



Designation: F3114 – 21

Standard Specification for Structures¹

This standard is issued under the fixed designation F3114; 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 structural requirements that apply to all portions of the airframe regardless of component, system, or structure.

1.2 This specification was originally conceived for small airplanes as defined in the F44 terminology standard but may find broader applicability. Use of the term aircraft throughout this specification is intended to allow the relevant CAA(s) to accept this standard as a means of compliance as they determine it to be appropriate, whether for small airplanes or for other types of aircraft.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*²
[F3060 Terminology for Aircraft](#)

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.

[F3061/F3061M Specification for Systems and Equipment in Small Aircraft](#)

[F3083/F3083M Specification for Emergency Conditions, Occupant Safety and Accommodations](#)

[F3093/F3093M Specification for Aeroelasticity Requirements](#)

[F3115/F3115M Specification for Structural Durability for Small Aeroplanes](#)

[F3116/F3116M Specification for Design Loads and Conditions](#)

3. Terminology

3.1 See Terminology [F3060](#) for more definitions and abbreviations.

4. Strength

4.1 *Loads*—Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety).

4.2 *Factor of Safety*—Unless otherwise provided, a factor of safety of 1.5 must be used.

4.3 *Strength and Deformation:*

4.3.1 The structure must be able to support limit loads without detrimental, permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

4.3.2 The structure must be able to support ultimate loads without failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds. However when proof of strength is shown by dynamic tests simulating actual load conditions, the three second limit does not apply.

4.4 *Proof of Structure:*

4.4.1 Compliance with the strength and deformation requirements of 4.3 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated.

4.4.2 Certain parts of the structure must be tested as specified.

4.5 *Mass Balance*—The supporting structure and the attachment of concentrated mass balance weight used on control surfaces must be designed for:

- 4.5.1 24 g normal to the plane of the control surface;
- 4.5.2 12 g fore and aft; and
- 4.5.3 12 g parallel to the hinge line.

4.6 *Canard or Tandem Wing Configurations*:

4.6.1 The forward structure of a canard or tandem wing configuration must:

- 4.6.1.1 Meet all requirements of this standard, Specifications **F3116/F3116M**, **F3093/F3093M**, **F3083/F3083M**, and **F3115/F3115M** applicable to a wing; and
- 4.6.1.2 Must meet all requirements applicable to the function performed by these surfaces.

4.7 *Windshields and Windows*:

4.7.1 The internal panels of windshields and windows must be constructed of a nonsplintering material, such as but not limited to:

- 4.7.1.1 Nonsplintering safety glass; or
- 4.7.1.2 Synthetic resins.

4.7.2 The design of windshields, windows, and canopies in pressurized airplanes must be based on factors peculiar to high altitude operation, including:

- 4.7.2.1 The effects of continuous and cyclic pressurization loadings;
- 4.7.2.2 The inherent characteristics of the material used; and
- 4.7.2.3 The effects of temperatures and temperature gradients.

4.7.3 On pressurized airplanes, if certification for operation up to and including 25 000 ft is requested, an enclosure canopy including a representative part of the installation must be subjected to special tests to account for the combined effects of continuous and cyclic pressurization loadings and flight loads, or compliance with the fail-safe requirements of 4.7.4 must be shown.

4.7.4 If certification for operation above 25 000 ft is requested, the windshields, window panels, and canopies must be strong enough to withstand the maximum cabin pressure differential loads combined with critical aerodynamic pressure and temperature effects, after failure of any load-carrying element of the windshield, window panel, or canopy.

4.7.5 In the event of any probable single failure, a transparency heating system must be incapable of raising the temperature of any windshield or window to a point where there would be:

- 4.7.5.1 Structural failure that adversely affects the integrity of the cabin; or
- 4.7.5.2 A danger of fire.

4.7.6 In addition, for Level 4 airplanes, the following applies:

4.7.6.1 Windshield panes directly in front of the pilots in the normal conduct of their duties, and the supporting structures for these panes, must withstand, without penetration, the impact of a 2 lb bird when the velocity of the airplane (relative

to the bird along the airplane's flight path) is equal to the airplane's maximum approach flap speed.

4.7.7 The windshield and side windows forward of the pilot's back when the pilot is seated in the normal flight position must have a luminous transmittance value of not less than 70 %.

4.8 *Landing Gear*:

4.8.1 For Level 4 airplanes, the following general requirements for the landing gear apply:

4.8.1.1 Each airplane must be designed so that, with the airplane under control, it can be landed on a paved runway with any one or more landing-gear legs not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard.

4.8.1.2 Compliance with the provisions of this section may be shown by analysis or tests, or both.

4.9 *Testing*—The suitability of each questionable design detail and part having an important bearing on safety in operations must be established by tests.

4.9.1 *Wings*—The strength of stressed-skin wings must be proven by load tests or by combined structural analysis and load tests.

4.9.2 *Control Surfaces*:

4.9.2.1 Limit load tests of control surfaces are required. These tests must include the horn or fitting to which the control system is attached.

