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Standard Specification for Aircraft Handling Characteristics[1]

This standard is issued under the fixed designation F3173/F3173M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification addresses the airworthiness requirements for aeroplane handling characteristics in flight and on ground and water.

1.2 The material was developed through open consensus of international experts in general aviation. This information was created by focusing on Normal Category aeroplanes; however, the content may be more broadly applicable, and should not be unduly limited. The topics covered within this specification are: Flight Characteristics, Controllability, Trim, Stability, Ground and Water Handling Characteristics, and Vibration, Buffet, and High-speed Characteristics.

1.3 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 specification (in whole or in part) as an acceptable Means of Compliance to their regulatory requirements (hereinafter "the Rules"), refer to the ASTM Committee F44 web page (www.astm.org/COMMITTEE/F44.htm). Annex A1 maps the Means of Compliance of the ASTM standards to EASA CS-23, amendment 5, or later, and FAA 14 CFR Part 23, amendment 64, or later, rules.

1.4 *Units*—This specification 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.

1.5 *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.*

1.6 *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

F3116/F3116M Specification for Design Loads and Conditions

F3174/F3174M Specification for Establishing Operating Limitations and Information for Aeroplanes

F3179/F3179M Specification for Performance of Aircraft

F3232/F3232M Specification for Flight Controls in Small Aircraft

F3233/F3233M Specification for Flight and Navigation Instrumentation in Aircraft

2.2 *EASA Standard:*[3]

EASA CS-23 Normal, Utility, Aerobatic and Commuter Aeroplanes

2.3 *FAA Standard:*[4]

14 CFR Part 23 Airworthiness Standards: Normal Category Airplanes

3. Terminology

3.1 Refer to Terminology F3060 referenced in Section 2.

4. Flight Characteristics—General

4.1 Unless otherwise specified in a specific requirement, the aeroplane shall meet the requirements of Sections 5 – 8 and 9.1 – 9.4 at all practical loading conditions and operating altitudes for which certification has been requested, not exceeding that

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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 European Union Aviation Safety Agency (EASA), Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, https://www.easa.europa.eu.

[4] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

established in Specification F3174/F3174M *Maximum Operating Altitude* and without requiring exceptional piloting skill, alertness, or strength.

5. Controllability

5.1 *General:*

5.1.1 The aeroplane shall be safely controllable and maneuverable during all flight phases including:

5.1.1.1 Takeoff,

5.1.1.2 Climb,

5.1.1.3 Level flight,

5.1.1.4 Descent,

5.1.1.5 Go-around, and

5.1.1.6 Landing (power on and idle power) with the wing flaps extended and retracted.

5.1.2 It shall be possible to make a smooth transition from one flight condition to another (including turns and slips) without danger of exceeding the limit load factor under any probable operating condition (including, for multiengine aeroplanes, those conditions normally encountered in the sudden critical loss of thrust).

5.1.3 If marginal conditions exist with regard to required pilot strength, the control forces necessary shall be determined by quantitative tests. In no case may the control forces under the conditions specified in 5.1.1 and 5.1.2 exceed those prescribed in Table 1.

TABLE 1 Control Forces

Level 1 Aeroplanes With $V_{S0} \leq 45$ KCAS			
Control	Longitudinal	Lateral	Directional
(a) For temporary application:	—	—	—
Stick	200 N [45 lbf]	100 N [22 lbf]	—
Wheel	250 N [56 lbf]	200 N [45 lbf]	—
Rudder pedal	—	—	400 N [90 lbf]
(b) For prolonged application:	20 N [4 lbf]	15 N [3 lbf]	100 N [22 lbf]
Level 1 Aeroplanes With $V_{S0} > 45$ KCAS and Level 2, 3 and 4 Aeroplanes			
Control	Longitudinal	Lateral	Directional
(a) For temporary application:			
Stick	267 N [60 lbf]	133 N [30 lbf]	
Wheel (two hands on rim)	334 N [75 lbf]	222 N [50 lbf]	
Wheel (one hand on rim)	222 N [50 lbf]	111 N [25 lbf]	
Rudder pedal	—	—	667 N [150 lbf]
(b) For prolonged application:	44 N [10 lbf]	22 N [5 lbf]	89 N [20 lbf]

5.2 *Longitudinal Control:*

5.2.1 With the aeroplane as nearly as possible in trim at 1.3 V_{S1}, it shall be possible, at speeds below the trim speed, to pitch the nose downward so that the rate of increase in airspeed allows prompt acceleration to the trim speed with:

5.2.1.1 Maximum continuous power on each engine;

5.2.1.2 Idle power; and

5.2.1.3 Wing flap and landing gear:

(1) Retracted and

(2) Extended.

