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Standard Specification for Design Loads and Conditions[1]

This standard is issued under the fixed designation F3116/F3116M; 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 specification addresses the airworthiness requirements for the design loads and conditions of small airplanes.

1.2 This specification is applicable to small airplanes as defined in the F44 terminology standard. Use of the term airplane is used throughout this specification and will mean "small airplane."

1.3 The applicant for a design approval must seek individual guidance from their respective CAA body concerning the use of this standard as part of a certification plan. For information on which CAA regulatory bodies have accepted this standard (in whole or in part) as a means of compliance to their Small Airplane Airworthiness Rules (hereinafter referred to as "the Rules"), refer to ASTM F44 webpage (www.ASTM.org/COMMITTEE/F44.htm) which includes CAA website links.

1.4 *Units*—Currently there is a mix of SI and Imperial units. In many locations, SI units have been included otherwise units are as they appear in Amendment 62 of 14 CFR Part 23. In a future revision values will be consistently stated in SI units followed by Imperial units in square brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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
F3331 Practice for Aircraft Water Loads
F3396/F3396M Practice for Aircraft Simplified Loads Criteria

2.2 *U.S. Code of Federal Regulations:*[3]
14 CFR Part 23 Airworthiness Standards: Normal, Utility, Aerobatic and Commuter Category Airplanes (Amendment 62)

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[1] This specification 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.

2.3 *European Aviation Safety Agency Regulations:*[4]
Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes (CS-23, Amendment 3)
Certification Specifications for Very Light Aeroplanes (CS-VLA, Amendment 1)

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.

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 airplane) to the weight of the airplane. A positive flight load factor is one in which the aerodynamic force acts upward, with respect to the airplane.

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 airplane's wingtip.

3.3 *Acronyms:*

3.3.1 *MCP*—maximum continuous power

3.4 *Symbols:*
C_{NA} = maximum airplane normal force coefficient
M_C = design cruising speed (Mach number)
V_E = design dive speed at zero or negative load factor
V_{SF} = stalling speed with flaps fully extended

4. Flight Loads

4.1 *Loads:*

4.1.1 Unless otherwise provided, prescribed loads are limit loads.

4.1.2 Unless otherwise provided, the 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 on canard and tandem wing configurations must be validated by flight test measurement unless the methods used for determining those loading conditions are shown to be reliable or conservative on the configuration under consideration.

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

4.1.4 Practice F3396/F3396M provides, within the limitations specified within this practice, a simplified means of compliance with several of the requirements set forth in 4.2 to 4.26 and 7.1 to 7.9 that can be applied as one (but not the only) means to comply.

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

4.2 *General:*

4.2.1 Flight load factors, *n*, 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 one in which the aerodynamic force acts upward, with respect to the airplane.

4.2.2 Compliance with the flight load requirements of this subpart must be shown:

4.2.2.1 At each critical altitude within the range in which the airplane may be expected to operate;

4.2.2.2 At each weight from the design minimum weight to the design maximum weight; and

4.2.2.3 For each required altitude and weight, for any practicable distribution of disposable load within the operating limitations specified in 14 CFR Part 23, Sections 23.1583 through 23.1589.

4.2.3 When significant, the effects of compressibility must be taken into account.

4.3 *Symmetrical Flight Conditions:*

4.3.1 The appropriate balancing horizontal tail load must be accounted for in a rational or conservative manner when determining the wing loads and linear inertia loads corresponding to any of the symmetrical flight conditions specified in 4.4 through 4.6.

4.3.2 The incremental horizontal tail loads due to maneuvering and gusts must be reacted by the angular inertia of the airplane in a rational or conservative manner.

4.3.3 Mutual influence of the aerodynamic surfaces must be taken into account when determining flight loads.

4.4 *Flight Envelope:*

4.4.1 *General*—Compliance with the strength requirements of this subpart must be shown at any combination of airspeed and load factor on and within the boundaries of a flight envelope (similar to the one in 4.4.4) that represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria of 4.4.2 and 4.4.3 respectively.