4.9.2.2 In structural analyses, rigging loads due to wire bracing must be accounted for in a rational or conservative manner.

4.9.3 *Pressurization Tests*—Strength test. The complete pressurized cabin, including doors, windows, canopy, and valves, must be tested as a pressure vessel for the pressure differential specified in Specification **F3116/F3116M**.

5. Mass and Mass Distribution

5.1 *Load Distribution Limits*—The load distribution limits may not exceed any of the limits at which the structure is proven.

5.2 *Leveling Means*—There must be means for determining when the airplane is in a level position on the ground.

6. Materials, Processes, and Methods of Fabrication

6.1 *Materials and Workmanship*:

6.1.1 The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must:

- 6.1.1.1 Be established by experience or tests;
- 6.1.1.2 Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and
- 6.1.1.3 Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

6.1.2 Workmanship must be of a high standard.

6.2 *Fabrication Methods*:

6.2.1 The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to

reach this objective, the process must be performed under an approved process specification.

6.2.2 Each new aircraft fabrication method must be substantiated by a test program.

6.3 *Material Strength Properties and Design Values:*

6.3.1 Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis.

6.3.2 Design values must be chosen to minimize the probability of structural failure due to material variability. Except as provided in 6.3.4 of this section, compliance with this paragraph must be shown by selecting design values that ensure material strength with the following probability:

6.3.2.1 Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component; 99 % probability with 95 % confidence.

6.3.2.2 For redundant structure, in which the failure of individual elements would result in applied loads being safely distributed to other load carrying members; 90 % probability with 95 % confidence.

6.3.3 The effects of temperature on allowable stresses used for design in an essential component or structure must be considered where thermal effects are significant under normal operating conditions.

6.3.4 Design values greater than the guaranteed minimums required by this section may be used where only guaranteed minimum values are normally allowed if a “premium selection” of the material is made in which a specimen of each individual item is tested before use to determine that the actual strength properties of that particular item will equal or exceed those used in design.

7. Protection of Structure

7.1 *Fasteners:*

7.1.1 Each removable fastener must incorporate two retaining devices if the loss of such fastener would preclude continued safe flight and landing.

7.1.2 Fasteners and their locking devices must not be adversely affected by the environmental conditions associated with the particular installation.

7.1.3 No self-locking nut may be used on any bolt subject to rotation in operation unless a non-friction locking device is used in addition to the self-locking device.

7.2 *Protection of Structure*—Each part of the structure must:

7.2.1 Be suitably protected against deterioration or loss of strength in service due to any cause, including:

- 7.2.1.1 Weathering;
- 7.2.1.2 Corrosion; and
- 7.2.1.3 Abrasion; and

7.2.2 Have adequate provisions for ventilation and drainage.

7.3 *Accessibility Provisions*—For each part that requires maintenance, inspection, or other servicing, appropriate means must be incorporated into the aircraft design to allow such servicing to be accomplished.

7.4 *Fire Protection of Engine Mounts, and Other Flight Structure:*

7.4.1 Engine mounts, and other flight structure located in designated fire zones, or in adjacent areas that would be subjected to the effects of fire in the designated fire zones, must be constructed of fireproof material or be shielded so that they are capable of withstanding the effects of a fire.

7.4.2 Engine vibration isolators must incorporate suitable features to ensure that the engine is retained if the non-fireproof portions of the isolators deteriorate from the effects of a fire.

8. Special Factors of Safety

8.1 *Special Factors*—The factor of safety prescribed in 4.2 must be multiplied by the highest pertinent special factors of safety prescribed in 8.2 through 8.4 for each part of the structure whose strength is:

8.1.1 Uncertain;

8.1.2 Likely to deteriorate in service before normal replacement; or

8.1.3 Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

8.2 *Casting Factors:*

8.2.1 *General*—The factors, tests, and inspections specified in 8.2.2 through 8.2.4 must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Sections 8.2.3 and 8.2.4 apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

8.2.2 *Bearing Stresses and Surfaces*—The casting factors specified in 8.2.3 and 8.2.4:

8.2.2.1 Need not exceed 1.25 with respect to bearing stresses regardless of the method of inspection used; and

8.2.2.2 Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.

8.2.3 *Critical Castings*—For each casting whose failure would preclude continued safe flight and landing of the airplane or result in serious injury to occupants, the following apply:

8.2.3.1 Each critical casting must either:

(1) Have a casting factor of not less than 1.25 and receive 100 % inspection by visual, radiographic, and either magnetic particle, penetrant or other approved equivalent non-destructive inspection method; or

(2) Have a casting factor of not less than 2.0 and receive 100 % visual inspection and 100 % approved non-destructive inspection. When an approved quality control procedure is established and an acceptable statistical analysis supports reduction, non-destructive inspection may be reduced from 100 %, and applied on a sampling basis.

8.2.3.2 For each critical casting with a casting factor less than 1.50, three sample castings must be static tested and shown to meet:

(1) The strength requirements of 4.3 at an ultimate load corresponding to a casting factor of 1.25; and

(2) The deformation requirements of 4.3 at a load of 1.15 times the limit load.

8.2.3.3 Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges