



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: COMPLIANCE WITH THE
ICE PROTECTION REQUIREMENTS
OF §§ 25.1419(e), (f), (g), and (h)

Date: 10/27/09

AC No: 25.1419-2

Initiated By: ANM-110

1. Purpose. This advisory circular (AC) describes an acceptable means for showing compliance with the requirements of Title 14, Code of Federal Regulations (14 CFR) 25.1419(e), (f), (g), and (h), Ice protection. Part 25 contains the airworthiness standards applicable to transport category airplanes. This AC provides guidance for:

- installing a primary ice detection system,
- developing visual cues and installing an advisory ice detection system to alert the flightcrew that the airframe ice protection system (IPS) must be activated,
- identifying conditions conducive to airframe icing through the use of temperature and visible moisture cues, and
- including in the airplane flight manual (AFM) procedures for activating and deactivating the airframe IPS.

2. Applicability.

a. This AC provides guidance directed to airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) airplane type certification engineers and their designees. This guidance applies to certification of part 25 transport category airplanes for flight in icing conditions.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. The FAA will consider other methods of demonstrating compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience. On the other hand, if 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.

c. This material does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

3. Definition of Terms. For the purposes of this advisory circular, the following definitions should be used.

NOTE: These definitions apply to the guidance material in this AC. Terms for which standard dictionary definitions apply are not defined in this AC.

a. **Advisory Ice Detection System.** An advisory system annunciates the presence of icing conditions or ice accretion. The advisory ice detection system provides information advising the flightcrew of the presence of ice accretion or icing conditions. It can only be used in conjunction with other means (most commonly, visual observation by the flightcrew) to determine the need for, or timing of, activating the anti-icing or deicing system. The flightcrew is responsible for monitoring the icing conditions or ice accretion as defined in the AFM (typically using total air temperature and visible moisture criteria or visible ice accretion) and activating the anti-icing or deicing system(s).

b. **Airframe Icing.** Airframe icing is ice accretions on the airplane, except for the propulsion system.

c. **Anti-Icing.** Anti-icing is the prevention of ice accretions on a protected surface, either:

- by evaporating the impinging water, or
- by allowing it to run back and off the protected surface or freeze on non-critical areas.

d. **Automatic Cycling Mode.** An automatic cycling mode is a mode of operation of the airframe deicing system that provides repetitive cycles of the system without the need for the pilot to select each cycle. This is generally done with a timer, and there may be more than one timing mode.

e. **Deicing.** Deicing is the removal or the process of removal of an ice accretion after it has formed on a surface.

f. **Ice Protection System.** An ice protection system (IPS) is a system that protects certain critical aircraft parts from ice accretion. To be an approved system, it must satisfy the requirements of § 25.1419.

g. **Primary Ice Detection System.** A primary ice detection system is used to determine when the IPS must be activated. The system annunciates the presence of ice accretion or icing conditions, and may also provide information to other aircraft systems. A primary *automatic* system automatically activates the anti-icing or deicing IPS. With a primary *manual* system, the flightcrew activates the anti-icing or deicing IPS upon indication from the primary ice detection system.

h. Static Air Temperature. The air temperature as would be measured by a temperature sensor not in motion with respect to that air. This temperature is also referred to in other documents as “outside air temperature,” “true outside temperature,” or “ambient temperature.”

i. Visual Cue. Ice accretion on a reference surface that has been demonstrated by testing to correlate with ice accretion on a monitored surface.

4. Compliance with § 25.1419(e)(1) and (e)(2).

a. Requirements of the Rule. Except as discussed in paragraph 5 of this AC, paragraphs (e)(1) and (2) of the rule require either a primary ice detection system, or defined visual cues of the first sign of ice accretion combined with an advisory ice detection system, to alert the flightcrew that the airframe IPS must be activated.

(1) One of the following provides an acceptable means of compliance with § 25.1419(e)(1):

- A primary manual ice detection system that provides an alert that the airframe IPS must be activated, or
- A primary automatic ice detection system.