4.4.2 *Maneuvering Envelope*—Except where limited by maximum (static) lift coefficients, the airplane is assumed to be subjected to symmetrical maneuvers resulting in the following limit load factors:

4.4.2.1 The positive maneuvering load factor specified in 4.5 at speeds up to V_D;

4.4.2.2 The negative maneuvering load factor specified in 4.5 at V_C; and

4.4.2.3 Factors varying linearly with speed from the specified value at V_C to 0.0 at V_D. For airplanes with a positive limit maneuvering load factor greater than 3.8, use a value of –1.0 at V_D.

4.4.3 *Gust Envelope:*

4.4.3.1 The airplane is assumed to be subjected to symmetrical vertical gusts in level flight. The resulting limit load factors must correspond to the conditions determined as follows:

(1) Positive (up) and negative (down) gusts of 15.24 m/s [50 fps] at V_C must be considered at altitudes between sea level and 6096 m [20 000 ft]. The gust velocity may be reduced linearly from 15.24 m/s [50 fps] at 6096 m [20 000 ft] to 7.62 m/s [25 fps] at 15 240 m [50 000 ft]; and

(2) Positive and negative gusts of 7.62 m/s [25 fps] at V_D must be considered at altitudes between sea level and 6096 m [20 000 ft]. The gust velocity may be reduced linearly from 7.62 m/s [25 fps] at 6096 m [20 000 ft] to 3.81 m/s [12.5 fps] at 15 240 m [50 000 ft].

(3) In addition, for level 4 airplanes, positive (up) and negative (down) rough air gusts of 20.12 m/s [66 fps] at V_B must be considered at altitudes between sea level and 6096 m [20 000 ft]. The gust velocity may be reduced linearly from 20.12 m/s [66 fps] at 6096 m [20 000 ft] to 11.58 m/s [38 fps] at 15 240 m [50 000 ft].

4.4.3.2 The following assumptions must be made:

(1) The shape of the gust is:

$$U = \frac{U_{de}}{2}\left(1 - \cos\frac{2\pi s}{25C}\right) \quad (1)$$

where:

s = distance penetrated into gust (m or [ft]);
C = mean geometric chord of wing (m or [ft]); and
U_{de} = derived gust velocity referred to in 4.4.3.1 (m/s or [fps]).

(2) Gust load factors vary linearly with speed between V_C and V_D.

4.4.4 *Flight Envelope*—See Fig. 1.

4.5 *Limit Maneuvering Load Factors:*

4.5.1 The positive limit maneuvering load factor n may not be less than:

4.5.1.1 $2.1+\frac{24{,}000}{W+10{,}000}$, where W = design maximum takeoff weight (lb), except that n need not be more than 3.8;

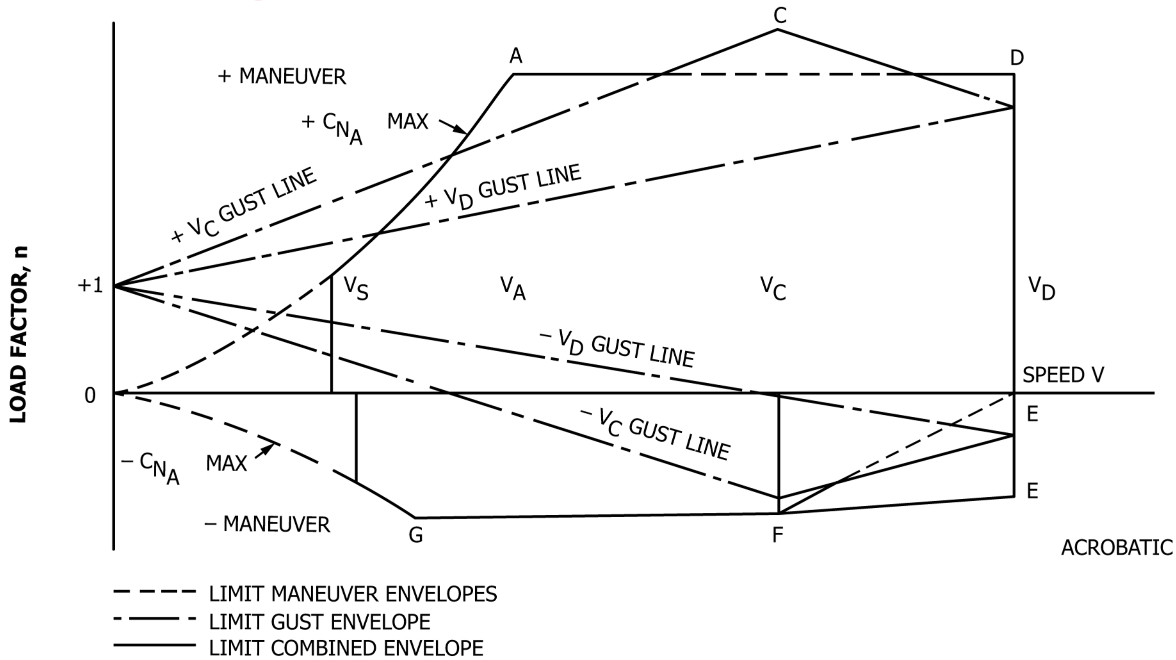
4.5.1.2 6.0 for airplanes approved for aerobatics.

