6.16 *Dynamic Stability (CS 25.181).* Provided that there are no marginal compliance aspects with the non-contaminated aeroplane, it is not necessary to demonstrate dynamic stability in specific tests. Qualitative evaluations should be combined with the other testing. Any tendency to sustain oscillations in turbulence or difficulty in achieving precise attitude control should be investigated.

6.17 *Stall Demonstration (CS 25.201).*

6.17.1 Sufficient stall testing should be conducted to demonstrate that the stall characteristics comply with the requirements. In general, it is not necessary to conduct a stall programme which encompasses all weights, centre of gravity positions (including lateral asymmetry), altitudes, high lift configurations, deceleration device configurations, straight and turning flight stalls, power off and power on stalls. Based on a review of the stall characteristics of the non-contaminated aeroplane, a reduced test matrix can be established. However, additional testing may be necessary if:

— the stall characteristics with ice accretion show a significant difference from the non-contaminated aeroplane,

— testing indicates marginal compliance, or

— a stall identification system (e.g. stick pusher) is required to be reset for icing conditions.

6.17.2 *Acceptable Test Programme*. Turning flight stalls at decelerations greater than 1 knot/sec are not required. Slow decelerations (much slower than 1 knot/sec) may be critical on aeroplanes with anticipation logic in their stall protection system or on aeroplanes with low directional stability, where large sideslip angles could develop. The following represents an acceptable test programme subject to the provisions outlined above.

a. The "Holding ice" accretion should be used.

b. Medium to light weight, aft centre of gravity position, symmetric fuel loading.

c. Normal stall test altitude.

d. In the configurations listed below, trim the aeroplane at the same initial stall speed factor used for stall speed determination. For power-on stalls, use the power setting as defined in CS 25.201 (a)(2) but with ice accretions on the aeroplane. Decrease speed at a rate not to exceed 1 knot/sec to stall identification and recover using the same test technique as for the non-contaminated aeroplane.

i. High lift devices retracted configuration: Straight/Power Off, Straight/Power On, Turning/Power Off, Turning/Power On.

ii. Lowest lift take-off configuration: Straight/Power On, Turning/Power Off.

iii. Highest lift take-off configuration: Straight/Power Off, Turning/Power On.

iv. Highest lift landing configuration: Straight/Power Off, Straight/Power On, Turning/Power Off, Turning/Power On.

e. For the configurations listed in paragraph 6.17.2(d)i and iv, and any other configuration if deemed more critical, in 1 knot/second deceleration rates down to stall warning with wings level and power off, roll the aeroplane left and right up to 10 degrees of bank using the lateral control.

6.18 Stall Warning (CS 25.207).

6.18.1 Stall warning should be assessed in conjunction with stall speed testing and stall demonstration testing (CS 25.103, CS 25.201 and paragraphs 6.2 and 6.17 of this AMC, respectively) and in tests with faster entry rates.

6.18.2 *Normal Ice Protection System Operation*. The following represents an acceptable test programme for stall warning in slow down turns of at least 1.5g and at entry rates of at least 1 m/sec^2 (2 knot/sec):

a. The "Holding ice" accretion should be used.

b. Medium to light weight, aft centre of gravity position, symmetric fuel loading.

c. Normal stall test altitude.

d. In the configurations listed below, trim the aeroplane at $1.3V_{SR}$ with the power or thrust necessary to maintain straight level flight. Maintain the trim power or thrust during the test demonstrations. Increase speed as necessary prior to establishing at least 1.5g and a deceleration of at least 1 m/sec^2 (2 knot/sec). Decrease speed until 1 sec after stall warning and recover using the same test technique as for the non-contaminated aeroplane.

i. High lift devices retracted configuration;

ii. Lowest lift take-off configuration; and

iii. Highest lift landing configuration.

