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Standard Specification for Low-Speed Flight Characteristics of Aircraft[1]

This standard is issued under the fixed designation F3180/F3180M; 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 ~~will cover~~ covers the low-speed flight characteristics of fixed-wing aircraft ~~with a certified maximum take-off weight of 8618 kg [19 000 lb] or less and a passenger-seating configuration of up to 19 at low speed and provide standards for departure characteristics, spinning, and stall warning.~~and provides standards for departure characteristics, spinning, and stall warning. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on 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: (4.1) Low-Speed Flight Characteristics Score, (4.2) Stall Characteristics, (4.3) Stall Warning, (4.4) Departure Characteristics: Single Engine, (4.5) Departure Characteristics: Multiengine, (4.6) Spinning, and (4.7) Safety-Enhancing Features.

~~1.2 The term "aeroplane" is utilized in this specification as it was originally conceived for normal category fixed wing aircraft with a maximum certificated weight of 8618 kg [19 000 lb] or less and a passenger seating configuration up to 19 as defined in the Rules. However, these standards may be more broadly applicable and their usage should not be unnecessarily limited.~~

1.2 ~~The applicant~~ An applicant intending to propose this information as Means of Compliance for a design approval ~~shall~~must seek ~~the individual~~ guidance ~~to~~from their respective ~~civil aviation authority (CAA) body concerning the use of this specification as part of a certification plan.~~oversight authority (for example, published guidance from applicable CAAs) concerning the acceptable use and application thereof. For information on which ~~CAA regulatory bodies~~ oversight authorities have accepted this ~~specification~~standard (in whole or in part) as ~~a means of compliance~~an acceptable Means of Compliance to their ~~Airworthiness Rules (hereinafter referred to as~~ regulatory requirements (hereinafter "the Rules"), refer to the ASTM Committee F44 webpage ~~(www.astm.org/COMMITTEE/F44.htm), which includes CAA website links.~~(www.astm.org/COMMITTEE/F44.htm).

~~1.4 It is the responsibility of the applicant to validate any applicability beyond that identified in this specification and request acceptance from the applicable CAA.~~

1.3 *Units*—~~Normally, the values stated are SI units followed by U.S. Customary Units in square brackets. The values stated in~~ This standard may present information in either SI units, English Engineering units, or both; the values stated in each system may not be exact ~~equivalents; therefore, each~~ equivalents. Each system shall be used independently of the ~~other. Combining~~other; combining values from the two systems may result in nonconformance with the standard. ~~In some cases other units may be used exclusively (such as knots) and no other unit will be identified. This technique should be used sparingly and rationale for its use shall be clear and included in 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 *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 F44.20 on Flight.

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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
F3117 Specification for Crew Interface in Aircraft
F3173/F3173M Specification for Aircraft Handling Characteristics
F3179/F3179M Specification for Performance of Aircraft
F3230 Practice for Safety Assessment of Systems and Equipment in Small Aircraft

2.2 *Other Standards:*
FAA AC 23–15A Small Airplane Certification Compliance Program[3]
FAA AC 23–8C Flight Test Guide for Certification of Part 23 Airplanes[4]
SAE ARP4102/7 Electronic Displays[5]

3. Terminology

3.1 See Terminology F3060 for more definitions and abbreviations.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 ~~*ball width—*~~*ball-width—*a lateral acceleration of tan (4π/180) = 0.07 G = 0.7 m/s^2 [2.3 ft/s^2], which corresponds to a typical unit displacement on a standardized slip-skid indicator.

3.2.2 *directional control—*cockpit control that is intended for, but not necessarily limited to, generation of aircraft yaw motion.

3.2.3 *lateral control—*cockpit control that is intended for, but not necessarily limited to, generation of aircraft roll motion.

3.2.4 *longitudinal control—*cockpit control that is intended for, but not necessarily limited to, generation of aircraft pitch motion.

4. Low-Speed Characteristics

4.1 The applicant shall demonstrate that the aeroplane has acceptable stall characteristics, stall warning, and spinning characteristics, if applicable, by compliance with performance criteria specified for stall characteristics and spinning, as applicable, and by accumulating a number of "points" from stall warning, departure characteristics, and safety-enhancing features.

4.1.1 The sum of the Stall Warning Score (S_{SW}), Departure Characteristics Score ($S_{DC,SE}$ or $S_{DC,ME}$, if required), and the safety-enhancing features score (S_{SEF}, if required) is called the Low-Speed Flight Characteristics Score (S_{LSC}).

NOTE 1—The rationale for the development of the Low-Speed Flight Characteristics Score is provided in Borer's "Development of a New Departure Aversion Standard for Light Aircraft."[6]

4.1.2 The minimum Low-Speed Flight Characteristics Score is dependent on the certification level, number of engines, and whether or not the aeroplane is approved for aerobatics, as summarized in Table 1.

