Standard Specification for Performance of Aeroplanes[1]

This standard is issued under the fixed designation F3179/F3179M; 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 aeroplane performance.

1.2 This specification is applicable to small aeroplanes as defined in Terminology F3060.

1.3 The applicant for a design approval shall seek the individual guidance to 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/COMMITTEE/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 limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3173 Specification for Handling Characteristics of Aeroplanes

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

3. Terminology

3.1 Refer to Terminology F3060.

4. Performance Requirements

4.1 *General:*

4.1.1 Unless otherwise prescribed, the performance requirements of this specification shall be met for:

4.1.1.1 Still air and standard atmosphere.

4.1.1.2 Ambient atmospheric conditions for high-speed Level 1 and 2 aeroplanes and all Level 3 and 4 aeroplanes.

4.1.2 Performance data shall be determined over not less than the following conditions for all aeroplanes except for aeroplanes with $V_{S0} \leq 45$ KCAS:

(1) Airport altitude from sea level to 3084 m [10 000 ft];

(2) The temperature from standard to 30°C [86°F] above standard or the maximum ambient atmospheric temperature at which compliance with the cooling provisions of is shown, if lower;

(3) With any means for controlling the engine cooling air supply in the position used in the engine cooling tests;

(4) The available propulsive thrust shall correspond to engine power, not exceeding the approved power, less:

(a) Installation losses.

(b) The power absorbed by the accessories and services appropriate to the particular ambient atmospheric conditions and the particular flight condition.

4.1.2.1 The performance, as affected by engine power or thrust, shall be based on a relative humidity:

(1) Of 80 % at and below standard temperature.

(2) From 80 % at the standard temperature, varying linearly down to 34 % at the standard temperature plus 28°C [plus 50°F].

4.1.3 Unless otherwise prescribed in determining the takeoff and landing distances, changes in the aeroplane's configuration, speed, and power shall be made in accordance with procedures established by the applicant for operation in service. These procedures shall be able to be executed consistently by pilots of average skill in atmospheric conditions reasonably expected to be encountered in service.

4.1.4 Takeoff and landing distances shall be determined on a smooth, dry, hard-surfaced runway.

NOTE 1—The effect on these distances of operation on other types of surfaces (for example, grass and gravel) when dry, may be determined or derived, and these surfaces listed in the aeroplane flight manual in

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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.

accordance with Specification F3174/F3174M.

4.1.5 For high-speed Level 3 aeroplanes and all Level 4 aeroplanes, the following also apply:

4.1.5.1 Unless otherwise prescribed, the applicant shall select the takeoff, en route, approach, and landing configurations for the aeroplane;

4.1.5.2 The aeroplane configuration may vary with weight, altitude, and temperature to the extent they are compatible with the operating procedures required by 4.1.5.3;

4.1.5.3 Unless otherwise prescribed, in determining the critical engine-inoperative takeoff performance, takeoff flight path, the accelerate-stop distance, changes in the aeroplane's configuration, speed, and power shall be made in accordance with procedures established by the applicant for operation in service;

4.1.5.4 Procedures for the execution of discontinued approaches and balked landings associated with the conditions prescribed in 4.12.3.4 and 4.17.3 shall be established; and

4.1.5.5 The procedures established under 4.1.5.3 and 4.1.5.4 shall:

(1) Be able to be consistently executed by a crew of average skill in atmospheric conditions reasonably expected to be encountered in service,

(2) Use methods or devices that are safe and reliable, and

(3) Include allowance for any reasonably expected time delays in the execution of the procedures.