6.18.3 *Ice Accretion Prior to Activation and Normal System Operation*. The following represent acceptable means for evaluating stall warning margin with the ice accretion prior to activation and normal operation of the ice protection system.

a. In the configurations listed below, with the ice accretion specified in the requirement, trim the aeroplane at 1.3 V_{SR}.

i. High lift devices retracted configuration: Straight/Power Off.

ii. Landing configuration: Straight/Power Off.

b. At decelerations of up to 0.5 m/sec^2 (1 knot per second), reduce the speed to stall warning plus 1 second, and demonstrate that stalling can be prevented using the same test technique as for the non-contaminated aeroplane, without encountering any adverse characteristics (e.g., a rapid roll-off). As required by CS 25.207(h)(3)(ii), where stall warning is provided by a different means than for the aeroplane without ice accretion, the stall characteristics must be satisfactory and the delay must be at least 3 seconds.

6.19 Wind Velocities (CS 25.237).

6.19.1 Crosswind landings with "Landing Ice" should be evaluated on an opportunity basis.

6.19.2 The results of the steady heading sideslip tests with "Landing Ice" may be used to establish the safe cross wind component. If the flight test data show that the maximum sideslip angle demonstrated is similar to that demonstrated with the non-contaminated aeroplane, and the flight characteristics (e.g. control forces and deflections) are similar, then the non-contaminated aeroplane crosswind component is considered valid.

6.19.3 If the results of the comparison discussed in paragraph 6.19.2, above, are not clearly similar, and in the absence of a more rational analysis, a conservative analysis based on the results of the steady heading sideslip tests may be used to establish the safe crosswind component. The crosswind value may be estimated from:

$V_{CW} = V_{REF} * \sin(\text{sideslip angle}) / 1.5$

Where:

V_{CW} is the crosswind component,

V_{REF} is the landing reference speed appropriate to a minimum landing weight, and *sideslip angle* is that demonstrated at V_{REF} (see paragraph 6.15 of this AMC).

6.20 Vibration and Buffeting (CS 25.251).

6.20.1 Qualitative evaluations should be combined with the other testing, including speeds up to the maximum speed obtained in the longitudinal stability tests (see paragraph 6.14 of this AMC).

6.20.2 It is also necessary to demonstrate that the aeroplane is free from harmful vibration due to residual ice accumulation. This may be done in conjunction with the natural icing tests.

6.20.3 An aeroplane with pneumatic de-icing boots should be evaluated to V_{DF}/M_{DF} with the de-icing boots operating and not operating. It is not necessary to do this demonstration with ice accretion.

6.21 Natural Icing Conditions.

6.21.1 *General.*

6.21.1.1 Whether the flight testing has been performed with artificial ice shapes or in natural icing conditions, additional limited flight testing described in this section should be conducted in natural icing conditions specified in Appendix C to CS-25 and, if necessary, in the icing conditions described in Appendix O to CS-25. (AMC 25.1420 provides guidance on when it is necessary to perform flight testing in the atmospheric icing conditions of Appendix O.) Where flight testing with artificial ice shapes is the primary means for showing compliance, the objective of the tests described in this section is to corroborate the handling characteristics and performance results obtained in flight testing with artificial ice shapes.

6.21.1.2 It is acceptable for some ice to be shed during the testing due to air loads or wing flexure, etc. However, an attempt should be made to accomplish the test manoeuvres as soon as possible after exiting the icing cloud to minimise the atmospheric influences on ice shedding.

6.21.1.3 During any of the manoeuvres specified in paragraph 6.21.2, below, the behaviour of the aeroplane should be consistent with that obtained with artificial ice shapes. There should be no unusual control responses or uncommanded aeroplane motions. Additionally, during the level turns and bank-to-bank rolls, there should be no buffeting or stall warning.

