Designation: F3173/F3173M − 15

Standard Specification for Handling Characteristics of Aeroplanes[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 establishes the airworthiness design standards associated with general airplane-handling characteristics in flight and on ground and water.

1.2 This specification is applicable to aeroplanes.

1.3 The applicant for a design approval shall seek the individual guidance of their respective civil aviation authority (CAA) body concerning the use of this specification as part of a certification plan. For information on which CAA regulatory bodies have accepted this specification (in whole or in part) as a means of compliance to their small aircraft airworthiness regulations (hereinafter referred to as "the Rules"), refer to the ASTM Committee F44 webpage (www.ASTM.org/COMITTEE/F44.htm) which includes CAA website links.

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

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 and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3061/F3061M Specification for Systems and Equipment in Small Aircraft

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

2.2 *Federal Standard:*[3]

14 CFR Part 23 (Amendment 62) Airworthiness Standards: Normal, Utility, Aerobatic, and Commuter Category Aircraft

3. Terminology

3.1 Refer to Terminology F3060 referenced in Section 2.

4. General Requirements

4.1 *General*—Unless otherwise specified in a specific requirement, the airplane shall meet the requirements of 4.2 – 4.9, Sections 5 – 8, 9.1, and 9.2 at all practical loading conditions and operating altitudes for which certification has been requested, not exceeding the maximum operating altitude established in Specification F3174/F3174M, subsection 4.11, and without requiring exceptional piloting skill, alertness, or strength.

4.2 *Control Forces (General):*

4.2.1 The airplane shall be safely controllable and maneuverable during all flight phases including:

4.2.1.1 Takeoff,

4.2.1.2 Climb,

4.2.1.3 Level flight,

4.2.1.4 Descent,

4.2.1.5 Go-around, and

4.2.1.6 Landing (power on and power off) with the wing flaps extended and retracted.

4.2.2 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 airplanes, those conditions normally encountered in the sudden failure of any engine).

4.2.3 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 4.2.1 and 4.2.2 exceed those prescribed in Table 1.

4.3 *Longitudinal Control:*

[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.

Current edition approved Dec. 1, 2015. Published February 2016. DOI: 10.1520/F3173_F3173M-15.

[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 U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

TABLE 1 Control Forces

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 kg [10 lbf]	22 N [5 lbf]	89 N [20 lbf]

4.3.1 *Longitudinal Control*—With the airplane 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:

4.3.1.1 Maximum continuous power on each engine;

4.3.1.2 Power off; and

4.3.1.3 Wing flap and landing gear:

(1) Retracted and

(2) Extended.

4.3.2 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.

4.3.2.1 With the landing gear extended, the flaps retracted, and the airplane 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 off and

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

4.3.2.2 With landing gear and flaps extended, power off, and the airplane 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.

4.3.2.3 With landing gear and flaps extended, in level flight, power necessary to attain level flight at 1.1 V_{S0}, and the airplane 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 not more than maximum continuous power. 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.

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

4.3.2.5 With power off, landing gear and flaps extended, and the airplane 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.

4.3.2.6 With maximum takeoff power, landing gear retracted, flaps in the takeoff position, and the airplane as nearly as possible in trim at VFE appropriate to the takeoff flap position, retract the flaps as rapidly as possible while maintaining constant speed.

4.3.3 At speeds above V_{MO}/M_{MO}, and up to the maximum speed shown under 8.1, a maneuvering capability of 1.5 g shall be demonstrated to provide a margin to recover from upset or inadvertent speed increase.

4.3.4 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 a power-off glide with landing gear and wing flaps extended, for any weight of the airplane, up to and including the maximum weight.

4.3.5 By using normal flight and power controls, except as otherwise noted in 4.3.5.1 and 4.3.5.2, it shall be possible to establish a zero rate of descent at an attitude suitable for a controlled landing without exceeding the operational and structural limitations of the airplane, as follows:

4.3.5.1 For single-engine airplanes with a stall speed in the landing configuration of more than 45 knots and multiengine airplanes, without the use of the primary longitudinal control system; and

4.3.5.2 For multiengine airplanes:

(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.

