(1) Controllability must be demonstrated with the most critical of the ice accretion(s) for the particular phase of flight as defined in Appendices C and O, as applicable, in accordance with CS 25.21(g).

(2) It must be shown that a push force is required throughout a pushover manoeuvre down to a zero g load factor, or the lowest load factor obtainable if limited by elevator power or other design characteristic of the flight control system. It must be possible to promptly recover from the manoeuvre without exceeding a pull control force of 222 N. (50 lbf); and

(3) Any changes in force that the pilot must apply to the pitch control to maintain speed with increasing sideslip angle must be steadily increasing with no force reversals, unless the change in control force is gradual and easily controllable by the pilot without using exceptional piloting skill, alertness, or strength.

(j) For flight in icing conditions before the ice protection system has been activated and is performing its intended function, it must be demonstrated in flight with the most critical of the ice accretion(s) defined in appendix C, part II(e), and Appendix O, part II(d), as applicable, in accordance with CS 25.21(g), that:

(1) The aeroplane is controllable in a pull-up manoeuvre up to 1.5 g load factor; and

(2) There is no pitch control force reversal during a pushover manoeuvre down to 0.5 g load factor.

(k) Side stick controllers

In lieu of the maximum control forces provided in CS 25.143(d) for pitch and roll, and in lieu of specific pitch force requirements of CS 25.145(b) and CS 25.175(d), it must be shown that the temporary and maximum prolonged force levels for side stick controllers are suitable for all expected operating conditions and configurations, whether normal or non-normal.

It must be shown by flight tests that turbulence does not produce unsuitable pilot-in-the-loop control problems when considering precision path control/tasks.

(l) Electronic flight control systems

For electronic flight control systems (EFCS) which embody a normal load factor limiting system and in the absence of aerodynamic limitation (lift capability at maximum angle of attack),

(1) The positive limiting load factor must not be less than:

(i) 2.5 g with the EFCS functioning in its normal mode and with the high-lift devices retracted up to V_{MO}/M_{MO}. The positive limiting load factor may be gradually reduced down to 2.25 g above V_{MO}/M_{MO}.;

(ii) 2.0 g with the EFCS functioning in its normal mode and with the high-lift devices extended.

(2) The negative limiting load factor must be equal to or more negative than:

(i) -1.0 g with the EFCS functioning in its normal mode and with the high-lift devices retracted;

(ii) 0 g with the EFCS functioning in its normal mode and with the high-lift devices extended.

(3) The maximum reachable positive load factor wings level may be limited by flight control system characteristics or flight envelope protections (other than load factor limitation), provided that:

(i) the required values are readily achievable in turn, and

(ii) wings level pitch up responsiveness is satisfactory.

(4) The maximum reachable negative load factor may be limited by flight control system characteristics or flight envelope protections (other than load factor limitation), provided that:

(i) pitch down responsiveness is satisfactory, and

(ii) from level flight, 0 g is readily achievable, or, at least, a trajectory change of 5 degrees per second is readily achievable at operational speeds (from V_{LS} to Max speed – 10 kt. V_{LS} is the lowest speed that the crew may fly with auto thrust or auto pilot engaged. Max speed – 10 kt) is intended to cover typical margin from V_{MO}/M_{MO} to cruise speeds and typical margin from V_{FE} to standard speed in high-lift configurations.

(5) Compliance demonstrations with the above requirements may be performed without ice accretion on the airframe.

[Amdt 25/3]
[Amdt 25/7]
[Amdt 25/13]
[Amdt 25/15]
[Amdt 25/16]
[Amdt 25/18]
[Amdt 25/21]
[Amdt 25/26]

AMC 25.143(a) and (b) Controllability and Manoeuvrability

ED Decision 2003/2/RM

In showing compliance with the requirements of CS 25.143(a) and (b) account should be taken of aeroelastic effects and structural dynamics (including aeroplane response to rough runways and water waves) which may influence the aeroplane handling qualities in flight and on the surface. The oscillation characteristics of the flightdeck, in likely atmospheric conditions, should be such that there is no reduction in ability to control and manoeuvre the aeroplane safely.