4.5.2 The negative limit maneuvering load factor may not be less than:

4.5.2.1 0.4 times the positive load factor;

4.5.2.2 0.5 times the positive load factor for airplanes approved for aerobatics.

4.5.3 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.



NOTE 1—Point G need not be investigated when the supplementary condition specified in 4.14 is investigated.

FIG. 1 Flight Envelope

4.6 *Gust Load Factors:*

4.6.1 Each airplane must be designed to withstand loads on each lifting surface resulting from gusts specified in 4.4.3.

4.6.2 The gust load factors for a canard or tandem wing configuration must be computed using a rational analysis, or may be computed in accordance with 4.6.3, provided that the resulting net loads are shown to be conservative with respect to the gust criteria of 4.4.3.

4.6.3 In the absence of a more rational analysis, the gust load factors must be computed as follows:

$$n = 1 + \frac{K_g U_{de} V a}{498\left(\frac{W}{S}\right)} \quad (2)$$

where:

$K_g = \frac{0.88\mu_g}{5.3+\mu_g}$	=	gust alleviation factor;
$\mu_g = \frac{2(W/S)}{\rho C a g}$	=	airplane mass ratio;
U_{de}	=	derived gust velocities referred to in 4.4.3 (fps).
ρ	=	density of air (slugs/ft^3);
W/S	=	wing loading (psf) due to the applicable weight of the airplane in the particular load case;
C	=	mean geometric chord (ft);
g	=	acceleration due to gravity (ft/s^2);
V	=	airplane equivalent speed (knots); and
a	=	slope of the airplane normal force coefficient curve C_{NA} per radian if the gust loads are applied to the wings and horizontal tail surfaces simultaneously by a rational method. The wing lift curve slope C_L per radian may be used when the gust load is applied to the wings only and the horizontal tail gust loads are treated as a separate condition.

4.7 *Design Fuel Loads:*

4.7.1 The disposable load combinations must include each fuel load in the range from zero fuel to the selected maximum fuel load.

4.7.2 If fuel is carried in the wings, the maximum allowable weight of the airplane without any fuel in the wing tank(s) must be established as "maximum zero wing fuel weight," if it is less than the maximum weight.

4.7.3 For level 4 airplanes, a structural reserve fuel condition, not exceeding fuel necessary for 45 min of operation at maximum continuous power, may be selected. 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 prescribed in this part and:

4.7.3.1 The structure must be designed to withstand a condition of zero fuel in the wing at limit loads corresponding to:
(1) 90 % of the maneuvering load factors defined in 4.5, and
(2) Gust velocities equal to 85 % of the values prescribed in 4.4.3.

4.7.3.2 The fatigue evaluation of the structure must account for any increase in operating stresses resulting from the design condition of 4.7.3.1.

4.7.3.3 The flutter, deformation, and vibration requirements must also be met with zero fuel in the wings.

4.8 *High Lift Devices:*

4.8.1 If wing flaps or similar high lift devices are installed for use in take-off, approach, or landing, the airplane, with the flaps fully deflected at V_F, is assumed to be subjected to symmetrical maneuvers and gusts resulting in limit load factors within the range determined by:

4.8.1.1 Maneuvering, to a positive limit load factor of 2.0; and

4.8.1.2 Positive and negative gust of 7.62 m⁄s [25 fps] acting normal to the flight path in level flight.

4.8.1.3 However, if an automatic flap load limiting device is used, the airplane may be designed for the critical combinations of airspeed and flap position allowed by that device.

