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of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Performance and Handling Characteristics in Icing Conditions

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This advisory circular describes an acceptable means of showing compliance with the airplane performance and handling characteristics certification requirements for flight in the icing conditions defined in Appendices C and O of Title 14, Code of Federal Regulations part 25.

If you have suggestions for improving this AC, you may use the feedback form at the end of this AC.

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CHAPTER 1. INTRODUCTION

1.1 Purpose.

1.1.1 This advisory circular (AC) describes an acceptable means of showing compliance with the airplane performance and handling characteristics certification requirements for flight in the icing conditions defined in Appendices C and O of Title 14, Code of Federal Regulations (14 CFR) part 25. Part 25 contains the airworthiness standards for transport category airplanes.

1.1.2 The following appendices appear at the end of this AC:

- Appendix A, *Airframe Ice Accretions*.
- Appendix B, *Simulated Ice Accretions*.
- Appendix C, *Design Features*.
- Appendix D, *Examples of Airplane Flight Manual Limitations and Operating Procedures for Operations in Supercooled Large Drop Icing Conditions*.
- Appendix E, *Related Regulations and Advisory Circulars*.
- Appendix F, *Acronyms and Definitions*.

1.2 Applicability.

1.2.1 The guidance provided in this AC is directed towards airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers, flight test pilots, and their designees.

1.2.2 The material in this AC is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for showing compliance with the applicable regulations. The FAA will consider other methods of showing compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. If, however, we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation or design changes as a basis for finding compliance.

1.2.3 The material in this AC does not change or create any additional, regulatory requirements, nor does it authorize changes in, or permit deviations from, regulatory requirements.

1.3 **Cancellation.**

This AC cancels AC 25-25, *Performance and Handling Characteristics in the Icing Conditions Specified in Part 25, Appendix C*, dated September 10, 2007.

CHAPTER 2. REQUIREMENTS AND GUIDANCE

2.1 Overview.

2.1.1 For certification for flight in icing conditions, § 25.21(g)(2) requires that an airplane meet certain performance and handling qualities requirements while operating in the icing environment defined in part 25, Appendix C. In addition, § 25.1420 requires applicants to consider icing conditions beyond those covered by Appendix C for airplanes with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls. The additional icing conditions that must be considered for these airplanes are the supercooled large drop (SLD) icing conditions defined in part 25, Appendix O. Appendix A of this AC provides detailed guidance for determining ice accretions in both Appendix C and Appendix O icing conditions that can be used for showing compliance.

2.1.2 For airplanes with a maximum takeoff weight less of than 60,000 pounds or with reversible flight controls to be certified for flight in icing conditions, § 25.1420 requires applicants to do one of the following:

2.1.2.1 Not seek approval for flight in the SLD atmospheric icing conditions defined in Appendix O.

2.1.2.2 Seek approval for flight in only a portion of Appendix O icing conditions.

2.1.2.3 Seek approval for flight throughout the entire Appendix O atmospheric icing envelope.

2.1.3 For airplanes with a maximum takeoff weight equal to or greater than 60,000 pounds that do not have reversible flight controls, applicants are not required to consider the icing conditions of Appendix O. The guidance provided in this AC related to Appendix O icing conditions does not apply to those airplanes.

2.1.4 Because an airplane may encounter SLD icing conditions at any time while flying in icing conditions, certain safety requirements must be met for the SLD icing conditions of Appendix O for airplanes with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls, even if the airplane will not be certified for flight in the complete range of Appendix O atmospheric icing conditions. For those airplanes that will not be certified for flight in all icing conditions defined in Appendix O, § 25.21(g)(3) requires certain part 25, subpart B, requirements to be met in SLD atmospheric icing conditions beyond those for which the airplane will be certified. Compliance with these requirements in addition to the requirements for flight in Appendix C icing conditions are intended to provide adequate airplane performance and handling qualities for a safe exit from all icing conditions after an encounter with SLD atmospheric icing conditions beyond those for which the airplane will be certified.

2.1.5 If an airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls is not to be certified for flight in all of the SLD icing conditions of Appendix O, then § 25.1420 requires a means of indicating when the airplane has encountered icing conditions beyond those for which it is certified. See AC 25-28, *Compliance of Transport Category Airplanes for Flight in Icing Conditions*, dated October 27, 2014, for guidance on acceptable means of detecting and indicating when the airplane has encountered icing conditions beyond those for which it is certified. The applicant should provide procedures in the airplane flight manual (AFM) that will enable the flightcrew to make a safe exit from all icing conditions after an encounter with icing conditions beyond those for which the airplane is certified.

2.1.6 To certify an airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls for operations in Appendix O icing conditions only for certain flight phase(s), the applicant should define the flight phase(s) for which approval is sought in a way that will allow a flightcrew to easily determine whether the airplane is operating inside or outside its certified icing envelope. The critical ice accretion or accretions used to show compliance with the applicable requirements should cover the range of airplane configurations, operating speeds, angles-of-attack, and engine thrust or power settings that may be encountered during that phase of flight (not just at the conditions specified in the part 25, subpart B, requirements). For the ice accretion scenarios defined in paragraph A.4.3.3 of Appendix A of this AC, the applicable flight phases are takeoff (including the ground roll, takeoff, and final takeoff segments), en route, holding, and approach/landing (including both the approach and landing segments).

2.1.7 Ice accretions used to show compliance with the applicable subpart B regulations should be consistent with the extent of the desired certification for flight in icing conditions. Appendices C and O define the ice accretions, as a function of flight phase, that must be considered for certification approval for flight in those icing conditions. Any of the applicable ice accretions (or a composite accretion representing a combination of accretions) may be used to show compliance with a particular subpart B requirement if it is either the ice accretion identified in the requirement or one shown to be more conservative than that. In addition, the ice accretion with the most adverse effect on handling characteristics may be used for compliance with the airplane performance requirements if each 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. For example, if the applicant desires certification for flight in the SLD icing conditions of Appendix O in addition to those of Appendix C, compliance with the applicable subpart B requirements may be shown using the most critical of the Appendix C and Appendix O ice accretions.

2.1.8 Certification experience has shown that it is usually unnecessary to consider ice accumulation on the propeller, induction system, or engine components of an inoperative engine when demonstrating airplane handling qualities. Similarly, for ice accreted anywhere on the airplane, the mass of any accreted ice need not normally be considered.

2.1.9 Requirements and guidance for flight in icing conditions also apply to operation of the airplane after leaving icing conditions until it is determined that no ice accretions remain on the airplane's critical surfaces.

2.1.10 Ice-contaminated tailplane stall (ICTS) refers to a phenomenon identified as a causal factor in several airplane incidents and accidents. It results from airflow separation on the lower surface of the tailplane because ice is present. ICTS can occur if the angle-of-attack of the horizontal tailplane exceeds its stall angle-of-attack. Even very small quantities of ice on the tailplane leading edge can significantly reduce the angle-of-attack at which the tailplane stalls. An increase in tailplane angle-of-attack, which may lead to a tailplane stall, can result from changes in airplane configuration (for example, extending flaps, which increases the downwash angle at the tail or the pitch trim required) or flight conditions (a high approach speed, gusts, or maneuvering, for example). An ICTS is characterized by reduction or loss of pitch control or pitch stability while in, or soon after leaving, icing conditions. A flight test procedure for determining susceptibility to ICTS is presented in paragraph 4.9.4, *Low g Maneuvers and Sideslips*, of this AC.

2.1.10.1 For airplanes with unpowered longitudinal control systems, the pressure differential between the upper and lower surfaces of the stalled tailplane may result in a high elevator hinge moment, forcing the elevator trailing edge down. This elevator hinge moment reversal can be of sufficient magnitude to cause the longitudinal control (for example, the control column) to suddenly move forward with a force beyond the capability of the flightcrew to overcome. On some airplanes, ICTS has been caused by a lateral flow component coming off the vertical stabilizer, as may occur in sideslip conditions or because of a wind gust with a lateral component.

2.1.10.2 Aerodynamic effects of reduced tailplane lift should be considered for all airplanes, including those with powered controls. Airplanes susceptible to this phenomenon are those having a near zero or negative tailplane stall margin with tailplane ice contamination.

2.1.11 There have been airplane controllability incidents in icing conditions as a result of ice on unprotected leading edges of extended trailing edge flaps or flap vanes. The primary safety concern illustrated by these incidents is the potential for controllability problems due to the accretion of ice on trailing edge flap or flap vane leading edges while extending flaps in icing conditions. The flight tests specified in table 4-5 of this AC, in which handling characteristics are tested at each flap position while ice is being accreted in natural icing conditions, are intended to investigate this safety concern. Unless controllability concerns arise from these tests, it is not necessary to conduct flight tests with simulated ice accretions on the extended trailing edge flap or flap vanes or to include extended trailing edge flap or flap vane ice accretions when evaluating airplane performance with flaps extended.

2.1.12 SLD icing conditions, or runback ice in any icing condition, can cause a ridge of ice to form aft of the protected area on the upper surface of the wing. This can lead to separated airflow over the aileron. Ice-induced airflow separation upstream of the aileron can have a significant effect on aileron hinge moment. Depending on the extent of the separated flow and the design of the flight control system, ice accretion upstream of the aileron may lead to aileron hinge moment reversal, reduced aileron effectiveness, and aileron control reversal. Although airplanes with deicing boots and unpowered aileron controls are most susceptible to this problem, all airplanes should be evaluated for roll control capability in icing conditions. Acceptable flight test procedures for checking roll control capability are presented in paragraphs 4.9.3, 4.15, and 4.17.2.5 of this AC and consist of bank-to-bank roll maneuvers, steady heading sideslips, and rolling maneuvers at stall warning speed.

2.2 Proof of Compliance, § 25.21(g).

2.2.1 You may show compliance with certification requirements for flight in icing conditions by any of the means discussed in chapter 3, *Acceptable Means of Compliance–General*, paragraph 3.1, *Overview*, of this AC.

2.2.2 Certification experience has shown that, for airplanes of conventional design applying for flight in icing conditions, it is usually not necessary to perform additional detailed substantiation of compliance with requirements of the following sections of part 25:

- § 25.23, *Load distribution limits*.
- § 25.25, *Weight limits*.
- § 25.27, *Center of gravity limits*.
- § 25.29, *Empty weight and corresponding center of gravity*.
- § 25.31, *Removable ballast*.
- § 25.231, *Longitudinal stability and control*.
- § 25.233, *Directional stability and control*.
- § 25.235, *Taxiing condition*.
- § 25.253(a) and (b), *High-speed characteristics*.
- § 25.255, *Out-of-trim characteristics*.

2.2.3 If different stall warning system or stall identification system activation settings are used for flight in icing conditions (for example, if the stall warning or stall identification system activation settings are changed when the ice protection system is activated), it is acceptable to return to the non-icing settings when the critical wing surfaces are free of ice. The applicant should validate that the means for determining when the critical wing surfaces are free of ice accretions is reliable under all expected operating conditions.

2.3 Propeller Speed and Pitch Limits, § 25.33.

Certification experience in meeting § 25.33 has shown that it may be necessary to impose additional propeller speed limits for operations in icing conditions.

2.4 Performance—General, § 25.101.

2.4.1 This regulation states that the propulsive power or thrust available for each flight condition must be appropriate to the airplane operating limitations and normal procedures for flight in icing conditions.

2.4.2 In general, propulsive power or thrust available may be determined by suitable analysis, substantiated when required by appropriate flight tests. An example would be when determining the power or thrust available for showing compliance with § 25.119. The following aspects should be considered:

2.4.2.1 Operation of induction system ice protection.

2.4.2.2 Operation of propeller ice protection.

2.4.2.3 Operation of engine ice protection.

2.4.2.4 Operation of airframe ice protection.

2.4.3 The applicant should consider the following when determining the change in performance due to flight in icing conditions:

2.4.3.1 Thrust loss due to ice accretion on propulsion system components, including the engine induction system and other engine components, and the propeller spinner and blades, with normal operation of the ice protection system.

