c. If ice protection system activation depends on the flight crew visually recognizing the first indication of ice accretion on a reference surface (for example, an ice accretion probe) combined with an advisory ice detection system, the assumed ice accretion should take into account flight crew delays in detecting the accreted ice and in activating the ice protection system, and the time it takes for the system to perform its intended function. This may be determined as follows:

   i. The ice accretion that would be easily recognizable by the flight crew under all foreseeable conditions (for example, at night in clouds) as it corresponds to the first indication of ice accretion on the reference surface, plus

   ii. the ice accretion equivalent to 30 seconds of operation in icing conditions, plus

   iii. the ice accreted during the system response time.

d. If ice protection system activation depends on pilot identification of icing conditions (as defined by an appropriate static or total air temperature in combination with visible moisture conditions) with or without an advisory ice detector, the assumed ice accretion should take into account flight crew delays in recognizing the presence of icing conditions and flight crew delays in activating the ice protection system, and the time it takes for the system to perform its intended function. This may be determined as follows:

   i. the ice accretion equivalent to 30 seconds of operation in icing conditions, plus

   ii. the ice accretion during the system response time.

A1.3 Ice Protection System Failure Cases.

A1.3.1 Unprotected parts. The same accretion as in paragraph A1.2.1 is applicable.

A1.3.2 Protected parts following system failure. "Failure Ice" is defined as follows:

A1.3.2.1 In the case where the failure condition is not annunciated, the ice accretion on normally protected parts where the ice protection system has failed should be the same as the accretion specified for unprotected parts.

A1.3.2.2 In the case where the failure condition is annunciated and the associated procedure does not require the aeroplane to exit icing conditions, the ice accretion on normally protected parts where the ice protection system has failed should be the same as the accretion specified for unprotected parts.

A1.3.2.3 In the case where the failure condition is annunciated and the associated procedure requires the aeroplane to exit icing conditions as soon as possible, the ice accretion on normally protected parts where the ice protection has failed, should be taken as one-half of the accretion specified for unprotected parts unless another value is agreed by the Agency.

A1.4 Additional guidance for Appendix O ice accretions.

A1.4.1 Ice Accretion in Appendix O Conditions Before those Conditions Have Been Detected by the Flight crew.

This ice accretion, defined as pre-detection ice in Appendix O, part II(b)(5), refers to the ice accretion existing at the time the flight crew become aware that they are in Appendix O icing conditions and have taken action to begin exiting from all icing conditions.

a. Both direct entry into Appendix O icing conditions and entry into Appendix O icing conditions from flight in Appendix C icing conditions should be considered.

b. The time that the applicant should assume it will take to detect Appendix O icing conditions exceeding those for which the aeroplane is certified should be based on the means of detection. AMC 25.1419 and AMC 25.1420 provide guidance for certifying the detection means. In general, the Agency expects that the time to detect exceedance icing conditions may be significantly longer for a detection means relying on the flight crew seeing and recognizing a visual icing cue than it is for an ice detection system that provides an attention-getting alert to the flight crew.

c. Visual detection requires time for accumulation on the reference surface(s) of enough ice to be reliably identified by either pilot in all atmospheric and lighting conditions. Time between pilot scans of reference surface(s) should be considered.

i. The amount of ice needed for reliable identification is a function of the distinguishing characteristics of the ice (for example, size, shape, contrast compared to the surface feature that it is adhered to), the distance from the pilots (for example, windshield vs. engine vs. wingtip), and the relative viewing angle (location with respect to the pilots' primary fields of view).

ii. Pilot scan time of the reference surface(s) will be influenced by many factors. Such factors include phase of flight, workload, frequency of occurrence of Appendix O conditions, pilot awareness of the possibility of supercooled large drop conditions, and ease of seeing the reference surface(s). The infrequency of Appendix O conditions (approximately 1 in 100 to 1 in 1 000, on average in all worldwide icing encounters) and the high workload associated with some phases of flight in instrument conditions (for example, approach and landing) justify using a conservative estimate for the time between pilot scans.

iii. In the absence of specific studies or tests validating visual detection times, the following times should be used for visual detection of exceedance icing conditions following accumulation of enough ice to be reliably identified by either pilot in all atmospheric and lighting conditions:

1. For a visual reference located on or immediately outside a cockpit window (for example, ice accretions on side windows, windshield wipers, or icing probe near the windows) – 3 minutes.

