TRIM

CS 25.161 Trim

ED Decision 2003/2/RM

(a) *General*. Each aeroplane must meet the trim requirements of this paragraph after being trimmed, and without further pressure upon, or movement of, either the primary controls or their corresponding trim controls by the pilot or the automatic pilot.

(b) *Lateral and directional trim.* The aeroplane must maintain lateral and directional trim with the most adverse lateral displacement of the centre of gravity within the relevant operating limitations, during normally expected conditions of operation (including operation at any speed from 1·3 V_{SR1}, to V_{MO}/M_{MO}).

(c) *Longitudinal trim.* The aeroplane must maintain longitudinal trim during –

(1) A climb with maximum continuous power at a speed not more than 1·3 V_{SR1}, with the landing gear retracted, and the wing-flaps (i) retracted and (ii) in the take-off position;

(2) Either a glide with power off at a speed not more than 1·3 V_{SR1}, or an approach within the normal range of approach speeds appropriate to the weight and configuration with power settings corresponding to a 3° glidepath, whichever is the most severe, with the landing gear extended, the wing-flaps retracted and extended, and with the most unfavourable combination of centre of gravity position and weight approved for landing; and

(3) Level flight at any speed from 1·3 V_{SR1}, to V_{MO}/M_{MO}, with the landing gear and wing-flaps retracted, and from 1·3 V_{SR1} to V_{LE} with the landing gear extended.

(d) *Longitudinal, directional, and lateral trim.* The aeroplane must maintain longitudinal, directional, and lateral trim (and for lateral trim, the angle of bank may not exceed 5°) at 1·3 V_{SR1}, during the climbing flight with –

(1) The critical engine inoperative;

(2) The remaining engines at maximum continuous power; and

(3) The landing gear and wing-flaps retracted.

(e) *Aeroplanes with four or more engines.* Each aeroplane with four or more engines must also maintain trim in rectilinear flight with the most unfavourable centre of gravity and at the climb speed, configuration, and power required by CS 25.123(a) for the purpose of establishing the en-route flight path with two engines inoperative.

STABILITY

CS 25.171 General

ED Decision 2003/2/RM

The aeroplane must be longitudinally, directionally and laterally stable in accordance with the provisions of CS 25.173 to 25.177. In addition, suitable stability and control feel (static stability) is required in any condition normally encountered in service, if flight tests show it is necessary for safe operation.

CS 25.173 Static longitudinal stability

ED Decision 2016/010/R

(See AMC 25.173)

Under the conditions specified in CS 25.175, the characteristics of the elevator control forces (including friction) must be as follows:

(a) A pull must be required to obtain and maintain speeds below the specified trim speed, and a push must be required to obtain and maintain speeds above the specified trim speed. This must be shown at any speed that can be obtained except speeds higher than the landing gear or wing flap operating limit speeds or V_{FC}/M_{FC}, whichever is appropriate, or lower than the minimum speed for steady unstalled flight.

(b) The airspeed must return to within 10% of the original trim speed for the climb, approach and landing conditions specified in CS 25.175(a), (c) and (d), and must return to within 7·5% of the original trim speed for the cruising condition specified in CS 25.175(b), when the control force is slowly released from any speed within the range specified in sub-paragraph (a) of this paragraph.

(c) The average gradient of the stable slope of the stick force versus speed curve may not be less than 4 N (1 pound) for each 11,2 km/h (6 kt). (See AMC 25.173(c).)

(d) Within the free return speed range specified in sub-paragraph (b) of this paragraph, it is permissible for the aeroplane, without control forces, to stabilise on speeds above or below the desired trim speeds if exceptional attention on the part of the pilot is not required to return to and maintain the desired trim speed and altitude.

[Amdt 25/18]

AMC 25.173(c) Static longitudinal stability

ED Decision 2003/2/RM

The average gradient is taken over each half of the speed range between 0·85 and 1·15 V_{trim}.

CS 25.175 Demonstration of static longitudinal stability

ED Decision 2003/2/RM

Static longitudinal stability must be shown as follows:

(a) *Climb*. The stick force curve must have a stable slope at speeds between 85% and 115% of the speed at which the aeroplane –

(1) Is trimmed with –

(i) Wing-flaps retracted;

(ii) Landing gear retracted;

(iii) Maximum take-off weight; and

(iv) The maximum power or thrust selected by the applicant as an operating limitation for use during climb; and

(2) Is trimmed at the speed for best rate-of-climb except that the speed need not be less than 1·3 V_{SR1}.

