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Standard Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems[1]

This standard is issued under the fixed designation F3563; 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 *Applicability:*

1.1.1 This specification identifies the industry standards that have been determined by consensus to demonstrate compliance to the requirements ("the Rules") for Unmanned Aircraft Systems (UAS).

1.1.2 This specification does not apply to UAS carrying passengers or crew.

1.1.3 The following are outside the scope of this Design and Construction Specification: Vertical Takeoff and Landing (VTOL) or Hybrid Aircraft, Passenger or Crew Carrying UAS, Seaplanes or Amphibians, UAS Certified for Acrobatic Flight, Lightweight UAS that fall under Specification F3298, Recreational UAS (Model Aircraft), Detect and Avoid Systems, Control Station Specifics to Human Factors, Building Codes that apply to Ground Control Stations, and Command and Control Link.

1.1.4 Only standards that are considered mature enough for general application to certification projects and have been found acceptable by committee consensus to propose to the civil aviation authorities (CAAs) for acceptance as a Means of Compliance (MoC) to their Rules are included.

1.1.5 In the event that a particular CAA's requirements are not harmonized with the other CAA's requirements, the standards will be written to include the non-harmonized requirements as well as the harmonized requirements with the applicability defined in the standard.

1.2 *Civil Aviation Authorities*—CAAs may accept a specific revision of this specification as an acceptable MoC to their requirements. Acceptance and applicability as an MoC to the CAA's airworthiness rules remains the decision of the respective CAAs. CAAs may accept this specification, with or without limitations as defined in their specification acceptance document. For information on which CAAs have accepted these standards (in whole or in part) as an acceptable MoC to their Rules, refer to the ASTM Committee F44 (General Aviation), ASTM Committee F38 (Unmanned Aerial Systems) or ASTM Committee F39 (Aircraft Systems) webpages (www.astm.org/COMMITTEE/F44.htm, www.astm.org/COMMITTEE/F38.htm, www.astm.org/COMMITTEE/F39.htm), which include CAA website links.

1.3 *Applicant Responsibility*—The applicant must seek individual guidance from their respective CAA concerning the use of this specification and any referenced Specifications, Practices, Test Methods, or Guides to show compliance to the CAA rules. Alternatively, an applicant may propose an MoC other than those included in this specification, but it is their responsibility to obtain acceptance of their proposed MoC from their CAA.

1.4 This specification is based heavily on the ASTM Committee F44 General Aviation means of compliance guidelines. Unmanned Aircraft System specific guidance is provided below for areas where considerations specific to the unmanned application of aircraft differs from traditional manned aircraft specification or certification requirements. ASTM F3264–18b, Standard Specification for Normal Category Aeroplanes Certification, from the Committee F44 General Aviation group was used as the starting point with referenced ASTM F44 MoC Specification referenced throughout. The referenced F44 standard is to be used as is except in the areas where UAS-specific changes to standard MoC practices have been identified. These changes are identified in the following manner:

1.4.1 *Unique Addition for UAS*—New UAS-specific MoC added in addition to standard MoC in areas where new UAS functionality is introduced.

1.4.2 *Substitutions for UAS*—Modification of standard MoC to create similar UAS-specific MoCs.

1.4.3 *Not Applicable for UAS*—MoCs not needed for Unmanned Aircraft or Remote Pilot Station.

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*

[1] This specification is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.01 on Airworthiness.

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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]

NOTE 1—Referenced ASTM standards are listed in Sections 5 – 12 of this specification.