(2) Section 25.1419(e)(2) of the rule requires defined visual cues for the 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. An acceptable means of compliance is identified in the preamble of the rule which states that the acceptability of visual cues combined with an advisory ice detection system is contingent upon:

(a) The advisory ice detection system annunciates when icing conditions exist or when the substantiated visual cues are present.

(b) The defined visual cues rely on the flightcrew’s observation of the first sign of ice accretion on the airplane and do not depend on the pilot determining the thickness of the accretion.

(c) The flightcrew activates the ice protection system when they observe the ice accretion or when the ice detector annunciates, whichever occurs first.

(3) The visual cues can either be direct observation of ice accretions on the airplane’s protected surfaces or observation of ice accretions on reference surfaces. Examples of potentially acceptable visual means include the first indication of:

- accretions forming on the windshield wiper posts,
- accretions forming on propeller spinners,

- accretions forming on radomes, and
- accretions on the protected surfaces.

(4) If accretions on the protected surfaces cannot be observed, a reference system would be necessary if compliance with § 25.1419(e)(2) is desired. The applicant should consider providing a reference surface which can be periodically deiced to allow the flightcrew to determine if the airframe is continuing to accumulate ice. Without a means to deice the reference surface, compliance with § 25.1419(e)(2) would require operation of the IPS as long as there is ice on the reference surface, even when additional ice is not accumulating. The applicant should substantiate, for the icing conditions defined in appendix C to part 25, that the reference surface accumulates ice at the same time as or prior to ice accumulating on the protected surfaces.

(5) Field of View. The visual cues should be developed with the following considerations:

(a) Visual cues should be within the flightcrew's primary field-of-view if possible. If outside the primary field-of-view, the cues should be visible from the design eye point and easily incorporated into the flightcrew's scan with a minimum of head movement while seated and performing their normal duties.

(b) The visual cues should be visible during all modes of operation (day and night).

(6) Verification. During the certification process, the applicant should verify the ability of the crew to observe the visual cues. Visibility of the visual cues should be evaluated from the most adverse flightcrew seat locations in combination with the range of flightcrew heights, within the approved range of eye reference point locations, if available. A visual cue is required for both the left and right seats. If a single visual cue is used, it should be visible from either seat. Consideration should be given to the difficulty of observing clear ice. If a reference surface is used, the applicant should validate that it correlates with ice accumulation on the airframe's protected areas. Visual cues should be validated by testing in measured natural icing.

(7) The applicant should present an icing certification plan, as suggested by AC 25.1419-1A, to the cognizant Aircraft Certification Office. The plan should include the method selected to demonstrate the ice detector system's compliance with §§ 25.1301, 25.1309, 25.1419, and any other applicable sections. Advisory Circular 20-73A, appendix K, provides guidance on the certification of ice detector systems. The appendix provides guidance regarding ice detection response times as the freezing fraction drops below 1. That guidance is equally applicable to advisory and primary ice detection systems.

b. System Performance When Installed. The applicant should accomplish a droplet impingement analysis and/or tests to ensure that the ice detector is properly located. It should be shown that under the various airplane operational configurations, airspeeds, and associated

angles of attack that the ice detector is exposed to the droplets. The detector and its installation should minimize nuisance warnings.

c. **System Safety Considerations.** The applicant should consult AC 25.1309-1A for guidance on compliance with § 25.1309. In accordance with AC 25.1309-1A, the applicant should accomplish a functional hazard assessment to determine the hazard level associated with failure of the ice detection system. The probability of encountering the icing conditions defined in appendix C to part 25 should be considered to be 1. The unannounced failure of a primary ice detection system is assumed to be a catastrophic failure condition, unless the characteristics of the airplane in icing conditions without activation of the airframe IPS(s) are demonstrated to result in a less severe hazard category. If visual cues are the primary means, the pilots retain responsibility to monitor and detect ice accretions when an advisory ice detection system is installed. However, the natural tendency of flightcrews to become accustomed to using the advisory ice detection system elevates the importance of the detector and increases the need to make flightcrews aware of an advisory ice detection system failure. Therefore, an undetected failure of the advisory ice detector should be considered as at least Major unless substantiated to be a lower failure condition classification.

d. **Software and Hardware Qualification.** For hardware and software qualification guidance, the applicant should consult RTCA/DO-178B, Software Considerations in Airborne Systems and Equipment Certification, RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware, and RTCA/DO-160F, Environmental Conditions and Test Procedures for Airborne Equipment. In the event a document is revised the latest version should be used.

e. **Safe Operations in Icing Conditions.**

(1) Section 25.1419 requires that the applicant demonstrate that the airplane is able to operate safely in the icing conditions defined in appendix C to part 25. The ice detection system should be shown to operate in the range of conditions defined by appendix C.

