AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

FEDERAL REGISTER

Vol. 79 Tuesday,

No. 213 November 4, 2014

Part III

Department of Transportation

Federal Aviation Administration

14 CFR Parts 25 and 33

Airplane and Engine Certification Requirements in Supercooled Large Drop, Mixed Phase, and Ice Crystal Icing Conditions; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 25 and 33

[Docket No. FAA–2010–0636; Amendment Nos. 25–140 and 33–34]

RIN 2120–AJ34

Airplane and Engine Certification Requirements in Supercooled Large Drop, Mixed Phase, and Ice Crystal Icing Conditions

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: The Federal Aviation Administration is amending the airworthiness standards applicable to certain transport category airplanes certified for flight in icing conditions and the icing airworthiness standards applicable to certain aircraft engines. The regulations will improve safety by addressing supercooled large drop icing conditions for transport category airplanes most affected by these icing conditions; mixed phase and ice crystal conditions for all transport category airplanes; and supercooled large drop, mixed phase, and ice crystal icing conditions for all turbojet, turbofan, and turboprop engines.

DATES: Effective January 5, 2015.

ADDRESSES: For information on where to obtain copies of rulemaking documents and other information related to this final rule, see ''How To Obtain Additional Information'' in the **SUPPLEMENTARY INFORMATION** section of this document.

FOR FURTHER INFORMATION CONTACT: For part 25 technical questions contact Robert Hettman, FAA, Propulsion/Mechanical Systems Branch, ANM–112, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind Avenue SW., Renton, WA 98057–3356; telephone (425) 227–2683; facsimile (425) 227–1320; email *robert.hettman@faa.gov.*

For part 33 technical questions contact John Fisher, FAA, Rulemaking and Policy Branch, ANE–111, Engine and Propeller Directorate Standards Staff, Aircraft Certification Service, 12 New England Executive Park, Burlington, MA 01803; telephone (781) 238–7149; facsimile (781) 238–7199; email *john.fisher@faa.gov.*

For part 25 legal questions contact Douglas Anderson, FAA, Office of the Regional Counsel, ANM–7, Northwest Mountain Region, 1601 Lind Avenue SW., Renton, WA 98057–3356; telephone (425) 227–2166; facsimile (425) 227–1007; email *douglas.anderson@faa.gov.*

For part 33 legal questions contact Vince Bennett, FAA, Office of the Regional Counsel, ANE–007, New England Region, 12 New England Executive Park, Burlington, MA 01803; telephone (781) 238–7044; facsimile (781) 238–7055; email *vincent.bennett@faa.gov.*

SUPPLEMENTARY INFORMATION:

Authority for This Rulemaking

The FAA's authority to issue rules on 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 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; regulations and minimum standards in the interest of safety for inspecting, servicing, and overhauling aircraft; and regulations for other practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority because it prescribes—

- New safety standards for the design and performance of certain transport category airplanes and aircraft engines; and
- New safety requirements necessary for the design, production, and operation of those airplanes, and for other practices, methods, and procedures relating to those airplanes and engines.

Overview of Final Rule

The FAA is adopting this final rule to revise certain regulations in Title 14, Code of Federal Regulations (14 CFR) part 25 (Airworthiness Standards: Transport Category Airplanes) and part 33 (Airworthiness Standards: Aircraft Engines) related to the certification of transport category airplanes and turbine airplane engines in icing conditions. We are also creating the following new regulations: § 25.1324—Angle of attack systems; § 25.1420—Supercooled Large Drop Icing Conditions; Appendix O to Part 25—Supercooled Large Drop Icing Conditions; Appendix C to Part 33 (this is intentionally left blank as a placeholder for potential future rulemaking unrelated to icing); and Appendix D to Part 33 Mixed Phase and Ice Crystal Icing Envelope (Deep Convective Clouds). To improve the safety of transport category airplanes operating in supercooled large drop (SLD), mixed phase, and ice crystal icing conditions, these regulations will:

- Require airplanes most affected by SLD icing conditions to meet certain safety standards in an expanded certification icing environment that includes freezing drizzle and freezing rain. These safety standards include airplane performance and handling qualities requirements.
- Expand the engine and engine installation certification, and some airplane component certification regulations (for example, angle of attack and airspeed indicating systems) to include freezing drizzle, freezing rain, mixed phase, and ice crystal icing conditions.

Summary of the Costs and Benefits of the Final Rule

The benefits and costs are summarized in the table below. As shown in the table, the total estimated benefits exceed the total estimated costs for this final rule.

	2012$		7% Present value	
	Benefit	Cost	Benefit	Cost
Part 33 Engines	Qualitative	$13,936,000	Qualitative	$11,375,927
Large Part 25 Airplanes	$362,319,857	14,126,333	$76,861,295	$11,531,295
Other Part 25 Airplanes	$220,570,582	33,198,788	$50,028,690	$19,385,401
Total	$582,890,439	61,261,121	$126,889,985	$42,292,624

Background

Safety concerns about the adequacy of the icing certification standards were brought to the forefront of public and governmental attention by a 1994 accident in Roselawn, Indiana, involving an Avions de Transport Régional (ATR) ATR 72 series airplane. The National Transportation Safety Board (NTSB), with assistance from ATR, the FAA, the French Direction Général de l'Aviation Civile, Bureau D'Enquetes et D'Analyses, the National Aeronautics and Space Administration (NASA), and others, conducted an extensive investigation of this accident. This investigation determined that freezing drizzle-sized drops created a ridge of ice on the wing's upper surface aft of the deicing boots and forward of the ailerons. The investigation further concluded that this ridge of ice contributed to an uncommanded roll of the airplane. Based on these findings, the NTSB recommended changes to the icing certification requirements.

The atmospheric icing conditions for certification are specified in part 25, appendix C. The atmospheric condition (freezing drizzle) that contributed to the Roselawn accident is outside the icing envelope currently used for certifying transport category airplanes. The term ''icing envelope'' is used in part 25, appendix C, and in this rule to refer to the environmental icing conditions within which the airplane must be shown to be able to safely operate. The term ''transport category airplanes'' is used throughout this rulemaking document to include all airplanes type-certificated to part 25 regulations.

Another atmospheric icing environment outside the current icing envelope is freezing rain. The FAA has not required airplane manufacturers to show that airplanes can operate safely in a freezing drizzle or freezing rain icing environment.

As a result of this accident and consistent with related NTSB recommendations,[1] the FAA tasked the Aviation Rulemaking Advisory Committee (ARAC),[2] through its Ice Protection Harmonization Working Group (IPHWG), to do the following:

- Define an icing environment that includes SLD conditions.
- Consider the need to define a mixed phase icing environment (supercooled liquid and ice crystals).
- Devise requirements to assess the ability of an airplane to either safely operate without restrictions in SLD and mixed phase conditions or safely operate until it can exit these conditions.
- Study the effects icing requirement changes could have on §§ 25.773, *Pilot compartment view;* 25.1323, *Airspeed indicating system;* and 25.1325, *Static pressure systems.*
- Consider the need for a regulation on ice protection for angle of attack probes.

The FAA ultimately determined that the revised icing certification standards should include SLD, mixed phase, and ice crystal icing conditions. This rule is based on ARAC's recommendations to the FAA.

A. Related Actions

ARAC's IPHWG submitted additional icing rulemaking recommendations to the FAA that led to the Part 25 and Part 121 Activation of Ice Protection final rules.[3] For certain airplanes certificated for flight in icing, those rulemaking actions revise the certification and operating rules for flight in icing conditions by requiring either installation of ice detection equipment or changes to the airplane flight manual (AFM) to ensure timely activation of the airframe ice protection system. Although those rulemaking actions address flight in icing conditions, they do not directly impact this final rule.

B. NTSB Recommendations

The NTSB issued NTSB Safety Recommendation Numbers A–96–54 and A–96–56 as a result of the Roselawn accident previously discussed. This rulemaking partially addresses those NTSB recommendations. The FAA is considering separate rulemaking activities associated with revisions to 14 CFR part 23 regulations for small airplanes and 14 CFR part 121 operational regulations to complete the FAA response to these NTSB recommendations. The NTSB recommendations are as follows:

1. A–96–54

Revise the icing criteria published in 14 CFR parts 23 and 25, in light of both recent research into aircraft ice accretion under varying conditions of liquid water content (LWC), drop size distribution, and temperature, and recent developments in both the design and use of aircraft. Also, expand the appendix C icing certification envelope to include freezing drizzle/freezing rain and mixed water/ice crystal conditions, as necessary (A–96–54 supersedes A–81–116 and –118).

2. A–96–56

Revise the icing certification testing regulation to ensure that airplanes are properly tested for all conditions in which they are authorized to operate, or are otherwise shown to be capable of safe flight into such conditions. If safe operations cannot be demonstrated by the manufacturer, operational limitations should be imposed to prohibit flight in such conditions, and flightcrews should be provided with the means to positively determine when they are in icing conditions that exceed the limits for aircraft certification.

C. Summary of the Notice of Proposed Rulemaking

The notice of proposed rulemaking (NPRM), Notice No. 10–10, published in the **Federal Register** on June 29, 2010 (75 FR 37311), is the basis for this final rule. After receiving several requests to extend the public comment period, the FAA extended the comment period by 30 days to September 29, 2010, with a document published in the **Federal Register** on August 16, 2010 (75 FR 49865).

To improve the safety of transport category airplanes operating in SLD, mixed phase, and ice crystal icing conditions, the FAA proposed new regulations in the NPRM to:

- Expand the certification icing environment to include freezing drizzle and freezing rain environments.
- Require airplanes most affected by SLD icing conditions to meet certain safety standards in the expanded certification icing environment, including airplane performance and handling qualities requirements.
- Expand the engine and engine installation certification regulations, and some airplane component certification regulations (for example, angle of attack and airspeed indicating systems), to include freezing rain environments, freezing drizzle environments, mixed phase, and ice crystal icing conditions. For certain regulations, we proposed using a subset of these icing conditions.

D. General Overview of Comments

The FAA received comments from 31 commenters during the public comment period: Five private citizens, the Aerospace Industries Association (AIA), Airbus Industrie (Airbus), AirDat LLC, the Airline Pilots Association (ALPA),

[1] NTSB Safety Recommendations A–96–54 and A–96–56 are available in the rule Docket No. FAA–2010–0636 and on the Internet at *http://www.ntsb.gov/doclib/recletters/1996/A96_48_69.pdf.*

[2] Published in the **Federal Register** on December 8, 1997 (62 FR 64621). *http://www.gpo.gov/fdsys/pkg/FR-1997-12-08/pdf/97-32034.pdf.*

[3] *Part 25 Activation of Ice Protection,* Docket No. FAA–2007–27654, published in the **Federal Register** on August 3, 2009 (74 FR 38328). *Part 121 Activation of Ice Protection,* Docket No. FAA–2009–0675, published in the **Federal Register** on August 22, 2011 (76 FR 52241).

American Kestrel Company, LLC, (AKC), The Boeing Company, Bombardier, Cessna, Dassault Aviation, Embraer, Eurocopter, the European Aviation Safety Agency (EASA), Foster Technology, LLC, the General Aviation Manufacturers Association (GAMA), GE Aviation, Gulfstream, Goodrich Sensors and Integrated Systems (GSIS), Honeywell Engines, the National Research Council (NRC), the NTSB, Pratt & Whitney Canada, the Regional Airline Association (RAA), the Swiss Federal Office of Civil Aviation (FOCA), Snecma, Transport Canada Civil Aviation (TCCA), and Turbomeca. Each commenter submitted multiple comments.

Twelve commenters stated specific support for the rulemaking, recognized the efforts made by the ARAC working group, and suggested specific changes intended to clarify the regulations or to clarify the intent. The NTSB and two private citizens were disappointed that the rulemaking took so long.

Fourteen commenters stated neither support nor opposition, but suggested specific changes or identified areas for clarification.

Two commenters, a rotorcraft manufacturer and a rotorcraft engine manufacturer, opposed the proposed changes to §§ 33.68 and 33.77. These commenters suggested the FAA make provisions to exclude rotorcraft from the revised regulations.

Two private citizens expressed concern for the data and methods used to define the SLD conditions proposed in part 25, appendix O.

One commenter suggested that the FAA should begin a certification process toward use of a new methodology for detecting ice over a pitot inlet, for which the commenter has filed a provisional patent.

The FAA received additional comments in a letter dated June 21, 2011, signed by four private citizens. The letter provided additional explanation for previously submitted comments. The FAA also considered this additional information while drafting this final rule.

The FAA made changes to the final rule in response to the public comments. Summaries of the issues raised by the public comments and FAA responses, including explanations of changes, are provided below. The full text of each commenter's submission is available in the docket for this rulemaking.

Discussion of Public Comments and Final Rule

Proposed Appendix O to Part 25

In the NPRM, the FAA proposed to expand the existing icing conditions identified in appendix C of part 25 to include new SLD icing conditions defined in a new appendix O. The FAA made changes to appendix O as a result of comments received, but the general format remains unchanged. Appendix O is structured like part 25, appendix C, with part I defining icing conditions and part II defining airframe ice accretions for showing compliance with the airplane performance and handling qualities requirements of part 25, subpart B.

Three private citizens provided comments related to the flight data collection approach used to acquire information about SLDs, the flight data used, and the analysis approach to generate the SLD engineering standards in part 25, appendix O. We will address these three commenters as a group.

One concern was with the methods related to collecting and evaluating SLD icing conditions. One commenter stated that the research aircraft were well equipped to document the environment; however, both research aircraft had serious deficiencies regarding their on-board ability to document aircraft performance degradation from icing.

Two commenters were concerned that only the database jointly created by Environment Canada and NASA was used to define the SLD icing conditions. Another commenter was concerned about the statistical significance of the data collected and did not think there was enough flight test evidence collected to provide the same level of probability established for part 25, appendix C, icing conditions. Two commenters stated that the flight test campaign failed to relate their data collection results to previously published results, such as those published by the University of Wyoming. Specifically, the commenters noted that appendix O does not contain data for a LWC greater than 0.45 grams per cubic meter.

One commenter also stated that other published analysis methods for an SLD encounter, such as the University of Wyoming LWC/drop size technique, result in the most adverse icing conditions and are not contained within appendix O. The commenter also noted that a clear distinction does not exist between the icing conditions defined in part 25, appendix C, and the conditions defined in part 25, appendix O. This uncertainty would leave the pilot with the responsibility of making a scientific finding of which icing conditions the airplane was in, unless on-board droplet size and LWC measurement means and droplet data processing are provided.

Regarding the flight research project's lack of on-board ability to document aircraft performance degradation from icing, we agree. However, obtaining measurements of aircraft performance within icing conditions was the lowest priority objective of the flight research project. The primary objectives of the test were to identify icing conditions beyond those covered in appendix C of part 25, and to identify a method for presenting the data in a way that could be used as an engineering standard. Specific aircraft performance and handling degradations in icing conditions are unique for each aircraft design. Performance degradation and handling qualities criteria for appendix C and appendix O icing encounters will need to be determined by the design approval holder for each aircraft design based on the applicable regulations, guidance materials, and testing as necessary to demonstrate compliance. This final rule specifies the expanded environmental icing conditions for consideration during the certification process as well as the performance and handling qualities that must be demonstrated.

Regarding the sufficiency of the flight test data to form a statistically reliable database, we disagree. In developing appendix O, we used all historically available flight research data on SLD, not just the Environment Canada-NASA flight test data. This broad collection of data is statistically similar to the data that was used to develop appendix C.

Regarding the comments about our proposed definition of SLD in appendix O, we also disagree. The University of Wyoming data were included in the FAA master database on SLD icing conditions. However, these data were not used to support the final determinations for the LWC values for the appendix O engineering standards. The University of Wyoming aircraft was not equipped with two-dimensional optical array probes, which were deemed essential by the IPHWG. Without the probes, it was not possible to distinguish between cloud drops and ice particles. Therefore, the University of Wyoming cloud data were not considered usable for supporting the analysis of SLD LWC/drop size properties for appendix O. As a result, the Environment Canada-NASA database was used to determine the engineering standards because of the quality of the data contained therein and the analysis methods used in that database. Both the quality of the data and the analysis method used by the database ensured the accuracy of the definition for appendix O icing conditions.

Regarding the comment that the University of Wyoming LWC/drop size technique results in the most adverse icing conditions and are not contained within appendix O, we disagree. That analysis technique suggests that one type of icing condition would be severe for all airplanes, regardless of the type of ice protection system used, or the extent of the protection. Appendix O contains a variety of icing conditions, not just those deemed most severe using the University of Wyoming analysis technique.

In response to other comments, figures 1 and 4 of appendix O have been revised in this final rule to reflect the LWC proposed by the IPHWG. As a result, freezing drizzle conditions with a median volume diameter (MVD) greater than 40 microns fall within the adverse region that would be identified using the University of Wyoming LWC/drop size technique. No changes to appendix O were made as a result of these comments.

With regard to the comment suggesting that the pilot will have to make a scientific finding to determine which icing conditions the airplane is in, we disagree. For those types of airplanes most vulnerable to SLD icing conditions, the level of operations in SLD icing conditions for which the airplane is approved will be determined during the airplane certification process in accordance with § 25.1420. If approval is requested for operations in a portion of the icing conditions defined in appendix O, then the airplane manufacturer will have to show that the pilot can determine if the operational envelope for which the airplane is certified has been exceeded as required by § 25.1420(a)(2). Since part of the certification will be evaluating the means used to distinguish when the airplane is in icing conditions outside the certified envelope, the pilot will not be faced with the ambiguity of trying to determine the distribution of water drops in the environment in which he or she is flying.

Several commenters said that proposed figures 1, 4, and 7 in appendix O of the NPRM were different than what was proposed by the IPHWG, and that the FAA did not provide an explanation for those differences. The commenters also noted that the higher LWC contained in the figures proposed in the NPRM could have a significant impact on an applicant's design. GSIS specifically noted that the higher water content defined in appendix O will have the effect of greatly increasing power requirements for electro-thermal deicing systems. Several commenters also suggested that figures 1, 3, 4, and 6 of appendix O would be easier to use if the corner data points were defined in the figures.

We agree. We reviewed the figures proposed in the NPRM and the data used by the IPHWG to generate the figures. We revised figures 1 and 4 to reflect the lower water content values proposed by the IPHWG, but the water content in appendix O is still higher than within appendix C at the same temperature. The higher water content may increase the power requirements for some electro-thermal deicing system designs, but not to the extent that may have been necessary with the water contents proposed in the NPRM. The environmental conditions defined in appendix O are valid conditions that will need to be considered for applicable future designs. Our review of the data used to generate the scaling factor curve in figure 7 indicates that the figure 7 proposed by the IPHWG in the task 2 working group report was incorrect;[4] figure 7 in the NPRM was correct. Therefore, figure 7 in this final rule remains as proposed in the NPRM. Figures 1, 3, 4, and 6 of appendix O in this final rule have been revised to identify the corner data points for clarity.

GSIS asked if there is a scientific basis for applying the horizontal extent of 17.4 nautical miles. GSIS also noted that the same MVD, temperature, and LWC at altitude exist in both appendix O and appendix C and asked the FAA to clearly define the mass distribution boundary between appendix O and appendix C.

Our application of the 17.4 nautical mile horizontal extent in appendix O was made on a practical basis and not on a purely scientific basis; it was selected for consistency with the appendix C continuous maximum icing conditions with which designers are already familiar. We are unaware of any scientific reasons for not applying the 17.4 nautical mile horizontal extent in this manner.