F2490 Guide for Aircraft Electrical Load and Power Source Capacity Analysis
F3060 Terminology for Aircraft
F3061/F3061M Specification for Systems and Equipment in Aircraft
F3062/F3062M Specification for Aircraft Powerplant Installation
F3063/F3063M Specification for Aircraft Fuel Storage and Delivery
F3064/F3064M Specification for Aircraft Powerplant Control, Operation, and Indication
F3065/F3065M Specification for Aircraft Propeller System Installation
F3066/F3066M Specification for Aircraft Powerplant Installation Hazard Mitigation
F3082/F3082M Specification for Weights and Centers of Gravity of Aircraft
F3083/F3083M Specification for Emergency Conditions, Occupant Safety and Accommodations
F3093/F3093M Specification for Aeroelasticity Requirements
F3114 Specification for Structures
F3115/F3115M Specification for Structural Durability for Small Aeroplanes
F3116/F3116M Specification for Design Loads and Conditions
F3117/F3117M Specification for Crew Interface in Aircraft
F3120/F3120M Specification for Ice Protection for General Aviation Aircraft
F3173/F3173M Specification for Aircraft Handling Characteristics
F3174/F3174M Specification for Establishing Operating Limitations and Information for Aeroplanes
F3179/F3179M Specification for Performance of Aircraft
F3180/F3180M Specification for Low-Speed Flight Characteristics of Aircraft
F3227/F3227M Specification for Environmental Systems in Aircraft
F3228 Specification for Flight Data and Voice Recording in Small Aircraft
F3229/F3229M Practice for Static Pressure System Tests in Small Aircraft
F3230 Practice for Safety Assessment of Systems and Equipment in Small Aircraft
F3231/F3231M Specification for Electrical Systems for Aircraft with Combustion Engine Electrical Power Generation
F3232/F3232M Specification for Flight Controls in Small Aircraft
F3233/F3233M Specification for Flight and Navigation Instrumentation in Aircraft
F3234/F3234M Specification for Exterior Lighting in Small Aircraft
F3235 Specification for Aircraft Storage Batteries
F3236 Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft
F3239 Specification for Aircraft Electric Propulsion Systems
F3254 Specification for Aircraft Interaction of Systems and Structures
F3264 Specification for Normal Category Aeroplanes Certification
F3298 Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)
F3309/F3309M Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft
F3316/F3316M Specification for Electrical Systems for Aircraft with Electric or Hybrid-Electric Propulsion
F3331 Practice for Aircraft Water Loads
F3341/F3341M Terminology for Unmanned Aircraft Systems
F3367 Practice for Simplified Methods for Addressing High-Intensity Radiated Fields (HIRF) and Indirect Effects of Lightning on Aircraft

2.2 *European Aviation Safety Agency (EASA) Regulations:*[3]

CS 23, Amendment 5 Certification Specifications for Normal Category Aeroplanes

2.3 *Federal Aviation Administration (FAA) Regulations:*

14 CFR 23, Amendment 64 Airworthiness Standards: Normal Category Airplanes[4]
DOT/FAA/AR-00 Aircraft Materials Fire Test Handbook[5]

NOTE 2—The above regulations and requirements are not directly referenced in the specification but are the "relevant applicable regulations" referred to in the *Rules* definition in 3.2.2.

3. Terminology

3.1 *Unique and Common Terminology*—Terminology used in multiple standards is defined in F3341/F3341M, UAS Terminology Standard, and F3060, Aircraft Terminology Standard. Terminology that is unique to this specification is defined in this section.

3.2 *Definitions:*

3.2.1 *Means of Compliance (MoC), n*—a method or process that is used to show that a rule has been complied with through either design, analysis, test, or a combination of design, analysis, and test.

[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 European Union Aviation Safety Agency (EASA), Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, https://www.easa.europa.eu/document-library/certification-specifications/cs-23-amendment-5.

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

[5] Available from https://www.regulations.gov/.

3.2.2 *Rules, n*—universal reference to the relevant applicable regulations or standards governing airworthiness requirements for Normal Category Aeroplanes issued by the CAAs.

3.3 *Abbreviations:*

3.3.1 *CAA, n*—Civil Aviation Authority

3.3.2 *MoC, n*—Means of Compliance

3.3.3 *UA, n*—Unmanned Aircraft

3.3.4 *UAS, n*—Unmanned Aircraft System

3.3.5 *RPS, n*—Remote Pilot Station

4. General

4.1 *Regulatory Applicability and Definitions:*

4.1.1 See the applicable CAA Rules for specific CAA's Applicability and Definitions. There are currently no standards written or anticipated for these requirements.

UAS Modification	Continued safe flight and landing is a condition whereby a UA is capable of continued controlled flight, and landing at a suitable location, possibly using emergency or abnormal procedures, without requiring exceptional pilot skill. Some UA damage may be associated with a failure condition during flight or upon landing.
UAS Change	Due to pilot not being onboard the aircraft and subjected to aerodynamic forces as well the reliance on flight control systems, pilot strength has no correlation to control of vehicle.