(b) *Cruise*. Static longitudinal stability must be shown in the cruise condition as follows:

(1) With the landing gear retracted at high speed, the stick force curve must have a stable slope at all speeds within a range which is the greater of 15% of the trim speed plus the resulting free return speed range, or 93 km/h (50 kt) plus the resulting free return speed range, above and below the trim speed (except that the speed range need not include speeds less than 1·3 V_{SR1} nor speeds greater than V_{FC}/M_{FC}, nor speeds that require a stick force of more than 222 N (50 lbf)), with –

(i) The wing-flaps retracted;

(ii) The centre of gravity in the most adverse position (see CS 25.27);

(iii) The most critical weight between the maximum take-off and maximum landing weights;

(iv) The maximum cruising power selected by the applicant as an operating limitation (see CS 25.1521), except that the power need not exceed that required at V_{MO}/M_{MO}; and

(v) The aeroplane trimmed for level flight with the power required in sub-paragraph (iv) above.

(2) With the landing gear retracted at low speed, the stick force curve must have a stable slope at all speeds within a range which is the greater of 15% of the trim speed plus the resulting free return speed range, or 93 km/h (50 kt) plus the resulting free return speed range, above and below the trim speed (except that the speed range need not include speeds less than 1·3 V_{SR1} nor speeds greater than the minimum speed of the applicable speed range prescribed in subparagraph (b)(1) of this paragraph, nor speeds that require a stick force of more than 222 N (50 lbf)), with –

(i) Wing-flaps, centre of gravity position, and weight as specified in sub-paragraph (1) of this paragraph;

(ii) Power required for level flight at a speed equal to $\frac{V_{MO}+1{\cdot}3V_{SR1}}{2}$; and

(iii) The aeroplane trimmed for level flight with the power required in sub-paragraph (ii) above.

(3) With the landing gear extended, the stick force curve must have a stable slope at all speeds within a range which is the greater of 15% of the trim speed plus the resulting free return speed range or 93 km/h (50 kt) plus the resulting free return speed range, above and below the trim speed (except that the speed range need not include speeds less than 1·3 V_{SR1}, nor speeds greater than V_{LE}, nor speeds that require a stick force of more than 222 N (50 lbf)), with –

(i) Wing-flap, centre of gravity position, and weight as specified in sub-paragraph (b)(1) of this paragraph;

(ii) The maximum cruising power selected by the applicant as an operating limitation, except that the power need not exceed that required for level flight at V_{LE}; and

(iii) The aeroplane trimmed for level flight with the power required in sub-paragraph (ii) above.

(c) *Approach.* The stick force curve must have a stable slope at speeds between V_{SW}, and 1·7 V_{SR1} with –

(1) Wing-flaps in the approach position;

(2) Landing gear retracted;

(3) Maximum landing weight; and

(4) The aeroplane trimmed at 1·3 V_{SR1}, with enough power to maintain level flight at this speed.

(d) *Landing*. The stick force curve must have a stable slope and the stick force may not exceed 356 N (80 lbf) at speeds between V_{SW}, and 1·7 V_{SR0} with –

(1) Wing-flaps in the landing position;

(2) Landing gear extended;

(3) Maximum landing weight;

(4) The aeroplane trimmed at 1·3 V_{SR0} with –

(i) Power or thrust off, and

(ii) Power or thrust for level flight.

CS 25.177 Static directional and lateral stability

ED Decision 2016/010/R

(See AMC 25.177)

(a) The static directional stability (as shown by the tendency to recover from a skid with the rudder free) must be positive for any landing gear and flap position and symmetrical power condition, at speeds from 1·13 V_{SR1}, up to V_{FE}, V_{LE}, or V_{FC}/M_{FC} (as appropriate).

(b) The static lateral stability (as shown by the tendency to raise the low wing in a sideslip with the aileron controls free) for any landing gear and wingflap position and symmetric power condition, may not be negative at any airspeed (except that speeds higher than V_{FE} need not be considered for wingflaps extended configurations nor speeds higher than V_{LE} for landing gear extended configurations) in the following airspeed ranges:

(1) From 1·13 V_{SR1} to V_{MO}/M_{MO}..

(2) From V_{MO}/M_{MO} to V_{FC}/M_{FC}, unless the divergence is –

(i) Gradual;

(ii) Easily recognisable by the pilot; and

(iii) Easily controllable by the pilot

(c) In straight, steady, sideslips over the range of sideslip angles appropriate to the operation of the aeroplane, the aileron and rudder control movements and forces must be substantially proportional to the angle of sideslip in a stable sense. The factor of proportionality must lie between limits found necessary for safe operation.