4.8.2 V_F must be assumed to be not less than 1.4 V_S or 1.8 V_{SF}, whichever is greater, where:

4.8.2.1 V_S is the 1g computed stalling speed with flaps retracted at the design weight; and

4.8.2.2 V_{SF} is the 1g computed stalling speed with flaps fully extended at the design weight.

4.8.3 In determining external loads on the airplane as a whole, thrust, slipstream, and pitching acceleration may be assumed to be zero.

4.8.4 The flaps, their operating mechanism, and their supporting structures, must be designed for the conditions prescribed in 4.8.1. In addition, with the flaps fully extended at V_F, the following conditions, taken separately, must be accounted for:

4.8.4.1 A head-on gust having a velocity of 7.62 m/s [25 fps] (EAS), combined with propeller slipstream corresponding to 75 % of maximum continuous power; and

4.8.4.2 The effects of propeller slipstream corresponding to maximum takeoff power.

4.8.4.3 For the investigation of slipstream effects, the load factor may be assumed to be 1.0.

4.9 *Unsymmetrical Flight Conditions:*

4.9.1 The airplane is assumed to be subjected to the unsymmetrical flight conditions of 4.10 and 4.11. 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.

4.9.2 Airplanes approved for aerobatics must be designed for additional asymmetric loads acting on the wing and the horizontal tail.

4.10 *Rolling Conditions*—The wing and wing bracing must be designed for the following loading conditions:

4.10.1 Unsymmetrical wing loads. Unless the following values result in unrealistic loads, the rolling accelerations may be obtained by modifying the symmetrical flight conditions in 4.4.4 as follows:

4.10.1.1 In Condition A, assume that 100 % of the semispan wing airload acts on one side of the airplane and 70 % of this load acts on the other side. For airplanes of more than 454 kg [1000 lb] design weight, the latter percentage may be increased linearly with weight up to 75 % at 5670 kg [12 500 lb].

4.10.1.2 For airplanes approved for aerobatics, in conditions A and F, assume that 100 % of the semispan wing airload acts on one side of the plane of symmetry and 60 % of this load acts on the other side.

4.10.2 The loads resulting from the aileron deflections and speeds specified in 4.25, in combination with an airplane load factor of at least two thirds of the positive maneuvering load factor used for design. Unless the following values result in unrealistic loads, the effect of aileron displacement on wing torsion may be accounted for by adding the following increment to the basic airfoil moment coefficient over the aileron portion of the span in the critical condition determined in 4.4.4:

$$\Delta c_m = -0.01\delta \tag{3}$$

where:

Δc_m = the moment coefficient increment; and
δ = the down aileron deflection in degrees in the critical condition.

4.11 *Yawing Conditions*—The airplane must be designed for yawing loads on the vertical surfaces resulting from the loads specified in 4.20 through 4.22.

4.12 *Pressurized Cabin Loads*—For each pressurized compartment, the following applies:

4.12.1 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.

4.12.2 The external pressure distribution in flight, and any stress concentrations, must be accounted for.

4.12.3 If landings may be made with the cabin pressurized, landing loads must be combined with pressure differential loads from zero up to the maximum allowed during landing.

4.12.4 The airplane structure must be strong enough to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33, omitting other loads.

4.12.5 If a pressurized cabin has two or more compartments separated by bulkheads or a floor, the primary structure must be designed for the effects of sudden release of pressure in any compartment with external doors or windows. This condition must be investigated for the effects of failure of the largest opening in the compartment. The effects of intercompartmental venting may be considered.

4.13 *Unsymmetrical Loads Due to Engine Failure:*

4.13.1 Multi-engine airplanes must be designed for the unsymmetrical loads resulting from the failure of the critical engine including the following conditions in combination with a single malfunction of the propeller drag limiting system, considering the probable pilot corrective action on the flight controls:

4.13.1.1 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.

4.13.1.2 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.

4.13.1.3 The time history of the thrust decay and drag buildup occurring as a result of the prescribed engine failures must be substantiated by test or other data applicable to the particular engine-propeller combination.

