DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. 2005–22840; Notice No. 05–10]

RIN 2120–AI14

Airplane Performance and Handling Qualities in Icing Conditions

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This action proposes to introduce new airworthiness standards to evaluate the performance and handling characteristics of transport category airplanes in icing conditions. This proposed action would improve the level of safety for new airplane designs when operating in icing conditions, and would harmonize the U.S. and European airworthiness standards for flight in icing conditions.

DATES: Send your comments on or before February 2, 2006.

ADDRESSES: You may send comments identified by Docket Number FAA–2005–22840 using any of the following methods:

- DOT Docket Web site: Go to *http://dms.dot.gov* and follow the instructions for sending your comments electronically.
- Government-wide Regulations and Policies Web site: Go to *http://www.faa.gov/regulations_policies/* and follow the instructions for sending your comments electronically.
- Mail: Docket Management Facility; U.S. Department of Transportation, 400 Seventh Street, SW., Nassif Building, Room PL–401, Washington, DC 20590–001.
- Fax: 1–202–493–2251.
- Hand Delivery: Room PL–401 on the plaza level of the Nassif Building, 400 Seventh Street, SW., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

For more information on the rulemaking process, see the **SUPPLEMENTARY INFORMATION** section of this document.

Privacy: We will post all comments we receive, without change, to *http://dms.dot.gov,* including any personal information you provide. For more information, see the Privacy Act discussion in the **SUPPLEMENTARY INFORMATION** section of this document.

Docket: To read background documents or comments received, go to *http://dms.dot.gov* at any time or to Room PL–401 on the plaza level of the Nassif Building, 400 Seventh Street, SW., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

FOR FURTHER INFORMATION CONTACT: Don Stimson, FAA, Airplane & Flight Crew Interface Branch, ANM–111, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, WA 98055–4056; telephone: (425) 227–1129; fax: (425) 227–1149, e-mail: *don.stimson@faa.gov.*

SUPPLEMENTARY INFORMATION:

Comments Invited

The FAA invites interested persons to participate in this rulemaking by submitting written comments, data, or views. We also invite comments relating to the economic, environmental, energy, or federalism impacts that might result from adopting the proposals in this document. The most helpful comments reference a specific portion of the proposal, explain the reason for any recommended change, and include supporting data. We ask that you send us two copies of written comments.

We will file in the docket all comments we receive, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking. The docket is available for public inspection before and after the comment closing date. If you wish to review the docket in person, go to the address in the **ADDRESSES** section of this preamble between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. You may also review the docket using the Internet at the Web address in the **ADDRESSES** section.

Privacy Act: Using the search function of our docket Web site, anyone can find and read the comments received into any of our dockets, including the name of the individual sending the comment (or signing the comment of behalf of an association, business, labor union, etc.). You may review DOT's complete Privacy Act statement in the **Federal Register** published on April 11, 2000 (65 FR 19477–78) or you may visit *http://dms.dot.gov.*

Before acting on this proposal, we will consider all comments we receive on or before the closing date for comments. We will consider comments filed late if it is possible to do so without incurring expense or delay. We may change this proposal in light of the comments we receive.

If you want the FAA to acknowledge receipt of your comments on this proposal, include with your comments a pre-addressed, stamped postcard on which the docket number appears. We will stamp the date on the postcard and mail it to you.

Availability of Rulemaking Documents

You can get an electronic copy using the Internet by:

(1) Searching the Department of Transportation's electronic Docket Management System (DMS) Web page (*http://dms.dot.gov/search*);

(2) Visiting the Office of Rulemaking's Web page at *http://www.faa.gov/avr/arm/index.cfm;* or

(3) Accessing the Government Printing Office's Web page at *http://www.gpoaccess.gov/fr/index.html.*

You can also get a copy by sending a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Make sure to identify the docket number, notice number, or amendment number of this rulemaking.

Authority for This Rulemaking

The FAA's authority to issue rules regarding aviation safety is found in Title 49 of the United States Code. Subtitle I, section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in subtitle VII, part A, subpart III, section 44701, ''General requirements.'' Under that section, the FAA is charged with promoting safe flight of civil aircraft in air commerce by prescribing minimum standards required in the interest of safety for the design and performance of aircraft. This regulation is within the scope of that authority because it prescribes new safety standards for the design of transport category airplanes.

Organization of This NPRM

Discussion of this proposal is organized under the headings listed below. Whenever there is a reference to a document being included in the docket for this NPRM, the docket referred to is Docket Number FAA–2005–22840. A list of acronyms used is included in an appendix located at the end of the preamble material, between the regulatory evaluation and the text of the proposed amendments. Unless stated otherwise, rule sections referenced in this NPRM are part of Title 14, Code of Federal Regulations (14 CFR).

I. Executive Summary

If adopted, this rulemaking would revise certain sections of part 25 of Title

14 Code of Federal Regulations (14 CFR). Part 25 contains the airworthiness standards for type certification of transport category airplanes, but it does not currently include specific requirements for airplane performance or handling qualities for flight in icing conditions. Although part 25 requires airplanes with approved ice protection features to be able to operate safely in icing conditions, there is no standard set of criteria defining what ''to safely operate'' in icing conditions means in terms of airplane performance and handling qualities. Further, because the existing icing regulations only address airplanes with ice protection provisions, it is unclear what requirements apply in cases where the applicant is seeking to have an airplane without an ice protection system certificated for flight in icing conditions.

This notice proposes to amend part 25 by adding a comprehensive set of airworthiness requirements that must be met to receive certification approval for flight in icing conditions, including specific performance and handling qualities requirements, and the ice accretion (that is, the size, shape, location, and texture of the ice) that must be considered for each phase of flight. These proposed revisions would ensure that minimum operating speeds determined during the certification of all future transport category airplanes would provide adequate maneuver capability in icing conditions for all phases of flight and all airplane configurations.

This notice proposes to require the same airplane handling characteristics that apply in non-icing conditions to continue to apply in icing conditions. Additionally, a specific evaluation for susceptibility to tailplane stall in icing conditions would be added. This proposal, if adopted, would harmonize the U.S. and European airworthiness standards for flight in icing conditions. It would benefit the public interest while retaining or enhancing the current level of safety for operation in icing conditions.

If adopted, this rulemaking would affect manufacturers, modifiers, and operators of transport category airplanes (but only for new designs or significant changes to current designs that would affect the safety of flight in icing conditions). Manufacturers and modifiers may need to develop new tests and analyses to determine ice accretions and to estimate performance effects for design and certification to address icing conditions. Operators may need to develop new or revised procedures regarding identification of icing conditions and the operation of the ice protection system.

Service history shows that flight in icing conditions may be a safety risk for transport category airplanes. There have been nine accidents since 1983 that may have been prevented if this proposed rule had been in effect.[1] The service history that we examined includes airplanes certificated to part 25, to its predecessor, the Civil Air Regulations (CAR) 4b, or to part 25 icing standards when the airplane was certified under part 23. In evaluating the potential for this rulemaking to avoid future accidents, we only considered past accidents involving tailplane stall or potential airframe ice accretion effects on drag or controllability. Accidents related to ground deicing were not considered.

The NTSB has issued several safety recommendations related to airframe icing, some of which are addressed, at least in part, by this notice. If adopted, this rulemaking would require, during type certification, that manufacturers of transport category airplanes:

- Investigate the susceptibility of their airplanes to ice-contaminated tailplane stall (ICTS);
- Provide for adequate warning on the flight deck of an impending stall in icing conditions;
- Show that their airplanes meet the same maneuvering capability and handling characteristics requirements in icing conditions as in non-icing conditions; and
- Show that their airplanes have adequate performance capability in icing conditions.

As discussed in more detail later, the FAA has tentatively determined that this rulemaking would have the following costs and benefits over a 45-year analysis period. The cost of the proposed rule would be $22.0 million (present value). The FAA assumes the initial certification costs of $6.7 million for four new airplane models are incurred in year one of a 45-year analysis period. The future additional fuel burn expense is estimated to be $59.7 million and would be incurred over the 45-year analysis period. The benefits of this proposed rule consist of the value of lives saved due to avoiding accidents involving part 25 airplanes operating in icing conditions. Over the 45-year period of analysis, the potential benefit of the proposed rule would be $89.9 million ($23.7 million in present value at seven percent).

[1] These accidents were selected from the National Transportation Safety Board's (NTSB) accident database, and are discussed in Appendix 3 of this premable.

A. Past Regulatory Approach

Currently, § 25.1419, ''Ice protection,'' requires transport category airplanes with approved ice protection features be capable of operating safely within the icing conditions identified in appendix C of part 25. This section also requires flight testing and analyses to be performed to make this determination. Although an airplane's performance capability and handling qualities are important in determining whether an airplane can operate safely, part 25 does not have specific airplane performance or handling qualities requirements for flight in icing conditions, nor does the FAA have a standard set of criteria defining what ''to safely operate'' in icing conditions means in terms of airplane performance and handling qualities. The proposed revisions to part 25 would provide a comprehensive set of harmonized requirements for airplane performance and handling qualities to address safe operation of transport category airplanes in icing conditions.

Further, § 25.1419 requires an applicant to demonstrate that the airplane can operate safely in icing conditions only when the applicant is seeking to certificate ice protection features. It fails to address certification approval for flight in icing conditions for airplanes without ice protection features.

In contrast, the European airworthiness standards specifically address certification for flight in icing conditions, independent of whether the airplane includes ice protection features. In addition, the European Joint Aviation Authorities (JAA) proposed additional guidance material in the early 1990s to provide criteria for determining whether an airplane's performance and handling qualities would allow the airplane to operate safely in icing conditions. The JAA's guidance material was proposed in draft Advisory Material—Joint (AMJ) 25.1419.[2] The JAA's draft AMJ was published on April 23, 1993, as a Notice of Proposed Amendment (NPA) 25F–219, ''Flight in Icing Conditions—Acceptable Handling Characteristics and Performance Effects.''

B. Harmonization of U.S. and European Regulatory Standards

1. Federal Aviation Administration

Title 14 CFR part 25 contains the U.S. airworthiness standards for type certification of transport category airplanes. The part 25 standards apply to airplanes manufactured within the

[2] A JAA AMJ is similar to an FAA advisory circular.

U.S. and to airplanes manufactured in other countries and imported to the U.S. under a bilateral airworthiness agreement.

2. Joint Aviation Authorities

The JAR–25 contains the European airworthiness standards for type certification of transport category airplanes. Thirty-seven European countries accept airplanes type certificated to the JAR–25 standards, including airplanes manufactured in the U.S. that are type certificated to JAR–25 standards for export to Europe.

3. European Aviation Safety Agency (EASA)

The European Community established a new aviation regulatory body, EASA, to develop standards to ensure the highest level of safety and environmental protection, oversee their uniform application across Europe, and promote them internationally. The EASA formally became operational for certification of aircraft, engines, parts, and appliances on September 28, 2003. The EASA will eventually absorb all of the functions and activities of the JAA, including its efforts to harmonize the European airworthiness certification regulations with those of the U.S.

The JAR–25 standards have been incorporated into the EASA's ''Certification Specifications for Large Aeroplanes,'' (CS)–25, in similar if not identical language. The EASA's CS–25 became effective October 17, 2003.

The proposals contained in this notice were developed in coordination with the JAA. However, since the JAA's JAR–25 and the EASA's CS–25 are essentially the same, all of the discussions of these proposals relative to JAR–25 also apply to CS–25.

The FAA's rulemaking proposal, if adopted, would parallel the JAA's rulemaking proposal, ''Notice of Proposed Amendment (NPA) 25B, E, F–332,'' published on June 1, 2002.

The EASA recently published for comment NPA 16/2004, ''Draft Decision of the Executive Director of the Agency on Certification Conditions.'' This NPA, published for comment in late 2004, is based on the standards that the JAA were expected to adopt.

Although the FAA, the JAA, and EASA intend to harmonize the standards for airplane performance and handling qualities for flight in icing conditions, there are some differences between this rulemaking proposal and the standards proposed by the JAA and EASA. The differences are primarily editorial and are not intended to result in significant regulatory differences.

C. Proposal Development—Aviation Rulemaking Advisory Committee

The FAA, in cooperation with the JAA and representatives of the American and European aerospace industries, recognized that a common set of standards would not only economically benefit the aviation industry, but also maintain a high level of safety. In 1988, the FAA and the JAA began a process to harmonize their respective airworthiness standards. To assist in the harmonization efforts, the FAA established the Aviation Rulemaking Advisory Committee (ARAC) in 1991,[3] to:

1. Provide advice and recommendations concerning the full range of our safety-related rulemaking activity;
2. Develop better rules in less overall time using fewer FAA resources than are currently needed; and
3. Obtain firsthand information and insight from interested parties regarding proposed new rules or revisions of existing rules.

There are 73 member organizations on the committee, representing a wide range of interests within the aviation community.

We tasked the ARAC Flight Test Harmonization Working Group (FTHWG) to recommend to the ARAC new or revised requirements and compliance methods related to airplane performance and handling qualities in icing conditions.[4]

The FTHWG reviewed in-service incidents and accidents involving transport category airplanes. This review revealed numerous incidents resulting from the effects of ice on airplane performance. The same review showed that the icing-related accidents resulted from a loss of control of the airplane due to the effect of the ice on airplane handling qualities. Considering this service history, the FTHWG determined that airplanes should generally meet the same handling qualities standards in icing conditions that they currently must meet for non-icing conditions. In certain areas, however, the FTHWG decided that the current handling qualities standards were inappropriate for flight in icing conditions. In these areas, the FTHWG developed alternative criteria that would apply to icing conditions.

Since airplane performance degradation was not a causal factor in any of the icing-related accidents, the FTHWG concluded that the current performance standards already provide some safety margin to offset the negative effects of ice accretion. On the basis of this service history, the FTHWG decided that the general approach to airplane performance in icing conditions used by the JAA in their draft AMJ 25.1419 was appropriate and used this approach in its recommendations to the FAA. This approach allows a limited reduction in airplane performance capability due to ice before the effects of icing must be fully taken into account in the performance data provided in the Airplane Flight Manual (AFM). Such an approach minimizes the costs to manufacturers and operators while increasing the current level of safety for flight in icing conditions.

This proposed rulemaking is based on the FTHWG's report, which ARAC approved and forwarded to the FAA, and refers to the ice accretions to be used in showing compliance. These ice accretions are defined in a new subsection of appendix C to part 25.[5]

D. Related Rulemaking Activity

1. Amendment 25–108

This Amendment, ''1-g Stall Speed as the Basis for Compliance With Part 25 of the Federal Aviation Regulations'' (referred to as the 1-g stall rule) (67 FR 708112, November 26, 2002) redefines the criteria for determining the stall speed for transport category airplanes. The stall speed is important because it is used as a reference speed for defining minimum operating speeds that provide a safety margin above the speed at which the airplane will stall. The previous part 25 definition of stall speed defined it as the minimum speed reached in a stalling maneuver. This definition could result in a stall speed being defined that is too low to support the weight of the airplane in level flight.

The recently adopted 1-g stall rule defines the stall speed as the speed at which the aerodynamic lift can support the weight of the airplane in 1-g flight. The 1-g stall rule also introduces a requirement to demonstrate adequate maneuver capability at the minimum operating speeds for airplane configurations associated with low speed operations around airports. The JAA adopted the same 1-g stall speed requirements in Change 15 to JAR–25.

[3] Published in the **Federal Register** (56 FR 2190), on January 22, 1991.

[4] Published in the **Federal Register** (56 FR 2190), on June 10, 1994.

[5] The complete text of the FTHWG's report is available at *http://www.faa.gov/avr/arm/arac/aractasks/fr0404report.pdf*. The FTHWG preferred the term ''ice accretion'' rather than ''ice shape'' because it includes physical characteristics of the ice build-up such as texture and surface roughness in addition to its general size and shape.

2. Ice Protection Harmonization Working Group (IPHWG) Recommendations

The FAA tasked the ARAC to consider whether airplane manufacturers or operators should be required to install ice detectors or provide some other acceptable way to warn flightcrews of potentially unsafe ice accumulations. The ARAC assigned this task to the IPHWG. The IPHWG recommended to the ARAC that the FAA adopt an operating rule for certain types of airplanes that would require a reliable method of informing pilots when to activate the ice protection system as well as a way of knowing when ice is accumulating aft of areas protected by the ice protection system. The IPHWG is also working on a recommendation for a type certification requirement that would identify acceptable ways to inform the flightcrew when to activate the ice protection system.