2.4.3.2 Incremental airframe drag due to ice accretion with normal operation of the ice protection system.

2.4.3.3 Changes in operating speeds provided in the AFM for flight in icing conditions.

2.4.4 Certification experience has shown that a suitable conservative analysis or flight test can determine any increase in drag (or decrease in thrust) resulting from ice accumulation on the landing gear, propeller, induction system, and engine components. Certification experience has also shown that runback ice may be critical for propellers, so runback ice on the propeller should be addressed. Research has shown that ice accretions on propellers, and resulting thrust loss, may be larger in Appendix O SLD icing conditions than in Appendix C icing conditions for some designs. Applicants may conduct airplane performance checks in natural icing conditions, icing tanker tests, icing wind tunnel tests, or propose the use of an assumed (conservative) loss in propeller efficiency. Testing should include a range of outside air temperatures, including warmer (near freezing) temperatures that could result in runback icing.

2.4.5 Apart from using appropriate speed adjustments to account for operation in icing conditions, all changes in the procedures established for takeoff or go-around should be agreed to by the responsible aircraft certification office (ACO).

2.5 Stall Speed, § 25.103.

Certification experience in meeting this requirement has shown that, for airplanes of conventional design, the effects of Mach number on stall speeds is unaffected by the presence of ice accretions.

2.6 Failure Conditions, § 25.1309.

2.6.1 The applicant should analyze failure modes of the ice protection system and resulting effects on airplane handling and performance in accordance with § 25.1309. In determining the probability of a failure condition, the applicant should assume that the probability of entering the icing conditions defined in part 25, Appendix C, is "1." As explained in AC 25-28 and AC 25.1419-2, *Compliance with the Ice Protection Requirements of § 25.1419(e), (f), (g), and (h)*, dated October 27, 2009, on an annual basis, the average probability of encountering the icing conditions defined in Appendix O may be assumed to be 1×10^{-2} per flight hour. This probability should not be reduced on a phase-of-flight basis. The ice accretion to use for failures of the ice protection system is defined in paragraph A.3 of appendix A of this AC.

Note: This guidance is not intended to apply to failures of other systems (or the engines) that may indirectly affect airplane handling and performance in icing conditions due to any effects of those failures on an otherwise normally functioning ice protection system. In such situations, the ice protection system itself is considered to be operating normally, although performance of its anti-ice or deice function may be degraded.

2.6.2 The guidance in this AC for a normal (that is, non-failure) condition is applicable, with the failure ice accretion, for probable failure conditions of the ice protection system that are (1) not annunciated to the flightcrew, or (2) annunciated to the flightcrew, but the associated procedure does not require exiting icing conditions.

2.6.3 For probable ice protection failure conditions annunciated to the flightcrew, when the associated operating procedure requires the airplane to leave the icing conditions as soon as practicable, the following applies: The applicant should show that, with the ice accretion resulting from the failure, the airplane's performance and handling characteristics are adequate as determined by a system safety analysis in accordance with § 25.1309. The operating procedures and related speeds may restrict the airplane's operating envelope, but the size of the restricted envelope should be consistent with the safety analysis.

2.6.4 For failure conditions that are improbable but not extremely improbable, the analysis and substantiation of continued safe flight and landing required by § 25.1309 should take into consideration whether the failure is annunciated, and what associated operating procedures and speeds would be used following the failure condition.

2.7 Flight-Related Systems.

The applicant should consider flight-related systems aspects when determining compliance with the subpart B flight requirements for flight in icing conditions. For example, the following considerations may be relevant.

2.7.1 Ice protection systems may not adequately perform their anti-ice or deice functions at some engine power or thrust settings. This may result in a need to establish a minimum useable power or thrust setting for operation in icing conditions, and this can affect descent or approach capabilities. The applicant should also consider the effect of power or thrust settings in determining the applicable ice accretions. For example, at low engine power or thrust, a thermal bleed air system may not be able to evaporate the liquid water completely after melting the ice, resulting in the potential for runback ice.

2.7.2 Ice may block control surface gaps, or freeze seals, causing increased control forces, control restrictions, or blockage.

2.7.3 Ice may block unprotected inlets and vents. This may affect flight controls or the propulsive thrust available, as well as powerplant control and cooling and aerodynamic drag.

2.7.4 Airspeed, altitude, or angle-of-attack sensing errors may occur due to ice accretion forward of the sensors (for example, radome ice). Control feel systems that use dynamic pressure inputs may also be affected.

2.7.5 There may be an effect on operation of stall warning and stall identification reset features for flight in icing conditions, including effects of failure to operate.

2.7.6 Operation of icing condition sensors, ice accretion sensors, and automatic or manual activation of ice protection systems may be affected.

2.7.7 Flight guidance and automatic flight control systems operation may be affected. See AC 25.1329-1C, *Approval of Flight Guidance Systems*, dated October 27, 2014, for guidance on compliance with § 25.1329 for flight in icing conditions, including stall and maneuverability evaluations with the airplane under flight guidance system control.

2.7.8 There may be an effect on installed thrust. Consideration of installed thrust includes consideration of ice protection systems operation when establishing acceptable power or thrust setting procedures, and when evaluating control, stability, temperature lapse rates, rotor speed margins, temperature margins, automatic takeoff thrust control system (ATTCS) operation, and power or thrust lever angle functions.

2.8 Airplane Flight Manual, § 25.1581 through § 25.1587.

2.8.1 Section 25.1581 states that an AFM must be furnished with each airplane and must contain information necessary for safe operation because of design, operating, or handling characteristics. To comply with this requirement, the AFM Limitations section should include the following:

2.8.1.1 The limitations required to ensure safe operation in icing conditions.

2.8.1.2 Performance limitations. These should be presented for flight in icing and reflect all effects on lift, drag, thrust, and operating speeds related to operating in icing conditions. These limitations may be presented in the AFM performance section and included as limitations by specific reference in the AFM Limitations section.

2.8.1.3 All airspeed limitations associated with flight in icing conditions, such as the minimum airspeed for each normal airplane configuration in icing conditions.

2.8.1.4 As applicable, a statement similar to the following:

"In icing conditions, this airplane must be operated and its ice protection systems used as described in the operating procedures section of this manual. Where specific operational speeds and performance information have been established for such conditions, this information must be used."

2.8.1.5 For turbojet airplanes without leading edge high-lift devices, unless all ice contamination would otherwise be detected and removed from the wing leading edges and upper surfaces before takeoff, statements similar to the following:

"Takeoff may not be initiated unless the flightcrew verifies that a visual and tactile (hands on surface) check of the wing upper surfaces and leading edges has been accomplished, and the wing has been found to be free of frost, ice, or snow in conditions conducive to ice/frost/snow formation. Conditions conducive to ice/frost/snow formation exist whenever the outside air temperature is below 6 °C (42 °F) and any of the following exists:

- Visible moisture is present in the air or on the wing.
- The difference between the dew point temperature and the outside air temperature is less than 3 °C (5 °F).
- Standing water, slush, ice, or snow is present on taxiways or runways."

Note: An acceptable means for showing that residual ice contamination could be detected and removed without needing a visual and tactile check would be to show that, on an airplane operated in accordance with § 121.629(c), a wing ice protection system or primary wing ice detection system can be used while the airplane is on the ground. In this case, the

AFM Limitations section should include a statement similar to the following:

"The [wing ice protection system or ice detection system–applicant to identify which one] must be operating after deicing until immediately before starting the takeoff roll whenever conditions conducive to ice/frost/snow formation exist."

2.8.2 To comply with § 25.1583(e), *Kinds of operation*, the AFM Limitations section should clearly identify the extent of each approval to operate in icing conditions, including the extent of any approval to operate in the SLD atmospheric icing conditions defined in part 25, Appendix O.

2.8.3 For airplanes not certified to operate throughout the atmospheric icing envelope of part 25, Appendix O, for every flight phase, the Limitations section of the AFM should also identify the means for detecting when the certified icing conditions have been exceeded and state that intentional flight, including takeoff and landing, into these conditions is prohibited. A requirement to exit all icing conditions must be included if icing conditions for which the airplane is not certified are encountered.

2.8.4 To comply with § 25.1585, the AFM operating procedures should include the following information:

2.8.4.1 Flight in icing conditions operating procedures should include both (1) normal operation of the ice protection system, and (2) operation of the airplane following ice protection system failures. All changes in procedures for other airplane system failures that affect the capability of the airplane to operate in icing conditions should be included.

2.8.4.2 Normal operating procedures should reflect the procedures used to certify the airplane for flight in icing conditions. These include configurations, speeds, ice protection system operation, and powerplant and systems operation for takeoff, climb, cruise, descent, holding, go-around, and landing. For airplanes not certified for flight in all of the SLD atmospheric icing conditions defined in part 25, Appendix O, procedures should be provided for safely exiting all icing conditions if the airplane encounters Appendix O icing conditions that exceed the icing conditions for which the airplane is certified.

2.8.4.3 For turbojet airplanes without leading edge high-lift devices, the AFM normal operating procedures section should contain a statement similar to the following, along with procedures to ensure that such contamination is detected and removed before takeoff:

"**WARNING**
Minute amounts of ice or other contamination on the leading edges or wing upper surfaces can result in a stall without warning, leading to loss of control on takeoff."

2.8.4.4 Non-normal operating procedures should include procedures to be followed in the event of annunciated ice protection system failures and suspected unannunciated ice protection system failures. If flight in icing conditions results in any changes to other non-normal procedures contained in the AFM, these changes should also be included.

2.8.5 Performance information, derived in accordance with part 25, subpart B, should be provided in the AFM for all relevant phases of flight in accordance with § 25.1587.

2.8.6 Examples of AFM limitations and operating procedures for operations in SLD icing conditions (i.e., Appendix O) are contained in appendix D of this AC.

CHAPTER 3. ACCEPTABLE MEANS OF COMPLIANCE—GENERAL

3.1 Overview.

3.1.1 This chapter describes acceptable methods and procedures that an applicant may use to show that an airplane meets the airplane performance and handling characteristics requirements of subpart B in the atmospheric icing conditions of part 25, Appendices C and O.

3.1.2 The applicant should show compliance by one or more of the methods listed in this chapter as agreed to by the responsible ACO.

3.1.3 The compliance process should address all phases of flight, including takeoff, climb, cruise, holding, descent, approach, landing, and go-around, as appropriate to the airplane type, considering its typical operating regime and the extent of its certification approval for operation in the atmospheric icing conditions of part 25, Appendix O.

3.1.4 The design features described in appendix C of this AC should be considered when determining the extent of the substantiation program.

3.1.5 Appropriate means for showing compliance include the items listed in table 3-1 below. These compliance means are explained in more detail in following chapters of this AC.

Table 3-1. Means for Showing Compliance

Item	Description
Flight Testing	Flight testing in dry air using simulated ice accretions or with ice accretions created in natural icing conditions.
Wind Tunnel Testing and Analysis	An analysis of results from wind tunnel tests with simulated or actual ice accretions.
Engineering Simulator Testing and Analysis	An analysis of results from engineering simulator tests.
Engineering Analysis	An analysis that may include the results from any of the other means of compliance as well as the use of engineering judgment.
Ancestor Airplane Analysis	An analysis of results from a closely related ancestor airplane (an airplane model from which this airplane model is a derivative).

3.1.6 Means of compliance guidance for determining the applicable ice accretion on the airframe is provided in appendix A of this AC.

3.1.7 Guidance for developing simulated ice accretions is given in appendix B of this AC.

3.2 Flight Testing.

3.2.1 Overview.

3.2.1.1 Section 21.35 requires applicants to perform all flight tests that the Administrator finds necessary to show compliance with the applicable requirements of part 25.

3.2.1.2 The extent of the flight test program should consider results of certification flight tests conducted with the uncontaminated airplane. This is the airplane without ice accretions, or the “clean” airplane. Design features of the airplane as discussed in appendix C of this AC should also be considered.

3.2.1.3 It is not necessary to repeat, this time with ice accretions, the extensive airplane performance and handling characteristics test program that is conducted with the uncontaminated airplane. A suitable program sufficient to demonstrate compliance with the requirements can be established from experience with airplanes of similar size, and from review of design features of the ice protection system, control system, wing, horizontal and vertical stabilizer, and the performance and handling characteristics of the uncontaminated airplane. In particular, it is not necessary to investigate all weight and center-of-gravity combinations when results from the uncontaminated airplane clearly indicate the most critical combination to be tested. It is also not usually necessary to investigate the flight characteristics of the airplane with ice accretions at high altitude (that is, above the highest altitude for the atmospheric icing envelope specified in part 25, Appendices C and O) if the ice protection system continues to provide the same level of protection as at lower altitudes.