TABLE 1 Summary of Minimum Requirements for Low-Speed Flight Characteristics

NOTE 1—N/A: Not Applicable; A/R: As Required

Certification Level	1	2, 3, 4	1, 2	3, 4	1, 2, 3, 4
Engine(s)	Single	Single	Multi	Multi	Any
Aerobatic?	No	No	No	No	Yes
4.1 Minimum Low-Speed Flight Characteristics Score (S_{LSC})	150	200	150	50	50^A
4.2 Stall Characteristics	Pass all	Pass all	Pass all	Pass all	Pass all
4.3 Stall Warning Score (S_{SW})	Min 50 Max 100	Min 50 Max 100	Min 50 Max 100	Min 50	Min 50
4.4 Departure Characteristics Score – Single Engine ($S_{DC,SE}$)	Min 50^B Max 100	Min 50^B Max 100	N/A	N/A	N/A^A
4.5 Departure Characteristics Score – Multiengine ($S_{DC,ME}$)	N/A	N/A	Min 50 Max 100	N/A	N/A
4.6 Spinning	N/A	N/A	N/A	N/A	Pass all^A
4.7 Safety-Enhancing Features Score (S_{SEF})	A/R to meet S_{LSC}	A/R to meet S_{LSC}	A/R to meet S_{LSC}	N/A	N/A^A

^{A}If spinning is requested for fewer than all possible conditions in 4.2.1 for single-engine aeroplanes, the scores and requirements are pro-rated based on the number of conditions approved for spinning vs. not approved for spinning, as appropriate to Certification Level and Engines.
^{B}$S_{DC,SE}$ may be less than 50 as outlined in 4.4.2.6(*3*), which requires particular equipment from 4.7.3 be installed.

[3] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74398.

[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1019676.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://standards.sae.org/arp4102/7/.

[6] Borer, N. K., "Development of a New Departure Aversion Standard for Light Aircraft," AIAA-2017-3438, 17th AIAA Aviation Technology, Integration, and Operations Conference, Denver Colorado, 2017. Publicly available at: https://ntrs.nasa.gov/search.jsp?R=20170005881, accessed 20 December 2017.

4.2 *Stall:* The applicant shall demonstrate that the aeroplane has controllable stall characteristics in straight flight, turning flight, and accelerated turning flight.

4.2.1 *Wings-Level Stall:* Compliance with these requirements shall be shown under the following conditions. An example table of relevant permutations of these conditions are given in Appendix X1.

4.1.1.1 *Primary Flight Control Behavior:*

(1) For single engine low-speed Level 1 aeroplanes with $V_{S0} \leq 45$ knots that have interconnected lateral and directional controls, it shall be possible to produce and correct roll by unreversed use of the lateral control without producing excessive yaw, up to the time the aeroplane stalls.

(2) For all other Level 1 aeroplanes, and all Level 2, 3, and 4 aeroplanes, it shall be possible to produce and correct roll by unreversed use of the lateral control and to produce and correct yaw by unreversed use of the directional control up to the time the aeroplane stalls.

NOTE 2—The differentiation in conditions between Level 1 and Level 2, Low-Speed, Single Engine aeroplanes, vs. all others, is based off guidance given in AC 23-15A (see 2.2).

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

(1) An uncontrollable downward pitching motion of the aeroplane,

(2) A downward pitching motion of the aeroplane that results from the activation of a stall avoidance device (for example, stick pusher activation), or

(3) The longitudinal control reaching the stop.

(1) Wing Flaps—As follows, based on the type of aeroplane:

(a) For Level 1 and Level 2, low-speed, single-engine aeroplanes: Retracted, fully extended, and in the maximum approved extension for the takeoff configuration,

(b) For all other aeroplanes: Retracted, fully extended, and each intermediate normal operating position as appropriate for the phase of flight;

(2) Landing Gear—As follows, based on the type of aeroplane:

(a) For Level 1 and Level 2, low-speed, single-engine aeroplanes: Retracted for the configuration in which the wing flaps are retracted, and extended for all other wing flap extensions,

(b) For all other aeroplanes: Retracted and extended as appropriate for the phase of flight and altitude;

(3) Cowl Flaps—As follows, based on the type of aeroplane:

(a) For Level 1 and Level 2, low-speed, single-engine aeroplanes: Open for the configuration in which the wing flaps are in the maximum approved extension for the takeoff configuration, otherwise closed,

(b) For all other aeroplanes: Appropriate to configuration;

(4) Spoilers/Speed Brakes—Retracted and extended unless they have no measurable effect at low speeds, or in their appropriate position if they are automatically actuated as part of normal operations;

(5) Power/thrust idle;

(6) Power/Thrust On—Depending on engine type, one of the following applies:

(a) For Reciprocating Engine Powered Aeroplanes—Seventy-five percent of maximum continuous power. However, if this power setting results in nose-high attitudes exceeding 30°, the test may be carried out with the power required for level flight in the landing configuration at maximum landing weight and a speed of 1.4 V_{S0}, except that the power may not be less than 50 % of maximum continuous power; or

(b) For Turbine Engine Powered Aeroplanes—At maximum engine thrust, except that it need not exceed the thrust necessary to maintain level flight at 1.5 V_{S1} (where V_{S1} corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight);

(7) Trim—The aeroplane trimmed at:

(a) 1.3 V_{S1} for any conditions with the flaps or landing gear extended,

(b) 1.5 V_{S1} or the minimum trim speed, whichever is higher for any conditions with the flaps and landing gear retracted;

(8) Propeller—Full increase revolutions per minute (rpm) position for the idle condition.

(9) Weight—With the aeroplane at the most adverse operational weight(s) for the particular stall characteristics test being conducted, as determined by simple analysis from the applicant; and

(10) CG—With the aeroplane at the most adverse center of gravity location(s) (along the longitudinal, lateral, and directional axes) for the particular stall characteristics test being conducted, as determined by simple analysis from the applicant.

4.1.1.3 Normal use of longitudinal control for recovery is allowed after the downward pitching motion from 4.1.1.2(*1*) or 4.1.1.2(*2*) has unmistakably been produced, or the longitudinal control has been held against the stop for not less than the longer of 2 s or the time used in the minimum steady flight speed determination discussed in Specification F3179/F3179M.