We also tasked the ARAC to:

• Define an icing environment that includes supercooled large drop (SLD) icing conditions;

• Recommend requirements to assess the ability of aircraft to safely operate in SLD icing conditions, either for the period of time necessary to exit or to operate without restriction; and

• Consider mixed phase conditions (a mixture of supercooled water droplets and ice crystals) if such conditions are more hazardous than the liquid phase icing environment containing supercooled water droplets.

When ARAC finishes its tasks, we expect it to forward to us a report containing their recommendations. These recommendations may lead to future rulemaking to address SLD icing conditions, but would not directly impact this rulemaking.

E. Advisory Material

In addition to being tasked to recommend new or revised requirements related to airplane performance and handling qualities in icing conditions, the ARAC FTHWG was tasked to recommend advisory material identifying acceptable ways to comply with the proposed new or revised requirements. The FTHWG developed a proposed Advisory Circular, (AC) 25.21–1X, ''Performance and Handling Characteristics in the Icing Conditions Specified in Part 25, Appendix C.'' We are requesting public comments on this proposed advisory circular through a separate notice of availability in this edition of the **Federal Register**.

II. Discussion of the Proposals

A. Proof of Compliance (§ 25.21)

We propose to add paragraph (g), to specify the requirements that must be met in icing conditions if an applicant seeks certification approval for flight in icing conditions. As discussed above, a review of icing-related incidents and accidents revealed loss of control to be the greatest threat to safety of flight in icing conditions. Consequently, the FTHWG identified the existing part 25 requirements that could prevent loss of control if they were applied to icing conditions. The FTHWG found, and we tentatively agree, that airplanes should continue to comply with most of subpart B of part 25 with ice on the airplane to ensure safe flight in icing conditions. The subpart B regulations that would be excluded by paragraph (g)(1) were determined to be beyond what was necessary to determine an airplane's ability to operate safely in icing conditions.

Because the airplane performance and handling qualities requirements are flight-related requirements, it is appropriate to place the proposed requirements for flight in icing conditions in part 25, subpart B (Flight) rather than in the current ice protection rule in § 25.1419. Section 25.1419 is in subpart F (Equipment), and, though it is closely linked with the subpart B requirements proposed in this notice, it primarily applies to the ice protection equipment on the airplane.

The proposed subpart B requirements would provide the minimum performance and handling qualities requirements corresponding to the § 25.1419 requirement that the airplane ''be able to safely operate in the continuous maximum and intermittent maximum icing conditions of appendix C.'' Additionally, the proposed requirements would supply the means for determining, from a performance and handling qualities standpoint, whether the ice protection system and its components are effective, as required by § 25.1419(b).

Compliance with the proposed performance and handling qualities requirements may be shown by a variety of means that would be evaluated during the particular airplane type certification program. These means may include flight testing in natural icing conditions or in non-icing conditions using artificial ice shapes, wind tunnel testing and analysis, engineering simulator testing and analysis, engineering analysis, and comparison to previous similar airplanes.

The proposed requirements would not specifically require performance and handling qualities flight testing to be conducted in natural icing conditions. However, we expect that for most new airplane designs, and for significant changes to existing designs, at least a limited set of tests would be flown in natural icing conditions. The purpose of these tests would be to confirm the airplane handling qualities and performance results found through other means. The proposed advisory material will provide guidance on an acceptable flight test program, including the specific tests that should be conducted in natural icing conditions.

Historically, flight tests in measured natural icing conditions have also been conducted to verify analyses used to generate ice accretions for compliance with § 25.1419(b), and to confirm the general physical characteristics and location of ice accretions used to evaluate airplane performance and handling qualities. This proposed rule is not intended to alter this practice or interpretation of § 25.1419(b). Existing AC 25.1419–1, ''Certification of Transport Category Airplanes for Flight in Icing Conditions,'' provides guidance on comparing the ice accretions used to evaluate airplane performance and handling qualities with those obtained in natural icing conditions.

Proposed paragraph (g)(1) would apply the same airplane handling qualities requirements to flight in icing conditions as are currently required for non-icing conditions. Paragraph (g)(1) would also apply most of the airplane performance requirements currently required for non-icing conditions to flight in icing conditions. The icing conditions for showing compliance would be defined in appendix C to part 25. These requirements would apply to normal operations of the airplane and its ice protection system as specified in the AFM. By referencing the AFM, this paragraph would require that this manual include the limitations and operating procedures that are specific to operating in icing conditions.

As noted in the introductory discussion, some degradation in airplane performance capability would be permitted when showing compliance with the requirements for non-icing conditions. The amount of performance degradation permitted in each case is identified in the discussion of the individual performance regulations.

Proposed paragraph (g)(2) would prevent the use of different load, weight, and center-of-gravity limits for flight in icing, except where compliance with the applicable performance requirements impose more restrictive weight limits.

The reason for these proposed requirements is that operation in icing conditions should be essentially transparent to the flightcrew. There should not be any special procedures or methods used for operating in icing conditions other than activating ice protection systems. This philosophy comes from applying human factors principles to reduce operational complexity and flightcrew workload.

B. Stall Speed (§ 25.103)

We propose to revise § 25.103 to require applicants to determine stall speeds with ice on the airplane. The proposed § 25.103(b)(3) adds ice accretion as a variable that must be considered when determining stall speeds to use for the different part 25 airplane performance standards.

Determining stall speeds with ice accretions is necessary to identify any increase in stall speeds from those determined for non-icing conditions. The applicant would then compare any change in stall speed due to ice accretion with the allowable stall and operating speed effects contained in the proposed airplane performance standards to determine whether or not airplane performance data must be determined specifically for icing conditions.

C. Takeoff (§ 25.105)

We propose to revise § 25.105(a) to add the net takeoff flight path described in § 25.115 to the list of airplane takeoff performance parameters that must be determined under the conditions specified in this paragraph. Additionally, § 25.105(a) would specify when compliance must be shown specifically for icing conditions.

We consider the proposed changes necessary to ensure the safety of takeoff operations in icing conditions. Ice on the wings and control surfaces can reduce the safety margins that currently are provided to prevent stalling the airplane. It can also degrade airplane climb performance, and cause controllability problems. We acknowledge that many transport category airplanes have safely operated in icing conditions using takeoff speeds determined for non-icing conditions. We agree with the FTHWG, however, that it is in the interest of safety to consider the effects of ice accretions on airplane takeoff performance.

In developing this proposal, the FTHWG and the FAA considered four factors:

- Operating rules and practices intended to ensure that critical surfaces of the airplane are free of snow or ice before beginning a takeoff;
- The use of anti-icing fluids that provide some protection from icing during the takeoff;
- Increasing use of ice detectors and deicing/anti-icing systems on airplanes that can be operated while the airplane is still on the ground; and
- The icing conditions that we propose to use for the takeoff flight phase.

Existing operating rules, §§ 91.527(a), 121.629(b), and 135.227(a), prohibit pilots from taking off with snow or ice adhering to the wings or other critical airplane surfaces. Additionally, §§ 121.629(c) and 135.227(b) require airplane operators to have either an approved ground deicing/anti-icing program or conduct a pre-takeoff contamination check within five minutes before beginning a takeoff to ensure that the wings, control surfaces, and other critical surfaces are free of frost, ice, or snow. Operators must train the pilots on the effects of these contaminants on airplane performance and controllability, on how to recognize airplane contamination, and on procedures intended to ensure that contamination is removed before takeoff.

Ground deicing/anti-icing programs include the use of deicing/anti-icing fluids to remove ice and snow and prevent them from reappearing on airplane surfaces during freezing precipitation conditions. Although these fluids are designed to flow off the airplane during the takeoff roll, we expect the fluids to continue to provide some protection throughout the takeoff ground run.

On some older airplane models, the wing ice protection system was designed for use in flight and cannot be operated while the airplane is on the ground. Yet many of the current generation of airplanes have ice protection systems that can be operated while the airplane is on the ground. Some of these systems are also coupled with ice detector systems that will automatically activate the ice protection system in icing conditions. These features tend to reduce the chances that ice will adhere to critical airfoil surfaces during airplane ground operations in atmospheric icing conditions.

As discussed later, we propose to revise appendix C of part 25 to define atmospheric icing conditions specifically for the takeoff phase of flight. These proposed atmospheric icing conditions would apply throughout the takeoff path, but are based on the more critical conditions that would be expected to occur at the end of the takeoff path. These conditions do not include freezing precipitation on the ground. At earlier points in the takeoff path, while the airplane is closer to the ground, the proposed takeoff icing conditions would be conservative, that is, they would predict larger ice accretions than would be likely to occur. If these conditions were to actually occur at ground level, they would form a freezing fog condition that would probably reduce visibility to the point that takeoffs could not be made.

An important part of determining the effects of ice accretion on takeoff performance is to decide at what point in the takeoff ice accretion is considered to begin. For the purposes of this rulemaking, we consider ice accretion to begin when the airplane lifts off the runway surface during takeoff.

Proposed § 25.105(a) would require applicants to determine airplane takeoff performance for icing conditions if the ice that can accrete during takeoff results in increasing the reference stall speed (VSR) or degrading climb performance beyond specified limits. Section 25.105(a) references all regulations related to the takeoff path. As a result, the performance for the entire takeoff path, including takeoff speeds and distances, must be determined for icing conditions if the stall speed or climb performance degradation limits are exceeded.

Section 25.105(a)(2)(i) of the proposal would require applicants to determine takeoff path performance for icing conditions if the stall speed increases by more than 3 knots in calibrated airspeed or 3 percent due to ice accretions. This proposed requirement would be more stringent than the guidance used by the JAA in their draft AMJ 25.1419. The draft AMJ allowed up to a 5 knot or 5 percent increase in stall speed before the takeoff performance would need to be recomputed for icing conditions.

Several commenters on the AMJ, including us, expressed concern over allowing such a large increase in stall speed believing it would result in a significant reduction in safety margin between the minimum operating speeds and the stall speed. We agree with the FTHWG recommendation that a 3 knot or 3 percent increase in stall speeds is the maximum that should be permitted before the takeoff performance data should be recalculated to consider the effects of icing.

Also, the JAA's draft AMJ 25.1419 used the effect of ice accretions on airplane drag rather than on climb performance to determine when the takeoff performance data must be provided for icing conditions. However, we agree with the FTHWG recommendation to consider the effect of ice accretions in terms of climb performance in § 25.105(a)(2)(ii) because it would cover more operating variables than just the effect of ice on airplane drag.

The part 25 takeoff climb requirements include a safety margin by requiring applicants to determine a net flight path based on the airplane's actual climb performance capability reduced by a set value that depends on the number of engines on the airplane. Proposed § 25.105(a)(2)(ii) would require applicants to determine takeoff path performance specifically for icing conditions if more than half of this safety margin would be lost due to the effects of ice accretion.

Part 25 divides the takeoff climb performance requirements into several segments. To establish the allowable limit for takeoff climb performance degradation in icing conditions, § 25.105(a)(2)(ii) would consider the effect of ice accretions on just the takeoff climb segment defined by § 25.121(b). For most transport category airplanes, this segment most often limits the allowable takeoff weight, and therefore is the most critical to safety. If the effects of ice accretions during the takeoff climb segment defined in § 25.121(b) are beyond specified limits, the airplane performance for the entire takeoff path must be determined with ice accretions on the airplane. This would include from the beginning of the takeoff roll until the airplane is at least 1,500 feet above the takeoff surface. Thus, for airplanes that would be most affected by ice accretions during the takeoff climb, additional safety margins would also be provided for the takeoff ground run even though ice accretion is assumed not to begin until liftoff.

D. Takeoff Speeds (§ 25.107)

We propose to revise § 25.107(c)(3) and (g) to change the reference for maneuver capability considerations from § 25.143(g) to § 25.143(h). This is an editorial change due to the redesignation of § 25.143(g) to § 25.143(h) proposed below.

We also propose to revise § 25.107 by adding a new paragraph (h). This new paragraph would state that the minimum control speeds (V_{MCG} and V_{MC}) and minimum unstick speeds (V_{MU}) determined for the airplane in non-icing conditions may also be used for the airplane in icing conditions. The V_{MU}, V_{MCG}, and V_{MC} speeds are used to determine the takeoff speeds V_1, V_R, and V_2.

The minimum unstick speed (V_{MU}) is defined in § 25.107(d) as the airspeed at and above which the airplane can safely lift off the ground and continue the takeoff. Takeoff speeds must be established sufficiently above this speed to assure the airplane can safely take off considering the variations in procedures and conditions that can reasonably be expected in day-to-day operations. Because these proposals assume that ice accretion does not begin until liftoff, this proposal would allow the V_{MU} speeds for non-icing conditions to be used for determining takeoff speeds in icing conditions.

The ground minimum control speed (V_{MCG}) is used in determining the takeoff V_1 speed. The takeoff V_1 speed is the highest speed at which the pilot must take the first action to be able to safely stop the airplane during a rejected takeoff and the lowest speed at which the takeoff can be safely continued after an engine failure. Since V_{MCG}, like V_{MU}, occurs before the airplane lifts off the runway, the assumption is that ice has not yet begun accreting on the airplane. Therefore, this proposal would allow the V_{MCG} speeds determined for non-icing conditions to be used for determining V_1 for icing conditions.

The air minimum control speed, V_{MC} (commonly referred to as V_{MCA}), is defined in § 25.149(b) as the airspeed at which it is possible to maintain control of the airplane, with no more than 5 degrees of bank, when the critical engine is suddenly made inoperative. Section 25.107 requires the rotation speed (V_R) and the takeoff safety speed (V_2) to be sufficiently higher than V_{MCA} to assure that the airplane will be safely controllable if the critical engine fails during the takeoff. Since V_R occurs before liftoff, like V_{MU} and V_{MCG}, this proposal would allow the V_{MCA} speeds determined for non-icing conditions to be used for determining V_R for icing conditions.

Several concerns must be addressed if we are to allow V_{MCA} speeds determined in non-icing conditions to be used to determine V_2 in icing conditions. Unlike V_R, V_2 occurs after liftoff and ice could have begun accreting on the airplane. Ice may accrete at V_2 because ice protection systems are typically not turned on until the airplane climbs more than 400 feet after takeoff. Also, many airplanes do not have any ice protection on the vertical stabilizer. These concerns could lead to a reduction in the airplane's directional control capability if ice accretion occurs. To alleviate these concerns, the proposed § 25.143(c) would require applicants to show that airplanes are safely controllable and maneuverable at the minimum V_2 speed with the critical engine inoperative and with the ice accretion applicable to the takeoff flight phase.

E. Takeoff Path (§ 25.111)

Currently, § 25.111 defines the takeoff path, describes the airplane configuration that applies to each portion of the takeoff path, and provides airplane performance requirements that must be met. We propose to revise § 25.111 by adding a new paragraph (c)(5) stating that the airplane's drag used to determine the takeoff path after liftoff would be based on the ice accretions defined in the proposed revision to appendix C. To accommodate the addition of the new paragraph, the ''and'' at the end of § 25.111(c)(3) would be moved to the end of § 25.111(c)(4).

The takeoff path begins at the start of the takeoff roll and ends when the airplane is either 1,500 feet above the takeoff surface, or at the altitude at which the transition from the takeoff to the en route configuration is completed and the final takeoff speed attained, whichever is higher. The takeoff path typically has two distinct climb segments: One from the point at which the airplane is 35 feet above the runway up to 400 feet, and the other from a height of 400 feet to the end of the takeoff path. The proposed changes to § 25.111 would identify when the takeoff path must be determined for flight in icing conditions and specify the ice accretion that must be used for these two climb segments.

New paragraph (c)(5) would refer back to the proposed § 25.105(a)(2) to identify when the takeoff path must be determined for flight in icing conditions. The ice accretions referenced in new paragraph (c)(5) would apply to the airborne portions of the takeoff path, since we are assuming that ice accretion does not begin until liftoff. If takeoff path performance must be determined for icing conditions, then the takeoff path must use the takeoff speeds of the proposed § 25.107 for icing conditions, using the ice accretions specified in paragraph (c)(5).

F. Landing Climb: All-Engines-Operating (§ 25.119)

We propose to revise § 25.119 by requiring the airplane landing climb performance to be determined for both non-icing and icing conditions; adding references to the appropriate paragraphs of the proposed § 25.125 revision for the landing climb speed to use for non-icing and icing conditions; referring to the proposed appendix C revision to identify the ice accretion that would be used in determining landing climb performance in icing conditions; and changing the speed used to show compliance with § 25.119 from a speed less than or equal to V_{REF} to V_{REF}.