3.2.1.4 Certification experience has shown that flight tests are usually necessary to evaluate the consequences of ice protection system failures on airplane performance and handling characteristics, and to demonstrate that the airplane is capable of continued safe flight and landing.

3.2.1.5 An example of an acceptable flight test program is provided in chapter 4, *Acceptable Means of Compliance—Flight Test Program*, of this AC.

3.2.2 Flight Testing Using Approved Simulated Ice Accretions.

3.2.2.1 Tests for airplane performance and handling characteristics in icing conditions may be based on flight testing performed in dry air using simulated ice accretions that have been agreed to by the responsible ACO.

3.2.2.2 Additional limited flight tests should be conducted in natural icing conditions, as discussed in paragraph 3.2.3.2 below.

3.2.3 Flight Testing in Natural Icing Conditions.

3.2.3.1 If the applicant uses flight testing with ice accretions obtained in natural atmospheric icing conditions as the primary means of showing compliance, all relevant meteorological conditions (including liquid water content (LWC) and median volume diameter (MVD) of the cloud drops) should be measured and recorded. (The Appendix C icing envelopes use the term mean effective diameter (MED) rather than MVD, but this equates to MVD for the instrumentation used and the drop size distribution assumed at the time those envelopes were established.) The tests should ensure good coverage of the atmospheric icing conditions of part 25, Appendices C and O (consistent with the extent of the certification approval sought for operation in Appendix O icing conditions) and, in particular, the critical conditions for the airplane. The conditions for accumulating ice (including the icing atmosphere, airplane configuration, speed, and duration of exposure) should be agreed to by the responsible ACO.

3.2.3.2 If the applicant uses flight testing with simulated ice accretions as the primary means of showing compliance, additional limited flight tests should be conducted with ice accretions obtained in natural icing conditions. The objective of these tests is to corroborate the simulated ice accretions, and the handling characteristics and performance results obtained in flight testing with the simulated ice accretions. It is not necessary to measure the atmospheric icing characteristics (for example, LWC and MVD) of these flight test icing conditions. For derivative airplanes with aerodynamic characteristics and ice protection systems similar to the ancestor airplane, it may not be necessary to carry out additional flight tests in natural icing conditions if such tests have already been performed with the ancestor airplane. Depending on the extent of the Appendix O icing conditions for which certification is being sought, and the means used for showing compliance with the performance and handling characteristics requirements, it may also not be necessary to conduct flight tests in the natural icing conditions of Appendix O. See AC 25-28 for guidance on when it is necessary to conduct flight tests in the natural atmospheric icing conditions of Appendix O.

3.3 **Wind Tunnel Testing and Analysis.**

To help substantiate acceptable performance and handling characteristics, the applicant may use analysis of results of dry air wind tunnel testing of models with the simulated ice accretions defined in Appendices C and O.

3.4 **Engineering Simulator Testing and Analysis.**

Results of an engineering simulator airplane analysis that includes effects of ice accretions defined in Appendices C and O may be used to help substantiate acceptable handling characteristics. Data used to model the effects of ice accretions for the engineering simulator may be based on results of dry air wind tunnel tests, flight tests, computational analysis, or on engineering judgment.

3.5 **Engineering Analysis.**

To help substantiate acceptable performance and handling characteristics, the applicant may use an engineering analysis that includes effects of the ice accretions defined in Appendices C and O. Effects of the ice accretions used in this analysis may be determined by analyzing results of dry air wind tunnel tests, flight tests, computational analyses, engineering simulator analyses, or by engineering judgment.

3.6 **Ancestor Airplane Analysis.**

3.6.1 To help substantiate acceptable performance and handling characteristics, the applicant may use an analysis of an ancestor airplane that includes effects of ice accretions as defined in Appendices C and O. This analysis should consider the similarity of the airplane configuration, operating envelope, performance and handling characteristics, and ice protection system of the ancestor airplane to the one being certified.

3.6.2 The analysis may include flight test data, dry air wind tunnel test data, icing tunnel test data, engineering simulator analysis, service history, or engineering judgment.

CHAPTER 4. ACCEPTABLE MEANS OF COMPLIANCE—FLIGHT TEST PROGRAM

4.1 Overview.

4.1.1 This chapter provides guidance for developing an acceptable flight test program. Such a test program may be used if the applicant selects flight testing as the primary means for showing compliance with the requirements for airplane performance and handling qualities for flight in icing conditions and if that method of showing compliance is agreed to by the responsible ACO.

4.1.2 Section 25.21(a)(1) states that compliance with each requirement of subpart B must be shown by tests upon an airplane of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing. In accordance with § 25.21(a)(1), calculations, if used, must provide at least the same degree of confidence of compliance as testing would provide.

4.1.3 Ice accretions for each flight phase are defined in part 25, part II of Appendices C and O. Additional guidance for determining the applicable ice accretions is provided in appendix A of this AC.

4.1.4 This example test program uses the holding ice accretion for the majority of the testing, assuming that it is the most conservative ice accretion. However, in accordance with part 25, Appendix C, part II(b), and part 25, Appendix O, part II(e), if the holding ice accretion is not as conservative as the ice accretion appropriate to the flight phase, then the ice accretion appropriate to the flight phase and icing conditions of Appendix C or O, as applicable, or a more conservative ice accretion, must be used. In general, the applicant may choose to use either a conservative ice accretion or the specific ice accretion appropriate to the particular phase of flight and icing conditions.

4.1.5 For the approach and landing configurations, in accordance with the guidance provided in paragraph 2.1.11 of this AC, the flight tests in natural icing conditions specified in table 4-5 of this AC are usually sufficient to evaluate whether ice accretions on trailing edge flaps adversely affect airplane performance or handling qualities. If these tests show that airplane performance or handling qualities are adversely affected, additional tests may be necessary to show compliance with the airplane performance and handling qualities requirements.

4.1.6 Unless otherwise specified, the speeds (for example, V_{SR}, V_{REF}, V_2, etc.) referenced in the flight tests described in this AC refer to the speeds used with the appropriate ice accretion on the airplane.

4.2 Stall Speed, § 25.103.

4.2.1 The stall speed for intermediate high lift configurations (for takeoff configurations, for example) can normally be obtained by interpolation. However, additional tests may be necessary if—

4.2.1.1 A stall identification system (for example, a stick pusher) activation point is set as a function of the high lift configuration,

4.2.1.2 The activation point is reset for icing conditions, or

4.2.1.3 Significant configuration changes occur with extension of trailing edge flaps (such as extension of wing leading edge high lift devices).

4.2.2 Acceptable Test Program.

The following specifications represent an example of an acceptable test program subject to the provisions outlined paragraph 4.2.1 of this AC.

Maneuvers

4.2.2.1 Load the airplane to a forward center-of-gravity position appropriate to the airplane configuration.

4.2.2.2 Conduct the test at the stall test altitude used in non-icing tests.

4.2.2.3 Trim at an initial speed of 1.13 to 1.30 V_{SR}. Decrease speed at a rate not to exceed 1 knot per second until an acceptable stall identification is obtained. Perform this maneuver with the following ice accretions:

4.2.2.3.1 In high lift devices retracted configuration—final takeoff ice.

4.2.2.3.2 In high lift devices retracted configuration—en route ice.

4.2.2.3.3 In holding configuration—holding ice.

4.2.2.3.4 In lowest lift takeoff configuration—holding ice.

4.2.2.3.5 In highest lift takeoff configuration—takeoff ice.

4.2.2.3.6 In highest lift landing configuration—holding ice.

4.3 Accelerate–Stop Distance, § 25.109.

To comply with this requirement, the effect of any increase in V_1 for taking off in icing conditions may be determined by a suitable analysis.

4.4 Takeoff Path, § 25.111.

In accordance with § 25.105(a), the applicant should conduct takeoff evaluations to substantiate the speed schedule and distances for takeoff in icing conditions if the following applies:

4.4.1 V_{SR} in the configuration defined by § 25.121(b) with the takeoff ice accretion exceeding V_{SR} for the same configuration without ice accretions by more than the greater of 3 knots or 3 percent.

4.4.2 Any need for a takeoff speed increase, and any effects of thrust loss or drag increase on the takeoff path, may be determined by a suitable analysis.

4.5 Landing Climb: All–Engines–Operating, § 25.119.

The following specifications represent an example of an acceptable test program for showing compliance with § 25.119.

Maneuvers

4.5.1 The holding ice accretion should be used.

4.5.2 The airplane should be loaded to a forward center-of-gravity position appropriate to the airplane configuration.

4.5.3 The airplane should be in the highest lift landing configuration, at a landing climb speed no greater than V_{REF}.

4.5.4 Stabilize the airplane at the specified speed and conduct two climbs or drag polar checks as agreed to by the responsible ACO.

4.6 Climb: One-Engine-Inoperative, § 25.121.

The following specifications represent an example of an acceptable test program for showing compliance with § 25.121.

Maneuvers

4.6.1 The airplane should be loaded to a forward center-of-gravity position appropriate to the configuration.

4.6.2 Stabilize the airplane at the specified speed with one engine inoperative (or simulated inoperative if all relevant effects of an inoperative engine can be taken into account) and conduct two climbs or drag polar checks in each of the following airplane configurations, with the specified ice accretions, to substantiate the asymmetric drag increment as agreed to by the responsible ACO.

4.6.2.1 High lift devices retracted configuration, final takeoff climb speed—final takeoff ice.

4.6.2.2 Lowest lift takeoff configuration, landing gear retracted, V_2 climb speed—takeoff ice.

4.6.2.3 Approach configuration appropriate to the highest lift landing configuration, landing gear retracted, approach climb speed—holding ice.

4.7 **En Route Flight Paths, § 25.123.**

The following specifications represent an example of an acceptable test program to show compliance with § 25.123.

Maneuvers

4.7.1 The en route ice accretion should be used.

4.7.2 The airplane should be loaded to a forward center-of-gravity position appropriate to the airplane configuration.

4.7.3 The airplane should be in the en route configuration at the en route climb speed.

4.7.4 Stabilize the airplane at the specified speed with one engine inoperative (or simulated inoperative if all relevant effects of an inoperative engine can be taken into account) and conduct two climbs or drag polar checks to substantiate the asymmetric drag increment as agreed to by the responsible ACO.

4.8 **Landing, § 25.125.**

The effect of any landing speed increase on the landing distance may be determined by a suitable analysis.

4.9 **Controllability and Maneuverability—General, § 25.143.**

4.9.1 A qualitative and quantitative evaluation is usually necessary to show compliance with the controllability and maneuverability requirements of § 25.143. Depending on how clearly compliance is demonstrated, or whether the force limits or stick force per g limits of § 25.143 are being approached, additional substantiation may be necessary to ensure that the airplane complies.

4.9.2 Acceptable Test Program.

The following specifications represent an example of an acceptable test program to evaluate general controllability and maneuverability, subject to the provisions outlined above.

Maneuvers

4.9.2.1 The holding ice accretion should be used.

4.9.2.2 The airplane should be loaded to a medium to light weight, with an aft center-of-gravity position, and symmetric fuel loading.

4.9.2.3 In the configurations listed in table 4-1 below, trim the airplane at the specified speeds and conduct the following maneuvers:

4.9.2.3.1 Thirty-degree banked turns left and right with rapid reversals.

4.9.2.3.2 A pull-up to 1.5 g (except that this may be limited to 1.3 g at V_{REF}) and a pushover to 0.5 g (except that the pushover is not required at V_{MO} and V_{FE}).

4.9.2.3.3 Include deployment and retraction of deceleration devices.

Table 4-1. Controllability and Maneuverability—Trim Speeds

Configuration	Trim Speed
High lift devices retracted configuration	1.3 V_{SR} and V_{MO} or 250 KIAS, whichever is less
Lowest lift takeoff configuration	1.3 V_{SR} and V_{FE} or 250 KIAS, whichever is less
Highest lift landing configuration	V_{REF} and V_{FE} or 250 KIAS, whichever is less

V_{SR} – Reference Stall Speed
V_{MO} – Maximum operating limit speed
KIAS – Knots indicated airspeed
V_{FE} – Maximum flap extended speed
V_{REF} – Reference landing speed

4.9.2.4 In the lowest lift takeoff configuration, at the greater of 1.13 V_{SR} or V_{2MIN}, with one engine inoperative (simulated), conduct 30° banked turns left and right with normal turn reversals and, in wings-level flight, a 5-knot speed decrease and increase.