The range of sideslip angles evaluated must include those sideslip angles resulting from the lesser of:

(1) one-half of the available rudder control input; and

(2) a rudder control force of 180 pounds.

This requirement must be met for the configurations and speeds specified in sub-paragraph (a) of this paragraph. (See AMC 25.177(c).)

(d) For sideslip angles greater than those prescribed by sub-paragraph (c) of this paragraph, up to the angle at which full rudder control is used or a rudder control force of 801 N (180 lbf) is obtained, the rudder control forces may not reverse, and increased rudder deflection must be needed for increased angles of sideslip. Compliance with this requirement must be shown using straight, steady sideslips, unless full lateral control input is achieved before reaching either full rudder control input or a rudder control force of 801 N (180 lbf) ; a straight, steady sideslip need not be maintained after achieving full lateral control input. This requirement must be met at all approved landing gear and wingflap positions for the range of operating speeds and power conditions appropriate to each landing gear and wing-flap position with all engines operating. (See AMC 25.177(d).)

[Amdt 25/11]
[Amdt 25/18]

AMC 25.177(c) Steady, Straight Sideslips

ED Decision 2011/004/R

1 CS 25.177(c) requires, in steady, straight sideslips throughout the range of sideslip angles appropriate to the operation of the aeroplane, that the aileron and rudder control movements and forces be proportional to the angle of sideslip. The factor of proportionality must lie between limits found necessary for safe operation. The range of sideslip angles evaluated must include those sideslip angles resulting from the lesser of: (1) one-half of the available rudder control input; and (2) a rudder control force of 180 pounds. CS 25.177(c) states, by cross-reference to CS 25.177(a), that these steady, straight sideslip criteria must be met for all landing gear and flap positions and symmetrical power conditions at speeds from 1.13 V_{SR1} to V_{FE}, V_{LE}, or V_{FC}/M_{FC}, as appropriate for the configuration.

2 *Sideslip Angles Appropriate to the Operation of the Aeroplane*

2.1 Experience has shown that an acceptable method for determining the appropriate sideslip angle for the operation of a transport category aeroplane is provided by the following equation:

ß = arc sin (30/V)

where

ß = Sideslip angle, and

V = Airspeed (KCAS)

Recognising that smaller sideslip angles are appropriate as speed is increased, this equation provides sideslip angle as a function of airspeed. The equation is based on the theoretical sideslip value for a 56 km/h (30-knot) crosswind, but has been shown to conservatively represent (i.e., exceed) the sideslip angles achieved in maximum crosswind take-offs and landings and minimum static and dynamic control speed testing for a variety of transport category aeroplanes. Experience has also shown that a maximum sideslip angle of 15 degrees is generally appropriate for most transport category aeroplanes even though the equation may provide a higher sideslip angle. However, limiting the maximum sideslip angle to 15 degrees may not be appropriate for aeroplanes with low approach speeds or high crosswind capability.

2.2 A lower sideslip angle than that provided in paragraph 2.1 may be used if it is substantiated that the lower value conservatively covers all crosswind conditions, engine failure scenarios, and other conditions where sideslip may be experienced within the approved operating envelope. Conversely, a higher value should be used for aeroplanes where test evidence indicates that a higher value would be appropriate to the operation of the aeroplane.

3 For the purposes of showing compliance with the requirement out to sideslip angles associated with one-half of the available rudder control input, there is no need to consider a rudder control input beyond that corresponding to full available rudder surface travel or a rudder control force of 801 N (180 lbf). Some rudder control system designs may limit the available rudder surface deflection such that full deflection for the particular flight condition is reached before the rudder control reaches onehalf of its available travel. In such cases, further rudder control input would not result in additional rudder surface deflection.

4 *Steady, straight sideslips*

4.1 Steady, straight sideslips should be conducted in each direction to show that the aileron and rudder control movements and forces are substantially proportional to the angle of sideslip in a stable sense, and that the factor of proportionality is within the limits found necessary for safe operation. These tests should be conducted at progressively greater sideslip angles up to the sideslip angle appropriate to the operation of the aeroplane (see paragraph 2.1) or the sideslip angle associated with one-half of the available rudder control input, whichever is greater.

4.2 When determining the rudder and aileron control forces, the controls should be relaxed at each point to find the minimum force needed to maintain the control surface deflection. If excessive friction is present, the resulting low forces will indicate the aeroplane does not have acceptable stability characteristics.

