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.

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Standard Specification for Systems and Equipment in Aircraft[1]

This standard is issued under the fixed designation F3061/F3061M; 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 covers the systems and equipment aspects of airworthiness and design for aircraft. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on Level 1, 2, 3, and 4 Normal Category aeroplanes. The content may be more broadly applicable; it is the responsibility of the Applicant to substantiate broader applicability as a specific means of compliance. The topics covered within this specification are: Basic Information, Electrical Systems, Environmental Requirements, Manual Flight Controls, Automatic Flight Controls, Flight Data and Voice Recording, Hazard Mitigation, Hydraulic Systems, Instrumentation, Mechanical Systems and Equipment, Exterior Lighting, Oxygen Systems, Pneumatic Systems, Lightning Protection, and High-Intensity Radiated Field (HIRF) Protection.

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

1.3 This document may present information in either SI units, English Engineering units, or both; the values stated in each system may not be exact equivalents. Each system shall be used independently of the other; combining values from the two systems may result in nonconformance with the standard.

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 Following is a list of external standards referenced throughout this specification; the earliest revision acceptable for use is indicated. In all cases later document revisions are acceptable if shown to be equivalent to the listed revision, or if otherwise formally accepted by the governing civil aviation authority; earlier revisions are not acceptable.

2.2 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3083/F3083M Specification for Emergency Conditions, Occupant Safety and Accommodations

F3116/F3116M Specification for Design Loads and Conditions

F3117/F3117M Specification for Crew Interface in Aircraft

F3153 Specification for Verification of Aircraft Systems and Equipment

F3173/F3173M Specification for Aircraft Handling Characteristics

F3179/F3179M Specification for Performance of Aircraft

F3227/F3227M Specification for Environmental Systems in Aircraft

F3228 Specification for Flight Data and Voice Recording 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

[1] This specification is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.50 on Systems and Equipment.

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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.

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F3234/F3234M Specification for Exterior Lighting in Small Aircraft
F3236 Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft
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
F3367 Practice for Simplified Methods for Addressing High-Intensity Radiated Fields (HIRF) and Indirect Effects of Lightning on Aircraft
F3532 Practice for Protection of Aircraft Systems from Intentional Unauthorized Electronic Interactions

2.3 *SAE Standard:*[3]
SAE ARP4754, Rev A Guidelines for Development of Civil Aircraft Systems

2.4 *Other Standards:*
AC/AMC 20-136 Protection of Aircraft Electrical/Electronic Systems against the Indirect Effects of Lightning[4]
FAA-S-8081-14B, Change 5 Private Pilot Practical Test Standards for Airplane[4]
RTCA DO-178, Rev B Software Considerations in Airborne Systems and Equipment Certification[5]
RTCA DO-254 Design Assurance Guidance for Airborne Electronic Hardware[5]

3. Terminology

3.1 Terminology specific to this standard is provided below. For general terminology, refer to Terminology F3060.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *closed, adj—in door systems (reference 13.12)*, means the door has been placed within the doorframe in such a position that the latches can be operated to the "latched" condition. Fully closed means the door is placed within the doorframe in the position it will occupy when the latches are in the latched condition.

3.2.2 *continued safe flight and landing, n*—continued safe flight and landing is defined as the capability for continued controlled flight and landing, possibly using emergency procedures, but without requiring pilot skill beyond that needed to pass the Private Pilot Practical Test Standard for Airplane (refer to FAA-S-8081-14B), or requiring pilot forces beyond those defined in Specification F3173/F3173M. Landing may occur either at an airport or at an emergency landing location consistent with established emergency procedures. Some aircraft damage may be realized, either during flight or upon landing.

3.2.3 *door, n—in door systems (reference 13.12)*, a movable barrier that is located on the exterior of the fuselage or in the primary pressure vessel on a pressurized aircraft with the intention to permit access or to enter/exit. The movable barrier must be opened and closed without the use of tools to operate.

3.2.4 *development assurance level, n*—a development assurance level is an indication of the level of those planned and systematic actions used to substantiate, to an adequate level of confidence, that errors in requirements, design, and implementation have been identified and corrected such that the system satisfies the applicable certification basis.

3.2.5 *latched, adj—in door systems (reference 13.12)*, means the latches are fully engaged with their structural counterparts and held in position by the latch operating mechanism.

3.2.6 *latches, n—in door systems (reference 13.12)*, movable mechanical elements that, when engaged, prevent the door from opening.

3.2.7 *locked, adj—in door systems (reference 13.12)*, means the locks are fully engaged.

3.2.8 *locks, n—in door systems (reference 13.12)*, mechanical elements, in addition to the latch operating mechanism, that monitor the latch positions and, when engaged, prevent latches from becoming disengaged.

3.2.9 *pneumatic system elements, n*—components associated with systems that use bleed air or other sources of compressed gas for their function (ice protection, vapor cycle cooling, rudder bias, door seal inflation, brake heating, emergency gear extension, emergency braking, etc.) Within the context of pressurization systems, pneumatic system elements include the valve(s) that regulates cabin inflow as well as all upstream equipment items that utilize bleed air; refer to 3.2.10.