4.1.1.4 During the entry into and the recovery from stalls performed below 7620 m [25 000 ft], it shall be possible to prevent more than 15° of roll or heading change by the normal use of controls.

~~4.1.1.5 For aeroplanes approved for a maximum operating altitude at or above 7620 m [25 000 ft], during the entry into and the recovery from stalls performed at or above 7620 m [25 000 ft], it shall be possible to prevent more than 25° of roll or heading change by the normal use of controls.~~

~~4.1.1.6 Compliance with these requirements shall be shown under the following conditions:~~

~~*(1) Wing Flaps*—Retracted, fully extended, and each intermediate normal operating position as appropriate for the phase of flight;~~

~~*(2) Landing Gear*—Retracted and extended as appropriate for the phase of flight and altitude;~~

~~*(3) Cowl Flaps*—Appropriate to configuration;~~

~~*(4) Spoilers/Speed Brakes*—Retracted and extended unless they have no measurable effect at low speeds, or in their appropriate position if they are automatically actuated as part of normal operations;~~

~~*(5)* Power/thrust idle;~~

~~*(6) Power/Thrust On*—Depending on engine type, one of the following applies:~~

~~*(a) For Reciprocating Engine Powered Aeroplanes*—Seventy-five percent of maximum continuous power. However, if this power setting results in nose-high attitudes exceeding 30°, the test may be carried out with the power required for level flight in the landing configuration at maximum landing weight and a speed of 1.4 V_{S0}, except that the power may not be less than 50 % of maximum continuous power; or~~

~~*(b) For Turbine Engine Powered Aeroplanes*—At maximum engine thrust, except that it need not exceed the thrust necessary to maintain level flight at 1.5 V_{S1} (where V_{S1} corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight);~~

~~*(7) Trim*—The aeroplane trimmed at 1.5 V_{S1} or the minimum trim speed, whichever is higher; and~~

~~*(8) Propeller*—Full increase revolutions per minute (rpm) position for the idle condition.~~

4.2.2 Controllable stall characteristics shall be determined in flight for Wings-Level Stall per the conditions outlined in 4.2.1.

4.2.2.1 The primary flight controls shall behave as follows during the determination of Wings-Level Stalls:

(1) For Level 1, low-speed, single-engine aeroplanes with $V_{S0} \leq 45$ knots that have interconnected lateral and directional controls, it shall be possible to produce and correct roll by unreversed use of the lateral control without producing excessive yaw, up to the time the aeroplane stalls.

(2) For all other Level 1 aeroplanes, and all Level 2, 3, and 4 aeroplanes, it shall be possible to produce and correct roll by unreversed use of the lateral control and to produce and correct yaw by unreversed use of the directional control up to the time the aeroplane stalls.

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

(1) An uncontrollable downward pitching motion of the aeroplane,

(2) A downward pitching motion of the aeroplane that results from the activation of a stall barrier device (for example, stick pusher activation), or

(3) The longitudinal control reaching the stop.

4.2.2.3 Normal use of longitudinal control for recovery is allowed after the downward pitching motion from 4.2.2.2(*1*) or 4.2.2.2(*2*) has unmistakably been produced, or the longitudinal control has been held against the stop for not less than the longer of 2 s or the time used in the minimum steady flight speed determination discussed in Specification F3179/F3179M.

4.2.2.4 During the entry into and the recovery from stalls performed below 7620 m [25 000 ft], it shall be possible to prevent more than 15° of roll or heading change by the normal use of controls.

4.2.2.5 For aeroplanes approved for a maximum operating altitude at or above 7620 m [25 000 ft], during the entry into and the recovery from stalls performed at or above 7620 m [25 000 ft], it shall be possible to prevent more than 25° of roll or heading change by the normal use of controls.

4.2.3 ~~*Turning Flight and Accelerated Turning Stalls:*~~ Controllable stall characteristics shall be determined in flight for Turning Flight and Accelerated Turning Stalls per the conditions outlined in 4.2.1.

4.2.3.1 Turning flight and accelerated turning stalls shall be demonstrated by establishing and maintaining a coordinated turn in a 30° bank. While maintaining this bank angle, the speed ~~should~~shall be steadily reduced with the longitudinal control until the aeroplane is stalled. The rate of speed reduction shall be constant and:

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

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

4.2.3.2 After the aeroplane has stalled, as defined in ~~4.1.1.2~~4.2.2.2, it shall be possible to regain wings-level flight by normal use of the flight controls but without increasing power and without:

(1) Excessive loss of altitude,

(2) Undue pitch-up,

(3) Exceeding a bank angle of 60° in the original direction of the turn or 30° in the opposite direction in the case of turning flight stalls,

(4) Exceeding a bank angle of 90° in the original direction of the turn or 60° in the opposite direction in the case of accelerated turning stalls, and

(5) Exceeding the maximum permissible speed or allowable limit load factor.

4.1.2.3 Compliance with 4.1.2 shall be shown under the following conditions:

(1) Wing Flaps—Retracted, fully extended, and each intermediate normal operating position as appropriate for the phase of flight.

(2) Landing Gear—Retracted and extended as appropriate for the phase of flight and altitude;

(3) Cowl Flaps—Appropriate to configuration;

(4) Spoilers/Speed Brakes—Retracted and extended unless they have no measurable effect at low speeds, or in their appropriate position if they are automatically actuated as part of normal operations;

(5) Power/thrust idle;

(6) Power/Thrust On—Depending on engine type, one of the following applies:

(a) For Reciprocating Engine Powered Aeroplanes—Seventy-five percent of maximum continuous power. However, if this power setting results in nose-high attitudes exceeding 30°, the test may be carried out with the power required for level flight in the landing configuration at maximum landing weight and a speed of 1.4 V_{S0}, except that the power may not be less than 50 % of maximum continuous power; or

(b) For Turbine Engine Powered Aeroplanes—At maximum engine thrust, except that it need not exceed the thrust necessary to maintain level flight at 1.5 V_{S1} (where V_{S1} corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight);

(7) Trim—The aeroplane trimmed at 1.5 V_{S1} or the minimum trim speed, whichever is higher; and

(8) Propeller—Full increase rpm position for the idle condition.