The LWC values in appendix O are based on an analysis of the data from the jointly created Environment Canada-NASA flight research SLD database, report DOT/FAA/AR–09/10.[5] Figure 11 of that report shows a plot of temperature versus LWC for appendix O freezing drizzle environments that is valid for the reference distance of 17.4 nautical miles (32.2 km). Appendix C and appendix O define environmental conditions that overlap one another as the conditions transition from appendix C to appendix O. Therefore, there is not a clear mass distribution boundary that can be defined.

One commenter, a private citizen, noted that the NPRM did not identify the vertical extent for part 25, appendix O, figure 6. We disagree. The pressure altitude range and vertical extent for freezing rain were provided in appendix O, part I, paragraph (b) in the NPRM located under figure 3. We clarified appendix O, part I, by moving all of the general text describing the meteorological parameters, including vertical extent, ahead of the figures.

One commenter suggested that the icing conditions in appendix O should be revised to reflect water drop distribution as a function of mean effective diameter (MED) as opposed to MVD. We do not agree. MED is the term used in part 25, appendix C. Examination of National Advisory Committee for Aeronautics (NACA) references[6] shows that MED is the same as MVD if certain assumptions are made about the drop distribution, namely that it is one of the Langmuir distributions. MVD, as the more general term, is applicable to any drop distribution. Since the drop distribution described in appendix O does not follow a Langmuir distribution, MVD is more appropriate. We did not change the final rule or appendix O as a result of this comment.

A private citizen commented that appendix O should define a time to use for delayed recognition of entry into icing conditions and the time to exit icing conditions. We do not agree. The responsibility for proposing delayed recognition times, delayed ice protection system activation times, or times required to exit icing conditions, based on unique operational procedures or performance characteristics of the ice protection system, rests with the applicant. We did not change the rule based on this comment.

Boeing suggested a change to appendix O, part I, paragraph (c), to add an equation to determine the LWC for

[4] The data used to complete the IPHWG report is detailed in report DOT/FAA/AR–09/10, *Data and Analysis for the Development of an Engineering Standard for Supercooled Large Drop Conditions,* dated March 2009. A copy of the report is available in the rule Docket No. FAA–2010–0636. The data used for figure 7 are described on pages 34–39 of that report.

[5] A copy of the report is in the rule Docket No. FAA–2010–0636.

[6] National Advisory Committee for Aeronautics Technical Note 2738, *A Probability Analysis of the Factors Conducive to Aircraft Icing in the United States,* by William Lewis and Norman R. Bergrun, July 1952.

horizontal distances other than 17.4 nautical miles.

We agree that adding such an equation could be beneficial. The equation proposed by Boeing, however, expressed horizontal distance in kilometers, which would be inconsistent with other figures in appendix O. Instead of the equation proposed by Boeing, we added to appendix O, part I, paragraph (c), a similar equation that uses units of nautical miles.

Several commenters noted that appendix O, part II, paragraph (b)(5)(ii), in the NPRM made reference to §§ 25.143(k) and 25.207(k). However, §§ 25.143(k) and 25.207(k) do not exist in the current part 25 and were not added by the NPRM.

We agree. The references to those sections were inadvertently included in the NPRM. We revised appendix O to delete the statement referencing §§ 25.143(k) and 25.207(k).

Airbus noted that part II, paragraph (c)(7)(v) of appendix O states that crew activation of the ice protection system is in accordance with a normal operating procedure provided in the AFM, except that after beginning the takeoff roll, 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. Airbus commented that this appears to be a direct cut and paste from the appendix C regulations and recommended removing the sentence. Airbus claimed that while this is perhaps understandable for appendix C icing conditions, it would seem reasonable to expect the crew to activate the wing anti-ice system (WAIS) prior to takeoff if there are SLD icing conditions within 400 feet of the runway, whether the AFM specifically states that it is required or not.

We do not agree. The rule addresses flightcrew actions occurring after beginning the takeoff roll, while Airbus' comment refers to actions that the flightcrew would take before beginning the takeoff. Nevertheless, the FAA does not expect flightcrews to be aware of all SLD icing conditions that may exist up to a height of 400 feet above the takeoff surface, nor do we agree that it would be reasonable to expect the flightcrew to activate the WAIS prior to takeoff if there was no procedure telling them to do so. We did not change the rule based on this comment.

Embraer commented that the last sentence in appendix O, part II, paragraph (b)(2)(ii), which proposed to define the holding ice conditions in part 25, appendix O, part II, paragraph (b)(2), should be applicable to the whole of paragraph (b)(2), and not just to the transit time through one appendix O cloud and one appendix C cloud specified in paragraph (b)(2)(ii). Embraer commented that it would be clearer to describe the total holding time in a separate paragraph (b)(2)(iii) that says: ''The total exposure to the icing conditions need not exceed 45 minutes.'' We agree, and changed appendix O, part II, paragraph (b)(2), to indicate that the total exposure time for holding ice does not need to exceed 45 minutes.

Availability of Engineering Tools To Show Compliance With the Rule

Several commenters stated that available engineering tools (icing wind tunnels and tankers, ice accretion prediction codes, and other analysis methods) are inadequate for showing compliance with the new rule. Bombardier commented that without validated tools, it is not practical to implement the requirements proposed in the NPRM. Bombardier believed that efforts should be focused on implementing incremental regulatory changes in parallel with the appropriate technological developments to meet that regulatory change.

Boeing commented similarly, stating that the FAA and NASA had developed a plan several years ago to align the timing of the new regulations with the availability of validated engineering tools and test capabilities for SLD conditions. Boeing added that the tools and test facilities necessary to effectively demonstrate compliance with the regulations are not available, and that this lack of availability will be particularly problematic for applicants desiring to operate within appendix O conditions. Boeing noted that the current situation will require applicants to either use highly conservative approaches, build new icing wind tunnel facilities, or expend great efforts to conduct extensive flight testing in search of a meteorological condition, which occurs very infrequently. Boeing said that this was not the approach anticipated by industry, and that it will impose a severe burden on many applicants beyond that established in the economic evaluation of the proposed regulation, without adding any commensurate safety benefit.

AKC also commented that current test facilities are limited in their ability to produce freezing drizzle, in particular drop distributions greater than 40 microns MVD. The water drop distribution curves provided in appendix O are not produced by any facility known to AKC, and there are no facilities that produce freezing rain in a fashion that duplicates either the flight or ground test environment.

The NRC of Canada's comments reflected concerns about how the water drop distribution curves in appendix O are to be used. Further, a private citizen commented that the droplet diameters for appendix O conditions can only be reproduced in a few icing wind tunnels.

We do not agree that available engineering tools (icing wind tunnels and tankers, ice accretion prediction codes, and other analysis methods) are inadequate for showing compliance with the new rule. We recognize that the current engineering tools available to show compliance with the new SLD rule have not been validated in every aspect, and also have some limitations. We also recognize that for freezing rain, few validated engineering tools are available. However, methods are available to simulate freezing drizzle. Further, we recognize that relying upon available simulation methods, combined with engineering judgment, will be required for finding compliance with the appendix O requirements of part 25, especially for freezing rain conditions.

After reviewing the current state of available compliance methods and engineering tools, the FAA has determined that there is sufficient capability for applicants to effectively demonstrate compliance with this final rule. The IPHWG evaluated the current capabilities of these tools in 2008–2009 during a review requested by industry members through ARAC. The IPHWG evaluation of SLD engineering tools, which proposed methods of compliance based on the current state of the available engineering tools, supports the FAA conclusion. The FAA considered estimates provided by industry and has made adjustments to the proposed economic evaluation, which is incorporated in the economic evaluation for this final rule. This adjustment increases the cost for complying with the requirements of this final rule; however, this final rule remains cost beneficial. A summary of the final regulatory evaluation is provided in the ''Regulatory Notices and Analyses'' section of this final rule and the complete document is included in the public docket.

As to freezing drizzle, the current icing wind tunnel test capabilities for SLD icing conditions have been demonstrated. However, we recognize that some limitations exist: Icing wind tunnel spray systems evaluated during the IPHWG's review do not support bi-modal mass distributions (mass ''peaks'' for two different drop sizes) provided in appendix O and do not produce realistic freezing rain simulations for the majority of those conditions. NASA examined alternate spray methods to simulate portions of a bi-modal spray using spray sequencing techniques to approximate drop distributions found in natural conditions (reference: American Institute of Aeronautics and Astronautics report AIAA 2005–76, *Simulation of a Bimodal Large Droplet Icing Cloud in the NASA Icing Research Tunnel*[7]). NASA demonstrated the water spray sequencing technique for an airfoil with unprotected surfaces and the results showed rougher ice accretion textures than appendix C ice shapes.

Experience indicates that SLD icing conditions generally result in rougher ice accretion textures. NASA has also developed preliminary scaling methods for SLD test applications and has developed large droplet algorithm improvements to its ice accretion prediction code by adding SLD subroutines. Other ice accretion code developers have incorporated SLD capabilities in their respective computational tools. A number of icing wind tunnel owners have tested SLD icing conditions in their facilities and are capable of performing tests for at least a portion of the appendix O environments.

Regarding flight testing, § 25.1420 requires that applicants provide analysis to establish that ice protection for the various airplane components is adequate, taking into account the various operational configurations. Section 25.1420 also describes flight testing in natural or simulated icing conditions, as necessary, to support the analysis. The IPHWG acknowledged the difficulties in flight testing in natural SLD, and agreed it would not be specifically required under § 25.1420. We concur, and have left flight testing as an option in the regulation. Until the engineering tools become more mature, flight tests in natural appendix O icing conditions may be necessary to achieve certification for unrestricted flight in appendix O conditions in accordance with § 25.1420(a)(3).

Proposed Revisions to § 33.68 Should Not Apply to Engines Installed on Rotorcraft

Eurocopter and Turbomeca noted the proposed part 33 changes would apply to all turbine engines, including turboshaft engines intended for installation in rotorcraft. The proposed revision to § 33.68 would require all turbine engines to be capable of operating in the extended icing conditions defined in part 25, appendix O. However, the IPHWG task 2 report and the NPRM only addressed airplane accidents and incidents; it did not include rotorcraft. Eurocopter and Turbomeca proposed provisions to exclude rotorcraft from the new engine requirements. The FAA did not receive any comments providing specific support for the proposed applicability to rotorcraft.

We agree. The IPHWG did not review rotorcraft accidents or incidents in icing conditions and did not propose rulemaking associated with rotorcraft. As a result, we revised the proposed § 33.68 to separate the icing requirements for turboshaft engines used for rotorcraft from turbojet, turbofan, and turboprop engines used for airplanes. The icing requirements pertaining to turboshaft engines are unchanged and require that turboshaft engines operate safely throughout the icing conditions defined in part 29, appendix C. Section 33.68 now requires that turbojet, turbofan, and turboprop engines not installed on rotorcraft operate safely throughout the icing conditions defined in part 25, appendix C, the SLD conditions defined in part 25, appendix O, and the mixed phase and ice crystal conditions defined in part 33, appendix D.

Applicability of Proposed § 25.1420

In the NPRM, the FAA proposed to add a new § 25.1420. Proposed § 25.1420 would have required specific airplanes certified for flight in icing conditions to be capable of either: (1) Operating safely within the new SLD icing conditions defined in part 25, appendix O; (2) operating safely in a portion of the new appendix O conditions, with the capability to detect when conditions beyond those used for certification have been encountered, and then safely exit all icing conditions; or (3) have a means to detect when appendix O icing conditions are encountered, and be capable of safely exiting all icing conditions. The FAA proposed to limit the applicability of § 25.1420 to airplanes that have a maximum takeoff weight (MTOW) of less than 60,000 pounds, or airplanes equipped with reversible flight controls regardless of MTOW.

The applicability of § 25.1420 was discussed within the IPHWG and consensus could not be reached. A discussion of this issue was provided in the NPRM under the heading ''Differences from the ARAC Recommendations.'' Bombardier, ALPA, EASA, Goodrich, Gulfstream, the NTSB, and the TCCA provided comments to the NPRM that supported the majority position of the IPHWG, questioning the technical justification used to exclude airplanes with a MTOW of 60,000 pounds or greater. Airbus, AIA, Boeing, and GAMA provided comments in response to the NPRM to support the proposed applicability based on MTOW because airplanes with a MTOW of 60,000 pounds or greater have not previously experienced accidents or incidents associated with flight in SLD. Embraer and Pratt & Whitney Canada comments to the NPRM specifically noted support for AIA's position.

A review of the IPHWG analysis indicates that airplanes with a MTOW of 60,000 pounds or greater have not experienced accidents or incidents associated with flight in SLD. The FAA originally considered including all new airplanes in the applicability for § 25.1420, regardless of MTOW; however, the projected costs of extending the rule to include airplanes with a MTOW of 60,000 pounds or greater exceeded the projected benefits due to the positive in-service history (i.e., lack of accidents) of these airplanes in SLD.

The commenters did not present any new data or information that was not discussed within the IPHWG, or discussed within the NPRM. The commenters that opposed limiting the applicability of the rule suggested that lift and control surface size, or wing chord length, are important parameters affecting sensitivity to a given ice accretion. They based their opposition on airplane weight, in part, because the ratio of wing and control surface sizes to airplane weight varies between airplane designs.

We agree that design features such as control surface size and wing chord length are important parameters, which can affect the sensitivity of a wing to the icing conditions described in part 25, appendix O. As proposed in the NPRM, in order to issue a rule with estimated costs commensurate with the estimated benefits, the applicability of § 25.1420 is limited based on airplane weight due to the positive service histories of certified airplanes.

If future designs for larger airplanes contain novel or unusual design features that affect this successful in-service history, and those design features make the airplane more susceptible to the effects of flight in SLD icing conditions, the FAA can issue special conditions to provide adequate safety standards. The FAA issues special conditions in accordance with § 21.16. No changes have been made to the applicability of § 25.1420 as a result of these comments.

[7] A copy of this report is available in the rule Docket No. FAA–2010–0636.

Clarification of Definitions

Embraer noted that § 25.1420(b) uses the terms ''simulated icing tests'' and ''simulated ice shapes'' in various subparagraphs. Embraer suggested that subparagraphs § 25.1420(b)(1) and (b)(2) use the phrase ''artificial ice'' as defined in Advisory Circular (AC) 25–28, *Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions,* instead of ''simulated icing tests.''

We do not agree. Section 25.1420(b)(1) and (b)(2) describe test methods, not the resulting ice shapes. The terminology ''simulated icing tests'' is used in § 25.1420 consistently with § 25.1419. We added definitions for ''Simulated Ice Shape'' and ''Simulated Icing Test'' to § 25.1420 that are consistent with previously issued guidance.

AIA, Boeing, and GAMA suggested a clarification to the definition of ''reversible flight controls.'' AIA and GAMA suggested that the addition of servo tab inputs in the examples provides a more complete and accurate description.

We agree and have clarified the definition of ''reversible flight controls'' to include the example of servo tab inputs. In addition, since the definition of ''reversible flight controls'' is necessary to determine the applicability of § 25.1420, we added the definition to § 25.1420.

Applicability of Proposed Appendix O Icing Conditions to Part 23 Airplanes and Previously Certified Part 25 Airplanes

The NTSB and a private citizen commented that the icing conditions proposed in appendix O should be applicable to part 23 airplanes because they are the type of airplanes most affected by flight into icing conditions. The NTSB also stated that the proposed rule should be expanded beyond newly certified airplanes to include all deice boot-equipped airplanes currently in service that are certified for flight in icing conditions (reference NTSB Safety Recommendation A–07–16).[8] The NTSB pointed out SLD is an atmospheric condition that can create dangerous flight conditions for both the current fleet of aircraft and newly certified aircraft.

Regarding the applicability of proposed appendix O to part 23 airplanes, we disagree with adding part 23 airplanes to the applicability, as that is beyond the scope of this rulemaking. However, we chartered an Aviation Rulemaking Committee (ARC) to review the IPHWG's rulemaking recommendations for part 25 and to make similar recommendations for part 23. The ARC transmitted a report detailing part 23 rulemaking recommendations to the FAA in a letter dated February 19, 2011, and provided supplemental recommendations in a letter dated April 27, 2011. The ARC transmitted its recommendations for a final task in early 2012. We are studying these recommendations and may pursue additional rulemaking for part 23 airplanes.

We agree that severe icing conditions, including SLD, can create dangerous flight conditions for both current and future airplanes. However, we do not agree that the part 25 and part 33 rule changes discussed in this amendment should apply to existing airplanes. Such a retroactive application would, in effect, be changing the certification basis of operational airplanes to correct an unsafe condition, something generally done by airworthiness directive (AD). To address the unsafe condition, we have already issued ADs to mandate procedures to activate the ice protection equipment at the first sign of ice accretion, and to incorporate procedures into the AFM so the flightcrew can identify when they are in severe icing conditions that exceed certificated limitations, and safely exit.

New airworthiness standards are not intended to correct an unsafe condition; rather, they are intended to improve the level of safety for new airplane designs. In the context of SLD, we are considering operational rules to mandate certain elements of the airworthiness standards adopted in this rulemaking for previously certified airplanes. However, those requirements are beyond the scope of this rulemaking and require separate rulemaking action.

Applicability of Part 33, Appendix D, to § 25.1093, Induction System Icing Protection, and § 33.68, Induction System Icing

The NTSB supported changes to §§ 33.68 and 33.77, noting that since we issued an icing-related AD for the Beechjet 400A no additional reports of unsafe icing conditions on that airplane have been noted. The FAA infers that the NTSB was referring to AD 2006–21–02.[9] That AD was issued following reports of dual engine flameouts in high altitude icing conditions believed to include ice crystals. AIA, Airbus, Boeing, and GAMA supported the addition of mixed phase and ice crystal conditions, such as those defined in part 33, appendix D.

Honeywell commented that the current lack of and/or immature state of engine test facilities to demonstrate compliance to part 33, appendix D, could result in a significant increase in an applicant's activities to show compliance because of the additional flight testing required to locate the ice crystal conditions. Honeywell also noted that flying in actual ice crystal conditions would put the flightcrew at considerable risk. Honeywell recommended that appendix D be removed until test facilities have developed the capabilities to run tests for ice crystal conditions. Honeywell also suggested that the FAA make research funds available to facilities to develop this capability.

We agree, in part. We agree that only limited capability exists for testing engines in ice crystal conditions. We also agree that flightcrews unnecessarily operating in icing conditions puts them at risk. We do not agree, however, that appendix D should be removed until test facilities develop the capabilities to run tests for ice crystal conditions, or that FAA make funds available for research to develop these capabilities. Section 33.68(e) allows for certification demonstration by test, analysis, or combination of the two. Consistent with ARAC Engine Harmonization Working Group (EHWG) recommendations, until ice crystal tools and test techniques have been developed and validated, the engine manufacturer may use a comparative analysis to specific field events. This analysis should show that the new engine cycle or design feature, or both, would result in acceptable engine operation when operating in the ice crystal environment defined in appendix D to part 33. This comparative analysis should also take into account both suspected susceptible design features, as well as mitigating design features. We did not change the rule based on this comment.

GSIS suggested that provisions be made for a detect-and-exit strategy for part 33, appendix D, conditions; similar to what was proposed in the NPRM for part 25, appendix O, conditions.