3.2.10 *pressurization system elements, n*—components downstream of the valve(s) that regulates cabin inflow; refer to 3.2.9.

3.2.11 *primary function, n*—a primary function is a function that is installed to comply with applicable requirements for a required function and that provides the most pertinent controls or information instantly and directly to the pilot.

3.2.12 *primary system, n*—a primary system is a system that provides a primary function.

3.2.13 *secondary system, n*—a secondary system is a redundancy system that provides the same function as the primary system.

3.2.14 *unsafe system operating condition, n*—an unsafe system operating condition is any system operating condition which, if not detected and properly accommodated by crew action, would cause one or more serious injuries.

3.3 Where reference is made to V_S (V_{SR}), use V_S or V_{SR} as appropriate for the stall speed basis established for the aeroplane in accordance with F3179/F3179M.

4. Basic Information

NOTE 1—The requirements of this chapter are applicable to all systems and equipment installed in the aircraft. These requirements are in addition to and do not supersede any additional system specific requirements identified elsewhere in these design standards or contained in the rules of the governing civil aviation authority.

4.1 *Function and Installation:*

[3] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.
[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.
[5] Available from RTCA, 1150 18th NW, Suite 910, Washington, DC 20036, https://www.rtca.org.

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4.1.1 Each item of installed equipment must be of a kind and design appropriate to its intended function.

4.1.2 Each item of installed equipment must be marked in a way that makes it clear to an installer the equipment's identification, function, or operating limitations, or any applicable combination of these factors. It is acceptable to reference equipment installation manuals for function or limitation information.

4.1.3 Each item of installed equipment must be installed according to limitations specified for that equipment.

4.1.4 Each item of installed equipment must function properly when installed.

4.1.5 The aircraft systems and equipment required for type certification or by operating rules must be designed and installed so that they perform as intended under the aircraft operating and environmental conditions.

NOTE 2—The intent of this requirement is to provide assurance that the required systems and equipment will function as intended in the expected operating and environmental conditions. It is recognized that random failures will occur throughout the aircraft life and that the failed device may no longer "perform as intended." The acceptability of such failures or combination of failures and their associated risks are addressed under the requirements of 4.2.

4.1.6

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	All aircraft systems and equipment must be designed and installed so that they do not adversely affect the safety of the aircraft or its occupants.

4.1.7 All aircraft systems and equipment must be designed and installed so that they do not adversely affect the proper functioning of those systems or equipment, or both, covered by 4.1.5.

4.1.8 Those systems and equipment not required for type certification or by operating rules are not required to perform their intended function under all aircraft operating and environmental conditions, provided that the resultant failure conditions are classified as "Negligible Failure Condition" in the assessment conducted in accordance with 4.2.1; refer to Practice F3230.

4.1.8.1 Non-required systems and equipment with failure conditions classified more severe than "Negligible Failure Condition" are not required to perform their intended function under all aircraft operating and environmental conditions, provided the failure is appropriately annunciated to the crew.

4.1.8.2 When addressing the requirements of 4.2, if any credit is taken for the installation, or any aspect, of these non-required systems, the portion of the system for which credit is taken must comply with 4.1.4.

4.2 *System Safety Requirements:*

4.2.1 An assessment of the aircraft and system functions must be performed to identify and classify the various Failure Conditions associated with each function.

4.2.2 The equipment, systems, and installations must be designed to minimize hazards to the aircraft in the event of a probable malfunction or failure.

4.2.3 The aircraft systems and associated components, considered separately and in relation to other systems, must be designed and installed so that:

4.2.3.1 Each Catastrophic failure condition is "extremely improbable."

4.2.3.2 Each Hazardous failure condition is "extremely remote."

4.2.3.3

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	Each major failure condition is "remote."

4.2.3.4 For definitions of the failure condition severities and the qualitative probability terms used in 4.2.3, refer to Practice F3230.

4.2.4 Acceptable methods for satisfying the provisions of 4.2.1 – 4.2.3 are provided in the following documents:

4.2.4.1 For all normal category aeroplanes, Practice F3230.

4.2.4.2 For a limited set of certification levels 1 and 2 aeroplanes as defined in that practice, Practice F3309/F3309M.

4.2.5 As used in 4.2, the term "systems" refers to all pneumatic systems, fluid systems, electrical systems, mechanical systems, and powerplant systems included in the aircraft design except as provided in 4.2.5.1 – 4.2.5.3.

4.2.5.1 Powerplant systems provided as part of the type-certified engine are not subject to the provisions of 4.2.

4.2.5.2 The flight structure (such as wing, fuselage, empennage, engine-mounting, control surfaces and their associated simple systems, and landing gear and their primary attachments) are not subject to the provisions of 4.2.

4.2.5.3 Single failures within brake systems, including associated systems and components, are not subject to the provisions of 4.2 provided it is shown that the aircraft can be brought to rest, with a braked-roll stopping distance of not more than two times that obtained in determining the landing distance in accordance with Specification F3179/F3179M, following:

(1) Failure of any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element; or

(2) Loss of any single source of hydraulic or other brake-operating energy.

NOTE 3—The allowances of 4.2.5.3 have traditionally been applied only to jet aircraft with high takeoff and landing speeds.