(2) Section 25.1419 also requires a combination of tests and analysis to demonstrate the performance of the ice detector and the ice detector system as installed on the airplane. This could include icing tunnel and icing tanker tests to evaluate the ice detector performance. Also required are analysis and flight tests in measured natural atmospheric conditions to demonstrate satisfactory performance of the system as installed on the airplane. Droplet impingement analysis may be used in determining that the ice detector functions properly over the droplet range of appendix C when validated through natural or artificial icing tests (for example, tanker, icing tunnel). It should be demonstrated that the airplane can be safely operated with the ice accretions formed at the time the IPS becomes effective.

f. **Cycling of Engine Thrust.** The primary automatic ice detection system should be designed to prevent frequent cycling of engine thrust in intermittent icing conditions. Small thrust changes will occur with the opening and closing of engine bleed valves, resulting in a possible nuisance to the flightcrew.

g. **Airplane Flight Manual.** The AFM should address the following:

- (1) Operational use of the in-flight ice detection system and IPS and any limitations,
- (2) Failure indications and appropriate crew procedures, and
- (3) Procedures for deactivating the IPS.

5. Compliance with § 25.1419(e)(3).

a. Requirements of the Rule. Paragraph (e)(3) of the rule provides an alternative to paragraph (e)(1), primary ice detection system, and paragraph (e)(2), visual cues combined with an advisory ice detection system. The alternative provided by paragraph (e)(3) requires operating the IPS when the airplane is in conditions conducive to airframe icing during all phases of flight.

b. Temperature Cue. The temperature cue used in combination with visible moisture should consider static temperature variations due to local pressure variations on the airframe. If the engine and airframe IPS are both activated based on visible moisture and temperature, a common conservative temperature for operation of both systems should be used. For example, if the engine IPS is activated at +5° C static air temperature or less, the airframe IPS should also be activated at the same temperature even if it is substantiated that airframe will not accrete ice above +2° C static air temperature. This would ease the flightcrew workload and increase the probability of procedural compliance. A minimum temperature limitation may be required on some systems due to equipment temperature limitations (such as elastomer pneumatic deice boot systems).

c. If this provision is used, the flightcrew should be able to easily determine the static air temperature. A display of static air temperature or a placard can be provided showing corrections for the available temperature, to the nearest degree Centigrade, so the flightcrew can determine the static air temperature in the region of interest (that is, around 0° C).

d. Airplane Flight Manual. The AFM should identify specific static or total air temperature and visible moisture conditions which must be considered as conditions conducive to airframe icing, and should specify the phases of flight in which the IPS must be operated when these conditions are encountered.

6. Compliance with § 25.1419(f).

a. Requirements of the Rule. This section states that the requirements of paragraphs (e)(1), (2), and (3) are applicable to all phases of flight unless it can be shown that the ice protection system (IPS) need not be operated.

b. To substantiate that the IPS need not be operated during certain phases of flight, the ice accretions that form during these phases, without the IPS operating, should be considered when establishing that the airplane is able to operate safely in the continuous maximum and intermittent maximum icing conditions of appendix C.

7. Compliance with § 25.1419(g).

a. Requirements of the Rule. This section requires that after the initial activation of the IPS:

- the IPS must operate continuously, or
- the IPS must automatically cycle, or
- an ice detection system must be provided to alert the flightcrew each time the IPS must be cycled.

(1) Any of the following provide an acceptable means to automatically cycle the IPS:

(a) A system that senses ice accretion on a detector and correlates it to ice accretion on a protected surface. This system then cycles the IPS at a predetermined condition.