4.4 *Directional and Lateral Control:*

4.4.1 For each multiengine airplane, 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:

4.4.1.1 Critical engine inoperative and its propeller in the minimum drag position;

4.4.1.2 Remaining engines at maximum continuous power;

4.4.1.3 Landing gear:

(1) Retracted,

(2) Extended, and

4.4.1.4 Flaps retracted.

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

4.4.2.1 Maximum continuous power on each engine,

4.4.2.2 The wing flaps retracted,

4.4.2.3 The landing gear retracted,

4.4.2.4 A speed equal to that at which compliance with 23.69(a) has been shown, and

4.4.2.5 All propeller controls in the position at which compliance with 23.69(a) has been shown.

4.4.3 For airplanes with a stall speed in the landing configuration of more than 45 knots, it shall be shown that the airplane 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 airplane'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 airplane. 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.

4.5 *Minimum Control Speed:*

4.5.1 V_{MC} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and, thereafter, maintain straight flight at the same speed with an angle of bank of not more than 5°. The method used to simulate critical engine failure shall represent the most critical mode of powerplant failure expected in service with respect to controllability.

4.5.2 V_{MC} for takeoff shall not exceed:

4.5.2.1 For multi-engine airplanes with a $V_{S0} \leq 65$ kt and that during the climb demonstration in 23.67(a)(2) cannot climb after a critical loss of thrust, V_{S1}, where V_{S1} is determined for all practical weights and takeoff configurations.

4.5.2.2 For all other multi-engine airplanes, 1.2 V_{S1}, where V_{S1} is determined at the maximum takeoff weight.

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

4.5.3.1 Maximum available takeoff power initially on each engine,

4.5.3.2 The airplane trimmed for takeoff,

4.5.3.3 Flaps in the takeoff position(s),

4.5.3.4 Landing gear retracted, and

4.5.3.5 All propeller controls in the recommended takeoff position throughout.

4.5.4 For all airplanes except low-speed Level 1 and 2 airplanes, the conditions of 4.5.1 shall also be met for the landing configuration with:

4.5.4.1 Maximum available takeoff power initially on each engine;

4.5.4.2 The airplane 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 23.75;

4.5.4.3 Flaps in the landing position;

4.5.4.4 Landing gear extended; and

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

4.5.5 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}).

4.5.6 At V_{MC}, the rudder pedal force required to maintain control shall not exceed 667 N [150 lbf] and it shall not be necessary to reduce power of the operative engine(s). During the maneuver, the airplane shall not assume any dangerous attitude and it shall be possible to prevent a heading change of more than 20°.

4.5.7 At the option of the applicant, to comply with the requirements of 23.51(c)(1), 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, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane using the rudder control alone (without the use of nose wheel steering) as limited by 667 N [150 lbf] of force 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 airplane 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:

4.5.7.1 The airplane in each takeoff configuration or, at the option of the applicant, in the most critical takeoff configuration;

4.5.7.2 Maximum available takeoff power on the operating engines;

4.5.7.3 The most unfavorable center of gravity position;

4.5.7.4 The airplane trimmed for takeoff; and

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

4.6 *Aerobatic Maneuvers*—Each aerobatic airplane shall be able to perform safely the aerobatic maneuvers for which certification is requested. Safe entry speeds for these maneuvers shall be determined.

4.7 *Control during Landings*—It shall be possible, while in the landing configuration, to complete a landing safely without exceeding the one-hand control force limits specified in Table 1 following an approach to land:

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

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

4.7.3 At an approach gradient equal to the steepest used in the landing distance demonstration of; and

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

4.8 *Elevator Control Force in Maneuvers:*

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

4.8.1.1 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

4.8.1.2 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].

4.8.2 The requirement of 4.8.1 shall be met at maximum cruise power and with the wing flaps and landing gear retracted:

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

4.8.2.2 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.

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

4.9 *Rate of Roll:*

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

4.9.1.1 For a Level 1 or 2 airplane, 5 s from initiation of roll and

4.9.1.2 For a Level 3 or 4 airplane, $(W + 200)/590$ but not more than 10 s, where W is the weight in kg [$(W + 500)/1300$, but not more than 10 s, where W = weight in lbs].