4.3 *Stall Warning*—There shall be a clear and distinctive stall warning with the flaps and landing gear in any normal position in straight and turning flight.

4.3.1 The stall warning shall give clearly distinguishable indications under expected conditions of flight. The type of warning shall be the same for all normal configurations throughout the flight envelope of the aeroplane.

4.3.2 When the speed is reduced at rates not exceeding 1.9 (km/h)/s [1 knot/s], stall warning shall begin, in each normal configuration, at a speed exceeding the speed at which the stall is identified in accordance with 4.2.2.2 by not less than 9.3 km/h [5 knots] or 5 % calibrated airspeed (CAS), whichever is greater. Once initiated, stall warning shall continue until the angle of attack is reduced to approximately that at which stall warning began.

NOTE 3—For the purpose of compliance with this specification, angle of attack can be measured directly or inferred through other measurements.

4.3.2.1 The stall warning system effectiveness score, S_{SW}, shall be determined based on the sum of the point value for installed stall warning equipment, X_{SW}. The maximum allowable point values for different implementations of stall warning are shown in Table 2. The performance values, indication options, and test methods for the stall warning equipment shall be proposed by the applicant in a manner acceptable to CAA.

NOTE 4—New standards are in development that will provide performance values, indication approaches, and test methods that will be acceptable to this standard in future revisions.

4.3.2.2 The Stall Warning Effectiveness Score is subject to the following limitations:

(1) S_{SW} must be at least 50 for all aeroplanes;

(2) If S_{SW} is greater than 100, then it shall be capped at a value of 100 for the purpose of compliance with other sections of this standard.

4.3.2.3 If more than one implementation in Table 2 is used for the purposes of compliance with 4.3.2.2, each additional implementation must utilize a different sensory path.

4.3.3 For all aeroplanes other than Level 1, low-speed, single-engine aeroplanes with $V_{S0} \leq 45$ knots, when following aeroplane flight manual (AFM) procedures, stall warning shall not occur during:

(1) Takeoff with all engines operating,

TABLE 2 Stall Warning Implementation Point Values for Determining Stall Warning System Effectiveness Score

Sensory Path	Description	X_{SW}
Aural	Constant tone	50
Aural	Interrupted tone	60
Aural	Synthetic voice	70
Tactile	Yoke or stick vibration	90
Visual	Visual indication independent of pilot focus	25
Visual	Visual indication in primary field of view	10

(2) Takeoff continued with one engine inoperative,

(3) Approach to landing.

4.3.4 During turning and accelerated turning stalls required by 4.2.3.1, the stall warning shall begin sufficiently in advance of the stall for the stall to be averted by pilot action taken after the stall warning first occurs.

4.3.5 For aeroplanes approved for aerobatics, an artificial stall warning may be mutable provided:

(1) The stall warning mute status is annunciated to the flight crew,

(2) The stall warning is re-armed automatically prior to the next flight.

4.4 ~~*Departure Characteristics*—~~All single engine aeroplanes that are not approved for ~~spinning~~aerobatics shall not have a tendency to inadvertently depart controlled flight. ~~All Level 1 and Level 2 multi-engine aeroplanes shall not have a tendency to depart controlled flight due to a critical loss of thrust.~~ Compliance to these requirements shall be found from the following alternatives. In all cases, maneuvers can be discontinued, and a normal recovery initiated, after a downward pitching motion of the aeroplane commences due to the activation of a stall ~~avoidance~~barrier device (for example, stick pusher activation).

4.4.1 *Alternative 1*—All single engine aeroplanes may demonstrate compliance with ~~4.2~~4.4, and yield 100 points for the Single Engine Departure Characteristics Score ($S_{DC,SE}$) for compliance with 4.1.2, as follows:

4.4.1.1 During the stall maneuver contained in ~~4.1.1~~4.2.2, the longitudinal control shall be pulled back and held against the stop. Then, using lateral and directional controls in the proper direction, it shall be possible to maintain wings-level flight within 15° of bank and to roll the aeroplane from a minimum of a 30° bank in one direction to a minimum of a 30° bank in the other direction.

(1) For aeroplanes approved for a maximum operating altitude at or above 7620 m [25 000 ft], compliance with 4.4.1.1 needs only to be shown at the lower altitudes used for stall characteristics testing.

4.4.1.2 Reduce the aeroplane speed using the longitudinal control at a rate of approximately 1.9 (km/h)/s [1 knot/s] until the longitudinal control reaches the stop.

(1) With the longitudinal control pulled back and held against the stop, apply full directional control until whichever of the following conditions occurs first:

(a) Seven seconds, or

(b) Through a 360° heading change, which shall take no fewer than 4 s.

(2) At the end of the maneuver, the aeroplane shall respond immediately and normally to primary flight controls applied to regain coordinated, unstalled flight without reversal of control effect and without exceeding the temporary control forces specified by Specification F3173/F3173M.