6.21.2 Ice Accretion/Manoeuvres.

6.21.2.1 Holding scenario.

a. The manoeuvres specified in Table 3, below, should be carried out with the following ice accretions representative of normal operation of the ice protection system:

i. *On unprotected Parts*: A thickness of 75 mm (3 inches) on those parts of the aerofoil where the collection efficiency is highest should be the objective. (A thickness of 50 mm (2 inches) is normally a minimum value, unless a lesser value is agreed by the Agency.)

ii. *On protected parts*: The ice accretion thickness should be that resulting from normal operation of the ice protection system.

b. For aeroplanes with control surfaces that may be susceptible to jamming due to ice accretion (e.g. elevator horns exposed to the air flow), the holding speed that is critical with respect to this ice accretion should be used.

Table 3: Holding Scenario – Manoeuvres

Configuration	Centre of Gravity Position	Trim speed	Manoeuvre
Flaps up, gear up	Optional (aft range)	Holding, except 1.3 V_{SR} for the stall manoeuvre	Level, 40° banked turn, Bank-to-bank rapid roll, 30° - 30°, Speedbrake extension, retraction, Full straight stall (1 knot/second deceleration rate, wings level, power off).
Flaps in intermediate positions, gear up	Optional (aft range)	1.3 V_{SR}	Deceleration to the speed reached 3 seconds after activation of stall warning in a 1 knot/second deceleration.
Landing flaps, gear down	Optional (aft range)	V_{REF}	Level, 40° banked turn, Bank-to-bank rapid roll, 30° - 30°, Speedbrake extension, retraction (if approved), Full straight stall (1 knot/second deceleration rate, wings level, power off).

6.21.2.2 *Approach/Landing Scenario.* The manoeuvres specified in Table 4, below, should be carried out with successive accretions in different configurations on unprotected surfaces. Each test condition should be accomplished with the ice accretion that exists at that point. The final ice accretion (Test Condition 3) represents the sum of the amounts that would accrete during a normal descent from holding to landing in icing conditions.

TABLE 4: Approach/Landing Scenario – Manoeuvres

Test Condition	Ice accretion thickness (*)	Configuration	Centre of Gravity Position	Trim speed	Manoeuvre
–	First 13 mm (0.5 in.)	Flaps up, gear up	Optional (aft range)	Holding	No specific test
1	Additional 6.3 mm (0.25 in.) (19 mm (0.75 in.) total)	First intermediate flaps, gear up	Optional (aft range)	Holding	-Level 40° banked turn, -Bank-to-bank rapid roll, 30°- 30°, -Speed brake extension and retraction (if approved), -Deceleration to stall warning.
2	Additional 6.3 mm (0.25 in.) (25 mm (1.00 in.) total)	Further intermediate flaps, gear up (as applicable)	Optional (aft range)	1.3 V_{SR}	-Bank-to-bank rapid roll, 30° - 30°, -Speed brake extension and retraction (if approved), -Deceleration to stall warning.
3	Additional 6.3 mm (0.25 in.) (31 mm (1.25 in.) total)	Landing flaps, gear down	Optional (aft range)	V_{REF}	-Bank-to-bank rapid roll, 30° - 30°, -Speed brake extension and retraction (if approved), -Bank to 40°, -Full straight stall.

(*) The indicated thickness is that obtained on the parts of the unprotected aerofoil with the highest collection efficiency.

6.21.3 For aeroplanes with unpowered elevator controls, in the absence of an agreed substantiation of the criticality of the artificial ice shape used to demonstrate compliance with the controllability requirement, the pushover test of paragraph 6.9.4 should be repeated with a thin accretion of natural ice on the unprotected surfaces.

6.21.4 Existing propeller speed limits or, if required, revised propeller speed limits for flight in icing, should be verified by flight tests in natural icing conditions.

6.22 Failure Conditions (CS 25.1309).

6.22.1 For failure conditions which are annunciated to the flight crew, credit may be taken for the established operating procedures following the failure.