NOTE 3—Mentions of pilot strength removed throughout due to pilot not needing to overcome onboard aerodynamic forces.

4.2 *Certification of Normal Category UAS:*

4.2.1 This specification will identify in Sections 5 – 12 the modifications required to make Committee F44 and the referenced standards that are applicable for certification of a fixed-wing *UA* of a Part 23 design in the normal category and the *RPS* that controls it.

4.2.2 UA performance levels are:

4.2.2.1 *Low Speed*—For UA with a V_{NO} and $V_{MO} \leq 250$ Knots Calibrated Airspeed (KCAS) and an $M_{MO} \leq 0.6$.

4.2.2.2 *High Speed*—For UA with a V_{NO} or $V_{MO} > 250$ KCAS or an $M_{MO} > 0.6$.

4.2.3 UA not certified for aerobatics may be used to perform any maneuver incident to normal flying, including:

4.2.3.1 Stalls (except whip stalls); and

4.2.3.2 Lazy eights, chandelles, and steep turns in which the angle of bank is not more than 60 degrees.

4.2.4 This specification will identify in Sections 11 and 12 the modifications required to make Committee F44 and the referenced standards applicable for the design and construction of a Remote Pilot Station.

4.2.5 This specification will identify in Appendix X1 other considerations applicable to UAS that an applicant will be expected to address.

5. Flight

5.1 *Weight/Mass and Center of Gravity:*

5.1.1 F3082/F3082M–17 Standard Specification for Weights and Centers of Gravity of Aircraft

Unique Additions for UAS—Add the following UAS-specific considerations to Specification F3082/F3082M:

4.1.1.3 Where appropriate and agreed upon by the Certification Authority, simulations (physical or computer) done upon the type and configuration of the aircraft. Note: 4.1.1.3 is added in addition to 4.1.1.1 and 4.1.1.2 [AND].

4.4.1.4 The payload or load configuration specified by the Applicant and agreed to by the Certifying Authority.

Substitutions for UAS—Replace the existing 4.4.1.3 with the following:

4.4.1.3(3) Other fluids required for normal operation of UA systems and water intended for injection in the engines.

Not Applicable for UAS—None

5.1.2 F3114–19 Standard Specification for Structures

5.2 *Performance Data:*

5.2.1 F3179/F3179M–18 Standard Specification for Performance of Aircraft

Unique Additions for UAS—None

Substitutions for UAS:

4.8 For High-Speed multiengine *UAS over 6000 lb*, the following also apply:

4.8.5.3 Include allowance for any reasonably expected time delays in the execution of the procedures, *including but not limited to datalink latencies*.

Not Applicable for UAS:

4.8.5.1 Descriptions of actions being made in atmospheric conditions experienced by assumed onboard pilot removed.

5.3 *Stall Speed:*

5.3.1 F3179/F3179M–18 Standard Specification for Performance of Aircraft

Unique Additions for UAS:

Note—Due to Flight Envelope Protection Systems, Minimum Steady Flight Speed is used universally in place of stall speed due to limitations on UA flight envelopes.

Substitutions for UAS:

5.1.1 The propulsive thrust not greater than zero at the minimum steady flight speed, or, if the resultant thrust has no appreciable effect on the minimum steady flight sped, with engine(s) at minimum flight thrust and throttle(s) closed with:

5.2 V_{S1} shall be determined by flight tests using the procedure and meeting the flight characteristics specified in the appropriate minimum steady flight speed handling characteristics testing.

Not Applicable for UAS—None

5.4 *Takeoff Performance:*

5.4.1 F3179/F3179M–18 Standard Specification for Performance of Aircraft

Unique Additions for UAS—None

Substitutions for UAS:

6.1 For UA, the rotation speed, V_R, is the speed at which the autopilot makes a control input with the intention of lifting the UA out of contact with the runway.

Not Applicable for UAS—6.1.3

5.5 *Climb Requirements:*

5.5.1 F3179/F3179M–18 Standard Specification for Performance of Aircraft

5.6 *Climb Information:*

5.6.1 F3179/F3179M–18 Standard Specification for Performance of Aircraft

5.7 *Landing:*

5.7.1 F3179/F3179M–18 Standard Specification for Performance of Aircraft

5.8 *Controllability:*

5.8.1 F3173/F3173M–18 Standard Specification for Aircraft Handling Characteristics

Unique Additions for UAS—None

Substitutions for UAS:

4.5.6 At V_{MC}, it shall not be necessary to reduce power of the operative engine(s). During the maneuver, the UA shall not assume any dangerous attitude, and it shall be possible to prevent a heading change of more than 20°.