We disagree. We do not believe part 33, appendix D, conditions can be detected with enough time to exit before damage occurs. Therefore, a detect-and-

[8] NTSB Safety Recommendation A–07–16 is available in the rule Docket No. FAA–2010–0636 and on the Internet at *http://www.ntsb.gov/doclib/recletters/2007/A07_12_17.pdf.*

[9] AD 2006–21–02, Docket No. FAA–2006–26004, published in the **Federal Register** on October 10, 2006 (71 FR 29363), is applicable to Raytheon (Beech) Model 400, 400A, and 400T series airplanes; and Raytheon (Mitsubishi) Model MU–300 airplanes.

exit strategy for part 33, appendix D, conditions is inappropriate. As proposed in the NPRM, the mixed phase and ice crystal icing conditions defined in part 33, appendix D, have been added to §§ 25.1093(b)(1) and 33.68(a).

Applicability of Proposed Appendix O to § 25.1093, Induction System Icing Protection, and § 33.68, Induction System Icing

AIA, Airbus, Boeing, and GAMA provided comments that there are no known events that support a safety concern due to engine induction system icing in SLD aloft. In particular, the EHWG evaluated known icing-related engine events since 1988 and found no events in SLD aloft. The EHWG credited this result to the current rigorous compliance to part 25, appendix C, conditions for engines. The commenters believe that the safety of these systems for flight in appendix O conditions has already been proven by service history. The commenters state that continuing to certify future systems to the requirements for appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in appendix O conditions, should be acceptable assurance of the safety of future designs. The commenters suggested that consideration of the icing conditions defined in appendix O be removed from § 25.1093.

We agree that there are no known events that support a safety concern due to engine induction system icing in SLD aloft. However, there have been reports of engine fan damage or high vibration while operating in SLD icing conditions. The ARAC database on engine events contains 231 icing events reported by engine manufacturers from approximately 1988 through 2003, and includes part 25, appendix C; part 25, appendix O; and part 33, appendix D events. Although the intent of the event database was to focus on icing events outside of appendix C, there are several appendix C events included in this database. The event database does not include any accidents.

The EHWG identified 46 part 25, appendix O (SLD) events. All events occurred on the ground and resulted in fan damage and/or high vibrations so a precise effect on the safety of these events was not discernible.

Additionally, the EHWG identified nine additional events that it thought might have been related to operations in SLD icing conditions: Four were in-flight and all nine were on tail mounted engine configurations. Again, the events resulted in fan damage and/or high vibrations, with indeterminable power loss. Although these nine events are of concern, the EHWG did not judge them to be safety significant.

An additional 14 in-flight events were not clearly identifiable as SLD events but were described as heavy icing below 22,000 feet and resulted in fan damage and/or high vibrations. These events did not clearly fall within conditions defined in either appendix C or appendix O. However, the general description of the icing conditions and engine damage is consistent with reports of engine damage that occurred within the icing conditions defined in appendix O, so those might have been SLD events.

After reviewing the data, the EHWG clearly identified SLD as a threat for engine damage during ground operations. Furthermore, the EHWG could not rule out SLD as a potential in-flight safety threat, and decided to include it as part of its recommendations to the FAA. As proposed in the NPRM, the part 25, appendix O, SLD icing conditions have been added to § 33.68. Also, as proposed in the NPRM, § 33.77 contains requirements to demonstrate engine capability to ingest the applicable minimum ice slab defined in Table 1 of § 33.77. The ice slab sizes defined in Table 1 of § 33.77 are a function of the engine inlet diameter. Turbojet, turbofan, and turboprop engine manufacturers must demonstrate, in part, that the engine will continue to operate throughout its power range in the icing conditions defined in part 25, appendix O, and following ingestion of an ice slab that is a function of the engine inlet diameter. The changes to the requirements in §§ 33.68 and 33.77 are intended to improve the level of safety for turbojet, turbofan, and turboprop engines used on transport category airplanes in icing conditions, in part because of reports of engine damage or high engine vibrations while operating in SLD conditions.

We agree large airplanes that have likely encountered appendix O conditions have had a successful in-service history with no clearly identifiable safety significant events. After considering the comments received, we revised § 25.1093(b), compared to what was proposed in the NPRM, so consideration of the icing conditions described in appendix O does not apply to airplanes with a MTOW equal to or greater than 60,000 pounds. As proposed in the NPRM, the applicability of the icing conditions described in part 25, appendix C; part 33, appendix D; and falling and blowing snow remain applicable to all turbine engine installations on transport category airplanes. In addition, the engine requirements in §§ 33.68 and 33.77 for operation in all icing conditions still apply to engines installed on part 25 airplanes regardless of the airplanes' MTOW. The applicability of appendix O conditions in § 25.1093(b) as a function of airplane weight is consistent with the revised applicability of § 25.1420, which establishes minimum airworthiness standards for detection and safe operation in appendix O conditions. Airplanes that have been susceptible to performance issues while operating in SLD icing conditions have been smaller airplanes with a MTOW less than 60,000 pounds.

Section 25.1093(b) was revised to provide relief for larger airplanes because of the successful in-service history of existing larger airplane designs and larger airplane engine inlet designs. As previously discussed, the changes to the requirements in §§ 33.68 and 33.77 are intended to improve the level of safety for turbine engines used on all airplanes, including large airplanes, while operating in SLD conditions. If future designs for larger airplanes contain novel or unusual design features that affect this successful in-service history, and those design features make the airplane more susceptible to the effects of flight in SLD icing conditions, the FAA can issue special conditions to provide adequate safety standards.

Boeing, AIA, and GAMA also provided comments on the results of an SLD analysis, including the use of the NASA Lewis Ice Accretion Program, commonly referred to as LEWICE. The analysis yielded overly conservative accreted ice mass calculations resulting in large amounts of ice on the radome. The results from this analysis indicated to Boeing that radome ice shedding would be a concern, and it would require ice protection on the currently unprotected radome surfaces to reduce ice build-up to acceptable limits. The weight increase for radome ice protection equipment would result in increased fuel burn and increased operational costs that were not included in the IPHWG economic analysis. Boeing also stated that most large airplanes are operating without restrictions today and are safely encountering SLD conditions.

Analytical methods used by Boeing to determine SLD ice accretions on radomes show considerably higher ice mass accretions than either past calculations or past experience has indicated for other icing conditions. These analyses were never presented to the IPHWG and details were not included with Boeing's comments to support the FAA's evaluation of Boeing's methods. As previously discussed, we revised § 25.1093(b) compared to what was proposed in the NPRM. For the purposes of compliance with § 25.1093(b), the icing conditions defined in appendix O are not applicable to airplanes with a MTOW equal to or greater than 60,000 pounds. To show compliance with § 25.1093(b), analysis may be used for the radome as a potential airframe ice source. For compliance with § 25.1093(b), applicants may use qualitative analysis supported by similarity to a previous design with a successful service history to show that ice accretions ingested into the engine from the new airplane design will be less than the ice slab size presented in § 33.77 Table 1, ''Minimum Ice Slab Dimensions Based on Engine Inlet Size.''

Applicability of Proposed Appendix O to § 25.773, Pilot Compartment View

AIA, Airbus, Boeing, and GAMA commented that there are no known events that support a safety concern due to windshield icing in SLD aloft. The commenters state the safety of these systems for flight in appendix O conditions has been proven by service history. They believe that continuing to certify future systems to the requirements for appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in appendix O conditions, should be an acceptable assurance of the safety of future designs. One commenter, an individual, commented that § 25.773 should not be changed, as ice accretion on the windshield is one of the few indications used to recognize the condition.

We do not agree. Section 25.773 is intended to ensure that a clear portion of the windshield is maintained in icing conditions, which enhances safety in icing conditions. For airplanes certified to detect appendix O conditions, or a portion of appendix O conditions, and required to exit all icing conditions when the icing conditions used for certification have been exceeded, the pilot must have a clear view out the windshield; not only when the airplane is in appendix O icing conditions, but also during the time it takes to detect and exit all icing conditions within which the airplane is not approved to operate. For airplanes not certified with the detect-and-exit strategy, appendix C and appendix O conditions need to be considered for the entire time the airplane is in the applicable icing conditions.

Section 25.773 does not require the windshield to be completely free of ice in all icing conditions. Therefore, this requirement does not preclude using ice accreting in certain locations on the windshield as an indication that the airplane is in icing conditions beyond those in which it is approved to operate. We did not change the rule based on these comments.

Applicability of Proposed Appendix O to § 25.1323, Airspeed Indicating System, § 25.1324, Angle of Attack System, and § 25.1325, Static Pressure Systems

AIA, Airbus, Boeing, and GAMA commented that there are no known events that support an in-flight safety concern for angle of attack systems in SLD aloft. They believe the safety of these component systems for flight in appendix O conditions has already been proven by service history. The commenters recommended the reference to appendix O be removed from the requirements in §§ 25.1323, 25.1324, and 25.1325.

We do not agree. If certification for flight in icing is desired, part 25 requires the airplane to be capable of safely operating in icing conditions. The airplane and its components are taken into account during flight in icing certification programs. For these reasons, all icing conditions should be considered. Sections 25.1323, 25.1324, and 25.1325 include considerations for the SLD icing environment defined in part 25, appendix O.

Applicability of Proposed Appendix O to § 25.929, Propeller Deicing

AIA and GAMA commented that there are no known events that support a safety concern with propeller icing in SLD. In particular, AIA and GAMA noted the EHWG evaluated all known icing-related events since 1988 and found no events in SLD aloft. The commenters credit the current rigorous compliance using appendix C conditions for this result. The commenters believe the safety of these systems for flight in appendix O conditions has already been proven by service history. They further believe that continuing to certify future systems to the requirements for appendix C icing conditions, in conjunction with consideration of excellent service history of similar designs in appendix O conditions, should be acceptable assurance for the safety of future designs.

We do not agree. Propeller icing is typically not implicated in events because ice accretion on the propeller is usually not visible in flight. However, in one suspected SLD event [10] included in the IPHWG list of applicable events, the NTSB Performance Group reported that the flight data recorder derived drag increment was much higher than an increment measured in flight test with intercycle ice (by a factor of 2 near the time where the pilot lost control of the airplane). The NTSB report does not speculate what caused the large drag increment, but it could have been airframe SLD ice accretion, propeller SLD ice accretion, or a combination of both. In addition, appendix J in AC 20–73A, *Aircraft Ice Protection,* dated August 16, 2006, documents a flight test encounter in which suspected SLD caused a severe performance penalty due to propeller ice accretion. FAA research tests, documented in report DOT/FAA/AR–06/60, *Propeller Icing Tunnel Test on a Full-Scale Turboprop Engine,*[11] have duplicated the event discussed in the AC, and showed that propeller ice accretion and resulting propeller efficiency loss is greater in SLD compared to appendix C conditions.

After further consideration, we have revised § 25.929 to require a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in appendix C and the portions of appendix O for which the airplane is approved for flight. As compared to the NPRM, the phrase ''defined in appendices C and O'' has been replaced with ''defined in appendix C and in the portions of appendix O of this part for which the airplane is approved for flight.''

A private citizen commented that the words ''would jeopardize engine performance'' in the last portion of § 25.929(a) makes this requirement specific to engine performance. The commenter requested that the words be stricken from the regulation. The commenter did not provide justification to substantiate his proposed change.

We do not agree. First, we did not propose a change to this portion of the rule. Second, we reviewed the wording presented by the IPHWG and agree with its intent and its phrasing. Its applicability is broader than just an engine rule. We did not change the rule based on this comment.

[10] NTSB Investigation No. DFCA01MA031, Embraer EMB–120 Zero Injury Incident Near West Palm Beach, Florida on March 19, 2001, *http://www.ntsb.gov.*

[11] FAA Data Report DOT/FAA/AR–06/60, *Propeller Icing Tunnel Test on a Full-Scale Turboprop Engine,* dated March 2010. A copy of this report is available in the rule Docket No. FAA–2010–0636.

Engine and Engine Installation Requirements

The RAA commented that current facilities lack the capability to test large turbofans at very cold temperatures, and, while new sites may come on-line in the future, such facilities could not be constructed to comply with the proposed test conditions. The RAA also pointed out that future airplanes would not be certified for operations below zero degrees Fahrenheit when ''freezing fog'' is present, so it would create a restriction to what is currently considered a safe operating condition.

Airbus, AIA, Boeing, GAMA, GE, and a private citizen suggested that the choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis, as required by § 33.68(b)(1). This analysis could also be used to show that a more critical point does not exist at temperatures below the Table 1, condition 2, test temperatures in § 33.68. Airbus, AIA, Boeing, GAMA, GE, a private citizen, and RAA further suggested that the applicant should be permitted to use analysis to demonstrate safe operation of the engine at temperatures below the required test demonstration temperature. If safe operation is shown by this analysis, a temperature limitation would not be required for the AFM.

Airbus also suggested a further change to § 25.1093(b)(2) to ensure that the test is performed in accordance with aircraft procedures to provide adequate conservatism. These procedures are defined in collaboration with the engine manufacturer and may be defined on the basis of engine certification or development test results.

EASA and the FAA have recently addressed cold ground fog conditions. Specifically, the choice of ambient temperature for the ground freezing fog rime icing demonstration should be driven by critical point analysis (as required by § 33.68(b)(1)). We determined this analysis may also be used to show that at colder temperatures below the Table 1, condition 2, test temperatures in § 33.68, a more critical point does not exist. The analysis may also be used to demonstrate safe operation of the engine at temperatures below the required test demonstration. If an applicant does not show unlimited cold temperature operation, then the minimum ambient temperature that was demonstrated through test and analysis should also be a limitation. Finally, the acceleration to takeoff power or thrust should be accomplished in accordance with the procedures defined in the AFM. As a result, we changed §§ 25.1093(b)(2) and 25.1521(c)(3) based on these comments, to reflect these changes and recent developments with EASA.

AIA, GAMA, and a private citizen commented that the MVD for high LWC in Table 2 of § 33.68 may be difficult to achieve in practice due to icing facility constraints, and may result in repetitive equivalent level of safety (ELOS) findings. Expanding the upper limits of droplet size ranges will allow flexibility in test demonstrations. An upper limit of 30 microns for glaze ice conditions (points 1 and 3 in Table 1) and 23 microns for rime ice conditions (point 2 in Table 1) can be accepted if the critical point analysis shows that the engine is tested to equivalent or greater severity.

AIA, GAMA, and a private citizen also suggested changes to the drop diameters in Table 1 of § 33.68, noting that practical application of the required conditions dictates a wider acceptable droplet diameter range, without measurably impacting the severity of the intended engine test demonstration.

We agree. Although the commenters did not provide any data to validate the suggested change in drop diameters, we are aware of test facility limitations, and concur that the upper tolerance of drop size is limiting for some test facilities. As a result, the proposed ±3 micron droplet tolerance has been removed and a range for the MVDs is specified instead. This will still provide an adequate safety margin. Likewise, the upper drop size limit has also been increased to represent current test facility capabilities while preserving an adequate safety margin. Section 33.68, Table 1, has been revised to reflect these changes.

AIA and GAMA also suggested that the ground test conditions in Table 1, condition (iii), of § 25.1093 and Table 2, condition 4, of § 33.68(d) should have a consistent range of droplet sizes based on the values from part 25, appendix O.

We agree. We changed Table 2, condition 4, in § 33.68 by removing the maximum drop diameter so it is consistent with Table 1, condition (iii), in § 25.1093. Table 2 in § 33.68 was also revised to correct the conversion of degrees Centigrade to degrees Fahrenheit.

A private citizen remarked that including parenthetical examples in the rule text of § 33.68(a)(3) was not helpful and may be construed to be exclusionary of other pertinent, topical considerations. Furthermore, their absence does not diminish the clarity or understanding of the requirement.

We agree. We removed the parenthetical examples from the regulatory text in § 33.68.

A private citizen suggested a word change to our proposed wording of § 33.68(d). In the NPRM, we proposed to change § 33.68(d) to state that the engine should be run at ground idle speed for a minimum of 30 minutes in each of the icing conditions shown in Table 2. The commenter suggested replacing the phrase ''should be run'' with ''must demonstrate the ability to acceptably operate.'' The commenter noted that use of the word ''should'' is ambiguous and contrary to existing § 33.68, which uses the word ''must.'' Furthermore, the commenter suggested that eliminating the word ''run'' would be more consistent with the demonstration methods for snow, ice, and large drop glaze ice conditions (i.e., test, analysis, or combination of both) shown in Table 2 of § 33.68.

We agree and have clarified §§ 25.1093(b)(2) and 33.68(d) to state that the engine must operate at ground idle speed in the specified icing conditions.

Alternatives to Rulemaking

Several commenters said that operational solutions have proven to be extremely effective in managing weather related risks (e.g., thunderstorms and windshear). They suggested that the FAA should have been, or should start, placing at least as much emphasis on advancing alternatives to rulemaking as it does on creating new certification requirements. ALPA encouraged continuous research and development of technical systems that would automatically detect the presence of hazardous ice, measure the rate of accumulation, and then alert the crew as appropriate to take action in order to avoid a potentially unsafe flight condition. AirDat, LLC, commented that the FAA may have overlooked state-of-the-art meteorological tools, including airborne sensors, that are commercially available today, fully deployed, and in operation. AIA, Airbus, Boeing, and GAMA commented that the IPHWG did not thoroughly consider any alternatives to new rulemaking because the tasking statement did not include this option.

We agree in part. We agree that careful operations and new technologies may often enhance safety. However, we note that rulemaking is at the discretion of the agency, and we have exercised our discretionary rulemaking authority in this instance. This rule provides additional safety for the flying public when icing conditions are encountered, and it will improve the level of safety of future airplane designs.

Applicability of Mixed Phase and Ice Crystal Conditions to Airspeed Indicating Systems

We received several comments suggesting that the mixed phase and ice crystal environment in part 33, appendix D, should be used instead of the mixed phase and ice crystal environment that was proposed in Table 1 of § 25.1323. AIA, Airbus, Boeing, and GAMA stated the NPRM acknowledged new information is available to guide development of an ice crystal envelope appropriate for evaluation of airspeed indication systems. They also noted that proposed Table 1 of § 25.1323 does not reflect the current understanding of the ice crystal environment, nor does it include known pitot icing events, which are published in ''Interim Report no. 2,'' Bureau D'Enquetes et D'Analyses pour la securite d'aviation civile (BEA) F–GZCP.[12] GSIS recommended that Table 1 of § 25.1323, which defines a subset of part 33, appendix D, conditions, should be removed. Instead, the rule should require that airspeed indication systems must not malfunction in any of the conditions specified in appendix D.

EASA stated that the proposed environment in Table 1 of § 25.1323 would not address known events of airspeed indicating system malfunctions. EASA also fully supported including in part 25, the proposed mixed phase and ice crystal parameters in proposed part 33, appendix D. TCCA suggested that the FAA reconsider the icing conditions for the airspeed indicating system proposed in the NPRM within Table 1 of § 25.1323 and include the −60 °C conditions described in part 33, appendix D, instead.

Airbus supported the application of appendix D icing conditions to pitot and pitot-static probes, but pointed out it is necessary to develop an acceptable means of compliance that takes into account the capabilities of the existing engineering tools (for example, models and icing tunnels) and provide guidance on these new requirements. GSIS also commented that recent testing suggests testing at sea level atmospheric conditions may not be a conservative assumption for ice crystal testing.