4.9.2.5 Conduct an approach and go-around with all engines operating using the AFM approach and go-around procedure.

4.9.2.6 Conduct an approach and go-around with one engine inoperative (simulated) using the AFM one-engine-inoperative approach and go-around procedure.

4.9.2.7 Conduct an approach and landing using the AFM approach and landing procedure. In addition, you should demonstrate satisfactory controllability during a landing at V_{REF} minus 5 knots. These tests should be done at heavy weight and forward center-of-gravity.

4.9.2.8 Conduct an approach and landing with one engine inoperative (or with one engine simulated to be inoperative if all effects associated with an engine failure can be taken into account) using the procedure provided in the AFM.

4.9.3 Evaluation of Lateral Control Characteristics.

Aileron hinge moment reversal and other lateral control anomalies have been identified as causal factors in icing accidents and incidents. The following maneuvers, along with the following two evaluations, are intended to determine susceptibility of the airplane to aileron hinge moment reversals or other adverse effects on lateral control characteristics due to ice accretion.

Evaluations

4.9.3.1 Evaluate lateral controllability during deceleration to the stall warning speed (covered in paragraph 4.17.2.5 of this AC), and

4.9.3.2 Evaluate static lateral-directional stability (covered in paragraph 4.15 of this AC).

Maneuvers

4.9.3.3 For each of the test conditions specified in table 4-2 below, Perform the following maneuvers:

4.9.3.3.1 Establish a 30° banked level turn in one direction.

4.9.3.3.2 Using a step input of approximately 1/3-full lateral control deflection, roll the airplane in the other direction.

4.9.3.3.3 Maintain the control input as the airplane passes through a wings level attitude.

4.9.3.3.4 At approximately 20° of bank, apply a step input in the opposite direction to approximately 1/3-full lateral control deflection.

4.9.3.3.5 Release the control input as the airplane passes through a wings level attitude.

4.9.3.3.6 Repeat this test procedure with 2/3- and up-to-full lateral control deflection unless the roll rate or structural loading is judged excessive. It should be possible to readily arrest and reverse the roll rate using only lateral control input, and the lateral control force should not reverse with increasing control deflection.

Table 4-2. Test Conditions—Lateral Control Characteristics

Test	Condition
1	Holding configuration, holding ice accretion, maximum landing weight, forward center-of-gravity position, at minimum holding speed (highest expected holding angle-of-attack)
2	Landing configuration, holding ice accretion, medium to light weight, forward center-of-gravity position, at V_{REF} (highest expected landing approach angle-of-attack)

4.9.4 Low g Maneuvers and Sideslips.

The maneuvers in paragraph 4.9.4.3 of this AC represent an example of an acceptable test program for showing compliance with controllability requirements in low g maneuvers and in sideslips to evaluate susceptibility to ice-contaminated tailplane stall.

4.9.4.1 Section 25.143(i)(2).

4.9.4.1.1 The regulation states: "It must be shown that a push force is required throughout a pushover maneuver down to a zero g load factor, or to 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 maneuver without exceeding a pull control force of 50 pounds…."

4.9.4.1.2 An example of another design characteristic of the flight control system that would limit the lowest obtainable load factor would be a g-limiting envelope protection system.

4.9.4.2 Section 25.143(i)(3).

4.9.4.2.1 For sideslips, the regulation requires that: "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.” (See paragraph 4.15.1 of this AC for lateral-directional aspects).

4.9.4.2.2 Abrupt changes in the control force characteristic, unless so small as to be unnoticeable, would not be considered compliant with the requirement that the force be steadily increasing. A gradual change in control force is a change that is not abrupt and does not have a steep gradient. It can be easily managed by a pilot of average skill, alertness, and strength. Control forces in excess of those permitted by § 25.143(d) would be considered excessive.

4.9.4.3 Test maneuvers used to show compliance with the regulatory requirements quoted in paragraphs 4.9.4.1.1 and 4.9.4.2.1 above should be conducted using the following ice accretions, configurations, and procedures:

Maneuvers

4.9.4.3.1 The holding ice accretion should be used. For airplanes with unpowered elevators, these tests should also be performed with sandpaper ice.

4.9.4.3.2 The airplane should be loaded to a medium to light weight, at the most critical center-of-gravity position, with symmetric fuel loading, and should be in the highest lift landing configuration.

4.9.4.3.3 Test maneuver for showing compliance with § 25.143(i)(2) is provided in table 4-3 below.

Table 4-3. Test Maneuver—§ 25.143(i)(2)

Step	Maneuver	
1	Start with the airplane in trim, or as near as possible to being in trim, at the most critical of the following trim speeds:	(1) Trim speed 1.23 V_{SR}, target speed not more than 1.23 V_{SR}.
		(2) Trim speed V_{FE}, target speed not less than V_{FE} - 20 knots.
2	Pull up to a suitable pitch attitude, then—	(1) Push over in a continuous maneuver (without changing trim) to reach zero g normal load factor or, if limited by elevator control authority (or other design characteristic), the lowest load factor obtainable at the target speed, as the airplane's pitch attitude passes through approximately level flight (that is, through the horizon), and
		(2) Perform this maneuver with idle power or thrust and with go-around power or thrust.

4.9.4.3.4 Test maneuver for showing compliance with § 25.143(i)(3): Conduct steady heading sideslips to full rudder input, 180 pounds rudder force, or full lateral control authority (whichever comes first) at a trim speed of 1.23 V_{SR} and with the power or thrust needed for a -3° flight path angle.

4.9.5 Controllability Prior to Activation and Operation of the Ice Protection System.

The following is an example of an acceptable test program for showing compliance with § 25.25.143(j).

Maneuvers

4.9.5.1 For the configurations, speeds, and power settings listed below, with the ice accretion specified in the requirement, trim the airplane at the specified speed, conduct a pull-up maneuver to 1.5 g and pushover maneuver to 0.5 g, and show that longitudinal control forces do not reverse.

4.9.5.1.1 High lift devices retracted configuration (or holding configuration if different), holding speed, power or thrust for level flight.

4.9.5.1.2 Landing configuration, V_{REF} for non-icing conditions, power or thrust for landing approach. If necessary, limit the pull-up maneuver to the point at which stall warning occurs.

4.10 Longitudinal Control, § 25.145.

4.10.1 No specific quantitative evaluations are required for demonstrating compliance with§ 25.145(b) and (c). Qualitative evaluations should be combined with the other testing. Review results of tests on the uncontaminated airplane for any cases of marginal compliance. All tests showing marginal compliance should be repeated with ice accretions on the airplane.

4.10.2 Acceptable Test Program.

The following specifications represent an example of an acceptable test program for compliance with § 25.145(a).

Maneuvers

4.10.2.1 The holding ice accretion should be used.

4.10.2.2 The airplane is at a medium to light weight, aft center-of-gravity position, with symmetric fuel loading.

4.10.2.3 In the configurations listed below, trim the airplane at 1.3 V_{SR}. Reduce speed approximately 1 knot per second using elevator control to 1 second past stall warning and demonstrate prompt recovery to the trim speed using elevator control.

4.10.2.3.1 High lift devices retracted configuration, maximum continuous power or thrust.

4.10.2.3.2 Maximum lift landing configuration, maximum continuous power or thrust.

4.11 Directional and Lateral Control, § 25.147.

To show compliance with § 25.147, applicants should combine qualitative evaluations with the other testing (for example, the roll tests described in paragraphs 4.9.2.3.1 and 4.9.2.4 of this AC). Review the results of the tests on the uncontaminated airplane for any cases of marginal compliance. All tests showing marginal compliance should be repeated with ice accretions on the airplane.

4.12 Trim, § 25.161.

4.12.1 To show compliance with this requirement, the applicant should combine qualitative evaluations with the other testing. Review results of tests on the uncontaminated airplane for any cases of marginal compliance. All tests showing marginal compliance should be repeated with ice accretions on the airplane. In addition, a specific check should be made to demonstrate compliance with § 25.161(c)(2).

4.12.2 Acceptable Test Program.

The following specifications represent an example of an acceptable test program for compliance with § 25.161(c)(2).

Maneuvers

4.12.2.1 The holding ice accretion should be used.

4.12.2.2 The airplane is at the most critical landing weight, with a forward center of gravity position and symmetric fuel loading.

4.12.2.3 In the maximum lift landing configuration, trim the airplane at the most critical of—

4.12.2.3.1 1.3 V_{SR1} at idle power or thrust, or

4.12.2.3.2 V_{REF} with the power or thrust for a -3° flight path angle.

4.13 Stability—General, § 25.171.

To show compliance with this requirement, applicants should combine qualitative evaluations with the other testing. Each tendency to change speed when trimmed and a need for frequent trim inputs should be specifically investigated.

4.14 Demonstration of Static Longitudinal Stability, § 25.175.

4.14.1 To show compliance with § 25.175, the applicant should test each of the following cases. In general, it is not necessary to test in the cruise configuration at low speed (§ 25.175(b)(2)) or in the cruise configuration with landing gear extended (§ 25.175(b)(3)); nor is it necessary to test at high altitude. Maximum speed for substantiation of stability characteristics in icing conditions (as prescribed by § 25.253(c)) is the lowest of—

- 300 knots calibrated airspeed (CAS),
- V_{FC}, or

- A speed at which it is demonstrated that the airframe will be free of ice accretion due to the effects of increased dynamic pressure.

4.14.2 Acceptable Test Program.

The following specifications represent an example of an acceptable test program for demonstrating static longitudinal stability.

Maneuvers

4.14.2.1 The holding ice accretion should be used.

4.14.2.2 The airplane is at a high landing weight, aft center-of-gravity position, with symmetric fuel loading.

4.14.2.3 In the configurations listed in paragraphs 4.14.2.3.1 through 4.14.2.3.4 below, trim the airplane at the specified speed. The power or thrust should be set and stability demonstrated over the speed ranges as stated in § 25.175(a) through (d), as applicable.

4.14.2.3.1 Climb: With high lift devices retracted, trim at the speed for best rate of climb, except that the speed need not be less than 1.3 V_{SR}.

4.14.2.3.2 Cruise: With high lift devices retracted, trim at V_{MO} or 250 knots CAS, whichever is lower.

4.14.2.3.3 Approach: With the high lift devices in the approach position appropriate to the highest lift landing configuration, trim at 1.3 V_{SR}.

4.14.2.3.4 Landing: With the highest lift landing configuration, trim at 1.3 V_{SR}.

4.15 Static Lateral–Directional Stability, § 25.177.

4.15.1 Use steady heading sideslips to show compliance with the directional and lateral stability requirements. The maximum sideslip angles obtained should be recorded and may be used to substantiate a crosswind value for landing. (See paragraph 4.19 of this AC.) Section 25.177(c) requires directional and lateral control movements and forces to be substantially proportional to the angle of sideslip without reversing.

4.15.2 Acceptable Test Program.

The following specifications represent an example of an acceptable test program for demonstrating static directional and lateral stability.

Maneuvers

4.15.2.1 The holding ice accretion should be used.

4.15.2.2 The airplane is at a medium to light weight, aft center-of-gravity position, with symmetric fuel loading.

4.15.2.3 In the configurations listed below, trim the airplane at the specified speed and conduct steady heading sideslips to full rudder authority, 180 pounds of rudder pedal force, or full lateral control authority, whichever comes first:

4.15.2.3.1 High lift devices retracted configuration: Trim at best rate-of-climb speed, but need not be less than 1.3 V_{SR}.

4.15.2.3.2 Lowest lift takeoff configuration: Trim at the all-engines-operating initial climb speed.

4.15.2.3.3 Highest lift landing configuration: Trim at V_{REF}.

4.16 Dynamic Stability, § 25.181.

If the uncontaminated airplane has no borderline compliance test results for § 25.181, dynamic stability tests with ice accretions on the airplane are not necessary. The applicant should combine qualitative evaluations with other testing. Each difficulty in achieving precise attitude control and each tendency to sustain oscillations in turbulence should be investigated.

4.17 Stall Demonstration, § 25.201/Stall Characteristics, § 25.203.

4.17.1 The applicant should conduct sufficient stall testing to demonstrate that the stall characteristics comply with the requirements of §§ 25.201 and 25.203. In general, it is not necessary to conduct a stall program that encompasses all weights, center-of-gravity positions, altitudes, high lift configurations, deceleration device configurations, straight and turning flight attitudes, and thrust or power settings. The applicant can establish a reduced test matrix based on a review of the stall characteristics of the uncontaminated airplane. However, additional tests may be necessary if—

4.17.1.1 The stall characteristics with ice accretion show a significant difference from those on the uncontaminated airplane,

4.17.1.2 The testing indicates borderline compliance, or

4.17.1.3 The activation point of a stall identification system (for example, a stick pusher) is reset for icing conditions.