4.2.6

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	Based on the results of the assessment per 4.2.1, the depth of analysis required to show compliance may be determined in accordance with Practice F3230 or Practice F3309/F3309M.

4.2.7 Reserved

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4.2.8

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	Information concerning an unsafe system operating condition must be provided in a timely manner to the crew to enable them to take appropriate corrective action; refer to 3.2.14.

4.2.8.1

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	In showing compliance with the provisions of 4.2.8, if immediate pilot awareness and immediate or subsequent corrective action is required, the information required by 4.2.8 must be presented in accordance with Specification F3117/F3117M.

4.2.8.2

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	In showing compliance with the provisions of 4.2.8, one method of assessing an unsafe system operating condition is presented in Appendix X2.

4.3 *Systems and Equipment, Network Information Security Protection:*

4.3.1

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	Connectivity of aircraft systems to external networks or devices can lead to an increased risk of intentional unauthorized electronic interactions (IUEI). Aircraft systems and equipment must have mitigations to protect against failure conditions that could result from IUEI.

4.3.2 When aircraft systems are connected to external networks or devices, a security assessment must be performed that:

4.3.2.1

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	Identifies any security risks that could lead to abnormal system operation that would be considered a failure condition;

4.3.2.2

Level 1 *and* Low-Stall *and* Day-VFR	All Others
Reserved	Demonstrates that adequate mitigations have been provided to prevent the failure condition from occurring. The mitigations must be shown to be appropriate for the severity of failure condition that they protect against.

4.3.3 Practice F3532 is an acceptable method of meeting 4.3.1 and 4.3.2.

4.4 *Software and Airborne Electronic Hardware:*

Level 1 *and* Low-Stall *and* Day-VFR	All other Level 1 and level 2	All Others
Reserved	Software and airborne electronic hardware can be addressed via development assurance in accordance with 4.4.1 Or Via System level verification in accordance with 4.4.2.	Software and airborne electronic hardware must be addressed via development assurance in accordance with 4.4.1.

4.4.1 *Development Assurance*—Software and Airborne Electronic Hardware must be designed with the appropriate Development Assurance Level (DAL) as specified in Table 1 or in accordance with the Development Assurance Level assignment methodology outlined in SAE ARP4754; refer to 3.2.4.

4.4.1.1 Once a DAL has been assigned, RTCA DO-178 provides an acceptable means to satisfy the requirements of 4.4.1 for software and DO-254 provides an acceptable means to satisfy 4.4.1 for AEH; refer to Section 2.

4.4.2 *System Level Verification*—Software and airborne electronic hardware within systems and equipment installed in certification level 1 and 2 normal category aircraft may be approved using system level verification.

4.4.2.1 Specification F3153 provides an acceptable method to meet the requirements of 4.4.2; Refer to Section 2.

NOTE 4—The acceptability of this method varies between regulatory agencies. It is generally not considered an acceptable approach for complex, novel systems such as fly-by-wire or propulsion systems. The applicant must seek individual guidance from their respective CAA concerning the use of system level verification.

5. Electrical Systems

5.1 *Electrical System Requirements*—In addition to the applicable requirements of this specification, electrical systems shall comply with the provisions of 5.1.1 and 5.1.2.

5.1.1 Electrical systems for aircraft equipped with combustion-engine propulsion shall comply with the provisions of Specification F3231/F3231M.

TABLE 1 Development Assurance Level Requirements

Assessment Level[A]	Classification of Failure Conditions[A]				
	Negligible	Minor	Major	Hazardous	Catastrophic
	Software (SW) and Airborne Electronic Hardware (AEH) Development Assurance Levels (DALs)[B]				
I	No SW and/or HW DAL Requirement	P=D	P=C, S=D (See[C])	P=C, S=D (See[C])	P=C, S=C (See[C])
II		P=D	P=C, S=D (See[C])	P=C, S=C (See[C])	P=C, S=C (See[C])
III		P=D	P=C, S=D (See[C])	P=C, S=C (See[C])	P=B, S=C (See[C])
IV		P=D	P=C, S=D (See[C])	P=B, S=C (See[C])	P=A, S=B (See[C])

[A] Refer to Practice F3230.

[B] The letters of the alphabet used above denote the typical SW and AEH DALs. "P" indicates the primary system; "S" indicates the secondary system; "A," "B," "C," and "D" indicate the DAL in accordance with RTCA DO-178 or RTCA DO-254 as applicable. For example, an indication of "P=A" would translate to a SW or AEH DAL of "A" on the primary system.

[C] A secondary system is not necessarily required; however, if a secondary system is needed to meet the probability goals of Practice F3230, then that secondary system must meet the stated DAL goal.

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5.1.2 Electrical systems for aircraft equipped with electric propulsion shall comply with the provisions of Specification F3316/F3316M.

6. Environmental Requirements

6.1 *Ventilation Requirements*—In addition to the applicable requirements of this specification, ventilation systems shall comply with the corresponding provisions of Specification F3227/F3227M.

6.2 *Pressurization Requirements*—In addition to the applicable requirements of this specification, pressurization systems shall comply with the corresponding provisions of Specification F3227/F3227M.