NRC noted the requirements of § 25.1323 do not appear to take into account the effects of displacing the free stream ice water content around the fuselage of the airplane. If the probe is in a region affected by this, then the concentration detected by the probe would be higher than that of the free stream. Airbus mentioned that one test facility has made significant improvements in its capability to reproduce icing conditions but it is limited by the size of the test article it can accommodate. However, no test facilities are currently capable of reproducing the full range of icing conditions and flight conditions required by part 33, appendix D. Considering the state of the art of the engineering tools, there is a need for an agreed means of compliance.

We agree that the mixed phase and ice crystal environment in part 33, appendix D, should be used instead of the mixed phase and ice crystal environment proposed in Table 1 of § 25.1323. Therefore, §§ 25.1323 and 25.1324 have been revised to add a requirement to prevent malfunctions in the mixed phase and ice crystal environment defined in part 33, appendix D.

With regard to comments suggesting that testing at sea level atmospheric conditions may not be a conservative assumption, or that ice crystal concentrations at an exterior mounted probe could be higher than the free stream conditions, we agree. The conditions defined in part 33, appendix D, are atmospheric conditions. These atmospheric conditions include parameters for total water content as a function of temperature, altitude, and horizontal extent. We also agree that altitude may be an important parameter. Altitude is a parameter identified in part 33, appendix D, and must be considered when developing the test conditions and supporting analysis necessary to show compliance.

We also agree that depending on airplane size and the location of the probe, the ice water content at the probe may be higher than the ice water content values defined in part 33, appendix D. Since part 33, appendix D, describes atmospheric conditions, the potential for higher ice crystal concentrations at the probe location compared to the atmospheric concentrations defined in part 33, appendix D, must be considered when developing the test conditions and supporting analysis necessary to show compliance. Installation effects could be evaluated with a combination of computational fluid dynamics codes and icing tunnels. Devices mounted on smaller surfaces could be assessed in an icing tunnel. However, if the device is mounted on the fuselage and tunnel blockage effects would preclude a meaningful icing tunnel test, then codes that adequately predict the shadowing and concentration effects may be acceptable compliance methods.

Foster Technology, LLC (Foster), is an engineering consulting firm that has filed a provisional patent that includes a methodology for detecting ice over a pitot inlet, providing a corrected airspeed, and removing ice deposits. Foster suggested that the FAA should certify its new methodology.

We agree that existing regulations would allow certification of a new pitot probe with ice detection capability. However, we would certify a new pitot probe as part of a product's type design to be approved for installation, not the methodology described by Foster. If Foster seeks independent certification of a new pitot probe, we suggest Foster complete and submit an application for a supplemental type certificate, at which time we will evaluate the new probe.

Heavy Rain Requirements for Airspeed Indication and Angle of Attack Systems

Airbus and EASA fully supported a new requirement to cover the heavy rain conditions being considered in the NPRM. Airbus commented that some testing at high LWCs, such as those proposed in the NPRM, would help to ensure that water drainage in rain conditions, especially at takeoff, is adequate. A private citizen commented that the maximum freezing rain static temperature under consideration would be unlikely to result in ice accretion and is not in line with figure 4 of appendix O. AIA, Boeing, and GAMA commented that the proposed expanded parameters, the source of which was not provided, do not appear congruous with hard data from extensive icing research. GSIS commented that it wanted to understand how the specific values for LWC, horizontal extent, and mean droplet diameter were determined and what the technical justifications are for these levels.

We consider analysis of heavy rain conditions as proposed in the NPRM to be necessary to substantiate that water drainage from the airspeed indication and angle of attack systems is adequate. If the water drainage is inadequate, then the residual water may freeze as the pitot probes or angle of attack sensors are subjected to below freezing temperatures as the airplane climbs following takeoff. The heavy rain conditions are not intended as an icing condition as described in the NPRM. The heavy rain LWC is based on heavy rainfall data documented in MIL–STD–210C, *Military Standard: Climatic Information to Determine Design and Test Requirements for Military Systems*

[12] This report can be found on the BEA Web site at *http://www.bea.aero/docspa/2009/f-cp090601e2.en/pdf/f-cp090601e2.en.pdf.*

and Equipment.[13] The same rain data was used for the AIA Propulsion Committee Study, Project PC 338–1 documented in part 33, appendix B. Heavy rain conditions have been added to §§ 25.1323 and 25.1324. However, the conditions have been revised compared to the conditions proposed in the NPRM by removing temperature as a parameter.

Applicability of the Icing Requirements in Part 25, Appendix O, and Part 33, Appendix D, to All Airspeed Indicating Systems

EASA and TCCA suggested that §§ 25.1323 and 25.1324 be revised to include the icing certification of all external probes for flight instruments. EASA proposed a specific regulation including, but not limited to, pitot, pitot-static, static, angle-of-attack, sideslip angle, and temperature sensors. The regulation proposed by EASA would require addressing the icing conditions in part 25, appendix C; part 25, appendix O; and part 33, appendix D. Similarly, since total air temperature (TAT) is an input to calculating true airspeed, Goodrich requested clarification of whether or not TAT sensors should be considered part of the airspeed indicating system when addressing ''preventing malfunction'' in part 25, appendix O, and part 33, appendix D, environments as described in § 25.1323(i).

We do not agree with the commenters' suggestions to include icing requirements for all external probes and sensors in §§ 25.1323 and 25.1324. Section 25.1323(i) has traditionally applied to pitot probes (indicated airspeed), and the FAA did not propose a change to this applicability in the NPRM. As such, we did not intend to include TAT sensors, or other externally mounted instrument probes in § 25.1323(i). In addition, § 25.1324 was proposed specifically for angle-of-attack sensors. Revising §§ 25.1323 and 25.1324 so that all externally mounted flight instrument probes and sensors must operate in the various icing conditions is beyond the scope of this rulemaking. We did not change the rule in response to these comments.

Proposal To Add Indication System for External Probes

EASA advised that some failures of the pitot probe heating resistance may not be seen by the flightcrew due to the low current detection system installed on the airplane. As a result, failure to provide proper pitot probe deicing may not be detected. EASA suggested that a new regulation be created to explicitly cover abnormal functioning of the heating system for externally mounted probes.

We do not agree. If insufficient functioning of an externally mounted probe creates an unsafe operating condition, then warning information must be provided to the flightcrew in accordance with § 25.1309(c). Since we did not propose warning information specific to failure modes for certain externally mounted probes in the NPRM and the public did not have the opportunity to comment, we consider the EASA proposal to be beyond the scope of this rulemaking. No changes to the final rule have been made as a result of EASA's proposal.

Expand the Parameters for Part 33, Appendix D

AIA, Boeing, and GAMA commented that part 33, appendix D, should be expanded to reflect new engine power loss and airspeed data loss events in ice crystal conditions. Appendix D is based on a theoretical model, and Airbus agreed that the conditions in appendix D should be applied.

We do not agree that appendix D should be expanded in this final rule. The majority of recent airspeed data anomalies occurred within the altitude and temperature range described in part 33, appendix D. We know of only one temporary loss of airspeed data event just outside or at the perimeter of the altitude and temperature range in part 33, appendix D. Other conditions described in appendix D, such as what the ice water content actually was during the loss of airspeed data event, are unknown because it was not measured. We agree that appendix D is based on a theoretical atmospheric model. We are continuing to support the research necessary to validate the part 33, appendix D, conditions with flight test data, and it would be premature to expand the appendix D environment at this time. Expansion of part 33, appendix D, is out of scope of the originally proposed rulemaking. We did not change appendix D based on these comments.

Airbus commented that using the EHWG event database and referring to the flight distance between a TAT sensor anomaly and the engine event, one can see that almost half of the engine events occurred at a flight distance equal to or less than 10 nautical miles from the occurrence of the TAT anomaly, with the majority of events happening within less than 4 nautical miles. Based on these facts, Airbus concluded that short cloud exposures are the most critical. However, the new appendix D definition implies that the longest clouds are the most critical for engines and auxiliary power units (APUs), and adds a factor of 2 to the conservatism of the definitions already defined in EASA documents CS–E 780, *Tests in Ice-Forming Conditions,* and AMC 25.1419, *Ice Protection.*[14] Airbus commented that it is inappropriate to add an additional factor of 2 to the icing conditions for long exposures in appendix D icing conditions considering the uncertainty in the new rule.

We do not agree. We acknowledge that a TAT sensor anomaly may be one indicator of ice crystals; however, it is not a very reliable indicator. The amount and concentration of ice crystals required to create a TAT sensor anomaly is not understood. Also, the TAT sensor anomaly was only present in a portion of the engine events in the EHWG database. Therefore, the TAT anomaly data cannot accurately show cloud extent. Additionally, detailed review of the event data indicated that once the TAT probe iced over enough to cause an indication anomaly, the engine often would demonstrate a power upset very soon after the TAT probe anomaly. This period of time was insufficient for the pilot to take action since the ice accretion within the engine had already progressed to an advanced stage. Therefore, we concluded that TAT probe anomalies are poor precursor indications of the ice crystal threat to engines, in terms of reliability of the indication and the time period in advance of power loss. When establishing the cloud extent factor in part 33, appendix D, the EHWG and FAA did take into account EASA CS–E–780 cloud definition requirements. However, the EHWG was not able to validate the analysis used to develop the cloud extent factor in EASA CS–E–780. The cloud extent factor proposed by the EHWG for part 33, appendix D, represents the most accurate cloud extent factor that can be established using the available data. No changes were made as a result of these comments.

Snecma commented that the y-axis value in proposed part 33, appendix D, figure D3, was incorrect. The value should be 0.6 but the NPRM showed the value as zero.

We concur. We also found that both the x- and y-axis values proposed in the NPRM were incorrect. We changed part

[13] A copy of MIL–STD–210C, dated January 9, 1987, is available in the rule Docket No. FAA–2010–0636. MIL–STD–210 has since been superseded by MIL–HDBK–310, dated June 23, 1997, which is also available in the rule docket.

[14] Both of these documents are available on the EASA Web site at *http://www.easa.europa.eu.*

33, appendix D, figure D3, to depict the correct axis values. The lowest x-axis value is now 1 and the lowest y-axis value is now 0.6.

Several commenters noted that the horizontal cloud length proposed in the NPRM was stated in statute miles, and commented it should be provided in nautical miles. The commenters suggested that changing to nautical miles would make the distance measurement consistent with other tables and figures in appendix D.

We agree, and changed Table 1 to identify that the horizontal cloud length is depicted in nautical miles.

Several commenters asked why we included the reference to ''Reference 1'' in the text immediately following Table 1 in proposed part 33, appendix D, especially considering the material constituting ''Reference 1'' was not identified anywhere within the NPRM.

We agree. We removed the reference to ''Reference 1'' from the final rule.

Establishing New Operating Limitations

TCCA stated that it was not clear if the proposed requirements to exit all icing conditions were applicable only to in-flight icing encounters, or if they were also applicable to the takeoff phase of flight.

We agree that clarification is needed. We changed § 25.1533(c) to clarify that the additional limitations apply to all phases of flight.

Additional Requirements for Safe Operation

AIA, Boeing, and GAMA commented that proposed appendix O, paragraph (b) does not define takeoff ice accretions for airplanes not certified for takeoff in appendix O conditions. Therefore, they suggested that § 25.207(e)(1), which defines stall warning requirements for takeoff with ice accretions, should be added to the list of exceptions specified in § 25.21(g)(3).

We agree. We added the stall warning requirements in § 25.207(e)(1) to the exceptions listed in § 25.21(g)(3). As a result, applicants will not need to determine the stall warning margin for takeoff with appendix O ice accretions for airplanes not certified to take off in appendix O icing conditions.

TCCA commented that exposure to appendix O icing conditions may result in icing accretions further aft on fuselage, wing and stabilizer surfaces, and control surfaces, beyond what would normally be obtained in appendix C conditions. Therefore, TCCA suggested that compliance to § 25.251(b) through (e) should be shown for appendix O conditions.

We proposed to retain the provision from Amendment 25–121 for not requiring compliance with § 25.251(b) through (e) in appendix C icing conditions and extend it to include appendix O icing conditions. Although Amendment 25–121 only addressed appendix C icing conditions, the conclusion that compliance to § 25.251(b) through (e) need not be shown in icing conditions was based on a review of in-service experience in all icing conditions, not just appendix C icing conditions. Therefore, including § 25.251(b) through (e) within the exceptions listed in § 25.21(g) for certifications is equally applicable to either appendix C or appendix O conditions. No changes were made to the final rule as a result of this comment.

Dassault commented that the proposed ice accretion definitions in part II of appendix O did not include an ice accretion specific to the flight phase covered by § 25.121(a). Dassault added that the ice accretion used for showing compliance with § 25.121(a)(1) should be the accretion occurring between liftoff and the point at which the landing gear is fully retracted. Dassault requested that the FAA add the following definition: ''Takeoff—landing gear extended ice is the most critical ice accretion on unprotected surfaces, and any ice accretion on protected surfaces appropriate to normal ice protection system operation, occurring between liftoff and the point at which the landing gear is fully retracted, assuming accretion starts at liftoff in the icing conditions defined in Part I of this appendix.''

Instead of adding a definition for the ice accretion during the initial takeoff segment covered by § 25.121(a), we have reconsidered this issue and determined that this flight segment does not last long enough for significant ice accretions to occur, even in appendix O icing conditions. Therefore, we added § 25.121(a) to the list of requirements in § 25.21(g)(4) that do not have to be met with appendix O ice accretions. We also agree that our proposed definition for takeoff ice was inadequate. We did not intend to require that applicants include the small effect (if any) of ice accretion from the point of liftoff to the end of the takeoff distance in determining the takeoff distance under § 25.113, which the appendix C definition and the proposed appendix O definition may have implied. Therefore, we revised the definitions of takeoff ice and final takeoff ice in part 25, appendix C and appendix O, such that the ice accretion begins at the end of the takeoff distance, not at the point of liftoff. This change better aligns the definition of the takeoff and final takeoff ice with that of the takeoff path used for determining takeoff performance under §§ 25.111, 25.113, and 25.115.

Request To Revise § 25.629

TCCA commented that for airplanes exempt from § 25.1420, no evaluation of aeroelastic stability is required in appendix O icing conditions. For that reason, TCCA recommended that all icing considerations be included directly in § 25.629.

We do not agree. Section 25.629(b)(1) requires aeroelastic stability evaluations of the airplane in normal conditions. For airplanes approved for operation in icing conditions, ice accumulations are considered a normal condition under the rule. Since § 25.629 does not specifically distinguish between various types of icing conditions, all icing conditions for which the airplane is approved are considered normal conditions. For airplanes exempt from § 25.1420, or for which approval is not sought for flight in appendix O icing conditions, § 25.629(d)(3) requires that ice accumulations due to inadvertent icing encounters must be considered for airplanes not approved for operation in icing conditions. The intent is to consider ice accumulations due to inadvertent icing encounters from any icing conditions for which the airplane is not approved, including appendix O conditions. We did not change the rule as a result of this comment.

Miscellaneous Issues

After the FAA issued the NPRM to this rulemaking, we issued a final rule for *Harmonization of Various Airworthiness Standards for Transport Category Airplanes—Flight Rules* (docket number FAA–2010–0310). That final rule revised § 25.21(g)(1) to add the requirement that the stall warning margin requirements of § 25.207(c) and (d) must be met in the landing configuration in the icing conditions of appendix C. That final rule also revised § 25.253(c) to define the maximum speeds at which the static lateral-directional stability requirements of § 25.177(a) through (c) and the directional and lateral control requirements of § 25.147(f) must be met in the icing conditions of appendix C. We have retained those changes in §§ 25.21(g)(2) and 25.253(c) of this final rule. For consistency, we also revised § 25.21(g)(4) to require that § 25.207(c) and (d) must be met in the landing configuration in the appendix O icing conditions for which certification is sought. This revision is a logical outgrowth of the notice in this rulemaking because the purpose of § 25.21(g)(4) is to ensure safe operation in appendix O conditions during all phases of flight, including the landing phase.

The FAA finds that clarifying the applicability of the proposed icing conditions to APU installations is necessary. Section 25.901(d) currently requires that each auxiliary power unit installation must meet the applicable provisions of the subpart. This requirement is unchanged by this rulemaking. The FAA considers § 25.1093(b) to be applicable to APU installations because they are turbine engines. An essential APU is used to provide air and/or power necessary to maintain safe airplane operation. A non-essential APU is used to provide air and/or power as a matter of convenience and may be shutdown without jeopardizing safe airplane operation. The FAA has traditionally required that essential APU installations continue to operate in part 25, appendix C, icing conditions. Non-essential APU installations either have restricted operation or are required to demonstrate that operation in icing conditions does not affect the safe operation of the airplane. References to part 25, appendix O, and part 33, appendix D, have been added to § 25.1093(b).

As previously discussed, the applicability of appendix O conditions in § 25.1093(b) excludes all turbine engine installations that are used on airplanes with a MTOW equal to or greater than 60,000 pounds. The FAA still considers APUs to be turbine engines that must comply with the installation requirements in §§ 25.901 and 25.1093; therefore, this rulemaking is not creating separate requirements for APU installations. Essential APU installations must continue to operate in the icing conditions applicable under § 25.1093(b). Non-essential APU installations must not affect the safe operation of the airplane when the icing conditions applicable under § 25.1093(b) are inadvertently encountered.

Also as previously discussed, the applicability of appendix O conditions in § 25.1093(b) was revised to provide relief for larger airplanes because of the successful in-service history of existing larger airplane and larger airplane turbine engine inlet designs. If future APU installations contain novel or unusual design features that affect this successful in-service history, and those design features make the airplane more susceptible to the effects of flight in SLD icing conditions, the FAA can issue special conditions to provide adequate safety standards.

A private citizen identified potential flightcrew training issues associated with this rulemaking. The commenter noted that while practical test standards for post-stall recovery procedures are clearly related to icing safety, they are not regulatory and may be changed without formal notice. The commenter also remarked that a common pilot input characteristic to add power and maintain the pitch angle of the airplane has been observed on the flight data recorder time histories related to several icing related accidents. In some cases, nose up pitch input was applied even against the nose down force being applied by the airplane's ''stick pusher'' that is designed to rapidly reduce the angle of attack. The commenter noted that these habit patterns are developed and reinforced as the required response in simulator training in accordance with FAA practical test standards for stall identification and recovery for minimum altitude loss. For example, ''Minimum altitude loss'' is trained as ''zero altitude loss.''

The flightcrew training issues addressed by the commenter are important safety considerations. However, flightcrew training is beyond the scope of this rulemaking because this rulemaking addresses design requirements. On July 6, 2010, the FAA published Safety Alert for Operators (SAFO) 10012. The SAFO discusses the possible misinterpretation of the practical test standards language ''minimal loss of altitude.'' [15]

In addition, on September 30, 2010, the FAA established the Stick Pusher and Adverse Weather Event Training Aviation Rulemaking Committee. One of the rulemaking committee objectives is to identify the best goals, procedures, and training practices that will enable air carrier pilots to accurately and consistently respond to unexpected stick pusher activations, icing conditions, and microburst and windshear events.[16] The ARC has submitted recommendations to the FAA, which are being considered for additional rulemaking activities. Such activities are beyond the scope of this rulemaking.

Regulatory Notices and Analyses

Regulatory Evaluation

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 and Executive Order 13563 direct that each Federal agency shall 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 (Pub. L. 96–354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96–39) 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, that they 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 with base year of 1995). This portion of the preamble summarizes the FAA's analysis of the economic impacts of this final rule. We suggest readers seeking greater detail read the full regulatory evaluation, a copy of which we have placed in the docket for this rulemaking.