4.9.2 The requirement of 4.9.1 shall be met when rolling the airplane in each direction with:

4.9.2.1 Flaps in the takeoff position;

4.9.2.2 Landing gear retracted;

4.9.2.3 For a single-engine airplane, at maximum takeoff power, and a multiengine airplane with the critical engine inoperative and the propeller in the minimum drag position and the other engines at maximum takeoff power; and

4.9.2.4 The airplane trimmed at a speed equal to the greater of 1.2 V_{S1} or 1.1 V_{MC} or as nearly as possible in trim for straight flight.

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

4.9.3.1 For a Level 1 or 2 airplane, 4 s from initiation of roll and

4.9.3.2 For a Level 3 or 4 airplane, $(W + 1300)/1000$, but not more than 7 s, where W is weight in kg [$(W + 2800)/2200$, but not more than 7 s, where W = weight in pounds].

4.9.4 The requirement of 4.9.3 shall be met when rolling the airplane in each direction in the following conditions:

4.9.4.1 Flaps in the landing position(s),

4.9.4.2 Landing gear extended,

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

4.9.4.4 The airplane trimmed at V_{REF}.

5. Trim Requirements

5.1 *General*—Each airplane 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 the automatic pilot. 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 airplane and, if applicable, to those conditions associated with the failure of one engine for which performance characteristics are established.

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

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

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

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

5.3.1 For Level 1 airplanes with $V_{S0} \leq 45$ KCAS:

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

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

5.3.1.3 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.

5.3.2 For Level 1 airplanes with $V_{S0} > 45$ KCAS and all other airplanes, a climb with:

5.3.2.1 Takeoff power, landing gear retracted, wing flaps in the takeoff position(s), at the speeds used in determining the climb performance required by 23.65 and

5.3.2.2 Maximum continuous power at the speeds and in the configuration used in determining the climb performance required by 23.69(a).

5.3.3 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;

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

5.3.5 Approach with landing gear extended and with:

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

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

5.3.5.3 An approach gradient equal to the steepest used in the landing distance demonstrations of 23.75 with flaps in the landing position(s) at V_{REF}.

5.4 In addition, each multiengine airplane 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 23.67(a), (b)(2), or (c)(3), as appropriate, with:

5.4.1 The critical engine inoperative and, if applicable, its propeller in the minimum drag position;

5.4.2 The remaining engines at maximum continuous power;

5.4.3 The landing gear retracted;

5.4.4 Wing flaps retracted; and

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

5.5 In addition, each Level 4 airplane for which, in the determination of the takeoff path in accordance with 23.57, 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:

5.5.1 The critical engine inoperative and its propeller in the minimum drag position,

5.5.2 The remaining engine(s) at takeoff power,

5.5.3 Landing gear retracted,

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

5.5.5 An angle of bank not exceeding 5°.

6. Stability Requirements

6.1 *General*—The airplane shall be longitudinally, directionally, and laterally stable under 6.2 through 6.5. In addition, the airplane 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.

6.2 *Static Longitudinal Stability*—Under the conditions specified in 6.3 and with the airplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system shall be as follows.

6.2.1 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.

6.2.2 The airspeed shall return to within the tolerances specified for applicable airplane levels when the control force is slowly released at any speed within the speed range specified in 6.2.1. The applicable tolerances are:

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

6.2.2.2 For Level 4 airplanes, the airspeed shall return to within ±7.5 % of the original trim airspeed for the cruising condition specified in 6.3.2.

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

6.3 *Demonstration of Static Longitudinal Stability:*

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

6.3.1.1 Flaps retracted,

6.3.1.2 Landing gear retracted,

6.3.1.3 Maximum continuous power, and

6.3.1.4 The airplane trimmed at the speed used in determining the climb performance required by 23.69(a).

6.3.2 *Cruise*—With flaps and landing gear retracted and the airplane 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:

6.3.2.1 For Level 1, 2, and 3 airplanes, 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 airplanes with V_{NE} established under Specification F3174/F3174M, subsection 4.2.1, at speeds greater than V_{NE}; or

(3) For airplanes with V_{MO}/M_{MO} established under Specification F3174/F3174M, subsection 4.2.3, at speeds greater than V_{FC}/M_{FC}.