2. For a visual reference located on a wing, wing mounted engine, or wing tip – 5 minutes.

A1.4.2 Ice Accretions for Encounters with Appendix O Conditions Beyond those in Which the Aeroplane is Certified to Operate.

a. Use the ice accretions in Table 1, below, to evaluate compliance with the applicable CS-25 subpart B requirements for operating safely after encountering Appendix O atmospheric icing conditions for which the aeroplane is not approved, and then safely exiting all icing conditions.

b. The ice accretions of Table 1 apply when the aeroplane is not certified for flight in any portion of Appendix O atmospheric icing conditions, when the aeroplane is certified for flight in only a portion of Appendix O conditions, and for any flight phase for which the aeroplane is not certified for flight throughout the Appendix O icing envelope.

c. Table 1 shows the scenarios to be used for determining ice accretions for certification testing of encounters with Appendix O conditions beyond those in which the aeroplane is certified to operate (for detecting and exiting those conditions):

Table 1

Flight Phase/Condition -	Appendix O Detect-and-Exit Ice Accretion
Ground Roll	No accretion
Take-off	No accretion[1]
Final Take-off	No accretion[1]
En Route	En Route Detect-and-Exit Ice Combination of: (1) either Appendix C en route ice or Appendix O en route ice for which approval is sought, whichever is applicable, (2) pre-detection ice, (3) accretion from one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix O conditions for which the aeroplane is not approved, and (4) accretion from one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix C continuous maximum icing conditions.
Holding	Holding Detect-and-Exit Ice Combination of: (1) either Appendix C holding ice or Appendix O holding ice for which approval is sought, whichever is applicable, (2) pre-detection ice, (3) accretion from one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix O conditions for which the aeroplane is not approved, and (4) accretion from one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix C continuous maximum icing conditions. The total time in icing conditions need not exceed 45 minutes.
Approach	Approach Detect-and-Exit Ice The more critical of holding detect-and-exit ice or the combination of: (1) ice accreted during a descent in the cruise configuration from the maximum vertical extent of the Appendix C continuous maximum icing conditions or the Appendix O icing environment for which approval is sought, whichever is applicable, to 610 m (2 000 feet) above the landing surface, where transition to the approach configuration is made, (2) pre-detection ice, and

Flight Phase/Condition -	Appendix O Detect-and-Exit Ice Accretion
	(3) ice accreted at 610 m (2 000 feet) above the landing surface while transiting one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix O conditions for which the aeroplane is not approved and one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix C continuous maximum icing conditions.
Landing	Landing Detect-and-Exit Ice The more critical of holding detect-and-exit ice or the combination of: (1) either Appendix C or Appendix O approach and landing ice for which approval is sought, whichever is applicable, (2) pre-detection ice, and (3) ice accreted during an exit maneuver beginning with the minimum climb gradient specified in CS 25.119 from a height of 61 m (200 feet) above the landing surface and transiting through one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix O conditions for which the aeroplane is not approved, and one standard cloud horizontal extent (32.2 km (17.4 nautical miles)) in Appendix C continuous maximum icing conditions. For the purposes of defining the landing detect-and-exit ice shape, the Appendix C approach and landing ice is defined as the ice accreted during: — a descent in the cruise configuration from the maximum vertical extent of the Appendix C continuous maximum icing environment to 610 m (2 000 feet) above the landing surface, — a transition to the approach configuration and manoeuvring for 15 minutes at 610 m (2 000 feet) above the landing surface, and — a descent from 610 m (2 000 feet) to 61 m (200 feet) above the landing surface with a transition to the landing configuration.
Ice Accretion Before the Ice Protection System Has Been Activated and is Performing its Intended Function	Ice accreted on protected and unprotected surfaces during the time it takes for icing conditions (either Appendix C or Appendix O) to be detected, the ice protection system to be activated, and the ice protection system to become fully effective in performing its intended function.
Ice Accretion in Appendix O Conditions Before Those Conditions Have Been Detected by the Flight crew and Actions Taken, in Accordance With the AFM, to Either Exit All Icing Conditions or Continue Flight in Appendix O Icing Conditions	Ice accreted on protected and unprotected surfaces during: — the time it takes to detect and identify Appendix O conditions (based on the method of detection) beyond those in which the aeroplane is certified to operate, and — the time it takes the flight crew to refer to and act on procedures, including coordinating with Air Traffic Control, to exit all icing conditions. — a minimum time period of two minutes should be used as the time needed for the flight crew to refer to and act on the procedures to exit all icing conditions after the Appendix O icing conditions are recognised.
Failures of the Ice Protection System	No accretion[2]

Notes:

1 Intentional flight, including Take-off, is not permitted into Appendix O conditions beyond those in which the aeroplane is certified to operate.

2 It is not necessary to consider an unintentional encounter with Appendix O icing conditions beyond those in which the aeroplane is certified to operate while operating with a failed ice protection system.