In conducting these analyses, the FAA has determined that this final rule: (1) Has benefits that justify its costs, (2) is not an economically ''significant regulatory action'' as defined in section 3(f) of Executive Order 12866, (3) is ''not significant'' as defined in DOT's Regulatory Policies and Procedures; (4) will not have a significant economic impact on a substantial number of small entities; (5) will not create unnecessary obstacles to the foreign commerce of the United States; and (6) will not impose an unfunded mandate on state, local, or tribal governments, or on the private sector by exceeding the threshold identified above. These analyses are summarized below.

Total Benefits and Costs of This Final Rule

[15] This document can be found at *http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2010/SAFO10012.pdf.*

[16] A copy of the charter is available at *http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs200/media/208_ARC_Charter.pdf.*

TABLE 1—TOTAL BENEFITS AND COSTS OF THIS RULE

	2012$		7% Present value	
	Benefit	Cost	Benefit	Cost
Part 33 Engines	Qualitative	$13,936,000	Qualitative	$11,375,927
Large Part 25 Airplanes	$362,319,857	14,126,333	$76,861,295	11,531,295
Other Part 25 Airplanes	$220,570,582	33,198,788	$50,028,650	19,385,401
Total	$582,890,439	61,261,121	$126,889,985	42,292,624

* Details may not add to row or column totals due to rounding.

Persons Potentially Affected by This Final Rule

Part 25 airplane manufacturers,
Engine manufacturers, and
Operators of affected equipment.

Assumptions

The deliveries and affected fleets are analyzed over appropriate time periods and are customized based upon actual historical data. The fleet development is customized to the various (and different) airplane types. We conservatively assume that all certifications will occur in 2015 and deliveries will occur in the following year. As production time spans differ by size of airplane, it is important for the reader to focus on present value benefits and costs.

Present Value Discount rate—7%
Value of an Averted Fatality—$9.1 million in 2012

Both Costs and Benefits are expressed in 2012 dollars.

Benefits of This Final Rule

The FAA has analyzed events that would have been prevented if this final rule were in place at the time of certification. The events were evaluated for applicability and preventability in context with the requirements contained in this final rule.

For the categories of airplanes, first, we develop casualty rates for fatalities, injuries, investigations, and destroyed airplanes based on historical ice-related accidents. Next, we multiply the total annual affected airplanes by the annual risk per airplane. Lastly, we multiply the casualty rates by the projected number of part 25 newly certificated deliveries. When summed over time, the total estimated benefits are shown in Table 1.

Viewed from a breakeven analysis using only preventable fatalities, with each fatality valued at $9.1 million, this rule has benefits exceeding costs with only 7 fatalities prevented.

Costs of This Final Rule

The total estimated costs are shown in Table 1. We obtained the basis of our cost estimates from the industry. Since the NPRM, we have modified the estimates based upon industry comments and clarifications to those comments. The compliance costs are analyzed in context of the part 25 and part 33 certification requirements.

As summarized in Table 2, the cost categories in the regulatory evaluation incorporate both certification and operational costs. We analyze each cost category separately. The cost categories in this evaluation are the same as those provided by industry to comply with the requirements contained in this rule.

TABLE 2—COST SUMMARY

	Nominal cost	7% PV cost
Engine Certification Cost	$7,936,000	$6,478,140
Engine Capital Cost	6,000,000	4,897,787
Total Engine Cost	13,936,000	11,375,927
New Large Airplane Certification Cost	14,126,333	11,531,295
Large Airplane Hardware Cost	0	0
Large Airplane Fuel Cost	0	0
Total Large Airplane Cost	14,126,333	11,531,295
Other Airplane Certification Cost	19,066,026	15,563,557
Other Airplane Hardware Cost	2,475,000	1,312,609
Other Airplane Fuel Burn Cost	11,657,762	2,509,236
Total Other Airplane Costs	33,198,788	19,385,401
Total Costs	61,261,121	42,292,624

* Details may not add to row or column totals due to rounding.

Alternatives Considered

Alternative 1—Make the entire rule applicable to all airplanes.

Not all the requirements in this rule extend to large transport category airplanes (those with a MTOW greater than 60,000 pounds). Under this alternative, the proposed design requirements would extend to all transport category airplanes. This alternative was rejected because this alternative would add significant costs without a commensurate increase in benefits.

Alternative 2—Limit the scope of applicability to small transport category airplanes.

Although this alternative would decrease the estimated cost, the FAA believes that medium and large airplanes are at risk of an SLD icing event. The FAA does not want a significant proportion of the future fleet to be disproportionately at risk.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (Pub. L. 96–354) (RFA) establishes as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration. 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 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 RFA.

However, if an agency determines that a rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 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. Our initial determination was that the proposed rule would not have a significant economic impact on a substantial number of small entities. We received no public comments regarding our initial determination. As such, this final rule will not have a significant economic impact on a substantial number of small entities for the following reasons.

Airplane and Engine Manufacturers

Airplane and engine manufacturers will be affected by the requirements contained in this rule.

For airplane manufacturers, we use the size standards from the Small Business Administration for Air Transportation and Aircraft Manufacturing specifying companies having less than 1,500 employees as small entities. The current United States part 25 airplane manufacturers include Boeing, Cessna Aircraft, Gulfstream Aerospace, Learjet (owned by Bombardier), Lockheed Martin, Raytheon Aircraft, and Sabreliner Corporation. Because all U.S. transport-category airplane manufacturers have more than 1,500 employees, none are considered small entities.

United States aircraft engine manufacturers include General Electric, CFM International, Pratt & Whitney, International Aero Engines, Rolls-Royce Corporation, Honeywell, and Williams International. All but one exceeds the Small Business Administration small-entity criteria for aircraft engine manufacturers. Williams International is the only one of these manufacturers that is a U.S. small business.

The FAA estimated that Williams International engines power approximately four percent of the engines on active U.S. airplanes. Assuming that future deliveries of newly certificated airplanes with Williams International engines will have the same percentage as the active fleet, we calculated that this final rule will add about 0.2 percent of their annual revenue. We do not consider a cost of 0.2 percent of annual revenue significant.

Operators

In addition to the certification cost incurred by manufacturers, operators will incur fuel costs due to the estimated additional impact of weight changes from equipment on affected airplanes. On average, operators affected by the final rule will incur no additional annual fuel costs for newly certificated large part 25 airplanes, and $189, in present value, in additional fuel costs for other newly certificated part 25 airplanes. This final rule will apply to airplanes that have yet to be designed; there will be no immediate cost to small entities. The other airplane annual fuel cost of $189, in present value, is not significant in terms of total operating expenses. We do not consider these annual fuel costs a significant economic impact.

This final rule will not have a significant economic impact on a substantial number of airplane manufacturers, engine manufacturers, or operators. Therefore, as the FAA Administrator, I certify that this rule will not have a significant economic impact on a substantial number of small entities.

International Trade Analysis

The Trade Agreements Act of 1979 (Pub. L. 96–39), as amended by the Uruguay Round Agreements Act (Pub. L. 103–465), prohibits Federal agencies from establishing standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to these Acts, the establishment of standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such as the protection of safety, and does not operate in a manner that excludes imports that meet this objective. 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 effect of this final rule and determined that it will not be an unnecessary obstacle to the foreign commerce of the United States as the purpose of this rule is to ensure aviation safety.

Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) 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 (in 1995 dollars) 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 $143.1 million in lieu of $100 million. This final rule does not contain such a mandate; therefore, the requirements of Title II do not apply.

Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. The information collection requirements associated with this final rule have been previously approved by the Office of Management and Budget (OMB) under the provisions of the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) and have been assigned OMB Control Number 2120–0018.

International Compatibility and Cooperation

(1) In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to conform to International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has reviewed the corresponding ICAO Standards and Recommended Practices and has identified no differences with these regulations.

(2) Executive Order 13609, Promoting International Regulatory Cooperation, promotes international regulatory cooperation to meet shared challenges involving health, safety, labor, security, environmental, and other issues and to reduce, eliminate, or prevent unnecessary differences in regulatory requirements. The FAA has analyzed this action under the policies and agency responsibilities of Executive Order 13609, and has determined that this action will have no effect on international regulatory cooperation.

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 rulemaking action qualifies for the categorical exclusion identified in paragraph 4(j) and involves no extraordinary circumstances.

Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the FAA, when modifying its regulations 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 appropriate regulatory distinctions. In the NPRM, the FAA requested comments on whether the proposed rule should apply differently to intrastate operations in Alaska. The agency did not receive any comments, and has determined, based on the administrative record of this rulemaking, that there is no need to make any regulatory distinctions applicable to intrastate aviation in Alaska.

Executive Order Determinations

Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. The agency determined that this action will not have a substantial direct effect on the States, or the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, does not have Federalism implications.

Executive Order 13211, Regulations That Significantly Affect Energy Supply, Distribution, or Use

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

How To Obtain Additional Information

Rulemaking Documents

An electronic copy of a rulemaking document may be obtained by using the Internet—

1. Search the Federal eRulemaking Portal (*http://www.regulations.gov*);
2. Visit the FAA's Regulations and Policies Web page at *http://www.faa.gov/regulations_policies/* or
3. Access the Government Printing Office's Web page at *http://www.gpo.gov/fdsys/browse/collection.action?collectionCode=FR.*

Copies may also be obtained by sending a request (identified by notice, amendment, or docket number of this rulemaking) to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680.

Comments Submitted to the Docket

Comments received may be viewed by going to *http://www.regulations.gov* and following the online instructions to search the docket number for this action. Anyone is able to search the electronic form of all comments received into any of the FAA's dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.).

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. A small entity with questions regarding this document, may contact its local FAA official, or the person listed under the **FOR FURTHER INFORMATION CONTACT** heading at the beginning of the preamble. To find out more about SBREFA on the Internet, visit *http://www.faa.gov/regulations_policies/rulemaking/sbre_act/*.

List of Subjects

14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements, Safety, Transportation.

14 CFR Part 33

Aircraft, Aviation safety.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends chapter I 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 revising paragraphs (g)(1) and (2) and adding paragraphs (g)(3) and (4) to read as follows:

§ 25.21 Proof of compliance.

* * * * *

(g) * * *

(1) Paragraphs (g)(3) and (4) of this section apply only to airplanes with one or both of the following attributes:

(i) Maximum takeoff gross weight is less than 60,000 lbs; or

(ii) The airplane is equipped with reversible flight controls.

(2) Each requirement of this subpart, except §§ 25.121(a), 25.123(c), 25.143(b)(1) and (2), 25.149, 25.201(c)(2), 25.239, and 25.251(b) through (e), must be met in the icing conditions specified in Appendix C of this part. Section 25.207(c) and (d) must be met in the landing configuration in the icing conditions specified in Appendix C, but need not be met for other configurations. Compliance must be shown using the ice accretions defined in part II of Appendix C of this part, 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.

(3) If the applicant does not seek certification for flight in all icing conditions defined in Appendix O of this part, each requirement of this subpart, except §§ 25.105, 25.107, 25.109, 25.111, 25.113, 25.115, 25.121, 25.123, 25.143(b)(1), (b)(2), and (c)(1), 25.149, 25.201(c)(2), 25.207(c), (d), and (e)(1), 25.239, and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is not

sought in order to allow a safe exit from those conditions. Compliance must be shown using the ice accretions defined in part II, paragraphs (b) and (d) of Appendix O, 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.

(4) If the applicant seeks certification for flight in any portion of the icing conditions of Appendix O of this part, each requirement of this subpart, except §§ 25.121(a), 25.123(c), 25.143(b)(1) and (2), 25.149, 25.201(c)(2), 25.239, and 25.251(b) through (e), must be met in the Appendix O icing conditions for which certification is sought. Section 25.207(c) and (d) must be met in the landing configuration in the Appendix O icing conditions for which certification is sought, but need not be met for other configurations. Compliance must be shown using the ice accretions defined in part II, paragraphs (c) and (d) of Appendix O, 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.

■ 3. Amend § 25.105 by revising paragraph (a)(2) introductory text to read as follows:

§ 25.105 Takeoff.

(a) * * *

(2) In icing conditions, if in the configuration used to show compliance with § 25.121(b), and with the most critical of the takeoff ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g):

* * * * *

■ 4. Amend § 25.111 by revising paragraphs (c)(5)(i) and (ii) to read as follows:

§ 25.111 Takeoff path.

* * * * *

(c) * * *

(5) * * *

(i) With the most critical of the takeoff ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), 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 most critical of the final takeoff ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), from the point where the airplane is 400 feet above the takeoff surface to the end of the takeoff path.

* * * * *

■ 5. Amend § 25.119 by revising paragraph (b) to read as follows:

§ 25.119 Landing climb: All-engines-operating.

* * * * *

(b) In icing conditions with the most critical of the landing ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), and with a climb speed of V_{REF} determined in accordance with § 25.125(b)(2)(ii).

■ 6. Amend § 25.121 by revising paragraphs (b)(2)(ii) introductory text, (c)(2)(ii) introductory text, and (d)(2)(ii) to read as follows:

§ 25.121 Climb: One-engine-inoperative.

* * * * *

(b) * * *

(2) * * *

(ii) In icing conditions with the most critical of the takeoff ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), if in the configuration used to show compliance with § 25.121(b) with this takeoff ice accretion:

* * * * *

(c) * * *

(2) * * *

(ii) In icing conditions with the most critical of the final takeoff ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), if in the configuration used to show compliance with § 25.121(b) with the takeoff ice accretion used to show compliance with § 25.111(c)(5)(i):

* * * * *

(d) * * *

(2) * * *

(ii) In icing conditions with the most critical of the approach ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g). 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.

■ 7. Amend § 25.123 by revising paragraph (b)(2) introductory text to read as follows:

§ 25.123 En route flight paths.

* * * * *

(b) * * *

(2) In icing conditions with the most critical of the en route ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), if:

* * * * *

■ 8. Amend § 25.125 by revising paragraphs (a)(2), (b)(2)(ii)(B), and (b)(2)(ii)(C) to read as follows:

§ 25.125 Landing.

(a) * * *

(2) In icing conditions with the most critical of the landing ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), if V_{REF} for icing conditions exceeds V_{REF} for non-icing conditions by more than 5 knots CAS at the maximum landing weight.

(b) * * *

(2) * * *

(ii) * * *

(B) 1.23 V_{SR0} with the most critical of the landing ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), if that speed exceeds V_{REF} selected 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 most critical of the landing ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g).

* * * * *

■ 9. Amend § 25.143 by revising paragraphs (c) introductory text, (i)(1), and (j) introductory text to read as follows:

§ 25.143 General.

* * * * *

(c) The airplane must be shown to be safely controllable and maneuverable with the most critical of the ice accretion(s) appropriate to the phase of flight as defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), and with the critical engine inoperative and its propeller (if applicable) in the minimum drag position:

* * * * *

(i) * * *

(1) Controllability must be demonstrated with the most critical of the ice accretion(s) for the particular flight phase as defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g);

* * * * *

(j) For flight in icing conditions before the ice protection system has been activated and is performing its intended function, it must be demonstrated in flight with the most critical of the ice accretion(s) defined in Appendix C, part

II, paragraph (e) of this part and Appendix O, part II, paragraph (d) of this part, as applicable, in accordance with § 25.21(g), that:

* * * * *

■ 10. Amend § 25.207 by revising paragraphs (b), (e)(1), (e)(2), (e)(3), (e)(4), (e)(5), and (h) introductory text 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)(3)(ii) of this section, the stall warning for flight in icing conditions must be provided by the same means as the stall warning for flight in non-icing conditions.

* * * * *

(e) * * *

(1) The most critical of the takeoff ice and final takeoff ice accretions defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), for each configuration used in the takeoff phase of flight;

(2) The most critical of the en route ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), for the en route configuration;

(3) The most critical of the holding ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), for the holding configuration(s);

(4) The most critical of the approach ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), for the approach configuration(s); and

(5) The most critical of the landing ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), for the landing and go-around configuration(s).

* * * * *

(h) The following stall warning margin is required for flight in icing conditions before the ice protection system has been activated and is performing its intended function. Compliance must be shown using the most critical of the ice accretion(s) defined in Appendix C, part II, paragraph (e) of this part and Appendix O, part II, paragraph (d) of this part, as applicable, in accordance with § 25.21(g). 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:

* * * * *

■ 11. Amend § 25.237 by revising paragraph (a)(3)(ii) to read as follows:

§ 25.237 Wind velocities.

(a) * * *

(3) * * *

(ii) Icing conditions with the most critical of the landing ice accretion(s) defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g).

* * * * *

■ 12. Amend § 25.253 by revising paragraph (c) introductory text to read as follows:

§ 25.253 High-speed characteristics.

* * * * *

(c) *Maximum speed for stability characteristics in icing conditions.* The maximum speed for stability characteristics with the most critical of the ice accretions defined in Appendices C and O of this part, as applicable, in accordance with § 25.21(g), at which the requirements of §§ 25.143(g), 25.147(f), 25.175(b)(1), 25.177(a) through (c), and 25.181 must be met, is the lower of:

* * * * *

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

§ 25.773 Pilot compartment view.

* * * * *

(b) * * *

(1) * * *

(ii) The icing conditions specified in Appendix C of this part and the following icing conditions specified in Appendix O of this part, if certification for flight in icing conditions is sought:

(A) For airplanes certificated in accordance with § 25.1420(a)(1), the icing conditions that the airplane is certified to safely exit following detection.

(B) For airplanes certificated in accordance with § 25.1420(a)(2), the icing conditions that the airplane is certified to safely operate in and the icing conditions that the airplane is certified to safely exit following detection.

(C) For airplanes certificated in accordance with § 25.1420(a)(3) and for airplanes not subject to § 25.1420, all icing conditions.

* * * * *

■ 14. Amend § 25.903 by adding a new paragraph (a)(3) to read as follows:

§ 25.903 Engines.

(a) * * *

(3) Each turbine engine must comply with one of the following paragraphs:

(i) Section 33.68 of this chapter in effect on January 5, 2015, or as subsequently amended; or

(ii) Section 33.68 of this chapter in effect on February 23, 1984, or as subsequently amended before January 5, 2015, unless that engine's ice accumulation service history has resulted in an unsafe condition; or

(iii) Section 33.68 of this chapter in effect on October 1, 1974, or as subsequently amended prior to February 23, 1984, unless that engine's ice accumulation service history has resulted in an unsafe condition; or

(iv) Be shown to have an ice accumulation service history in similar installation locations which has not resulted in any unsafe conditions.

* * * * *

■ 15. Amend § 25.929 by revising paragraph (a) to read as follows:

§ 25.929 Propeller deicing.

(a) If certification for flight in icing is sought there must be a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in Appendix C of this part and in the portions of Appendix O of this part for which the airplane is approved for flight on propellers or on accessories where ice accumulation would jeopardize engine performance.

* * * * *

■ 16. Amend § 25.1093 by revising paragraph (b) to read as follows:

§ 25.1093 Induction system icing protection.

* * * * *

(b) *Turbine engines.* Except as provided in paragraph (b)(3) of this section, each engine, with all icing protection systems operating, must:

(1) Operate throughout its flight power range, including the minimum descent idling speeds, in the icing conditions defined in Appendices C and O of this part, and Appendix D of part 33 of this chapter, and in falling and blowing snow within the limitations established for the airplane for such operation, without the accumulation of ice on the engine, inlet system components, or airframe components that would do any of the following:

(i) Adversely affect installed engine operation or cause a sustained loss of power or thrust; or an unacceptable increase in gas path operating temperature; or an airframe/engine incompatibility; or

(ii) Result in unacceptable temporary power loss or engine damage; or

(iii) Cause a stall, surge, or flameout or loss of engine controllability (for example, rollback).