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

4.13.2 Pilot corrective action may be assumed to be initiated at the time maximum yawing velocity is reached, but not earlier than 2 s after the engine failure. The magnitude of the corrective action may be based on the limit pilot forces specified in 7.4 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.

4.14 *Rear Lift Truss:*

4.14.1 If a rear lift truss is used, it must be designed for conditions of reversed airflow at a design speed of:

$$V = 8.7\sqrt{\frac{W}{S}} + 8.7(\text{knots}) \quad (4)$$

where:

W/S = wing loading (lb/ft^2) at design maximum takeoff weight.

4.14.2 Either aerodynamic data for the particular wing section used, or a value of C_L equalling –0.8 with a chordwise distribution that is triangular between a peak at the trailing edge and zero at the leading edge, must be used.

4.15 *Speed Control Devices*—If speed control devices (such as spoilers and drag flaps) are incorporated for use in enroute conditions:

4.15.1 The airplane must be designed for the symmetrical maneuvers and gusts prescribed in 4.4, 4.5, and 4.6, and the yawing maneuvers and lateral gusts in 4.20 and 4.21, with the device extended at speeds up to the placard device extended speed; and

4.15.2 If the device has automatic operating or load limiting features, the airplane must be designed for the maneuver and gust conditions prescribed in 4.15.1 at the speeds and corresponding device positions that the mechanism allows.

4.16 *Balancing Loads:*

4.16.1 A horizontal surface balancing load is a load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.

4.16.2 Horizontal balancing surfaces must be designed for the balancing loads occurring at any point on the limit maneuvering envelope and in the flap conditions specified in 4.8.

4.16.3 For airplanes meeting the limitations of Practice F3396/F3396M, Control Surface Loading (Level 1 Aeroplanes), the distribution of horizontal tail balancing loads, Practice F3396/F3396M, *Tail Surface Balancing and Maneuvering Load Distribution*, may be used.

4.17 *Maneuvering Loads for Horizontal Surfaces*—Each horizontal surface and its supporting structure, and the main wing of a canard or tandem wing configuration, if that surface has pitch control, must be designed for the maneuvering loads imposed by conditions 4.17.1 and 4.17.2. For airplanes meeting the limitations of Practice F3396/F3396M, Control Surface Loading (Level 1 Aircraft), either the condition of 4.17.3 or 4.17.4 can be used instead of the loads determined in conditions 4.17.1 and 4.17.2.

4.17.1 A sudden movement of the pitching control at the speed V_A,

4.17.1.1 to the maximum aft movement (upward deflection), and

4.17.1.2 the maximum forward movement (downward deflection), as limited by the control stops, or pilot effort, whichever is critical.

4.17.1.3 For airplanes meeting the limitations of Practice F3396/F3396M, Control Surface Loading (Level 1 Aeroplane), the average loading of Practice F3396/F3396M, *Acceptable Methods for Control Surface Loads Calculations, Control Surface Loads* and the distribution for horizontal tail surfaces, Practice F3396/F3396M, *Tail Surface, Horizontal Down Load Distribution*, may be used.

4.17.2 A sudden aft movement of the pitching control at speeds above V_A, followed by a forward movement of the pitching control resulting in the following combinations of normal and angular acceleration:

Condition	Normal acceleration (n)	Angular acceleration (radian/s^2)
Nose-up pitching (down load)	1.0	$+\frac{39}{V}n_m(n_m - 1.5)$
Nose-down pitching (up load)	n_m	$-\frac{39}{V}n_m(n_m - 1.5)$

where:

n_m = positive limit maneuvering load factor used in the design of the airplane; and
V = initial speed in knots.