7. Manual Flight Controls

7.1 *Manual Flight Control Requirements*—In addition to the applicable requirements of this specification, manual flight controls shall comply with the corresponding provisions of Specification F3232/F3232M.

8. Automatic Flight Controls

8.1 *Automatic Flight Control Requirements*—In addition to the applicable requirements of this specification, automatic flight controls shall comply with the corresponding provisions of Specification F3232/F3232M.

9. Flight Data and Voice Recording

9.1 *Flight Recorder Requirements*—In addition to the applicable requirements of this specification, flight data and voice recording installations shall comply with the provisions of Specification F3228.

10. Hazard Mitigation

10.1 *Takeoff Warning System:*

Level 1	All Others
Reserved	Unless it can be shown that a lift or longitudinal trim device that affects the takeoff performance of the aircraft would not give an unsafe takeoff configuration when selected out of an approved takeoff position, a takeoff warning system must be installed and meet the requirements of 10.1.1 – 10.1.4.

10.1.1

Level 1	All Others
Reserved	In showing compliance with 10.1, the system must provide to the pilots an aural warning that is automatically activated during the initial portion of the takeoff roll if the aircraft is in a configuration that would not allow a safe takeoff.

10.1.2

Level 1	All Others
Reserved	The warning provided in accordance with 10.1.1 must continue until the configuration is changed to allow safe takeoff, or action is taken by the pilot to abandon the takeoff roll.

10.1.3

Level 1	All Others
Reserved	In showing compliance with 10.1, the means used to activate the system must function properly for all authorized takeoff power settings and procedures and throughout the ranges of takeoff weights, altitudes, and temperatures for which certification is requested.

10.1.4

Level 1	All Others
Reserved	For the purpose of showing compliance with 10.1, an unsafe takeoff configuration is the inability to rotate or the inability to prevent an immediate stall after rotation. This section is not intended to apply to control locks; refer to Specification F3232/F3232M.

10.2 *Pilot Compartment*—For each pilot compartment, the pilot and the aerodynamic controls listed in Specification F3117/F3117M, excluding cables and control rods, must be suitably protected from items of mass departing a propeller.

10.2.1 The provisions of 10.2 may be met by ensuring that no part of the pilot or the controls lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub making an angle of 5° forward or aft of the plane of rotation of the propeller.

10.3 *Flammable Fluid Fire Protection:*

10.3.1 Lines, tanks, or equipment containing fuel, oil, or other flammable fluids may not be installed in compartments to be used by the crew or passengers unless adequately shielded, isolated, or otherwise protected so that any breakage or failure of such an item would not create a hazard.

10.3.2 In each area where flammable fluids or vapors might escape by leakage of a fluid system, there must be means to minimize the probability of ignition of the fluids and vapors, and the resultant hazard if ignition does occur; compliance must be shown by analysis or test.

10.3.3

Level 1	All Others
Reserved	Possible sources and paths of fluid leakage, and means of detecting leakage, must be considered when showing compliance with 10.3.2.

10.3.4

Level 1	All Others
Reserved	Flammability characteristics of fluids, including effects of any combustible or absorbing materials, must be considered when showing compliance with 10.3.2.

10.3.5

Level 1	All Others
Reserved	Possible ignition sources, including electrical faults, overheating of equipment, and malfunctioning of protective devices, must be considered when showing compliance with 10.3.2.

10.3.6

Level 1	All Others
Reserved	Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents, must be considered when showing compliance with 10.3.2.

10.3.7

Level 1	All Others
Reserved	Ability of aircraft components that are critical to safety of flight to withstand fire and heat must be considered when showing compliance with 10.3.2.

10.3.8

Level 1	All Others
Reserved	If action by the flight crew is required to prevent or counteract a fluid fire (for example, equipment shutdown or actuation of a fire extinguisher), quick acting means must be provided to alert the crew.

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10.3.9

Level 1	All Others
Reserved	Each area where flammable fluids or vapors might escape by leakage of a fluid system must be identified and defined.

10.4 *Fire Protection of Cargo and Baggage Compartments:*

10.4.1 Sources of heat within each cargo and baggage compartment that are capable of igniting the compartment contents must be shielded and insulated to prevent such ignition.

10.4.2

Level 4	All Others
If the requirements of either 10.4.3 or 10.4.4 are not met, each cargo and baggage compartment must be located where the presence of a fire would be easily discovered by the pilots when seated at their duty station, or it must be equipped with a smoke or fire detector system to give a warning at the pilots' station, and provide sufficient access to enable a pilot to effectively reach any part of the compartment with the contents of a hand held fire extinguisher.	Reserved

10.4.3

Level 4	All Others
If the requirements of either 10.4.2 or 10.4.4 are not met, each cargo and baggage compartment must be equipped with a smoke or fire detector system to give a warning at the pilots' station. In addition, each compartment must meet the requirements of Specification F3083/F3083M.	Reserved

10.4.4

Level 4	All Others
If the requirements of either 10.4.2 or 10.4.3 are not met, each cargo and baggage compartment must be constructed and sealed to contain any fire within the compartment.	Reserved

10.5 *Fire Protection of Flight Controls*—Flight controls 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.

