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 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 covers the low-speed flight characteristics of fixed-wing aircraft 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 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 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 webpage (www.astm.org/COMMITTEE/F44.htm).

1.3 *Units*—This standard may present information in either SI units, English Engineering units, or both; 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 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3061/F3061M Specification for Systems and Equipment in Aircraft

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

F3117/F3117M 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

F3232/F3232M Specification for Flight Controls 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.

[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.

[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, https://www.sae.org/standards/content/arp4102/7/.

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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
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[A] Max 100	Min 50[A] Max 100	N/A	N/A	N/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
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] $S_{DC,SE}$ may be less than 50 as outlined in 4.4.2.6(*3*), which requires particular equipment from 4.7.3 be installed.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *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.

3.2.5 *thrust control*—cockpit control that is intended for, but not necessarily limited to, modulation of aircraft thrust.

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 per Specification F3179/F3179M.

4. Low-Speed Characteristics

4.1 *Low-Speed Flight Characteristics Score*—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]

[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.

4.1.2 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.

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

4.2.1 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.

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

(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;

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(5) Power/Thrust Off—Propulsion controls set for the lowest power/thrust setting normally accessible during flight operations;

(6) Power/Thrust On—At the maximum power/thrust setting normally accessible during flight operations, subject to the following conditions:

(a) For Reciprocating Engine Powered Aeroplanes—Seventy-five percent 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} (1.4 V_{SR1}) (where V_{S1} (V_{SR1}) corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight); or

(c) In all cases, if the power/thrust 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} (1.3 V_{SR0}), except that the power may not be less than 50 % of maximum continuous power/thrust.

(7) Trim—The aeroplane trimmed at:

(a) 1.3 V_{S1} (1.23 V_{SR1}) for any conditions with the flaps or landing gear extended,

(b) 1.5 V_{S1} (1.4 V_{SR1}) 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 Power/Thrust Off 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.

4.2.2 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 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 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, 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 4.2.2.2, 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,

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

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

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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.

(1) In addition, for aeroplanes with a reference stall speed basis (V_{SR}) established for the aeroplane per Specification F3179/F3179M the following also applies:

(a) When the speed is reduced at rates not exceeding 1.9 (km/h)/s [1 knot/s] in straight flight with engines idling and at the center of gravity position specified in Specification F3179/F3179M, Stall Speed, stall warning shall begin at a speed, in each normal configuration, at a speed exceeding V_{SR} by not less than 5.6 km/hr [3 knots] or three percent calibrated airspeed (CAS), whichever is greater.

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 human 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,

(2) Takeoff continued with one engine inoperative,

(3) Approach to landing.

4.3.3.1 In addition, for aeroplanes with a reference stall speed basis (V_{SR}) established for the aeroplane per Specification F3179/F3179M the following also applies:

(1) The maneuvering capabilities in a constant speed coordinated turn at forward center of gravity, as specified in Table 3, must be free of stall warning or other characteristics that might interfere with normal maneuvering.

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: Single Engine*—All single-engine aeroplanes that are not approved for aerobatics shall not have a tendency to inadvertently depart controlled flight. 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 barrier device (for example, stick pusher activation).

4.4.1 *Alternative 1*—All single-engine aeroplanes may demonstrate compliance with 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 4.2.2, 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.

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

Human Sensory Path	Description	X_{SW}
Aural	Constant sound	50
Aural	Interrupted sound	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

TABLE 3 Maneuver Margin

Configuration	Speed	Maneuvering bank angle in a coordinated turn	Maximum Thrust/power setting[A]
Takeoff	V_2	30°	Asymmetric WAT-Limited[B]
Takeoff	V_2+XX[C]	40°	All-engines-operating climb[D]
En route	$V_{en\ route}$[E]	40°	Asymmetric WAT-Limited[B]
Landing	V_{REF}	40°	Symmetric for -3° flight path angle

[A] If desired, for conditions with positive excess power or thrust, the power or thrust may be reduced to less than the maximum allowed so that compliance is shown with a completely stabilized, constant-altitude turn.

[B] A combination of weight, altitude, and temperature (WAT) such that the thrust or power setting produces the minimum climb gradient specified in Specification F3179/F3179M, Climb after Partial Loss of Thrust, for the flight condition.

[C] Airspeed approved for all-engines operating initial climb.