6.22.2 *Acceptable Test Programme*. In addition to a general qualitative evaluation, the following test programme (modified as necessary to reflect the specific operating procedures) should be carried out for the most critical probable failure condition where the associated procedure requires the aeroplane to exit the icing condition:

a. The ice accretion is defined as a combination of the following:

i. On the unprotected surfaces - the “Holding ice” accretion described in paragraph A1.2.1 of this AMC;

ii. On the normally protected surfaces that are no longer protected - the “Failure ice” accretion described in paragraph A1.3.2 of this AMC; and

iii. On the normally protected surfaces that are still functioning following the segmental failure of a cyclical de-ice system – the ice accretion that will form during the rest time of the de-ice system following the critical failure condition.

b. Medium to light weight, aft centre of gravity position, symmetric fuel loading.

c. In the configurations listed below, trim the aeroplane at the specified speed. Conduct 30° banked turns left and right with normal reversals. Conduct pull up to 1.5g and pushover to 0.5g.

i. High lift devices retracted configuration (or holding configuration if different): Holding speed, power or thrust for level flight. In addition, deploy and retract deceleration devices.

ii. Approach configuration: Approach speed, power or thrust for level flight.

iii. Landing configuration: Landing speed, power or thrust for landing approach (limit pull up to 1.3g). In addition, conduct steady heading sideslips to angle of sideslip appropriate to type and landing procedure.

d. In the configurations listed below, trim the aeroplane at estimated 1.3 V_{SR} Decrease speed to stall warning plus 1 second, and demonstrate prompt recovery using the same test technique as for the non-contaminated aeroplane. Natural stall warning is acceptable for the failure case.

i. High lift devices retracted configuration: Straight/Power Off.

ii. Landing configuration: Straight/Power Off.

e. Conduct an approach and go-around with all engines operating using the recommended procedure.

f. Conduct an approach and landing with all engines operating (unless the one-engine-inoperative condition results in a more critical probable failure condition) using the recommended procedure.

6.22.3 For improbable failure conditions, flight test may be required to demonstrate that the effect on safety of flight (as measured by degradation in flight characteristics) is commensurate with the failure probability or to verify the results of analyses and/or wind tunnel tests. The extent of any required flight test should be similar to that described in paragraph 6.22.2, above, or as agreed with the Agency for the specific failure condition.

[Amdt No: 25/3]
[Amdt No: 25/6]
[Amdt No: 25/13]
[Amdt No: 25/16]
[Amdt No: 25/18]
[Amdt No: 25/21]

Appendix 1 – Airframe Ice Accretion

ED Decision 2016/010/R

A1.1 General.

a. In accordance with CS 25.1419, each aeroplane certified for flight in icing conditions must be capable of safely operating in the continuous maximum and intermittent maximum icing conditions of Appendix C. Therefore, at a minimum, certification for flight in icing conditions must include consideration of ice accretions that can occur in Appendix C icing conditions.

b. In accordance with CS 25.1420(a)(1), each aeroplane certified for flight in icing conditions must, at a minimum, be capable of safely operating:

i. In the atmospheric icing conditions of Appendix C to CS-25, and

ii. After encountering the atmospheric icing conditions of Appendix O, and subsequently while exiting all icing conditions.

Therefore, at a minimum, certification for flight in icing conditions must consider ice accretions that can occur during flight in Appendix C icing conditions and during detection and exiting of Appendix O icing conditions.

c. In accordance with CS 25.1420(a)(2), an aeroplane may also be certified for operation in a portion of the atmospheric icing conditions of Appendix O to CS-25. In that case, the aeroplane must also be capable of operating safely after encountering, and while exiting, atmospheric icing conditions in the portion of Appendix O for which operation is not approved. Ice accretions used for certification must consider:

i. Operations in Appendix C icing conditions,

ii. Operations in the Appendix O icing conditions for which approval is sought, and

iii. Detection and exiting of the Appendix O icing conditions beyond those for which approval is sought.

d. In accordance with CS 25.1420(a)(3), in addition to being certified for flight in Appendix C conditions, an aeroplane may be certified for operation throughout the atmospheric icing conditions of Appendix O to CS-25. Certification for flight throughout the atmospheric icing conditions of Appendix O must consider ice accretions resulting from:

i. Operations in Appendix C icing conditions, and

ii. Operations in Appendix O icing conditions.