10.6 *Lines, Fittings, and Components:*

10.6.1 Except as provided in 10.6.3 and 10.6.4, components, lines, and fittings must be shielded or located so as to safeguard against the ignition of leaking flammable fluid.

10.6.2 Except as provided in 10.6.3 and 10.6.4, flexible hose assemblies (hose and end fittings) must be shown to be suitable for the particular application.

10.6.3 Subsections 10.6.1 and 10.6.2 do not apply to lines, fittings, and components, which are already approved as part of the type certificated engine.

10.6.4 Subsections 10.6.1 and 10.6.2 do not apply to vent and drain lines, and their fittings, whose failure will not result in, or add to, a fire hazard.

10.7 *Shutoff Means:*

10.7.1

Single Engine	All Others
Reserved	Each engine installation must have means to shut off or otherwise prevent hazardous quantities of flammable liquids from flowing into, within, or through any engine compartment, except in lines, fittings, and components forming an integral part of an engine.

10.7.2

Single Engine	All Others
Reserved	The closing of the fuel shutoff valve for any engine may not make any fuel unavailable to the remaining engines that would be available to those engines with that valve open.

10.7.3

Single Engine	All Others
Reserved	Operation of any shutoff means may not interfere with the later emergency operation of other equipment such as propeller feathering devices.

10.7.4

Single Engine	All Others
Reserved	Each shutoff must be outside of the engine compartment unless an equal degree of safety is provided with the shutoff inside the compartment.

10.7.5

Single Engine	All Others
Reserved	Not more than 0.95 L [0.25 US gal] of flammable fluid may escape into the engine compartment after engine shutoff. For those installations where the flammable fluid that escapes after shutdown cannot be limited to 0.95 L [0.25 US gal], it must be demonstrated that this greater amount can be safely contained or drained overboard.

10.7.6

Single Engine	All Others
Reserved	There must be means to guard against inadvertent operations of each shutoff means, and to make it possible for the crew to reopen the shutoff means in flight after it has been closed.

10.7.7

Reciprocating Engine Aircraft	Turbine Engine Aircraft
Reserved	Engine installations need not have an engine oil system shutoff if the conditions of 10.7.7.1 and 10.7.7.2 are met.

10.7.7.1

Reciprocating Engine Aircraft	Turbine Engine Aircraft
Reserved	To comply with 10.7.7, the oil tank must be integral with, or mounted on, the engine.

10.7.7.2

Reciprocating Engine Aircraft	Turbine Engine Aircraft
Reserved	To comply with 10.7.7, all oil system components external to the engine must be fireproof or located in areas not subject to engine fire conditions.

10.7.8 Power operated shut off valves must have means to indicate to the flight crew when the valve has reached the selected position and must be designed so that the valve will not move from the selected position under vibration conditions likely to exist at the valve location.

10.8

Single Engine	All Others
Reserved	Engine-driven accessories essential to safe operation must be distributed among two or more engines so that the failure of any one engine will not impair safe operation through the malfunctioning of these accessories.

10.9 *Equipment Containing High Energy Rotors:*

10.9.1 High energy rotors contained in equipment such as Auxiliary Power Units (APUs) and constant speed drive units

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must be able to withstand damage caused by malfunctions, vibration, abnormal speeds, and abnormal temperatures.

10.9.2 Auxiliary rotor cases in equipment such as Auxiliary Power Units (APUs) and constant speed drive units must be able to contain damage caused by the failure of high energy rotor blades.

10.9.3 Equipment control devices, systems, and instrumentation must reasonably ensure that no operating limitations affecting the integrity of high energy rotors in equipment such as Auxiliary Power Units (APUs) and constant speed drive units will be exceeded in service.

10.9.4 As an alternative to 10.9.1 – 10.9.3, it may be shown by test that equipment containing high energy rotors can contain any failure of a high energy rotor that occurs at the highest speed obtainable with the normal speed control devices inoperative.

10.9.5 As an alternative to 10.9.1 – 10.9.4, equipment containing high energy rotors may be located where rotor failure will neither endanger the occupants nor adversely affect continued safe flight.

11. Hydraulic Systems

11.1 *Hydraulic Systems:*

11.1.1 Each hydraulic system and its elements must withstand, without yielding, the structural loads expected in addition to hydraulic loads.

11.1.2 A means to verify the quantity of hydraulic fluid in the system must be provided.

11.1.3 A means to indicate the pressure in each hydraulic system which supplies two or more primary functions must be provided to the flight crew.

11.1.4 There must be means to ensure that the pressure, including transient (surge) pressure, in any part of the system will not exceed the safe limit above design operating pressure.

11.1.5 There must be means to prevent excessive pressure resulting from fluid volumetric changes in all lines which are likely to remain closed long enough for such changes to occur.

11.1.6 The minimum design burst pressure must be 2.5 times the operating pressure.

11.1.7 Each system must be substantiated by proof pressure tests.

11.1.7.1 When proof tested, no part of any system may fail, malfunction, or experience a permanent set.

11.1.7.2 The proof load of each system must be at least 1.5 times the maximum operating pressure of that system.

11.1.8 A hydraulic accumulator or reservoir may be installed on the engine side of any firewall if: it is an integral part of an engine or propeller system; or, the reservoir is nonpressurized and the total capacity of all such nonpressurized reservoirs is 0.95 L [0.25 US gal] or less.