[D] That thrust or power setting which, in the event of critical loss of thrust or power and without any crew action to adjust the thrust or power of the remaining engines, would result in the thrust or power specified for the takeoff condition at V_2, or any lesser thrust or power setting that is used for all-engines-operating initial climb procedures.

[E] Airspeed used to comply with Specification F3179/F3179M, Climb after Partial Loss of Thrust, En Route.

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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 conditions shall be used during the maneuver discussed in 4.4.1.2(*1*):

(a) Full right and full left directional control,

(b) Lateral control:

(1) Neutral,

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

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

4.4.1.3 Compliance with 4.2.2 and 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*—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. 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 4.1.2 as described below. 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 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.

(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 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—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.

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

(i) Seven seconds, or

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

(b) 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.

(c) The following conditions shall be used during the maneuver discussed in 4.4.2.3(*2*):

(i) Full right and full left directional control;

(ii) Lateral control neutral, though 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; and

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

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.

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 4.2.2

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(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 6—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.

4.5 *Departure Characteristics: Multiengine*—All Level 1 and 2 multiengine aeroplanes that are not approved for aerobatics 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 alternatives:

4.5.1 *Alternative 1*—Level 1 and 2 multiengine aeroplanes, regardless of speed classification or V_{S0} (V_{SR0}), 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 $V_{MC} < V_{S1}$ (V_{SR1}), yield 100 points for the Multiengine Departure Characteristics Score ($S_{DC,ME}$) for compliance with 4.1.2.

4.6 *Spinning*—Aeroplanes certified for aerobatics 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 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;

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;

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 recover from a one-turn spin or a 3 s spin, whichever takes longer, in not more than one additional turn after initiation of the first control action for recovery for the conditions in 4.2.1 that are not approved for spinning.

4.6.5.1 The following conditions apply to one-turn or 3 s spins:

(a) For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor shall not be exceeded.

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

(c) It shall be impossible to obtain unrecoverable spins with any use of the flight or engine power controls either at the entry into or during the spin; and

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

4.7 *Safety-Enhancing Features*—The applicant may elect to install safety-enhancing features to make up for the shortfall in total score required from 4.1.2. The performance values, indication approaches, and test methods for the systems shall be proposed by the applicant in a manner acceptable to CAA.

NOTE 7—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*—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/F3117M. The maximum allowable point values, X_{EI} for various types of enhanced indication systems are given in Table 4.

4.7.1.1 The information defined in Table 4 must be presented to the pilot in a manner acceptable to the local CAA, such as SAE ARP4102/7 (2.2). When applicable, acceptable display methods are given in Specification F3117/F3117M. Additional suggested approaches are described in Appendix X2 (soon to be one or more new work items).

4.7.1.2 The total enhanced indication feature score, S_{EI}, shall be the sum of all the features in Table 4 for which the applicant wishes to take credit.

(1) If the applicant wishes to use multiple items from Table 4 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 4, 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.

TABLE 4 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
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

4.7.2 *Enhanced Envelope Awareness*—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 4.2 and 4.4. More detailed requirements for EEAS systems may be found in Specification F3232/F3232M.

4.7.2.1 The enhanced envelope awareness score, S_{EEA}, shall be the sum of:

(a) 5 points for a system that acts on the lateral control;

(b) 15 points for a system that acts on the longitudinal control;

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

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

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*—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 the ground does not violate the maximum impact loads specified in Specification F3083/F3083M.

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 The safety-enhancing feature score, S_{SEF}, 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 list for all approved types of operations. Hence, the total score is $S_{SEF} = S_{EI} + S_{EEA} + S_{DAS}$.

5. Keywords

5.1 airworthiness; flight; general aviation

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APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE PERMUTATIONS OF CONDITIONS USED TO COMPLY WITH 4.2 STALL CHARACTERISTICS AND 4.4 DEPARTURE CHARACTERISTICS (SINGLE ENGINE) FOR NOTIONAL AEROPLANES

X1.1 This appendix develops a number of different tables of conditions that must be uniquely tested as part of the compliance with 4.2 of this standard, as well as the alternatives presented in 4.4 for single-engine aeroplanes, not approved for aerobatics. The column headers for each table assume the following, for now:

(1) No. – numeric identifier for series in that particular type of maneuver (Wings-Level stalls, etc.)