4.5.7 At the option of the applicant, to comply with the requirements of Specification F3179/F3179M, Takeoff Speed, V_{MCG} may be determined. V_{MCG}, is the minimum control speed on the ground and is the calibrated airspeed during the takeoff run at which, following a sudden critical loss of thrust, it is possible to maintain control of the UA using the rudder control alone (without the use of nose wheel steering) using the lateral control to the extent of keeping the wings level to enable the takeoff to be safely continued. In the determination of V_{MCG}, assuming that the path of the UA accelerating with all engines operating is along the centerline of the runway, its path from the point at which the critical engine is made inoperative to the point at which recovery to a direction parallel to the centerline is completed may not deviate more than 9.1 m [30 ft] laterally from the centerline at any point. V_{MCG}, shall be established with:

4.7 *Control during Landings*—It shall be possible, while in the landing configuration, to complete a landing without causing substantial damage to the aircraft.

Not Applicable for UAS:

4.2.3, Table 1 Control Forces, 4.3.2, 4.7.1, 4.7.2, and 4.8.

5.9 *Trim:*

5.9.1 F3173/F3173M–18 Standard Specification for Aircraft Handling Characteristics

Unique Additions for UAS—None

Substitutions for UAS:

5.1 *General*—Each UA shall meet the trim requirements of this section after being trimmed and without further pressure upon, or movement of, the primary controls or their corresponding trim controls by the pilot or the flight control system.

Not Applicable for UAS—None

5.10 *Stability:*

5.10.1 F3173/F3173M–18 Standard Specification for Aircraft Handling Characteristics

5.11 *Stall Characteristics, Stall Warning, and Spins:*

5.11.1 F3180/F3180M–19 Standard Specification for Low-Speed Flight Characteristics of Aircraft

Unique Additions for UAS—None

Substitutions for UAS:

4.2.2.2 The wings-level stall characteristics shall be demonstrated in flight as follows. Starting from a speed at least 18.5 km/h [10 knots] above the stall speed, the longitudinal control shall be pulled back so that the rate of speed reduction will not exceed 1.9 (km/h)/s [1 knot/s] until a minimum steady flight speed for which the aircraft is still controllable (V_S) is produced, as shown by either:

4.2.2.2(3) The longitudinal control reaching a mechanical or electronic/software stop or limit

4.2.1(6)(b) *For Turbine Engine Powered UA*—At maximum engine thrust, except that it need not exceed the thrust necessary to maintain level flight at 1.5 V_{S1} (where V_{S1} corresponds to the minimum steady flight speed for which the aircraft is still controllable with flaps in the approach position, the landing gear retracted, and maximum landing weight);

4.1.2 Turning Flight Stall Preventions and Accelerated Turning Stalls Prevention:

4.1.2.1 Turning flight stall preventions and accelerated stall prevention shall be demonstrated by establishing and maintaining a coordinated turn in a 30° bank. While maintaining this bank angle, the speed should be steadily reduced with the longitudinal control until the aeroplane reaches is minimum steady flight speed for which the aircraft is still controllable. The rate of speed reduction shall be constant and:

(1) For a turning flight stall prevention demonstration, may not exceed 1.9 (km/h)/s [1 knot/s], and

(2) For an accelerated stall prevention demonstration, 5.6 to 9.3 (km/h)/s [3 to 5 knots/s].

Not Applicable for UAS—4.2.2.3, 4.2.2.4 and 4.2.2.5

5.12 *Ground and Water Handling Characteristics:*

5.12.1 F3173/F3173M–18 Standard Specification for Aircraft Handling Characteristics

Unique Additions for UAS—None

Substitutions for UAS:

7.1.1 An aircraft may have no uncontrollable tendency to change pitch attitude that would adversely affect aircraft handling characteristics in any reasonably expected operating condition, including rebound during landing or takeoff. Wheel brakes shall operate smoothly and may not induce any undue tendency to nose over or change pitch attitude in a way that would adversely affect aircraft handling characteristics.

