Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Engine Harmonization Working Group

Task 1 -- Bird Ingestion

Task Assignment

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Subcommittee; Propulsion Harmonization Working Group

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of establishment of Propulsion Harmonization Working Group.

SUMMARY: Notice is given of the establishment of the Propulsion Harmonization Working Group of the Transport Airplane and Engine Subcommittee. This notice informs the public of the activities of the Transport Airplane and Engine Subcommittee of the Aviation Rulemaking Advisory Committee.

FOR FURTHER INFORMATION CONTACT: Mr. William J. (Joe) Sullivan, Executive Director, Transport Airplane and Engine Subcommittee, Aircraft Certification Service (AIR-3), 800 Independence Avenue SW., Washington, DC 20591, Telephone: (202) 267-9554; FAX: (202) 267-5364.

SUPPLEMENTARY INFORMATION: The Federal Aviation Administration (FAA) established an Aviation Rulemaking Advisory Committee (56 FR 2190, January 22, 1991) which held its first meeting on May 23, 1991 (56 FR 20492, May 3, 1991). The Transport Airplane and Engine Subcommittee was established at that meeting to provide advice and recommendations to the Director, Aircraft Certification Service, FAA, regarding the airworthiness standards for transport airplanes, engines and propellers in parts 25, 33, and 35 of the Federal Aviation Regulations (14 CFR parts 25, 33, and 35).

The FAA announced at the Joint Aviation Authorities (JAA)—Federal Aviation Administration (FAA) Harmonization Conference in Toronto, Ontario, Canada, (June 2–5, 1992) that it would consolidate within the Aviation Rulemaking Advisory Committee structure an ongoing objective to "harmonize" the Joint Aviation Requirements (JAR) and the Federal Aviation Regulations (FAR). Coincident with that announcement, the FAA assigned to the Transport Airplane and Engine Subcommittee those projects related to JAR/FAR 25, 33, and 35 harmonization which were then in the process of being coordinated between the JAA and the FAA. The harmonization process included the intention to present the results of JAA/FAA coordination to the public in the form of either a Notice of Proposed Rulemaking or an advisory circular—an objective comparable to and compatible with that assigned to the Aviation Rulemaking Advisory Committee. The transport Airplane and Engine Subcommittee, consequently, established the Propulsion Harmonization Working Group.

Specifically, the Working Group's tasks are the following: The Propulsion Harmonization Working Group is charged with making recommendations to the Transport Airplane and Engine Subcommittee concerning the FAA disposition of the following subjects recently coordinated between the JAA and the FAA:

Task 1—Bird Ingestion: Update turbine engine bird ingestion requirements, including size and number of birds and pass/fail criteria (FAR 33.77)

Task 2—Inclement Weather: Update the inclement weather requirements for rain and hail in turbine engines (FAR 33.77).

Task 3—Vibration Surveys: Determine test requirements and pass/Fail criteria for turbine engine vibration tests (FAR 33.83).

Task 4—Rotor Integrity: Determine test requirements and pass/fail criteria for turbine, compressor, fan, and turbosupercharger rotor overspeed tests (FAR 33.27).

Task 5—Turbine Rotor Overtemperature: Clarify test and pass/fail requirements for turbine engine overtemperature tests to assure consistent certification criteria (FAR 33.88).

Task 6—Windmilling: Exmaine current turbine engine windmilling requirements and specify appropriate test and analysis requirements (FAR 33.92).

Reports:

A. Recommend time line(s) for completion of each task, including rationale, for Subcommittee consideration at the meeting of the subcommittee held following publication of this notice.

B. Give a detailed conceptual presentation on each task to the Subcommittee before proceeding with the work stated under items C and D, below. If task 1–6 require the development of more than one Notice of Proposed Rulemaking, identify what proposed amendments will be included in each notice.

C. Draft a Notice of Proposed Rulemaking for tasks 1–6 proposing new or revised requirements, a supporting economic analysis, and other required analysis, with any other collateral documents (such as Advisory Circulars) the Working Group determines to be needed.