e. The CS-25 subpart B aeroplane performance and handling characteristics requirements identify the specific ice accretions that apply in showing compliance. In accordance with Appendix C, part II(b) and Appendix O, part II(e), to reduce the number of ice accretions used for demonstrating compliance, the applicant may use any of the applicable ice accretions (or a composite accretion representing a combination of accretions) to show compliance with a particular subpart B requirement if that accretion is either the ice accretion identified in the requirement or is shown to be more conservative than the ice accretion identified in the requirement. In addition, the ice accretion with the most adverse effect on handling characteristics may be used for compliance with the aeroplane performance requirements if any difference in performance is conservatively taken into account. Ice accretion(s) used to show compliance should take into account the speeds, configurations (including configuration changes), angles of attack, power or thrust settings, etc. for the flight phases and icing conditions they are intended to cover.

f. The applicant should determine the most critical ice accretion in terms of handling characteristics and performance for each flight phase. Parameters to be considered include:

— flight conditions (for example, aeroplane configuration, speed, angle-of-attack, altitude) and

— atmospheric icing conditions for which certification is desired (for example, temperature, liquid water content (LWC), mean effective drop diameter (MED), drop median volume diameter (MVD)).

If a comparative analysis (refer to AMC 25.1420(f)) is used as the means of compliance with the CS-25 certification specifications relative to the Appendix O icing conditions, the most critical ice accretions determined for Appendix C icing conditions are acceptable.

g. For each phase of flight, the shape, chordwise and spanwise, and the roughness of the shapes, considered in selection of a critical ice shape should accurately reflect the full range of atmospheric icing conditions for which certification is desired in terms of MED, LWC, MVD, and temperature during the respective phase of flight. Justification and selection of the most critical ice shape for each phase of flight should be agreed to by the Agency.

h. See Appendix R of FAA Advisory Circular AC 20-73A, Aircraft Ice Protection, for additional detailed information about determining the applicable critical ice accretion (shape and roughness).

A1.2 Operative Ice Protection System.

A1.2.1 **All flight phases except take-off**.

A1.2.1.1 For unprotected parts, the ice accretion to be considered should be determined in accordance with Appendices C and O to CS-25.

A1.2.1.2 Unprotected parts consist of the unprotected aerofoil leading edges and all unprotected airframe parts on which ice may accrete. The effect of ice accretion on protuberances such as antennae or flap hinge fairings need not normally be investigated. However aeroplanes that are characterised by unusual unprotected airframe protuberances, e.g. fixed landing gear, large engine pylons, or exposed control surface horns or winglets, etc., may experience significant additional effects, which should therefore be taken into consideration.

A1.2.1.3 For holding ice, the applicant should determine the effect of a 45-minute hold in continuous maximum icing conditions. The analysis should assume that the aeroplane remains in a rectangular “race track” pattern, with all turns being made within the icing cloud. Therefore, no horizontal extent correction should be used for this analysis. For some previous aeroplane certification programs, the maximum pinnacle height was limited to 75 mm (3 inches). This method of compliance may continue to be accepted for follow-on products if service experience has been satisfactory, and the designs are similar enough to conclude that the previous experience is applicable. The applicant should substantiate the critical mean effective drop diameter, liquid water content, and temperature that result in the formation of an ice accretion that is critical to the aeroplane’s performance and handling qualities. The shape and texture of the ice are important and should be agreed with the Agency.

A1.2.1.4 For protected parts, the ice protection systems are normally assumed to be operative. However, the applicant should consider the effect of ice accretion on the protected surfaces that result from:

a. The rest time of a de-icing cycle. Performance may be established on the basis of a representative intercycle ice accretion for normal operation of the de-icing system (consideration should also be given to the effects of any residual ice accretion that is not shed.) The average drag increment determined over the de-icing cycle may be used for performance calculations.

b. Runback ice which occurs on or downstream of the protected surface.

c. Ice accretion prior to activation and normal operation of the ice protection system (see paragraph A1.2.3, below).