A1.4.3 Ice Accretions for Encounters with Appendix O Atmospheric Icing Conditions in Which the Aeroplane is Certified to Operate.

a. The applicant should use the ice accretions in Table 2 to evaluate compliance with the applicable CS-25 subpart B requirements for operating safely in the Appendix O atmospheric icing conditions for which approval is sought.

b. The decision about which ice accretions to use should include consideration of combinations of Appendix C and Appendix O icing conditions within the scenarios defined in paragraph A1.4.3(c) of this appendix. For example, flight in Appendix O conditions may result in ice accumulating, and potentially forming a ridge, behind a protected surface. Once this accretion site has been established, flight in Appendix C icing conditions for the remaining portion of the applicable flight phase scenario may result in a more critical additional accretion than would occur for continued flight in Appendix O icing conditions.

c. Table 2 shows the scenarios the applicant should use for determining ice accretions for certification for flight in the icing conditions of Appendix O to CS-25.

Table 2

Flight Phase/Condition	Appendix O Ice Accretion
Ground Roll	No accretion
Take-off	Take-off Ice Ice accretion occurring between the end of the take-off distance and 122 m (400 feet) above the take-off surface assuming ice accretion starts at the end of the take-off distance.
Final Take-off	Final Take-off Ice Ice accretion occurring between a height of 122 m (400 ft) above the take-off surface and the height at which the transition to the en-route configuration and speed is completed, or 457 m (1 500 feet) above the take-off surface, whichever is higher, assuming ice accretion starts at the end of the take-off distance.
En Route	En Route Ice Ice accreted during the en route phase of flight.
Holding	Holding Ice Ice accreted during a 45-minute hold with no reduction for horizontal cloud extent (that is, the hold is conducted entirely within the 32.2 km (17.4 nautical mile) standard cloud extent).
Approach	Approach Ice More critical ice accretion of: (1) Ice accreted during a descent in the cruise configuration from the maximum vertical extent of the Appendix O icing environment to 610 m (2 000 feet) above the landing surface, followed by: — transition to the approach configuration and — manoeuvring for 15 minutes at 610 m (2 000 feet) above the landing surface; or (2) Holding ice (if the aeroplane is certified for holding in Appendix O conditions).
Landing	Landing Ice More critical ice accretion of: (1) Approach ice plus ice accreted during descent from 610 m (2 000 feet) above the landing surface to 61 m (200 feet) above the landing surface with:

Flight Phase/Condition	Appendix O Ice Accretion
	— a transition to the landing configuration, followed by — a go-around manoeuvre beginning with the minimum climb gradient specified in CS 25.119 from 61 m (200 feet) to 610 m (2 000 feet) above the landing surface, and — holding for 15 minutes at 610 m (2 000 feet) above the landing surface in the approach configuration, and — a descent to the landing surface in the landing configuration, or (2) Holding ice (if the aeroplane is certified for holding in Appendix O conditions).
Ice Accretion Before the Ice Protection System has been Activated and is Performing its Intended Function	Ice accreted during the time it takes for the flight crew to recognise icing conditions and activate the ice protection system, plus the time for the ice protection system to perform its intended function.
Ice Accretion in Appendix O Conditions Before those Conditions have been Detected by the Flight crew and Actions Taken, in Accordance With the AFM, to Either Exit All Icing Conditions or Continue Flight in Appendix O Icing Conditions	Ice accreted during the time it takes for the flight crew to detect Appendix O conditions and refer to and initiate associated procedures, and any time it takes for systems to perform their intended functions (if applicable). Pre-detection ice need not be considered if there are no specific crew actions or systems changes associated with flight in Appendix O conditions.
Failures of the Ice Protection System	Same criteria as for Appendix C (see paragraph A1.3 of this appendix), but in Appendix O conditions.

[Amdt 25/3]
[Amdt 25/16]
[Amdt 25/18]

Appendix 2 – Artificial Ice Shapes

ED Decision 2015/008/R

A2.1 General.

A2.1.1 The artificial ice shapes used for flight testing should be those which have the most adverse effects on handling characteristics. If analytical data show that other reasonably expected ice shapes could be generated which could produce higher performance decrements, then the ice shape having the most adverse effect on handling characteristics may be used for performance tests provided that any difference in performance can be conservatively taken into account.

A2.1.2 The artificial shapes should be representative of natural icing conditions in terms of location, general shape, thickness and texture. Following determination of the form and surface texture of the ice shape under paragraph A2.2, a surface roughness for the shape should be agreed with the Agency as being representative of natural ice accretion.