(b) A system that directly senses the ice thickness on a protected surface and cycles the IPS.

(c) A system which cycles the IPS based on the use of a timer.

1 It should be substantiated that the airplane can safely operate with ice accretions that form between the time the deicing cycle is completed and the next cycle is initiated.

2 If more than one cycle time (for example, 1- or 3-minute intervals) is provided it should be substantiated that the flightcrew is able to determine which cycle time is appropriate.

NOTE: A common attribute of the above systems is that the pilot is not required to manually cycle the IPS after initial activation.

(2) Some examples of an ice detection system which alerts the flightcrew each time the IPS must be cycled could be the same as paragraphs (a) and (b) above, except that an ice detection system alerts the crew each time the IPS must be manually cycled. The flightcrew workload associated with such a system should be evaluated. Because of flightcrew workload and human factors considerations, a timed system that does not have ice sensing capability should not be used to meet this requirement.

b. System Performance when Installed. The applicant should accomplish a droplet impingement analysis and/or tests to ensure that the ice detector is properly located. It should be shown that under the various airplane operational configurations, airspeeds, and associated angles of attack that the ice detector is exposed to the droplets. The detector and its installation should minimize nuisance warnings.

NOTE: This is the same information provided in paragraph 4(b), System Performance When Installed.

c. **System Safety Considerations.** Any system installed to comply with § 25.1419(g) must comply with § 25.1309 and the applicant should consult AC 25.1309-1A for guidance. In accordance with the AC, the applicant should accomplish a functional hazard assessment to determine the hazard level associated with failure of the system. The probability of encountering the icing conditions defined in appendix C to part 25 should be considered to be 1. The unannounced failure of the system is assumed to be a catastrophic failure condition, unless the characteristics of the airplane in icing conditions without activation of the IPS(s) are demonstrated to result in a less severe hazard category. If visual cues are not available to indicate repeated cycles of a manually cycled deicing system, an advisory ice detection system certificated for compliance with § 25.1419(e)(2) may need to become a primary ice detection system for compliance with § 25.1419(g). If visual cues are available the flightcrew workload should be evaluated.

d. **Hardware and Software Qualification.** For hardware and software qualification guidance, the applicant should consult RTCA/DO-178B, Software Considerations in Airborne Systems and Equipment Certification, RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware, and RTCA/DO-160E, Environmental Conditions and Test Procedures for Airborne Equipment.

NOTE: This is the same information provided in paragraph 4(d), Software and Hardware Qualification.

e. **Safe Operations in Icing Conditions.**

(1) Section 25.1419 requires that the applicant demonstrate that the airplane is able to operate safely in the icing conditions defined in appendix C to part 25. The ice detection system should be shown to operate in the range of conditions defined by appendix C.

(2) Section 25.1419 also requires a combination of tests and analysis to demonstrate the performance of any system and its components used to comply with § 25.1419(g). If an ice detector is used this could include icing tunnel and icing tanker tests to evaluate the ice detector performance. Also required are analysis and flight tests in measured natural atmospheric conditions to demonstrate satisfactory performance of the system as installed on the airplane. Droplet impingement analysis may be used in determining that the ice detector functions properly over the droplet range of appendix C when validated through natural or artificial icing tests (for example, tanker, icing tunnel). It should be demonstrated that the airplane can be safely operated with the ice accretions formed at the time the IPS becomes effective.

f. **Cycling of Engine Thrust.** The primary automatic ice detection system should be designed to prevent frequent cycling of engine thrust in intermittent icing conditions. Small thrust changes will occur with the opening and closing of engine bleed valves, resulting in a possible nuisance to the flightcrew.

NOTE: This is the same information provided in paragraph 4(f), Engine Thrust.

g. Airplane Flight Manual. The AFM should address the following:

- (1) Operational use of the in-flight ice detection system and IPS and any limitations,
- (2) Failure indications and appropriate crew procedures, and
- (3) Procedures for deactivating the IPS.

NOTE: This is the same information provided in paragraph 4(g), Airplane Flight Manual.