D. Give a status report on each task at each meeting of the Subcommittee.

The Propulsion Harmonization Working Group will be comprised of experts from those organizations having an interest in the tasks assigned. A working Group member need not necessarily be a representative of one of the organizations of the parent Transport Airplane and Engine Subcommittee or of the full Aviation Rulemaking Advisory Committee. An individual who has expertise in the subject matter and wishes to become a member of the Working Group should *write* the person listed under the caption **FOR FURTHER INFORMATION CONTACT** expressing that desire, describing his or her interest in the task, and the expertise he or she would bring to the Working Group. The request will be reviewed with the Subcommittee and Working Group Chairs and the individual will be advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the information and use of the Aviation Rulemaking Advisory Committee and its subcommittees are necessary in the public interest in connection with the performance of duties of the FAA by law. Meetings of the full Committee and any subcommittees will be open to the public except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Propulsion Harmonization Working Group will not be open to the public except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of Working Group meetings will be made.

Issued in Washington, DC, on December 4, 1992.

William J. Sullivan,

Executive Director, Transport Airplane and Engine Subcommittee, Aviation Rulemaking Advisory Committee.

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Recommendation

Date: 13 DECEMBER 1996

Revision: 11

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DRAFT NPRM FOR BIRD INGESTION

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 33

[Docket No. XXXXX; Notice No. XX-XXX]

RIN NO. XXXX

Airworthiness Standards; Bird Ingestion Standards

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This notice proposes to amend the bird ingestion type certification standards for aircraft turbine engines. This proposal revises the bird ingestion standards to reflect recent analyses defining the actual bird threat encountered in service by turbine engines. This proposal also harmonizes the FAA's type certification standards on this issue with requirements being drafted by the Joint Aviation Authorities (JAA). The proposed changes, if adopted, would establish nearly uniform bird ingestion standards for aircraft turbine engines certified in the United States under 14 CFR part 33 (part 33) and in the JAA countries under Joint Aviation Requirements, simplifying airworthiness approvals for import and export.

DATES: Comments to be submitted on or before [Insert date 90 days after the date of publication in the Federal Register].

ADDRESSES: Comments on this notice should be mailed in triplicate to: Federal Aviation Administration, Office of the Chief Counsel, Attention: Rules Docket (AGC-10), Docket No. , 800 Independence Avenue, SW., Washington, DC 20591. Comments delivered must be

marked Docket No. . Comments may be inspected in Room 915G weekdays between 9:00 a.m. and 5:00 p.m., except on Federal holidays.

FOR FURTHER INFORMATION CONTACT: Marc Bouthillier, Engine and Propeller Standards Staff, ANE-110, Engine and Propeller Directorate, Aircraft Certification Service, FAA, New England Region, 12 New England Executive Park, Burlington, Massachusetts 01803-5299; telephone (617) 238-7120; fax (617) 238-7199.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to submit written data, views, or arguments on this proposed rule. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this notice are also invited. Substantive comments should be accompanied by cost estimates. Comments should identify the regulatory docket number and should be submitted in triplicate to the Rules Docket address specified above. All comments received on or before the closing date for comments specified will be considered by the Administrator before taking action on this proposed rulemaking. The proposals contained in this notice may be changed in light of comments received. All comments received will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons. A report summarizing each substantive public contact with Federal Aviation Administration (FAA) personnel concerned with this rulemaking will be filed in the docket. Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this notice must include a pre addressed, stamped postcard on which the following statement is made: "Comments to Docket No. ." The postcard will be date stamped and mailed to the commenter.

Availability of NPRMs

Any person may obtain a copy of this NPRM by submitting a request to the Federal Aviation Administration, Office of Public Affairs, Attention: Public Inquiry Center, APA-200,

800 Independence Avenue, SW., Washington, DC 20591, or by calling (202) 267-3484. Communications must identify the Notice Number of this NPRM.

Persons interested in being placed on the mailing list for future NPRMs should request, from the above office, a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

Background

Statement of the Problem

In 1976 the National Transportation Safety Board (NTSB), in response to an accident involving a wide bodied aircraft that may have experienced multiple bird ingestion into the engines, issued safety recommendation A-76-64, recommending the FAA, "amend 14 CFR 33.77 to increase the maximum number of birds in the various size categories required to be ingested into turbine engines with large inlets". Safety recommendation A-76-64 also stated, "these increased numbers and sizes should be consistent with the birds ingested during service experience of these engines." As a result of this recommendation, the FAA sponsored an industry wide study of the types, sizes, and quantities of birds, and their resulting effects, that had been ingested into aircraft turbine engines of all sizes. Following this data collection period, the FAA requested the Aerospace Industries Association (AIA) to analyze the data and resulting damage to the engines, and to report back to the FAA . Based on that report, the FAA determined the actions to be taken as well as the disposition of the NTSB safety recommendation A-76-64. The FAA found that the regulations then specified as FAR 33.77 should be modified to increase the severity of the bird ingestion testing requirements regarding large high bypass ratio engines. In addition, the FAA found that it should update the design and testing requirements for all engine sizes to reflect the actual numbers and bird sizes being ingested. This effort was adopted as a Federal Aviation Regulation (FAR) Part 33 and Joint Aviation Regulations for engines (JAR-E) harmonization project and was selected as an Aviation Rulemaking Advisory Committee (ARAC) project.

