Designation: ~~F3232/F3232M – 23~~ F3232/F3232M – 23a

Standard Specification for Flight Controls in Small Aircraft[1]

This standard is issued under the fixed designation F3232/F3232M; 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 international standards for the flight control aspects of airworthiness and design for "small" aircraft.

1.2 The applicant for a design approval must seek the individual guidance of their respective CAA body concerning the use of this specification as part of a certification plan. For information on which CAA regulatory bodies have accepted this specification (in whole or in part) as a means of compliance to their Small Aircraft Airworthiness regulations (hereinafter referred to as "the Rules"), refer to ASTM F44 webpage (www.ASTM.org/COMMITTEE/F44.htm) which includes CAA website links. Annex A1 maps the Means of Compliance described in this Standard to EASA CS 23, amendment 5, or later, and FAA 14 CFR 23, amendment 64, or later.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

F3061/F3061M Specification for Systems and Equipment in Aircraft

F3116/F3116M Specification for Design Loads and Conditions

F3117/F3117M Specification for Crew Interface 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.

Current edition approved ~~May 1, 2023~~Oct. 1, 2023. Published ~~May 2023~~November 2023. Originally approved in 2017. Last previous edition approved in ~~2020~~2023 as ~~F3232/F3232M – 20.~~F3232/F3232M – 23. DOI: ~~10.1520/F3232_F3232M-23.~~10.1520/F3232_F3232M-23A.

[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.

F3173/F3173M Specification for Aircraft Handling Characteristics
F3180/F3180M Specification for Low-Speed Flight Characteristics of Aircraft
F3230 Practice for Safety Assessment of Systems and Equipment in Small Aircraft
2.3 *Other Standards:*
FAA-S-ACS Private Pilot - Airplane Airman Certification Standards[3]
RTCA/DO-335 Guidance for Installation of Automatic Flight Guidance and Control Systems (AFGCS) for Part 23 Airplanes[4]

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aircraft type code, n*—an Aircraft Type Code (ATC) is defined by considering both the technical considerations regarding the design of the aircraft and the aeroplane certification level established based upon risk-based criteria; the method of defining an ATC applicable to this specification is defined in Specification F3061/F3061M.

3.2.2 *continued safe flight and landing, n*—continued safe flight and landing as applicable to this specification is defined in Specification F3061/F3061M.

3.2.3 *single failure, n*—a single failure as applicable to this specification is defined in Practice F3230.

4. Manual Flight Controls

NOTE 1—Table 1 provides correlation between various Aircraft Type Codes and the individual requirements contained within this section; refer to 3.2.1. For each subsection, an indicator can be found under each ATC character field; three indicators are used:
An empty cell ( ) in all applicable ATC character field columns indicates that an aircraft must meet the requirements of that subsection.
A white circle (○) in multiple columns indicates that the requirements of that subsection are not applicable to an aircraft *only* if all such ATC character fields are applicable.
A mark-out (×) in any of the applicable ATC character field columns indicates that the requirements of that subsection are not applicable to an aircraft if that ATC character field is applicable.
Examples—An aircraft with an ATC of 1SRLLDLN is being considered. Since all applicable columns are empty for 4.1.2, that subsection is applicable to the aircraft. However, since the "S" number-of-engines column for 4.4.8 contains an ×, then that subsection is not applicable.

4.1 *Control Surface Installation:*

4.1.1 Movable surfaces must be installed so that there is no interference between any surfaces, their bracing, or adjacent fixed structure, when one surface is held in its most critical clearance positions and the others are operated through their full movement.

4.1.2 If an adjustable stabilizer is used, it must have stops that will limit its range of travel to that allowing safe flight and landing.

4.1.3 Control surface hinges, except ball and roller bearing hinges, must have a factor of safety of not less than 6.67 with respect to the ultimate bearings strength of the softest material used as a bearing.

4.1.3.1 For ball or roller bearing hinges, the approved rating of the bearing may not be exceeded.

4.1.4 Control system joints (in push-pull systems) that are subject to angular motion, except those in ball and roller bearing systems, must have a special factor of safety of not less than 3.33 with respect to ultimate bearing strength of the softest material used as a bearing.