4.17.2.1 The conditions in this section involve loads corresponding to the loads that may occur in a "checked maneuver" (a maneuver in which the pitching control is suddenly displaced in one direction and then suddenly moved in the opposite direction). The deflections and timing of the "checked maneuver" must avoid exceeding the limit maneuvering load factor. The total horizontal surface load for both nose-up and nose-down pitching conditions is the sum of the balancing loads at V and the specified value of the normal load factor n, plus the maneuvering load increment due to the specified value of the angular acceleration. For airplanes meeting the limitations of Practice F3396/F3396M, Control Surface Loading (Level 1 Aeroplanes), the maneuvering load increment in Practice F3396/F3396M, *Maneuvering Tail Load Increment (Up or Down)* and; for Down Loads, the distributions for horizontal tail surfaces, Practice F3396/F3396M, *Tail Surface, Horizontal Down Load Distribution* may be used. For Up Loads, the distributions for vertical tail surfaces, Practice F3396/F3396M, *Tail Surface Vertical and Horizontal Up Load Distribution* may be used.

4.17.3 A sudden deflection of the elevator, the following cases must be considered:

4.17.3.1 Speed V_A, maximum upward deflection;

4.17.3.2 Speed V_A, maximum downward deflection;

4.17.3.3 Speed V_D, one-third maximum upward deflection;

4.17.3.4 Speed V_D, one-third maximum downward deflection.

4.17.3.5 The following assumptions must be made:

(1) The airplane is initially in level flight, and its attitude and air speed do not change.

(2) The loads are balanced by inertia forces.

A sudden deflection of the elevator such as to cause the normal acceleration to change from an initial value to a final value, the following cases being considered (see Fig. 2):

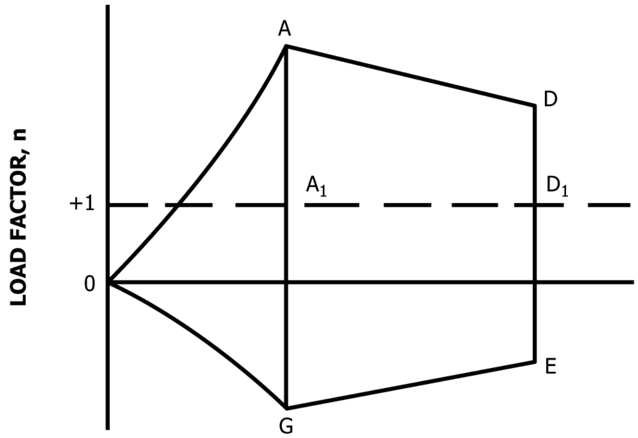


FIG. 2 Pitching Maneuvers

Speed	Initial Condition	Final Condition	Load Factor Increment
V_A	A_1	A	$n1 - 1$
	A	A_1	$1 - n1$
	A_1	G	$n4 - 1$
	G	A_1	$1 - n4$
V_D	D_1	D	$n2 - 1$
	D	D_1	$1 - n2$
	D_1	E	$n3 - 1$
	E	D_1	$1 - n3$

4.17.4 For the purpose of this calculation, the difference in air speed between V_A and the value corresponding to point G on the maneuvering envelope can be ignored. The following assumptions must be made:

4.17.4.1 The airplane is initially in level flight, and its attitude and airspeed do not change;

4.17.4.2 The loads are balanced by inertia forces;

4.17.4.3 The aerodynamic tail load increment is given by:

$$\Delta P = \Delta n M g \left[\frac{X_{cg}}{l_t} - \frac{S_{ht}}{S} \frac{a_{ht}}{a} \left(1 - \frac{d\epsilon}{d\alpha} \right) - \frac{\rho_0}{2} \left(\frac{S_{ht} a_{ht} l_t}{M} \right) \right] \quad (5)$$

where:

ΔP = horizontal tail load increment, positive upwards (N),
Δn = load factor increment,
M = mass of the airplane (kg),
g = acceleration due to gravity (m/s^2),
X_{cg} = longitudinal distance of airplane c.g. aft of aerodynamic center of airplane less horizontal tail (m),
S_{ht} = horizontal tail area (m^2),
a_{ht} = slope of horizontal tail lift curve per radian,
$\frac{d\epsilon}{d\alpha}$ = rate of change of downwash angle with angle of attack,
ρ_0 = density of air at sea-level (kg/m^3),
l_t = tail arm (m),
S = wing area (m^2), and
a = slope of wing lift curve per radian.

4.18 *Gust Loads for Horizontal Surfaces:*

4.18.1 Each horizontal surface, other than a main wing, must be designed for loads resulting from:

4.18.1.1 Gust velocities specified in 4.4.3 with flaps retracted; and