8. Compliance with § 25.1419(h).

a. Requirements of the Rule. Procedures for operation of the IPS including activation and deactivation must be established.

b. Deactivation of IPS. The procedures for IPS deactivation must be consistent with the § 25.1419(e) requirements for activation of the IPS. The exact timing of the deactivation should consider the type of ice protection system (e.g., deicing, anti-icing, or running wet) and any delays in deactivation necessary to ensure residual ice is minimized. Pneumatic deicing boots should be operated for three complete cycles following the absence of the cues used for activation. For example,

(1) If the airplane is certificated in accordance with § 25.1419(e)(2), pneumatic deicing boots may be deactivated following the completion of three boot cycles after both the substantiated visual cues and the advisory ice detection system no longer indicate ice accretion, or,

(2) If the airplane is certificated in accordance with § 25.1419(e)(3), pneumatic deicing boots may be deactivated following the completion of three boot cycles after leaving icing conditions even if residual ice is observed on the boots. The boots must be activated upon reentry into icing conditions.

c. AFM Procedures. Procedures for operation of the IPS should be provided in the AFM as discussed in this paragraph and in paragraphs 4 and 5 above.



Stephen P. Boyd
Acting Manager, Transport Airplane Directorate
Aircraft Certification Service

Appendix 1**RELATED DOCUMENTS**

a. Regulations Contained in 14 CFR. The following documents provide additional information and are not necessarily directly referenced in this advisory circular. You can download the full text of 14 CFR from the Internet at <http://www.gpoaccess.gov/nara>. You can order a paper copy from the Government Printing Office (GPO), Superintendent of Documents, Attn: New Orders, PO Box 371954, Pittsburgh, PA 15250-7954.

Section	Title
§ 25.1301	Equipment - Function and installation
§ 25.1309	Equipment, systems, and installations
§ 25.1316(b)	System lightning protection
§ 25.1321	Instruments Installation - Arrangement and visibility
§ 25.1322	Warning, caution, and advisory lights
§ 25.1419	Ice protection
§ 25.1585(a)(6)	Operating procedures
Appendix C to part 25	

b. Advisory Circulars. You can download an electronic copy of the following ACs from the Internet at <http://www.airweb.faa.gov/rgl>.

Number	Title and Date
AC 20-73A	Aircraft Ice Protection, dated August 16, 2006.
AC 20-117	Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing, dated December 17, 1982.
AC 20-115B	RTCA, Inc., Document RTCA/DO-178B [Radio Technical Commission for Aeronautics] dated January 11, 1993.
AC 21-16E	RTCA, Inc. Document DO-160E, Environmental Conditions and Test Procedures for Airborne Equipment, dated December 20, 2005.
AC 25-7A, Change 1	Flight Test Guide for Certification of Transport Category Airplanes, dated June 3, 1999.
AC 25-11A	Electronic Flight Deck Displays, dated June 21, 2007.
AC 25-25	Performance and Handling Characteristics in the Icing Conditions Specified in Part 25, Appendix C, dated September 10, 2007.
AC 25.1309-1A	System Design and Analysis, dated June 21, 1988.
AC 25.1419-1A	Certification of Transport Category Airplanes for Flight in Icing Conditions, dated May 7, 2004.

NOTE: This table represents the latest version of each AC at the time of publication. These individual ACs may be updated in the future, such that this table may reference a specific version of an AC that has been superseded. The latest version of each AC should always be used, even though this document may reference a previous version of an AC.

c. Other FAA Documents. You can obtain the following document from the National Information Service, Department of Commerce, 5385 Port Royal Road, Springfield, VA 22161

Number	Title and Date
DOT/FAA/CT-88/8-1	"Aircraft Icing Handbook," issued March 1991, updated September 1993

d. Industry Documents. You can obtain the following documents from Radio Technical Commission for Aeronautics (RTCA), Inc., 1140 Connecticut Ave., NW, Suite 1020, Washington, DC 20036.

Number	Title
RTCA/DO-178B	Software Considerations in Airborne Systems and Equipment Certification
RTCA/DO160E	Environmental Conditions and Test Procedures for Airborne Equipment
RTCA/DO-254	Design Assurance Guidance for Airborne Electronic Hardware