We consider the approach and landing phases of flight to be the flight phases most affected by icing conditions because of the potential for descending into and holding in icing conditions prior to landing. In addition, service history has shown that the majority of icing accidents and incidents occur in the holding, approach, and landing flight phases. For these reasons, our policy for the last 40 years has been for applicants to account for the effects of airframe ice accretion in their airplane's approach and landing climb performance data provided in the Airplane Flight Manual. (Approach and landing climb performance refer to the airplane's climb capability in the approach and landing configurations during the approach and landing flight phases. Sections 25.121(d) and 25.119 require minimum level of approach and landing climb performance to ensure that airplanes can abort an approach or landing attempt and safely climb away.) The proposed changes to §§ 25.119 and 25.121(d) (see below) serve to codify this policy.

G. Climb: One-Engine-Inoperative (§ 25.121)

We propose to revise § 25.121 by rearranging paragraphs (b), (c), and (d) to specify when the required climb performance must be determined for icing conditions; refer to the proposed appendix C revision to identify the ice accretion that would be used in calculating approach climb performance in icing conditions; and provide the conditions under which the approach climb speed must be increased to account for the effect of ice accretion.

Sections 25.121(b) and (c) provide the climb performance requirements for the takeoff path segments beginning at the point the landing gear is fully retracted and ending at the end of the takeoff path. As in the proposed revision to § 25.105, we propose to revise § 25.121(b) and (c) to require takeoff climb performance to be determined for icing conditions if the effect of ice: (1) Increases the stall speed at maximum takeoff weight by more than 3 knots or 3 percent, or (2) reduces the climb performance determined in § 25.121(b) by more than half the safety margin provided by the net gradient adjustment required by § 25.115.

Section 25.121(a) provides the climb performance requirements for the takeoff path segment beginning at liftoff and ending when the landing gear is fully retracted. Since we are assuming that ice accretion does not begin until liftoff, only a minimal amount of ice could be accreted during this climb segment. Therefore, the proposal for § 25.21(g)(1) excludes compliance with § 25.121(a) with ice accretions on the airplane.

We propose revising § 25.121(d) to state when the approach climb speed must be adjusted for use in icing conditions. Unlike the speeds used in the takeoff path, the need to adjust the approach climb speed would not be based on the effect of ice accretions on the airplane's stall speed. Instead, the measure for determining whether the approach climb speed needs to be adjusted for icing conditions is based on the effect of ice accretions on the approach climb speed. If the approach climb speed for icing conditions does not exceed the climb speed for non-icing conditions by more than the greater of 3 knots calibrated airspeed (CAS) or 3 percent V_{SR}, then non-icing speeds may be used for calculating approach climb performance for icing conditions.

The existing requirement for determining the approach climb speed in non-icing conditions provides applicants some flexibility by only specifying the maximum allowable approach climb speed. No lower limit is specified and we have accepted approach climb speeds as low as 1.13 V_{SR} (that is, 13 percent above the reference stall speeds). We would accept this same level of flexibility for establishing the approach climb speeds in icing conditions. The approach climb speeds for icing conditions should also be evaluated to ensure that they provide adequate maneuver capability.

This proposal for the approach climb segment is less stringent than the 3 knots or 3 percent V_{SR} standard used for takeoff path speeds. For example, if the approach climb speed is 1.25 V_{SR} and V_{SR} is 100 knots, 3 percent of the approach climb speed is 3.75 knots, while 3 percent of V_{SR} would be only 3 knots. The approach climb speed could increase by 3.75 knots without requiring this increased approach climb speed to be used for calculating the approach climb performance in icing conditions. We consider this small alleviation to be acceptable since it is only relative to the need for increasing the approach climb speed for icing conditions. The approach climb performance must be recalculated with the holding ice accretion and presented in the AFM regardless of whether the approach climb speed is adjusted for operations in icing conditions.

H. En Route Flight Paths (§ 25.123)

We propose to revise § 25.123(a) by specifying a minimum allowable speed for determining en route flight paths, which would apply to both icing and non-icing conditions. The proposed speed, V_{FTO}, is currently used as the minimum allowable speed for the final takeoff.

Additionally, the proposed revision to § 25.123(b) would state when an applicant must determine the en route flight paths specifically for icing conditions. Similar to the takeoff path requirements of the proposed revision to § 25.111, en route flight path performance needs to be specifically determined for icing conditions if the effect of ice: (1) Increases the en route speed by more than 3 knots or 3 percent, or (2) reduces climb performance by more than half the safety margin provided by the net gradient adjustment required by § 25.123(b). The ice accretion to be used would be specified in the proposed revision to appendix C.

The reason for proposing to limit the minimum allowable en route climb speed to V_{FTO} to is to prevent applicants from showing compliance with § 25.123 by trading altitude for airspeed when transitioning from the final takeoff to the en route climb segment. This clarifying change is consistent with our original intent for § 25.123(a).

Another reason for not allowing an en route climb speed less than V_{FTO} is that V_{FTO} is the speed at which the maneuver capability requirements contained in the existing § 25.143(g) must be met in the en route configuration. Allowing an en route climb speed lower than V_{FTO} would not ensure that the airplane has adequate maneuvering capability during the en route climb phase of flight.

We are not proposing any changes to the two-engine-inoperative en route flight path requirements contained in § 25.123(c) for flight in icing conditions. We do not expect the pilot to stay in icing conditions with one engine inoperative for a long enough duration for the failure of a second engine in icing conditions to be an issue.

En route and takeoff flight paths have similar safety issues. Therefore, we are proposing requirements for identifying when en route climb flight paths must be determined for icing conditions that are similar to those proposed for takeoff flight paths. The only significant difference is that for the en route climb paths, a speed of 1.18 V_{SR} determined with the en route ice accretion of proposed appendix C is compared to the en route climb speed selected for non-icing conditions instead of comparing stall speeds with and without ice accretions.

The reason for this difference is to provide a more stringent requirement for airplanes that use the minimum allowable en route climb speed of 1.18 V_{SR}. (1.18 V_{SR} is the minimum allowable value of V_{FTO} prescribed by § 25.107(g)). Airplanes that use a higher en route climb speed have a larger speed margin to the stall speed and more maneuvering capability in the en route climb phase to help offset the negative effects of ice accumulation.

Due to differences in their methods of generating thrust, propeller-driven airplanes generally have better climb performance at lower airspeeds than turbojet-powered airplanes. To optimize performance, the en route climb speed used for propeller-driven airplanes is usually the minimum allowable speed of 1.18 V_{SR}, while the en route climb speed used for turbojet-powered airplanes is usually higher. Therefore, the proposed requirement would be more stringent for propeller-driven airplanes. We consider the increased stringency for propeller-driven airplanes to be desirable for the following reasons:

- Propeller-driven airplanes generally have deicing systems that cycle on and off, allowing ice to accrete on the protected surfaces before removing it. Also, these deicing systems typically do not remove all of the ice with each cycle, leaving some residual ice. Both of these effects result in drag increases that are generally not present on turbojet airplanes that have ice protection systems using hot bleed air from the engines.
- Propeller-driven airplanes will likely be subjected to increased exposure to icing conditions, due to their slower operating speeds, shorter flight lengths, and lower cruising altitudes.

I. Landing (§ 25.125)

We propose to revise § 25.125(a) to identify when the landing distance must be determined specifically for icing conditions. The proposed requirement would specify that the landing distance must be determined for icing conditions if the V_{REF} in icing conditions exceeds the V_{REF} in non-icing conditions by more than 5 knots CAS. For icing conditions, the landing distance would be determined with the landing ice accretion defined in the proposed revision to appendix C.

Additionally, a new paragraph (b) would be added to include the landing distance requirements that would be moved from the existing paragraph (a). The new paragraph (b) would also set the requirements for determining the landing speeds to use in determining the landing distances for both icing and non-icing conditions. For icing conditions, the landing speed must not be lower than 1.23 V_{SR0} with the landing ice accretion on the airplane if that speed exceeds the V_{REF} for non-icing conditions by more than 5 knots CAS.

The existing paragraphs (b) through (f) would be redesignated as (c) through (g).

Whether landing distances or landing speeds must be determined specifically for icing conditions depends on whether V_{REF} needs to be increased by more than 5 knots CAS to counteract the effect of ice on airplane stall speeds. The reasons behind allowing V_{REF} to increase by up to 5 knots CAS in icing conditions before requiring landing distance performance to be recomputed for icing conditions are:

- As part of the flight testing to demonstrate compliance with the landing distance requirements, we typically evaluate airplane controllability when landing at speeds lower than the normal landing speeds. We usually perform this evaluation at a speed 5 knots below V_{REF} to cover inadvertent speed variations that may occur in operational service. Plus or minus five knots variation from V_{REF} is frequently used as a guideline for evaluating expected operational variations in landing speeds.
- Normal approaches in transport category airplanes are typically flown at speeds above V_{REF} to provide speed margins to account for wind gusts. Although the additional speed should be bled off by the time that the airplane is over the landing threshold, it may not be. Service history does not indicate any safety problems with the resulting longer landing distance.
- Many transport category airplanes are flown at a speed 5 knots higher than V_{REF} during final approach to counter any inadvertent speed loss. Often this additional speed has not been bled off before reaching the landing threshold. Again, service history does not indicate any safety problems with the resulting longer landing distance.
- A 5-knot increase above the V_{REF} speed for non-icing conditions equates to approximately 3 percent of the 1-g stall speed (slightly less than 3 percent for larger airplanes). This is consistent with the allowable stall speed increase proposed for the takeoff path requirements for icing conditions.

As a further safety consideration for the V_{REF} speed, § 25.125(b)(ii)(c) would require that V_{REF} for icing conditions must provide the same maneuvering capability (with ice accretions on the airplane) as is currently required at V_{REF} for non-icing conditions. This may result in an increase to V_{REF} for icing conditions even if this increase is less than 5 knots.

The current § 25.125(a)(2), which would be redesignated as § 25.125(b)(2)(i), requires V_{REF} for non-icing conditions to be not less than the landing minimum control speed, V_{MCL}. This existing requirement ensures that adequate directional control is available in case an engine fails during a go-around. Under the proposed new rule, the V_{MCL} determined for non-icing conditions would continue to be used for icing conditions. This would be similar to the takeoff flight phase, where the takeoff minimum control speeds, V_{MCG} and V_{MCA}, determined for non-icing conditions would continue to be used for icing conditions. Unlike the takeoff case; however, the continued use of the non-icing V_{MCL} is not explicitly stated. We consider the proposed requirements to adequately address this issue without proposing an additional explicit requirement. Section 25.125(b)(2)(ii) requires V_{REF} for icing conditions to be not less than V_{REF} for non-icing conditions. Under § 25.125(b)(2)(i), V_{REF} for non-icing conditions must be not less than V_{MCL} for non-icing conditions. Taken together, these two proposed requirements would allow the V_{MCL} determined for non-icing conditions to continue to be used for icing conditions.

To assure that using the V_{MCL} determined for non-icing conditions will provide safe controllability and maneuverability for icing conditions, the proposed §§ 25.143(c)(2) and (c)(3) would require the applicant to show that the airplane will be safely controllable and maneuverable during an approach and go-around and an approach and landing, both with the critical engine inoperative. For added safety during certification flight testing, these maneuvers may be accomplished with a simulated engine failure (as noted in the proposed advisory material associated with this proposal).

J. Controllability and Maneuverability—General (§ 25.143)

We propose to revise § 25.143 to add a new paragraph (c) that requires the applicant to show that the airplane with ice accretions and with the critical engine inoperative is safely controllable and maneuverable during takeoff, an approach and go-around, and an approach and landing; a new paragraph (i) to identify the ice accretions that must be used in showing compliance with § 25.143 in icing conditions, and to introduce two specific controllability requirements that apply to flight in icing conditions; and a new paragraph (j) to specify tests for ensuring that the airplane has adequate controllability for flight in icing conditions before the ice protection system is activated and performing its intended function of removing any ice accretions from protected surfaces.

In addition, existing paragraphs (c) through (g) would be redesignated as paragraphs (d) through (h), and paragraph references in the newly designated paragraphs (d), (e), and (f) would be revised accordingly.

The requirements proposed in new paragraph (c) are intended to ensure that using the minimum control speeds for non-icing conditions would not result in controllability and maneuverability safety concerns when the same speeds are used for icing conditions.

The proposed new paragraph (i)(1) would require compliance with all of § 25.143 in icing conditions except paragraphs (b)(1) and (2). Sections 25.143(b)(1) and (2) are excepted from icing analysis under proposed section 25.21(g).

These proposed requirements assume a conventional empennage (that is, wing/fuselage/tailplane) configuration. Special conditions, issued in accordance with § 21.16, may be necessary for certification of airplanes with an unconventional empennage configuration.

Applicants can minimize the number of ice accretions to be tested by using one accretion that is shown to be the most critical accretion for several flight phases.

In many cases, a thin, rough, layer of ice (defined as sandpaper ice in the proposed revision to appendix C) has been shown to have a more detrimental effect on handling qualities for airplanes with unpowered control systems than larger ice accretions. The effect of sandpaper ice accretions may be more significant than larger ice accretions on these airplanes. In some cases, such an accretion has resulted in control surface hinge moment reversals that required the flightcrew to apply extremely high forces to the controls to regain control of the airplane. Applicants would have to consider sandpaper ice in showing compliance with the proposed § 25.143(i).

The proposed paragraph (i)(2) would require applicants to conduct a pushover maneuver down to a zero g load factor with the critical ice accretion on the airplane. (If the airplane lacks enough elevator power to get to a zero g load factor, the maneuver may be ended at the lowest load factor obtainable.) The purpose of this proposed requirement is to evaluate an airplane's susceptibility to a phenomenon known as ice-contaminated tailplane stall (ICTS). Ice-contaminated tailplane stall can be characterized either by completely stalled airflow over the horizontal stabilizer, or by an elevator hinge moment reversal due to separated flow on the lower surface of the horizontal stabilizer caused by ice accretions on the tailplane.

Several incidents and accidents have been caused by ICTS. These incidents and accidents have typically occurred during landing approach when the flightcrew either lowered the flaps or abruptly decreased the airplane's pitch attitude. Either of these actions will increase the angle-of-attack (AOA) of the local airflow over the tailplane. If there is ice on the tailplane, the increased AOA may lead to an ICTS.

The proposed pushover maneuver increases the AOA on an ice-contaminated tailplane by inducing a nose down pitch rate. An airplane is *not* susceptible to an ICTS if, during the pushover maneuver:

- The pilot must continue to apply a push force to the pitch control throughout the maneuver (that is, the airplane will not continue the maneuver to or toward a zero g load factor unless the pilot applies a push force to the pitch control); and
- The pilot can promptly recover from the maneuver without exceeding 50 pounds of pull force on the pitch control.

The proposed pushover maneuver evolved from earlier criteria developed shortly after a series of incidents and accidents highlighted the safety concerns related to ICTS. For example, early ICTS test criteria called for executing a pushover to a 0.3 g to 0.4 g load factor with a pitch rate of not less than 10 degrees per second in an attempt to copy the documented ICTS accident conditions. An aggressive pushover to zero g was later found to result in the same combination of load factor and pitch rate, but with the advantage of not needing sophisticated test instrumentation to perform the test.

In addition to the pushover maneuver, we propose that applicants demonstrate the safety of a sideslip maneuver with an ice-contaminated tailplane, since this has been shown to be a more critical ICTS triggering maneuver for some airplanes. The proposed § 25.143(i)(3) would require that any changes in the force the pilot must apply to the pitch control to maintain speed with increasing sideslip angle must steadily increase with no force reversals.

Proposed § 25.143(j) would address airplane controllability between the time when the airplane first enters icing conditions and when the ice protection system is activated and performing its intended function. In developing the controllability criteria proposed in paragraph (j), we considered the likely duration of this time period and the means that might be used for detecting icing conditions and activating the ice protection system. The proposed advisory material for part 25, appendix C, part II(e) would provide additional guidance for determining the appropriate ice accretion for this testing based on the means of ice detection.

