 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 δ_u and δ_d. In this case, V_D is the critical speed which must be used in computing the wing torsion loads over the aileron span.

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

5.3.4.1 In designing the rear lift truss, the special condition specified in Specification F3116/F3116M may be investigated instead of condition "G" of Fig. 1.

5.3.4.2 Each engine mount and its supporting structures must be designed for:

(1) The maximum limit torque corresponding to maximum take-off power (MTO power) and propeller speed acting simultaneously with 75 % of the limit loads resulting from the maximum positive maneuvering flight load factor n_1.

(2) The maximum limit torque corresponding to MCP (maximum continuous power) and propeller speed acting simultaneously with the limit loads resulting from the maximum positive maneuvering flight load factor n_1; and

(3) The maximum limit torque must be obtained by multiplying the mean torque by a factor of 1.33 for engines with five or more cylinders. For 4, 3, and 2-cylinder engines, the factor must be 2, 3, and 4, respectively.

5.3.4.3 Each engine mount and its supporting structure must be designed for the loads resulting from a lateral limit load factor of not less than 1.47, or 2.0 for aeroplanes approved for aerobatics.

6. Acceptable Methods for Control Surface Loads Calculations

6.1 *Limitations:*

6.1.1 The methods provided in this section provide one possible means (but not the only possible means) of compliance and can only be applied to level 1 and level 2 aeroplanes.

6.1.2 These methods may be applied to aeroplanes meeting the following limitations without further justification:

6.1.2.1 A leading-edge sweep angle (of the control surface) of not more than 15° fore or aft.

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

6.1.2.3 For ailerons and flaps, a main wing that does not have winglets, outboard fins, or other wingtip devices.

6.1.3 Section 6 may be used outside of the limitations in 6.1.2 when evidence can be provided that the method provides safe and reliable results.

6.1.4 Aeroplanes with any of the following design features shall not use this section:

6.1.4.1 For flaps and ailerons, biplane or multiplane wing arrangements.

6.1.4.2 Stabilizers and control surfaces on V-tail arrangements.

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

6.1.4.4 For flaps and ailerons, wings with delta planforms.

6.1.4.5 On surfaces and their associated control surface which employ slatted lifting devices.

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

6.2 *Control Surface Loads:*

6.2.1 *General*—Each control surface load must be determined using the criteria of 6.2.2 and must lie within the simplified loadings of 6.2.3.

6.2.2 *Limit Pilot Forces*—In each control surface loading condition described in 6.2.3 through 6.2.5, the air loads on the movable surfaces and the corresponding deflections need not exceed those which could be obtained in flight by employing the maximum limit pilot forces specified in the table in Specification F3116/F3116M. If the surface loads are limited by these maximum limit pilot forces, the tabs must either be considered to be deflected to their maximum travel in the direction which would assist the pilot, or the deflection must correspond to the maximum degree of "out of trim" expected at the speed for the condition under consideration. The tab load, however, need not exceed the value specified in Table 2.

6.2.3 *Surface Loading Conditions*—Each surface loading condition must be investigated as follows:

6.2.3.1 Simplified limit surface loadings and distributions for the horizontal tail, vertical tail, aileron, wing flaps, and trim tabs are specified in Table 2, Fig. 4, and Fig. 5. If more than one distribution is given, each distribution must be investigated. Fig. 4 is limited to use with vertical tails with aspect ratios less than 2.5, horizontal tails with aspect ratios less than 5, and tail volumes greater than 0.4.

(1) The distribution of load along the span of the surface, irrespective of the chordwise load distribution, must be assumed proportional to the total chord, except on horn balanced surfaces.

(2) The load on the stabilizer and elevator and the load on fin and rudder, must be distributed chordwise as shown in Fig. 6.

(3) In order to ensure adequate torsional strength and also to cover maneuvers and gusts, the most severe loads must be considered in association with every center of pressure position between the leading edge and the half chord of the mean chord of the surface (stabilizer and elevator, or fin and rudder).

(4) To ensure adequate strength under high leading-edge loads, the most severe stabilizer and fin loads must be further considered as being increased by 50 % over the leading 10 % of the chord with the loads aft of this appropriately decreased to retain the same total load.