4.17.2 Acceptable Test Program.

Turning flight stalls at decelerations greater than 1 knot per second are not required. Note that slow decelerations (much slower than 1 knot per second) may be critical on airplanes with anticipation logic in their stall protection system or on airplanes with low directional stability, where large sideslip angles could develop. The following specifications represent an example of an acceptable test program subject to the provisions outlined above.

Maneuvers

4.17.2.1 The holding ice accretion should be used.

4.17.2.2 The airplane should be loaded to a medium to light weight, aft center-of-gravity position, with symmetric fuel loading.

4.17.2.3 The tests should be conducted at the normal stall test altitude.

4.17.2.4 In the configurations listed in paragraphs 4.17.2.4.1 through 4.17.2.4.4 below, trim the airplane at the same initial stall speed factor used for stall speed determination. For power on stalls, use the power setting as defined in § 25.201(a)(2), but with ice accretions on the airplane. Decrease speed at a rate not to exceed 1 knot per second to stall identification and recover using the same recovery maneuver as for the uncontaminated airplane.

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

4.17.2.4.2 Lowest lift takeoff configuration: Straight/Power On, Turning/Power Off.

4.17.2.4.3 Highest lift takeoff configuration: Straight/Power Off, Turning/Power On.

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

4.17.2.5 For the configurations listed in paragraphs 4.17.2.4.1 and 4.17.2.4.4 above, and each other configuration if deemed more critical, in 1 knot per second deceleration rates down to stall warning with wings level and power off, roll the airplane left and right up to 10° of bank using the lateral control.

4.18 **Stall Warning, § 25.207.**

4.18.1 To show compliance with § 25.207, the applicant should assess stall warning in conjunction with stall speed testing and stall demonstration/characteristics testing (§§ 25.103, 25.201, and 25.203, and paragraphs 4.2 and 4.17 of this AC, respectively), and in tests with faster entry rates.

4.18.2 Normal Ice Protection System Operation.

The following specifications represent an example of an acceptable test program for stall warning in slow-down turns of at least 1.5 g and at entry rates of at least 2 knots per second:

Maneuvers

4.18.2.1 The holding ice accretion should be used.

4.18.2.2 The airplane should be loaded to a medium to light weight, aft center-of-gravity position, with symmetric fuel loading.

4.18.2.3 The test should be conducted at the normal stall test altitude.

4.18.2.4 In the configurations listed in paragraphs 4.18.2.4.1 through 4.18.2.4.3 below, trim the airplane at 1.3 V_{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 before establishing at least 1.5 g and a deceleration of at least 2 knots per second. Decrease speed until 1 second after stall warning and recover using the same recovery maneuver as for the uncontaminated airplane.

4.18.2.4.1 High lift devices retracted configuration.

4.18.2.4.2 Lowest lift takeoff configuration.

4.18.2.4.3 Highest lift landing configuration.

4.18.3 Stall Warning Prior to Activation and Operation of the Ice Protection System.

The following represents an acceptable means for showing compliance with § 25.207(h).

Maneuvers

4.18.3.1 In the configurations listed in paragraphs 4.18.3.1.1 and 4.18.3.1.2 below, with the ice accretion specified in the requirement, trim the airplane at 1.3 V_{SR}.

4.18.3.1.1 High lift devices retracted configuration: Straight Flight/Power Off.

4.18.3.1.2 Landing configuration: Straight Flight/Power Off.

4.18.3.2 At deceleration rates of up to 1 knot per second, reduce the speed until 1 second past stall warning, and demonstrate that stalling can be prevented using the same recovery maneuver as used for the uncontaminated airplane, without encountering any adverse characteristics (for example, rapid wing roll-off). If stall warning for the airplane with ice accretion is provided by a different means than it is for the airplane without ice accretion, the following requirements must be met:

4.18.3.2.1 Section 25.207(h)(3)(ii) requires that stalling be preventable even if the pilot takes no recovery action for at least 3 seconds after stall warning.

4.18.3.2.2 Section 25.207(i) requires that satisfactory stall characteristics be demonstrated if stall warning is provided by a different means in icing conditions than for non-icing conditions.

4.19 **Wind Velocities, § 25.237. To show compliance with this requirement:**

4.19.1 Crosswind landings with the landing ice accretion should be evaluated on an opportunity basis.

4.19.2 Results of the steady heading sideslip tests with landing ice may be used to establish the safe crosswind component of this requirement. If the flight test data show that the maximum sideslip angle demonstrated is similar to that shown with the uncontaminated airplane, and the flight characteristics (control forces and deflections, for example) are similar, then the non-contaminated airplane crosswind component test result is considered valid for icing conditions.

4.19.3 If results of the comparison discussed in paragraph 4.19.2 above are not clearly similar, and in the absence of a more extensive analysis, the applicant may use a conservative analysis based on results of the steady heading sideslip tests to establish the safe crosswind component value. The crosswind value may be estimated from:

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

Where:

V_{CW} is the crosswind component, and

V_{REF} is the landing reference speed appropriate to a minimum landing weight, and

Sideslip angle is that demonstrated at V_{REF} (see paragraph 4.15 of this AC).

4.20 **Vibration and Buffeting, § 25.251.**

To show compliance with this requirement:

4.20.1 Combine qualitative evaluations with the other testing, including speeds up to the maximum speed obtained in the longitudinal stability tests. (See paragraph 4.14 of this AC).

4.20.2 Demonstrate that the airplane is free from harmful vibration due to residual ice accumulation. This may be done in conjunction with the natural icing tests.

4.20.3 Evaluate an airplane with pneumatic deicing boots up to V_{DF}/M_{DF}, both with the deicing boots operating (including deicing boot inflation cycles) and not operating. It is not necessary to do this demonstration with ice accretions on the airplane.

4.21 **Natural Icing Conditions, § 25.1419(b).**

To show compliance with this requirement, the applicant should perform additional flight testing.

4.21.1 Whether flight testing has been performed with artificial or simulated ice accretions or in natural icing conditions, additional limited flight testing described in this section should be conducted in the natural atmospheric icing conditions specified in part 25, Appendix C, and, if necessary, in the icing conditions described in Appendix O. (AC 25-28 provides guidance on when it is necessary to perform flight testing in the natural atmospheric icing conditions of Appendix O). If flight testing with simulated ice accretions 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 the flight testing with simulated ice accretions. Validating all aspects of predicted ice accretions through natural icing flight tests is not required. The flight testing should confirm the general physical characteristics and location of the ice accretions and their effect on airplane performance and handling characteristics. The applicant should make at least a qualitative assessment to confirm that the artificial ice accretions are conservative relative to ice accretions resulting from natural atmospheric icing conditions, and that ice in natural atmospheric icing conditions does not accrete in unexpected places.

4.21.2 It is acceptable for some ice to be shed during the testing due to air loads or wing flexure, etc. However, the applicant should attempt to accomplish the test maneuvers as soon as possible after exiting the icing cloud in order to minimize atmospheric influences on ice shedding.

4.21.3 Acceptable Test Program.

During each of the maneuvers specified in paragraph 4.21.4 below, the behavior of the airplane should be consistent with that obtained with simulated ice accretions. There should be no unusual control responses or uncommanded airplane motions. Additionally, during the level turns and bank-to-bank rolls, there should be no buffeting or stall warning.

Maneuvers

4.21.4 Ice Accretion Maneuvers.

4.21.4.1 Holding scenario.

4.21.4.1.1 The maneuvers specified in table 4-4. below should be carried out with ice accretions defined in paragraphs 4.21.4.1.2 and 4.21.4.1.3 below, which is representative of normal operation of the ice protection system:

4.21.4.1.2 Ice on unprotected parts. A target accretion thickness equivalent to the 45-minute dry air ice accretions on an unprotected part of the wing should be the objective. (A thickness of 2 inches is normally a minimum value, unless a lesser value is agreed to with the responsible ACO).

4.21.4.1.3 Ice on protected parts. The ice accretion thickness should be that resulting from normal operation of the ice protection system.

4.21.4.1.4 For airplanes with control surfaces that may be susceptible to jamming due to ice accretion (for example, elevator horns exposed to the air flow), the holding speed that is critical with respect to this ice accretion should be used.

Table 4-4. Holding Scenario—Maneuvers

Airplane Configuration	Center-of-Gravity Position	Trim Speed	Maneuver
Flaps up, Gear up	Any position in the aft range	Holding, except 1.3 V_{SR} for the stall maneuver	Level, 40° banked turn; Bank-to-bank rapid roll, 30° - 30°; Speedbrake extension, retraction; Full straight stall (1 knot per second deceleration rate, wings level, power off)
Flaps in intermediate positions, gear up	Any position in the aft range	1.3 V_{SR}	Deceleration to the speed reached 3 seconds after activation of stall warning in a 1 knot per second deceleration
Landing flaps, gear down	Any position in the 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 per second deceleration rate, wings level, power off)

4.21.4.2 Approach/Landing Scenario.

4.21.4.2.1 The maneuvers specified in table 4-5 of this AC should be carried out with successive accretions in different configurations on unprotected surfaces.

4.21.4.2.2 Each test condition should be accomplished with the ice accretion that exists at that point.

4.21.4.2.3 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.

4.21.5 For airplanes with unpowered elevator controls, unless the applicant can adequately substantiate the critical simulated ice accretion used to demonstrate compliance with the controllability requirement, the pushover test of paragraph 4.9.4.3.3 should be repeated with a thin accretion of natural ice.

4.21.6 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.

Table 4-5. Approach/Landing Scenario—Maneuvers

Test Condition	**Ice Accretion Thickness***	**Airplane Configuration**	**Center-of-Gravity Position**	**Trim Speed**	**Maneuver**
—	First 0.5 inch	Flaps up, gear up	Any position in the aft range	Holding	No specific test
1	Additional 0.25 inch (0.75 inch total)	First intermediate flaps, gear up	Any position in the aft range	Holding, except 1.3 V_{SR} for the deceleration maneuver	Level 40° banked turn; Bank-to-bank rapid roll, 30°- 30°; Speed brake extension and retraction (if approved); Deceleration to the speed reached 3 seconds after activation of stall warning in a 1 knot per second deceleration.
2	Additional 0.25 inch (1.00 inch total)	Further intermediate flaps, gear up (as applicable)	Any position in the aft range	1.3 V_{SR}	Bank-to-bank rapid roll, 30° - 30°; Speed brake extension and retraction (if approved); Deceleration to the speed reached 3 seconds after activation of stall warning in a 1 knot per second deceleration.
3	Additional 0.25 inch (1.25 inch total)	Landing flaps, gear down	Any position in the aft range	V_{REF}	Bank-to-bank rapid roll, 30° - 30°; Speed brake extension and retraction (if approved), Bank to 40°; Full straight stall (1 knot per second deceleration rate, wings level, power off).

* The indicated thickness is that accumulated on the parts of the unprotected airfoil most likely to accumulate ice.

4.22 Failure Conditions, § 25.1309.

To show compliance with this requirement:

4.22.1 For failure conditions that are annunciated to the flightcrew, the applicant may take credit for flightcrew action to follow the established operating procedures provided in the AFM.

4.22.2 Acceptable Test Program.

In addition to a general qualitative evaluation, the applicant should carry out the following test program for the most critical, probable failure condition for which the associated procedure requires the airplane to exit the icing condition. The test program should be modified as necessary to reflect the specific operating procedures.

Maneuvers

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

4.22.2.1.1 Ice on unprotected surfaces. The holding ice accretion described in paragraph A.2.1.3 of appendix A of this AC.

4.22.2.1.2 Ice on normally protected surfaces that are no longer protected. The failure ice accretion described in paragraph A.3.2 of appendix A of this AC.

4.22.2.1.3 Ice on normally protected surfaces that are still protected following segmental failure of a cyclical deice system. The ice accretion that will form during the rest time of the deice system following the critical failure condition.

4.22.2.2 The airplane should be loaded to a medium to light weight, at aft center-of-gravity position, with symmetric fuel loading.

