Designation: F3116/F3116M – 23

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 nonconformance 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)

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

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

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.

4.2 *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.

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.

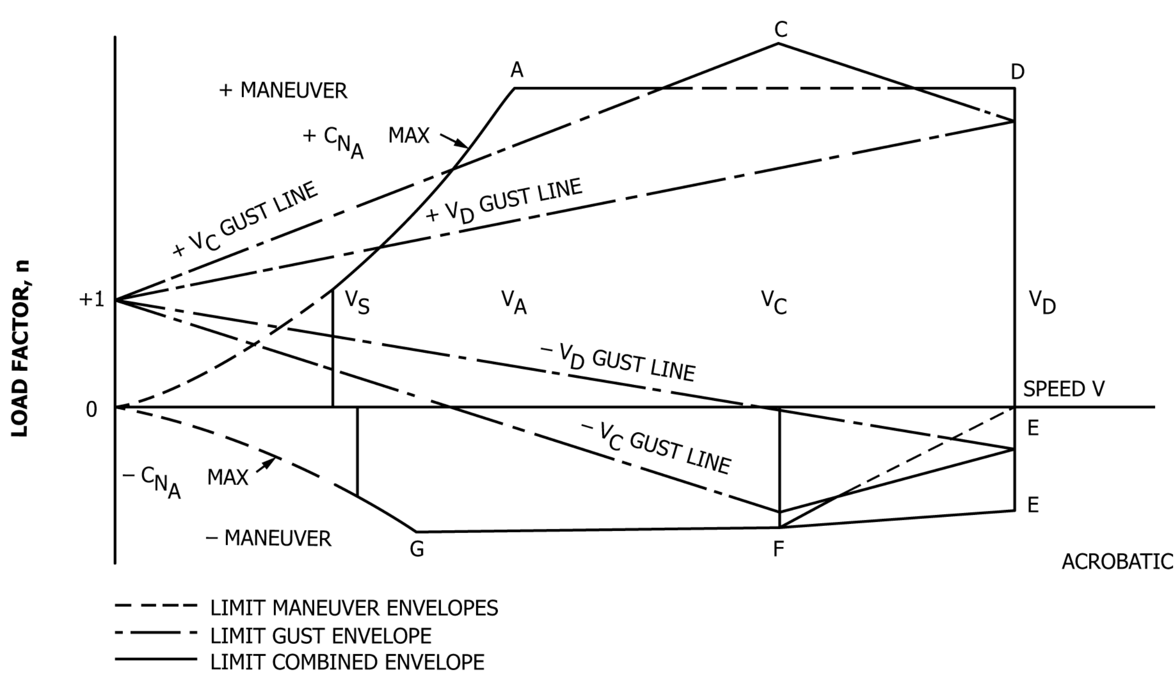
4.6.2 The gust load factors for a canard or tandem wing configuration must be computed using a rational analysis, or may be computed in accordance with 4.6.3, provided that the resulting net loads are shown to be conservative with respect to the gust criteria of 4.4.3.

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.



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

FIG. 1 Flight Envelope