12. Instrumentation

12.1 *Instrumentation Requirements*—In addition to the applicable requirements of this specification, instrumentation shall comply with the provisions of Specification F3233/F3233M.

13. Mechanical Systems & Equipment

13.1 *Landing Gear:*

13.1.1

Level 4	All Others
The main landing gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.	Reserved

13.1.2

Level 4	All Others
Compliance with the provisions of 13.1.1 may be shown by analysis or tests, or both.	Reserved

13.2 *Shock Absorption Tests:*

13.2.1 Except as provided in 13.2.1.1 – 13.2.1.3, it must be shown by energy absorption tests that the limit load factors selected for design in accordance with Specification F3116/F3116M for takeoff and landing weights will not be exceeded.

13.2.1.1 For increases in previously approved takeoff or landing weights, or both, the requirements of 13.2.1 may be shown by analysis based on tests conducted on a landing gear system with identical energy absorption characteristics.

13.2.1.2

Level 1 *and* Low-Stall	All Others
The requirements of 13.2.1 may be shown by analysis based on previously approved wheel-type landing gear on aircraft with similar weights and performance.	Reserved

13.2.1.3

Level 1 *and* Low-Stall	All Others
The requirements of 13.2.1 may be shown by analysis based on landing gear for which adequate experience and substantiating data are available.	Reserved

13.2.2 The landing gear may not fail, but may yield, in a test showing its reserve energy absorption capacity, simulating a descent velocity of 1.2 times the limit descent velocity, assuming wing lift equal to the weight of the aeroplane.

13.3 *Limit Drop Tests:*

13.3.1 If compliance with 13.2.1 is shown by free drop tests, these tests must be made on the complete aeroplane, or on units consisting of wheel, tire, and shock absorber, in their proper relation, from free drop heights not less than those determined by the following formula in conjunction with Table 2:

$$h = C \cdot \left(\frac{W}{S} \right)^{1/2} \quad (1)$$

TABLE 2 Legend for Drop Test Height Formula

Variable	Value	SI Units	English Units
h	Height of Free Drop Test	m	in.
C	Unit Correction Factor	0.0414	3.6
W	Design Maximum Takeoff Weight	kg	lb_m
S	Wing Area (including fuselage projection)	m^2	ft^2

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13.3.1.1 In complying with the requirements of 13.3.1, the free drop height may not be less than 0.234 m [9.2 in.] and need not be more than 0.475 m [18.7 in.].

13.3.2 If the effect of wing lift is provided for in free drop tests, the landing gear must be dropped with an effective weight equal to that derived from the following formula in conjunction with Table 3:

$$W_e = W \cdot \left(\frac{h + [d \cdot (1 - L)]}{h + d} \right) \quad (2)$$

13.3.3 The limit inertia load factor must be determined in a rational or conservative manner, during the drop test, using a landing gear unit attitude, and applied drag loads, that represent the landing conditions.

13.3.4 The value of d used in the computation of W_e in 13.3.2 may not exceed the value actually obtained in the drop test.

13.3.5 The limit inertia load factor must be determined from the drop test in 13.3.2 according to the following formula in conjunction with Table 4:

$$n = \frac{n_j \cdot W_e}{W} + L \quad (3)$$

13.3.6 The value of n determined in accordance with 13.3.5 may not be more than the limit inertia load factor used in the landing conditions in Specification F3116/F3116M.

13.4 *Ground Load Dynamic Tests:*

13.4.1 If compliance with the ground load requirements of Specification F3116/F3116M is shown dynamically by drop test, one drop test must be conducted that meets the requirements of 13.3 except that the drop height must be either: 2.25 times the drop height prescribed in 13.3.1; or, sufficient to develop 1.5 times the limit load factor.

13.4.2 The critical landing condition for each of the design conditions specified in Specification F3116/F3116M must be used for proof strength.

13.5 *Reserve Energy Absorption Drop Tests:*

13.5.1 If compliance with the reserve energy absorption requirements in 13.2.2 is shown by free drop tests, the drop height may not be less than 1.44 times that specified in 13.3.

13.5.2 If the effect of wing lift is provided for, the units must be dropped with an effective weight equal to that derived from the following formula in conjunction with Table 5:

$$W_e = W \cdot \left(\frac{h}{h + d} \right) \quad (4)$$

13.6 *Landing Gear Extension / Retraction Systems:*

13.6.1 For aircraft with retractable landing gear, each landing gear retracting mechanism and its supporting structure must be designed for maximum flight load factors with the gear retracted.

13.6.2 For aircraft with retractable landing gear, each landing gear retracting mechanism and its supporting structure must be designed for the combination of friction, inertia, brake torque, and air loads, occurring during retraction at any airspeed up to 1.6 times V_{S1} (1.5 times V_{SR1})with flaps retracted.

13.6.3 For aircraft with retractable landing gear, each landing gear retracting mechanism and its supporting structure must be designed for any load factor up to those specified in Specification F3116/F3116M for the flaps-extended condition.

13.6.4 For aircraft with retractable landing gear, the landing gear and retracting mechanism, including the wheel well doors, must withstand flight loads, including loads resulting from all yawing conditions specified in Specification F3116/F3116M, with the landing gear extended at any speed up to at least 1.6 times V_{S1} (1.5 times V_{SR1}) with the flaps retracted.

13.6.5 For aircraft with retractable landing gear, there must be positive means (other than the use of hydraulic pressure) to keep the landing gear extended.

13.6.6 For landplanes with retractable landing gear that cannot be extended manually, there must be means to extend the landing gear in the event of either: any reasonably probable failure in the normal landing gear operation system; or, any reasonably probable failure in a power source that would prevent the operation of the normal landing gear operation system.

13.6.7 For aircraft with retractable landing gear, the proper functioning of the retracting mechanism must be shown by operation tests.

TABLE 3 Legend for Effective Weight Formula

Variable	Value	SI Units	English Units
W_e	Effective Weight to be used in Drop Test	kg	lb_m
h	Specified Drop Height	m	in.
d	Deflection Under Impact of the Tire at the Approved Inflation Pressure PLUS Vertical Component of Axle Travel relative to the Drop Mass	m	in.
W	For Main Gear Units, W_M (Static Weight on that Unit with the Aircraft in Level Attitude, with the Nose Wheel clear for nose-wheel type aircraft) For Tail Gear Units, W_T (Static Weight on the Tail Unit with the Aircraft in the Tail-Down Attitude) For Nose Wheel Units, W_N (Vertical Component of the Static Reaction at the Nose Wheel, assuming that the Mass of the Aircraft acts at the Center of Gravity and exerts a force of 1.0 g Downward and 0.33 g Forward)	kg	lb_m
L^A	Ratio of Assumed Wing Lift to Aircraft Weight	—	—

[A] L need not be more than 0.667.

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TABLE 4 Legend for Limit Inertia Load Factor Formula

Variable	Value	SI Units	English Units
n	Limit Inertia Load Factor	—	—
n_j	Acceleration (dv/dt, in g's) as recorded in the Drop Test PLUS 1.0	—	—
W_e	Effective Weight to be used in Drop Test	kg	lb_m
W	For Main Gear Units, W_M (Static Weight on that Unit with the Aircraft in Level Attitude, with the Nose Wheel clear for nose-wheel type aircraft) For Tail Gear Units, W_T (Static Weight on the Tail Unit with the Aircraft in the Tail-Down Attitude) For Nose Wheel Units, W_N (Vertical Component of the Static Reaction at the Nose Wheel, assuming that the Mass of the Aircraft acts at the Center of Gravity and exerts a force of 1.0 g Downward and 0.33 g Forward)	kg	lb_m
L^A	Ratio of Assumed Wing Lift to Aircraft Weight	—	—

[A] L need not be more than 0.667.

TABLE 5 Legend for Reserve Energy Effective Weight Formula

Variable	Value	SI Units	English Units
W_e	Effective Weight to be used in Drop Test	kg	lb_m
h	Specified Drop Height	m	in
d	Deflection Under Impact of the Tire at the Approved Inflation Pressure PLUS Vertical Component of Axle Travel relative to the Drop Mass	m	in
W	For Main Gear Units, W_M (Static Weight on that Unit with the Aircraft in Level Attitude, with the Nose Wheel clear for nose-wheel type aircraft) For Tail Gear Units, W_T (Static Weight on the Tail Unit with the Aircraft in the Tail-Down Attitude) For Nose Wheel Units, W_N (Vertical Component of the Static Reaction at the Nose Wheel, assuming that the Mass of the Aircraft acts at the Center of Gravity and exerts a force of 1.0 g Downward and 0.33 g Forward)	kg	lb_m

13.6.8 For aircraft with retractable landing gear, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that each gear is secured in the extended (or retracted) position.

13.6.8.1 If switches are used, they must be located and coupled to the landing gear mechanical system in a manner that prevents an erroneous indication of either "down and locked" if each gear is not in the fully extended position, or "up and locked" if each landing gear is not in the fully retracted position.

13.6.9 For landplanes with retractable landing gear, aural or equally effective landing gear warning devices must be provided in accordance with 13.6.9.1 – 13.6.9.7.

13.6.9.1 Except as provided in 13.6.9.3, at least one warning device must function continuously when one or more throttles are closed beyond the power settings normally used for landing approach if the landing gear is not fully extended and locked.

13.6.9.2 A throttle stop may not be used to satisfy 13.6.9.1 in place of an aural warning device.

13.6.9.3 If there is a manual shutoff for the warning device used to satisfy 13.6.9.1, the warning system must be designed so that when the warning has been suspended after one or more throttles are closed, subsequent retardation of any throttle to, or beyond, the position for normal landing approach will activate the warning device.

13.6.9.4 At least one warning device must function continuously when the wing flaps are extended beyond the maximum approach flap position, using a normal landing procedure, if the landing gear is not fully extended and locked.

13.6.9.5 There may not be a manual shutoff for the warning device used to satisfy 13.6.9.4.

13.6.9.6 The flap position sensing unit for the warning device used to satisfy 13.6.9.4 may be installed at any suitable location.