Industry Study

The industry study consisted of FAA sponsored contracts which are summarized in FAA report number DOT/FAA/CT-84/13, dated September 1984. The industry powerplant bird group, consisting of the AIA and AECMA, initially reviewed the historical bird threat and resulting impact to flight safety for a 20 year period through 1987. The data collected represented a cross-section of large high bypass turbofan engines in service during that time period. After collection and review of the available data, an analysis was performed to characterize both the environmental threat (sizes, quantities and occurrence rates) and consequences. The results of this initial data analysis were presented to the FAA in AIA reports dated October 17, 1986 and November 10, 1988. The results of the analysis were compared to the historical design standards and certification bases for the family of engines comprised in the data base. Subsequent to the above described data collection and analysis, additional data was collected and analyzed for small and medium sized turbine engines which were not represented within the initial database. This data is contained within FAA Technical Center reports dated December 1990 & 1991, and July 1992. The above described data were combined to form the basis for this proposed rule.

As a result of that analysis, the industry study group identified bird encounter threats more severe than were addressed in either engine design practices of the time, or in the part 33 regulations.

In addition to the industry study/data analysis for large engines, industry also addressed the service experience of the small turbojet/turbofan designs. With the rapid expansion of the turbojet/turbofan powered business jet fleet in the late 1960's and early 1970's, a significant number of multiple engine power loss accidents due to flocking bird ingestion occurred. Careful review of these turbojet/turbofan events showed that the flight crews had often flown through very large flocks of birds with ingestion of many birds in each engine which resulted in multiple engine flameouts.

Following discussion with the manufacturers which showed that mechanical design changes would not alleviate the adverse effects of severe inlet blockage caused by massive

flocking bird ingestions, the FAA and the manufacturers embarked upon an educational/publicity campaign to better inform the aviation community regarding bird hazards and necessary controls. Subsequent to implementation of this educational campaign in late 1976, there was a marked decrease in the accident rate. Additionally, after the introduction of bird ingestion requirements in part 33, Amendment 6 on October 31, 1974, manufacturers were required to incorporate significant design improvements to address the typical flocking bird threat. Service experience of business jet engine designs that have met the Amendment 6 standard indicate that their resistance to bird ingestion induced damage is greatly improved over that early service history.

ARAC Project

The FAA is committed to undertaking and supporting the harmonization of the FAR Part 33 with the JAR-E. In August 1989, as a result of that commitment, the FAA Engine and Propeller Directorate participated in a meeting with the Joint Aviation Authorities (JAA), AIA, and the Association Europeenne Des Constructeurs De Material Aerospatial (AECMA). The purpose of the meeting was to establish a philosophy, guidelines, and a working relationship regarding the resolution of issues identified as needing to be harmonized, including some where new standards are needed. All parties agreed to work in a partnership to jointly address the harmonization effort task. This partnership was later expanded to include the airworthiness authority of Canada, Transport Canada.

This partnership identified seven items which were considered the most critical to the initial harmonization effort. The new proposed bird ingestion standards are an item on this list of seven items, and, therefore, represent a critical harmonization effort.

This proposal has been selected as an ARAC project. The issues were assigned to the Engine ~~Propulsion~~ Harmonization Working Group of the Transport Airplane and Engine Issues Group (TAEIG) on December 11, 1992 (57 FR 58840). On XXXX XX, 199X, the TAEIG recommended to the FAA that it proceed with the rulemaking and associated advisory material even though one airworthiness authority expressed disagreement with the proposed rule. This NPRM and associated advisory material reflect the ARAC recommendations.