AMC 25.143(b)(1) Control Following Engine Failure

ED Decision 2003/2/RM

1 An acceptable means of showing compliance with CS 25.143(b)(1) is to demonstrate that it is possible to regain full control of the aeroplane without attaining a dangerous flight condition in the event of a sudden and complete failure of the critical engine in the following conditions:

a. At each take-off flap setting at the lowest speed recommended for initial steady climb with all engines operating after take-off, with –

i. All engines, prior to the critical engine becoming inoperative, at maximum take-off power or thrust;

ii. All propeller controls in the take-off position;

iii. The landing gear retracted;

iv. The aeroplane in trim in the prescribed initial conditions; and

b. With wing-flaps retracted at a speed of 1.23 V_{SR1} with –

i. All engines, prior to the critical engine becoming inoperative, at maximum continuous power or thrust;

ii. All propeller controls in the en-route position;

iii. The landing gear retracted;

iv. The aeroplane in trim in the prescribed initial conditions.

2 The demonstrations should be made with simulated engine failure occurring during straight flight with wings level. In order to allow for likely delay in the initiation of recovery action, no action to recover the aeroplane should be taken for 2 seconds following engine failure. The recovery action should not necessitate movement of the engine, propeller or trimming controls, nor require excessive control forces. The aeroplane will be considered to have reached an unacceptable attitude if a bank angle of 45° is exceeded during recovery.

AMC 25.143(b)(4) Go-around Manoeuvres

ED Decision 2020/024/R

1. Background

When full thrust or power is applied during a go-around, an excessive level of performance (rate of climb, accelerations) may be reached very quickly, and make it difficult for the flight crew to undertake all the actions required during a go-around, especially in an environment that is constrained (due to Air Traffic Control instructions, operational procedures, etc) and rapidly changing.

This level of performance can also generate acceleration levels (in particular, forward linear accelerations) that could lead to spatial disorientation of the flight crew (e.g. a somatogravic illusion), in particular when combined with reduced visibility conditions and a lack of monitoring of primary flight parameters, such as pitch attitude.

Accidents and incidents have occurred during or after go-arounds where somatogravic illusions have led flight crews to make inappropriate nose-down inputs, leading to an aircraft upset, a loss of control or a deviation from the normal go-around flight path, and in some cases, controlled flight into terrain with catastrophic consequences.

Other accidents resulting in loss of control were due to excessive pitch attitudes combined with the flight crew’s inadequate awareness of the situation.

The risk is higher on aeroplanes that have a large operational range of thrust to weight ratios, in particular for twin-engine aeroplanes and those with long-range capabilities.

2. Criteria for assessing the go-around manoeuvre risk with respect to somatogravic illusions and the flight crew workload

2.1 Somatogravic illusions

It is considered that the risk of a somatogravic illusion is high when encountering high longitudinal acceleration or combined high values of pitch attitude (nose-up), pitch rate and longitudinal acceleration, associated with a loss of outside visual references.

2.2 Workload

In order to provide sufficient time to the flight crew to manage its tasks, and therefore keep their workload at a reasonable level, longitudinal acceleration and vertical speed may need to be constrained. The assessment of the workload should be performed considering the basic workload functions described in Appendix D of CS-25.

2.3 Risk assessment and mitigation means

There are no scientifically demonstrated aeroplane performance limits to ensure that the risks of somatogravic illusions and excessive workloads remain at acceptable levels. However, the following criteria should not be exceeded during a recommended go-around manoeuvre:

— a pitch rate value of 4 degrees per second,

— a pitch attitude of 20 degrees nose-up,

— an energy level corresponding to either:

  — a vertical speed of 3 000 ft/min at constant calibrated airspeed,

  — a climb gradient of 22 % at constant calibrated airspeed, or

  — a level flight longitudinal acceleration capability of 7.8 km/h (4.2 kt) per second.

Note 1: these boundaries should not affect operational performance, as they are considered to be beyond the operational needs for a go-around.

Note 2: the numbers above should not be considered as hard limits, but as a reference only.