13.6.9.7 The system for the warning device used to satisfy 13.6.9.4 may use any part of the system (including the aural warning device) for the warning device used to satisfy 13.6.9.1.

13.6.10 For aircraft with retractable landing gear, if the landing gear bay is used as the location for equipment other than the landing gear, that equipment must be designed and installed to minimize damage from items such as a tire burst, or rocks, water, and slush that may enter the landing gear bay.

13.6.11 If nose/tail wheel steering is installed, movement of the pilot's steering control must not result in a condition that would interfere with the retraction or extension of the landing gear.

13.7 *Wheels:*

13.7.1 The maximum static load rating of each wheel may not be less than the corresponding static ground reaction at the design maximum weight and critical center of gravity.

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13.7.2 The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of Specification F3116/F3116M.

13.8 *Tires:*

13.8.1 Each main wheel tire must have a static tire rating that is not exceeded by a load on each main wheel tire equal to the corresponding static ground reaction under the design maximum weight and critical center of gravity.

13.8.2 Each nose wheel tire must have a dynamic tire rating that is not exceeded by a load on nose wheel tires equal to the reaction obtained at the nose wheel, assuming the mass of the aircraft to be concentrated at the most critical center of gravity and exerting a downward force of 1.0*W* and a forward force as described in Table 6 (where *W* is the design maximum weight), with the reactions distributed to the nose and main wheels by the principles of statics, and with the drag reaction at the ground applied only at wheels with brakes.

13.8.3 If specially constructed tires are used, the wheels must be plainly and conspicuously marked to that effect. The markings must include the make, size, number of plies, and identification marking of the proper tire.

13.8.4 Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tire and any part of the structure or systems.

13.9 *Brakes:*

13.9.1 If brakes are provided, the landing brake kinetic energy capacity rating of each main wheel brake assembly must not be less than the kinetic energy absorption requirements determined under either of the methods presented in 13.9.1.1 and 13.9.1.2.

13.9.1.1 The brake kinetic energy absorption requirements must be based on a conservative analysis of the sequence of events expected during landing at the design landing weight.

13.9.1.2 Instead of an analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula in conjunction with Table 7:

$$KE = \frac{C \cdot W \cdot V^2}{N} \tag{5}$$

13.9.2 Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the aircraft with wheels locked.

13.9.3 If a landing distance determination is required by Specification F3179/F3179M, the pressure on the wheel braking system must not exceed the maximum design pressure established for the system; higher pressures are not allowed for this determination.

TABLE 6 Forward Nose Gear Forces

Aircraft Stall Speed	Forward Force
Less than or equal to 83 km/h [45 knots]	0.21*W*
Greater than 83 km/h [45 knots]	0.31*W*

13.9.4 If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction or failure will result in a hazardous loss of braking ability or directional control of the aircraft; refer to Practice F3230.

13.9.5 For aircraft required to meet Specification F3179/F3179M, the aborted takeoff brake kinetic energy capacity rating of each main wheel brake assembly may not be less than the kinetic energy absorption requirements determined under either of the methods presented in 13.9.5.1 and 13.9.5.2.

13.9.5.1 In showing compliance with 13.9.5, the brake kinetic energy absorption requirements must be based on a conservative analysis of the sequence of events expected during an aborted takeoff at the design takeoff weight.

13.9.5.2 In showing compliance with 13.9.5, instead of an analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula in conjunction with Table 8:

$$KE = \frac{C \cdot W \cdot V^2}{N} \tag{6}$$

13.10 *Skis*—The maximum limit load rating of each ski must equal or exceed the maximum limit load determined under the applicable ground load requirements of Specification F3116/F3116M.

13.11 *Reserved (refer to 13.12):*

13.12 *Door Systems:*

13.12.1 Each door on the exterior of the fuselage and each door of the primary pressure vessel on a pressurized aircraft must comply with the requirements of either 13.12.2 or 13.12.3 unless the door can be shown to meet all of the requirements of 13.12.4.

NOTE 5—Doors that meet the conditions in 13.12.4 are Category C. Doors that meet the conditions in 13.12.3.1 – 13.12.3.7 are Category B. All other doors are Category A.

13.12.2 Category A Doors are protected against inadvertent opening in flight if they comply with all the following requirements:

13.12.2.1 There must be a means to safeguard the door against inadvertent opening in flight, by persons, by cargo, or as a result of mechanical failure or failure of a single structural element, either during or after closure, latching and locking.

NOTE 6—If a door has a handle accessible to occupants while in flight, it should be considered in the assessment of protecting inadvertent opening of doors by persons.

13.12.2.2 There must be a provision to latch the door.

13.12.2.3 There must be a locking means to prevent the latches from becoming disengaged and it must not be possible to position the locks in a locked position if any of the latches are not in the fully latched position.

13.12.2.4 There must be a means visible by the flight crew when seated at their duty station to indicate if the door is not fully closed, latched, and locked. The means must be designed so that any failure, or combination of failures, that would result in an incorrect closed, latched, and locked indication is remote.

NOTE 7—For example, the visible means can be a light or electronic in

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