4.3 In lieu of conducting each of the separate qualitative tests required by CS 25.177(a) and (b), the applicant may use recorded quantitative data showing aileron and rudder control force and position versus sideslip (left and right) to the appropriate limits in the steady heading sideslips conducted to show compliance with CS 25.177(c). If the control force and position versus sideslip indicates positive dihedral effect and positive directional stability, compliance with CS 25.177(a) and (b) will have been successfully demonstrated."

[Amdt 25/11]

AMC 25.177(d) Full Rudder Sideslips

ED Decision 2003/2/RM

1.1 At sideslip angles greater than those appropriate for normal operation of the aeroplane, up to the sideslip angle at which full rudder control is used or a rudder control force of 801 N (180 lbf) is obtained, CS 25.177(d) requires that the rudder control forces may not reverse and increased rudder deflection must be needed for increased angles of sideslip. The goals of this higher-than-normal sideslip angle test are to show that at full rudder, or at maximum expected pilot effort: (1) the rudder control force does not reverse, and (2) increased rudder deflection must be needed for increased angles of sideslip, thus demonstrating freedom from rudder lock or fin stall, and adequate directional stability for manoeuvres involving large rudder inputs.

1.2 Compliance with this requirement should be shown using straight, steady sideslips. However, if full lateral control input is reached before full rudder control travel or a rudder control force of 801 N (180 lbf) is reached, the manoeuvre may be continued in a non-steady heading (i.e., rolling and yawing) manoeuvre. Care should be taken to prevent excessive bank angles that may occur during this manoeuvre.

1.3 CS 25.177(d) states that the criteria listed in paragraph 1.1 must be met at all approved landing gear and flap positions for the range of operating speeds and power conditions appropriate to each landing gear and flap position with all engines operating. The range of operating speeds and power conditions appropriate to each landing gear and flap position with all engines operating should be consistent with the following:

a. For take-off configurations, speeds from V_2+xx (airspeed approved for all-engines-operating initial climb) to V_{FE} or V_{LE}, as appropriate, and take-off power/thrust;

b. For flaps up configurations, speeds from 1.23 V_{SR} to V_{LE} or V_{MO}/M_{MO}, as appropriate, and power from idle to maximum continuous power/thrust;

c. For approach configurations, speeds from 1.23 V_{SR} to V_{FE} or V_{LE}, as appropriate, and power from idle to go-around power/thrust; and

d. For landing configurations, speeds from V_{REF}-9.3 km/h (5 knots) to V_{FE} or V_{LE}, as appropriate, with power from idle to go-around power/thrust at speeds from V_{REF} to V_{FE}/V_{LE}, and idle power at V_{REF}-9.3 km/h (5 knots) (to cover the landing flare).

2 *Full Rudder Sideslips*

2.1 Rudder lock is that condition where the rudder over-balances aerodynamically and either deflects fully with no additional pilot input or does not tend to return to neutral when the pilot input is released. It is indicated by a reversal in the rudder control force as sideslip angle is increased. Full rudder sideslips are conducted to determine the rudder control forces and deflections out to sideslip angles associated with full rudder control input (or as limited by a rudder control force of 801 N (180 lbf)) to investigate the potential for rudder lock and lack of directional stability.

2.2 To check for positive directional stability and for the absence of rudder lock, conduct steady heading sideslips at increasing sideslip angles until obtaining full rudder control input or a rudder control force of 801 N (180 lbf). If full lateral control is reached before reaching the rudder control limit or 801 (180 lbf) of rudder control force, continue the test to the rudder limiting condition in a non-steady heading sideslip manoeuvre.

3 The control limits approved for the aeroplane should not be exceeded when conducting the flight tests required by CS 25.177.

4 *Flight Test Safety Concerns.* In planning for and conducting the full rudder sideslips, items relevant to flight test safety should be considered, including:

a. Inadvertent stalls,

b. Effects of sideslip on stall protection systems,

c. Actuation of stick pusher, including the effects of sideslip on angle-of-attack sensor vanes,

d. Heavy buffet,

e. Exceeding flap loads or other structural limits,

f. Extreme bank angles,

g. Propulsion system behaviour (e.g., propeller stress, fuel and oil supply, and inlet stability),

h. Minimum altitude for recovery,

i. Resulting roll rates when aileron limit is exceeded, and

j. Position errors and effects on electronic or augmented flight control systems, especially when using the aeroplane's production airspeed system.

CS 25.181 Dynamic stability

ED Decision 2003/2/RM

(See AMC 25.181)

(a) Any short period oscillation, not including combined lateral-directional oscillations, occurring between 1·13 V_{SR} and maximum allowable speed appropriate to the configuration of the aeroplane must be heavily damped with the primary controls –

(1) Free; and

(2) In a fixed position.