Design mitigation means should be put in place in order to avoid exceeding these criteria and reduce the risk at an acceptable level. These means should:

— provide a robust method to reduce the risk identified, and

— be used during recommended go-around procedures.

A reduced go-around (RGA) thrust or power function is considered to be an acceptable means of mitigation (refer to Chapter 4 below).

Alternatively, exceeding any one of the above criteria should be duly justified by the applicant and accepted by EASA.

3. Go-around evaluation

Go-around manoeuvres should be performed during flight testing in order to verify, in addition to the controllability and manoeuvrability aspects, that the flight crew workload and the risk of a somatogravic illusion are maintained at an acceptable level (for an acceptable level of risk of a somatogravic illusion, refer to Chapter 2.3 of this AMC). The go-around manoeuvres should be performed with all engines operating (AEO) and for each approved landing configuration as per the recommended AFM go-around procedure:

— with the most unfavourable, and practicable, combination of centre of gravity position and weight approved for landing,

— with any practicable combination of flight guidance/autothrust-throttle/autopilot to be approved, including manual,

— with a level-off altitude 1 000 ft above the go-around initiation altitude.

4. Implementation of a reduced go-around (RGA) thrust or power function

The applicant may provide an RGA thrust or power function for use when the flight crew initiates a go-around. The function should operate with any practicable combination of the flight guidance/autothrust-throttle/autopilot modes to be approved for operation, including manual modes.

This function should limit the engine thrust or power applied and maintain the performance of the aeroplane (in particular, its rate of climb) at a level that:

— is not less than the minimum required performance compatible with the operational needs and the flight crew workload during this phase; and

— reduces the flight crew's risk of suffering a somatogravic illusion.

This thrust or power reduction function may be available either through aircraft system automation or manually.

In any case, acceptable procedure(s) should be available in the aeroplane flight manual (AFM), and the recommended go-around procedure should be based on the RGA thrust or power function.

Note: When a reduced go-around thrust or power function is provided, the applicant should still use the most critical thrust or power within the range of available go-around thrust or power when showing compliance with the CS-25 specifications.

4.1 Design target

RGA functions with a design target of a 2 000 ft/min rate of climb capability have been accepted by EASA.

4.2 Cockpit indications and information to the flight crew

In automatic mode, information that thrust or power is reduced in the RGA mode should be indicated to the flight crew.

In manual mode, the thrust level tables should be made available to the flight crew.

4.3 Evaluation

An evaluation of the go-around manoeuvre with the RGA thrust or power function should be conducted following the recommendations of Chapter 3 above.

4.4 Thrust or power mode command

It should be possible for the flight crew, at any time and without any delay, to select and apply the full go-around thrust or power.

The applicant should provide specific procedures for which full thrust or power may be required, such as wind shear alert procedures, TCAS alert procedures, etc.

4.5 Engine failure during go-around with RGA thrust or power

When an engine failure occurs during a go-around performed with active RGA thrust or power, if the required thrust or power from the remaining engine(s) to achieve an adequate performance level cannot be applied automatically, a warning alert to the flight crew is required to prompt them to take the necessary thrust or power recovery action. For non-moving autothrust-throttle lever designs or designs relying on manual thrust or power setting procedures, compelling flight deck alerts may be acceptable in lieu of automatic thrust or power recovery of the operating engine(s) to permit the use of maximum go-around thrust or power for compliance with CS 25.121 (d).

The procedure for the recovery of the engine thrust or power setting must be demonstrated to be acceptable in terms of the detection of the situation by the pilot and the required actions in a high-workload environment.

The following items should be evaluated:

— the timeliness of achieving the minimum required performance;

— flight crew awareness (indications, alerting…);

— flight crew actions (commands);

— the flight crew workload in general.