4.22.2.3 In the configurations listed in paragraphs 4.22.2.3.1 through 4.22.2.3.3 below, trim the airplane at the specified speed. Conduct 30° banked turns left and right with normal reversals. Conduct a pull-up maneuver to 1.5 g and a pushover maneuver to 0.5 g.

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

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

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

4.22.2.4 In the configurations listed in paragraphs 4.22.2.4.1 and 4.22.2.4.2 below, trim the airplane at the estimated 1.3 V_{SR}. Decrease speed at approximately 1 knot per second until 1 second after stall warning, and demonstrate prompt recovery using the same recovery maneuver as for the uncontaminated airplane. It is acceptable for stall warning to be provided by a different means (for example, by the behavior of the airplane rather than by stick shaker) for failure cases not considered probable.

4.22.2.4.1 High lift devices retracted configuration: Straight Flight/Power Off.

4.22.2.4.2 Landing configuration: Straight Flight/Power Off.

4.22.2.5 Conduct an approach and go-around with all engines operating using the AFM approach and go-around procedure.

4.22.2.6 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 appropriate AFM approach and landing procedure.

4.22.3 For improbable failure conditions, flight testing may be required to demonstrate that the effect on safety of flight (as measured by degradation in flight characteristics) supports the system safety analysis, or to verify results of analyses or wind tunnel tests. The extent of each required flight testing should be similar to that described in paragraph 4.22.3 above, or as agreed to by the responsible ACO for the specific failure condition.

APPENDIX A. AIRFRAME ICE ACCRETIONS

A.1 Overview.

A.1.1 In accordance with § 25.1419, each airplane certified for flight in icing conditions must be capable of safely operating in the continuous maximum and intermittent maximum icing conditions of part 25, 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.

A.1.2 In accordance with § 25.1420(a)(1), each airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls certified for flight in icing conditions must, at a minimum, be capable of safely operating: (1) in the atmospheric icing conditions of part 25, Appendix C, and (2) after encountering the atmospheric icing conditions of part 25, Appendix O, and while subsequently exiting all icing conditions. Therefore, for airplanes with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls, certification for flight in icing conditions must consider, at a minimum, ice accretions that can occur during flight in Appendix C icing conditions and during detection and exiting of Appendix O icing conditions.

A.1.3 In accordance with § 25.1420(a)(2), an airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls may also be certified for operation in a portion of the atmospheric icing conditions of part 25, Appendix O. In that case, the airplane 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—

A.1.3.1 Operations in Appendix C icing conditions,

A.1.3.2 Operations in the Appendix O icing conditions for which approval is sought, and

A.1.3.3 Detection and exiting of the Appendix O icing conditions beyond those for which approval is sought.

A.1.4 In accordance with § 25.1420(a)(3), in addition to being certified for flight in Appendix C conditions, an airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls may be certified for operation throughout the atmospheric icing conditions of part 25, Appendix O. Certification for flight throughout the atmospheric icing conditions of Appendix O must consider ice accretions resulting from—

A.1.4.1 Operations in Appendix C icing conditions, and

A.1.4.2 Operations in Appendix O icing conditions.

A.1.5 The part 25, subpart B, airplane 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 airplane 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.

A.1.6 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—

A.1.6.1 Flight conditions (for example, airplane configuration, speed, angle-of-attack, altitude), and

A.1.6.2 Atmospheric icing conditions for which certification is desired (for example, temperature, liquid water content (LWC), drop mean effective diameter (MED), and drop median volume diameter (MVD)).

A.1.7 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. Justification and selection of the most critical ice shape for each phase of flight should be agreed to by the responsible ACO.

A.1.8 See Appendix R of AC 20-73A, *Aircraft Ice Protection*, dated August 16, 2009, for additional detailed information about determining the applicable critical ice accretion (shape and roughness).

A.2 **Ice Accretions With an Operative Ice Protection System.**

A.2.1 <u>All Flight Phases Except Takeoff.</u>

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

A.2.1.2 Unprotected parts consist of the unprotected airfoil leading edges and all unprotected airframe parts on which ice may accrete. The effect of ice accretion on protuberances such as antennas or flap hinge fairings need not normally be investigated. However, airplanes characterized by unusual unprotected airframe protuberances, for example fixed landing gear, large engine pylons, or exposed control surface horns or winglets may experience significant additional effects, which should therefore be taken into consideration.

A.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 airplane 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 airplane certification programs, the maximum pinnacle height was limited to 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 MED, LWC, and temperature resulting in the formation of an ice accretion critical to the airplane’s performance and handling qualities. The shape and texture of the ice are important and should be agreed to by the responsible ACO.

A.2.1.4 In accordance with the definitions of holding ice, approach ice, and landing ice in Appendices C and O, these flight segments are considered contiguous and sequential. Unless there is a procedure to deice surfaces that have previously accreted ice in the holding flight phase, approach ice is normally the same accretion as the holding ice accretion plus any additional ice accreted during the transition to the approach configuration. Similarly, unless there is a procedure to deice surfaces before landing, the landing ice accretion is normally the same accretion as the approach ice accretion plus any additional ice accreted during transition to the final landing configuration. A total time of 45 minutes can be used for the combination of hold, approach, and landing ice.

A.2.1.5 For protected parts, the ice protection systems are normally assumed to be operative. However, the applicant should consider the effect of ice accretion on or behind the protected surfaces that results from the rest time of a deicing cycle. Performance may be established on the basis of a representative intercycle ice accretion for normal operation of the deicing system. (The applicant should also consider effects of each residual ice accretion that is not shed). The average drag increment determined over the deicing cycle may be used for performance calculations. Consider the effect of—

A.2.1.5.1 Runback ice that occurs on or downstream of the protected surface (including deicing boots), and

A.2.1.5.2 Ice accretion prior to activation and operation of the ice protection system. (See paragraph A.2.3 of this appendix.)

A.2.2 Takeoff Phase.

A.2.2.1 For both unprotected and protected parts, the ice accretion identified in part 25, Appendices C and O, for the takeoff phase may be determined by calculation, assuming the following:

A.2.2.1.1 Airfoils, control surfaces, and propellers if applicable are free from frost, snow, or ice at the start of the takeoff.

A.2.2.1.2 The ice accretion starts at the end of the takeoff distance.

A.2.2.1.3 The airplane is at the critical ratio of power/thrust-to-weight.

A.2.2.1.4 Failure of the critical engine occurs at V_{EF}.

A.2.2.1.5 The flightcrew activates the ice protection system in accordance with an AFM procedure; except that after beginning the takeoff roll, no flightcrew action to activate the ice protection system should be assumed to occur until the airplane is 400 feet above the takeoff surface.

A.2.2.2 The ice accretions identified in part 25, Appendix C, for the takeoff phase are takeoff ice and final takeoff ice.

A.2.2.2.1 Takeoff ice: The most critical ice accretion on unprotected surfaces, and any ice accretion on protected surfaces appropriate to normal ice protection system operation, occurring between the end of the takeoff distance and 400 feet above the takeoff surface, assuming accretion starts at the end of the takeoff distance in the takeoff maximum icing conditions of part 25, Appendix C, part I(c).

A.2.2.2.2 Final takeoff ice: The most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, between 400 feet and the height at which the transition to the en route configuration and speed is completed, or 1,500 feet above the takeoff surface, whichever is higher, assuming accretion starts at the end of the takeoff distance in the takeoff maximum icing conditions of part 25, Appendix C, part I(c).

A.2.2.3 The final takeoff ice accretion includes the takeoff ice accretion since these flight segments are contiguous and sequential. For both flight path segments, ice begins accreting at the end of the takeoff distance. The reference to a height of 400 feet above the takeoff surface in these definitions is only used to separate the two takeoff segments. It does not mean that ice accreted before reaching 400 feet above the takeoff surface may be ignored when determining the final takeoff ice accretion.

A.2.2.4 The takeoff ice and final takeoff ice accretions for Appendix O are the same as those for Appendix C, except that the icing conditions are defined in part 25, Appendix O, part I.

A.2.3 Ice Accretion Before Activation and Effective System Operation.

A.2.3.1 When considering the ice accretion before the ice protection system has been activated and is performing its intended function, you should take into account the means of activating the ice protection system and the system response time. However, if artificial stall warning is provided and the point at which stall warning is initiated changes when the ice protection system is activated, then the pre-activation ice accretion used to evaluate the "clean" stall warning schedule does not need to include consideration of the ice protection system response time. 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 deicing, the time to heat the surface and perform its deicing function). If activation of the ice protection system depends on flightcrew 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 airplane 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.

A.2.3.2 Section 25.1419(e) requires one of the following three methods for detecting icing and activating the airframe ice protection system:

A.2.3.2.1 A primary ice detection system that automatically activates or that alerts the flightcrew to activate the airframe ice protection system.

A.2.3.2.2 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 flightcrew to activate the airframe ice protection system.

A.2.3.2.3 Identification of conditions conducive to airframe icing as defined by an appropriate static or total air temperature and visible moisture for use by the flightcrew to activate the airframe ice protection system.

A.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.2.3.3.1 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 the system to perform its intended function. The assumed ice accretion can be determined as follows: (1) the ice accreted on the protected surfaces during the time between entry into the icing conditions and activation of the system, plus (2) the ice accreted during the system response time.

A.2.3.3.2 If ice protection system activation depends on pilot action following annunciation from a primary ice detection system, the assumed ice accretion should include flightcrew delays in activating the ice protection system and the time it takes the system to perform its intended function. The assumed ice accretion should be determined as follows: (1) the ice accreted during the time between entry into the icing conditions and annunciation from the primary ice detection system, plus (2) the ice accreted during 10 additional seconds of operation in icing conditions, plus (3) the ice accreted during the system response time.

A.2.3.3.3 If ice protection system activation depends on the flightcrew 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 flightcrew 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: (1) the ice accretion on the aerodynamic surfaces corresponding to the ice accretion on the reference surface that would be easily recognizable by the flightcrew under all foreseeable conditions (for example, at night in clouds), plus (2) the ice accreted during 30 additional seconds of operation in icing conditions, plus (3) the ice accreted during the system response time.

A.2.3.3.4 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 flightcrew delays in recognizing the presence of icing conditions and flightcrew 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: (1) the ice accreted during 30 seconds of operation in icing conditions, plus (2) the ice accreted during the system response time.

A.3 Ice Accreted During Ice Protection System Failure.

A.3.1 Unprotected Parts.

The same accretion as in paragraph A.2 of this appendix is applicable.

A.3.2 Protected Parts Following System Failure.

The assumed ice accretion for failures of the ice protection system is defined as follows:

A.3.2.1 If the failure condition is not annunciated, the ice accretion on normally protected parts where the ice protection system has failed should be assumed to be the same as the accretion specified for unprotected parts.

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

A.3.2.3 If the failure condition is annunciated and the associated AFM procedure requires the airplane to exit icing conditions as soon as possible, the ice accretion on normally protected parts where the ice protection has failed should be assumed to be one-half of the accretion specified for unprotected parts unless another value is agreed to by the responsible ACO.

A.4 **Additional Guidance for Appendix O Ice Accretions.**

A.4.1 Ice Accretion in Appendix O Conditions before those Conditions have been Detected by the Flightcrew.

A.4.1.1 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 flightcrew becomes aware that they are in Appendix O icing conditions and have taken action to begin exiting from all icing conditions.

A.4.1.2 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.

A.4.1.3 The time that the applicant should assume it will take to detect Appendix O icing conditions exceeding those for which the airplane is certified should be based on the means of detection. AC 25-28 provides guidance for certifying the detection means. In general, we expect that the time to detect exceedance icing conditions may be significantly longer for a detection means relying on the flightcrew seeing and recognizing a visual icing cue than it is for an ice detection system that provides an attention-getting alert to the flightcrew.

A.4.1.4 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 included.

A.4.1.4.1 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).

A.4.1.4.2 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

SLD conditions, and ease of seeing the reference surface(s). The infrequency of Appendix O conditions (approximately 1 in 100 to 1 in 1000, 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.

A.4.1.4.3 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) three minutes 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), and (2) Five minutes for a visual reference located on a wing, wing-mounted engine, or wing tip.

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

A.4.2.1 Use the ice accretions in table A-1 below, to evaluate compliance with the applicable subpart B requirements for operating safely after encountering Appendix O atmospheric icing conditions for which the airplane is not approved, and then safely exiting all icing conditions.