5.2.2 Unless otherwise required, it shall be possible to carry out the following maneuvers without requiring the application of single-handed control forces exceeding those specified in Table 1. The trimming controls shall not be adjusted during the maneuvers.

5.2.2.1 With the landing gear extended, the flaps retracted, and the aeroplane as nearly as possible in trim at 1.4 V_{S1}, extend the flaps as rapidly as possible and allow the airspeed to transition from 1.4 V_{S1} to 1.4 V_{S0}:

(1) With power idle and

(2) With the power necessary to maintain level flight in the initial condition.

5.2.2.2 With landing gear and flaps extended, idle power, and the aeroplane as nearly as possible in trim at 1.3 V_{S0}, quickly apply takeoff power and retract the flaps as rapidly as possible to the recommended go around setting and allow the airspeed to transition from 1.3 V_{S0} to 1.3 V_{S1}. Retract the gear when a positive rate of climb is established.

5.2.2.3 With landing gear and flaps extended, power necessary to maintain level flight at 1.1 V_{S0} and the aeroplane as nearly as possible in trim, it shall be possible to maintain approximately level flight while retracting the flaps as rapidly as possible with simultaneous application of maximum continuous power. Power must not be reduced during the level acceleration unless a flap speed exceedance (V_{FE} of the initial position) is imminent. The maneuver is completed when the flaps have reached the selected position and the airspeed is not less than 1.3 V_{S1}. If gated flap positions are provided, the flap retraction may be demonstrated in stages with power and trim reset for level flight at 1.1 V_{S1}, in the initial configuration for each stage:

(1) From the fully extended position to the most extended gated position;

(2) Between intermediate gated positions, if applicable; and

(3) From the least extended gated position to the fully retracted position.

5.2.2.4 With idle power, flaps and landing gear retracted and the aeroplane as nearly as possible in trim at 1.4 V_{S1}, apply takeoff power rapidly while maintaining the same airspeed.

5.2.2.5 With idle power, landing gear and flaps extended, and the aeroplane as nearly as possible in trim at V_{REF}, obtain and maintain airspeeds between 1.1 V_{S0} and either 1.7 V_{S0} or V_{FE}, whichever is lower without requiring the application of two-handed control forces exceeding those specified in Table 1.

5.2.2.6 With maximum takeoff power, landing gear retracted, flaps in the takeoff position, and the aeroplane as nearly as possible in trim at V_{FE} appropriate to the takeoff flap position, retract the flaps as rapidly as possible while maintaining constant speed.

5.2.3 At speeds above $V_{MO}/M_{MO}/V_{NE}$, and up to the maximum speed shown under 9.1:

5.2.3.1 For Level 1 aeroplanes with $V_{S0} \leq 45$ KCAS, it must be possible to raise the nose at all permitted c.g. positions and engine powers.

5.2.3.2 For Level 1 aeroplanes with $V_{S0} > 45$ KCAS and Level 2, 3, and 4 aeroplanes, a maneuvering capability of 1.5 g shall be demonstrated to provide a margin to recover from upset or inadvertent speed increase.

5.2.4 For Level 1 aeroplanes with $V_{S0} > 45$ KCAS and Level 2, 3, and 4 aeroplanes, it shall be possible, with a pilot control force of not more than 45 N [10 lbf], to maintain a speed of not more than V_{REF} during an idle power glide with landing gear and wing flaps extended, for any weight of the aeroplane, up to and including the maximum weight.

5.2.5 For Level 1 aeroplanes with V_{S0} > 45 KCAS and Level 2, 3, and 4 aeroplanes, by using normal flight and power controls, except as otherwise noted in 5.2.5.1 and 5.2.5.2, it shall be possible to arrest the rate of descent to zero at an attitude suitable for a controlled landing without exceeding the operational and structural limitations of the aeroplane, as follows:

5.2.5.1 For single-engine aeroplanes and multiengine aeroplanes, without the use of the primary longitudinal control system; and

5.2.5.2 For multiengine aeroplanes:

(1) Without the use of the primary directional control and

(2) If a single failure of any one connecting or transmitting link would affect both the longitudinal and directional primary control system, without the primary longitudinal and directional control system.

5.2.6 For Level 1 aeroplanes with $V_{S0} \leq 45$ KCAS, for any trim setting required under 6.3.1, it must be possible to takeoff, climb, descend, and land the aeroplane in required configurations with no adverse effect and with acceptable forces.