(2) Operate at ground idle speed for a minimum of 30 minutes on the ground in the following icing conditions shown in Table 1 of this section, unless replaced by similar test conditions that are more critical. These conditions must be demonstrated with the available air bleed for icing protection at its critical condition, without adverse effect, followed by an acceleration to takeoff power or thrust in accordance with the procedures defined in the airplane flight manual. During the idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator. Analysis may be used to show ambient temperatures below the tested temperature are less critical. The applicant must document the engine run-up procedure (including the maximum time interval between run-ups from idle, run-up power setting, and duration at power), the associated minimum ambient temperature, and the maximum time interval. These conditions must be used in the analysis that establishes the airplane operating limitations in accordance with § 25.1521.

(3) For the purposes of this section, the icing conditions defined in appendix O of this part, including the conditions specified in Condition 3 of Table 1 of this section, are not applicable to airplanes with a maximum takeoff weight equal to or greater than 60,000 pounds.

TABLE 1—ICING CONDITIONS FOR GROUND TESTS

Condition	Total air temperature	Water concentration (minimum)	Mean effective particle diameter	Demonstration
1. Rime ice condition	0 to 15 °F (18 to −9 °C)	Liquid—0.3 g/m³	15–25 microns	By test, analysis or combination of the two.
2. Glaze ice condition	20 to 30 °F (−7 to −1 °C).	Liquid—0.3 g/m³	15–25 microns	By test, analysis or combination of the two.
3. Large drop condition	15 to 30 °F (−9 to −1 °C).	Liquid—0.3 g/m³	100 microns (minimum)	By test, analysis or combination of the two.

* * * * *

■ 17. Amend § 25.1323 by revising paragraph (i) to read as follows:

§ 25.1323 Airspeed indicating system.

* * * * *

(i) Each system must have a heated pitot tube or an equivalent means of preventing malfunction in the heavy rain conditions defined in Table 1 of this section; mixed phase and ice crystal conditions as defined in part 33, Appendix D, of this chapter; the icing conditions defined in Appendix C of this part; and the following icing conditions specified in Appendix O of this part:

(1) For airplanes certificated in accordance with § 25.1420(a)(1), the icing conditions that the airplane is certified to safely exit following detection.

(2) For airplanes certificated in accordance with § 25.1420(a)(2), the icing conditions that the airplane is certified to safely operate in and the icing conditions that the airplane is certified to safely exit following detection.

(3) For airplanes certificated in accordance with § 25.1420(a)(3) and for airplanes not subject to § 25.1420, all icing conditions.

TABLE 1—HEAVY RAIN CONDITIONS FOR AIRSPEED INDICATING SYSTEM TESTS

Altitude range		Liquid water content	Horizontal extent		Droplet MVD
(ft)	(m)	(g/m3)	(km)	(nmiles)	(µm)
0 to 10 000	0 to 3000	1	100	50	1000
		6	5	3	2000
		15	1	0.5	2000

* * * * *

■ 18. Amend part 25 by adding a new section § 25.1324 to read as follows:

§ 25.1324 Angle of attack system.

Each angle of attack system sensor must be heated or have an equivalent means of preventing malfunction in the heavy rain conditions defined in Table 1 of § 25.1323, the mixed phase and ice crystal conditions as defined in part 33, Appendix D, of this chapter, the icing conditions defined in Appendix C of this part, and the following icing conditions specified in Appendix O of this part:

(a) For airplanes certificated in accordance with § 25.1420(a)(1), the icing conditions that the airplane is certified to safely exit following detection.

(b) For airplanes certificated in accordance with § 25.1420(a)(2), the icing conditions that the airplane is certified to safely operate in and the icing conditions that the airplane is certified to safely exit following detection.

(c) For airplanes certificated in accordance with § 25.1420(a)(3) and for airplanes not subject to § 25.1420, all icing conditions.

■ 19. Amend § 25.1325 by revising paragraph (b) to read as follows:

§ 25.1325 Static pressure systems.

* * * * *

(b) Each static port must be designed and located so that:

(1) The static pressure system performance is least affected by airflow variation, or by moisture or other foreign matter; and

(2) The correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not changed when the airplane is exposed to the icing conditions defined in Appendix C of

this part, and the following icing conditions specified in Appendix O of this part:

(i) For airplanes certificated in accordance with § 25.1420(a)(1), the icing conditions that the airplane is certified to safely exit following detection.

(ii) For airplanes certificated in accordance with § 25.1420(a)(2), the icing conditions that the airplane is certified to safely operate in and the icing conditions that the airplane is certified to safely exit following detection.

(iii) For airplanes certificated in accordance with § 25.1420(a)(3) and for airplanes not subject to § 25.1420, all icing conditions.

* * * * *

■ 20. Amend part 25 by adding a new § 25.1420 to read as follows:

§ 25.1420 Supercooled large drop icing conditions.

(a) If certification for flight in icing conditions is sought, in addition to the requirements of § 25.1419, an airplane with a maximum takeoff weight less than 60,000 pounds or with reversible flight controls must be capable of operating in accordance with paragraphs (a)(1), (2), or (3), of this section.

(1) Operating safely after encountering the icing conditions defined in Appendix O of this part:

(i) The airplane must have a means to detect that it is operating in Appendix O icing conditions; and

(ii) Following detection of Appendix O icing conditions, the airplane must be capable of operating safely while exiting all icing conditions.

(2) Operating safely in a portion of the icing conditions defined in Appendix O of this part as selected by the applicant:

(i) The airplane must have a means to detect that it is operating in conditions that exceed the selected portion of Appendix O icing conditions; and

(ii) Following detection, the airplane must be capable of operating safely while exiting all icing conditions.

(3) Operating safely in the icing conditions defined in Appendix O of this part.

(b) To establish that the airplane can operate safely as required in paragraph (a) of this section, an applicant must show through analysis that the ice protection for the various components of the airplane is adequate, taking into account the various airplane operational configurations. To verify the analysis, one, or more as found necessary, of the following methods must be used:

(1) Laboratory dry air or simulated icing tests, or a combination of both, of the components or models of the components.

(2) Laboratory dry air or simulated icing tests, or a combination of both, of models of the airplane.

(3) Flight tests of the airplane or its components in simulated icing conditions, measured as necessary to support the analysis.

(4) Flight tests of the airplane with simulated ice shapes.

(5) Flight tests of the airplane in natural icing conditions, measured as necessary to support the analysis.

(c) For an airplane certified in accordance with paragraph (a)(2) or (3) of this section, the requirements of § 25.1419(e), (f), (g), and (h) must be met for the icing conditions defined in Appendix O of this part in which the airplane is certified to operate.

(d) For the purposes of this section, the following definitions apply:

(1) *Reversible Flight Controls.* Flight controls in the normal operating configuration that have force or motion originating at the airplane's control surface (for example, through aerodynamic loads, static imbalance, or trim or servo tab inputs) that is transmitted back to flight deck controls. This term refers to flight deck controls connected to the pitch, roll, or yaw control surfaces by direct mechanical linkages, cables, or push-pull rods in such a way that pilot effort produces motion or force about the hinge line.

(2) *Simulated Icing Test.* Testing conducted in simulated icing conditions, such as in an icing tunnel or behind an icing tanker.

(3) *Simulated Ice Shape.* Ice shape fabricated from wood, epoxy, or other materials by any construction technique.

■ 21. Amend § 25.1521 by redesignating paragraph (c)(3) as paragraph (c)(4), revising newly redesignated paragraph (c)(4), and adding new paragraph (c)(3) to read as follows:

§ 25.1521 Powerplant limitations.

* * * * *

(c) * * *

(3) Maximum time interval between engine run-ups from idle, run-up power setting and duration at power for ground operation in icing conditions, as defined in § 25.1093(b)(2).

(4) Any other parameter for which a limitation has been established as part of the engine type certificate except that a limitation need not be established for a parameter that cannot be exceeded during normal operation due to the design of the installation or to another established limitation.

* * * * *

■ 22. Amend § 25.1533 by adding a new paragraph (c) to read as follows:

§ 25.1533 Additional operating limitations.

* * * * *

(c) For airplanes certified in accordance with § 25.1420(a)(1) or (2), an operating limitation must be established to:

(1) Prohibit intentional flight, including takeoff and landing, into icing conditions defined in Appendix O of this part for which the airplane has not been certified to safely operate; and

(2) Require exiting all icing conditions if icing conditions defined in Appendix O of this part are encountered for which the airplane has not been certified to safely operate.

■ 23. Amend Appendix C to part 25, in part II, by revising paragraph (a)(1), the second sentence of paragraph (a)(2), and paragraph (d)(2) to read as follows:

Appendix C to Part 25

* * * * *

PART II—AIRFRAME ICE ACCRETIONS FOR SHOWING COMPLIANCE WITH SUBPART B

(a) * * *

(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 the end of the takeoff distance and 400 feet above the takeoff surface, assuming accretion starts at the end of the takeoff distance in the takeoff maximum icing conditions defined in part I of this Appendix.

(2) * * * Ice accretion is assumed to start at the end of the takeoff distance in the takeoff maximum icing conditions of part I, paragraph (c) of this Appendix.

* * * * *

(d) * * *

(2) The ice accretion starts at the end of the takeoff distance.

* * * * *

■ 24. Amend part 25 by adding new Appendix O to read as follows:

Appendix O to Part 25—Supercooled Large Drop Icing Conditions

This Appendix consists of two parts. Part I defines this Appendix as a description of supercooled large drop icing conditions in which the drop median volume diameter (MVD) is less than or greater than 40 μm, the maximum mean effective drop diameter (MED) of Appendix C of this part continuous maximum (stratiform clouds) icing conditions. For this Appendix, supercooled large drop icing conditions consist of freezing drizzle and freezing rain occurring in and/or below stratiform clouds. Part II defines ice accretions used to show compliance with the airplane performance and handling qualities requirements of subpart B of this part.

PART I—METEOROLOGY

In this Appendix icing conditions are defined by the parameters of altitude, vertical and horizontal extent, temperature, liquid water content, and water mass distribution as a function of drop diameter distribution.

(a) Freezing Drizzle (Conditions with spectra maximum drop diameters from 100µm to 500 µm):

(1) Pressure altitude range: 0 to 22,000 feet MSL.

(2) Maximum vertical extent: 12,000 feet.

(3) Horizontal extent: Standard distance of 17.4 nautical miles.

(4) Total liquid water content.

Note: Liquid water content (LWC) in grams per cubic meter (g/m^3) based on horizontal extent standard distance of 17.4 nautical miles.

(5) Drop diameter distribution: Figure 2.

(6) Altitude and temperature envelope: Figure 3.

(b) Freezing Rain (Conditions with spectra maximum drop diameters greater than 500 µm):

(1) Pressure altitude range: 0 to 12,000 ft MSL.

(2) Maximum vertical extent: 7,000 ft.

(3) Horizontal extent: Standard distance of 17.4 nautical miles.

(4) Total liquid water content.

Note: LWC in grams per cubic meter (g/m^3) based on horizontal extent standard distance of 17.4 nautical miles.

(5) Drop Diameter Distribution: Figure 5.

(6) Altitude and temperature envelope: Figure 6.

(c) Horizontal extent.

The liquid water content for freezing drizzle and freezing rain conditions for horizontal extents other than the standard 17.4 nautical miles can be determined by the value of the liquid water content determined from Figure 1 or Figure 4, multiplied by the factor provided in Figure 7, which is defined by the following equation:

$S = 1.266 - 0.213 \log10(H)$

Where:

S = Liquid Water Content Scale Factor (dimensionless) and

H = horizontal extent in nautical miles

BILLING CODE 4910–13–P

FIGURE 1 — Appendix O, Freezing Drizzle, Liquid Water Content

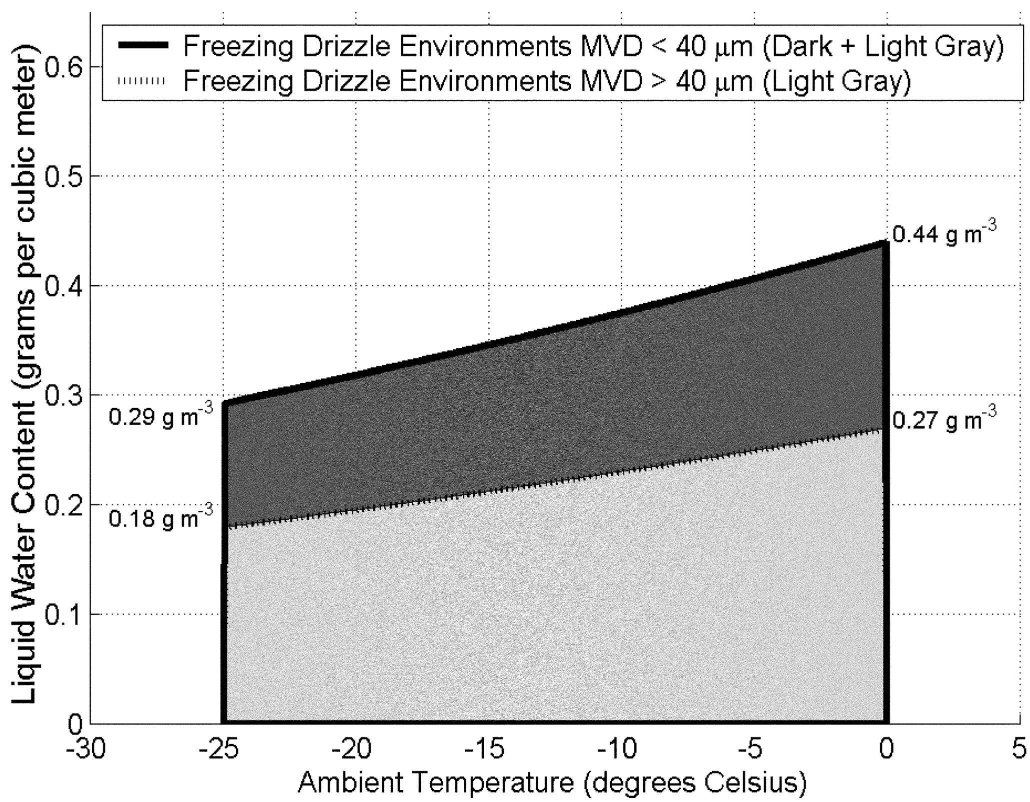


FIGURE 2 — Appendix O, Freezing Drizzle, Drop Diameter Distribution

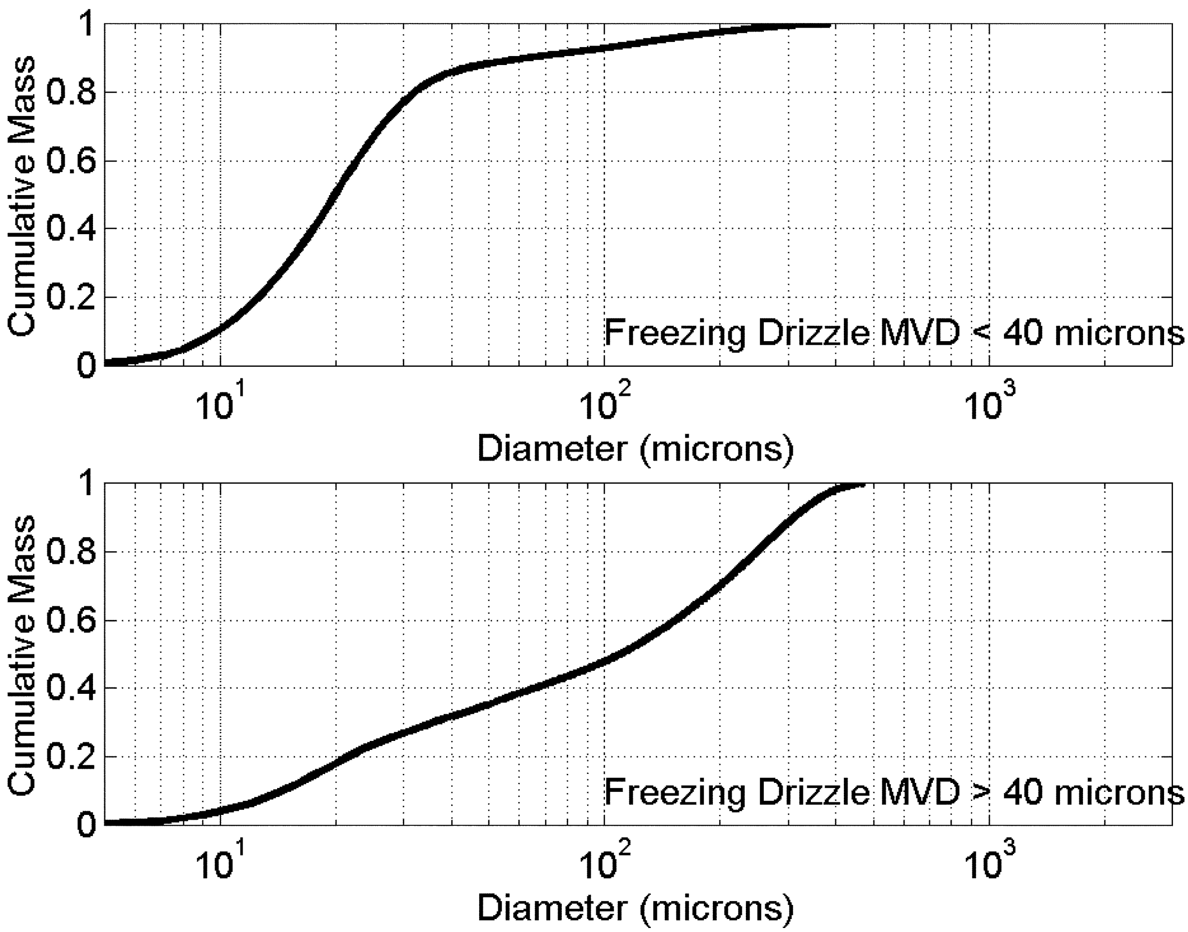


FIGURE 3 — Appendix O, Freezing Drizzle, Temperature and Altitude

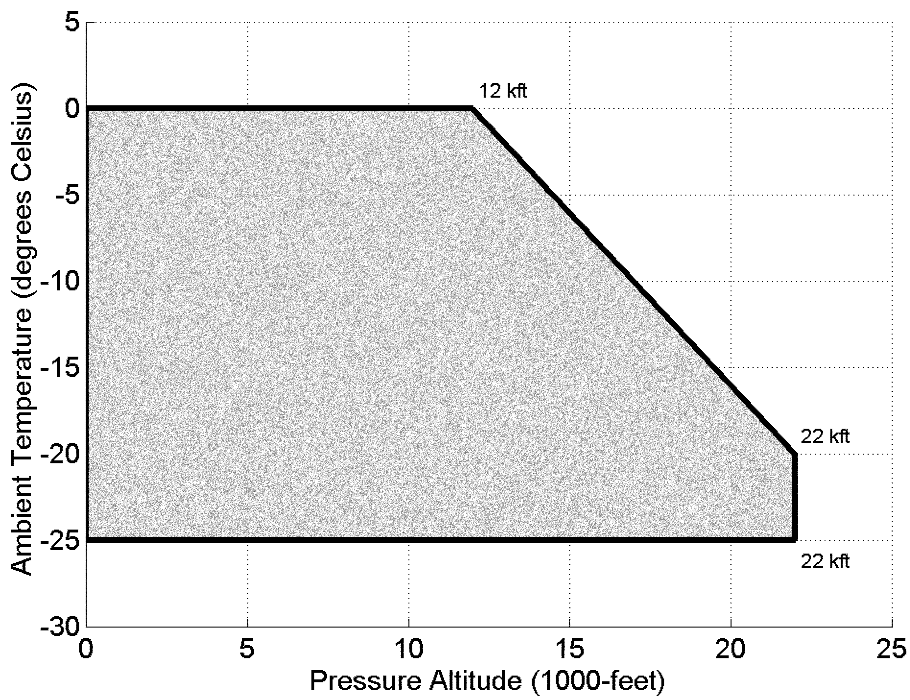


FIGURE 4 — Appendix O, Freezing Rain, Liquid Water Content

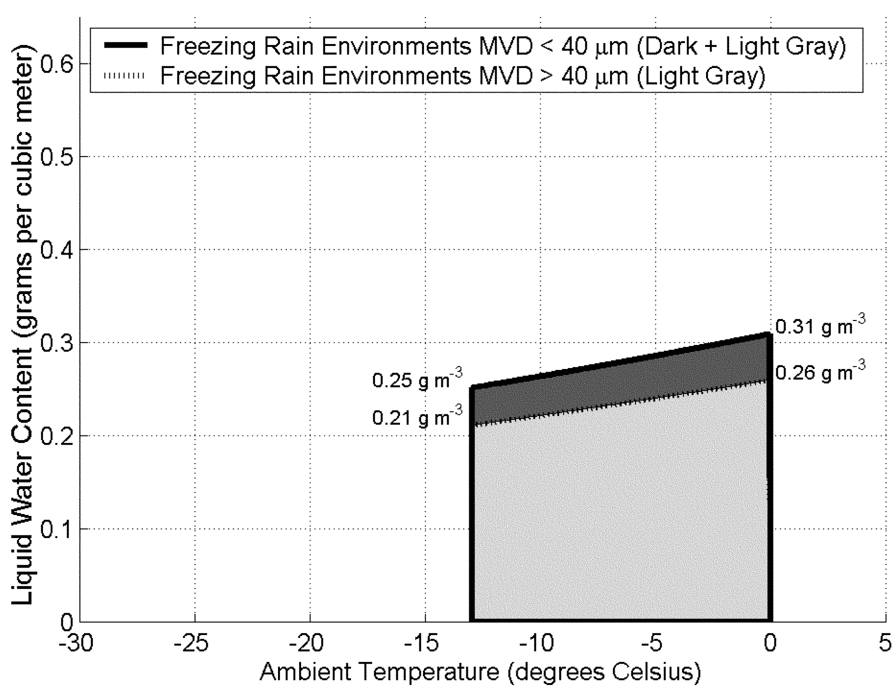


FIGURE 5 — Appendix O, Freezing Rain, Drop Diameter Distribution

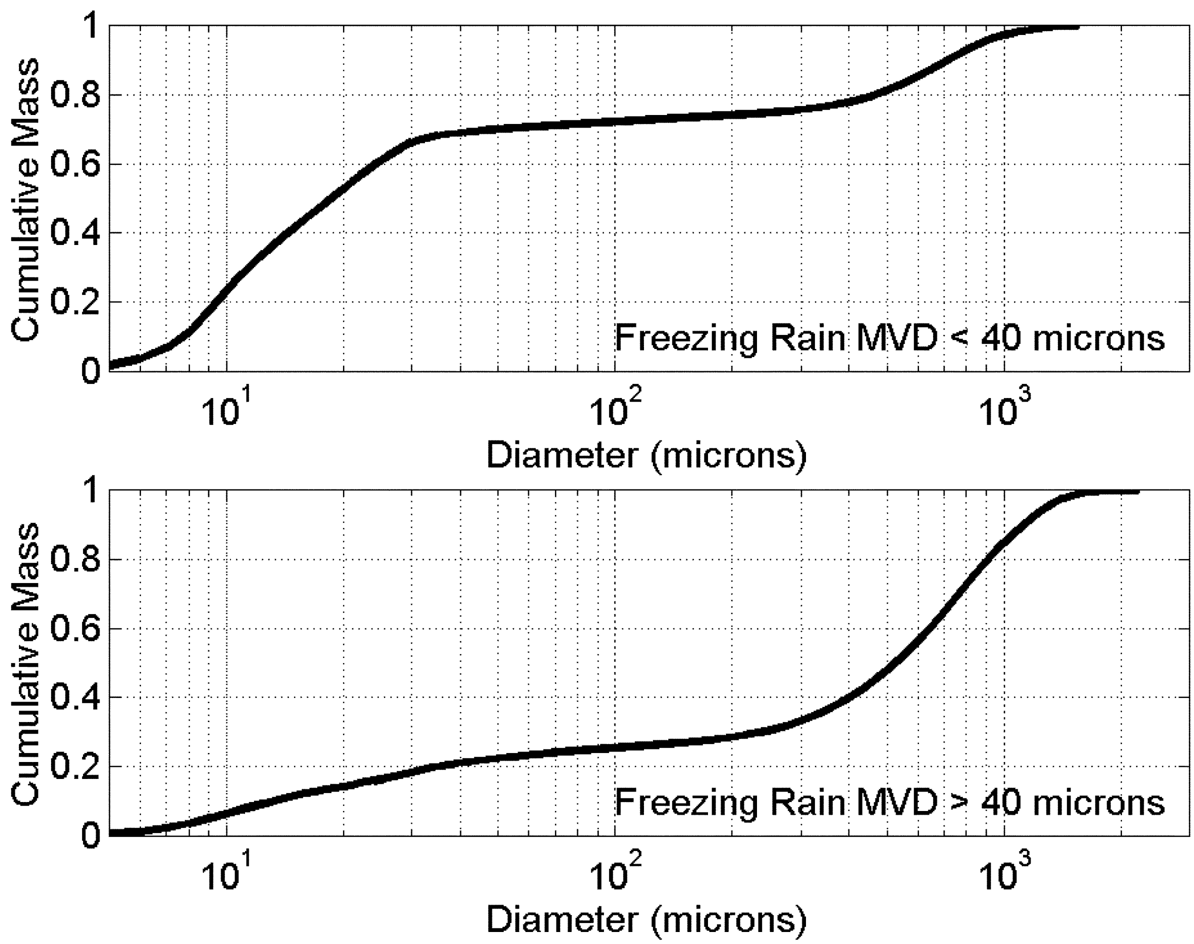


FIGURE 6 — Appendix O, Freezing Rain, Temperature and Altitude

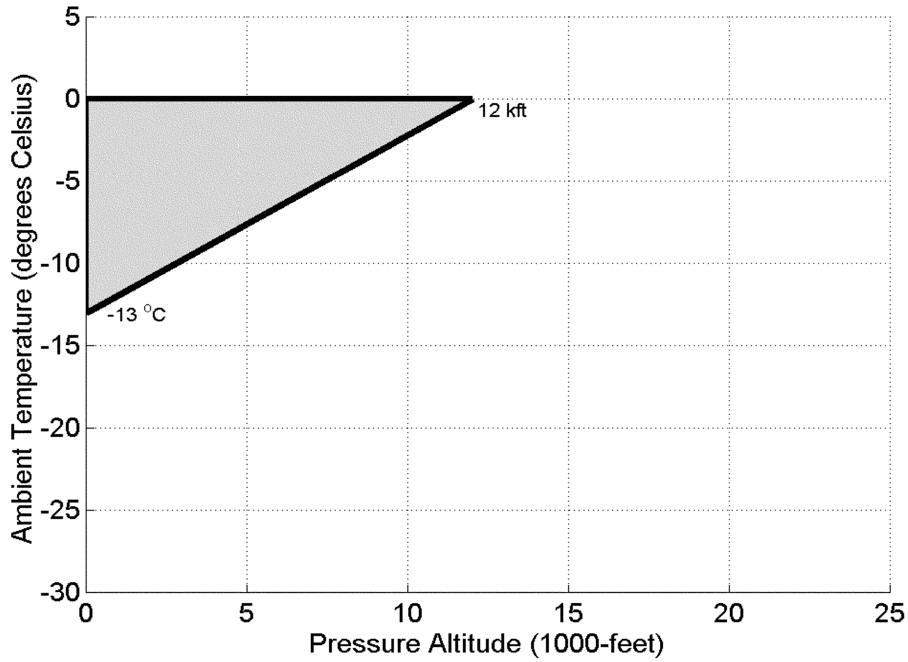
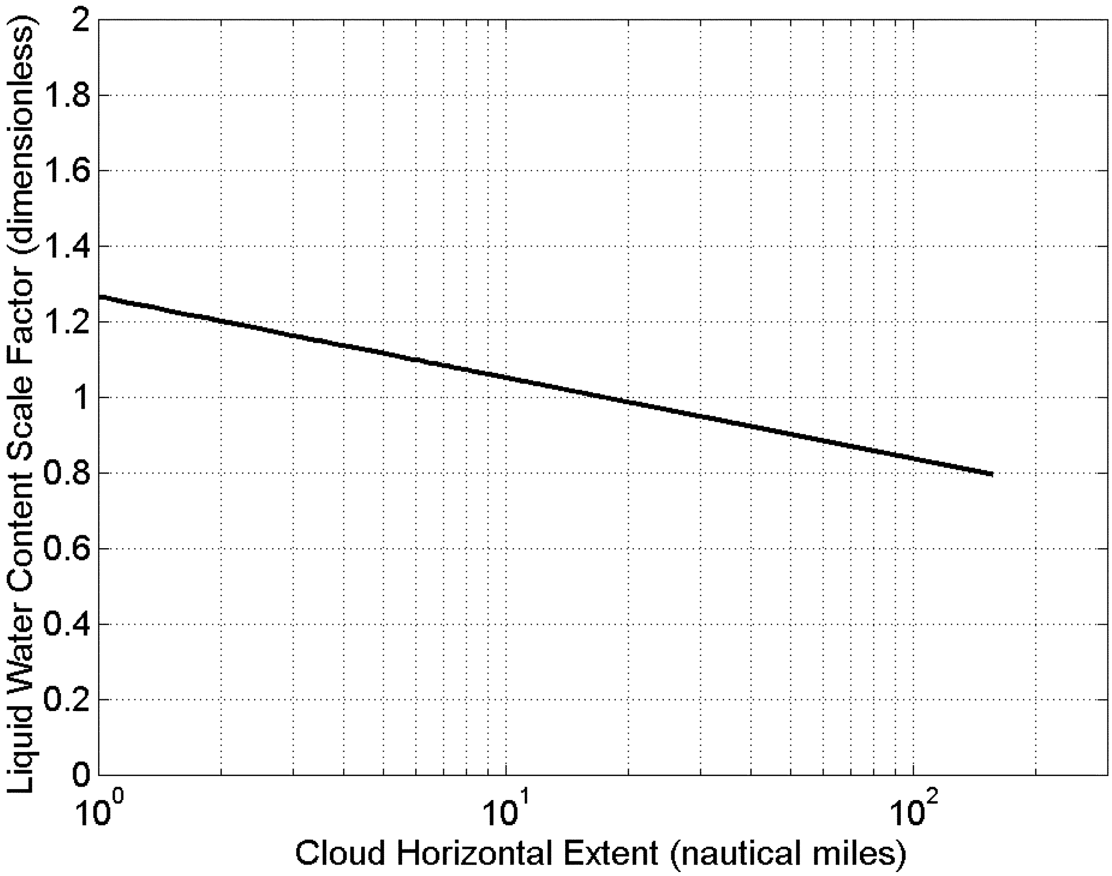


FIGURE 7 — Appendix O, Horizontal Extent, Freezing Drizzle and Freezing Rain



BILLING CODE 4910–13–C

PART II—AIRFRAME ICE ACCRETIONS FOR SHOWING COMPLIANCE WITH SUBPART B OF THIS PART

(a) *General.*

The most critical ice accretion in terms of airplane performance and handling qualities for each flight phase must be used to show compliance with the applicable airplane performance and handling qualities requirements for icing conditions contained in subpart B of this part. Applicants must demonstrate that the full range of atmospheric icing conditions specified in part I of this Appendix have been considered, including drop diameter distributions, liquid water content, and temperature appropriate to the flight conditions (for example, configuration, speed, angle of attack, and altitude).

(1) For an airplane certified in accordance with § 25.1420(a)(1), the ice accretions for each flight phase are defined in part II, paragraph (b) of this Appendix.

(2) For an airplane certified in accordance with § 25.1420(a)(2), the most critical ice accretion for each flight phase defined in part II, paragraphs (b) and (c) of this Appendix, must be used. For the ice accretions defined in part II, paragraph (c) of this Appendix, only the portion of part I of this Appendix in which the airplane is capable of operating safely must be considered.

(3) For an airplane certified in accordance with § 25.1420(a)(3), the ice accretions for each flight phase are defined in part II, paragraph (c) of this Appendix.

(b) Ice accretions for airplanes certified in accordance with § 25.1420(a)(1) or (2).

(1) *En route ice* is the en route ice as defined by part II, paragraph (c)(3), of this Appendix, for an airplane certified in accordance with § 25.1420(a)(2), or defined by part II, paragraph (a)(3), of Appendix C of this part, for an airplane certified in accordance with § 25.1420(a)(1), plus:

(i) Pre-detection ice as defined by part II, paragraph (b)(5), of this Appendix; and

(ii) The ice accumulated during the transit of one cloud with a horizontal extent of 17.4 nautical miles in the most critical of the icing conditions defined in part I of this Appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in Appendix C of this part.

(2) *Holding ice* is the holding ice defined by part II, paragraph (c)(4), of this Appendix, for an airplane certified in accordance with § 25.1420(a)(2), or defined by part II, paragraph (a)(4), of Appendix C of this part, for an airplane certified in accordance with § 25.1420(a)(1), plus:

(i) Pre-detection ice as defined by part II, paragraph (b)(5), of this Appendix; and

(ii) The ice accumulated during the transit of one cloud with a 17.4 nautical miles horizontal extent in the most critical of the icing conditions defined in part I of this Appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in Appendix C of this part.

(iii) Except the total exposure to holding ice conditions does not need to exceed 45 minutes.

(3) *Approach ice* is the more critical of the holding ice defined by part II, paragraph (b)(2), of this Appendix, or the ice calculated in the applicable paragraphs (b)(3)(i) or (ii) of part II, of this Appendix:

(i) For an airplane certified in accordance with § 25.1420(a)(2), the ice accumulated during descent from the maximum vertical extent of the icing conditions defined in part I of this Appendix to 2,000 feet above the landing surface in the cruise configuration, plus transition to the approach configuration, plus:

(A) Pre-detection ice, as defined by part II, paragraph (b)(5), of this Appendix; and

(B) The ice accumulated during the transit at 2,000 feet above the landing surface of one cloud with a horizontal extent of 17.4 nautical miles in the most critical of the icing conditions defined in part I of this Appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in Appendix C of this part.

(ii) For an airplane certified in accordance with § 25.1420(a)(1), the ice accumulated during descent from the maximum vertical extent of the maximum continuous icing conditions defined in part I of Appendix C to 2,000 feet above the landing surface in the cruise configuration, plus transition to the approach configuration, plus:

(A) Pre-detection ice, as defined by part II, paragraph (b)(5), of this Appendix; and

(B) The ice accumulated during the transit at 2,000 feet above the landing surface of one cloud with a horizontal extent of 17.4 nautical miles in the most critical of the icing conditions defined in part I of this Appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in Appendix C of this part.

(4) *Landing ice* is the more critical of the holding ice as defined by part II, paragraph (b)(2), of this Appendix, or the ice calculated in the applicable paragraphs (b)(4)(i) or (ii) of part II of this Appendix:

(i) For an airplane certified in accordance with § 25.1420(a)(2), the ice accretion defined by part II, paragraph (c)(5)(i), of this Appendix, plus a descent from 2,000 feet above the landing surface to a height of 200 feet above the landing surface with a transition to the landing configuration in the icing conditions defined in part I of this Appendix, plus:

(A) Pre-detection ice, as defined in part II, paragraph (b)(5), of this Appendix; and

(B) The ice accumulated during an exit maneuver, beginning with the minimum climb gradient required by § 25.119, from a height of 200 feet above the landing surface through one cloud with a horizontal extent of 17.4 nautical miles in the most critical of the icing conditions defined in part I of this Appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in Appendix C of this part.

(ii) For an airplane certified in accordance with § 25.1420(a)(1), the ice accumulated in the maximum continuous icing conditions defined in Appendix C of this part, during a descent from the maximum vertical extent of the icing conditions defined in Appendix C of this part, to 2,000 feet above the landing surface in the cruise configuration, plus transition to the approach configuration and flying for 15 minutes at 2,000 feet above the landing surface, plus a descent from 2,000 feet above the landing surface to a height of 200 feet above the landing surface with a transition to the landing configuration, plus:

(A) Pre-detection ice, as described by part II, paragraph (b)(5), of this Appendix; and

(B) The ice accumulated during an exit maneuver, beginning with the minimum climb gradient required by § 25.119, from a height of 200 feet above the landing surface through one cloud with a horizontal extent of 17.4 nautical miles in the most critical of the icing conditions defined in part I of this Appendix and one cloud with a horizontal extent of 17.4 nautical miles in the continuous maximum icing conditions defined in Appendix C of this part.

(5) *Pre-detection ice* is the ice accretion before detection of flight conditions in this Appendix that require exiting per § 25.1420(a)(1) and (2). It is the pre-existing ice accretion that may exist from operating in icing conditions in which the airplane is approved to operate prior to encountering the icing conditions requiring an exit, plus the ice accumulated during the time needed to detect the icing conditions, followed by two minutes of further ice accumulation to take into account the time for the flightcrew to take action to exit the icing conditions, including coordination with air traffic control.

(i) For an airplane certified in accordance with § 25.1420(a)(1), the pre-existing ice accretion must be based on the icing conditions defined in Appendix C of this part.

(ii) For an airplane certified in accordance with § 25.1420(a)(2), the pre-existing ice accretion must be based on the more critical of the icing conditions defined in Appendix C of this part, or the icing conditions defined in part I of this Appendix in which the airplane is capable of safely operating.

(c) *Ice accretions for airplanes certified in accordance with §§ 25.1420(a)(2) or (3).* For an airplane certified in accordance with § 25.1420(a)(2), only the portion of the icing conditions of part I of this Appendix in which the airplane is capable of operating safely must be considered.

(1) *Takeoff ice* is the most critical ice accretion on unprotected surfaces, and any ice accretion on the protected surfaces, occurring between the end of the takeoff distance and 400 feet above the takeoff surface, assuming accretion starts at the end of the takeoff distance in the icing conditions defined in part I 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 either 1,500 feet above the takeoff surface, or the height at which the transition from the takeoff to the en route configuration is completed and V_{FTO} is reached, whichever is higher. Ice accretion is assumed to start at the end of the takeoff distance in the icing conditions defined in part I of this Appendix.

(3) *En route ice* is the most 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 flight phase in the icing conditions defined in part I of this Appendix.

(4) *Holding ice* is the most critical ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from 45 minutes of flight within a cloud with a 17.4 nautical miles horizontal extent in the icing conditions defined in part I of this Appendix, during the holding phase of flight.