4.6 Performance published in the AFM for RGA thrust or power

The climb performance required by CS 25.119 (in a landing climb, i.e. with all engines operating) should be based on the actual RGA thrust or power available (applied by following the recommended AFM procedure). The climb performance required by CS 25.121 (in an approach climb, i.e. with one engine inoperative) should be based on:

— either the RGA thrust or power available, if no thrust or power recovery is implemented,

— or the go-around thrust or power available after the application of the thrust or power recovery action (either automatically, or manually after an alert is triggered). For non-moving autothrust-throttle lever designs or manual thrust or power setting procedures, compelling flight deck alerts may be acceptable in lieu of automatic thrust or power recovery of the operating engine to permit the use of maximum go-around thrust or power for compliance with CS 25.121(d).

[Amdt 25/21]
[Amdt 25/26]

AMC 25.143(d) Controllability and Manoeuvrability

ED Decision 2007/010/R

1 The maximum forces given in the table in CS 25.143(c) for pitch and roll control for short term application are applicable to manoeuvres in which the control force is only needed for a short period. Where the manoeuvre is such that the pilot will need to use one hand to operate other controls (such as the landing flare or go-around, or during changes of configuration or power resulting in a change of control force that must be trimmed out) the single-handed maximum control forces will be applicable. In other cases (such as take-off rotation, or manoeuvring during en-route flight) the two handed maximum forces will apply.

2 Short term and long term forces should be interpreted as follows:–

Short term forces are the initial stabilised control forces that result from maintaining the intended flight path during configuration changes and normal transitions from one flight condition to another, or from regaining control following a failure. It is assumed that the pilot will take immediate action to reduce or eliminate such forces by re-trimming or changing configuration or flight conditions, and consequently short term forces are not considered to exist for any significant duration. They do not include transient force peaks that may occur during the configuration change, change of flight condition or recovery of control following a failure.

Long term forces are those control forces that result from normal or failure conditions that cannot readily be trimmed out or eliminated.

[Amdt 25/3]

AMC No. 1 to CS 25.143(g) Controllability and Manoeuvrability

ED Decision 2007/010/R

An acceptable means of compliance with the requirement that stick forces may not be excessive when manoeuvring the aeroplane, is to demonstrate that, in a turn for 0·5g incremental normal acceleration (0·3g above 6096 m (20 000 ft)) at speeds up to V_{FC}/M_{FC}, the average stick force gradient does not exceed 534 N (120 lbf)/g.

[Amdt 25/3]

AMC No. 2 to CS 25.143(g) Controllability and Manoeuvrability

ED Decision 2007/010/R

1 The objective of CS 25.143(g) is to ensure that the limit strength of any critical component on the aeroplane would not be exceeded in manoeuvring flight. In much of the structure the load sustained in manoeuvring flight can be assumed to be directly proportional to the load factor applied. However, this may not be the case for some parts of the structure, e.g., the tail and rear fuselage. Nevertheless, it is accepted that the aeroplane load factor will be a sufficient guide to the possibility of exceeding limit strength on any critical component if a structural investigation is undertaken whenever the design positive limit manoeuvring load factor is closely approached. If flight testing indicates that the design positive limit manoeuvring load factor could be exceeded in steady manoeuvring flight with a 222 N (50 lbf) stick force, the aeroplane structure should be evaluated for the anticipated load at a 222 N (50 lbf) stick force. The aeroplane will be considered to have been overstressed if limit strength has been exceeded in any critical component. For the purposes of this evaluation, limit strength is defined as the larger of either the limit design loads envelope increased by the available margins of safety, or the ultimate static test strength divided by 1·5.

2 *Minimum Stick Force to Reach Limit Strength*

2.1 A stick force of at least 222 N (50 lbf) to reach limit strength in steady manoeuvres or wind up turns is considered acceptable to demonstrate adequate minimum force at limit strength in the absence of deterrent buffeting. If heavy buffeting occurs before the limit strength condition is reached, a somewhat lower stick force at limit strength may be acceptable. The acceptability of a stick force of less than 222 N (50 lbf) at the limit strength condition will depend upon the intensity of the buffet, the adequacy of the warning margin (i.e., the load factor increment between the heavy buffet and the limit strength condition) and the stick force characteristics. In determining the limit strength condition for each critical component, the contribution of buffet loads to the overall manoeuvring loads should be taken into account.