A2.1.3 "Sandpaper Ice" is addressed in paragraph A2.3.

A2.2 Shape and Texture of Artificial Ice.

A2.2.1 The shape and texture of the artificial ice should be established and substantiated by agreed methods. Common practices include:

— use of computer codes,

— flight in measured natural icing conditions,

— icing wind tunnel tests, and

— flight in a controlled simulated icing cloud (e.g. from an icing tanker).

A2.2.2 In absence of another agreed definition of texture the following may be used:

— roughness height: 3 mm

— particle density: 8 to 10/cm²

A2.3 "Sandpaper Ice."

A2.3.1 "Sandpaper Ice" is the most critical thin, rough layer of ice. Any representation of "Sandpaper Ice" (e.g. carborundum paper no. 40) should be agreed by the Agency.

A2.3.2 Because sandpaper ice must be considered in the basic icing certification within the Appendix C environmental icing envelope, it does not need to be considered for certification of flight in Appendix O icing conditions.

A2.3.3 The spanwise and chordwise coverage should be consistent with the areas of ice accretion determined for the conditions of CS-25, Appendix C except that, for the zero g pushover manoeuvre of paragraph 6.9.4 of this AMC, the "Sandpaper Ice" may be restricted to the horizontal stabiliser if this can be shown to be conservative.

[Amdt 25/3]
[Amdt 25/16]

Appendix 3 – Design Features

ED Decision 2015/008/R

A3.1 Aeroplane Configuration and Ancestry. An important design feature of an overall aeroplane configuration that can affect performance, controllability and manoeuvrability is its size. In addition, the safety record of the aeroplane's closely-related ancestors may be taken into consideration.

A3.1.1 Size. The size of an aeroplane determines the sensitivity of its flight characteristics to ice thickness and roughness. The relative effect of a given ice height (or ice roughness height) decreases as aeroplane size increases.

A3.1.2 Ancestors. If a closely related ancestor aeroplane was certified for flight in icing conditions, its safety record may be used to evaluate its general arrangement and systems integration.

A3.2 Wing. Design features of a wing that can affect performance, controllability, and manoeuvrability include aerofoil type, leading edge devices and stall protection devices.

A3.2.1 Aerofoil. Aerodynamic effects of ice accretions result mainly from the effects of the ice accretion on the behaviour of the aerofoil’s boundary layer. The boundary layer is the layer of air close to the surface of the aerofoil that is moving across the aerofoil at a velocity lower than the freestream velocity, that is, the velocity of the aerofoil. Ice accretions that occur in areas favourable to keeping the boundary layer attached to the aircraft surface will result in effects that are less aerodynamically adverse than ice accretions that occur in areas less favourable to attached boundary layer conditions. Ice shapes that build up in areas of local airflow deceleration (positively increasing surface pressure), or result in conditions unfavourable to keeping attached flow conditions, as the airflow negotiates the ice surface, will result in the most adverse effects.

A3.2.2 Leading Edge Device. The presence of a leading edge device (such as a slat) reduces the percentage decrease in C_{LMAX} due to ice by increasing the overall level of C_L. Gapping the slat may improve the situation further. Leading edge devices can also reduce the loss in angle of attack at stall due to ice.

A3.2.3 Stall Protection Device. An aeroplane with an automatic slat-gapping device may generate a greater C_{LMAX} with ice than the certified C_{LMAX} with the slat sealed and a non-contaminated leading edge. This may provide effective protection against degradation in stall performance or characteristics.

A3.2.4 Lateral Control. The effectiveness of the lateral control system in icing conditions can be evaluated by comparison with closely related ancestor aeroplanes.

A3.3 Empennage. The effects of size and aerofoil type also apply to the horizontal and vertical tails. Other design features include tailplane sizing philosophy, aerofoil design, trimmable stabiliser, and control surface actuation. Since tails are usually not equipped with leading edge devices, the effects of ice on tail aerodynamics are similar to those on a wing with no leading edge devices. However, these effects usually result in changes to aeroplane handling and/or control characteristics rather than degraded performance.

A3.3.1 Tail Sizing. The effect on aeroplane handling characteristics depends on the tailplane design philosophy. The tailplane may be designed and sized to provide full functionality in icing conditions without ice protection, or it may be designed with a de-icing or anti-icing system.

A3.3.2 Horizontal Stabiliser Design. Cambered aerofoils and trimmable stabilisers may reduce the susceptibility and consequences of elevator hinge moment reversal due to ice-induced tailplane stall.

A3.3.3 Control Surface Actuation. Hydraulically powered irreversible elevator controls are not affected by ice-induced aerodynamic hinge moment reversal.