(5) The most severe elevator and rudder loads should be further considered as being distributed parabolically from three times the mean loading of the surface (stabilizer and elevator, or fin and rudder) at the leading edge of the elevator and rudder, respectively, to zero at the trailing edge according to the following equation (see Fig. 7).

(6) The chordwise loading distribution for ailerons, wing flaps, and trim tabs is specified in Table 2.

TABLE 2 Average Limit Control Surface Loading

NOTE 1—The surface loading of I, II, III, and V are based on speeds $V_{A\ min}$ and $V_{C\ min}$. The loading of IV is based on $V_{F\ min}$. If values of speed greater than these minimums are selected for design, the appropriate surface loadings must be multiplied by the ratio:

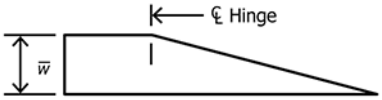
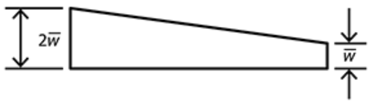
$$\left[\frac{V_{selected}}{V_{minimum}}\right]^2 \tag{4}$$

For conditions I, II, III, and V the multiplying factor used must be the higher of:

$$\left[\frac{V_{A\ selected}}{V_{A\ minimum}}\right]^2 \tag{5}$$

or

$$\left[\frac{V_{C\ selected}}{V_{C\ minimum}}\right]^2 \tag{6}$$

Surface	Direction of Loading	Magnitude of Loading	Chordwise Distribution
Horizontal Tail I	(a) Up and Down (b) Unsymmetrical loading Up and Down	Fig. 4, Curve (2) 100 % w on one side, 65 % w on the other side of aeroplane centerline. For aircraft approved for aerobatics, see 6.2.3.	See Fig. 6
Vertical Tail II	(a) Left and Right	Fig. 4, Curve (1)	See Fig. 6
Aileron III	(a) Up and Down	Fig. 5, Curve (5)	(C) 
Wing Flap IV	(a) Up (b) Down	Fig. 5, Curve (4) 0.25 x Up Load	(D) 
Trim Tab V	(a) Up and Down	Fig. 5, Curve (3)	Same as D above

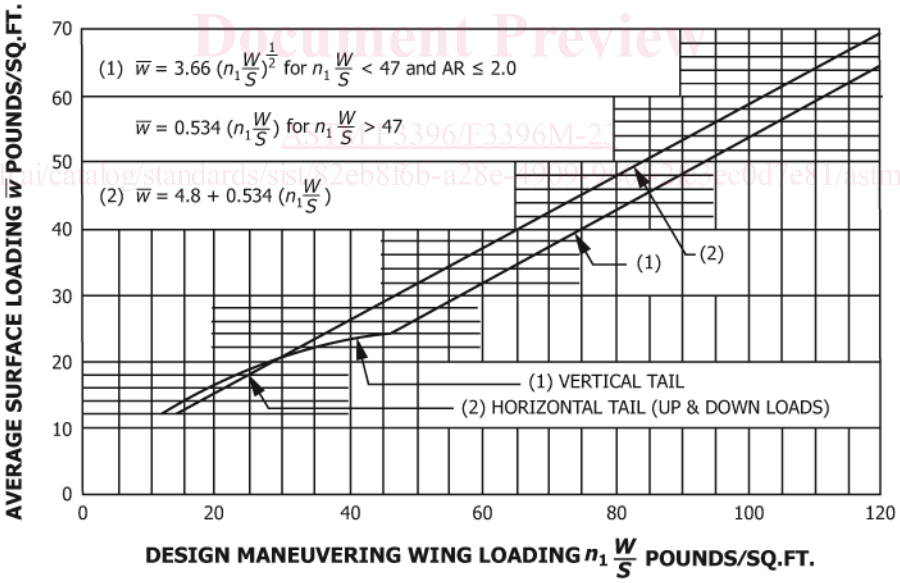


FIG. 4 Average Limit Control Surface Loading

6.2.3.2 For aeroplanes approved for aerobatics, the horizontal tail must be investigated for an unsymmetrical load of 100 % w̄ on one side of the aeroplane centerline and 50 % on the other side of the aeroplane centerline.

6.2.4 *Outboard Fins*—Outboard fins must meet the requirements of Specification F3116/F3116M.

6.2.5 *T- and V-Tails*—T- and V-tails must meet the requirements of Specification F3116/F3116M.