(3) The following ~~control positions and configurations~~ conditions shall be used during the maneuver discussed in ~~4.2.1.2~~4.4.1.2(*1*):

(a) Full right and full left directional control,

(b) Lateral control:

(1) Neutral,~~ and~~

(2) Fully deflected opposite of the direction of the turn;~~ and~~

(c) Power and aeroplane configuration set in accordance with ~~4.1.1.6~~4.2.1 without change during the maneuver.

4.4.1.3 Compliance with ~~4.1.1~~4.2.2 and ~~4.1.2~~4.2.3 shall be demonstrated with the aeroplane in uncoordinated flight, corresponding to one ball-width displacement on a slip-skid indicator, unless one ball-width displacement cannot be obtained with full directional control, in which case the demonstration shall be with full directional control applied.

(1) For aeroplanes approved for a maximum operating altitude at or above 7620 m [25 000 ft], compliance with 4.4.1.3 needs only to be shown at the lower altitudes used for stall characteristics testing.

4.4.2 *Alternative 2*—~~All single engine aeroplanes~~ The applicant may quantify the resistance of a single engine aeroplane to inadvertent departure from controlled flight by accomplishing a series of low-speed maneuvers and recovery procedures that include demonstration of recovery from non-coordinated stall maneuvers. Many of these maneuvers are similar to 4.4.1~~may demonstrate~~ , but, for this Alternative, it may not be necessary to demonstrate resistance from departure to controlled flight for *all* conditions. Rather, summation of the unique conditions that are successfully resisted will yield a score for compliance with ~~4.2~~4.1.2 as ~~follows:~~described below. Additionally, the maneuvers are re-organized as compared to Alternative 1, to emphasize the purpose of the associated demonstration. Example tables of relevant permutations of these conditions are given in Appendix X1.

4.4.2.1 Regardless of certification level, speed classification, number of engines, or ceiling, the applicant shall only use the configurations as required in 4.2.1 for Level 1 and Level 2, low-speed, single-engine aeroplanes, with a maximum operating altitude below 7620 m [25 000 ft], to comply with 4.4.2.2 and 4.4.2.3.

4.4.2.2 The applicant shall demonstrate the aeroplane's resistance to poor piloting technique through the following maneuvers:

(1) Abused Stalls—The wings-level stalls outlined in 4.2.2 and the unaccelerated turning stalls outlined in 4.2.3, with each condition duplicated with the directional control positioned at stall identification at a deflection that corresponds to the amount of deflection required to sustain 1 ball-width of lateral acceleration, unless one ball-width displacement cannot be obtained with full directional control, in which case the full directional control shall be applied;

(2) Poorly Coordinated Accelerated Stalls—The accelerated turning stalls outlined in 4.2.3, with each entry configuration duplicated with the directional control free of any pilot input throughout the entry.

4.4.2.3 At their discretion, the applicant shall utilize an approach acceptable to the local CAA that may utilize aerodynamic design characteristics, systems-based protection features, or a combination thereof to lower the probability of departure from controlled flight to an acceptable level.The applicant shall demonstrate the aeroplane's post-stall controllability through the following maneuvers:

(1) Post-Stall Lateral Controllability—During the stall maneuvers required by 4.2.2, the longitudinal control shall be pulled back and held against the aft stop. Using properly coordinated lateral and directional controls, the aeroplane shall be rolled to a minimum of 30° bank in one direction, to a minimum of a 30° bank in the other direction, and back to wings-level flight, prior to normal stall recovery.

(2) Lateral/Directional Control Balance—The maneuvers and configurations described in 4.4.1.2, with the following modifications:

(a) Omission of the conditions with the lateral control fully deflected opposite of the direction of the turn,

(b) The lateral control may be used throughout the maneuver to prevent departure, provided that the lateral control does not reverse normal control effect or exceed the temporary control forces specified in Specification F3173/F3173M.

NOTE 5—The use of the lateral control per 4.4.2.3(*2*)(*b*) is not intended to allow for quasi-coordinated flight as a means to pass the maneuver. Rather, the intent is to simulate the response of the average pilot to resist excessive bank angles.

(3) In all cases, the maneuver may be discontinued, and a normal recovery initiated, if the aeroplane exhibits an uncontrollable downward pitching motion as described in 4.2.2.2(*1*) or 4.2.2.2(*2*). In such a case, the applicant shall utilize an approach acceptable to the local CAA to demonstrate post-stall controllability.

NOTE 6—Several proposals Proposals are in development for alternate means of compliance to the parent requirement demonstrating post-stall controllability for aeroplanes that have limited longitudinal control as described in 4.24.4.2.3.(*3*). Future revisions of this specificationstandard will include those alternate approaches under this (and potentially other) requirements.approaches.

4.4.2.4 The aeroplane is considered to have *resisted* the maneuvers outlined in 4.4.2.2 and 4.4.2.3 if, for the particular unique condition tested, the following applies as appropriate:

(1) For the wings-level abused stall maneuvers of 4.4.2.2(*1*), the aeroplane shall, without reversal of lateral or directional control effect, recover per the criteria in 4.2.2.3 and 4.2.2.4.

(2) For the abused turning stall maneuvers of 4.4.2.2(*1*) and the poorly coordinated accelerated stall maneuvers of 4.4.2.2(*2*), the aeroplane shall, without reversal of lateral or directional control effect, recover per the criteria in 4.2.3.2.