A3.3.4 Control Surface Size. For mechanical elevator controls, the size of the surface significantly affects the control force due to an ice-induced aerodynamic hinge moment reversal. Small surfaces are less susceptible to control difficulties for given hinge moment coefficients.

A3.3.5 Vertical Stabiliser Design. The effectiveness of the vertical stabiliser in icing conditions can be evaluated by comparison with closely-related ancestor aeroplanes.

A3.4 Aerodynamic Balancing of Flight Control Surfaces. The aerodynamic balance of unpowered or boosted reversible flight control surfaces is an important design feature to consider. The design should be carefully evaluated to account for the effects of ice accretion on flight control system hinge moment characteristics. Closely balanced controls may be vulnerable to overbalance in icing. The effect of ice in front of the control surface, or on the surface, may upset the balance of hinge moments leading to either increased positive force gradients or negative force gradients.

A3.4.1 This feature is particularly important with respect to lateral flight control systems when large aileron hinge moments are balanced by equally large hinge moments on the opposite aileron. Any asymmetric disturbance in flow which affects this critical balance can lead to a sudden uncommanded deflection of the control. This auto deflection, in extreme cases, may be to the control stops.

A3.5 Ice Protection/Detection System. The ice protection/detection system design philosophy may include design features that reduce the ice accretion on the wing and/or tailplane.

A3.5.1 Wing Ice Protection/Detection. A primary ice detection system that automatically activates a wing de-icing or anti-icing system may ensure that there is no significant ice accretion on wings that are susceptible to performance losses with small amounts of ice.

A3.5.1.1 If the wing leading edge is not entirely protected, the part that is protected may be selected to provide good handling characteristics at stall, with an acceptable performance degradation.

A3.5.2 Tail Ice Protection/Detection. A primary ice detection system may automatically activate a tailplane de-icing or anti-icing system on aeroplanes that do not have visible cues for system operation.

A3.5.2.1 An ice protection system on the unshielded aerodynamic balances of aeroplanes with unpowered reversible controls can reduce the risk of ice-induced aerodynamic hinge moment reversal.

[Amdt 25/3]
[Amdt 25/16]

Appendix 4 – Examples of Aeroplane Flight Manual Limitations and Operating Procedures for Operations in Supercooled Large Drop Icing Conditions

ED Decision 2015/008/R

A4.1 Aeroplane approved for flight in Appendix C icing conditions but not approved for flight in Appendix O icing conditions.

a. AFM Limitations.

Intentional flight, including take-off and landing, into supercooled large drop (SLD) icing conditions, which includes freezing drizzle or freezing rain, is prohibited. If freezing drizzle or freezing rain conditions are encountered, or if [insert cue description here], immediately request priority handling from air traffic control to facilitate a route or altitude change to exit all icing conditions. Stay clear of all icing conditions for the remainder of the flight, including landing, unless it can be determined that ice accretions no longer remain on the airframe.

b. AFM Operating Procedures (Normal Procedures Section).

Freezing drizzle and freezing rain conditions are severe icing conditions for this aeroplane. Intentional flight, including take-off and landing, into freezing drizzle or freezing rain conditions is prohibited. A flight delay or diversion to an alternate airport is required if these conditions exist at the departure or destination airports.

[insert cue description here] is one indication of severe icing for this aeroplane. If severe icing is encountered, immediately request priority handling from air traffic control to facilitate a route or altitude change to exit all icing conditions. Stay clear of all icing conditions for the remainder of the flight, including landing, unless it can be determined that ice accretions no longer remain on the airframe.

c. Flight Crew Operating Manual Operating Procedures.

Warning: Hazardous icing effects may result from environmental conditions outside of those for which this aeroplane is certified. Flight into unapproved icing conditions may result in ice build-up on protected surfaces exceeding the capability of the ice protection system, or in ice forming aft of the protected surfaces. This ice might not be shed when using the ice protection systems, and may seriously degrade performance and controllability of the aeroplane.

Operations in icing conditions were evaluated as part of the certification process for this aeroplane. Freezing drizzle and freezing rain conditions were not evaluated and are considered severe icing conditions for this aeroplane.

Intentional flight, including take-off and landing, into freezing drizzle or freezing rain conditions is prohibited. A flight delay or diversion to an alternate airport is required if these conditions exist at the departure or destination airports. [insert cue description here] is an indication of severe icing conditions that exceed those for which this aeroplane is certified. If severe icing is encountered, immediately request priority handling from air traffic control to facilitate a route or altitude change to exit all icing conditions. Stay clear of all icing conditions for the remainder of the flight, including landing, unless it can be determined that ice accretions no longer remain on the airframe.