5.3 *Directional and Lateral Control:*

5.3.1 For each multiengine aeroplane, it shall be possible, while holding the wings level within 5°, to make sudden changes in heading safely in both directions. This ability shall be shown at 1.4 V_{S1} with heading changes up to 15°, except that the heading change at which the rudder force corresponds to the limits specified in Table 1 need not be exceeded, with the:

5.3.1.1 Critical loss of thrust and its propeller in the minimum drag position;

5.3.1.2 Remaining engines at maximum continuous power;

5.3.1.3 Landing gear:

(1) Retracted, and

(2) Extended.

5.3.1.4 Flaps retracted.

5.3.2 For each multiengine aeroplane, it shall be possible to regain full control of the aeroplane without exceeding a bank angle of 45°, reaching a dangerous attitude, or encountering dangerous characteristics in the event of a sudden and complete loss of critical thrust, making allowance for a delay of 2 s in the initiation of recovery action appropriate to the situation, with the aeroplane initially in trim, in the following condition:

5.3.2.1 Maximum continuous power on each engine,

5.3.2.2 The wing flaps retracted,

5.3.2.3 The landing gear retracted,

5.3.2.4 A speed equal to that at which compliance with Specification F3179/F3179M *Climb Information* for the all engines operating condition has been shown, and

5.3.2.5 All propeller controls in the position at which compliance with Specification F3179/F3179M *Climb Information* for the all engines operating condition has been shown.

5.3.3 For Level 1 aeroplanes with V_{S0} > 45 KCAS and Level 2, 3, and 4 aeroplanes, it shall be shown that the aeroplane is safely controllable without the use of the primary lateral control system in any all-engine configuration(s) and at any speed or altitude within the approved operating envelope. It shall also be shown that the aeroplane's flight characteristics are not impaired below a level needed to permit continued safe flight and the ability to maintain attitudes suitable for a controlled landing without exceeding the operational and structural limitations of the aeroplane. If a single failure of any one connecting or transmitting link in the lateral control system would also cause the loss of additional control system(s), compliance with the above requirement shall be shown with those additional systems also assumed to be inoperative.

5.4 *Elevator Control Force in Maneuvers:*

5.4.1 The elevator control force needed to achieve the positive limit maneuvering load factor shall not be less than:

5.4.1.1 For wheel controls, $W/10$ N (where W is the maximum mass in kg) [$W/100$ lbf (where W = maximum weight in lbf)] or 89 N [20 lbf], whichever is greater, except that it need not be greater than 222 N [50 lbf], or

5.4.1.2 For stick controls, $W/14$ N (where W is the maximum mass in kg) [$W/140$ lbf (where W = maximum weight in lbf)] or 67 N [15 lbf], whichever is greater, except that it need not be greater than 156 N [35 lbf].

5.4.2 The requirement of 5.4.1 shall be met at 75 percent of maximum continuous power for reciprocating engines, or the maximum continuous power for turbine engines and with the wing flaps and landing gear retracted:

5.4.2.1 In a turn, with the trim setting used for wings level flight at V_O, and

5.4.2.2 In a turn, with the trim setting used for the maximum wings level flight speed, except that the speed may not exceed V_{NE} or V_{MO}/M_{MO}, whichever is appropriate.

5.4.3 There shall be no excessive decrease in the gradient of the curve of stick force versus maneuvering load factor with increasing load factor.

5.5 *Rate of Roll:*

5.5.1 *Takeoff*—It shall be possible, using a favorable combination of controls, to roll the aeroplane from a steady 30° banked turn through an angle of 60°, so as to reverse the direction of the turn within:

5.5.1.1 For an aeroplane of 2722 kg [6000 lb] or less maximum weight, 5 s from initiation of roll and

5.5.1.2 For an aeroplane of over 2722 kg [6000 lb], $(W + 200) / 590$ s where W is the weight in kg [$(W + 500) / 1300$ s where W = weight in lbs] but not more than 10 s.

5.5.2 The requirement of 5.5.1 shall be met when rolling the aeroplane in each direction with:

5.5.2.1 Flaps in the takeoff position;

5.5.2.2 Landing gear retracted;

5.5.2.3 For a single-engine aeroplane, at maximum takeoff power, and a multiengine aeroplane with the critical loss of thrust with the affected propeller(s) in the minimum drag position and the other engines at maximum takeoff power; and

5.5.2.4 The aeroplane trimmed, or trimmed as nearly as possible, in straight flight at a speed equal to the greater of 1.2 V_{S1} or 1.1 V_{MC}.