A1.2.2 **Take-off phase**.

A1.2.2.1 For both unprotected and protected parts, the ice accretion identified in Appendix C and Appendix O to CS-25 for the take-off phase may be determined by calculation, assuming the following:

— aerofoils, control surfaces and, if applicable, propellers are free from frost, snow, or ice at the start of the take-off;

— the ice accretion starts at the end of the take-off distance

— the critical ratio of thrust/power-to-weight;

— failure of the critical engine occurs at VEF; and

— flight crew activation of the ice protection system in accordance with an AFM procedure, except that after commencement of the take-off roll no flight crew action to activate the ice protection system should be assumed to occur until the aeroplane is 122 m (400 ft) above the take-off surface.

A1.2.2.2 The ice accretions identified in Appendix C and Appendix O to CS-25 for the take-off phase are:

— "Take-off ice": The most critical ice accretion between the end of the take-off distance and 122 m (400 ft) above the takeoff surface, assuming accretion starts at the end of the take-off distance in the icing environment.

— "Final Take-off ice": The most critical ice accretion between 122 m (400 ft)) and the height at which the transition to the en route configuration and speed is completed, or 457 m (1500 ft) above the take-off surface, whichever is higher, assuming accretion starts at the end of the take-off distance in the icing environment.

A1.2.3 **Ice accretion prior to activation and normal system operation**.

A1.2.3.1 When considering ice accretion before the ice protection system has been activated and is performing its intended function, the means of activating the ice protection system and the system response time should be taken into account. System response time is defined as the time interval between activation of the system and its effective operation (for example, for a thermal ice protection system used for de-icing, the time to heat the surface and perform its de-icing function).

If activation of the ice protection system depends on flight crew recognition of icing conditions or response to a cockpit annunciation, appropriate delays in identifying the icing conditions and activating the ice protection system should be taken into account. For the icing conditions of Appendix C, the aeroplane should be assumed to be in continuous maximum icing conditions during the time between entering the icing conditions and effective operation of the ice protection system.

A1.2.3.2 For an aeroplane certified in accordance with CS 25.1420 (a)(2) or (a)(3), the requirements of CS 25.1419 (e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O in which the aeroplane is certified to operate.

CS 25.1419(e) requires one of the following three methods for detecting icing and activating the airframe ice protection system:

(a) A primary ice detection system that automatically activates or that alerts the flight crew to activate the airframe ice protection system; or

(b) A definition of visual cues for recognition of the first sign of ice accretion on a specified surface combined with an advisory ice detection system that alerts the flight crew to activate the airframe ice protection system; or

(c) Identification of conditions conducive to airframe icing as defined by an appropriate static or total air temperature and visible moisture for use by the flight crew to activate the airframe ice protection system.

A1.2.3.3 The following guidance should be used to determine the ice accretion on the unprotected and protected aerodynamic surfaces before activation and normal system operation of the ice protection system.

a. If the ice protection system activates automatically after annunciation from a primary ice detection system, the assumed ice accretion should take into account the time it takes for automatic activation of the ice protection system and the time it takes for the system to perform its intended function. The assumed ice accretion can be determined as follows:

   i. The ice accretion on the protected surfaces corresponding to the time between entry into the icing conditions and activation of the system, plus

   ii. The ice accretion during the system response time.

b. If ice protection system activation depends on pilot action following annunciation from a primary ice detection system, the assumed ice accretion should take into account flight crew delays in activating the ice protection system and the time it takes for the system to perform its intended function. The assumed ice accretion can be determined as follows:

   i. The ice accretion corresponding to the time between entry into the icing conditions and annunciation from the primary ice detection system, plus

   ii. The ice accretion corresponding to 10 additional seconds of operation in icing conditions, plus

   iii. The ice accretion during the system response time.