4.1.4.1 The factor specified in 4.1.4 may be reduced to 2.0 for joints in cable control systems.

4.1.4.2 For ball or roller bearings, the approved rating of the bearing may not be exceeded.

4.2 *Operation and Arrangement:*

4.2.1 Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.

[3] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.
[4] Available from RTCA, Inc., 1150 18th St., NW, Suite 910, Washington, DC 20036, http://www.rtca.org.

TABLE 1 ATC Compliance Matrix, Section 4

Section	Aeroplane Certification Level				Number of Engines		Type of Engine(s)		Stall Speed			Cruise Speed		Meteorological Conditions			Altitude		Maneuvers	
	1	2	3	4	S	M	R	T	L	M	H	L	H	D	N	I	L	H	N	A
4																				
4.1																				
4.1.1																				
4.1.2																				
4.1.3																				
4.1.3.1																				
4.1.4																				
4.1.4.1																				
4.1.4.2																				
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4.3.3																				
4.4																				
4.4.1																				
4.4.2																				
4.4.3																				
4.4.4																				
4.4.5																				
4.4.6		×	×	×		×				×	×									
4.4.7	○					×			○											
4.4.8					×															
4.4.9																				
4.4.10																				
4.5																				
4.5.1																				
4.5.2	×																			
4.5.3																				
4.6																				
4.6.1																				
4.6.1.1																				
4.6.2																				
4.7																				
4.7.1																				
4.7.2																				
4.7.3																				
4.8																				
4.8.1																				
4.8.2																				
4.8.3																				
4.8.4																				
4.9																				
4.10																				
4.10.1																				
4.10.2																				
4.10.2.1																				
4.10.3																				
4.10.4																				
4.10.5																				
4.10.6																				
4.10.7																				
4.10.8																				
4.10.9																				
4.10.10																				
4.11																				
4.11.1																				
4.11.2																				
4.11.3																				
4.12																				
4.12.1																				
4.12.2																				
4.13																				
4.13.1																				
4.13.2																				
4.13.3				×									×					×		
4.13.4																				
4.13.5					×															
4.13.6	○								○					○						

4.2.2 Controls must be arranged and identified to provide for convenience in operation and so as to not cause confusion and subsequent inadvertent operation; refer to Specification F3117/F3117M.

4.3 *Control System Stops:*

4.3.1 Each control system must have stops that positively limit the range of motion of each movable aerodynamic surface controlled by the system.

4.3.2 Each stop must be located so that wear, slackness, or takeup adjustments will not adversely affect the control characteristics of the aircraft because of a change in the range of surface travel.

4.3.3 Each stop must be able to withstand any loads corresponding to the design conditions for the control system.

4.4 *Trim Systems:*

4.4.1 Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation.

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

4.4.3 There must be means to indicate to the pilot the position of the trim device with respect to both the range of adjustment and, in the case of lateral and directional trim, the neutral position.

4.4.4 The means provided to satisfy the requirements of 4.4.2 and 4.4.3 must be visible to the pilot and must be located and designed so as to not cause confusion.

4.4.5 The pitch trim indicator must be clearly marked with a position or range within which it has been demonstrated that take-off is safe for all center of gravity positions and each flap position approved for takeoff.

4.4.6 The design of the primary flight controls must be such as to minimize the likelihood of failure of any connecting or transmitting element in the control system that could result in loss of control of any axis.

4.4.7 Trimming devices must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, adequate control for safe flight and landing is available with the longitudinal trimming devices.

4.4.8 Trimming devices must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, adequate control for safe flight and landing is available with the longitudinal and directional trimming devices.

4.4.9 Tab controls must be irreversible unless the tab is properly balanced and has no unsafe flutter characteristics. Irreversible tab systems must have adequate rigidity and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the aircraft structure.

4.4.10 If a powered trim system is installed, it must be demonstrated that the aeroplane is safely controllable, and that the pilot can perform all the maneuvers and operations necessary for continued safe flight and landing following any powered trim system runaway that is not extremely improbable, allowing for appropriate time delay after pilot recognition of the trim system runaway. The demonstration must be conducted at the critical aeroplane weights and center of gravity positions.

4.5 *Control System Locks:*

4.5.1 If there is a device to lock the control system on the ground or water, there must be a means to give unmistakable warning to the pilot when lock is engaged, or to automatically disengage the device when the pilot operates the primary flight controls in a normal manner.