5.5.3 *Approach*—It shall be possible, using a favorable combination of controls, to roll the aeroplane from a steady 30° banked turn through an angle of 60°, so as to reverse the direction of the turn within:

5.5.3.1 For an aeroplane of 2722 kg [6000 lb] or less maximum weight, 4 s from initiation of roll and

5.5.3.2 For an aeroplane of over 2722 kg [6000 lb] maximum weight, $(W + 1300) / 1000$ s where W is weight in kg [$(W + 2800) / 2200$ s where W = weight in pounds] but not more than 7 s.

5.5.4 The requirement of 5.5.3 shall be met when rolling the aeroplane in each direction in the following conditions:

5.5.4.1 Flaps in the landing position(s),

5.5.4.2 Landing gear extended,

5.5.4.3 All engines operating at the power for a 3° approach, and

5.5.4.4 The aeroplane trimmed at V_{REF}.

5.6 *Control during Landings*—It shall be possible, while in the landing configuration, to complete a landing without causing substantial damage or serious injury. The one-hand control force limits specified in Table 1 shall not be exceeded following an approach to land.

5.6.1 At a speed of V_{REF} minus 5 knots;

5.6.2 With the aeroplane in trim, or as nearly as possible in trim and without the trimming control being moved throughout the maneuver;

5.6.3 At an approach gradient equal to:

5.6.3.1 For Level 1 aeroplanes with $V_{S0} \leq 45$ KCAS, that resulting from an approach at idle power, or

5.6.3.2 For Level 1 aeroplanes with $V_{S0} > 45$ KCAS and Level 2, 3, and 4 aeroplanes, the steepest used in the landing distance demonstration of Specification F3179/F3179M *Landing*.

5.6.4 With only those power changes, if any, that would be made when landing normally from an approach at V_{REF}.

5.7 *Minimum Control Speed:*

5.7.1 V_{MC} is the calibrated airspeed at which, following a sudden critical loss of thrust, it is possible to maintain control of the aeroplane with the failed components of the propulsion system remaining inoperative. Thereafter, it shall be possible to maintain straight flight at the same speed with an angle of bank of not more than 5°. The method used to simulate critical loss of thrust shall represent the most critical mode of powerplant failure expected in service with respect to controllability.

5.7.2 V_{MC} for takeoff shall not exceed 1.2 V_{S1}, where V_{S1} is determined at the maximum takeoff weight.

5.7.3 V_{MC} shall be determined with the most unfavorable weight and center-of-gravity position and the aeroplane airborne and the ground effect negligible, for the takeoff configuration(s) with:

5.7.3.1 Maximum available takeoff power initially on each engine,

5.7.3.2 The aeroplane trimmed for takeoff,

5.7.3.3 Flaps in the takeoff position(s),

5.7.3.4 Landing gear retracted, and

5.7.3.5 All propeller controls in the recommended takeoff position throughout.

5.7.4 For all aeroplanes except low-speed Level 1 and 2 aeroplanes, the conditions of 5.7.1 shall also be met for the landing configuration with:

5.7.4.1 Maximum available takeoff power initially on each engine;

5.7.4.2 The aeroplane trimmed for an approach, with all engines operating, at V_{REF}, at an approach gradient equal to the steepest used in the landing distance demonstration of Specification F3179/F3179M *Landing*;

5.7.4.3 Flaps in the landing position;

5.7.4.4 Landing gear extended; and

5.7.4.5 All propeller controls in the position recommended for approach with all engines operating.

5.7.5 A minimum speed to render the critical engine inoperative intentionally shall be established and designated as the safe, intentional, one-engine-inoperative speed (V_{SSE}).

5.7.6 At V_{MC}, the rudder pedal force required to maintain control shall not exceed the temporary rudder pedal force limit specified in Table 1 and it shall not be necessary to reduce power of the operative engine(s). During the maneuver, the aeroplane shall not assume any dangerous attitude and it shall be possible to prevent a heading change of more than 20°.