Although activation of the ice protection system is expected to occur shortly after entering icing conditions, it may not occur for a relatively long time if the method of detecting icing conditions depends on the crew visually observing a specified amount of ice buildup on some reference surface (for example, windshield wiper, icing probe). To address this concern, proposed § 25.143(j)(1) requires compliance with all of the requirements of § 25.143 that would apply to flight in icing conditions for this method of detecting icing conditions. In this case, the ice accretion to be used in showing compliance would be the ice accretion that would exist before the ice protection system is activated and is performing its intended function.

For airplanes that use other means of detecting icing conditions, the proposed requirements would be less stringent. This reflects the expectation that the airplane would fly only briefly in icing conditions before activation of the ice protection system. Instead of requiring compliance with all of the requirements of § 25.143 that apply to flight in icing conditions, § 25.143(j)(2) would require only a demonstration that the airplane is controllable in a pull-up maneuver up to 1.5 g load factor, and that there is no longitudinal control force reversal during a pushover maneuver down to a 0.5 g load factor.

K. Stall Warning (§ 25.207)

We propose to revise paragraph (b) to require that the means for providing a warning of an impending stall must be the same for both icing and non-icing conditions. There would be one exception to this general rule. If the means of detecting icing conditions does not involve waiting until some specified amount of ice has accreted on a reference surface, then the stall warning may be provided by a different means during the time from when the airplane first enters icing conditions until the ice protection system is activated and is performing its intended function.

We propose to add a new paragraph (e) to specify the stall warning margin that the stall warning system must provide in icing conditions. The stall warning margin is how far in advance the pilot is warned of a potential stall. We propose to evaluate the stall warning margin in both straight and turning flight while decelerating the airplane at rates of up to one knot per second. The pilot must be able to prevent stalling the airplane using the same recovery maneuver that would be used in non-icing conditions, starting the recovery maneuver not less than 3 seconds after the stall warning begins. Paragraph (e) also specifies the ice accretions that would be used for showing compliance.

We propose to revise paragraph (f) to consist of the existing paragraph (e), revised to clarify that the pilot must use the same maneuver to demonstrate that the airplane can safely recover from a stall in icing conditions as is used for non-icing conditions.

We propose to add a new paragraph (h) to specify the stall warning requirements for the time period when the airplane first enters icing conditions until the ice protection system is activated and is performing its intended function. The proposed stall warning requirements would be different for different means of detecting icing conditions and whether or not the stall warning is provided by the same means for icing conditions and non-icing conditions.

Currently, part 25 requires airplanes to provide the flightcrew an adequate warning of an impending stall so that the flightcrew can prevent the stall. The current requirement does not consider the effects of ice accretions on the airplane. With ice accretions on the airplane, the airplane may stall sooner (that is, at a higher speed or lower AOA), possibly even before the stall warning would occur. For an airplane to be approved for flight in icing conditions, we consider it necessary to provide an adequate stall warning margin with ice accretions on the airplane. For human factors reasons, we also consider it necessary for the means of providing the stall warning to be the same in icing conditions and non-icing conditions. But as discussed in the specific proposal for § 25.207(h), we would allow a limited exception to this general requirement.

In most transport category airplanes, the stall warning is provided by a device called a stick shaker, which shakes the control column to alert the pilot when the airplane is close to stalling. The proposed addition to § 25.207(b) would establish the general requirement for the same means for the stall warning in icing conditions and non-icing conditions. Section 25.207(b) would, however, allow an exception to the general requirement. The conditions for the exception to the general requirement would be established in § 25.207(h)(2)(ii).

The general rule of § 25.207(b) may result in a different stick shaker activation point for icing conditions because the airplane may stall at a different speed or AOA with ice accretions. In order to maintain a safe margin above the stall speed and to provide sufficient maneuvering capability, an increase in the minimum operating speeds may be needed. Increasing the minimum operating speeds, such as takeoff and landing speeds, may result in a cost increase if operators have to reduce payload to comply with performance requirements at the higher operating speeds.

These potential cost impacts may be minimized for stall warning in icing conditions after the ice protection system has been turned on. Then the higher settings for flight in icing conditions would only be used if the ice protection system has been activated. The higher operating speeds would not be a factor, or cost, in other operations.

However, this design solution would not protect the airplane during the time that the airplane is in icing conditions before activation of the ice protection system. To protect the airplane during this time period, any changes to the stall warning system settings for potential ice accretions would need to be active at all times. This would mean that the minimum operating speeds would be increased for both icing and non-icing conditions with resulting cost implications.

To minimize the potential cost impact, while ensuring flight safety, the FTHWG examined whether different stall warning requirements could be used for flight in icing conditions before activation of the ice protection system. Flight in icing conditions before activation of the ice protection system is a temporary condition. In most cases, this time is expected to be relatively short. In those cases, proposed paragraph (h)(2) would allow the stall warning to be provided by a different means than is used for non-icing conditions. For example, natural airplane buffeting might be used instead of a stick shaker. By allowing a different means of stall warning, the need to change the stall warning system setting would be minimized.

However, if the stall warning is provided by a different means than for flight in non-icing conditions, the proposal seeks to balance this with more stringent flight demonstration requirements. The requirements would be more stringent for demonstrating that the pilot can safely recover the airplane after a stall warning has occurred. This demonstration occurs during the flight tests to show acceptable flight characteristics for stall recovery. For the time that the airplane is in icing conditions before the ice protections system has been activated, if stall warning is provided by a different means than for non-icing conditions, it may take longer for the flightcrew to recognize the impending stall and take recovery action. Therefore, instead of allowing a recovery maneuver to be started one second after the onset of stall warning, the recovery maneuver must not begin until at least 3 seconds after the onset of stall warning. Paragraph (h)(2)(i) of the proposal allows the recovery to start within one second of the stall warning. The more stringent three-second requirement is contained in the proposed paragraph (h)(2)(ii).

Additionally, proposed paragraph (h)(2)(ii) would require the applicant to show that the airplane has safe handling qualities in case the flightcrew does not take suitable recovery action in time to prevent stalling. Compliance with the stall characteristics requirements of § 25.203 would be required for stalls demonstrated using a one knot per second deceleration rate.

Earlier, we stated that in most cases, flight in icing conditions before activation of the icing system is expected to be relatively brief. However, if the means of detecting icing conditions and activating the ice protection system depends on the flightcrew visually identifying a discrete amount of ice on a reference surface (for example, one-quarter-inch of ice on the wing's leading edge), then this temporary condition may be of a relatively long duration. Therefore, we consider it appropriate to apply the same requirements for stall warning to this case as are applied to the case of flight in icing conditions after the ice protection system is fully active. For this case, we propose that the stall warning indication must be provided by the same means as in non-icing conditions. Proposed paragraph (h)(1) contains this requirement.

The FTHWG determined that applying the existing stall warning margin requirements of § 25.207(c) and (d) to icing conditions would be far more stringent than best current practices and would unduly penalize designs that have not exhibited safety problems in icing conditions. The FTHWG examined whether the stall warning requirements of existing § 25.207(c) and (d) could be made less stringent for icing conditions without compromising safety. The proposed § 25.207(e) resulted from this effort.

In developing the proposed § 25.207(e), the FTHWG determined that the types of transport category airplanes involved in icing-related stall accidents:

- Were equipped with deicing boots that operated cyclically (for example, a boot cycle every one to three minutes), and
- Were generally very susceptible to large affects on stall speeds from ice accretions during the periods between boot cycles (known as intercycle ice).

The proposed criteria of § 25.207(e), in combination with the proposed § 25.207(b), would likely require different stall warning system settings for icing conditions and non-icing conditions on future airplanes with those characteristics. These proposals would have a lesser impact on airplanes without those characteristics. The stall warning settings established for the airplane without ice accretions may be retained for operation in icing conditions, provided they are still adequate to prevent stalling if the pilot does not take any action to recover until three seconds after the initiation of stall warning. Since all modern conventional transport category airplanes use some type of artificial stall warning system (stick shaker or combined aural and visual warning), and since three seconds is considered adequate time for response by a trained pilot, we agree with the FTHWG that this stall warning definition would be acceptable for icing conditions.

The proposed revision of § 25.207(f) would require the pilot to use the same stall recovery maneuver during the compliance demonstration for icing conditions as is used for non-icing conditions. This proposal is based on human factors considerations. In operational service, pilots would not be expected to respond differently to a stall warning indication in icing conditions versus non-icing conditions.

L. Wind Velocities (§ 25.237)

The proposed revisions to § 25.237(a) would add a requirement to establish a safe landing crosswind component for use in icing conditions. The proposed revision to paragraph (a) also would state that the crosswind component established for takeoff without ice accretions may be used for takeoffs conducted in icing conditions.

For taking off in crosswinds, we consider it unnecessary to consider the effect of ice accretions since these proposals assume that ice accretions do not begin until liftoff. Therefore, airplanes will accrete very little ice, if any, while close to the ground where crosswinds are a significant safety concern. Proposed § 25.237(a)(2) explicitly states that the takeoff crosswind component without icing is valid for icing conditions.

However, the conditions on landing are different. Before landing, the airplane may spend a significant amount of time exposed to icing conditions. These ice accretions may affect directional control when crosswinds are encountered close to the ground. As a result, (a)(3)(ii) requires evaluation of the landing crosswind component with ice accretion.

M. High-Speed Characteristics (§ 25.253)

We propose to revise § 25.253 by adding a new paragraph (c) to define the maximum speed for stability characteristics, V_{FC}/M_{FC}, for icing conditions. The proposal would permit applicants to define a V_{FC}/M_{FC} for icing conditions that is different than the V_{FC}/M_{FC} defined for non-icing conditions. Additionally, § 25.253(b) would be revised to refer to § 25.143(g) rather than § 25.143(f) due to the proposed renumbering of § 25.143.

V_{FC}/M_{FC} is the highest speed at which compliance with several airplane handling qualities requirements must be shown. The FTHWG's review of historical certification data showed that none of the flight tests for airplane handling qualities performed with ice accretions were conducted above 300 knots CAS. The air loads associated with such high speeds tend to make it difficult to keep either artificial or natural ice attached to the airframe to accomplish the testing. It also minimizes the possibility of encountering this condition in operational service. Therefore, we propose that the maximum speed for demonstrating stability characteristics with ice accretions is the lower of V_{FC}, 300 KCAS, or any other speed at which it can be shown that the airframe will be free of ice.

N. Pilot Compartment View (§ 25.773)

We propose to revise § 25.773(b)(1)(ii) to replace the phrase ''if certification with ice protection provisions is requested'' with ''if certification for flight in icing conditions is requested.''

The proposed change is necessary to be consistent with the proposed change to § 25.1419. As discussed in the reason for revising § 25.1419, compliance with icing-related safety of flight requirements should depend on whether the airplane would be approved to operate in icing conditions, not on whether the airplane has approved ice protection provisions installed.

O. Inlet, Engine, and Exhaust Compatibility (§ 25.941)

We propose to revise the references to §§ 25.143(c), (d), and (e), contained in paragraph (c) of § 25.941, to read § 25.143(d), (e), and (f).

The proposed changes are necessary to maintain references to the correct paragraphs of § 25.143 if the changes to § 25.143 being proposed by this rulemaking are adopted.

P. Ice Protection (§ 25.1419)

We propose to revise the introductory text of § 25.1419 to replace the phrase, ''If certification with ice protection provisions is desired * * *'' with ''If certification for flight in icing conditions is desired * * *'' The current rule requires an applicant to demonstrate an airplane's ability to safely operate in icing conditions only when the applicant is seeking to certificate ice protection features. It fails to address certification approval for flight in icing conditions for airplanes without ice protection features. The proposed revision, which would adopt the existing wording from JAR 25.1419, would require an applicant to demonstrate the airplane's ability to safely operate in icing conditions whenever the applicant is seeking approval for flight in icing conditions.

We also propose to simplify the second sentence of § 25.1419 to remove redundant wording. This change is editorial in nature and is not intended to change the requirement in any way.

We propose to amend § 25.1419 to incorporate the revised introductory text for the following reasons:

- A literal reading of the current § 25.1419 wording could imply that the applicant does not have to demonstrate that the airplane can be safely operated in icing conditions unless an ice protection system is installed.
- The revised text would clarify that any airplane approved to fly in icing conditions must be capable of operating in the icing conditions of appendix C of part 25 regardless of whether or not the airplane has an ice protection system.

Q. Part 25, Appendix C

We propose to revise appendix C of part 25 to create two subsections: Part I to define the atmospheric icing conditions that must be considered when showing compliance with the icing-related requirements of part 25, and part II to define ice accretions for each phase of flight. We also propose to add a definition of the atmospheric icing conditions to use specifically for the takeoff phase of flight.

Proposed Appendix C, Part I

Proposed appendix C, part I would contain the existing appendix C definitions of atmospheric icing conditions. We propose adding a definition of ''takeoff maximum icing,'' which is to be used in determining ice accretions for the takeoff phase of flight.

Proposed Appendix C, Part II

Proposed appendix C, part II(a) would contain definitions of the ice accretions appropriate to each phase of flight. Proposed appendix C, part II(b) would provide options for reducing the number of ice accretions to be considered for each phase of flight. Proposed appendix C, part II(c) would permit applicants to use, for the airplane performance tests, the same ice accretion used for evaluating handling characteristics. Proposed appendix C, part II(d) would define the conditions for determining the ice accretions for the takeoff phase of flight. Proposed appendix C, part II(e) would define what ice accretion must be considered prior to normal ice protection system operation.

One early concern with developing appropriate airplane performance and handling qualities requirements for the takeoff phase of flight was the atmospheric icing environment close to the ground. The FTHWG members expressed significant concerns with using the existing appendix C atmospheric icing envelopes for this purpose. The FAA meteorologists confirmed that the existing appendix C atmospheric envelopes are not generally representative of icing conditions close to the ground.

In general, for determining the size, shape, location, and texture of ice accretions on the airplane, one needs information about the atmospheric icing environment, *i.e.*, icing cloud size, cloud liquid water content, water droplet size, expressed in terms of the mean effective diameter of the droplets, and ambient air temperature.

We propose to use the following definition of atmospheric icing conditions for takeoff maximum icing conditions in appendix C, part I(e): An icing cloud extending from ground level to a height of 1,500 feet above the takeoff surface with a liquid water content of 0.35 grams/meter^3, water droplets with a mean effective diameter of 20 microns, and an ambient temperature of minus 9 degrees Celsius (−9° C). The following discussion presents the reasons for selecting these values.

Since the takeoff phase of flight is relatively short, generally ending at a height of 1,500 feet above the takeoff surface (ref. § 25.111(a)), we consider it reasonable to assume that the entire takeoff phase could be flown within the same icing cloud. Therefore, we propose that the takeoff maximum icing conditions would extend from ground level to a height of 1,500 feet above the level of the takeoff surface.

Although measured data for liquid water content at low altitudes are sparse, a comparison of data contained in the FAA Technical Center's database on inflight icing conditions with theoretical predictions suggest a maximum liquid water content within the icing cloud of 0.35 grams/meter^3 from ground level up to 1,500 feet. We propose to use this value within the definition of the maximum takeoff icing conditions. This proposed value would also cover the potential for dense ground fog at freezing temperatures, which our meteorologists stated would expose the airplane to a liquid water content of approximately 0.30 grams/meter^3.

For the size of the water droplets, both industry and FAA icing specialists concurred that a mean effective diameter of 20 microns would be appropriate for icing conditions occurring near ground level. We propose to use this value within the definition of the maximum takeoff icing conditions.

Selection of the ambient temperature for takeoff icing was based on theoretical predictions that showed the effect of temperature to decrease significantly as the temperature itself decreased. We propose to use an ambient temperature for the takeoff icing atmosphere of minus 9 degrees Celsius (−9° C), the point at which any further decrease in temperature had a negligible effect on the resulting ice accretion.

According to our meteorologists, the amount of water vapor that can be held without condensing in a given volume of space depends only on the temperature of the gas (water vapor, air, etc.) in that space. It does not vary with altitude. Therefore, the proposed takeoff icing atmosphere would be equally applicable to all airport runway elevations.

Proposed part II(a) references specific phases of flight and defines the critical ice accretions associated with the specific phase of flight. In the main body of the rule, various sections require evaluation using the ice accretion defined in appendix C. Proposed part II(a) contains those definitions. For example, § 25.125(a)(1) requires evaluation of landing distance using the ice accretion defined in appendix C. To perform the evaluation required by § 25.125(a)(1), an applicant would use the landing ice definition found in paragraph (5) of this section.