(3) For the post-stall lateral controllability maneuvers of 4.4.2.3(*1*), the aeroplane shall be able to roll from a 30° bank, to the opposite 30° bank, and back to wings-level flight, without exceeding 45° of bank in the direction of the applied lateral control throughout the maneuver. Upon reaching wings level flight, the aeroplane must maintain ±15° for at least 2 s prior to recovering from the stall. In all cases, the controls shall be manipulated without reversal of lateral or directional control effect;

(4) For the lateral/directional control balance maneuvers of 4.4.2.3(*2*), the aeroplane shall respond immediately and normally to primary flight controls applied to regain coordinated, unstalled flight, without reversal of control effect for the lateral and directional controls, and without exceeding the temporary control forces specified by Specification F3173/F3173M.

NOTE 7—For the purpose of this specification, "immediately and normally" can coincide to ¼ of a turn in an incipient spin.

4.4.2.5 If the aeroplane does not meet the criteria of 4.4.2.4 for any of unique conditions tested under 4.4.2.2 or 4.4.2.3, the aeroplane is considered to have *recovered* from the maneuver for the particular condition tested as follows:

(1) If the aeroplane enters a spin, after the controls are held in the position specified for the maneuver for the longer of one turn or 3 s after stall identification, if the aeroplane can recover to wings-level controlled flight in not more than one additional turn after initiation of the first control action for recovery, subject to the following conditions:

(a) The applicable airspeed limit and positive limit maneuvering load factors are not exceeded with respect to the aeroplane's current configuration;

(b) No control forces or characteristic encountered during the spin or recovery shall adversely affect prompt recovery; and

(c) For flaps-extended configurations, the flaps may be retracted during the recovery but not before rotation has ceased.

(2) If the aeroplane does not enter a spin, the aeroplane can recover to wings-level controlled flight with normal use of the controls subject to the following conditions:

(a) The applicable airspeed limit and positive limit maneuvering load factors are not exceeded with respect to the aeroplane's current configuration.

(b) No control forces or characteristic encountered during the recovery shall adversely affect prompt recovery; and

(c) No more than 366 m [1200 ft] of altitude is lost from the moment that the aeroplane fails the departure resistance criteria in 4.4.2.2 until controlled wings-level flight is resumed.

4.4.2.6 *Scoring*—The Single Engine Departure Characteristics Score ($S_{DC,SE}$), shall be the product of 100 times the ratio of the number of unique conditions that pass the criteria in 4.4.2.4 to the total number of unique conditions tested in 4.4.2.2 and 4.4.2.3, rounded to the nearest whole number, meaning the score can be no greater than 100. The total score is subject to the following conditions:

(1) The minimum allowable score for the purposes of compliance with 4.1.2 is 50 (for example, the aeroplane must resist, per 4.4.2.4, at least 50 % of the unique conditions tested in 4.4.2.2 and 4.4.2.3);

(2) The aeroplane shall resist, per 4.4.2.4, or recover, per 4.4.2.5, for at least 95 % of the unique conditions tested in 4.4.2.1; or

(3) If the aeroplane cannot comply with 4.4.2.6(*1*) and 4.4.2.6(*2*), it shall have a Descent Arrest System installed that, as a minimum, meets the performance requirements in 4.7.3.2(*2*), in addition to other features discussed in 4.3 and 4.7, to meet the Low-Speed Flight Characteristics Score required by 4.1.2.

4.4.3 *Alternative 3*—Single engine low-speed Level 1 aeroplanes Level 1, single-engine, low-speed aeroplanes, with $V_{S0} \leq 45$ knots may comply with 4.24.4, and yield 100 points for the Single Engine Departure Characteristics Score ($S_{DC,SE}$) for compliance with 4.1.2 as follows:

4.4.3.1 The aeroplane shall fly a series of maneuvers according to the entry procedures described in 4.1.1.24.2.2.2 and 4.1.2.14.2.3.1.

4.4.3.2 The aeroplane shall be configured as per 4.1.1.64.2.1 for the wings-level entries, and as per , 4.1.2.3 for the banked and accelerated entries, except that the configurations will be modified as follows:

(1) The aeroplane weight shall be 5 % more than the highest weight for which approval is requested;

(2) The aeroplane center of gravity shall be at least 3 % of the mean aerodynamic chord aft of the rearmost position for which approval is requested;

(3) The available longitudinal control up-travel is set 4° in excess of that to which the longitudinal control travel is to be limited for approval; and

(4) For aeroplanes that have independent lateral and directional controls, the lateral control travel set 7° in both directions, in excess of that to which the lateral control travel is to be limited for approval, or

(5) For aeroplanes with interconnected lateral and directional controls, the lateral-directional control travel set 7° in both directions, in excess of that to which the lateral-directional control travel is to be limited for approval.

4.4.3.3 The maneuvers specified in 4.2.3.14.4.3.1 shall continue until the longitudinal control reaches the aft stop. The aft stop shall be held for a period of 4 s with the following additional control inputs:

(1) For aeroplanes with independent lateral and directional controls:

(a) Lateral control neutral,

(b) Directional control full left and right; or

(2) For aeroplanes with interconnected lateral and directional controls, the lateral-directional control full left and full right, though the control may be neutralized if the aircraftaeroplane exceeds 60° of bank.

4.4.3.4 After the conditions of 4.2.3.34.4.3.3 have been met, it must be possible to regain wings-level flight according to the criteria in 4.1.2.24.2.2. for wings-level stalls, and 4.2.3 for turning and accelerated stalls.

4.2.4 *Alternative 4*—Level 1 and 2 multi-engine aeroplanes may demonstrate compliance with 4.2 as follows:

4.2.4.1 At their discretion, the applicant shall utilize an approach acceptable to the local CAA that may utilize aerodynamic design characteristics, systems-based protection features, or a combination thereof to lower the probability of departure from controlled flight after a critical loss of thrust to an acceptable level.