(5) *Approach ice* is the ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from the more critical of the:

(i) Ice accumulated in the icing conditions defined in part I of this Appendix during a descent from the maximum vertical extent of the icing conditions defined in part I of this Appendix, to 2,000 feet above the landing surface in the cruise configuration, plus transition to the approach configuration and flying for 15 minutes at 2,000 feet above the landing surface; or

(ii) Holding ice as defined by part II, paragraph (c)(4), of this Appendix.

(6) *Landing ice* is the ice accretion on the unprotected surfaces, and any ice accretion on the protected surfaces appropriate to normal ice protection system operation, resulting from the more critical of the:

(i) Ice accretion defined by part II, paragraph (c)(5)(i), of this Appendix, plus ice accumulated in the icing conditions defined in part I of this Appendix during a descent from 2,000 feet above the landing surface to a height of 200 feet above the landing surface with a transition to the landing configuration, followed by a go-around at the minimum climb gradient required by § 25.119, from a height of 200 feet above the landing surface to 2,000 feet above the landing surface, flying for 15 minutes at 2,000 feet above the landing surface in the approach configuration, and a descent to the landing surface (touchdown) in the landing configuration; or

(ii) Holding ice as defined by part II, paragraph (c)(4), of this Appendix.

(7) For both unprotected and protected parts, the ice accretion for the takeoff phase must be determined for the icing conditions defined in part I of this Appendix, using the following assumptions:

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

(ii) The ice accretion starts at the end of the takeoff distance;

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

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

(v) 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.

(d) The ice accretion before the ice protection system has been activated and is performing its intended function is the critical ice accretion formed on the unprotected and normally protected surfaces before activation and effective operation of the ice protection system in the icing conditions defined in part I of this Appendix. This ice accretion only applies in showing compliance to §§ 25.143(j) and 25.207(h).

(e) 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 this Appendix may be used for any other flight phase if it is shown to be at least as critical as the specific ice accretion defined for that flight phase. Configuration differences and their effects on ice accretions must be taken into account.

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

PART 33—AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

■ 25. The authority citation for part 33 is revised to read as follows:

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

■ 26. Revise § 33.68 to read as follows:

§ 33.68 Induction system icing.

Each engine, with all icing protection systems operating, must:

(a) Operate throughout its flight power range, including the minimum descent idle rotor speeds achievable in flight, in the icing conditions defined for turbojet, turbofan, and turboprop engines in Appendices C and O of part 25 of this chapter, and Appendix D of this part, and for turboshaft engines in Appendix C of part 29 of this chapter, without the accumulation of ice on the engine components that:

(1) Adversely affects engine operation or that causes an unacceptable permanent loss of power or thrust or unacceptable increase in engine operating temperature; or

(2) Results in unacceptable temporary power loss or engine damage; or

(3) Causes a stall, surge, or flameout or loss of engine controllability. The applicant must account for in-flight ram effects in any critical point analysis or test demonstration of these flight conditions.

(b) Operate throughout its flight power range, including minimum descent idle rotor speeds achievable in flight, in the icing conditions defined for turbojet, turbofan, and turboprop engines in Appendices C and O of part 25 of this chapter, and for turboshaft engines in Appendix C of part 29 of this chapter. In addition:

(1) It must be shown through Critical Point Analysis (CPA) that the complete ice envelope has been analyzed, and that the most critical points must be demonstrated by engine test, analysis, or a combination of the two to operate acceptably. Extended flight in critical flight conditions such as hold, descent, approach, climb, and cruise, must be addressed, for the ice conditions defined in these appendices.

(2) It must be shown by engine test, analysis, or a combination of the two that the engine can operate acceptably for the following durations:

(i) At engine powers that can sustain level flight: A duration that achieves repetitive, stabilized operation for turbojet, turbofan, and turboprop engines in the icing conditions defined in Appendices C and O of part 25 of this chapter, and for turboshaft engines in the icing conditions defined in Appendix C of part 29 of this chapter.

(ii) At engine power below that which can sustain level flight:

(A) Demonstration in altitude flight simulation test facility: A duration of 10 minutes consistent with a simulated flight descent of 10,000 ft (3 km) in altitude while operating in Continuous Maximum icing conditions defined in Appendix C of part 25 of this chapter for turbojet, turbofan, and turboprop engines, and for turboshaft engines in the icing conditions defined in Appendix C of part 29 of this chapter, plus 40 percent liquid water content margin, at the critical level of airspeed and air temperature; or

(B) Demonstration in ground test facility: A duration of 3 cycles of alternating icing exposure corresponding to the liquid water content levels and standard cloud lengths starting in Intermittent Maximum and then in Continuous Maximum icing conditions defined in Appendix C of part 25 of this chapter for turbojet, turbofan, and turboprop engines, and for turboshaft engines in the icing conditions defined in Appendix C of part 29 of this chapter, at the critical level of air temperature.

(c) In addition to complying with paragraph (b) of this section, the following conditions shown in Table 1 of this section unless replaced by similar CPA test conditions that are more critical or produce an equivalent level of severity, must be demonstrated by an engine test:

TABLE 1—CONDITIONS THAT MUST BE DEMONSTRATED BY AN ENGINE TEST

Condition	Total air temperature	Supercooled water concentrations (minimum)	Median volume drop diameter	Duration
1. Glaze ice conditions	21 to 25 °F (-6 to -4 °C)	2 g/m³	25 to 35 microns	(a) 10-minutes for power below sustainable level flight (idle descent). (b) Must show repetitive, stabilized operation for higher powers (50%, 75%, 100%MC).
2. Rime ice conditions	-10 to 0 °F (-23 to -18 °C)	1 g/m³	15 to 25 microns	(a) 10-minutes for power below sustainable level flight (idle descent). (b) Must show repetitive, stabilized operation for higher powers (50%, 75%, 100%MC).
3. Glaze ice holding conditions. (Turbojet, turbofan, and turboprop only).	Turbojet and Turbofan, only: 10 to 18 °F (-12 to -8 °C).	Alternating cycle: First 1.7 g/m³ (1 minute), Then 0.3 g/m³ (6 minute).	20 to 30 microns	Must show repetitive, stabilized operation (or 45 minutes max).
	Turboprop, only: 2 to 10 °F (-17 to -12 °C).	....	....	
4. Rime ice holding conditions. (Turbojet, turbofan, and turboprop only).	Turbojet and Turbofan, only: -10 to 0 °F (-23 to -18 °C).	0.25 g/m³	20 to 30 microns	Must show repetitive, stabilized operation (or 45 minutes max).
	Turboprop, only: 2 to 10 °F (-17 to -12 °C).	....	....	

(d) Operate at ground idle speed for a minimum of 30 minutes at each of the following icing conditions shown in Table 2 of this section with the available air bleed for icing protection at its critical condition, without adverse effect, followed by acceleration to takeoff power or thrust. During the idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator. Analysis may be used to show ambient temperatures below the tested temperature are less critical. The applicant must document any demonstrated run ups and minimum ambient temperature capability in the engine operating manual as mandatory in icing conditions. The applicant must demonstrate, with consideration of expected airport elevations, the following:

TABLE 2—DEMONSTRATION METHODS FOR SPECIFIC ICING CONDITIONS

Condition	Total air temperature	Supercooled water concentrations (minimum)	Mean effective particle diameter	Demonstration
1. Rime ice condition	0 to 15 °F (-18 to -9 °C)	Liquid—0.3 g/m³	15–25 microns	By engine test.
2. Glaze ice condition	20 to 30 °F (-7 to -1 °C)	Liquid—0.3 g/m³	15–25 microns	By engine test.
3. Snow ice condition	26 to 32 °F (-3 to 0 °C)	Ice—0.9 g/m³	100 microns (minimum)	By test, analysis or combination of the two.
4. Large drop glaze ice condition (Turbojet, turbofan, and turboprop only).	15 to 30 °F (-9 to -1 °C)	Liquid—0.3 g/m³	100 microns (minimum).	By test, analysis or combination of the two.

(e) Demonstrate by test, analysis, or combination of the two, acceptable operation for turbojet, turbofan, and turboprop engines in mixed phase and ice crystal icing conditions throughout Appendix D of this part, icing envelope throughout its flight power range, including minimum descent idling speeds.

■ 27. Amend § 33.77 by adding paragraph (a) and revising paragraphs (c) introductory text, (c)(1), (d), and (e) to read as follows:

§ 33.77 Foreign object ingestion ice.

(a) Compliance with the requirements of this section must be demonstrated by engine ice ingestion test or by validated analysis showing equivalence of other means for demonstrating soft body damage tolerance.

* * * * *

(c) Ingestion of ice under the conditions of this section may not—

(1) Cause an immediate or ultimate unacceptable sustained power or thrust loss; or

* * * * *

(d) For an engine that incorporates a protection device, compliance with this section need not be demonstrated with respect to ice formed forward of the protection device if it is shown that—

(1) Such ice is of a size that will not pass through the protective device;

(2) The protective device will withstand the impact of the ice; and

(3) The ice stopped by the protective device will not obstruct the flow of induction air into the engine with a resultant sustained reduction in power or thrust greater than those values defined by paragraph (c) of this section.

(e) Compliance with the requirements of this section must be demonstrated by engine ice ingestion test under the following ingestion conditions or by validated analysis showing equivalence of other means for demonstrating soft body damage tolerance.

(1) The minimum ice quantity and dimensions will be established by the engine size as defined in Table 1 of this section.

(2) The ingested ice dimensions are determined by linear interpolation between table values, and are based on the actual engine's inlet hilite area.

(3) The ingestion velocity will simulate ice from the inlet being sucked into the engine.

(4) Engine operation will be at the maximum cruise power or thrust unless lower power is more critical.

TABLE 1—MINIMUM ICE SLAB DIMENSIONS BASED ON ENGINE INLET SIZE

Engine Inlet Hilite area (sq. inch)	Thickness (inch)	Width (inch)	Length (inch)
0	0.25	0	3.6
80	0.25	6	3.6
300	0.25	12	3.6
700	0.25	12	4.8
2800	0.35	12	8.5
5000	0.43	12	11.0
7000	0.50	12	12.7
7900	0.50	12	13.4
9500	0.50	12	14.6
11300	0.50	12	15.9
13300	0.50	12	17.1
16500	0.5	12	18.9
20000	0.5	12	20.0

Appendix C [Added and Reserved]

■ 28. Amend part 33 by adding and reserving a new Appendix C.

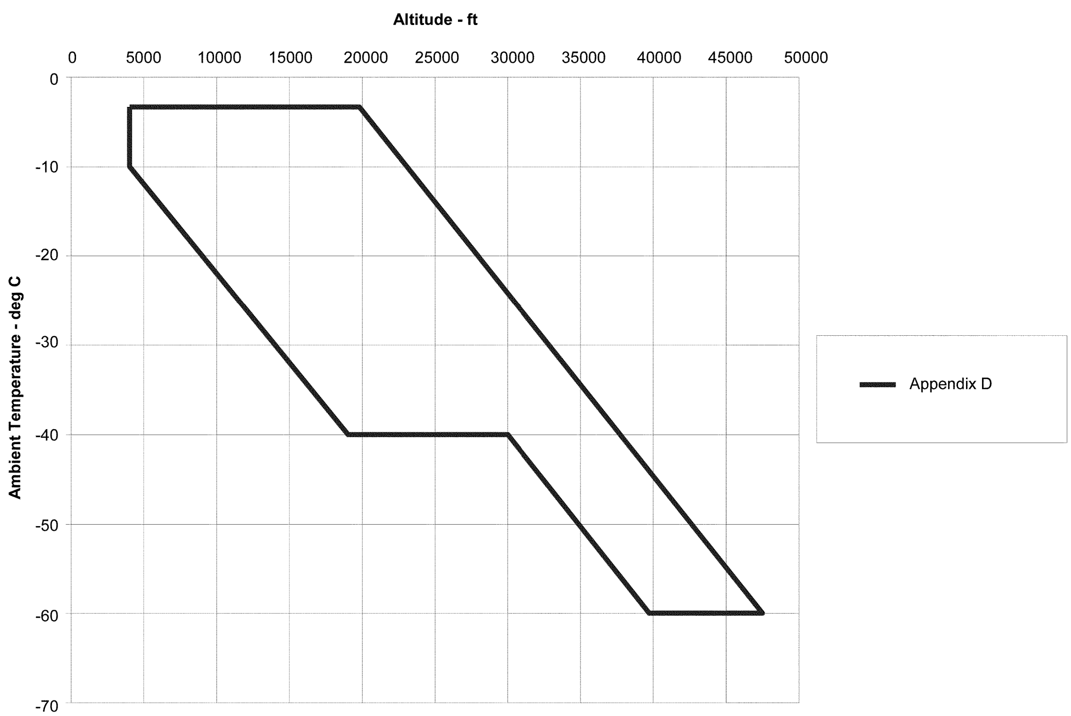
■ 29. Amend part 33 by adding a new Appendix D to read as follows:

Appendix D to Part 33—Mixed Phase and Ice Crystal Icing Envelope (Deep Convective Clouds)

The ice crystal icing envelope is depicted in Figure D1 of this Appendix.

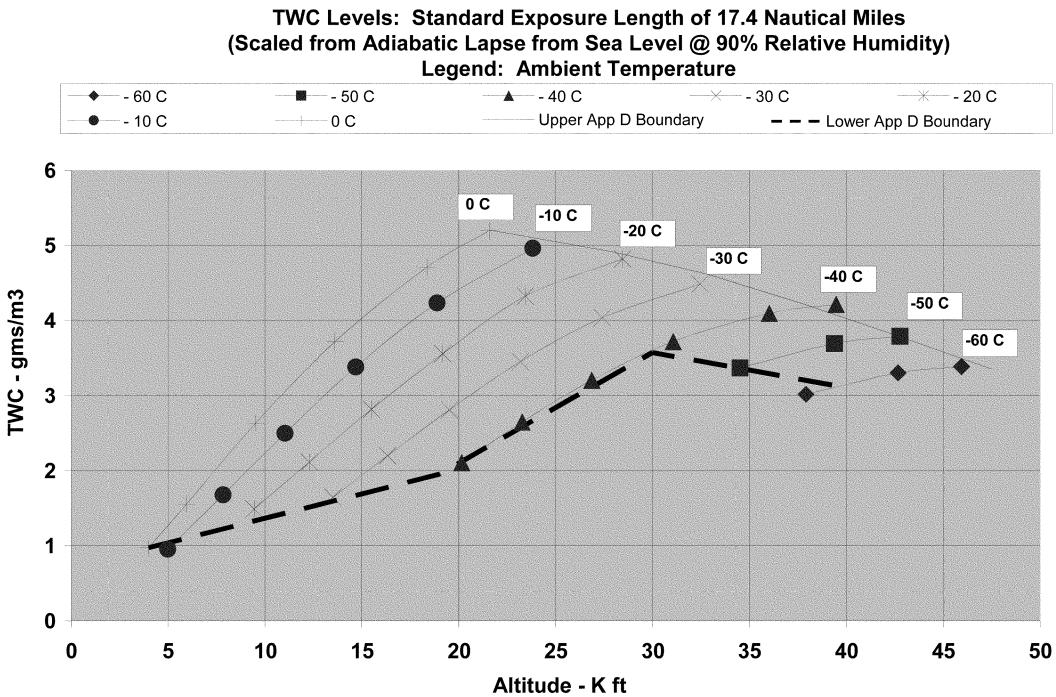
BILLING CODE 4910–13–P

FIGURE D1 — Convective Cloud Ice Crystal Envelope



Within the envelope, total water content (TWC) in g/m³ has been determined based upon the adiabatic lapse defined by the convective rise of 90% relative humidity air from sea level to higher altitudes and scaled by a factor of 0.65 to a standard cloud length of 17.4 nautical miles. Figure D2 of this Appendix displays TWC for this distance over a range of ambient temperature within the boundaries of the ice crystal envelope specified in Figure D1 of this Appendix.

FIGURE D2 — Total Water Content



Ice crystal size median mass dimension (MMD) range is 50–200 microns (equivalent spherical size) based upon measurements near convective storm cores.

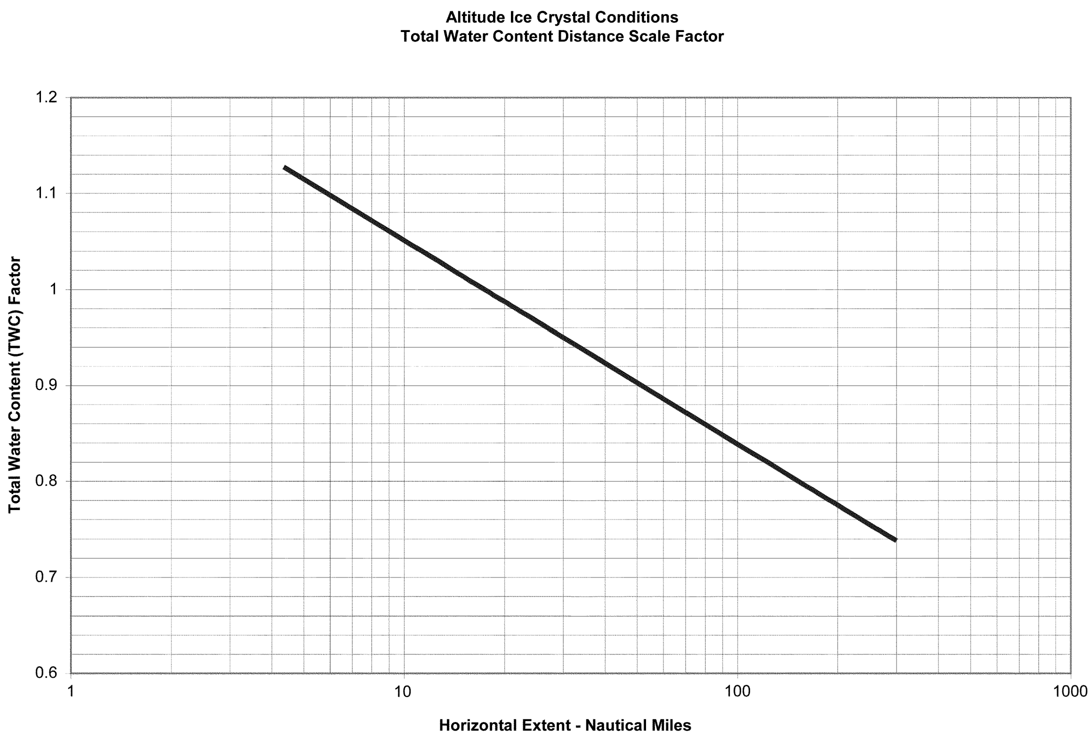
The TWC can be treated as completely glaciated (ice crystal) except as noted in the Table 1 of this Appendix.

TABLE 1—SUPERCOOLED LIQUID PORTION OF TWC

Temperature range—deg C	Horizontal cloud length—nautical miles	LWC—g/m³
0 to −20	≤50	≤1.0
0 to −20	Indefinite	≤0.5
< −20		0

The TWC levels displayed in Figure D2 of this Appendix represent TWC values for a standard exposure distance (horizontal cloud length) of 17.4 nautical miles that must be adjusted with length of icing exposure.

FIGURE D3 — Exposure Length Influence on TWC



Issued under authority provided by 49 U.S.C. 106(f) and 44701(a) in Washington, DC, on October 22, 2014.

Michael P. Huerta,

Administrator.

[FR Doc. 2014–25789 Filed 11–3–14; 8:45 am]

BILLING CODE 4910–13–C