Therefore, the basis for the development of this revised rule is to (1) minimize the threat to the aircraft for the above noted historical bird threat to one or more engines; and (2) substantiate that the engine design provides at least a 1E-8 per aircraft cycle freedom from risk of a hazardous consequence to the aircraft due to the bird ingestion threat For all bird ingestion threats, a hazardous consequence occurs when the resulting damage results in an unsafe condition as defined in Section 33.75; and in the specific case of small and medium birds, where insufficient power is retained to provide safe flight and landing.

The medium bird ingestion criteria for small engines were established consistent with corresponding criteria for medium and large engines which is freedom from multi-engine power loss events at a rate of 1E-8 per aircraft cycle. These criteria are based on the assumption that current standards for airport certification will be maintained, that the historical environment will not worsen, and that airport operators and pilots will maintain at least their current awareness of the threat.

The development of the rule recognizes that the engine design must address the threat without regard to past successes as shown in the service history data base. Unless the rule addresses the actual in-service bird ingestion threat, there can be no assurance that future designs would continue to exhibit acceptable capability.

The results of this data analysis are summarized as follows:

1. Dual engine power loss events with hazardous consequences (flocking birds of all sizes) have occurred at the rate of 3.2E-7 occurrences per aircraft cycle for large high-bypass ratio engines. This finding reflects service data for the 20 year period through 1987.

2. Multiple engine ingestion of flocking birds up to 2.5 pounds has occurred at the rate of 1E-6 occurrences per aircraft cycle for large high-bypass ratio engines.

3. Single engine power loss events due to ingestion of birds smaller than the current section 33.77 standard has occurred at a rate of 1E-6 or greater per aircraft cycle for all large high-bypass ratio engines.

4. Single engine ingestion of a large bird (4-8 lb. based on inlet area) has occurred at a rate up to 3.1E-6 occurrences per aircraft cycle.

5. Dual engine ingestion of flocking birds up to 1.5 pounds has occurred at a rate of 1E-8 occurrences per aircraft cycle for small engines.

6. Bird ingestion service difficulty issues relating to engine models not type certificated to the new proposed requirements, can safely be addressed by continued airworthiness control programs.

Recognition was also given to the need to design a conservative test, while at the same time being representative of in-service combinations of critical ingestion parameters It was recognized that it was impractical to test all possible combinations of events, but that a degree of conservatism was called for in a single test demonstration. Conservatism was incorporated into the test by selecting bird sizes or quantities, or both, among the most severe encountered within the 1E-8 service history, as well as requiring critical test parameters to be at worse case combination (speeds and aim points). It is therefore considered reasonable to accept a satisfactory test outcome which is conservative with respect to the various combinations of critical test parameters, and their demonstrated rate of occurrence in service.

An example of parametric rule consideration during regulatory tests is the question of multiple bird impacts to the same blade. The likelihood of multiple impacts on one blade is dependent on the number of birds, the number of blades, and the exposed frontal area. The manufacturers have stated that it is not always possible to achieve a uniform distribution of birds across the complete face of the engine in a single engine test. This may result in multiple birds striking the same blade. This may be viewed as unrepresentative and overly conservative based on probabilities appropriate to a random ingestion (averaged over a multiple ingestion event).

With respect to the flocking bird threat, the applicant needs to consider the potential effects on the engine associated with the size and number of birds, and operating conditions of a typical aircraft. For smaller flocking birds (0.5-1.5 lb.), greater quantities of birds may be ingested compared to quantities associated with larger size flocking birds. Both the effects of

bird size on the impact loading of the engine components, as well as the quantity ingested with potential multiple target locations being struck on the face of the engine, must be considered. Additionally, the applicant must consider the potential effects of the ingestion and the resultant damage effects to the front face of the engine as well as the core to the engine's run-on capability.

Analysis of the service record of engines larger than 2000 square inches over a 20 year period has lead to the conclusion that some additional certification standards are required. The proposed standards are intended to reduce the risk of a dual engine power loss from current in-service rates. The improvement goal is approximately 1E-8 or better per aircraft departure. The data analysis has identified specific flocking bird threats up to approximately 8 pound size (Canada goose). Therefore, it is the intent of this proposed rule to strengthen the engine airworthiness requirements by increasing the medium bird ingestion requirements from 1.5 lb. to 2.5 lb. birds (representing the herring gull threat); and by increasing the single large bird ingestion requirements to address bird threats from 4 lb. up to 8 lb. (Canada goose).