(2) Flaps – flap position. These tables assume three positions possible: Up, Maximum Takeoff ("Max TO"), and Landing. Per 4.2.1(*1*), for other than Level 1 and 2, low-speed, single-engine aeroplanes, other intermediate flap conditions need to be tested as well.

(3) Cowl Flaps – Cowl flap position as specified per 4.2.1(*3*).

(4) Speed Brakes – Speed brake position: "Ret/Ext or Auto," meaning that if they have an effect on stall characteristics, this condition must be duplicated for retracted and extended. If they deploy automatically, then the system shall be armed and the maneuver does not need to be duplicated. Ref 4.2.1(*4*).

(5) Trim V_{S1} (V_{SR1}) – trim setting, in terms of speed of multiples of V_{S1}, per 4.2.1(*7*).

(6) Power – "Off" per 4.2.1(*5*) and "On" per 4.2.1(6).

(7) Entry bank – If bank angle given ("Wings Level," "Left 30 deg," etc.) then the entry bank angle per the appropriate stall/departure resistance maneuver. If "Neutral," "Full Left," or "Full Right," indicates position of lateral control.

(8) Ball – lateral acceleration, in terms of slip/skid indicator per instructions for the appropriate stall/departure resistance maneuver. If "Full Left" or "Full Right," indicates that directional control is fully displaced. If "No Input," indicates that no pilot input is made to the control.

(9) CG – center of gravity position. Currently "most adverse" for all cases per 4.2.1(*10*).

(10) Weight – aeroplane weight at start of maneuver. Currently "most adverse" for all cases per 4.2.1(*9*).

(11) Gear – landing gear up or down. For the low-speed L1 and L2 aeroplanes, uses the conditions as specified in 4.2.1(*2*)(*a*). For the others, 4.2.1(*2*)(*b*) notes that gear shall be "appropriate to phase of flight and altitude," so the table only shows gear up for the flaps up and flaps at max takeoff condition.

(12) Altitude – Per 4.2.2.5, aeroplane with altitudes approved above 7620 m [25 000 ft] need to do some stall testing at altitude. "Low" means only at the appropriate lower altitude for testing. "Low/High" indicates the conditions that shall be tested at this "low" altitude as well as the "high" altitude, which AC-23-8C indicates shall be near the maximum altitude capability of the aeroplane. Hence, if "low/high" is present, that means the condition is duplicated at low and high altitude.

(13) Decel – deceleration rate of the maneuver. Generally 1 kt/sec for unaccelerated, and 3 to 5 kts/sec for accelerated configurations.

X1.2 All aeroplanes are required to demonstrate acceptable stall characteristics. These include wings-level stalls (4.2.2), turning stalls and accelerated turning stalls (4.2.3).

X1.2.1 The conditions applicable to wings-level stalls are given in Table X1.1 for Level 1 and Level 2, low-speed, single-engine aeroplanes, and in Table X1.2 for all other aeroplanes.

X1.2.2 The notional conditions for turning stalls and accelerated turning stalls are given in Table X1.3 for Level 1 and Level 2, low-speed, single-engine aeroplanes, and in Table X1.4 for all other aeroplanes.

X1.3 All single-engine aeroplanes, not approved for aerobatics, need to meet the departure characteristics criteria defined in 4.4. One option is to pass all of the conditions outlined by "Alternative 1" (4.4.1). As with the stall characteristics, there are several different maneuvers to be considered. These include enhanced maneuverability during the wings-level stall tests, per 4.4.1.1. These conditions will be

TABLE X1.1 Notional Wings-Level Stall Conditions for Level 1 and Level 2, Low-Speed, Single-Engine Aeroplanes (4.2.2, also appropriate for 4.4.1.1 and 4.4.2.3(*1*))

No.	Flaps	Cowl Flaps	Speed Brakes	Trim V_{S1}	Power	Entry Bank	Ball	CG	Weight	Gear	Altitude	Decel
1	Up	Closed	Ret/Ext or Auto	1.5	On	Wings Level	Centered	Most adverse	Most adverse	Up	Low/ High	1 kt/sec
2	Up	Closed	Ret/Ext or Auto	1.5	Off	Wings Level	Centered	Most adverse	Most adverse	Up	Low/ High	1 kt/sec
3	Max TO	Open	Ret/Ext or Auto	1.3	On	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
4	Max TO	Open	Ret/Ext or Auto	1.3	Off	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
5	Full	Closed	Ret/Ext or Auto	1.3	On	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
6	Full	Closed	Ret/Ext or Auto	1.3	Off	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec

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TABLE X1.2 Notional Wings-Level Stall Conditions for All Other Aeroplanes (4.2.2, also appropriate for 4.4.1.1)

No.	Flaps	Cowl Flaps	Speed Brakes	Trim V_{S1} (V_{SR1})	Power	Entry Bank	Ball	CG	Weight	Gear	Altitude	Decel
1	Up	Appropriate	Ret/Ext or Auto	1.5 (1.4)	On	Wings Level	Centered	Most adverse	Most adverse	Up	Low/High	1 kt/sec
2	Up	Appropriate	Ret/Ext or Auto	1.5 (1.4)	Off	Wings Level	Centered	Most adverse	Most adverse	Up	Low/High	1 kt/sec
3	Max TO	Appropriate	Ret/Ext or Auto	1.3 (1.23)	On	Wings Level	Centered	Most adverse	Most adverse	Up	Low	1 kt/sec
4	Max TO	Appropriate	Ret/Ext or Auto	1.3 (1.23)	Off	Wings Level	Centered	Most adverse	Most adverse	Up	Low	1 kt/sec
5	Up	Appropriate	Ret/Ext or Auto	1.3 (1.23)	On	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
6	Up	Appropriate	Ret/Ext or Auto	1.3 (1.23)	Off	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
7	Max TO	Appropriate	Ret/Ext or Auto	1.3 (1.23)	On	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
8	Max TO	Appropriate	Ret/Ext or Auto	1.3 (1.23)	Off	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
9	Full	Appropriate	Ret/Ext or Auto	1.3 (1.23)	On	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
10	Full	Appropriate	Ret/Ext or Auto	1.3 (1.23)	Off	Wings Level	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec

TABLE X1.3 Notional Turning and Accelerated Stall Conditions for Level 1 and Level 2, Low-Speed, Single-Engine Aeroplanes (4.2.3)

No.	Flaps	Cowl Flaps	Speed Brakes	Trim V_{S1}	Power	Entry Bank	Ball	CG	Weight	Gear	Altitude	Decel
1	Up	Closed	Ret/Ext or Auto	1.5	On	Left 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	1 kt/sec
2	Up	Closed	Ret/Ext or Auto	1.5	Off	Left 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	1 kt/sec
3	Max TO	Open	Ret/Ext or Auto	1.3	On	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
4	Max TO	Open	Ret/Ext or Auto	1.3	Off	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
5	Full	Closed	Ret/Ext or Auto	1.3	On	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
6	Full	Closed	Ret/Ext or Auto	1.3	Off	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
7	Up	Closed	Ret/Ext or Auto	1.5	On	Right 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	1 kt/sec
8	Up	Closed	Ret/Ext or Auto	1.5	Off	Right 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	1 kt/sec
9	Max TO	Open	Ret/Ext or Auto	1.3	On	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
10	Max TO	Open	Ret/Ext or Auto	1.3	Off	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
11	Full	Closed	Ret/Ext or Auto	1.3	On	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
12	Full	Closed	Ret/Ext or Auto	1.3	Off	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	1 kt/sec
13	Up	Closed	Ret/Ext or Auto	1.5	On	Left 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	3–5 kt/sec
14	Up	Closed	Ret/Ext or Auto	1.5	Off	Left 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	3–5 kt/sec
15	Max TO	Open	Ret/Ext or Auto	1.3	On	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
16	Max TO	Open	Ret/Ext or Auto	1.3	Off	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
17	Full	Closed	Ret/Ext or Auto	1.3	On	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
18	Full	Closed	Ret/Ext or Auto	1.3	Off	Left 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
19	Up	Closed	Ret/Ext or Auto	1.5	On	Right 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	3–5 kt/sec
20	Up	Closed	Ret/Ext or Auto	1.5	Off	Right 30 deg	Centered	Most adverse	Most adverse	Up	Low/High	3–5 kt/sec
21	Max TO	Open	Ret/Ext or Auto	1.3	On	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
22	Max TO	Open	Ret/Ext or Auto	1.3	Off	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
23	Full	Closed	Ret/Ext or Auto	1.3	On	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec
24	Full	Closed	Ret/Ext or Auto	1.3	Off	Right 30 deg	Centered	Most adverse	Most adverse	Down	Low	3–5 kt/sec

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