2.2 This minimum stick force applies in the en-route configuration with the aeroplane trimmed for straight flight, at all speeds above the minimum speed at which the limit strength condition can be achieved without stalling. No minimum stick force is specified for other configurations, but the requirements of CS 25.143(g) are applicable in these conditions.

3 *Stick Force Characteristics*

3.1 At all points within the buffet onset boundary determined in accordance with CS 25.251(e), but not including speeds above V_{FC}/M_{FC}, the stick force should increase progressively with increasing load factor. Any reduction in stick force gradient with change of load factor should not be so large or abrupt as to impair significantly the ability of the pilot to maintain control over the load factor and pitch attitude of the aeroplane.

3.2 Beyond the buffet onset boundary, hazardous stick force characteristics should not be encountered within the permitted manoeuvring envelope as limited by paragraph 3.3. It should be possible, by use of the primary longitudinal control alone, to pitch the aeroplane rapidly nose down so as to regain the initial trimmed conditions. The stick force characteristics demonstrated should comply with the following:

a. For normal acceleration increments of up to 0·3 g beyond buffet onset, where these can be achieved, local reversal of the stick force gradient may be acceptable provided that any tendency to pitch up is mild and easily controllable.

b. For normal acceleration increments of more than 0·3 g beyond buffet onset, where these can be achieved, more marked reversals of the stick force gradient may be acceptable. It should be possible for any tendency to pitch up to be contained within the allowable manoeuvring limits without applying push forces to the control column and without making a large and rapid forward movement of the control column.

3.3 In flight tests to satisfy paragraph 3.1 and 3.2 the load factor should be increased until either –

a. The level of buffet becomes sufficient to provide a strong and effective deterrent to further increase of load factor; or

b. Further increase of load factor requires a stick force in excess of 667 N (150 lbf) (or in excess of 445 N (100 lbf) when beyond the buffet onset boundary) or is impossible because of the limitations of the control system; or

c. The positive limit manoeuvring load factor established in compliance with CS 25.337(b) is achieved.

4 *Negative Load Factors*

It is not intended that a detailed flight test assessment of the manoeuvring characteristics under negative load factors should necessarily be made throughout the specified range of conditions. An assessment of the characteristics in the normal flight envelope involving normal accelerations from 1 g to 0 g will normally be sufficient. Stick forces should also be assessed during other required flight testing involving negative load factors. Where these assessments reveal stick force gradients that are unusually low, or that are subject to significant variation, a more detailed assessment, in the most critical of the specified conditions, will be required. This may be based on calculations provided these are supported by adequate flight test or wind tunnel data.

[Amdt 25/3]

AMC 25.143(h) Manoeuvre Capability

ED Decision 2007/010/R

1 As an alternative to a detailed quantitative demonstration and analysis of coordinated turn capabilities, the levels of manoeuvrability free of stall warning required by CS 25.143(h) can normally be assumed where the scheduled operating speeds are not less than –

$1.08\ V_{SW}$ for V_2

$1.16\ V_{SW}$ for V_2 + xx, V_{FTO} and V_{REF}

where V_{SW} is the stall warning speed determined at idle power and at 1g in the same conditions of configuration, weight and centre of gravity, all expressed in CAS. Neverthless, a limited number of turning flight manoeuvres should be conducted to confirm qualitatively that the aeroplane does meet the manoeuvre bank angle objectives (e.g. for an aeroplane with a significant Mach effect on the C_L/α relationship) and does not exhibit other characteristics which might interfere with normal manoeuvring.

2 The effect of thrust or power is normally a function of thrust to weight ratio alone and, therefore, it is acceptable for flight test purposes to use the thrust or power setting that is consistent with a WAT-limited climb gradient at the test conditions of weight, altitude and temperature. However, if the manoeuvre margin to stall warning (or other relevant characteristic that might interfere with normal manoeuvring) is reduced with increasing thrust or power, the critical conditions of both thrust or power and thrust-to-weight ratio must be taken into account when demonstrating the required manoeuvring capabilities.