(b) Any combined lateral-directional oscillations ('Dutch roll') occurring between 1·13 V_{SR} and maximum allowable speed appropriate to the configuration of the aeroplane must be positively damped with controls free, and must be controllable with normal use of the primary controls without requiring exceptional pilot skill.

AMC 25.181 Dynamic stability

ED Decision 2003/2/RM

The requirements of CS 25.181 are applicable at all speeds between the stalling speed and V_{FE}, V_{LE} or V_{FC}/M_{FC}, as appropriate.

STALLS

CS 25.201 Stall demonstration

ED Decision 2016/010/R

(a) Stalls must be shown in straight flight and in 30° banked turns with –

(1) Power off; and

(2) The power necessary to maintain level flight at 1·5 V_{SR1} (where VS_{R1} corresponds to the reference stall speed at maximum landing weight with flaps in the approach position and the landing gear retracted. (See AMC 25.201(a)(2).)

(b) In each condition required by sub-paragraph (a) of this paragraph, it must be possible to meet the applicable requirements of CS 25.203 with –

(1) Flaps, landing gear and deceleration devices in any likely combination of positions approved for operation; (See AMC 25.201(b)(1).)

(2) Representative weights within the range for which certification is requested;

(3) The most adverse centre of gravity for recovery; and

(4) The aeroplane trimmed for straight flight at the speed prescribed in CS 25.103(b)(6).

(c) The following procedures must be used to show compliance with CS 25.203:

(1) Starting at a speed sufficiently above the stalling speed to ensure that a steady rate of speed reduction can be established, apply the longitudinal control so that the speed reduction does not exceed 0.5 m/s^2 (one knot per second) until the aeroplane is stalled. (See AMC 25.103(c).)

(2) In addition, for turning flight stalls, apply the longitudinal control to achieve airspeed deceleration rates up to 5,6 km/h (3 kt) per second. (See AMC 25.201(c)(2).)

(3) As soon as the aeroplane is stalled, recover by normal recovery techniques.

(d) The aeroplane is considered stalled when the behaviour of the aeroplane gives the pilot a clear and distinctive indication of an acceptable nature that the aeroplane is stalled. (See AMC 25.201(d).) Acceptable indications of a stall, occurring either individually or in combination, are –

(1) A nose-down pitch that cannot be readily arrested;

(2) Buffeting, of a magnitude and severity that is a strong and effective deterrent to further speed reduction; or

(3) The pitch control reaches the aft stop and no further increase in pitch attitude occurs when the control is held full aft for a short time before recovery is initiated. (See AMC 25.201(d)(3).)

[Amdt 25/18]

AMC 25.201(a)(2) Stall demonstration

ED Decision 2003/2/RM

The power for all power-on stall demonstrations is that power necessary to maintain level flight at a speed of 1·5 V_{SR1} at maximum landing weight, with flaps in the approach position and landing gear retracted, where V_{SR1} is the reference stall speed in the same conditions (except power). The flap position to be used to determine this power setting is that position in which the reference stall speed does not exceed 110% of the reference stall speed with the flaps in the most extended landing position.

AMC 25.201(b)(1) Stall demonstration

ED Decision 2003/2/RM

Stall demonstrations for compliance with CS 25.201 should include demonstrations with deceleration devices deployed for all flap positions unless limitations against use of the devices with particular flap positions are imposed. 'Deceleration devices' include spoilers when used as air brakes, and thrust reversers when use in flight is permitted. Stall demonstrations with deceleration devices deployed should normally be carried out with power off, except where deployment of the deceleration devices while power is applied is likely to occur in normal operations (e.g. use of extended air brakes during landing approach).

AMC 25.201(c)(2) Turning Flight Stalls At Higher Deceleration Rates

ED Decision 2003/2/RM

The intent of evaluating higher deceleration rates is to demonstrate safe characteristics at higher rates of increase of angle of attack than are obtained from the 0.5 m/s^2 (1 knot per second) stalls. The specified airspeed deceleration rate, and associated angle of attack rate, should be maintained up to the point at which the aeroplane stalls.

AMC 25.201(d) Stall demonstration

ED Decision 2018/005/R

1 The behaviour of the aeroplane includes the behaviour as affected by the normal functioning of any systems with which the aeroplane is equipped, including devices intended to alter the stalling characteristics of the aeroplane.

2 Unless the design of the automatic flight control system of the aeroplane protects against such an event, the stalling characteristics and adequacy of stall warning, when the aeroplane is stalled under the control of the automatic flight control system, should be investigated. (See also CS 25.1329(h).)

[Amdt 25/19]
[Amdt 25/21]