5.7.7 At the option of the applicant, to comply with the requirements of Specification F3179/F3179M *Takeoff Speeds*, V_{MCG} may be determined. V_{MCG}, is the minimum control speed on the ground and is the calibrated airspeed during the takeoff run at which, following a sudden critical loss of thrust, it is possible to maintain control of the aeroplane using the rudder control alone (without the use of nose wheel steering) as limited by the temporary rudder pedal force limit specified in Table 1 and using the lateral control to the extent of keeping the wings level to enable the takeoff to be safely continued. In the determination of V_{MCG}, assuming that the path of the aeroplane accelerating with all engines operating is along the centerline of the runway, its path from the point at which the critical engine is made inoperative to the point at which recovery to a direction parallel to the centerline is completed may not deviate more than 9.1 m [30 ft] laterally from the centerline at any point. V_{MCG}, shall be established with:

5.7.7.1 The aeroplane in each takeoff configuration or, at the option of the applicant, in the most critical takeoff configuration;

5.7.7.2 Maximum available takeoff power on the operating engines;

5.7.7.3 The most unfavorable center of gravity position;

5.7.7.4 The aeroplane trimmed for takeoff; and

5.7.7.5 The most unfavorable weight in the range of takeoff weights.

5.8 *Aerobatic Maneuvers*—Each aerobatic aeroplane shall be able to perform safely the aerobatic maneuvers for which certification is requested. Safe entry speeds for successful completion of these maneuvers shall be determined.

6. Trim

6.1 *General*—Each aeroplane shall meet the trim requirements of this section after being trimmed and without further pressure upon, or movement of, the primary controls or their corresponding trim controls by the pilot or any function of the flight control system that requires pilot action to engage. In addition, it shall be possible in other conditions of loading, configuration, speed, and power to ensure that the pilot will not be unduly fatigued or distracted by the need to apply residual control forces exceeding those for prolonged application of

Table 1. This applies in normal operation of the aeroplane and likely abnormal or emergency operations, including those conditions associated with a critical loss of thrust for which performance characteristics are established.

6.2 *Lateral and Directional Trim*—The aeroplane shall maintain lateral and directional trim in level flight with the landing gear and wing flaps retracted as follows:

6.2.1 For Level 1, 2, and 3 aeroplanes, at a speed of 0.9 V_H, V_C, or V_{MO}/M_{MO}, whichever is lowest and

6.2.2 For Level 4 aeroplanes, at all speeds from 1.4 V_{S1} to the lesser of V_H or V_{MO}/M_{MO}.

6.3 *Longitudinal Trim*—The aeroplane shall maintain longitudinal trim under each of the following conditions:

6.3.1 For Level 1 aeroplanes with $V_{S0} \leq 45$ KCAS:

6.3.1.1 In level flight at any speed from 1.4 V_{S1} to 0.9 V_H or V_C (whichever is lower), and

6.3.1.2 In a climb with maximum continuous power at a speed VY with landing gear and wing flaps retracted, and

6.3.1.3 In a descent with idle power at a speed of 1.3 V_{S1} with landing gear extended and wing flaps in the landing position.

6.3.2 For Level 1 aeroplanes with $V_{S0} > 45$ KCAS and Level 2, 3, and 4 aeroplanes, a climb with:

6.3.2.1 Takeoff power, landing gear retracted, wing flaps in the takeoff position(s), at the speeds used in determining the climb performance required by Specification F3179/F3179M *Climb with all engines operating*, and

6.3.2.2 Maximum continuous power at the speeds and in the configuration used in determining the climb performance required by Specification F3179/F3179M *Climb Information* for the all engines operating condition.

6.3.3 Level flight at all speeds from the lesser of V_H and either V_{NO} or V_{MO}/M_{MO} (as appropriate), to 1.4 V_{S1}, with the landing gear and flaps retracted;

6.3.4 A descent at V_{NO} or V_{MO}/M_{MO}, whichever is applicable, with idle power and with the landing gear and flaps retracted; and

6.3.5 Approach with landing gear extended and with:

6.3.5.1 A 3° angle of descent with flaps retracted and at a speed of 1.4 V_{S1};

6.3.5.2 A 3° angle of descent with flaps in the landing position(s) at V_{REF}, and

6.3.5.3 An approach gradient equal to the steepest used in the landing distance demonstrations of Specification F3179/F3179M *Landing* with flaps in the landing position(s) at V_{REF}.

6.4 *Residual Control Forces:*

6.4.1 Each multiengine aeroplane shall maintain longitudinal and directional trim, and the lateral control force shall not exceed 22 N [5 lbf] at the speed used in complying with the applicable demonstration required by Specification F3179/F3179M *Climb after Partial Loss of Thrust* with:

6.4.1.1 The critical loss of thrust and, if applicable, affected propeller(s) in the minimum drag position;

6.4.1.2 The remaining engines at maximum continuous power;

6.4.1.3 The landing gear retracted;

6.4.1.4 Wing flaps retracted; and

6.4.1.5 An angle of bank of not more than 5°.

6.4.2 Each Level 4 aeroplane for which, in the determination of the takeoff path in accordance with Specification F3179/F3179M *Takeoff Path*, the climb in the takeoff configuration at V_2 extends beyond 122 m [400 ft] above the takeoff surface, it shall be possible to reduce the longitudinal and lateral control forces to 45 and 22 N [10 and 5 lbf], respectively, and the directional control force shall not exceed 222 N [50 lbf] with:

6.4.2.1 The critical loss of thrust and affected propeller(s) in the minimum drag position,

6.4.2.2 The remaining engine(s) at takeoff power,

6.4.2.3 Landing gear retracted,

6.4.2.4 Wing flaps in the takeoff position(s), and

6.4.2.5 An angle of bank not exceeding 5°.

7. Stability

7.1 *Maximum Speed for Stability Characteristics*—V_{FC}/M_{FC} may not be less than a speed midway between V_{MO}/M_{MO} and V_{DF}/M_{DF} except that, for altitudes in which Mach number is the limiting factor, M_{FC} need not exceed the Mach number at which effective speed warning occurs.

7.2 *Static Longitudinal Stability*—Under the conditions specified in 7.3 and with the aeroplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system shall be as follows:

7.2.1 A pull shall be required to obtain and maintain speeds below the specified trim speed and a push required to obtain and maintain speeds above the specified trim speed. This shall be shown at any speed that can be obtained, except that speeds requiring a control force in excess of 178 N [40 lbf] or speeds above the maximum allowable speed or below the minimum speed for steady unstalled flight, need not be considered.

7.2.2 The airspeed shall return to within the tolerances specified for applicable aeroplane levels when the control force is slowly released at any speed within the speed range specified in 7.2.1. The applicable tolerances are:

7.2.2.1 The airspeed shall return to within ±10 % of the original trim airspeed and

7.2.2.2 For Level 4 aeroplanes, the airspeed shall return to within ±7.5 % of the original trim airspeed for the cruising condition specified in 7.3.2.

7.2.3 The stick force shall vary with speed so that any substantial speed change results in a stick force clearly perceptible to the pilot.

7.3 *Demonstration of Static Longitudinal Stability:*

7.3.1 *Climb*—The stick force curve shall have a stable slope at speeds between 85 and 115 % of the trim speed with:

7.3.1.1 Flaps retracted,

7.3.1.2 Landing gear retracted,

7.3.1.3 Maximum continuous power, and

7.3.1.4 The aeroplane trimmed at the speed used in determining the climb performance required by Specification F3179/F3179M *Climb Information* for the all engines operating condition.

7.3.2 *Cruise*—With flaps and landing gear retracted and the aeroplane in trim with power for level flight at representative cruising speeds at high and low altitudes, including speeds up to V_{NO} or V_{MO}/M_{MO} as appropriate, except that the speed need not exceed V_H:

7.3.2.1 For Level 1, 2, and 3 aeroplanes, the stick force curve shall have a stable slope at all speeds within a range that is the greater of 15 % of the trim speed plus the resulting free return speed range, or 40 knots plus the resulting free return speed range, above and below the trim speed, except that the slope need not be stable:

(1) At speeds less than 1.3 V_{S1};

(2) For aeroplanes with V_{NE} established under Specification F3174/F3174M *Airspeed Limitations* at speeds greater than V_{NE}; or

(3) For aeroplanes with V_{MO}/M_{MO} established under Specification F3174/F3174M *Airspeed Limitations* at speeds greater than V_{FC}/M_{FC}.

7.3.2.2 For Level 4 aeroplanes, the stick force curve shall have a stable slope at all speeds within a range of 50 knots plus the resulting free return speed range, above and below the trim speed, except that the slope need not be stable:

(1) At speeds less than 1.4 V_{S1},

(2) At speeds greater than V_{FC}/M_{FC}, or

(3) At speeds that require a stick force greater than 222 N [50 lbf].

7.3.3 *Landing*—The stick force curve shall have a stable slope at speeds between 1.1 and 1.8 V_{S1} with:

7.3.3.1 Flaps in the landing position,

7.3.3.2 Landing gear extended, and

7.3.3.3 The aeroplane trimmed at:

(1) V_{REF}, or the minimum trim speed if higher, with idle power and

(2) V_{REF} with enough power to maintain a 3° angle of descent.

7.4 *Static Directional and Lateral Stability:*

7.4.1 The static directional stability, as shown by the tendency to recover from a wings level sideslip with the rudder free, shall be positive for any landing gear and flap position appropriate to the takeoff, climb, cruise, approach, and landing configurations. This shall be shown with symmetrical power up to maximum continuous power and at speeds from 1.2 V_{S1} up to V_{FE}, V_{LE}, V_{NO}, and V_{FC}/M_{FC}, whichever is appropriate.