4.2 *Stalling Speed:*

4.2.1 V_{S0} and V_{S1} are the stalling speeds or the minimum steady flight speeds in knots (KCAS) at which the aeroplane is controllable with:

4.2.1.1 The propulsive thrust not greater than zero at the stalling speed, or, if the resultant thrust has no appreciable effect on the stalling speed, with engine(s) at minimum flight thrust and throttle(s) closed with:

(1) The propeller(s) in the takeoff position;

(2) The aeroplane in the configuration existing in the test, in which V_{S0} and V_{S1} are being used;

(3) The center of gravity in the position that results in the highest value of V_{S0} and V_{S1}; and

(4) The weight used when V_{S0} or V_{S1} are being used as a factor to determine compliance with a required performance standard.

4.2.2 V_{S0} and V_{S1} shall be determined by flight tests using the procedure and meeting the flight characteristics specified in the appropriate stall handling characteristics testing.

4.3 *Takeoff Speeds:*

4.3.1 The rotation speed, V_R, is the speed at which the pilot makes a control input with the intention of lifting the aeroplane out of contact with the runway or water surface.

4.3.1.1 For low-speed Levels 1, 2, and 3 multiengine landplanes, V_R shall not be less than the greater of 1.05 V_{MC} or 1.10 V_{S1}.

4.3.1.2 For single-engine landplanes, V_R shall not be less than V_{S1}.

4.3.1.3 For seaplanes and amphibians taking off from water, V_R may be any speed that is shown to be safe under all reasonably expected conditions, including turbulence and complete failure of the critical engine.

4.3.2 The speed at 15 m [50 ft] above the takeoff surface level shall not be less than:

4.3.2.1 For low-speed Level 1 aeroplanes with $V_{S0} \leq 45$ knots, not less than 1.3 V_{S1};

4.3.2.2 For low-speed Levels 1, 2, and 3 multiengine aeroplanes, the highest of:

(1) A speed that is shown to be safe for continued flight (or emergency landing, if applicable) under all reasonable expected conditions, including turbulence and complete failure of the critical engine;

(2) 1.10 V_{MC}; or

(3) 1.20 V_{S1}.

4.3.2.3 For Level 1 with a $V_{S0} > 45$ knots and all Levels 2 and 3 single-engine aeroplanes, the higher of:

(1) A speed that is shown to be safe under all reasonably expected conditions, including turbulence and complete engine failure, or

(2) 1.20 V_{S1}.

4.3.3 For high-speed multiengine aeroplanes and all Level 4 aeroplanes, the following apply:

4.3.3.1 The value, V_1, shall be established in relation to V_{EF} as follows:

(1) The value, V_{EF}, is the calibrated airspeed at which the critical engine is assumed to fail. The value, V_{EF}, shall be selected by the applicant but shall not be less than 1.05 V_{MC} determined under Specification F3173 or, at the option of the applicant, not less than V_{MCG} determined under Specification F3173.

(2) The takeoff decision speed, V_1, is the calibrated airspeed on the ground at which, as a result of engine failure or other reasons, the pilot is assumed to have made a decision to continue or discontinue the takeoff. The takeoff decision speed, V_1, shall be selected by the applicant but shall not be less than V_{EF} plus the speed gained with the critical engine inoperative during the time interval between the instant at which the critical engine is failed and the instant at which the pilot recognizes and reacts to the engine failure, as indicated by the pilot's application of the first retarding means during the accelerate-stop determination of 4.5.

4.3.3.2 The rotation speed, V_R, in terms of calibrated airspeed, shall be selected by the applicant and shall not be less than the greatest of the following:

(1) V_1;

(2) 1.05 V_{MC} determined under Specification F3173;

(3) 1.10 V_{S1}; or

(4) The speed that allows attaining the initial climb-out speed, V_2, before reaching a height of 11 m [35 ft] above the takeoff surface in accordance with 4.6.

4.3.3.3 For any given set of conditions, such as weight, altitude, temperature, and configuration, a single value of V_R shall be used to show compliance with both the one-engine-inoperative takeoff and all-engines-operating takeoff requirements.

4.3.3.4 The takeoff safety speed, V_2, in terms of calibrated airspeed, shall be selected by the applicant so as to allow the gradient of climb required in 4.12 but shall not be less than 1.10 V_{MC} or less than 1.20 V_{S1}.