NOTE 2—Proposals are in development for alternate means of compliance to the parent requirement in 4.2. Future revisions of this specification will include those alternate approaches.

4.5 All Level 1 and 2 multi-engine aeroplanes that are not approved for aerobatcis shall not have a tendency to inadvertently depart controlled flight due to a critical loss of thrust. Compliance may be shown by one of the following three alternatives:

4.5.1 *Alternative 1*—Level 1 and 2 multiengine aeroplanes, regardless of speed classification or V_{S0}, that meet the climb gradient requirement described in *Climb after Partial Loss of Thrust* in Specification F3179/F3179M for *Level 1 and 2, low-speed multiengine aeroplanes that do not meet the single-engine crashworthiness requirements*, yield 100 points for the Multiengine Departure Characteristics Score ($S_{DC,ME}$) for compliance with 4.1.2.

4.5.2 *Alternative 2*—Level 1 and 2 multiengine aeroplanes that have a V_{MC} defined by *Minimum Control Speed* in Specification F3179/F3179M such that $V_{MC} < V_{S1}$, yield 100 points for the Multiengine Departure Characteristics Score ($S_{DC,ME}$) for compliance with 4.1.2.

4.5.3 *Alternative 3*—The applicant may incorporate an approach acceptable to the local CAA that may utilize aerodynamic design characteristics, systems-based protection features, or a combination thereof to lower the probability of departure from controlled flight after a critical loss of thrust to an acceptable level. The resulting Multiengine Departure Characteristics Score ($S_{DC,ME}$) used for compliance in 4.1.2 shall be proposed by the applicant and accepted by the CAA, and must be at least 50 and no more than 100.

NOTE 8—Proposals are in development for alternate means of compliance with the parent requirement in 4.5. Future revisions of this standard will include those alternate approaches.

4.6 *Spinning*—Aeroplanes shall meet the following spin recovery requirements in each configuration for which approval for spinning is requested:

4.6.1 The aeroplane shall recover from any point in a spin up to and including six turns, or any greater number of turns for which certification is requested, in not more than one-and-one-half additional turns after initiation of the first control action for recovery. However, beyond three turns, the spin may be discontinued if spiral characteristics appear;

4.6.2 The applicable airspeed limits and limit maneuvering load factors shall not be exceeded. For flaps-extended configurations for which approval is requested, the flaps shall not be retracted during the recovery;

4.6.3 ~~It shall be impossible to obtain unrecoverable spins with any~~ The aeroplane must be recoverable with any typical use of the flight or engine power controls either at the entry into or during the spin;~~ and~~

4.6.4 There shall be no characteristics during the spin (such as excessive rates of rotation or extreme oscillatory motion) that might prevent a successful recovery because of disorientation or incapacitation of the ~~pilot.~~pilot;

4.6.5 If the applicant does not seek approval for spinning in all of the conditions specified in 4.2.1, then the aeroplane shall comply with 4.4 or 4.5 of this standard, as applicable for the conditions in 4.2.1 that are not approved for spinning.

4.7 ~~*Stall Warning*~~—*Safety-Enhancing Features*—~~There~~ The applicant may elect to install safety-enhancing features to make up for the shortfall in total score required from 4.1.2~~shall be a clear and distinctive stall warning with the flaps and landing gear in any normal position in straight and turning flight.~~. The performance values, indication approaches, and test methods for the systems shall be proposed by the applicant in a manner acceptable to CAA.

NOTE 9—New standards are in development that will provide performance values, indication options, and test methods that will be acceptable to this standard in future revisions.

4.7.1 *Enhanced Indication*—~~The stall warning shall give clearly distinguishable indications under expected conditions of flight. The type of warning shall be the same for all normal configurations throughout the flight envelope of the aeroplane.~~Enhanced indication systems are intended to provide additional information regarding the low-speed aeroplane control and performance state, beyond the requirements of the Flight Instrumentation described in Specification F3061/F3061M and the Markings and Placards described in Specification F3117. The maximum allowable point values, X_{EI} for various types of enhanced indication systems are given in Table 3.

4.7.1.1 The information defined in Table 3 must be presented to the pilot in a manner acceptable to the local CAA, such as SAE ARP4102/7 (2.2). When aplicable, acceptable display methods are given in Specification F3117. Additional suggested approaches are described in Appendix X2 (soon to be one or more new work items).

4.7.1.2 ~~A visual alert that requires~~ The total enhanced indication feature score, S_{EI}, shall be the ~~attention~~sum of all the ~~crew within~~features in Table 3~~the cockpit is not acceptable by itself.~~ for which the applicant wishes to take credit.

(1) If the applicant wishes to use multiple items from Table 3 as Safety-Enhancing Features for compliance with 4.1.2, each system must be a unique "Type" (for example, the applicant cannot install two systems of type "Angle of Attack" and receive credit for both).

4.7.1.3 If an applicant wishes to install one or more of the items described in Table 3, but does not wish to declare such equipment as Safety-Enhancing Features for compliance with 4.1.2, then this equipment may be considered as non-required equipment for the purposes of compliance with Specification F3061/F3061M, and the resulting point value, X_{EI}, for the purposes of calculation of S_{EI} per 4.7.1.2 for that system is 0.