4.5.2 If there is a device to lock the control system on the ground or water, the device must be installed to limit the operation of the aircraft so that, when the device is engaged, the pilot receives unmistakable warning at the start of the takeoff.

4.5.3 If there is a device to lock the control system on the ground or water, the device must have a means to preclude the possibility of it becoming inadvertently engaged in flight.

4.6 *Limit Load Static Tests:*

4.6.1 Compliance with established limit load requirements must be shown by limit load tests in which the direction of the test loads produces the most severe loading in the control system.

4.6.1.1 In meeting the requirements of 4.6.1, each fitting, pulley, and bracket used in attaching the system to the main structure must be included.

4.6.2 Compliance must be shown by analysis or by individual load tests with the special factor requirements for control system joints subject to angular motion.

4.7 *Operation Tests:*

4.7.1 It must be shown by operation tests that, when the controls are operated from the pilot compartment 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.

4.7.2 For the entire system, the prescribed test loads are those corresponding to the limit airloads on the appropriate surface, or the limit pilot forces in Specification F3116/F3116M, whichever are less.

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

NOTE 2—Sections 4.6 and 4.7 are intended for primary flight control systems such as elevator systems, aileron systems, and rudder systems, as well as secondary control systems such as flap systems, trim systems, brake systems and steering systems. Although not required, they could also be used for any control system that transmits motions through mechanisms such as cables, pulleys, and pushrods.

4.8 *Control System Details:*

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

4.8.2 There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam the system.

4.8.3 There must be means to prevent the slapping of cables or tubes against other parts.

4.8.4 Each element of the flight control system must have design features, or must be distinctively and permanently marked, to minimize the possibility of incorrect assembly that could result in malfunction or reverse operation of the control system.

4.9 *Spring Devices*—The reliability of any spring device used in the control system must be established by tests simulating service conditions unless failure of the spring will not cause flutter or unsafe flight characteristics.

4.10 *Cable Systems:*

4.10.1 Each cable, cable fitting, turnbuckle, splice, and pulley used must meet specifications that are acceptable to the governing civil aviation authority.

4.10.2 No cable smaller than 3.2 mm [0.125 in.] diameter may be used in primary control systems.

4.10.2.1 Tab control cables are not part of the primary control system and may be less than 3.2 mm [0.125 in.] diameter in aircraft that are safely controllable with the tabs in the most adverse positions.

4.10.3 Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations.

4.10.4 There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle.

4.10.5 Each kind and size of pulley must correspond to the cable with which it is used.

4.10.6 Each pulley must have closely fitted guards to prevent the cables from being misplaced or fouled, even when slack.

4.10.7 Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.

4.10.8 Fairleads must be installed so that they do not cause a change in cable direction of more than 3°.

4.10.9 Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system.

4.10.10 Turnbuckles must be attached to parts having angular motion in a manner that will positively prevent binding throughout the range of travel.

4.11 *Wing Flap Controls:*

4.11.1 Each wing flap control must be designed so that, when the flap has been placed in any position upon which compliance with the performance requirements of the rules of governing civil aviation authority is based, the flap will not move from that position unless the control is adjusted or is moved by the automatic operation of a flap load limiting device.

4.11.2 The rate of movement of the flaps in response to the operation of the pilot's control or automatic device must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power, and attitude.

4.11.3 If compliance with Longitudinal Control requirements in Specification F3173/F3173M necessitates wing flap retraction to positions that are not fully retracted, movement of the flap control past the intermediate position must require a different or additional physical action to prevent unintentional movement past the intermediate position.

4.12 *Wing Flap Position Information:*

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, unless: a direct operating mechanism provides a sense of "feel" and position (such as when a mechanical linkage is employed); or, the flap position is readily determined without seriously detracting from other piloting duties under any flight condition, day or night.

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, and the flap installation does not provide a sense of "feel" and position (such as when a mechanical linkage is employed).

4.13 *Flap Interconnection*—The aircraft must be designed to protect against unsafe wing flap asymmetry using one of the following options: 4.13.1, 4.13.2, 4.13.3, or 4.13.4.