4.3.3.5 The one-engine-inoperative takeoff distance, using a normal rotation rate at a speed 5 knots less than V_R, established in accordance with 4.3.3.2, shall be shown not to exceed the corresponding one-engine-inoperative takeoff distance, determined in accordance with 4.12 and 4.7, using the established V_R. The takeoff, otherwise performed in accordance with 4.6, shall be continued safely from the point at which the aeroplane is 11 m [35 ft] above the takeoff surface and at a speed not less than the established V_2 minus 5 knots.

4.3.3.6 The applicant shall show, with all engines operating, that marked increases in the scheduled takeoff distances, determined in accordance with 4.7, do not result from over-rotation of the aeroplane or out-of-trim conditions.

4.4 *Takeoff Performance:*

4.4.1 For low-speed Level 1 aeroplanes with $V_{S0} \leq 45$ knots, the distance required to takeoff from a dry, level, hard surface and climb over a 15 m [50 ft] obstacle shall not exceed 500 m [1640 ft] for still air and a standard atmosphere using speeds determined in accordance with 4.3.1 and 4.3.2 at sea level with:

4.4.1.1 The engine(s) operating within approved operating limitations, and

4.4.1.2 The cowl flaps in the normal takeoff position.

4.4.2 For low-speed Level 1 aeroplanes with $V_{S0} > 45$ kt and low-speed Levels 2 and 3 aeroplanes, the distance shall be determined that is required to takeoff and climb to a height of 15 m [50 ft] above the takeoff surface for each weight, altitude, and temperature within the operational limits established for takeoff using speeds determined in accordance with 4.3.1 and 4.3.2 with:

(1) Takeoff power on each engine,

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

(3) Landing gear extended.

4.4.3 For high-speed aeroplanes and all Level 4 aeroplanes, takeoff performance, as required by 4.5 through 4.7, shall be determined with the operating engine(s) within approved operating limitations.

4.5 *Accelerate-Stop Distance*—For high-speed multiengine aeroplanes and all Level 4 aeroplanes, the accelerate-stop distance shall be determined as follows:

4.5.1 The accelerate-stop distance is the sum of the distances necessary to:

4.5.1.1 Accelerate the aeroplane from a standing start to V_{EF} with all engines operating;

4.5.1.2 Accelerate the aeroplane from V_{EF} to V_1, assuming the critical engine fails at V_{EF};

4.5.1.3 Come to a full stop from the point at which V_1 is reached.

4.5.2 Means other than wheel brakes may be used to determine the accelerate-stop distances if that means it is:

4.5.2.1 Safe and reliable,

4.5.2.2 Used so that consistent results can be expected under normal operating conditions,

4.5.2.3 Such that exceptional skill is not required to control the aeroplane.

4.6 *Takeoff Path*—For high-speed multiengine aeroplanes and all Level 4 aeroplanes, the takeoff path is as follows:

4.6.1 The takeoff path extends from a standing start to a point in the takeoff at which the aeroplane is 457 m [1500 ft] above the takeoff surface at or below which height the transition from the takeoff to the en-route configuration shall be completed.

4.6.1.1 The takeoff path shall be based on the procedures prescribed in 4.1;

4.6.1.2 The aeroplane shall be accelerated on the ground to V_{EF} at which point the critical engine shall be made inoperative and remain inoperative for the rest of the takeoff;

4.6.1.3 After reaching V_{EF}, the aeroplane shall be accelerated to V_2.

4.6.2 During the acceleration to speed, V_2, the nose gear may be raised off the ground at a speed not less than V_R. However, landing gear retraction shall not be initiated until the aeroplane is airborne.