Not Applicable for UAS—None

5.13 *Vibration, Buffering, and High-Speed Characteristics:*

5.13.1 F3173/F3173M–18 Standard Specification for Aircraft Handling Characteristics

Unique Additions for UAS—None

Substitutions for UAS:

8.1 There shall be no vibration or buffeting severe enough to result in structural damage, and each part of the UA shall be free from excessive vibration under any appropriate speed and power conditions up to V_D/M_D, or V_{DF}/M_{DF} for turbojets. In addition, there shall be no buffeting in any normal flight condition, severe enough to interfere with the satisfactory control of the UA.

8.2 For high speed UA and all UA with a maximum operating altitude greater than 7620 m [25 000 ft], there shall be no perceptible buffeting in the cruise configuration at 1 g and at any speed up to V_{MO}/M_{MO}.

9.1.1 Operating conditions and characteristics likely to cause inadvertent speed increases (including upsets in pitch and roll) shall be simulated with the UA trimmed at any likely speed up to V_{MO}/M_{MO}. These conditions and characteristics include gust upsets inadvertent control movements leveling off from climb, cargo/payload movement and descent from Mach to airspeed limit altitude.

9.1.2.1 Exceptional piloting skill;

9.1.2.3 Buffeting that would impair the unmanned aerial vehicle (UAV)'s ability to recover.

9.1.3 There may be no control reversal about any axis at any speed up to the maximum speed shown in Section 8. Any reversal of elevator control force or tendency of the UA to pitch, roll, or yaw shall be mild and readily controllable.

9.3.6 In the out-of-trim condition specified in 9.3.1, it shall be possible from an overspeed condition at V_{DF}/M_{DF} to produce at least 1.5 g for recovery through longitudinal control force or longitudinal control and the longitudinal trim system. If the longitudinal trim is used to assist in producing the required load factor, it shall be shown at V_{DF}/M_{DF} that the longitudinal trim can be actuated in the UA nose-up direction.

Not Applicable for UAS—9.3.2.1

5.14 *Performance and Flight Characteristics Requirements for Flight in Icing Conditions:*

5.14.1 F3120/F3120M–19 Standard Specification for Ice Protection for General Aviation Aircraft

5.15 *Operating Limitations:*

5.15.1 F3174/F3174M–19 Standard Specification for Establishing Operating Limitations and Information for Aeroplanes

6. Structures

6.1 *Structural Design Envelope:*

6.1.1 F3116/F3116M–18 Standard Specification for Design Loads and Conditions

Unique Additions for UAS—None

Substitutions for UAS:

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, as bounded by the flight control system (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.

If a failure of the flight control system could lead to an excursion from the approved flight envelope, then it shall be shown that this failure condition is extremely improbable.

4.4.3.1 The UA 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:

Positive (up) and Negative (down) gust values at V_C and V_D should be determined by rational analysis of the intended use of the UA system, considering the time spent at low altitude levels and the cruise speed, however, as a minimum:

(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].

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

4.12.3 If landings may be made with the pressurized compartments, landing loads must be combined with pressure differential loads from zero up to the maximum allowed during landing. If the aircraft has pressurized areas, this applies.

4.12.5 If a pressurized compartment 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.

Not Applicable for UAS—4.7.3 and 4.20.3

6.2 *Interaction of Systems and Structure:*

6.2.1 F3254–19 Standard Specification for Aircraft Interaction of Systems and Structures

6.3 *Structural Design Loads:*

6.3.1 F3116/F3116M–18 Standard Specification for Design Loads and Conditions

Unique Additions for UAS—None

Substitutions for UAS:

4.1.2 Unless otherwise provided, the air and ground 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.

Not Applicable for UAS—None

6.4 *Flight Load Conditions:*

6.4.1 F3116/F3116M–18 Standard Specification for Design Loads and Conditions

6.5 *Ground and Water Load Conditions:*

6.5.1 F3116/F3116M–18 Standard Specification for Design Loads and Conditions

Unique Additions for UAS:

8.9.3.3 In determining the ground loads on the tail skid and affected supporting structures, the following applies:

(1) If the c.g. of the unloaded UA – in side view – is situated behind the ground contact area of the main landing gear, the rear portion of the fuselage, the tail skid and the empennage must be designed to withstand the loads arising when the tail landing skid is raised to its highest possible position, consistent with the main wheel remaining on the ground, and is then released and allowed to fall freely.