4.13.1 The main wing flaps and related movable surfaces as a system must be synchronized by a mechanical interconnection between the movable flap surfaces that is independent of the flap drive system.

4.13.2 The aircraft must be designed so that any catastrophic flap system failure condition is extremely improbable (refer to Practice F3230).

4.13.3 Moveable flap surfaces must be synchronized by a simple and reliable mechanical interconnection. The entire flap system must be designed to withstand the loading, which would occur due to a jam at any point in the flap system with a 1.5 factor of safety.

NOTE 3—For 4.13.3, the mechanical interconnection may be part of the flap actuation system. Some examples of simple and reliable mechanical interconnections include:
(1) Flap surfaces interconnected by a torque tube and bell cranks.
(2) Flap surfaces interconnected by cables and bell cranks.
(3) Flap surfaces interconnected by pushrods and bell cranks.
Flexible shafts are not considered simple and reliable.

4.13.4 The aircraft must be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces (surfaces synchronized by a mechanical interconnection that is independent of the flap drive system are to be considered as a single surface).

4.13.5 Except as provided in 4.13.6, if compliance with 4.13.1 through 4.13.4 is met through the use of an interconnection, it must be designed to account for the unsymmetrical loads resulting from flight with the engine(s) on one side of the plane of symmetry inoperative and the remaining engines at takeoff power.

4.13.6 For single-engine aircraft and multiengine aircraft with no slipstream effects on the flaps, if compliance with 4.13.1 through 4.13.4 is met through the use of an interconnection, it must be designed to account for unsymmetrical loads assuming 100 % of the critical air load acts on one side and 70 % on the other.

5. Automatic Flight Controls

NOTE 4—Table 2 provides correlation between various Aircraft Type Codes and the individual requirements contained within this section; refer to 3.2.1. For each subsection, an indicator can be found under each ATC character field; three indicators are used:

An empty cell ( ) in all applicable ATC character field columns indicates that an aircraft must meet the requirements of that subsection.

A white circle (○) in multiple columns indicates that the requirements of that subsection are not applicable to an aircraft *only* if all such ATC character fields are applicable.

TABLE 2 ATC Compliance Matrix, Section 5

	Aeroplane Certification Level				Number of Engines		Type of Engine(s)		Stall Speed			Cruise Speed		Meteorological Conditions			Altitude		Maneuvers	
Section	1	2	3	4	S	M	R	T	L	M	H	L	H	D	N	I	L	H	N	A
5																				
5.1																				
5.1.1																				
5.1.2																				
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5.4.3.2																				
5.4.4																				

A mark-out (×) in any of the applicable ATC character field columns indicates that the requirements of that subsection are not applicable to an aircraft if that ATC character field is applicable.

Example—An aircraft with an ATC of 1SRLLDLN is being considered. Since all applicable columns are empty for 5.1.1, that subsection is applicable to the aircraft.

5.1 *Automatic Pilot Systems:*

5.1.1 If an automatic pilot system is installed, it must be designed so that: the automatic pilot can be quickly and positively disengaged by the pilots to prevent it from interfering with their control of the aircraft; or, be sufficiently overpowered by one pilot to let him control the aircraft.

5.1.2 If an automatic pilot system is installed and is designed so that it can be quickly and positively disengaged by the pilots as described in 5.1.1, the quick release (emergency) control must be located on the control wheel (both control wheels if the aircraft can be operated from either pilot seat) on the side opposite the throttles, or on the stick control (both stick controls if the aircraft can be operated from either pilot seat), such that it can be operated without moving the hand from its normal position on the control.

5.1.3 If an automatic pilot system is installed, unless there is automatic synchronization, each such 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 If an automatic pilot system is installed, 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 If an automatic pilot system is installed, it 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 If an automatic pilot system is installed, it must be designed so that a single malfunction will not produce a hardover signal in more than one control axis.

5.1.7 If an automatic pilot is installed and 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 If an automatic pilot system is installed, there must be protection against adverse interaction of integrated components, resulting from a malfunction.

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

5.2 *Stability Augmentation*—If the functioning of stability augmentation or other automatic or power-operated systems is necessary to show compliance with the flight characteristics requirements of the rules of the governing civil aviation authority, such systems must comply with 4.2 and 5.2.1 – 5.2.6.