4.6.3 During the takeoff path determination, in accordance with 4.6.1 and 4.6.2:

4.6.3.1 The slope of the airborne part of the takeoff path shall not be negative at any point;

4.6.3.2 The aeroplane shall reach V_2 before it is 11 m [35 ft] above the takeoff surface and shall continue at a speed as close as practical to, but not less than V_2, until it is 122 m [400 ft] above the takeoff surface;

4.6.3.3 At each point along the takeoff path, starting at the point at which the aeroplane reaches 122 m [400 ft] above the takeoff surface, the available gradient of climb must not be less than 1.2 %;

4.6.3.4 Except for gear retraction and automatic propeller feathering, the aeroplane configuration shall not be changed, and no change in power that requires action by the pilot may be made, until the aeroplane is 122 m [400 ft] above the takeoff surface.

4.6.4 The takeoff path to 11 m [35 ft] above the takeoff surface shall be determined by a continuous demonstrated takeoff.

4.6.5 The takeoff path from 11 m [35 ft] above the takeoff surface shall be determined by synthesis from segments.

4.6.5.1 The segments shall be clearly defined and related to distinct changes in configuration, power, and speed;

4.6.5.2 The weight of the aeroplane, the configuration, and the power shall be assumed constant throughout each segment and shall correspond to the most critical condition prevailing in the segment; and

4.6.5.3 The takeoff flight path shall be based on the aeroplane's performance without using ground effect.

4.7 *Takeoff Distance and Takeoff Run*—For high-speed multi-engine aeroplanes and all Level 4 aeroplanes, the takeoff distance and, at the option of the applicant, the takeoff run, shall be determined.

4.7.1 Takeoff distance is the greater of:

4.7.1.1 The horizontal distance along the takeoff path from the start of the takeoff to the point at which the aeroplane is 11 m [35 ft] above the takeoff surface as determined under 4.6, or

4.7.1.2 With all engines operating, 115 % of the horizontal distance from the start of the takeoff to the point at which the aeroplane is 11 m [35 ft] above the takeoff surface determined by a procedure consistent with 4.6.

4.7.2 The takeoff run is the greater of:

4.7.2.1 The horizontal distance along the takeoff path from the start of the takeoff to a point equidistant between the liftoff point and the point at which the aeroplane is 11 m [35 ft] above the takeoff surface as determined under 4.6, or

4.7.2.2 With all engines operating, 115 % of the horizontal distance from the start of the takeoff to a point equidistant between the liftoff point and the point at which the aeroplane is 11 m [35 ft] above the takeoff surface determined by a procedure consistent with 4.6.

4.8 *Takeoff Flight Path*—For high-speed multiengine and all Level 4 aeroplanes, the takeoff flight path shall be determined as follows:

4.8.1 The takeoff flight path begins 11 m [35 ft] above the takeoff surface at the end of the takeoff distance determined in accordance with 4.7.

4.8.2 The net takeoff flight path data shall be determined so that they represent the actual takeoff flight paths as determined in accordance with 4.6 and with 4.8.1 reduced at each point by a gradient of climb equal to 0.8 %.

4.8.3 The prescribed reduction in climb gradient may be applied as an equivalent reduction in acceleration along that part of the takeoff flight path at which the aeroplane is accelerated in level flight.

4.9 *Climb—General:*

4.9.1 Compliance with the climb requirements (4.10 – 4.13 and 4.17) shall be shown:

(1) Out-of-ground effect;

(2) At speeds that are not less than those at which compliance with the powerplant cooling requirements has been demonstrated.

(3) Unless otherwise specified, with critical power unit failure at a bank angle not exceeding 5°.

4.10 *Climb—All Engines Operating:*

4.10.1 Low-speed Level 1 aeroplanes with a $V_{S0} \leq 45$ knots shall meet a climb gradient of at least 6.5 % at sea level with:

(1) Not more than takeoff power;

(2) Landing gear retracted;

(3) Wing flaps in the takeoff position; and

(4) Cowl flaps in the position used in the cooling tests.