7.4.1.1 The angle of sideslip for these tests shall be appropriate to the type of aeroplane. The rudder pedal force shall not reverse at larger angles of sideslip up to that at which full rudder is used or a control force limit in Table 1 is reached, whichever occurs first, and at speeds from 1.2 V_{S1} to V_O.

7.4.2 The static lateral stability, as shown by the tendency to raise the low wing in a sideslip with the aileron controls free, shall not be negative for any landing gear and flap position appropriate to the takeoff, climb, cruise, approach, and landing configurations. This shall be shown with symmetrical power from idle up to 75 % of maximum continuous power. For the landing configuration, the power shall be that necessary to maintain a 3° angle of descent in coordinated flight.

7.4.2.1 For Level 1 aeroplanes with $V_{S0} \leq 45$ KCAS this shall be shown at speeds from 1.2 V_{S1} up to the maximum allowable airspeed for the configuration being investigated (V_{FE}, V_{LE}, V_{NO}, and V_{FC}/M_{FC}, whichever is appropriate) in the takeoff, climb, cruise, descent, approach, and landing configurations.

7.4.2.2 For Level 1 aeroplanes with $V_{S0} > 45$ KCAS and Level 2, 3, and 4 aeroplanes this shall be shown.

(1) At speeds from 1.2 V_{S1} in the takeoff configuration(s) and at speeds from 1.3 V_{S1} in other configurations up to the maximum allowable airspeed for the configuration being investigated (V_{FE}, V_{LE}, V_{NO}, and V_{FC}/M_{MC}, whichever is appropriate) in the takeoff, climb, cruise, descent, and approach configurations, and

(2) At 1.3 V_{S0} in the landing configuration.

7.4.2.3 The angle of sideslip for these tests shall be appropriate to the type of aeroplane, but in no case may the constant heading sideslip angle be less than that obtainable with a 10° bank or, if less, the maximum bank angle obtainable with full rudder deflection or the temporary rudder pedal force limit specified in Table 1, whichever occurs first.

7.4.3 Paragraph 7.4.2 does not apply to aeroplanes certified for aerobatics that include inverted flight.

7.4.4 In straight, steady slips at 1.2 V_{S1} for any landing gear and flap position appropriate to the takeoff, climb, cruise, approach, and landing configurations, and for any symmetrical power conditions up to 50 % of maximum continuous power, the aileron and rudder control movements and forces shall increase steadily, but not necessarily in constant proportion, as the angle of sideslip is increased up to the maximum appropriate to the type of aeroplane.

7.4.4.1 At larger slip angles, up to the angle at which the full rudder or aileron control is used or a control force limit contained in Table 1 is reached, the aileron and rudder control movements and forces may not reverse as the angle of sideslip is increased.

7.4.4.2 Rapid entry into, and recovery from, a maximum sideslip considered appropriate for the aeroplane may not result in uncontrollable flight characteristics.

7.4.5 *Two-Control (or Simplified Control) Aeroplanes*—The stability requirements for aeroplanes with only one lateral/directional control available to the pilot are as follows:

7.4.5.1 The directional stability of the aeroplane shall be shown by showing that, in each configuration, it can be rapidly rolled from a 45° bank in one direction to a 45° bank in the opposite direction without showing dangerous skid characteristics.

7.4.5.2 The lateral stability of the aeroplane shall be shown by showing that it will not assume a dangerous attitude or speed when the controls are abandoned for 2 min. This shall be done:

(1) In moderately smooth air;

(2) With the aeroplane trimmed for straight level flight at 0.9 V_H or V_C, whichever is lower;

(3) With flaps and landing gear retracted; and

(4) At the most unfavorable center of gravity.

7.5 *Dynamic Short Period and Dutch Roll Stability:*

7.5.1 Any short period oscillation not including combined lateral-directional oscillations occurring between the stalling speed and the maximum allowable speed appropriate to the configuration of the aeroplane shall be heavily damped with primary controls:

7.5.1.1 Free, and

7.5.1.2 In a fixed position.

7.5.2 Any combined lateral-directional oscillations (Dutch roll) occurring between the stalling speed and the maximum allowable speed (V_{FE}, V_{LE}, V_{NO}, V_{FC}/M_{FC}) appropriate to the configuration of the aeroplane with the primary controls in both free and fixed position shall be damped to 1/10 amplitude in:

7.5.2.1 Seven cycles below 5486 m [18 000 ft], and

7.5.2.2 Thirteen cycles from 5486 m [18 000 ft] to the certified maximum altitude.

7.5.3 If it is determined that the function of a stability augmentation system (reference Specification F3232/F3232M *Stability Augmentation*) is needed to meet the flight characteristic requirements of this part, the primary control requirements of 7.5.1.2 and the fixed position testing of 7.5.2 are not applicable to the tests needed to verify the acceptability of that system.