To reduce the number of artificial ice accretions that must be considered, proposed part II(b) would permit the ice accretion determined for one flight phase to be used in showing compliance with the flight requirements of another phase, provided the applicant can show it has a more critical effect on the flight parameter being evaluated. For example, using the ice accretion determined for the holding phase to show compliance with the requirements for the takeoff phase will generally have a larger effect on performance and therefore be more penalizing than using an ice accretion determined specifically for the takeoff phase.

Proposed part II(c) clarifies that the ice accretion with the most adverse effect on handling qualities may also be used during the flight test demonstrations of performance as long as any performance differences are conservatively taken into account. This proposed section is consistent with the intent behind proposed part II(b) to reduce the number of ice accretions that must be considered. Unlike handling qualities, performance effects between relatively small differences in ice accretion generally can be addressed adequately through analysis.

Proposed part II(d) states the assumptions under which the takeoff ice accretions are determined. Proposed part II(d) also states that it must be assumed that the crew does not take any action to activate the ice protection system until the airplane is at least 400 feet above the takeoff surface. This requirement is consistent with the existing requirement of § 25.111(c)(4) that limits the types of configuration changes requiring crew action before reaching 400 feet above the takeoff surface.

We consider it necessary to also take into account the effects of any ice accretion that may form on the airplane from the time the airplane enters icing conditions until the ice protection system is activated and is performing its intended function. The size, shape, location, and texture of this ice accretion will depend on: (1) The means used to identify that the airplane is in icing conditions (for example, the pilot seeing ice accreting on the airplane, an ice detector, a combination of freezing temperatures and visible moisture), (2) the means and procedures for activating the ice protection system (for example, the pilot manually activating the system after a specified amount of ice builds up or automatic activation), and (3) the system characteristics (for example, the time it takes to effectively remove the ice). We propose to define the ice accretion applicable to the time period before the ice protection system has been activated and is performing its intended function as a period of time in the continuous maximum icing conditions of proposed part I of appendix C, including:

- The time for recognition,
- A delay time appropriate to the means of ice detection and activation of the ice protection system, and
- The time needed for the ice protection system to perform its intended function after manual or automatic activation.

III. Discussion of Non-Consensus Issues

One of the goals of the ARAC process is consensus on the proposed recommendations. Due to the variety of interests represented in the FTHWG, this goal was not fully achieved. The areas of non-consensus, however, were confined to specific details within the proposals, and not to the overall need to amend part 25 to address airplane performance and handling qualities in icing conditions. The issues for which full consensus was not achieved within the FTHWG were:

1. The requirement that a push force must be needed throughout the pushover maneuver proposed in the new § 25.143(i)(2);
2. Whether the test to evaluate longitudinal handling qualities during sideslip maneuvers should be required by regulation as proposed in the new § 25.143(i)(3), or should only be included in advisory material as one means of showing compliance;
3. Whether the same airplane performance and handling qualities requirements (§§ 25.143(j) and 25.207(h)) should always apply whenever the means to activate the ice protection system depends on the pilot to visually identify when the airplane is in icing conditions; and
4. Whether the proposed revision to appendix C adequately ensures that the full range of variables are considered in determining what the critical ice accretion is for a particular flight phase.

Each of these non-consensus issues is discussed in more detail below.

A. Non-Consensus Issue 1—§ 25.143(i)(2)

The FTHWG did not reach a consensus on the issue of requiring a push force throughout the maneuver down to a zero g load factor (or the lowest load factor obtainable if limited by elevator power). Although there was consensus that the test maneuver should be performed to zero g, the group did not reach a consensus on whether the pilot should be required to apply a push force to the longitudinal control system throughout the maneuver until a zero g load factor is attained. The FTHWG considered two alternatives.

Alternative 1 was developed by FTHWG members who did not support our proposal of requiring a push force to be maintained down to zero g load factor in the pushover maneuver. These FTHWG members disagreed with the proposal for the following reasons:

- Historically, the pushover test was performed to a 0.5 g load factor rather than zero g. For example, as practiced by Transport Canada (the Canadian airworthiness regulatory authority), this demonstration was done with a high pitch rate. Consequently, there was significant overshoot of the 0.5 g load factor, down to approximately 0.25 g or less. This maneuver was intended to be a controllability test beginning with the pilot abruptly pushing on the control column to achieve a high nose-down pitch rate, followed by a pull to recover. The intent was not to reach a specific g level below 0.5 g, but to show that the pilot could perform a satisfactory recovery. This has proven to be an acceptable test technique. To date, airplanes evaluated with this technique have had a satisfactory safety record in service.
- Since the beginning of the 1980s, the practice of many certification authorities has been to require testing to lower load factors. This evolved until the introduction of the JAA's NPA 25F–219, which not only requires testing to zero g, but also requires a push force throughout the maneuver to zero g. A zero-g pushover is considered to be an improbable condition, going well beyond any operational maneuver, and does not properly represent gusts, pitch rate, elevator position, or other factors that may contribute to tailplane stalls. Also, since the NPA requirement was developed for a specific turboprop, and motivated by service experience on turboprop airplanes, other requirements were proposed for other types of airplanes.

For the above reasons, the supporters of alternative 1 to § 25.143(i)(2) consider that requiring a push force to load factors as low as zero g is excessive. Instead, they recommend replacing proposed § 25.143(i)(2) with:

> The airplane must be controllable in a pushover maneuver down to zero g, or the lowest load factor obtainable if limited by elevator power. It must be shown that a push force is required throughout the maneuver down to 0.5 g. It must be possible to promptly recover from the maneuver without exceeding 50 pounds pull control force.

Further supporting rationale: FAA Advisory Circular 25–7A, ''Flight Test Guide for Certification of Transport Category Airplanes,'' defines the boundaries of various flight envelopes. With regard to the minimum load factor with flaps down:

- The normal flight envelope (NFE) goes to 0.8 g;
- The operational flight envelope (OFE) goes to 0.5 g; and
- The limit flight envelope (LFE) goes to zero g.

Conceptually, the boundaries of the OFE are as far as the pilot is expected to go intentionally, while the LFE is based on structural or other limits that should not be exceeded. Between the OFE and the LFE, it is acceptable for degraded handling qualities, but the airplane must remain controllable and it must be possible to avoid exceeding the limit load factor (see § 25.143(b)).

Although existing regulations do not allow force reversals (for example, from a push force on the control column to a pull force in this case) for the en route flight phase, in practice, the certification tests for these rules do not cover the full structural limit flight envelope. Rather, the certification tests cover a reasonable range of load factors sufficient to cover normal operations. For example, in the en route configuration, where the limit minimum load factor is usually negative 1 g, the JAA's Advisory Circular Joint (ACJ) No. 2 to JAR 25.143(f) states: ''* * * assessment of the characteristics in the normal flight envelope involving normal accelerations from 1 g to zero g, will normally be sufficient.''

With flaps up, zero g is the midpoint between the limit load factor and the trim point. The corresponding points for flaps down are zero g for the limit load factor and 0.5 g for the midpoint assessment of characteristics. The supporters of alternative 1 to § 25.143(i)(2) are concerned that requiring a push force to zero g means that this limit load factor will be routinely exceeded in the flight tests used to show compliance with the proposed rule.

The zero-g pushover is not like typical stability tests where it is possible to establish steady state conditions and measure a repeatable control force. The pushover is an extremely dynamic maneuver lasting only a few seconds and involving high pitch rates in both directions. There will always be variability due to pilot technique. The pilot may pull slightly before reaching zero g to reduce the nose-down pitch rate and anticipate the recovery. This makes it impossible to distinguish between the force required to reach a given g level and the force the pilot applies to track the targeted pitch rate. At critical conditions, airplanes that meet the criterion suggested in the alternative proposal still require a significant pull force to recover.

Alternative 1 to § 25.143(i)(2) would set a limit of 50 pounds on the total control force needed to recover promptly. This would ensure that the force that the pilot must exert is low enough so that even with only one hand on the pitch control (the other hand might be on the thrust levers or another control), the pilot can handle a combination of:

- The force to halt the nose-down pitch rate,
- The force due to any hinge moment reversal, and
- The force to establish a satisfactory nose-up pitch rate for recovery.

The 50-pound limit is used for a similar purpose in several other rules. The effect of data scatter and variations in pilot technique will cause airplanes that are not clearly free of ICTS concerns to exceed the 50-pound limit too often, so they will not pass this test.

The supporters of alternative 1 to § 25.143(i)(2) believe that the proposal contained in this rulemaking has the potential for adversely affecting an entire class of airplanes—namely light to medium business jets with trimmable stabilizers and unpowered elevators. Many of these airplanes exhibit a mild control force reversal from a push force to a pull force between zero g and 0.5 g.

Although such a characteristic will not comply with the proposed rule, the airplane remains easily controllable. The proposed requirement for a push force to be required down to a zero g load factor would reduce the stabilizer incidence available for trimming the airplane by two to four degrees. This would require either a 20 to 40 percent larger stabilizer or other design changes to compensate for the reduction in stabilizer trim range. The supporters of alternative 1 to § 25.143(i)(2) do not believe that the cost of these changes is justified by any safety benefit, as these airplanes are not the types having ICTS accidents.

Furthermore, the proposed § 25.143(i)(1) would require that sandpaper ice be considered if the elevator is unpowered, regardless of the ice protection system. Many of the current business jets are equipped with anti-ice systems that prevent ice formation on the stabilizer leading edge. Thus, the jets would be evaluated under more critical assumptions (that is, with the anti-ice system off) than the types that have had accidents.

Ice-contaminated tailplanes retain normal linear characteristics until the onset of flow separation. The separation causes the hinge moment coefficient to slope gradually from one level to another over a range of 4 to 10 degrees AOA. With the elevator down, the hinge moment coefficient changes sign at an AOA in this range, which results in the control force reversal from a push to a pull. On a particular business jet with a relatively small elevator, this results in a gradually increasing pull force from 0 pounds at approximately 0.4 g to 25 pounds at zero g.

On airplanes with large unpowered elevators, especially those with long chord lengths, the elevator control forces resulting from a stalled tail can be very high. These forces may even be too high for the pilots to counteract. For example, assume the elevator dimensions of the previous example are scaled up by a factor of 2. The elevator chord is then doubled, the area is quadrupled, and the pilot must exert 8 times as much force on the control to move the elevator. If the control force in the previous example were 25 pounds at zero g, the control force for this larger elevator would be 200 pounds. These examples illustrate how the size and design of elevators for certain airplanes determine whether the control forces would be acceptable or hazardous. The test criteria recommended for showing compliance with the requirements proposed as alternative 1 to § 25.143(i)(2) would identify those airplanes with the hazardous characteristics. Therefore, the supporters of alternative 1 to § 25.143(i)(2) believe that there is no difference in safety between this alternative and our proposal.

Results of the National Aeronautics and Space Administration's (NASA) Tailplane Icing Program provide a basis for evaluating whether the proposed requirements adequately address the safety concerns. Flight tests were conducted in which a test airplane performed a series of pushovers and other maneuvers with and without ice accretions. Even without ice accretions, reversed control forces were sometimes experienced in the pushover maneuvers for some configurations. With the ice accretions, control forces exceeding 100 pounds were experienced in some of the pushovers although the airplane remained controllable. In one test, a departure from controlled flight occurred during a power transition with a critical ice accretion and flaps 40 (which is the maximum landing flap configuration for this airplane). This event involved a sudden nose-down pitch-over from 1-g flight like the ICTS accident scenarios. The same ice accretion had degraded pushover characteristics to the point that a 50-pound pull was required to recover from zero g with flaps 10, and 100 pounds was required with flaps 20. Accordingly, the criteria proposed as alternative 1 to § 25.143(i)(2) provide an adequate safety margin, and would have identified the aircraft as unacceptable before it ever got to the flaps 40 configuration at which it lost control.

We disagree with the position of the supporters of alternative 1 to § 25.143(i)(2) for the following reasons:

a. Ice contaminated tailplane stall/elevator hinge moment reversal has been a significant factor in accidents occurring in icing conditions. Rapid and large changes in pitch, significant changes in control forces, pilot surprise, and possible disorientation in poor visibility that can follow from a tailplane stall/elevator hinge moment reversal can result in loss of pitch control. Coupled with the weather conditions that lead to ICTS, this loss of control will usually occur at low altitude where there is a higher probability of an accident.

b. Historically, the pushover test was usually performed to 0.5 g load factor, although this was often done with a high pitch rate and, hence, there was some overshoot of the 0.5 g load factor. A push force on the elevator control was required to reach this g level. Certification testing and service experience has since shown that testing to only to 0.5 g is inadequate, considering the relatively high frequency of experiencing 0.5 g in operations. Since the beginning of the 1980s, the practice of many certification authorities has been to require testing to lower load factors, and the JAA's Notice of Proposed Amendment (NPA) 25F–219 requires a push force throughout the maneuver to zero g.

c. Reversal of elevator control force versus normal acceleration is not acceptable within the flight envelope. Existing requirements and advisory material addressing elevator control force characteristics (§§ 25.143(f), 25.255(b)(2), and the guidance material to § 25.143(f)) do not allow force reversals. Furthermore, a survey of FAA, JAA, and other flight test personnel showed that a clear majority did not favor anything less than a push force on the elevator control to zero g.

Alternative 1 to § 25.143(i)(2) would at least partially address the cause of past ICTS accidents. However, the method proposed for determining the acceptability of a control force reversal is subjective and would lead to inconsistent evaluations. We maintain that a push force to zero g with an ice-contaminated tailplane is the minimum standard that can be accepted. Zero g is within the flight envelope of the airplane and this criterion addresses the need to have acceptable handling qualities for operational service when the pilot would not expect any control force reversal. Requiring a push force to zero g also removes subjectivity in the assessment of the airplane's controllability and provides readily understood criteria of acceptability. Any lesser standard would not give confidence that the problem has been fully addressed.

Transport Canada proposed the following alternative as a compromise between requiring a push force to either zero g or 0.5 g:

Transport Canada advisory material dating back to the mid-1980s specified that applicants must demonstrate ± 0.5 g applied to the longitudinal control. In practice, the demonstration was done in a fairly abrupt maneuver that generated a significantly higher transient pitch rate than that associated with a steady normal acceleration. The minimum normal acceleration obtained was usually around 0.25 g or less. It was considered that the pitch rate aspect was just as important as the actual normal acceleration in determining whether there were unsafe characteristics associated with tailplane stall. No pass/fail criteria were provided in the Transport Canada guidance except that the characteristics had to be satisfactory.

The accident record on ice contaminated tailplane stall indicates that a significant factor was the pilot's startled reaction to an abrupt hinge moment reversal and the magnitude of the control force required to recover the airplane to a normal 1 g condition. Alternative 1 to § 25.143(i)(2) would recognize this controllability issue by limiting the amount of pull force required to promptly recover the airplane from a zero g condition to a 50-pound pull force. In addition, recognizing that positive stability is also important, alternative 1 to § 25.143(i)(2) would require a push force down to 0.5 g.

Accident data available to Transport Canada indicate that aircraft involved in incidents and/or accidents incurred a tailplane stall at approximately 0.3 g to 0.4 g. Based on this data and Transport Canada's past practice, alternative 1 to § 25.143(i)(2) would be acceptable, except that the issue of pitch rate is not specifically identified in the criteria. Transport Canada recognizes that combining pitch rate with a normal acceleration in a requirement is probably too complex, especially for the wide range of aircraft designs encompassed by part 25 and the parallel JAR–25 standards. Thus, Transport Canada considers that, if the requirement would only specify a 'g' level, then 0.5 g for positive stability is inadequate. As a compromise, Transport Canada proposes requiring a push force down to a value of 0.25 g as alternative 2 to § 25.143(i)(2).

While it is a compromise between the requirement proposed in this rulemaking and alternative 1 (by specifying 0.25 g for the push force requirement), we disagree with this alternative because it does not fully address the safety concerns throughout the flight envelope. It also does not fully address the cost concerns expressed within the FTHWG regarding § 25.143(i)(2) as proposed in this rulemaking.

The Transport Canada alternative recognizes the importance of pitch rate. An abrupt nose-down control input is required to reach zero g. We consider that testing to zero g, however, ensures that high pitch rates are adequately evaluated without the added complication of specifying a pitch rate requirement.