4.10.2 Low-speed Level 1 aeroplanes with a $V_{S0} > 45$ knots and low-speed Level 2 aeroplanes shall meet a climb gradient of at least 6.5 % at sea level with:

(1) Not more than maximum continuous power on each engine,

(2) The landing gear retracted,

(3) The wing flaps in the takeoff position(s), and

(4) A climb speed not less than the greater of 1.1 V_{MC} and 1.2 V_{S1} for multiengine aeroplanes and not less than 1.2 V_{S1} for single-engine aeroplanes.

4.10.3 High-speed Level 1, 2, and all Level 3 and 4 aeroplanes shall have a steady gradient of climb after takeoff of at least 4 % with:

(1) Takeoff power on each engine;

(2) The landing gear extended, except that if the landing gear can be retracted in not more than 7 s, the test may be conducted with the gear retracted;

(3) The wing flaps in the takeoff position(s); and

(4) A climb speed as specified in 4.10.2.

4.11 *Takeoff Climb—Partial Loss of Thrust*—For high-speed multiengine aeroplanes, the steady gradient of climb or descent shall be determined at each weight, altitude, and ambient temperature within the operational limits established by the applicant with:

(1) The loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed;

(2) The remaining engine(s) at takeoff power;

(3) The landing gear extended, except that if the landing gear can be retracted in not more than 7 s, the test may be conducted with the gear retracted;

(4) The wing flaps in the takeoff position(s);

(5) The wings level; and

(6) A climb speed equal to that achieved at 15 m [50 ft] in the demonstration of 4.4.

4.12 *Climb after Partial Loss of Thrust:*

4.12.1 For low-speed Levels 1 and 2 multiengine aeroplanes, the following apply:

4.12.1.1 Aeroplanes with a $V_{S0} > 61$ knots shall be able to maintain a steady climb gradient of at least 1.5 % at a pressure altitude of 1524 m [5000 ft] with the:

(1) Loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed, if applicable;

(2) Remaining engine(s) at not more than maximum continuous power;

(3) Landing gear retracted;

(4) Wing flaps retracted; and

(5) Climb speed not less than 1.2 V_{S1}.

4.12.1.2 For aeroplanes with $V_{S0} \leq 61$ knots the steady gradient of climb or descent at a pressure altitude of 1524 m [5000 ft] shall be determined with the:

(1) Loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed, if applicable;

(2) Remaining engine(s) at not more than maximum continuous power;

(3) Landing gear retracted;

(4) Wing flaps retracted; and

(5) Climb speed not less than 1.2 V_{S1}.

4.12.2 For high-speed Levels 1 and 2 aeroplanes and low-speed Level 3 multiengine aeroplanes:

4.12.2.1 The steady gradient of climb at an altitude of 122 m [400 ft] above the takeoff shall be no less than 1 % with the:

(1) Loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed, if applicable;

(2) Remaining engine(s) at takeoff power;

(3) Landing gear retracted;

(4) Wing flaps in the takeoff position(s); and

(5) Climb speed equal to that achieved at 15 m [50 ft] in the demonstration of 4.4.

4.12.2.2 The steady gradient of climb shall not be less than 0.75 % at an altitude of 457 m [1500 ft] above the takeoff surface or landing surface, as appropriate, with the:

(1) Loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed, if applicable;

(2) Remaining engine(s) at not more than maximum continuous power;

(3) Landing gear retracted;

(4) Wing flaps retracted; and

(5) Climb speed not less than 1.2 V_{S1}.

4.12.3 For high-speed Level 3 multiengine aeroplanes and all Level 4 aeroplanes, the following apply:

4.12.3.1 *Takeoff—Landing Gear Extended*—The steady gradient of climb at the altitude of the takeoff surface shall be no less than 1 % with:

(1) The loss of the critical engine (or motor(s)) including any propulsive drag changes that are rapidly and automatically assumed, if applicable;

(2) The remaining engine(s) at takeoff power;

(3) The landing gear extended and all landing gear doors open;

(4) The wing flaps in the takeoff position(s);

(5) The wings level; and

(6) A climb speed equal to V_2.