(2) If the c.g. in all loading conditions is situated above the ground contact area of the main landing gear 8.9.3.3(1) need not be applied.

Substitutions for UAS:

8.2.4 The selected limit vertical inertia load factor at the center of gravity of the airplane for the ground load conditions prescribed in this subpart may not be less than that which would be obtained when landing with a descent velocity (V), in feet per second equal to 4.4 $(W/S)^{1/4}$, except that this velocity need not be more than 10 ft/s and may not be less than 7 ft/s. If the UA cannot reach these descent velocities, the UA maximum descent velocity shall be used instead.

8.5.1.2 For airplanes with nose wheels, a stalling attitude (or maximum attitude allowed by the flight envelope protection system), or the maximum angle allowing ground clearance by each part of the airplane, whichever is less.

8.10 *Supplementary Conditions for Nose Wheels*—In determining the ground loads on nose wheels and affected supporting structures, and assuming that the shock absorbers and tires are in their static positions, the following conditions must be met:

8.10.1 For aft loads, the limit force components at the axle must be:

8.10.1.1 A vertical component of 2.25 times the static load on the wheel; and

8.10.1.2 A drag component of 0.8 times the vertical load.

8.10.2 For forward loads, the limit force components at the axle must be:

8.10.2.1 A vertical component of 2.25 times the static load on the wheel; and

8.10.2.2 A forward component of 0.4 times the vertical load.

8.10.3 For side loads, the limit force components at ground contact must be:

8.10.3.1 A vertical component of 2.25 times the static load on the wheel; and

8.10.3.2 A side component of 0.7 times the vertical load.

8.10.4 For airplanes with a steerable nose wheel that is controlled by hydraulic or other power, at design takeoff weight with the nose wheel in any steerable position, the application of 1.33 times the full steering torque combined with a vertical reaction equal to 1.33 times the maximum static reaction on the nose gear must be assumed. However, if a torque limiting device is installed, the steering torque can be reduced to the maximum value allowed by that device.

Not Applicable for UAS—None

6.5.1.1 F3331–18 Standard Practice for Aircraft Water Loads

6.6 *Component Loading Conditions:*

6.6.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.6.1.1 F3232/F3232M–19a Standard Specification for Flight Controls in Small Aircraft

6.6.2 F3116/F3116M–18 Standard Specification for Design Loads and Conditions

Unique Additions for UAS—None

Substitutions for UAS:

4.12 *Pressurized Compartment 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.
7.3 *Control System Loads:*
7.3.1 Each flight control system and its supporting structure must be designed for loads corresponding to at least 125 % of the computed hinge moments of the movable control surface in the conditions prescribed in 4.16 through 4.26 and 7.1 through 7.9. In addition, the following apply:
7.3.1.1 The system limit loads need not exceed the highest load that can be applied by servo-controls or actuators.
7.3.1.2 The design must, in any case, provide a rugged system for service use, considering jamming, ground gusts, taxiing downwind, control inertia, and friction. Compliance with this subparagraph may be shown by designing for loads resulting from application of the minimum forces prescribed in 7.4.2.
7.3.3 Control system actuating forces used for design are assumed to act at the appropriate attachments of the control system to the aircraft and control surface horns.
7.4 *Limit Control Forces and Torques:*
7.4.1 The control system must be able to bear the maximum loads and torques generated by the actuating system. In the control surface flight loading condition, the air loads on movable surfaces and the corresponding deflections need exceed those that would result in flight from the application of any automated flight control system force within the ranges declared and implemented by the manufacturer. In applying this criterion, the effects of control system boost, servo-mechanisms, dynamic response of the automatic control system (including structural resonance), and the effects of tabs must be considered.
7.4.2 The automated control system forces and torques shall be declared by the manufacturer.
7.5 *Dual Control System:*
7.5.1 Each dual control system must be designed to withstand the force of flight control inputs accounting for feedback, operating in opposition, using individual servo forces not less than the greater of:
7.5.1.1 0.75 times those obtained under 7.3; or
7.5.1.2 The minimum forces specified in 7.4.2.
7.5.2 Each dual control system must be designed to withstand the force of flight control inputs accounting for feedback, applied together, in the same direction, using individual servo forces not less than 0.75 times those obtained under 7.3.
7.6 *Secondary Control System*—Secondary controls, such as wheel brakes, spoilers, and tab controls, must be designed for the maximum forces that the flight control system is likely to apply to those controls.
7.7 *Trim Tab Effects*—The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by the flight control system. In these cases, the tabs are considered to be deflected in the direction that would assist the flight control system. These deflections must correspond to the maximum degree of ″out of trim″ expected at the speed for the condition under consideration.
7.9.1.2 If flight control system forces less than the minimums specified in 7.4.2 are used for design, the effects of surface loads due to ground gusts and taxiing downwind must be investigated for the entire control system according to the formula:
[See formula]
4.25 *Ailerons:*
4.25.1 The ailerons must be designed for the loads to which they are subjected; allowance may be made for the capability of the flight control system (such as rate of movement or limitations on deflection).
4.25.1.1 In the neutral position during symmetrical flight conditions; and
4.25.1.2 By the following deflections (except as limited by pilot effort), during unsymmetrical flight conditions:
(1) Sudden maximum displacement of the aileron control at V_A. Suitable allowance may be made for control system deflections.
(2) Sufficient deflection at V_C, where V_C is more than V_A, to produce a rate of roll not less than obtained in 4.25.1.2.
(3) Sufficient deflection at V_D to produce a rate of roll not less than one-third of that obtained in 4.25.1.2.
4.25.2 For airplanes meeting the limitations of X4.1, the average loading in Appendix X4, X4.3 and Fig. X4.1 of Appendix X4 and the distribution in Fig. X4.8 of Appendix X4 may be used.