B. Non-Consensus Issue 2—§ 25.143(i)(3)

The proposed new § 25.143(i)(3) would add a requirement that any changes in longitudinal control force to maintain speed with increasing sideslip angle be progressive with no reversals or unacceptable discontinuities. The FTHWG did not reach a consensus on whether it would be necessary to add a specific regulatory requirement to address this issue. The majority of the FTHWG members felt that there did not appear to be sufficient data to establish criteria specific enough to stand as a regulatory requirement and proposed that the issue be addressed through non-regulatory guidance material.

Anomalies in longitudinal control force during sideslip maneuvers have been of concern to some accident investigators and regulatory specialists. At one time, we proposed that pushover maneuvers be conducted while in sideslips. Transport Canada considered that performing sideslips in a pushover maneuver was excessive, but recognizing the concern, proposed an additional requirement that would specifically assess longitudinal control stick forces while in sideslip maneuvers.

We consider that a consensus was reached on the need to address this issue; the only difference appears to be whether it should be addressed in advisory material or in the proposed rule. We consider that this issue raises important safety concerns that must be addressed as a specific evaluation requirement. Therefore, it is appropriate to place it in the rule rather than in an AC. We recognize that AC material may also be needed to provide guidance on an acceptable means of compliance.

C. Non-Consensus Issue 3—§§ 25.143(j)(1) and 25.207(h)

The proposed new §§ 25.143(j)(1) and 25.207(h) would apply different requirements when different means are used for the pilot to visually recognize icing conditions. Compliance with all of the § 25.143 controllability requirements for non-icing conditions would apply if activation of the ice protection system depends on seeing a specified ice accretion on a reference surface (for example, on an ice accretion probe, or a wing leading edge). However, less stringent requirements using a lesser ice accretion would apply to any other means of identifying icing conditions, including seeing the first indication of an ice accretion on a reference surface.

The FTHWG did not reach a consensus on the proposed § 25.143(j)(1). The Air Line Pilots Association (ALPA), which was represented in the FTHWG, disagrees with the proposal. The ALPA considers visually recognizing the first indication of ice accreting on a reference surface to be the same situation as visually recognizing a specific amount of ice accretion on a reference surface. To the ALPA, both are means of visual recognition that require the flightcrew to monitor conditions outside the cockpit. Whenever it is necessary for the pilots to check outside the cockpit (which the ALPA does not consider to be equivalent to a primary instrument visual scan pattern), the ALPA believes that the same basic maneuver capabilities, stall protection requirements, and ice accretion amounts should apply.

The ALPA proposes the following alternative text for § 25.143(j)(1):

''If normal operation of any ice protection system is dependent upon visual recognition of ice accretion, the requirements of § 25.143 are applicable with the ice accretion defined in proposed appendix C, part II(e).''

The ALPA has similar concerns with the proposed § 25.207(h)(1) and proposes the following alternative text:

''If normal operation of any ice protection system is dependent upon visual recognition of ice accretion, the requirements of this section, except paragraphs (c) and (d), are applicable with the ice accretion defined in appendix C, part II(e).''

We disagree with the alternative proposals for §§ 25.143(j)(1) and 25.207(h)(1).

The FTHWG found that there are significant differences in the aerodynamic effects on an airplane between the two different means of visual recognition of icing conditions identified in the ALPA alternative proposal discussion. The best example of the means covered by §§ 25.143(j)(1) and 25.207(h)(1), as proposed in this notice, are airplanes with pneumatic deicing boots. The operating procedures call for a specified amount of ice build-up before activating the ice protection system, a process that is repeated often during an icing encounter. In this case, the airplane is assured of being operated with some level of aerodynamic degradation before activation of the ice protection system.

The best example of the second type of visual recognition of icing conditions are airplane models that are equipped with an ice accretion probe in the pilot's field of view outside the airplane. The published procedure calls for activating the ice protection system at the first indication of ice buildup on the accretion probe. Such accretion probes, or an equivalent such as a windshield wiper post, are highly efficient ice collectors, and typically will accrete visible ice prior to ice accretion on aerodynamic surfaces. Under this means of detecting icing conditions, there may be little or no ice buildup on aerodynamic surfaces before activation and normal operation of the ice protection system, and little or no aerodynamic degradation. These two means of visually recognizing that icing conditions are present are distinctly different.

D. Non-Consensus Issue 4—Appendix C

The ALPA representative on the FTHWG did not consider that the combination of the proposed regulatory changes and associated proposed advisory material provided a definitive enough description of the required ice accretions, particularly with regard to the variables that must be considered in determining the critical ice accretion for a particular flight phase. The ALPA alternative proposal recommends adding specific references to ''all flight conditions within the operational limits of the airplane'' and ''configuration changes'' to the general ice accretion requirements of proposed part II(a) of appendix C to ensure that the full range of possible accretion locations for atmospheric conditions are considered. The alternative text would read:

Section 25.21(g) states that if certification for flight in icing conditions is desired, the applicable requirements of subpart B must be met in the icing conditions of appendix C, unless otherwise prescribed. The most critical ice accretion in terms of handling characteristics and performance for each flight phase must be determined, taking into consideration the atmospheric conditions of part I of this appendix, and all flight conditions within the operational limits of the airplane (for example, configuration, configuration changes, speed, angle-of-attack, and altitude). The following ice accretions must be determined:

The NASA research following the Model ATR–72 accident at Roselawn, Indiana, in 1994, observed that decreasing AOA causes an increase in aft ice accretion limit on the upper surface of an airfoil. Likewise, the fact that airflow separation on the negative pressure side (upper surface for a typical wing) is caused by ice accretions on the upper surface is discussed. Research performed by Dr. Michael B. Bragg and others at the University of Illinois has demonstrated significant variation in the effects on airfoil aerodynamics of a simulated ice accretion depending upon its location on the negative pressure side of the airfoil.

Differing airspeeds and high lift device configurations significantly change the AOA and, consequently, the location of the stagnation point around which any ice accretion forms on an airfoil. For normal operation, this should make no difference on surfaces that are protected by the icing system. But for unprotected surfaces, in the failure case and for ice that accumulates prior to normal system operation, changing the location of ice on the negative pressure side of the airfoil may be significant. Procedural restrictions (that is, no holding with flaps extended, speed or configuration restrictions in case of ice system failure, etc.) could be used to limit the configurations necessary to determine the most critical ice accretion. However, the full range of possible accumulation locations must be considered.

In their report on the Embraer Model EMB 120 accident at Monroe, Michigan, in 1997, the NTSB concluded that:

The icing certification process has been inadequate because it has not required manufacturers to demonstrate the airplane's flight handling and stall characteristics under a sufficiently realistic range of adverse accretion/flight handling conditions. (Finding #27)

The recommendations submitted by the FTHWG, and this proposed rule, consider ice accretions for all phases of flight and all configurations of high lift devices. The proposed rule would require consideration of the effects of the ice accretion during the phases of flight with high lift devices extended. The associated proposed advisory material specifically recommends that natural icing flight testing with high lift devices extended in the approach and landing conditions be conducted.

We do not concur with the alternative discussed above. The research referred to above determined the effect on lift and drag of a spoiler-like shape located at various chord locations of a two dimensional airfoil. (A two dimensional airfoil is a wing with an infinite wingspan, that is, there are no wingtips. It is common practice for wind tunnel testing to use wings that span the test section from one wall of the wind tunnel to the other. Results obtained for a two dimensional airfoil must usually be adjusted to properly represent a real wing.) These data do not support the alternative position because no data were presented in the references to connect either this shape or its location with airplane flight conditions or icing conditions, either inside or outside of proposed appendix C. There were no data showing the effect of the shape on an airfoil with high lift devices extended.

The effect of any shape on a two-dimensional airfoil is much larger than the effect of a similar shape on a complete airplane with high lift devices extended, and the effect of such a shape diminishes with increasing airplane size.

The effect of ice accretions similar to the shapes tested in the referenced report were also considered by the FTHWG when it discussed ice accreted in conditions outside of proposed appendix C. The majority of the FTHWG recommended not including these accretions in the recommendations because the only icing design envelope available is proposed appendix C.

IV. Rulemaking Notices and Analyses

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA to consider the impact of paperwork and other information collection burdens imposed on the public. We have determined that there are no current new information collection requirements associated with this proposed rule.

International Compatibility

In keeping with U.S. obligations under the Convention on International

Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that there are no ICAO Standards and Recommended Practices that correspond to these proposed regulations.

Executive Order 13132, Federalism

The FAA analyzed this proposed rule under the principles and criteria of Executive Order 13132, Federalism. We determined that this action would not have a substantial direct effect on the States, on the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government, and therefore would not have federalism implications.

Regulatory Evaluation, Regulatory Flexibility Determination, International Trade Impact Assessment, and Unfunded Mandates Assessment

This portion of the preamble summarizes the FAA's analysis of the economic impacts of a proposed rule amending part 25 of 14 CFR to change the regulations applicable to transport category airplanes certificated for flight in icing conditions. It also includes summaries of the initial regulatory flexibility determination. We suggest readers seeking greater detail read the full regulatory evaluation, which is in the docket for this rulemaking.

Introduction

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (19 U.S.C. 2531–2533) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, to be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation).

In conducting these analyses, FAA has determined this rule (1) has benefits that justify its costs, (2) is not a ''significant regulatory action'' as defined in section 3(f) of Executive Order 12866, and is not ''significant'' as defined in DOT's Regulatory Policies and Procedures; (3) would not have a significant economic impact on a substantial number of small entities; (4) would have a neutral impact on international trade; and (5) does not impose an unfunded mandate on state, local, or tribal governments, or on the private sector. These analyses, available in the docket, are summarized below.

Total Benefits and Costs of This Rulemaking

The estimated cost of this proposed rule is $66.4 million ($22.0 million in present value at seven percent). The estimated potential benefits of avoiding 13 fatalities are $89.9 million ($23.7 million in present value at seven percent).

Who Is Potentially Affected by This Rulemaking

- Operators of part 25 U.S.-registered aircraft conducting operations under 14 CFR parts 121, 129, 135, and
- Manufacturers of those part 25 aircraft.

Our Cost Assumptions and Sources of Information

This evaluation makes the following assumptions:

- The base year is 2003.
- This proposed rule is assumed to become a final rule in 2 years, and will then be effective immediately.
- The production run for newly certificated airplane models is 20 years.
- The average life of an airplane is 25 years.
- We analyzed the costs and benefits of this proposed rule over the 45-year period (20 + 25 = 45) 2005 through 2049.
- We used a 10-year certification compliance period. For the 10-year life-cycle period, the FAA calculated an average of four new certifications would occur.
- We performed sensitivity analysis on present value discount rates of one, three, and the base case seven percent.
- New airplane certifications will occur in year one of the analysis time period.
- Value of fatality avoided—$3.0 million (Source: ''Treatment of Value of Life and Injury In Economic Analysis,'' (FAA APO Bulletin, February 2002).)

Benefits of This Rulemaking

The benefits of this proposed rule consist of the value of lives saved due to avoiding accidents involving part 25 airplanes operating in icing conditions. We estimate that a total of 13 fatalities could potentially be avoided by adopting the proposed rule. We use $3.0 million as the value of an avoided fatality. Over the 45-year period of analysis, the potential benefit of the proposed rule would be $89.9 million ($23.7 million in present value at seven percent).

Cost of This Rulemaking

We estimate the costs of this proposed rule to be about $66.4 million ($22.0 million in present value at seven percent) over the 45-year analysis period. The total cost of $66.4 million equals the fixed certification costs of $6.7 million incurred in the first year plus the variable annual fuel burn cost of $59.7 million.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the business, organizations, and governmental jurisdictions subject to regulation.'' To achieve that principle, the RFA requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The RFA covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the Act.

However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear. This proposed rule would not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The Trade Agreement Act of 1979 prohibits Federal agencies from establishing any standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards. The FAA has assessed the potential effect of this proposed rule and determined that it would impose the same costs on domestic and international entities and thus have a neutral trade impact.

Unfunded Mandates Assessment

The Unfunded Mandates Reform Act of 1995 (the Act) is intended, among other things, to curb the practice of imposing unfunded Federal mandates on State, local, and tribal governments. Title II of the Act requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (adjusted annually for inflation) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a ''significant regulatory action.'' The FAA currently uses an inflation-adjusted value of $120.7 million in lieu of $100 million. This proposed rule does not contain such a mandate. The requirements of Title II of the Act, therefore, do not apply.

Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying regulations in Title 14 of the CFR in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish such regulatory distinctions as he or she considers appropriate. Because this proposed rule would apply to the certification of future designs of transport category airplanes and their subsequent operation, it could, if adopted, affect intrastate aviation in Alaska. The FAA therefore specifically requests comments on whether there is justification for applying the proposed rule differently in intrastate operations in Alaska.

Plain Language

Executive Order 12866 (58 FR 51735, Oct. 4, 1993) requires each agency to write regulations that are simple and easy to understand. We invite your comments on how to make these proposed regulations easier to understand, including answers to questions such as the following:

Are the requirements in the proposed regulations clearly stated?

- Do the proposed regulations contain unnecessary technical language or jargon that interferes with their clarity?
- Would the proposed regulations be easier to understand if they were divided into more (but shorter) sections?
- Is the description in the NPRM preamble helpful in understanding the proposed regulations?

Please send your comments to the address specified in the **FOR FURTHER INFORMATION CONTACT** section. [new template uses **ADDRESSES**]

Environmental Analysis

FAA Order 1050.1E identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this proposed rulemaking action qualifies for the categorical exclusion identified in paragraph number 312f and involves no extraordinary circumstances.

Regulations That Significantly Affect Energy Supply, Distribution, or Use

The FAA has analyzed this NPRM under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). We have determined that it is not a ''significant energy action'' under the executive order because it is not a ''significant regulatory action'' under Executive Order 12866, and it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

V. Appendixes to the Preamble

APPENDIX I.—LIST OF ACRONYMS USED IN THIS DOCUMENT

[For your reference and ease of reading, the following list defines the acronyms that are used throughout this document. This appendix will not appear in the *Code of Federal Regulations*.]

Acronym	Definition
AC	Advisory Circular.
ACJ	Advisory Circular Joint (issued by JAA).
AFM	Airplane Flight Manual.
ALPA	Air Line Pilots Association.
AMJ	Advisory Material Joint (issued by JAA).
AOA	Angle-of-Attack.
ARAC	Aviation Rulemaking Advisory Committee.
CAS	Calibrated Airspeed.
CS	Certification Specifications (EASA airworthiness standards).
EASA	European Aviation Safety Agency.
FAA	Federal Aviation Administration.
FTHWG	Flight Test Harmonization Working Group.
ICTS	Ice-Contaminated Tailplane Stall.
IPHWG	Ice Protection Harmonization Working Group.
JAA	Joint Aviation Authorities.
JAR	Joint Aviation Requirements (JAA airworthiness standards).
LFE	Limit Flight Envelope.
NASA	National Aeronautics and Space Administration.
NFE	Normal Flight Envelope.
NPA	Notice of Proposed Amendment (issued by JAA or EASA).
NPRM	Notice of Proposed Rulemaking.
NTSB	National Transportation Safety Board.
OFE	Operational Flight Envelope.

APPENDIX I.—LIST OF ACRONYMS USED IN THIS DOCUMENT—Continued

[For your reference and ease of reading, the following list defines the acronyms that are used throughout this document. This appendix will not appear in the *Code of Federal Regulations*.]

Acronym	Definition
SLD	Supercooled Large Drop.
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_{DF}/M_{DF}	Demonstrated Flight Diving Speed.
V_{EF}	Engine Failure Speed. The speed at which the critical engine is assumed to fail during takeoff.
V_{FC}/M_{FC}	Maximum Speed for Stability Characteristics.
V_{FE}	Maximum Flaps Extended Speed.
V_{FTO}	Final Takeoff Speed. The speed at which compliance is shown with the final takeoff climb gradient requirements of § 25.121(c).
V_{MC}	Minimum Control Speed with the critical engine inoperative.
V_{MCA}	Air Minimum Control Speed. (Commonly used terminology for V_{MC}.)
V_{MCG}	Ground Minimum Control Speed.
V_{MCL}	Landing Minimum Control Speed.
V_{MO}/M_{MO}	Maximum Operating Limit Speed.
V_{MU}	Minimum Unstick Speed. The minimum airspeed at and above which the airplane can safely lift off the ground and continue the takeoff.
V_R	Rotation Speed. The speed at which the pilot first makes an input to the airplane controls to rotate the airplane to the takeoff pitch attitude.
V_{REF}	Landing Reference Speed.
$V_{S\ 1-g}$	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 $V_{S\ 1-g}$. 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_{SR0}	Reference Stall Speed in the landing configuration.