[Amdt 25/3]

CS 25.145 Longitudinal control

ED Decision 2018/005/R

(a) (See AMC 25.145(a).) It must be possible at any point between the trim speed prescribed in CS 25.103(b)(6) and stall identification (as defined in CS 25.201(d)), to pitch the nose downward so that the acceleration to this selected trim speed is prompt with:

(1) the aeroplane trimmed at the trim speed prescribed in CS 25.103(b)(6);

(2) the most critical landing gear configuration;

(3) the wing-flaps (i) retracted and (ii) extended; and

(4) engine trust or power (i) off and (ii) at go-around setting.

(b) With the landing gear extended, no change in trim control, or exertion of more than 222 N (50 pounds) control force (representative of the maximum short term force that can be applied readily by one hand) may be required for the following manoeuvres:

(1) With power off, wing-flaps retracted, and the aeroplane trimmed at $1{\cdot}3\ V_{SR1}$, extend the wing-flaps as rapidly as possible while maintaining the airspeed at approximately 30% above the reference stall speed existing at each instant throughout the manoeuvre. (See AMC 25.145(b)(1), (b)(2) and (b)(3).)

(2) Repeat sub-paragraph (b)(1) of this paragraph except initially extend the wing-flaps and then retract them as rapidly as possible. (See AMC 25.145(b)(2) and AMC 25.145(b)(1), (b)(2) and (b)(3).)

(3) Repeat sub-paragraph (b)(2) of this paragraph except at the go-around power or thrust setting. (See AMC 25.145(b)(1), (b)(2) and (b)(3).)

(4) With power off, wing-flaps retracted and the aeroplane trimmed at 1·3 V_{SR1}, rapidly set go-around power or thrust while maintaining the same airspeed.

(5) Repeat sub-paragraph (b)(4) of this paragraph except with wing-flaps extended.

(6) With power off, wing-flaps extended and the aeroplane trimmed at 1·3 V_{SR1} obtain and maintain airspeeds between V_{SW} and either 1·6 V_{SR1}, or V_{FE}, whichever is the lower.

(c) It must be possible, without exceptional piloting skill, to prevent loss of altitude when complete retraction of the high lift devices from any position is begun during steady, straight, level flight at 1·08 V_{SR1}, for propeller powered aeroplanes or 1·13 V_{SR1}, for turbo-jet powered aeroplanes, with –

(1) Simultaneous movement of the power or thrust controls to the go-around power or thrust setting;

(2) The landing gear extended; and

(3) The critical combinations of landing weights and altitudes.

(d) Revoked

(e) (See AMC 25.145(e).) If gated high-lift device control positions are provided, sub-paragraph (c) of this paragraph applies to retractions of the high-lift devices from any position from the maximum landing position to the first gated position, between gated positions, and from the last gated position to the fully retracted position. The requirements of sub-paragraph (c) of this paragraph also apply to retractions from each approved landing position to the control position(s) associated with the high-lift device configuration(s) used to establish the go-around procedure(s) from that landing position. In addition, the first gated control position from the maximum landing position must correspond with a configuration of the high-lift devices used to establish a go-around procedure from a landing configuration. Each gated control position must require a separate and distinct motion of the control to pass through the gated position and must have features to prevent inadvertent movement of the control through the gated position. It must only be possible to make this separate and distinct motion once the control has reached the gated position.

(f) It must be possible to maintain adequate longitudinal and speed control under the following conditions without exceptional piloting skill, alertness, or strength, without danger of exceeding the aeroplane limit-load factor and while maintaining an adequate stall margin throughout the manoeuvre:

(1) Starting with the aeroplane in each approved approach and landing configuration, trimmed longitudinally and with the thrust or power setting per CS 25.161(c)(2), perform a go-around, transition to the next flight phase and level off at the desired altitude:

(i) with all engines operating and the thrust or power controls moved to the go-around power or thrust setting;

(ii) with the configuration changes, as per the approved operating procedures or conventional operating practices; and

(iii) with any practicable combination of Flight Guidance/Autothrust-throttle/Autopilot to be approved, including manual.