It is recognized that flocking birds larger than those specified in this rule may be encountered. It is believed that available engine technology alone cannot economically provide mitigation of this risk to approximately E-8 or better per aircraft departure. However, mitigation of this threat may be provided by the more severe conditions of the medium flocking and single large bird requirements proposed herein (i.e., bird size and number, run on requirement, etc.), introduction of aircraft that can be operated with up to a 50 percent power loss from each engine (large twin engine transport aircraft), and improved airport bird control methods and awareness.

The data summary supporting this conclusion for medium to large high bypass engines (70-100 inch inlet diameter except as noted) is as follows:

Multiple engine ingestions of birds greater than 1.0 lb. = 2.1E-6*

Multiple engine ingestions of birds greater than 1.5 lb. = 1.4E-6*

Multiple engine ingestions of birds greater than 2.5 lb. = 1.4E-7**

Multiple engine ingestions of birds greater than 4.0 lb. = 8.8E-8**

Multiple engine ingestions of birds greater than 2.5 lb. = 9.5E-8***

*Data collection period 1970-1987

**Data collection period 1970-1995

***Data collection period 1970-1995 for 60-100 in diameter inlets

It was also noted that the number of birds likely to be ingested into all engines during a flock encounter was inversely proportional to the size of birds. These were examined on an exceedence basis; i.e., 95% of the time no more than the following quantities of birds would be ingested into all of the engines on an aircraft during a flock encounter. As an example of this the following quantities of birds ingested for engines in the 6000 square inch class are as follows:

For birds in the 1.0-1.5 lb. species: 3 birds

For birds in the 1.5-2.5 lb. species: 3 birds

For birds greater than 2.5 lb.: 2 birds

In consideration of the desire to evaluate multiple critical target locations on the face of the engine, it was decided to select a size of flocking bird that corresponded to a bird quantity of 2 or more birds. However, it is recognized that there would be a residual risk of encounter of potentially larger bird sizes than specified in the rule, and possibly greater quantities of birds than specified in the rule. This proposed rule change significantly increases the severity of the certification demonstration, and provides a reduction in risk of a dual engine power loss due to flocking bird ingestion.

In considering single large bird threats for sizes greater than that demonstrated under the medium flocking bird threat to multiple engines, the data analysis attempted to quantify exposure rates for birds weighing 4 pounds and up as a function of inlet threat area. Data from FAA Technical Center reports from 1990 through 1992 were used in addition to the original AIA studies.

The data showed that small and medium engine sizes up to an inlet throat area of 2100 square inches had a relatively constant threat from birds greater than 4 pounds at approximately 5E-7 ingestions per aircraft departure. Reports from the manufacturers also showed that this size

of engine was more likely to ingest only portions of large birds, due to the much higher probability that an ingested bird may not enter the inlet on the engine centerline, and therefore would strike the inlet structure and be dismembered before reaching the engine rotor blades. This is further substantiated by the absence of reports of unsafe shutdown due to single large birds greater than 4 pounds for engines in this size range.

For engines larger than 2100 square inches, the rate of exposure to single large birds was observed to track roughly with increasing inlet size. The exposure rate for birds larger than 4 pounds for the large population of engines in the 2100-6000 square inch range was 1.5E-6 ingestions per aircraft departure. Review of the revenue service data however showed that medium and large turbofans exposed to single large birds above 4 pounds have demonstrated safe shutdown characteristics as defined under section 33.75 even with bird sizes up to 15 pounds. The rate of unsafe shutdown occurrences in accordance with section 33.75 criteria was approximately one event per 120 occurrences. This was attributed to the blade-out containment test requirements of section 33.94 constituting a more severe test relative to safe shutdown criteria for almost all engines.

The intent of the new rule is to establish the single large bird size as a function of inlet area greater than 2100 square inches at a level where the exposure to birds beyond that specified in this rule would be in the range of 1E-6 to 1E-7 ingestions per aircraft departure. This coupled with the prior service history record of satisfactory shutdown experience when exposed to very large birds, provides a potential improvement for hazardous consequences to continued safe flight into the extremely remote range of probability, i.e., 1E-7 to 1E-9.

The new rule conservatively established the single large bird requirement for engines in the 2100 -6000 square inch range at 6 pounds where the average exposure to larger birds was 8E-7 ingestions per aircraft departure. For engines greater than 6000 square inches the requirement was increased to 8 pounds to maintain an equivalent margin of safety.