4.12.3.2 *Takeoff—Landing Gear Retracted*—The steady gradient of climb at an altitude of 122 m [400 ft] above the takeoff surface shall not be less than 2.0 % with:

(1) The loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed, if applicable;

(2) The remaining engine(s) at takeoff power;

(3) The landing gear retracted;

(4) The wing flaps in the takeoff position(s); and

(5) A climb speed equal to V_2.

4.12.3.3 *En Route*—The steady gradient of climb at an altitude of 457 m [1500 ft] above the takeoff or landing surface, as appropriate, shall be not less than 1.2 % with:

(1) The loss of the critical engine (or motor(s)) including any propulsive drag changes that are rapidly and automatically assumed, if applicable;

(2) The remaining engine(s) at not more than maximum continuous power;

(3) The landing gear retracted;

(4) The wing flaps retracted; and

(5) A climb speed not less than 1.2 V_{S1}.

4.12.3.4 *Discontinued Approach*—The steady gradient of climb at an altitude of 122 m [400 ft] above the landing surface shall be no less than 2.1 % with:

(1) The loss of the critical engine (or motor(s)) including any propulsive drag changes that are rapidly and automatically assumed, if applicable;

(2) The remaining engine(s) at takeoff power;

(3) Landing gear retracted;

(4) Wing flaps in the approach position(s) in which V_{S1} for these position(s) does not exceed 110 % of the V_{S1} for the related all-engines-operating landing position(s); and

(5) A climb speed established in connection with normal landing procedures but not exceeding 1.5 V_{S1}.

4.13 *En Route Climb/Descent:*

4.13.1 *All Engines Operating*—The steady gradient and rate of climb shall be determined at each weight, altitude, and ambient temperature within the operational limits established by the applicant with:

(1) Not more than maximum continuous power on each engine,

(2) The landing gear retracted,

(3) The wing flaps retracted, and

(4) A climb speed not less than 1.3 V_{S1}.

4.13.2 *One Engine Inoperative*—The steady gradient and rate of climb/descent shall be determined at each weight, altitude, and ambient temperature within the operational limits established by the applicant with:

(1) The loss of the critical engine (or motor(s)) including any drag changes that are rapidly and automatically assumed,

(2) The remaining engine(s) at no more than maximum continuous power,

(3) The landing gear retracted,

(4) The wing flaps retracted, and

(5) A climb speed not less than 1.2 V_{S1}.

4.14 *Glide—Single Engine Aeroplanes*—The maximum horizontal distance travelled in still air, in kilometres per 1000 m [nautical miles per 1000 ft] of altitude lost in a glide, and the speed necessary to achieve this shall be determined with the engine(s) inoperative and the engine(s) and aeroplane in the best glide configuration.

4.15 *Reference Landing Approach Speed:*

4.15.1 For low-speed Levels 1 and 2 aeroplanes, the reference landing approach speed, V_{REF}, may not be less than the greater of V_{MC} with the wing flaps in the most extended takeoff position and 1.3 V_{S1}.

4.15.2 For high-speed Levels 1 and 2 aeroplanes and low-speed Level 3 aeroplanes, the reference landing approach speed, V_{REF}, may not be less than the greater of V_{MC}, and 1.3 V_{S1}.

4.15.3 For high-speed Level 3 aeroplanes and all Level 4 aeroplanes, the reference landing approach speed, V_{REF}, may not be less than the greater of 1.05 V_{MC}, and 1.3 V_{S1}.