Not Applicable for UAS—7.3.4

6.7 *Limit and Ultimate Loads:*

6.7.1 F3114–19 Standard Specification for Structures

6.8 *Structural Strength:*

6.8.1 F3114–19 Standard Specification for Structures

6.9 *Structural Durability:*

6.9.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.9.2 F3115/F3115M–19 Standard Specification for Structural Durability for Small Aeroplanes

6.10 *Aeroelasticity:*

6.10.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.10.2 F3093/F3093M–19 Standard Specification for Aeroelasticity Requirements

6.11 *Design and Construction Principles:*

6.11.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.11.1.1 F3232/F3232M–19a Standard Specification for Flight Controls in Small Aircraft

6.11.2 F3114–19 Standard Specification for Structures

6.12 *Protection of Structure:*

6.12.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.12.1.1 F3232/F3232M–19a Standard Specification for Flight Controls in Small Aircraft

6.12.2 F3114–19 Standard Specification for Structures

6.12.3 F3066/F3066M–18 Standard Specification for Aircraft Powerplant Installation Hazard Mitigation

6.13 *Materials and Processes:*

6.13.1 F3114–19 Standard Specification for Structures

6.14 *Special Factors of Safety:*

6.14.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.14.2 F3114–19 Standard Specification for Structures

Unique Additions for UAS—None

Substitutions for UAS:
8.2.3 *Critical Castings*—For each casting whose failure would preclude continued safe flight and landing of the airplane, the following apply:

Not Applicable for UAS—8.4.4

6.15 *Emergency Conditions:*

6.15.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

6.15.1.1 F3232/F3232M–19a Standard Specification for Flight Controls in Small Aircraft

6.15.2 F3083/F3083M–19 Standard Specification for Emergency Conditions, Occupant Safety and Accommodations

Unique Additions for UAS—None

Substitutions for UAS:

4.1.6 Powerplant and ESS mounts and supporting structures must withstand 15.0 g forward.

5.3 Cargo Compartments:

5.3.1 Each cargo compartment must:

Not Applicable for UAS—4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.1.7.2, 4.2.1, 4.2.2, 4.2.3, 4.2.4.2, 4.2.5, 4.2.6, 5.1, 5.2, 5.3.1.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5,11, 7.1, and 7.2

7. Design and Construction

7.1 *Flight Control Systems:*

7.1.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

7.1.1.1 F3232/F3232M–19a Standard Specification for Flight Controls in Small Aircraft

Unique Additions for UAS—None

Substitutions for UAS:

4.4.2 There must be means to indicate to the pilot the direction of trim control movement relative to aircraft motion.

4.7.1 It must be shown by operation tests that, when the controls are operated from the control station with the system loaded as prescribed in 4.7.2 and 4.7.3, the system is free from jamming, excessive friction, excessive deflection, or any combination thereof.