The selection of the 200 knots ingestion speed for the large bird test was based on consideration of impact loading on the engine front stage blading. It was determined that for

most current turbine engine designs, conducting the test at 250 knots (maximum allowed airspeed below 10,000 feet altitude) would likely result in a relatively low blade impact vector, which results in less than maximum bird impact forces on the blade(s). This, coupled with the specified bird mass variations with engine inlet size, led to the decision to fix the ingestion speed at 200 knots, and perform an analysis to determine the critical spanwise target location for a particular engine application.

Large turbofan engines certified to the medium bird requirements of section 33.77 Amendment 6, which required bird velocities of 250 knots, sustained blade fractures and loss of power for ingested bird weights less than those demonstrated for certification test. Second generation turbofans certified under section 33.77 Amendment 10 rules which were in force during the 1980's used bird velocities which were equivalent to V2 speed for the application aircraft (160-180 knots for the large transports). While the in-service record was significantly improved, these engines were still experiencing blade fractures and power loss for bird weights less than the certification standard.

Engine ingestion parameters contributing to more than 50% power loss events were evaluated by AIA and AECMA. The most critical of the parameters evaluated which affected power loss were found to be bird weight, bird velocity, aiming point, and engine power setting. Each of these critical ingestion parameters have been evaluated in the proposed rule to determine the most severe conditions under which the medium bird test should be conducted.

The velocity to be used for the medium bird test was first established as the most critical velocity between V1 and 250 knots in order to cover the full range of takeoff and initial climb conditions that were considered to be potentially hazardous to the aircraft. In recognition of commuter and small business jet applications, the criterion was modified to reflect the fact that 250 knots was above the normal takeoff and climb speeds for this class of aircraft. A compromise criterion was chosen which required the medium bird ingestion velocity to be the most critical velocity between V1 and the velocity reached at 1500 feet above ground level (AGL).

Bird strike data for rotorcraft are not as comprehensive as that available for fixed wing aircraft, probably for a variety of reasons associated with reporting standards, forward speed, low altitude operations, and the extensive use of inlet protection or inherent installation shielding on rotorcraft. The following helicopter bird ingestion data has been reviewed in support of this rule: DGAC (France) 1983-1990; CAA (U.K.) 1976-1987 & 1989-1990; FAA (U.S.A.) 1985-1990; Transport Canada (Canada) 1981-1989; ICAO 1981-1989. The review showed reports of more than 600 bird strike events, but only four of these were reported as engine ingestions, and none of these were multiple events. Many of the 600 events involved flocks of small birds making engine ingestion very probable. Since there are no reports of significant power loss or mechanical damage it must be assumed that these ingestions had no effect on the engine.

It is concluded by the FAA that there are no records of any hazardous events or service difficulties associated with engine bird ingestion in multi-engine rotorcraft operation; and that to require a rotorcraft engine to demonstrate medium bird ingestion capability will impose an unnecessary burden upon the design while producing no measurable safety benefit. The FAA therefore proposes that engines intended for use in multi-engine rotorcraft need not show compliance with the medium bird ingestion requirements of this proposed rule.

With respect to the actual test day conditions where demonstrations are made, the proposal also considers the variability of engine performance as a function of changing ambient conditions. For example, substantial variations in engine rotor speed may take place between test demonstrations performed on cold days versus testing on hot days. These variations in rotor speed could in turn lead to variations in resulting damage, engine power, and operating characteristics. Even with no variation in blading damage, significant variations in power or other characteristics could be expected for conditions considerably different than for the test demonstration. Therefore, it was decided to allow the actual test day ambient conditions and engine pretest conditions to vary to permit equal flexibility among applicants, and to avoid conducting engine tests in unrepresentative conditions which could lead to cycle mismatches. However, each applicant must account for these potential variations by extrapolation to other

conditions specified in his type design. From the standpoint of power and operating characteristics, the applicant must show that the engine condition following the ingestion can be extrapolated to that specified in the type design. Therefore, it was determined that the sea level hot day corner point must be substantiated for both single large and flocking birds. It is believed that the hot day corner point case represents a worst case set of ambient conditions for which to substantiate bird ingestion capability. From the standpoint of potential limit exceedences, the applicant must consider the worst performing production engine that is allowed by the type design.