4.16 *Landing Distance*—The horizontal distance necessary to land and come to a complete stop (or to a speed of approximately 5.6 km/h [3 knots] for water landings of seaplanes and amphibians) from a point 15 m [50 ft] above the landing surface shall be determined, for standard temperatures at each weight and altitude within the operational limits established for landing, as follows:

4.16.1 A steady approach at not less than V_{REF}, determined in accordance with 4.15.1 – 4.15.3, as appropriate, shall be maintained down to the 15 m [50 ft] height:

4.16.1.1 The steady approach shall be at a gradient of descent not greater than 5.2 % (3°) down to the 15 m [50 ft] height;

4.16.1.2 In addition, an applicant may demonstrate by tests that a maximum steady approach gradient steeper than 5.2 % (3°), down to the 15 m [50 ft] height, is safe. The gradient shall be established as an operating limitation and the information necessary to display the gradient shall be available to the pilot by an appropriate instrument.

4.16.2 A constant configuration shall be maintained throughout the maneuver.

4.16.3 The landing shall be made without excessive vertical acceleration or tendency to bounce, nose over, ground loop, porpoise, or water loop.

4.16.4 It shall be shown that a safe transition to the balked landing conditions of 4.17 can be made from the conditions that exist at the 15 m [50 ft] height, maximum landing weight, or maximum landing weight for altitude and temperature of 4.9.1, as appropriate.

4.16.5 The brakes shall be used so as to not cause excessive wear of brakes or tires.

4.16.6 Retardation means other than wheel brakes may be used if that means:

(1) Is safe and reliable, and

(2) Is used so that consistent results can be expected in service.

4.16.7 If any device is used that depends on the operation of any engine, and the landing distance would be increased when a landing is made with that engine inoperative, the landing distance shall be determined with that engine inoperative unless the use of other compensating means will result in a landing distance not more than that with each engine operating.

4.17 *Balked Landing:*

4.17.1 Low-speed Level 1 and 2 aeroplanes with $V_{S0} \leq 45$ knots shall be able to maintain:

4.17.1.1 Either a steady climb gradient at sea level of at least 3.3 % width:

(1) Takeoff power;

(2) Landing gear extended;

(3) Wing flaps in the landing position, except that if the flaps may be safely retracted in 2 s or less, without the loss of altitude and without sudden changes of angle of attack or exceptional piloting skill, they may be retracted, or

4.17.1.2 Level flight at an altitude of 915 m [3000 ft] and at a speed at which the balked landing transition has been shown to be safe with:

(1) Takeoff power;

(2) Landing gear extended; and

(3) Wing flaps in the landing position, except that if the flaps may be safely retracted in 2 s or less, without the loss of altitude and without sudden changes of angle of attack or exceptional piloting skill, they may be retracted.

4.17.2 Low-speed Level 1 and 2 aeroplanes shall be able to maintain a steady gradient of climb at sea level of at least 3.3 % with:

(1) Not more than the power that is available on each engine 8 s after initiation of movement of the power controls from the minimum flight idle position;

(2) Landing gear extended;

(3) Wing flaps in the landing position, except that if the flaps may safely be retracted in 2 s or less without loss of altitude and without sudden changes of angle of attack, they may be retracted;

(4) Climb speed equal to V_{REF} appropriate for the configuration.

4.17.3 High-speed Levels 1 and 2 aeroplanes and low-speed Level 3 aeroplanes shall be able to maintain a steady gradient of climb of at least 2.5 % with:

(1) Not more than the power that is available on each engine 8 s after initiation of movement of the power controls from the minimum flight idle position,

(2) The landing gear extended,

(3) The wing flaps in the landing position, and

(4) A climb speed equal to V_{REF} appropriate for the configuration.

4.17.4 High-speed Level 3 aeroplanes and all Level 4 aeroplanes shall be able to maintain a steady gradient of climb of at least 3.2 % with:

(1) Not more than the power that is available on each engine 8 s after initiation of movement of the power controls from minimum flight idle position,

(2) Landing gear extended,

(3) Wing flaps in the landing position, and

(4) A climb speed equal to V_{REF} appropriate for the configuration.

5. Keywords

5.1 aeroplane; aeroplane performance; airworthiness