APPENDIX 2.—LIST OF TERMS USED IN THIS NPRM

[For the reader's reference and ease of reading, the following list defines terms that are used throughout this document. This appendix will not appear in the *Code of Federal Regulations*.]

Term	Definition
Airfoil	The shape of the wing when looking at its profile.
Airplane handling qualities	The response of the airplane to control inputs as assessed primarily by a pilot evaluating the ease of accomplishing maneuvering tasks. Airplane handling qualities refer to the stability, controllability, and maneuverability of the airplane.
Airplane performance	The capability of the airplane in terms of speeds, distances, weights, flight paths, etc., expressed in terms of characteristics like takeoff and landing distances, en route altitude capability, climb and descent rates, flight paths, fuel burn, payload capability, range, etc.
En route ice	The critical ice accretion appropriate to normal operation of the ice protection system during the en route phase of flight.
Final takeoff ice	The most critical ice accretion appropriate to normal operation of the ice protection system during the final takeoff segment. Ice accretion is assumed to start at liftoff in the takeoff maximum icing conditions of 14 CFR part 25, appendix C, part 1, paragraph (c).
Force reversal	A reversal in the direction of the force that the pilot needs to apply to perform a specified maneuver or achieve a specified load factor. For example, in a maneuver to reduce the load factor, a push force on the pitch control is initially needed to begin the maneuver, but changes to a pull force as the load factor is reduced.
Holding ice	The critical ice accretion appropriate to normal operation of the ice protection system during the holding phase of flight.
Hinge moment	The rotational force about the hinge of a control surface. Depending on the design of the airplane's flight control system, large hinge moments can result in large forces at the pilot's control, and hinge moment reversals can result in forces reversals.
Ice-contaminated tailplane stall	Ice accretions on the tailplane leading to either completely stalled airflow over the horizontal stabilizer, or an elevator hinge moment reversal due to separated flow on the lower surface of the horizontal stabilizer.
Landing ice	The critical ice accretion appropriate to normal operation of the ice protection system during the landing phase of flight. This is usually the same as holding ice.
Load factor	The lift divided by the weight, expressed in units of gravity, or "g." For example, in straight and level flight, the lift equals the weight and the load factor is 1 g.
Pushover maneuver	A maneuver resulting from the pilot applying a push force to the airplane pitch control to pitch the airplane's nose down.
Sandpaper ice	A thin, rough layer of ice.
Stall	Loss of lift caused by the airflow becoming detached from the upper surface of a lifting surface such as a wing or tailplane.

APPENDIX 2.—LIST OF TERMS USED IN THIS NPRM—Continued

[For the reader's reference and ease of reading, the following list defines terms that are used throughout this document. This appendix will not appear in the *Code of Federal Regulations*.]

Term	Definition
Takeoff ice	The critical ice accretion appropriate to normal operation of the ice protection system during the takeoff phase of flight, assuming accretion starts at liftoff in the takeoff maximum icing conditions of 14 CFR part 25, appendix C, part 1, paragraph (c).
Tailplane	The horizontal wing attached to the tail assembly of the airplane.

Appendix 3: Relevant NTSB Recommendations

If adopted, this rulemaking would respond to the following National Transportation Safety Board (NTSB) Safety Recommendations.

1. *Safety Recommendation A–91–87. ''Amend the icing certification rules to require flight tests wherein ice is accumulated in those cruise and approach flap configurations in which extensive exposure to icing conditions can be expected, and require subsequent changes in configuration, to include landing flaps.''* [complete text available in the docket]

This safety recommendation resulted from an accident on December 26, 1989, at Pasco, Washington, where the airplane stalled due to ice-contamination on the tailplane.[6] The radar data revealed that the airplane was in the clouds in icing conditions for almost 9½ minutes. The NTSB determined that the probable cause of this accident was the flightcrew's decision to continue an unstabilized ILS approach that led to a stall, most likely of the horizontal stabilizer, and loss of control at low altitude. Contributing to the stall and loss of control was the accumulation of airframe ice that degraded the aerodynamic performance of the airplane.[7] The airplane was destroyed and the two pilots and all four passengers received fatal injuries. As discussed in more detail later, this notice proposes to require applicants to demonstrate during type certification that their airplane is not susceptible to ice-contaminated tailplane stall.

2. *Safety Recommendation A–98–94. ''Require manufacturers of all turbine-engine driven airplanes (including the EMB–120) to provide minimum maneuvering airspeed information for all airplane configurations, phases, and conditions of flight (icing and non-icing conditions); minimum airspeeds also should take into consideration the effects of various types, amounts, and locations of ice accumulations, including thin amounts of very rough ice, ice accumulated in supercooled large droplet icing conditions, and tailplane icing.''* [complete text available on the NTSB Web site at: *http://ntsb.gov/Recs/letters/1998/A98_88_106.pdf*]

This safety recommendation resulted from an accident on January 9, 1997, near Monroe, Michigan.[8] In that accident, the flightcrew were attempting a turning maneuver and did not know there was ice on the wing's leading edge. With the degraded aerodynamics due to the ice on the wing's leading edge, the airplane was at too low an airspeed to conduct the turning maneuver without stalling. This caused a rapid descent after an uncommanded roll excursion, resulting in a crash. The airplane was destroyed and the 2 flight crewmembers, 1 flight attendant, and 26 passengers all died. The NTSB determined that the probable cause of this accident was the FAA's failure to establish adequate aircraft certification standards for flight in icing conditions, and to require the establishment of adequate minimum airspeed for icing conditions.[9]

As discussed in more detail later, this notice proposes to require applicants to demonstrate during type certification that their airplane has adequate maneuvering capabilities in icing conditions. The requirements added to part 25 by the 1-g stall rule[10] and the requirements proposed in this NPRM would ensure that the minimum operating speeds determined during the certification of all future transport category airplanes provide adequate maneuver capability in both non-icing and icing conditions.

3. *Safety Recommendation A–98–96. ''Require the manufacturers and operators of all airplanes that are certificated to operate in icing conditions to install stall warning/protection systems that provide a cockpit warning (aural warning and/or stick shaker) before the onset of stall when the airplane is operating in icing conditions.''* [complete text available on the NTSB Web site at: *http://ntsb.gov/Recs/letters/1998/A98_88_106.pdf*]

This safety recommendation resulted from the same accident discussed under Safety Recommendation A–98–94, above. The airplane stalled before either the stall warning system or the stall protection system activated. As discussed in more detail later, this notice proposes to require applicants to demonstrate during type certification that their airplane provides adequate warning of an impending stall in icing conditions.

Although we do not currently have a part 25 regulatory requirement for stall warning to be provided by a warning device in the cockpit, general industry design practice is to use a device called a stick shaker to shake the control column to warn the pilot of an impending stall.

XIV. Proposed Amendment

List of Subjects in 14 CFR Part 25:

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 25 of Title 14, Code of Federal Regulations, as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, and 44704

2. Amend § 25.21 by adding a new paragraph (g) to read as follows:

§ 25.21 Proof of compliance.

* * * * *

(g) The requirements of this subpart associated with icing conditions apply only if certification for flight in icing conditions is desired. If certification for flight in icing conditions is desired, the following requirements also apply:

(1) Each requirement of this subpart, except §§ 25.121(a), 25.123(c), 25.143(b)(1) and (b)(2), 25.149, 25.201(c)(2), 25.207(c) and (d), 25.239, and 25.251(b) through (e), must be met in icing conditions. Compliance must be shown using the ice accretions defined in appendix C, assuming normal operation of the airplane and its ice protection system in accordance with the operating limitations and operating procedures established by the applicant and provided in the Airplane Flight Manual.

(2) No changes in the load distribution limits of § 25.23, the weight limits of § 25.25 (except where limited by performance requirements of this

[6] United Express flight 2415 (Sundance 415), a British Aerospace BA–3101 Jetstream, operated by NPA Inc., (NPA is the name of the airline and is not an abbreviation).

[7] ''Effect of Ice on Aircraft Handling Characteristics (1984 Trials),'' Jetstream 31—G–JSSD, British Aerospace Flight Test Report FTR.177/JM, dated May 13, 1985.

[8] Comair flight 3272, Empresa Brasileira de Aeronautica, S/A (Embraer) EMB–120, operated by COMAIR Airlines, Inc.

[9] National Transportation Safety Board, 1998. ''In-Flight Icing Encounter and Uncontrolled Collision With Terrain, Comair Flight 3272, Embraer EMB–120RT, N265CA, Monroe, Michigan, January 9, 1997.'' Aircraft Accident Report NTSB/AR–98/04. Washington, DC.

[10] Docket No. FAA–2002–13982, published in the **Federal Register** (67 FR 70812, November 26, 2002).

subpart), and the center of gravity limits of § 25.27, from those for non-icing conditions, are allowed for flight in icing conditions or with ice accretion.

3. Amend § 25.103 by revising paragraph (b)(3) to read as follows:

§ 25.103 Stall speed.

* * * * *

(b) * * *

(3) The airplane in other respects (such as flaps, landing gear, and ice accretions) in the condition existing in the test or performance standard in which V_{SR} is being used;

* * * * *

4. Amend § 25.105 by revising paragraph (a) to read as follows:

§ 25.105 Takeoff.

(a) The takeoff speeds prescribed by § 25.107, the accelerate-stop distance prescribed by § 25.109, the takeoff path prescribed by § 25.111, the takeoff distance and takeoff run prescribed by § 25.113, and the net takeoff flight path prescribed by § 25.115, must be determined in the selected configuration for takeoff at each weight, altitude, and ambient temperature within the operational limits selected by the applicant—

(1) In non-icing conditions; and

(2) In icing conditions, if in the configuration of § 25.121(b) with the takeoff ice accretion defined in appendix C:

(i) The stall speed at maximum takeoff weight exceeds that in non-icing conditions by more than the greater of 3 knots CAS or 3 percent of V_{SR}; or

(ii) The degradation of the gradient of climb determined in accordance with § 25.121(b) is greater than one-half of the applicable actual-to-net takeoff flight path gradient reduction defined in § 25.115(b).

* * * * *

5. Amend § 25.107 by revising paragraph (c)(3) and (g)(2) and adding new paragraph (h) to read as follows:

§ 25.107 Takeoff speeds.

* * * * *

(c) * * *

(3) A speed that provides the maneuvering capability specified in § 25.143(h).

* * * * *

(g) * * *

(2) A speed that provides the maneuvering capability specified in § 25.143(h).

(h) In determining the takeoff speeds V_1, V_R, and V_2 for flight in icing conditions, the values of V_{MCG}, V_{MC}, and V_{MU} determined for non-icing conditions may be used.

6. Amend § 25.111 by revising paragraph (c)(3)(iii), (c)(4), and adding a new paragraph (c)(5) to read as follows:

§ 25.111 Takeoff path.

* * * * *

(c) * * *

(3) * * *

(iii) 1.7 percent for four-engine airplanes.

(4) The airplane configuration may not be changed, except for gear retraction and automatic propeller feathering, and no change in power or thrust that requires action by the pilot may be made until the airplane is 400 feet above the takeoff surface; and

(5) If § 25.105(a)(2) requires the takeoff path to be determined for flight in icing conditions, the airborne part of the takeoff must be based on the airplane drag:

(i) With the takeoff ice accretion defined in appendix C, from a height of 35 feet above the takeoff surface up to the point where the airplane is 400 feet above the takeoff surface; and

(ii) With the final takeoff ice accretion defined in appendix C, from the point where the airplane is 400 feet above the takeoff surface to the end of the takeoff path.

* * * * *

7. Revise § 25.119 to read as follows:

§ 25.119 Landing climb: All-engines-operating.

In the landing configuration, the steady gradient of climb may not be less than 3.2 percent, with the engines at the power or thrust that is available 8 seconds after initiation of movement of the power or thrust controls from the minimum flight idle to the go-around power or thrust setting—

(a) In non-icing conditions, with a climb speed of V_{REF} determined in accordance with § 25.125(b)(2)(i); and

(b) In icing conditions with the landing ice accretion defined in appendix C, and with a climb speed of V_{REF} determined in accordance with § 25.125(b)(2)(ii).

8. Amend § 25.121 by revising paragraphs (b), (c), and (d) to read as follows:

§ 25.121 Climb: One-engine inoperative.

* * * * *

(b) *Takeoff; landing gear retracted.* In the takeoff configuration existing at the point of the flight path at which the landing gear is fully retracted, and in the configuration used in § 25.111 but without ground effect:

(1) The steady gradient of climb may not be less than 2.4 percent for two-engine airplanes, 2.7 percent for three-engine airplanes, and 3.0 percent for four-engine airplanes, at V_2 with:

(i) The critical engine inoperative, the remaining engines at the takeoff power or thrust available at the time the landing gear is fully retracted, determined under § 25.111, unless there is a more critical power operating condition existing later along the flight path but before the point where the airplane reaches a height of 400 feet above the takeoff surface; and

(ii) The weight equal to the weight existing when the airplane's landing gear is fully retracted, determined under § 25.111.

(2) The requirements of paragraph (b)(1) of this section must be met:

(i) In non-icing conditions; and

(ii) In icing conditions with the takeoff ice accretion defined in appendix C, if in the configuration of § 25.121(b) with the takeoff ice accretion:

(A) The stall speed at maximum takeoff weight exceeds that in non-icing conditions by more than the greater of 3 knots CAS or 3 percent of V_{SR}; or

(B) The degradation of the gradient of climb determined in accordance with § 25.121(b) is greater than one-half of the applicable actual-to-net takeoff flight path gradient reduction defined in § 25.115(b).

(c) *Final takeoff.* In the en route configuration at the end of the takeoff path determined in accordance with § 25.111:

(1) The steady gradient of climb may not be less than 1.2 percent for two-engine airplanes, 1.5 percent for three-engine airplanes, and 1.7 percent for four-engine airplanes, at V_{FTO} with—

(i) The critical engine inoperative and the remaining engines at the available maximum continuous power or thrust; and

(ii) The weight equal to the weight existing at the end of the takeoff path, determined under § 25.111.

(2) The requirements of paragraph (c)(1) of this section must be met:

(i) In non-icing conditions; and

(ii) In icing conditions with the final takeoff ice accretion defined in appendix C, if in the configuration of § 25.121(b) with the takeoff ice accretion:

(A) The stall speed at maximum takeoff weight exceeds that in non-icing conditions by more than the greater of 3 knots CAS or 3 percent of V_{SR}; or

(B) The degradation of the gradient of climb determined in accordance with § 25.121(b) is greater than one-half of the applicable actual-to-net takeoff flight path gradient reduction defined in § 25.115(b).

(d) *Approach.* In a configuration corresponding to the normal all-engines-operating procedure in which V_{SR} for this configuration does not exceed 110 percent of the V_{SR} for the related all-engines-operating landing configuration:

(1) The steady gradient of climb may not be less than 2.1 percent for two-engine airplanes, 2.4 percent for three-engine airplanes, and 2.7 percent for four-engine airplanes, with—

(i) The critical engine inoperative, the remaining engines at the go-around power or thrust setting;

(ii) The maximum landing weight;

(iii) A climb speed established in connection with normal landing procedures, but not exceeding 1.4 V_{SR}; and

(iv) Landing gear retracted.

(2) The requirements of paragraph (d)(1) of this section must be met:

(i) In non-icing conditions; and

(ii) In icing conditions with the holding ice accretion defined in appendix C. The climb speed selected for non-icing conditions may be used if the climb speed for icing conditions, computed in accordance with paragraph (d)(1)(iii) of this section, does not exceed that for non-icing conditions by more than the greater of 3 knots CAS or 3 percent.

9. Amend § 25.123 by revising paragraphs (a) introductory text and (b) to read as follows:

§ 25.123 En route flight paths.