6.3.2.2 For Level 4 airplanes, 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].

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

6.3.3.1 Flaps in the landing position,

6.3.3.2 Landing gear extended, and

6.3.3.3 The airplane trimmed at:

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

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

6.4 *Static Directional and Lateral Stability:*

6.4.1 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.

6.4.1.1 The angle of sideslip for these tests shall be appropriate to the type of airplane. 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 4.2 is reached, whichever occurs first, and at speeds from 1.2 V_{S1} to V_O.

6.4.2 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 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_{FC}, whichever is appropriate) in the takeoff, climb, cruise, descent, and approach configurations. For the landing configuration, the power shall be that necessary to maintain a 3° angle of descent in coordinated flight.

6.4.2.1 The static lateral stability may not be negative at 1.2 V_{S1} in the takeoff configuration or at 1.3 V_{S1} in other configurations.

6.4.2.2 The angle of sideslip for these tests shall be appropriate to the type of airplane, 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 667 N [150 lb] rudder force, whichever occurs first.

6.4.3 Paragraph 6.4.2 does not apply to aerobatic category airplanes certificated for inverted flight.

6.4.4 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 airplane.

6.4.4.1 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.

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

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

6.4.5.1 The directional stability of the airplane 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.

6.4.5.2 The lateral stability of the airplane 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 airplane 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.

6.5 *Dynamic Stability:*

6.5.1 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 airplane shall be heavily damped with primary controls:

6.5.1.1 Free and

6.5.1.2 In a fixed position.

6.5.2 Any combined lateral-directional oscillations (Dutch roll) occurring between the stalling speed and the maximum allowable speed (V_{FE}, V_{LE}, V_{N0}, V_{FC}/M_{FC}) appropriate to the configuration of the airplane with the primary controls in both free and fixed position shall be damped to 1/10 amplitude in:

6.5.2.1 Seven cycles below 5486 m [18 000 ft] and

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

6.5.3 If it is determined that the function of a stability augmentation system (reference 23.672) is needed to meet the flight characteristic requirements of this part, the primary control requirements of 6.5.1.2 and 6.5.2.2 are not applicable to the tests needed to verify the acceptability of that system.

6.5.4 During the conditions as specified in 4.3, 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 airplane 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 at to increase the pilot's workload or otherwise endanger the airplane.

7. Ground and Water Handling Characteristics

7.1 *Longitudinal Stability and Control:*

7.1.1 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.

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

7.2 *Directional Stability and Control:*

7.2.1 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}.

7.2.2 The airplane shall be satisfactorily controllable in power-off 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.

7.2.3 The airplane shall have adequate directional control during taxiing.

7.2.4 Seaplanes shall demonstrate satisfactory directional stability and control for water operations up to the maximum wind velocity specified in 7.2.1.

7.3 *Operation on Unpaved Surfaces*—The airplane shall be demonstrated to have satisfactory characteristics and the shock-absorbing mechanism shall not damage the structure of the airplane when the airplane 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.

7.4 *Operation on Water:*

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

7.4.2 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.

8. Vibration and Buffeting

8.1 There shall be no vibration or buffeting severe enough to result in structural damage, and each part of the airplane 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 airplane or cause excessive fatigue to the flight crew. Stall warning buffeting within these limits is allowable.

8.2 There shall be no perceptible buffeting condition in the cruise configuration in straight flight at any speed up to V_{MO}/M_{MO}, except stall buffeting, which is allowable.

8.3 For airplanes with M_D greater than M 0.6 or a maximum operating altitude greater than 7620 m [25 000 ft], the positive maneuvering load factors at which the onset of perceptible buffeting occurs shall be determined with the airplane in the cruise configuration for the ranges of airspeed or Mach number, weight, and altitude for which the airplane 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. High Speed Characteristics

9.1 If a maximum operating speed, V_{MO}/M_{MO}, is established under Specification F3174/F3174M, subsection 4.2.3, the following speed increase and recovery characteristics shall be met:

9.1.1 Operating conditions and characteristics likely to cause inadvertent speed increases (including upsets in pitch and roll) shall be simulated with the airplane trimmed at any likely speed up to V_{MO}/M_{MO}. These conditions and characteristics include gust upsets, inadvertent control movements, low stick force gradients in relation to control friction, passenger movement, leveling off from climb, and descent from Mach to airspeed limit altitude.