5.2.1 In showing compliance with 5.2, a warning which is clearly distinguishable to the pilot under expected flight conditions without requiring the pilot's attention, must be provided for any failure in the stability augmentation system or in any other automatic or power-operated system that could result in an unsafe condition if the pilot was not aware of the failure.

5.2.2 In showing compliance with 5.2, warning systems must not activate the control system.

5.2.3 In showing compliance with 5.2, the design of the stability augmentation system or of any other automatic or power-operated system must permit initial counteraction of failures without requiring exceptional pilot skill or strength, by either the deactivation of the system or a failed portion thereof, or by overriding the failure by movement of the flight controls in the normal sense.

5.2.4 In showing compliance with 5.2, it must be shown that, after any single failure of the stability augmentation system or any

other automatic or power-operated system, the aircraft is safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations that is critical for the type of failure being considered.

5.2.5 In showing compliance with 5.2, it must be shown that, after any single failure of the stability augmentation system or any other automatic or power-operated system, the controllability and maneuverability requirements of the rules of the governing civil aviation authority are met within a practical operational flight envelope (for example, speed, altitude, normal acceleration, and aircraft configuration) that is described in the Airplane Flight Manual (AFM).

5.2.6 In showing compliance with 5.2, it must be shown that, after any single failure of the stability augmentation system or any other automatic or power-operated system, the trim, stability, and stall characteristics are not impaired below a level needed to permit continued safe flight and landing.

5.3 *Artificial Stall Barrier System*—If the function of an artificial stall barrier (for example, stick pusher) is used to show compliance with Stall Characteristics requirements in Specification F3180/F3180M, the system must meet the requirements of 5.3.1 – 5.3.8.

5.3.1 In showing compliance with 5.3, with the system adjusted for operation, the plus and minus airspeeds at which control input will be provided must be established.

5.3.2 In showing compliance with 5.3, considering the plus and minus airspeed tolerances established by 5.3.1, an airspeed must be selected for the activation of the control input that provides a safe margin above any airspeed at which any unsatisfactory stall characteristics occur.

5.3.3 In showing compliance with 5.3, in addition to the Stall Warning required by Specification F3180/F3180M, a warning that is clearly distinguishable to the pilot under all expected flight conditions, without requiring the pilot's attention, must be provided for faults that would prevent the system from providing the required control input.

5.3.4 In showing compliance with 5.3, each system must be designed so that the artificial stall barrier can be quickly and positively disengaged by the pilot to prevent unwanted control input by a quick release (emergency) control that meets the requirements of 5.1.2.

5.3.5 In showing compliance with 5.3, a preflight check of the complete system must be established and the procedure for this check made available in the Airplane Flight Manual (AFM).

5.3.5.1 In showing compliance with 5.3.5, preflight checks that are critical to the safety of the aircraft must be included in the limitations section of the AFM.

5.3.6 In showing compliance with 5.3, for those aircraft whose design includes an autopilot system, a quick release (emergency) control installed in accordance with 5.1.2 may be used to meet the requirements of 5.3.4.

5.3.6.1 For those aircraft showing compliance by utilizing the provisions of 5.3.6, the pitch servo for that system may be used to provide the control input.

5.3.7 In showing compliance with 5.3 and Specification F3061/F3061M, the system must be evaluated to determine the effect that any announced or unannounced failure may have on the continued safe flight and landing of the aircraft or the ability of the crew to cope with any adverse conditions that may result from such failures. This evaluation must consider the hazards that would result from the aircraft's flight characteristics if the system was not provided, and the hazard that may result from unwanted control input, which could result from a failure at airspeeds above the selected stall speed.

5.3.8 In showing compliance with 5.3, the servos for the artificial stall barrier must be sized such that the control force when activated is not less than 356 N [80 lb_f] for wheel control, not less than 311 N [70 lb_f] for stick controls, and not less than 178 N [40 lb_f] for side stick controls.

5.4 If the function of an Enhanced Envelope Awareness System (EEAS) is incorporated in accordance with Specification F3180/F3180M, the system must meet the requirements of 5.4.1 through 5.4.4.

5.4.1 The EEAS shall provide control force feedback to the pilot along the corresponding control axes to provide further