4.7.3 For secondary controls, the prescribed test loads must be not less than those corresponding to the expected loads established under Specification F3116/F3116M.

4.8.1 Each detail of each control system must be designed and installed to prevent jamming, chafing, and interference from cargo, loose objects, or the freezing of moisture.

4.12.1 There must be a means to provide wing flap position information for flap installations with only the retracted and fully extended positions.

4.12.2 There must be a means to provide wing flap position information for flap installations with intermediate flap positions if any flap position other than retracted or fully extended is used to show compliance with the performance requirements of the rules of the governing civil aviation authority.

5.1.1 For UAS an automatic pilot system must be installed, and it must not be designed so that the automatic pilot system can be disengaged by a pilot during flight.

5.1.3 Each automatic pilot system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates; refer to Specification F3117/F3117M.

5.1.4 Each manually operated control for the automatic pilot system operation must be readily accessible to the pilot. Each control must operate in the same plane and sense of motion as specified in Specification F3117/F3117M for cockpit controls. The direction of motion must be plainly indicated on or near each control.

5.1.5 The automatic pilot system must be designed and adjusted so that, within the range of adjustment available to the pilot, it cannot produce hazardous loads on the aircraft or create hazardous deviations in the flight path, under any flight condition appropriate to its use, either during normal operation or in the event of a malfunction, assuming that corrective action begins within a reasonable period of time.

5.1.6 The automatic pilot system must be designed so that a single malfunction will not produce a hardover signal in more than one control axis.

5.1.7 For an automatic pilot system that integrates signals from auxiliary controls or furnishes signals for operation of other equipment, positive interlocks and sequencing of engagement to prevent improper operation are required.

5.1.8 The automatic pilot system must have protection against adverse interaction of integrated components, resulting from a malfunction.

5.1.9 The automatic pilot system must be coupled to airborne navigation equipment, and means must be provided to indicate to the flight crew in the control station the current mode of operation. Selector switch position is not acceptable as a means of indication; refer to Specification F3117/F3117M.

5.3.4 In showing compliance with 5.3, each system must be designed so that the artificial stall barrier cannot be disengaged by the pilot.

Not Applicable for UAS—4.8.2 and 5.1.2

7.1.2 F3066/F3066M–18 Standard Specification for Aircraft Powerplant Installation Hazard Mitigation

7.2 *Landing Gear Systems:*

7.2.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

Unique Additions for UAS—None

Substitutions for UAS—None

Not Applicable for UAS—13.3.3

7.3 *Buoyancy for Seaplanes and Amphibians:*

7.3.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

7.4 *Means of Egress and Emergency Exits:*

7.4.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

Unique Additions for UAS—None

Substitutions for UAS:

13.11.1 There must be a means to lock and safeguard each door or access panel against inadvertent opening during flight by cargo or as a result of mechanical failure.

Not Applicable for UAS—13.11.2, 13.11.3, 13.11.4, 13.11.5, 13.11.6, 13.11.7, 13.11.8, and 13.11.9

7.4.2 F3083/F3083M–19 Standard Specification for Emergency Conditions, Occupant Safety and Accommodations

Unique Additions for UAS—None

Substitutions for UAS:

5.3 *Cargo Compartments:*

5.3.1 Each cargo compartment must:

Not Applicable for UAS—5.2 (entire section), 5.3.1.3, 5.3.2, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, and 5.11

7.5 *Occupant Physical Environment:*

7.5.1 F3061/F3061M–19a Standard Specification for Systems and Equipment in Small Aircraft

Unique Additions for UAS—None

Substitutions for UAS—None

Not Applicable for UAS—10.2

7.5.1.1 F3227/F3227M–17 Standard Specification for Environmental Systems in Small Aircraft

Unique Additions for UAS—None

Substitutions for UAS—None

Not Applicable for UAS—3.2.3, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.1.6, 5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.5, 5.1.10, 5.1.11, 5.1.12, 5.1.13, 5.1.14, 5.1.15 , 5.1.16, 6.1, 6.2, 6.3, 6.4, 6.5, 6.7, and 6.8

7.5.2 F3083/F3083M–19 Standard Specification for Emergency Conditions, Occupant Safety and Accommodations