9.1.2 Allowing for pilot reaction time after occurrence of the effective inherent or artificial speed warning specified in Specification F3061/F3061M, it shall be shown that the airplane can be recovered to a normal attitude and its speed reduced to V_{MO}/M_{MO}, without:

9.1.2.1 Exceptional piloting strength or skill;

9.1.2.2 Exceeding V_D/M_D, or V_{DF}/M_{DF} for turbojets, the maximum speed shown under Section 8, or the structural limitations; and

9.1.2.3 Buffeting that would impair the pilot's ability to read the instruments or to control the airplane for recovery.

9.1.3 There may be no control reversal about any axis at any speed up to the maximum speed shown in Section 8. Any reversal of elevator control force or tendency of the airplane to pitch, roll, or yaw shall be mild and readily controllable using normal piloting techniques.

9.2 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.

9.3 *Out-of-Trim Characteristics*—For airplanes with an M_D greater than M 0.6 and that incorporate a horizontal stabilizer that can be trimmed, the following requirements for out-of-trim characteristics apply:

9.3.1 From an initial condition with the airplane trimmed at cruise speeds up to V_{MO}/M_{MO}, the airplane shall have satisfactory maneuvering stability and controllability with the degree of out of trim in both the airplane nose-up and nose-down directions, which results from the greater of the following:

9.3.1.1 A 3 s movement of the longitudinal trim system at its normal rate for the particular flight condition with no aerodynamic load (or an equivalent degree of trim for airplanes that do not have a power-operated trim system), except as limited by stops in the trim system, including those required by 23.655(b) for adjustable stabilizers.

9.3.1.2 The maximum mis-trim that can be sustained by the autopilot while maintaining level flight in the high-speed cruising condition.

9.3.2 In the out-of-trim condition specified in 9.3.1, when the normal acceleration is varied from +l g to the positive and negative values specified in 9.3.3, the following apply:

9.3.2.1 The stick force versus g curve shall have a positive slope at any speed up to and including V_{FC}/M_{FC} and

9.3.3 At speeds between V_{FC}/M_{FC} and V_{DF}/M_{DF}, the direction of the primary longitudinal control force may not reverse.

9.3.3.1 Except as provided in 9.3.4 and 9.3.5, compliance with the provisions of 9.3.1 shall be demonstrated in flight over the acceleration range as follows:

9.3.3.2 –1 to +2.5 g or

9.3.3.3 0 to 2.0 g and extrapolating by an acceptable method to –1 and +2.5 g.

9.3.4 If the procedure set forth in 9.3.3.2 is used to demonstrate compliance and marginal conditions existing during flight test with regard to reversal of primary longitudinal control force, flight tests shall be accomplished from the normal acceleration at which a marginal condition is found to exist to the applicable limit specified in 9.3.2.1.

9.3.5 During flight tests required by 9.3.1, the limit maneuvering load factors, prescribed in 23.333(b) and 23.337, need not be exceeded. In addition, the entry speeds for flight test demonstrations at normal acceleration values less than 1 g shall be limited to the extent necessary to accomplish a recovery without exceeding V_{DF}/M_{DF}.

9.3.6 In the out-of-trim condition specified in 9.3.1, it shall be possible from an overspeed condition at V_{DF}/M_{DF} to produce at least 1.5 g for recovery by applying not more than 556 N [125 lbf] of longitudinal control force using either the primary longitudinal control alone or the primary longitudinal control and the longitudinal trim system. If the longitudinal trim is used to assist in producing the required load factor, it shall be shown at V_{DF}/M_{DF} that the longitudinal trim can be actuated in the airplane nose-up direction with the primary surface loaded to correspond to the least of the following airplane nose-up control forces:

9.3.6.1 The maximum control forces expected in service as specified in 23.301 and 23.397, 9.3.6.2 The control force required to produce 1.5 g, and

9.3.6.3 The control force corresponding to buffeting or other phenomena of such intensity that it is a strong deterrent to further application of primary longitudinal control force.

10. Keywords

10.1 airworthiness; flight; general aviation