A.4.2.2 These ice accretions apply when the airplane is not certified for flight in any portion of Appendix O atmospheric icing conditions, when the airplane is certified for flight in only a portion of Appendix O conditions, and for any flight phase for which the airplane is not certified for flight throughout the Appendix O icing envelope.

A.4.2.3 Table A-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 airplane is certified to operate (for detecting and exiting those conditions).

Table A-1. Appendix O Detect-and-Exit Ice Accretions per Flight Phase

Flight Phase/ Condition	**Appendix O Detect-and-Exit Ice Accretion**
Ground Roll	No accretion
Takeoff	No accretion[a]
Final Takeoff	No accretion[a]

Flight Phase/ Condition	**Appendix O Detect-and-Exit Ice Accretion**
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 the airplane is approved, whichever is applicable, (2) Pre-detection ice, (3) Accretion from one standard cloud horizontal extent (17.4 nautical miles) in Appendix O conditions for which the airplane is not approved, and (4) Accretion from one standard cloud horizontal extent (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 the airplane is approved, whichever is applicable, (2) Pre-detection ice, (3) Accretion from one standard cloud horizontal extent (17.4 nautical miles) in Appendix O conditions for which the airplane is not approved, and (4) Accretion from one standard cloud horizontal extent (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 and the combination of— (1) Ice accreted during a descent in the cruise configuration from the maximum vertical extent of the Appendix C maximum continuous icing conditions or the Appendix O icing environment for which the airplane is approved, whichever is applicable, to 2,000 feet above the landing surface, where transition to the approach configuration is made, (2) Pre-detection ice, and (3) Ice accreted at 2,000 feet above the landing surface while transiting one standard cloud horizontal extent (17.4 nautical miles) in Appendix O conditions for which the airplane is not approved and one standard cloud horizontal extent (17.4 nautical miles) in Appendix C continuous maximum icing conditions.

<table>
<tr><th>Flight Phase/ Condition</th><th>Appendix O Detect-and-Exit Ice Accretion</th></tr>
<tr><td>Landing</td><td>Landing Detect-and-Exit Ice

The more critical of holding detect-and-exit ice and the combination of—

(1) Either Appendix C or Appendix O approach and landing ice for which the airplane is approved, whichever is applicable,

(2) Pre-detection ice, and

(3) Ice accreted during an exit maneuver beginning with the minimum climb gradient specified in § 25.119 from a height of 200 feet above the landing surface and transiting through one standard cloud horizontal extent (17.4 nautical miles) in Appendix O conditions for which the airplane is not approved, and one standard cloud horizontal extent (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 maximum continuous icing environment to 2,000 feet above the landing surface,

• A transition to the approach configuration and maneuvering for 15 minutes at 2,000 feet above the landing surface, and

• A descent from 2,000 feet to 200 feet above the landing surface with a transition to the landing configuration.</td></tr>
<tr><td>Ice Accretion Before the Ice Protection System Has Been Activated and is Performing its Intended Function</td><td>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. (Note: If artificial stall warning is provided and the initiation point of that warning changes when the ice protection system is activated, this ice accretion does not need to include consideration of the time it takes for the ice protection system to be effective in performing its intended function.)</td></tr>
</table>

Flight Phase/ Condition	**Appendix O Detect-and-Exit Ice Accretion**
Ice Accretion in Appendix O Conditions Before Those Conditions Have Been Detected by the Flightcrew 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 airplane is certified to operate, and • The time it takes the flightcrew 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 flightcrew to refer to and act on the procedures to exit all icing conditions after the Appendix O icing conditions are recognized.
Failures of the Ice Protection System	No accretion[b]

[a] Intentional flight, including takeoff, is not permitted into Appendix O conditions beyond those in which the airplane is certified to operate.

[b] It is not necessary to consider an unintentional encounter with Appendix O icing conditions beyond those for which the airplane is certified to operate while operating with a failed ice protection system.

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

A.4.3.1 The applicant should use the ice accretions in table A-2 to evaluate compliance with the applicable subpart B requirements for operating safely in the Appendix O atmospheric icing conditions for which the airplane is approved.

A.4.3.2 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 A.4.3.3 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.

A.4.3.3 Table A-2 shows the scenarios the applicant should use for determining ice accretions for certification for flight in the icing conditions of part 25, Appendix O.

Table A-2. Appendix O Ice Accretion per Flight Phase

Flight Phase/Condition	**Appendix O Ice Accretion**
Ground Roll	No accretion
Takeoff	Takeoff Ice Ice accretion occurring between the end of the takeoff distance and 400 feet above the takeoff surface assuming ice accretion starts at the end of the takeoff distance.
Final Takeoff	Final Takeoff Ice Ice accretion occurring between a height of 400 feet above the takeoff surface and the height at which the transition to the en route configuration and speed is completed, or 1500 feet above the takeoff surface, whichever is higher, assuming ice accretion starts at the end of the takeoff 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 17.4 nautical mile standard cloud extent).

Flight Phase/Condition	**Appendix O Ice Accretion**
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 2,000 feet above the landing surface, followed by— • Transition to the approach configuration, and • Maneuvering for 15 minutes at 2,000 feet above the landing surface; and (2) Holding ice (if the airplane 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 2,000 feet above the landing surface to 200 feet above the landing surface with— • A transition to the landing configuration, followed by • A go-around maneuver beginning with the minimum climb gradient specified in § 25.119 from 200 feet to 2,000 feet above the landing surface, • Holding for 15 minutes at 2,000 feet above the landing surface in the approach configuration, and • A descent to the landing surface in the landing configuration; and (2) Holding ice (if the airplane 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 flightcrew to recognize icing conditions and activate the ice protection system, plus the time for the ice protection system to perform its intended function.

Flight Phase/Condition	Appendix O Ice Accretion
Ice Accretion in Appendix O Conditions Before those Conditions have been Detected by the Flightcrew 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 flightcrew 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 A.3 of this appendix), but in Appendix O conditions.

APPENDIX B. SIMULATED ICE ACCRETIONS

B.1 Overview.

B.1.1 In general, the simulated ice accretions used for flight testing should be those that have the most adverse effects on handling characteristics. However, if analytical data show that other reasonably expected ice accretions could be generated that could have a more adverse effect on performance, then the ice accretion having the most adverse effect on handling characteristics may be used for performance tests only if each difference in performance can be conservatively taken into account.

B.1.2 Simulated accretions should be representative of natural icing conditions in terms of location, general shape, thickness, and texture. The determination of the form and surface texture of the ice accretion (see paragraph B.2 below) should be agreed to by the responsible ACO as being representative of natural ice accretion.

B.1.3 Sandpaper ice is addressed in paragraph B.3 below.

B.2 Shape and Texture of Simulated Ice Accretion.

B.2.1 The shape and texture of the simulated ice accretion should be established and substantiated by agreed-upon methods. Common practices used to accomplish this include—

- Use of computer codes,
- Flight in measured natural icing conditions,
- Icing wind tunnel tests, and
- Flight in a controlled simulated icing cloud (for example, from an icing tanker).

B.2.2 Unless another texture is substantiated by the applicant and agreed to by the ACO, the applicant should use an ice accretion roughness height of 3 mm with a particle density of 8 to 10/cm^2.

B.3 Sandpaper Ice.

B.3.1 Sandpaper ice is the most critical thin, rough layer of ice. Carborundum sandpaper No. 40 (40-grit carborundum sandpaper) has been used in past certification programs to represent sandpaper ice. However, as detailed in Appendix R of AC 20-73A, the uniformly distributed roughness of carborundum grit may not result in aerodynamic effects similar to those of the actual intercycle ice surface roughness. The applicant should validate use of uniformly distributed roughness to simulate sandpaper ice, particularly for intercycle ice accretions.

B.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.

B.3.3 The spanwise and chordwise coverage of simulated ice should be consistent with the areas of ice accretion determined for the conditions of part 25, Appendix C, except that, for the zero-g pushover maneuver of paragraph 4.9.4.3.3 of this AC, the sandpaper ice may be restricted to the horizontal stabilizer if this can be shown to be conservative.

B.3.4 Appendix C, part II(a) requires applicants to use the most critical ice accretion to show compliance with the applicable subpart B airplane requirements for performance and handling characteristics in icing conditions. When determining the most critical ice accretion, the applicant must consider the full range of atmospheric icing conditions of Appendix C, part I, as well as the characteristics of the ice protection system, in accordance with § 25.21(g)(2) and Appendix C, part II(a). This would include consideration of sandpaper ice (as well as any other type of ice accretion that may occur in the applicable atmospheric icing conditions), taking into account the operating characteristics of the ice protection system and the flight phase. Sandpaper ice can be particularly critical for showing compliance with either § 25.143(i)(2) or (j)(2). If sandpaper ice can be present, it must be considered in showing compliance with both of these requirements.

APPENDIX C. DESIGN FEATURES

C.1 Airplane Configuration and Ancestry.

An airplane's size is an important design characteristic that can affect performance, controllability, and maneuverability in icing conditions. The safety record of the airplane's closely related ancestors is another aspect that may be taken into consideration.

C.1.1 Size.

The size of an airplane 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 airplane size increases.

C.1.2 Ancestors.

If a closely related ancestor airplane was certified for flight in icing conditions, that airplane's safety record may be used on a similarity basis when evaluating the subject airplane's general capabilities for flight in icing conditions.

C.2 Wing.

Design features of a wing that can affect performance, controllability, and maneuverability include airfoil type, leading edge devices, and lateral control system effectiveness.

C.2.1 Airfoil Type.

Aerodynamic effects of ice accretions result mainly from the effects of the ice accretion on the behavior of the airfoil's boundary layer. The boundary layer is the layer of air close to the surface of the airfoil that is moving across the airfoil at a velocity lower than the freestream velocity, that is, the velocity of the airfoil. Ice accretions that occur in areas favorable 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 favorable to attached boundary layer conditions. Ice shapes that build up in areas of local airflow deceleration (positively increasing surface pressure), or result in conditions unfavorable to keeping attached flow conditions, as the airflow negotiates the ice surface, will result in the most adverse effects.

C.2.2 Leading Edge Devices.

The presence of a leading edge device (such as a slat) reduces the percentage decrease in the maximum lift coefficient (C_{LMAX}) due to ice by increasing the overall level of the lift coefficient (C_L). Movement of a slat so that a gap forms may improve the situation further. Leading edge devices can also reduce loss in angle-of-attack at stall due to ice.

C.2.3 Lateral Control System Effectiveness.

The applicant can evaluate effectiveness of the lateral control system in icing conditions by comparing it with the lateral control system in closely related ancestor airplanes, with consideration of the design of aerodynamic balance surfaces.

C.3 Empennage.

The effects of size and airfoil type also apply to the horizontal and vertical tails. Other design features include tailplane design philosophy, horizontal stabilizer design, control surface actuation, control surface size, and vertical stabilizer and rudder design. 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 airplane handling and/or control characteristics rather than degraded performance.

C.3.1 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 deicing or anti-icing system.

C.3.2 Horizontal Stabilizer Design.

Cambered airfoils and/or trimmable stabilizers may reduce the susceptibility to and consequences of elevator hinge moment reversal due to ice-induced tailplane stall.

C.3.3 Control Surface Actuation.

Hydraulically powered irreversible elevator controls are usually not affected by ice-induced aerodynamic hinge moment reversal.

C.3.4 Control Surface Size.

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

C.3.5 Vertical Stabilizer and Rudder Design.

Effectiveness of the vertical stabilizer and rudder in icing conditions can be evaluated by comparison with the vertical stabilizer and rudder in closely related ancestor airplanes, with consideration of the design of aerodynamic balance surfaces.

C.4 Aerodynamic Balancing of Flight Control Surfaces.

C.4.1 The aerodynamic balance of unpowered or boosted reversible flight control surfaces is an important design feature to consider. The applicant should carefully evaluate the design to account for 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 or negative force gradients.

C.4.2 The aerodynamic balancing of unpowered or boosted reversible flight control surfaces 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 that 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.

C.5 Ice Protection/Detection System.

The ice protection/detection system design philosophy may include design features that reduce ice accretion on the wing and/or tailplane.

C.5.1 Wing Ice Protection/Detection.

C.5.1.1 A primary ice detection system that automatically activates a wing deicing system may ensure that there is no significant ice accretion on wings that are susceptible to performance losses with small amounts of ice.

C.5.1.2 If portions of the wing leading edge are not protected, the part that is protected may be selected to provide good handling characteristics at stall, with an acceptable performance degradation.