4.7.2 *Enhanced Envelope Awareness*—~~When the speed is reduced at rates not exceeding 1.9 km/h [1 knot/s], stall warning shall begin, in each normal configuration, at a speed exceeding the speed at which the stall is identified in accordance with~~ Enhanced envelope awareness systems (EEAS) are intended to provide effective control feedback when the flight crew provides control inputs that place the aeroplane in flight conditions that have reduced margin over loss-of-control. Stall barrier devices (such as stick pushers) and envelope-limiting control systems are not considered here; such devices may instead be used for compliance with the maneuvers in ~~4.1.1.2~~4.2 and 4.4~~by not less than 9.3 km/h [5 knots] or 5 % calibrated airspeed (CAS), whichever is greater. Once initiated,~~. The performance values, crew interface protocols, and test methods for any EEAS systems shall be proposed by the applicant in a manner acceptable to CAA. Suggested guidance for EEAS is given in Appendix X3 ~~stall warning shall continue until the angle of attack is reduced to approximately that at which stall warning began.~~(soon to be a new work item).

NOTE 10—~~For the purpose of compliance with this specification, angle of attack can be measured directly or inferred through other measurements.~~New

TABLE 3 Enhanced Indication System Options and Point Values

Type	Description	X_{EI}
Angle of Attack	Angle of attack indication	5
Angle of Attack	Angle of attack indication with trend marker	7
Pitch Limit	Pitch limit indication displayed on attitude indication	5
Pitch Limit	Pitch limit indication displayed on attitude indication with trend marker	7
Dynamic Low-Speed Markings	Indicated airspeed markings that change with flight condition	10
Airspeed Trend	Indicated airspeed trend marker displayed on airspeed indication	5
Flight Path Marker	Flight path marker displayed on attitude indication	5
LOC Alert	Alert issued when loss of control likely within trend window	5

standards are in development that will provide performance values, crew interface protocols, and test methods that will be acceptable to this standard in future revisions.

~~4.4.2.1 For Level 1 aeroplanes, a voice warning such as "STALL STALL" or an aural horn or tone is acceptable. If an aural horn or tone is utilized, it must be the only aural tone or horn in the cockpit.~~

4.7.2.1 ~~For Level 2, 3, and~~The enhanced envelope awareness score, ~~4~~S_{EEA}, ~~aeroplanes, the stall warning shall consist of either:~~shall be the sum of

(a) ~~An aural warning in combination with~~ 5 points for a system that ~~provides tactile feedback through the pilot's controls to deter the pilot from further reducing airspeed or increasing angle of attack, or~~acts around the lateral control axis;

(b) ~~A voice warning such as "STALL STALL" along with an additional voice callout that occurs prior to the stall warning.~~15 points for a system that acts around the longitudinal control axis;

~~*(a)* The additional voice callout shall be provided no less than 4 s in advance of the stall warning callout assuming a steady deceleration in straight or turning flight for the maneuvers specified in 4.1, and~~

~~*(b)* Must not overlap or conflict with the stall warning.~~

(c) 10 points for a system that acts around the directional control axis;

(d) 10 points for a system that acts along the thrust control axis;

4.7.2.2 If an applicant wishes to install one or more systems defined in 4.7.2.1, but does not wish to declare such equipment as Safety-Enhancing Features for compliance with 4.1.2, then this equipment can be considered as non-required equipment for the purposes of compliance with Specification F3061/F3061M.

4.7.3 *Descent Arrest Systems—*~~For all aeroplanes other than single engine low-speed Level 1 aeroplanes~~ Descent arrest systems are intended to slow the descent of an aeroplane that has departed controlled flight, and place the aeroplane in an attitude and at an appropriate velocity such that the resulting impact with ~~V~~the~~$_{S0}$ ≤ 45 knots, when following aeroplane flight manual (AFM) procedures, stall~~ground does not violate the maximum impact loads specified in Specification F3083/F3083M~~warning shall not occur during:~~.

~~*(1)* Takeoff with all engines operating,~~

~~*(2)* Takeoff continued with one engine inoperative, and~~

~~*(3)* Approach to landing.~~

4.7.3.1 The applicant shall determine, in a manner acceptable to the CAA, the following values:

(a) The steady-state attitude and descent velocity with the descent arrest system deployed; and

(b) The altitude lost from the onset of a one-turn spin (if possible) or other adverse deployment situation until the steady-state attitude and descent velocities are reached with the descent arrest system deployed.

4.7.3.2 The Descent Arrest System score, S_{DAS}, shall be:

(1) 0 points if the altitude loss from 4.7.3.1 exceeds 366 m [1200 ft];

(2) 10 points if altitude loss from 4.7.3.1 is no less than 244 m [800 ft] and no more than 366 m [1200 ft];

(3) $10+40(1-h_{loss}/244)$ if altitude loss from 4.7.3.1 is less than 244 m [800 ft], where h_{loss} is altitude loss in meters (score is $10+40(1-h_{loss}/800)$ if h_{loss} is the altitude loss in feet).

4.7.4 ~~During turning and accelerated~~The safety-enhancing feature score, ~~*turning*~~S_{SEE}, ~~stalls required by~~shall be the sum of all installed equipment for which the applicant wishes to take credit, with the caveat that such systems will be part of the required equipment ~~4.1.2.1~~(list~~2), the stall warning shall begin sufficiently in advance of the stall~~ for all approved types of operations. Hence, the total score is ~~*for*~~S_{SEE} ~~the~~= ~~*stall*~~S_{EI} ~~to~~+ ~~*be*~~S_{EEA} ~~averted~~+ ~~*by*~~ S_{DAS}~~*pilot*~~ ~~.action taken after the stall warning first occurs.~~

~~4.4.5 For aeroplanes approved for aerobatics, an artificial stall warning may be mutable provided that it is armed automatically during takeoff and rearmed automatically in the approach configuration.~~

5. Keywords

5.1 airworthiness; flight; general aviation