(a) For the en route configuration, the flight paths prescribed in paragraph (b) and (c) of this section must be determined at each weight, altitude, and ambient temperature, within the operating limits established for the airplane. The variation of weight along the flight path, accounting for the progressive consumption of fuel and oil by the operating engines, may be included in the computation. The flight paths must be determined at a speed not less than V_{FTO}, with—

* * * * *

(b) The one-engine-inoperative net flight path data must represent the actual climb performance diminished by a gradient of climb of 1.1 percent for two-engine airplanes, 1.4 percent for three-engine airplanes, and 1.6 percent for four-engine airplanes—

(1) In non-icing conditions; and

(2) In icing conditions with the en route ice accretion defined in appendix C, if:

(i) A speed of 1.18 V_{SR} with the en route ice accretion exceeds the en route speed selected for non-icing conditions by more than the greater of 3 knots CAS or 3 percent of V_{SR}; or

(ii) The degradation of the gradient of climb is greater than one-half of the applicable actual-to-net flight path reduction defined in paragraph (b) of this section.

* * * * *

10. Revise § 25.125 to read as follows:

§ 25.125 Landing.

(a) The horizontal distance necessary to land and to come to a complete stop (or to a speed of approximately 3 knots for water landings) from a point 50 feet above the landing surface must be determined (for standard temperatures, at each weight, altitude, and wind within the operational limits established by the applicant for the airplane):

(1) In non-icing conditions; and

(2) In icing conditions with the landing ice accretion defined in appendix C if V_{REF} for icing conditions exceeds V_{REF} for non-icing conditions by more than 5 knots CAS.

(b) In determining the distance in (a):

(1) The airplane must be in the landing configuration.

(2) A stabilized approach, with a calibrated airspeed of not less than V_{REF}, must be maintained down to the 50-foot height.

(i) In non-icing conditions, V_{REF} may not be less than:

(A) 1.23 V_{SR0};

(B) V_{MCL} established under § 25.149(f); and

(C) A speed that provides the maneuvering capability specified in § 25.143(h).

(ii) In icing conditions, V_{REF} may not be less than:

(A) The speed determined in paragraph (b)(2)(i) of this section;

(B) 1.23 V_{SR0} with the landing ice accretion defined in appendix C if that speed exceeds V_{REF} for non-icing conditions by more than 5 knots CAS; and

(C) A speed that provides the maneuvering capability specified in § 25.143(h) with the landing ice accretion defined in appendix C.

(3) Changes in configuration, power or thrust, and speed, must be made in accordance with the established procedures for service operation.

(4) The landing must be made without excessive vertical acceleration, tendency to bounce, nose over, ground loop, porpoise, or water loop.

(5) The landings may not require exceptional piloting skill or alertness.

(c) For landplanes and amphibians, the landing distance on land must be determined on a level, smooth, dry, hard-surfaced runway. In addition—

(1) The pressures on the wheel braking systems may not exceed those specified by the brake manufacturer;

(2) The brakes may not be used so as to cause excessive wear of brakes or tires; and

(3) Means other than wheel brakes may be used if that means—

(i) Is safe and reliable;

(ii) Is used so that consistent results can be expected in service; and

(iii) Is such that exceptional skill is not required to control the airplane.

(d) For seaplanes and amphibians, the landing distance on water must be determined on smooth water.

(e) For skiplanes, the landing distance on snow must be determined on smooth, dry, snow.

(f) The landing distance data must include correction factors for not more than 50 percent of the nominal wind components along the landing path opposite to the direction of landing, and not less than 150 percent of the nominal wind components along the landing path in the direction of landing.

(g) If any device is used that depends on the operation of any engine, and if the landing distance would be noticeably increased when a landing is made with that engine inoperative, the landing distance must be determined with that engine inoperative unless the use of compensating means will result in a landing distance not more than that with each engine operating.

11. Amend § 25.143 by revising paragraphs (c), (d), (e), (f), and (g), and by adding new paragraphs (h), (i), and (j) to read as follows:

§ 25.143 General.

* * * * *

(c) The airplane must be shown to be safely controllable and maneuverable with the critical ice accretion appropriate to the phase of flight defined in appendix C, and with the critical engine inoperative and its propeller (if applicable) in the minimum drag position:—

(1) At the minimum V_2 for takeoff;

(2) During an approach and go-around; and

(3) During an approach and landing.

(d) The following table prescribes, for conventional wheel type controls, the maximum control forces permitted during the testing required by paragraph (a) through (c) of this section:

Force, in pounds, applied to the control wheel or rudder pedals	Pitch	Roll	Yaw
For short term application for pitch and roll control—two hands available for control	75	50	....
For short term application for pitch and roll control—one hand available for control	50	25	....
For short term application for yaw control	....	....	150
For long term application	10	5	20

(e) Approved operating procedures or conventional operating practices must be followed when demonstrating compliance with the control force limitations for short term application that are prescribed in paragraph (d) of this section. The airplane must be in trim, or as near to being in trim as practical, in the preceding steady flight condition. For the takeoff condition, the airplane must be trimmed according to the approved operating procedures.

(f) When demonstrating compliance with the control force limitations for long term application that are prescribed in paragraph (d) this section, the airplane must be in trim, or as near to being in trim as practical.

(g) When maneuvering at a constant airspeed or Mach number (up V_{FC}/M_{FC}), the stick forces and the gradient of the stick versus maneuvering load factor must lie within satisfactory limits. The stick forces must not be so great as to make excessive demands on the pilot's strength when maneuvering the airplane, and must not be so low that the airplane can easily be overstressed inadvertently. Changes of gradient that occur with changes of load factor must not cause undue difficulty maintaining control of the airplane, and local gradients must not be so low as to result in a danger of overcontrolling.

(h) The maneuvering capabilities in a constant speed coordinated turn at forward center of gravity, as specified in the following table, must be free of stall warning or other characteristics that might interfere with normal maneuvering:

Configuration	Speed	Maneuvering bank angle in a coordinated turn	Thrust/power setting
Takeoff	V_2	30°	Asymmetric WAT-limited.[1]
Takeoff	V_2 + XX[2]	40°	All-engines-operating climb.[3]
En route	V_{FTO}	40°	Asymmetric WAT-limited.[1]
Landing	V_{REF}	40°	Symmetric for −3° flight path angle.

[1] *A combination of weight, altitude, and temperature (WAT) such that the thrust or power setting produces the minimum climb gradient specified in § 25.121 for the flight condition.*

[2] *Airspeed approved for all-engines-operating initial climb.*

[3] *That thrust or power setting which, in the event of failure of the critical engine and without any crew action to adjust the thrust or power of the remaining engines, would result in the thrust or power specified for the takeoff condition at V_2, or any lesser thrust or power setting that is used for all-engines-operating initial climb procedures.*

(i) When demonstrating compliance with § 25.143 in icing conditions—

(1) Controllability must be demonstrated with the ice accretion defined in appendix C that is most critical for the particular flight phase;

(2) It must be shown that a push force is required throughout a pushover maneuver down to a zero g load factor, or the lowest load factor obtainable if limited by elevator power. It must be possible to promptly recover from the maneuver without exceeding 50 pounds pull control force; and

(3) 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.

(j) For flight in icing conditions before the ice protection system has been activated and is performing its intended function, the following requirements apply:

(1) If activating the ice protection system depends on the pilot seeing a specified ice accretion on a reference surface (not just the first indication of icing), the requirements of § 25.143 apply with the ice accretion defined in appendix C, part II(e).

(2) For other means of activating the ice protection system, it must be demonstrated in flight with the ice accretion defined in appendix C, part II(e) that:

(i) The airplane is controllable in a pull-up maneuver up to 1.5 g load factor; and

(ii) There is no longitudinal control force reversal during a pushover maneuver down to 0.5 g load factor.

12. Amend § 25.207 by revising paragraph (b), revising paragraphs (e) and (f), and adding paragraphs (g) and (h) to read as follows:

§ 25.207 Stall warning.

* * * * *

(b) The warning must be furnished either through the inherent aerodynamic qualities of the airplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself. If a warning device is used, it must provide a warning in each of the airplane configurations prescribed in paragraph (a) of this section at the speed prescribed in paragraphs (c) and (d) of this section. Except for the stall warning prescribed in paragraph (h)(2)(ii) of this section, the stall warning for flight in icing conditions prescribed in paragraph (e) of this section must be provided by the same means as the stall warning for flight in non-icing conditions.

(c) * * *

(d) * * *

(e) In icing conditions, the stall warning margin in straight and turning flight must be sufficient to allow the pilot to prevent stalling (as defined in § 25.201(d)) when the pilot starts a recovery maneuver not less than three seconds after the onset of stall warning. When demonstrating compliance with this paragraph, the pilot must perform the recovery maneuver in the same way as for the airplane in non-icing conditions. Compliance with this requirement must be demonstrated in flight with the speed reduced at rates not exceeding one knot per second, with—

(1) The en route ice accretion defined in appendix C for the en route configuration;

(2) The holding ice accretion defined in appendix C for the holding and approach configurations;

(3) The landing ice accretion defined in appendix C for the landing and go-around configurations; and

(4) The more critical of the takeoff ice and final takeoff ice accretions defined in appendix C for each configuration used in the takeoff phase of flight.

(f) The stall warning margin must be sufficient in both non-icing and icing conditions to allow the pilot to prevent stalling when the pilot starts a recovery maneuver not less than one second after the onset of stall warning in slow-down turns with at least 1.5 g load factor normal to the flight path and airspeed deceleration rates of at least 2 knots per second. When demonstrating compliance with this paragraph for icing conditions, the pilot must perform the recovery maneuver in the same way as for the airplane in non-icing conditions. Compliance with this requirement must be demonstrated in flight with—

(1) The flaps and landing gear in any normal position;

(2) The airplane trimmed for straight flight at a speed of 1.3 V_{SR}; and

(3) The power or thrust necessary to maintain level flight at 1.3 V_{SR}.

(g) Stall warning must also be provided in each abnormal configuration of the high lift devices that is likely to be used in flight following system failures (including all configurations covered by Airplane Flight Manual procedures).

(h) For flight in icing conditions before the ice protection system has been activated and is performing its intended function, the following requirements apply, with the ice accretion defined in appendix C, part II(e):

(1) If activating the ice protection system depends on the pilot seeing a specified ice accretion on a reference surface (not just the first indication of icing), the requirements of this section apply, except for paragraphs (c) and (d) of this section.

(2) For other means of activating the ice protection system, the stall warning margin in straight and turning flight must be sufficient to allow the pilot to prevent stalling without encountering any adverse flight characteristics when the speed is reduced at rates not exceeding one knot per second and the pilot performs the recovery maneuver in the same way as for flight in non-icing conditions.

(i) If stall warning is provided by the same means as for flight in non-icing conditions, the pilot may not start the recovery maneuver earlier than one second after the onset of stall warning.

(ii) If stall warning is provided by a different means than for flight in non-icing conditions, the pilot may not start the recovery maneuver earlier than 3 seconds after the onset of stall warning. Also, compliance must be shown with § 25.203 using the demonstration prescribed by § 25.201, except that the deceleration rates of § 25.201(c)(2) need not be demonstrated.

13. Amend § 25.237 by revising paragraph (a) to read as follows:

§ 25.237 Wind velocities.

(a) For landplanes and amphibians, the following applies:

(1) A 90-degree cross component of wind velocity, demonstrated to be safe for takeoff and landing, must be established for dry runways and must be at least 20 knots or 0.2 V_{SRO}, whichever is greater, except that it need not exceed 25 knots.

(2) The crosswind component for takeoff established without ice accretions is valid in icing conditions.

(3) The landing crosswind component must be established for:

(i) Non-icing conditions, and

(ii) Icing conditions with the landing ice accretion defined in appendix C.

* * * * *

14. Amend § 25.253 by revising paragraph (b), and adding a new paragraph (c) to read as follows:

§ 25.253 High-speed characteristics.

* * * * *

(b) *Maximum speed for stability characteristics.* V_{FC}/M_{FC}. V_{FC}/M_{FC} is the maximum speed at which the requirements of §§ 25.143(g), 25.147(e), 25.175(b)(1), 25.177, and 25.181 must be met with flaps and landing gear retracted. Except as noted in § 25.253(c), V_{FC}/M_{FC} may not be less than a speed midway between V_{MO}/M_{MO} and V_{DF}/M_{DF}, except that for altitudes where Mach number is the limiting factor, M_{FC} need not exceed the Mach number at which effective speed warning occurs.

(c) *Maximum speed for stability characteristics in icing conditions.* The maximum speed for stability characteristics with the ice accretions defined in appendix C, at which the requirements of §§ 25.143(g), 25.147(e), 25.175(b)(1), 25.177, and 25.181 must be met, is the lower of:

(1) 300 knots CAS;

(2) V_{FC}; or

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

15. Amend § 25.773 by revising paragraph (b)(1)(ii) to read as follows:

§ 25.773 Pilot compartment view.

* * * * *

(b) * * *

(1) * * *

(i) * * *

(ii) The icing conditions specified in § 25.1419 if certification for flight in icing conditions is requested.

* * * * *

16. Amend § 25.941 by revising paragraph (c) to read as follows:

§ 25.941 Inlet, engine, and exhaust compatibility.

* * * * *

(c) In showing compliance with paragraph (b) of this section, the pilot strength required may not exceed the limits set forth in § 25.143(d), subject to the conditions set forth in paragraphs (e) and (f) of § 25.143.

17. Amend § 25.1419 by revising the introductory text to read as follows:

§ 25.1419 Ice protection.

If certification for flight in icing conditions is desired, the airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions of appendix C. To establish this—

* * * * *

18. Amend appendix C of part 25 by adding a new part I heading and a new paragraph (c) to part I; and adding a new part II to read as follows:

Appendix C of Part 25

Part I—Atmospheric Icing Conditions

(a) * * *

(c) *Takeoff maximum icing.* The maximum intensity of atmospheric icing conditions for takeoff (takeoff maximum icing) is defined by the cloud liquid water content of 0.35 g/m^3, the mean effective diameter of the cloud droplets of 20 microns, and the ambient air temperature at ground level of minus 9 degrees Celsius (−9°C). The takeoff maximum icing conditions extend from ground level to a height of 1,500 feet above the level of the takeoff surface.

Part II—Airframe Ice Accretions for Showing Compliance With Subpart B

(a) *Ice accretions—General.* Section 25.21(g) states that if certification for flight in icing conditions is desired, the applicable requirements of subpart B must be met in the icing conditions of appendix C. The most critical ice accretion in terms of handling characteristics and performance for each flight phase must be determined, taking into consideration the atmospheric conditions of part I of this appendix, and the flight conditions (for example, configuration, speed, angle-of-attack, and altitude). The following ice accretions must be determined:

(1) *Takeoff ice* is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, occurring between liftoff and 400 feet above the takeoff surface, assuming accretion starts at liftoff in the takeoff maximum icing conditions of part I, paragraph (c) of this appendix.

(2) *Final takeoff* ice is 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 1,500 feet above the takeoff surface, assuming accretion starts at liftoff in the takeoff maximum icing conditions of part I, paragraph (c) of this appendix.

(3) *En route ice* is the critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, during the en route phase.

(4) *Holding ice* is the critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, during the holding flight phase.

(5) *Landing ice* is the critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation following exit from the holding flight phase and transition to the final landing configuration.

(6) *Sandpaper ice* is a thin, rough layer of ice.

(b) In order to reduce the number of ice accretions to be considered when demonstrating compliance with the requirements of § 25.21(g), any of the ice accretions defined in paragraph (a) of this section may be used for any other flight phase if it is shown to be more conservative than the specific ice accretion defined for that flight phase.

(c) The ice accretion that has the most adverse effect on handling characteristics may be used for airplane performance tests provided any difference in performance is conservatively taken into account.

(d) *Ice accretions for the takeoff phase.* For both unprotected and protected parts, the ice accretion may be determined by calculation, assuming the takeoff maximum icing conditions defined in appendix C, and assuming that:

(1) Airfoils, control surfaces and, if applicable, propellers are free from frost, snow, or ice at the start of the takeoff;

(2) The ice accretion starts at liftoff;

(3) The critical ratio of thrust/power-to-weight;

(4) Failure of the critical engine occurs at V_{EF}; and

(5) Crew activation of the ice protection system is in accordance with a normal operating procedure provided in the Airplane Flight Manual, except that after beginning the takeoff roll, it must be assumed that the crew takes no action to activate the ice protection system until the airplane is at least 400 feet above the takeoff surface.

(e) *Ice accretion before the ice protection system has been activated and is performing its intended function.* The ice accretion before the ice protection system has been activated and is performing its intended function is the ice accretion formed on the unprotected and normally protected surfaces before activation and effective operation of the ice protection system in continuous maximum atmospheric icing conditions.

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John J. Hickey,

Director, Aircraft Certification Service.

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