C.5.2 Tail Ice Protection/Detection.

C.5.2.1 A primary ice detection system may automatically activate a tailplane deicing system on airplanes that do not have visible cues for system operation.

C.5.2.2 An ice protection system on the unshielded aerodynamic balances of airplanes with unpowered reversible controls can reduce the risk of ice-induced aerodynamic hinge moment reversals.

APPENDIX D. EXAMPLES OF AIRPLANE FLIGHT MANUAL LIMITATIONS AND OPERATING PROCEDURES FOR OPERATIONS IN SUPERCOOLED LARGE DROP ICING CONDITIONS

D.1 Airplane Approved for Flight in Appendix C Icing Conditions but not Approved for Flight in Appendix O Icing Conditions.

D.1.1 AFM Limitations.

Intentional flight, including takeoff 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 {*placeholder for applicant to insert description of pilot cues 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.

D.1.2 AFM Operating Procedures (Normal Procedures Section).

Supercooled large drop (SLD) icing conditions, including freezing drizzle and freezing rain conditions, are severe icing conditions for this airplane. Intentional flight, including takeoff and landing, into SLD icing conditions is prohibited. A flight delay or diversion to an alternate airport is required if these conditions exist at the departure or destination airports.

{*Placeholder for applicant to insert description of pilot cues here*} is one indication of severe icing for this airplane. 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.

D.1.3 Flightcrew Operating Manual Operating Procedures.

Warning: Hazardous icing effects may result from environmental conditions outside of those for which this airplane 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 airplane.

Operations in icing conditions were evaluated as part of the certification process for this airplane. Supercooled large drop (SLD) icing conditions, including freezing drizzle and freezing rain, were not evaluated and are considered severe icing conditions for this airplane.

Intentional flight, including takeoff and landing, into SLD icing conditions, including freezing drizzle or freezing rain, is prohibited. A flight delay or diversion to an alternate airport is required if these conditions exist at the departure or destination airports. {*Placeholder for applicant to insert description of pilot cues here*} is an indication of severe icing conditions that exceed those for which this airplane 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.

D.2 Airplane Approved for Flight in Appendix C Icing Conditions and Freezing Drizzle Conditions of Appendix O but not Approved for Flight in Freezing Rain Conditions of Appendix O.

D.2.1 AFM Limitations.

Intentional flight, including takeoff and landing, into freezing rain conditions is prohibited. If freezing rain conditions are encountered, or if {*placeholder for applicant to insert description of pilot cues 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.

D.2.2 AFM Operating Procedures (Normal Procedures Section).

Freezing rain conditions are severe icing conditions for this airplane. Intentional flight, including takeoff and landing, into 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.

{*Placeholder for applicant to insert description of pilot cues here*} is one indication of severe icing for this airplane. 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.

D.2.3 Flightcrew Operating Manual Operating Procedures.

Warning: Hazardous icing effects may result from environmental conditions outside of those for which this airplane 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 may result in ice forming aft of the protected surfaces. This ice might not be shed when using the ice protection systems, and may seriously degrade the performance and controllability of the airplane.

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

Intentional flight, including takeoff and landing, into 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. {*Placeholder for applicant to insert description of pilot cues here*} is an indication of severe icing conditions that exceed those for which this airplane 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.

D.3 Airplane Approved for Flight in Appendix C and Appendix O Icing Conditions Except for En Route and Holding Flight Phases in Appendix O Icing Conditions.

D.3.1 AFM Limitations.

Intentional holding or en route flight into supercooled large drop (SLD) icing conditions, including freezing drizzle or freezing rain, is prohibited. If SLD icing conditions, including freezing drizzle or freezing rain, are encountered during a hold (in any airplane configuration) or in the en route phase of flight (climb, cruise, or descent with high lift devices and gear retracted), or if {*placeholder for applicant to insert description of pilot cues here*} is present, 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.

D.3.2 AFM Operating Procedures (Normal Procedures Section).

Supercooled large drop (SLD) icing conditions, including freezing drizzle and freezing rain, encountered during a hold (in any airplane configuration) or in the en route phase of flight (climb, cruise, or descent with high lift devices and gear retracted) are severe icing conditions for this airplane. Intentional holding or en route flight in SLD icing conditions, including freezing drizzle or freezing rain, is prohibited.

{*Placeholder for applicant to insert description of pilot cues here*} is one indication of severe icing for this airplane. 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.

D.3.3 Flightcrew Operating Manual Operating Procedures.

Warning: Hazardous icing effects may result from environmental conditions outside of those for which this airplane 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 the performance and controllability of the airplane.

Operations in icing conditions were evaluated as part of the certification process for this airplane. En route (climb, cruise, and descent with high left devices and gear retracted) and holding flight (in any airplane configuration) in supercooled large drop (SLD) icing conditions, including freezing drizzle and freezing rain, were not evaluated and are considered severe icing conditions for this airplane.

Intentional holding or en route flight in SLD icing conditions, including freezing drizzle or freezing rain, is prohibited. {*Placeholder for applicant to insert description of pilot cues here*} is an indication of severe icing conditions that exceed those for which the airplane 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.

D.4 Airplane Approved for Flight in Appendix C Icing Conditions and a Portion of Appendix O Icing Conditions.

D.4.1 AFM Limitations.

Intentional flight, including takeoff and landing, into {*Placeholder for applicant to insert pilot usable description here*} conditions is prohibited. If {*insert pilot usable description here*} 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.

D.4.2 AFM Operating Procedures (Normal Procedures Section).

{*Placeholder for applicant to insert description for pilots to use here*} are severe icing conditions for this airplane. Intentional flight, including takeoff and landing, into {insert pilot usable description here} conditions is prohibited. A flight delay or diversion to an alternate airport is required if these conditions exist at the departure or destination airports.

{*Placeholder for applicant to insert description of pilot cues here*} is one indication of severe icing for this airplane. 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.

D.4.3 Flightcrew Operating Manual Operating Procedures.

Warning: Hazardous icing effects may result from environmental conditions outside of those for which this airplane 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 may result in ice forming aft of the protected surfaces. This ice might not be shed when using the ice protection systems, and may seriously degrade the performance and controllability of the airplane.

Operations in icing conditions were evaluated as part of the certification process for this airplane. {*Placeholder for applicant to insert description for pilots to use here*} were not evaluated and are considered severe icing conditions for this airplane.

Intentional flight, including takeoff and landing, into {*Placeholder for applicant to insert description for pilots to use here*} is prohibited. A flight delay or diversion to an alternate airport is required if these conditions exist at the departure or destination airports. {*Placeholder for applicant to insert description of pilot cues here*} is an indication of severe icing conditions that exceed those for which this airplane 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. Remain 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.

APPENDIX E. RELATED REGULATIONS AND ADVISORY CIRCULARS

E.1 Regulations.

The following sections of Title 14, Code of Federal Regulations (14 CFR) part 25 are referenced in this AC. The full text of these regulations can be downloaded from the U.S. Government Printing Office e-CFR. A paper copy may be ordered from the Government Printing Office, Superintendent of Documents, Attn: New Orders, PO Box 371954, Pittsburgh, PA, 15250-7954.

Table E-1. Related Regulations

14 CFR	Title
§ 25.21	Proof of compliance
§ 25.23	Load distribution limits
§ 25.25	Weight limits
§ 25.27	Center of gravity limits
§ 25.29	Empty weight and corresponding center of gravity
§ 25.31	Removable ballast
§ 25.33	Propeller speed and pitch limits
§ 25.101	Performance—General
§ 25.103	Stall speed
§ 25.105	Takeoff
§ 25.107	Takeoff speeds
§ 25.109	Accelerate-stop distance
§ 25.111	Takeoff path
§ 25.119	Landing climb: All-engines-operating
§ 25.121	Climb: One-engine-inoperative
§ 25.123	En route flight paths

14 CFR	Title
§ 25.125	Landing
§ 25.143	Controllability and Maneuverability—General
§ 25.145	Longitudinal control
§ 25.147	Directional and lateral control
§ 25.161	Trim
§ 25.171	Stability—General
§ 25.175	Demonstration of static longitudinal stability
§ 25.177	Static lateral-directional stability
§ 25.181	Dynamic stability
§ 25.201	Stall demonstration
§ 25.203	Stall characteristics
§ 25.207	Stall warning
§ 25.231	Longitudinal stability and control
§ 25.233	Directional stability and control
§ 25.235	Taxiing condition
§ 25.237	Wind velocities
§ 25.251	Vibration and buffeting
§ 25.253	High-speed characteristics
§ 25.255	Out-of-trim characteristics
§ 25.1309	Equipment, systems, and installations
§ 25.1329	Flight guidance system
§ 25.1419	Ice protection
§ 25.1420	Supercooled large drop icing conditions
§ 25.1581	Airplane Flight Manual—General

14 CFR	Title
§ 25.1583	Operating limitations
§ 25.1585	Operating procedures
§ 25.1587	Performance information
Part 25, Appendix C	
Part 25, Appendix O	Supercooled Large Drop Icing Conditions

E.2 **Advisory Circulars.**

The following ACs are related to the guidance in this AC. Table E-2 identifies the latest version of each AC at the time of publication. If any AC is revised after publication of this AC, you should refer to the latest version for guidance. You can find the latest version at the FAA website.

Table E-2. Related Advisory Circulars

Number	Title	Date
AC 20-73A	Aircraft Ice Protection	August 16, 2006
AC 25-7C	Flight Test Guide for Certification of Transport Category Airplanes	October 16, 2012
AC 25.1309-1A	System Design and Analysis	June 21, 1988
AC 25.1329-1C	Approval of Flight Guidance Systems	October 27, 2014
AC 25.1419-2	Compliance with the Ice Protection Requirements of §§ 25.1419(e), (f), (g), and (h)	October 27, 2009
AC 25-28	Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions	October 27, 2014

APPENDIX F. ACRONYMS

Table F-1. Acronyms, Terms, and Definitions

Acronym/Term	Definition
AC	Advisory Circular
ACO	Aircraft Certification Office
AFM	Airplane Flight Manual
ATTCS	Automatic Takeoff Thrust Control System
CAS	Calibrated Airspeed
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
ICTS	Ice-Contaminated Tailplane Stall
KIAS	Knots Indicated Airspeed
LWC	Liquid Water Content
MED	Mean Effective Diameter
MVD	Median Volume Diameter
C_L	Lift Coefficient
C_{LMAX}	Maximum Lift Coefficient
SLD	Supercooled Large Drop
Trim	A flight condition in which the aerodynamic moment acting about the axis of interest is zero. In the absence of an external disturbance, no control input is needed to maintain the flight condition.

Acronym/Term	Definition
V_1	The maximum speed in the takeoff at which the pilot must take the first action (for example, apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.
V_2	Takeoff Safety Speed. (The target speed to be reached by the time the airplane is 35 feet above the takeoff surface.)
V_{2MIN}	Minimum Takeoff Safety Speed
V_{CW}	Crosswind Component of Wind Speed
$V_{DF/MDF}$	Demonstrated Flight Diving Speed
V_{EF}	Engine Failure Speed. The speed at which the critical engine is assumed to fail during takeoff.
V_{FC}	Maximum Speed for Stability Characteristics
V_{FE}	Maximum Flaps Extended Speed
V_{MO}	Maximum Operating Limit Speed
V_{REF}	Landing Reference Speed
$V_{S\ 1\text{-}g}$	1-g Stall Speed. The calibrated airspeed at which aerodynamic forces alone can support the airplane in 1-g flight.
V_{SR}	Reference Stall Speed. V_{SR} may not be less than $V_{S\ 1\text{-}g}$. For airplanes with a device that abruptly pushes the nose down at a selected angle of attack (for example, a stick pusher), V_{SR} may not be less than 2 knots or 2 percent, whichever is greater, above the speed at which the device operates.
V_{SR1}	Reference Stall Speed in a Specific Configuration

Advisory Circular Feedback

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) emailing this form to 9-AWA-AVS-AIR500-Coord@faa.gov or (2) faxing it to the attention of the Aircraft Certification Service Directives Management Officer at (202) 267-3983.

Subject: ________________________ Date: ____________________

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph ______________ on page ____________________.

☐ Recommend paragraph _____________ on page ________ be changed as follows:

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

☐ Other comments:

☐ I would like to discuss the above. Please contact me.

Submitted by: _________________________________ Date: __________________________