7.6 *Control Force Feedback*—The aeroplane shall show suitable stability and control "feel" (static stability) in any condition normally encountered in service, if flight tests show it is necessary for safe operation.

7.7 *Divergent Longitudinal Stability*—During the conditions as specified in 7.3, when the longitudinal control force required to maintain speeds differing from the trim speed by at least ±15 % is suddenly released, the response of the aeroplane shall not exhibit any dangerous characteristics nor be excessive in relation to the magnitude of the control force released. Any long-period oscillation of flight path, phugoid oscillation, that results shall not be so unstable as to increase the pilot's workload or otherwise endanger the aeroplane and its occupants.

8. Ground and Water Handling Characteristics

8.1 *Longitudinal Stability and Control:*

8.1.1 A landplane may have no uncontrollable tendency to nose over in any reasonably expected operating condition, including rebound during landing or takeoff. Wheel brakes shall operate smoothly and may not induce any undue tendency to nose over.

8.1.2 A seaplane or amphibian may not have dangerous or uncontrollable porpoising characteristics at any normal operating speed on the water.

8.2 *Directional Stability and Control:*

8.2.1 A 90° cross component of wind velocity demonstrated to be safe for taxiing, takeoff, and landing shall be established and shall be not less than 0.2 V_{S0} or 10 knots, whichever is greater.

8.2.2 The aeroplane shall be satisfactorily controllable in idle power landings at normal landing speed without using brakes or engine power to maintain a straight path until the speed has decreased to at least 50 % of the speed at touchdown.

8.2.3 The aeroplane shall have adequate directional control during taxiing.

8.2.4 Seaplanes shall demonstrate satisfactory directional stability and control for water operations up to the maximum wind velocity specified in 8.2.1.

8.3 *Operation on Unpaved Surfaces*—The aeroplane shall be demonstrated to have satisfactory characteristics and the shock-absorbing mechanism shall not damage the structure of the aeroplane when the aeroplane is taxied on the roughest ground that may reasonably be expected in normal operation and when takeoffs and landings are performed on unpaved runways having the roughest surface that may reasonably be expected in normal operation.

8.4 *Operation on Water:*

8.4.1 A wave height, demonstrated to be safe for operation, and any necessary water-handling procedures for seaplanes and amphibians, shall be established.

8.4.2 Spray may not dangerously obscure the vision of the pilots or damage the propellers or other parts of a seaplane or amphibian at any time during taxiing, takeoff, and landing.

9. Vibration, Buffeting, and High-speed Characteristics

9.1 *Vibration and Buffeting*—There shall be no vibration or buffeting severe enough to result in structural damage, and each part of the aeroplane shall be free from excessive vibration under any appropriate speed and power conditions up to V_D/M_D, or V_{DF}/M_{DF} for turbojets. In addition, there shall be no buffeting in any normal flight condition, including configuration changes during cruise, severe enough to interfere with the satisfactory control of the aeroplane or cause excessive fatigue to the flight crew. Stall warning buffeting within these limits is allowable.

9.2 *Cruise Buffeting*—For high-speed aeroplanes and all aeroplanes with a maximum operating altitude greater than 7620 m [25 000 ft], there shall be no perceptible buffeting in the cruise configuration at 1 g and at any speed up to V_{MO}/M_{MO}, except stall buffeting, which is allowable.

9.3 *Buffet Boundary*—For high-speed aeroplanes, the positive maneuvering load factors at which the onset of perceptible buffeting occurs shall be determined with the aeroplane in the cruise configuration for the ranges of airspeed or Mach number, weight, and altitude for which the aeroplane is to be certificated. The envelopes of load factor, speed, altitude, and weight shall provide a sufficient range of speeds and load factors for normal operations. Probable inadvertent excursions beyond the boundaries of the buffet onset envelopes may not result in unsafe conditions.

9.4 *Inadvertent Speed Increase*—If a maximum operating speed, V_{MO}/M_{MO}, is established under Specification F3174/F3174M *Airspeed Limitations*, the following speed increase and recovery characteristics shall be met:

9.4.1 Operating conditions and characteristics likely to cause inadvertent speed increases (including upsets in pitch and roll) shall be simulated with the aeroplane trimmed at any