The current rules consider the possibility of imminent failure following a bird ingestion encounter producing damage. In consideration of this possibility, the rule recognizes the need to provide positive margin to demonstrate run-on capability and the ability for the engine to safely function throughout a conservative time for an emergency air-turn-back. This consideration includes recognition that the most critical encounters typically occur during heavy weight takeoffs, and may require dumping of fuel before returning to land. During this period it may be necessary to operate damaged engines throughout their operating cycle, including a need to make a go-around due to debris or equipment being on the runway. It is intent of this proposed rule to require the applicant to demonstrate the engine's ability to operate satisfactorily during such a circumstance. It is also recognized that it is not possible to extend this demonstration to include all possible conditions occurring throughout a flight, should the pilot decide to continue the flight to its destination. It was also judged that extended, but seemingly normal operation of multiple damaged engines was not likely to result in failure of multiple engines within the same flight. Lastly, considering the probable nature of bird ingestions, compliance with section 33.75 would not allow for a result which could lead to a hazardous failure as defined under that section. For these reasons, there is no requirement within this proposed rule to further consider imminent failure.

This proposed rule was also considered for harmonizing the part 33 and JAR-E, with respect to the maximum emergency rating which must be considered under this rule.

Consensus was achieved that there is no need to consider emergency ratings if it could be shown that the relative frequency of a bird ingestion event when using an emergency engine rating was less than 1E-8 . However, it was not possible to harmonize the part 33 and JAR-E in this regard since the part 33 does not define emergency ratings for turbofan engines.

Critical ingestion parameter tolerances were reviewed and supporting arguments made to justify the reasonableness of using a plus or minus 10 percent tolerance for variations within test parameters. The application of this tolerance was discussed in relationship to the intent to set the engine speed and thrust parameters to test-day takeoff conditions as described within the proposed rule, while the bird weight is expected to be controlled to "no less than" the weight specified within the rule. The expectations of achieving the bird aim points and impact speed within plus or minus 10 percent or its equivalent regarding aim point was compared against the general collective test experience. A sensitivity analysis was conducted to evaluate the expected effect on thrust or power, should there be first stage blade damage, for variations in test parameters up to 10 percent for the following parameters; engine speed, bird speed, target location, and bird weight. In general, these tolerances resulted in damage variations which produced approximately a 5 percent effect on thrust or power.

The harmonization working group determined that the current requirements of FAR 33.75 and JAR-E510 are not exactly the same and therefore, not fully harmonized. The FAR 33.75 requirements are restated as pass/fail criteria for the proposed medium and large bird ingestion tests. The bird ingestion requirements proposed by the JAA (NPA-E-20) includes a reference to JAR-E 510 for pass/fail criteria. However, that criteria is not the same as contained in this proposed rule. It is recognized that harmonization of Section 33.75 and JAR-E 510 is required, and will be addressed in future propulsion harmonization activities.

Disposition of Minority Position

The JAA has expressed disagreement with a portion of the proposal. The disagreement focuses on the degree of conservatism that the proposal offers with respect to certain flocking bird threats. The specific concern is that the proposed rule could potentially allow an engine to have

reduced operational capability after a 4 pound bird ingestion event than for an engine certified to the current rule. The authority also expressed concerns about the service history database, and the working groups determination of what level of flocking bird threat the proposal should address. The JAA minority position statement follows:

"The JAA expressed a dissenting opinion by requiring the new rules to include consideration of the threat which is created by flocking birds larger than 2.5 lb. The JAA proposed, in the draft new rules, the imposition of an additional requirement for each engine having an inlet area of 2100 square-inches or more. The applicant would be required to establish that when the fan assembly of such an engine is subjected to the ingestion of a single bird weighing at least 4 lb., under the same ingestion conditions as prescribed for the 6 lb. or 8 lb. bird ingestion test, the fan assembly retains sufficient integrity to demonstrate a total imbalance level less than 12% of the imbalance level corresponding to the loss of one complete fan blade airfoil.

The JAA rationale is as follows:

- The stated aims of the draft new rules include reducing the risk of a dual engine power loss, the improvement goal being approximately 1E-8 or better per aircraft departure, and substantiation of that goal. The preamble also states that "unless the rule addresses the actual in-service bird threat, there can be no assurance that future designs would continue to exhibit acceptable capability". Allowing fan blades to be shown, during certification, as being less capable to withstand some sizes of birds than current in-service designs is not compatible with those stated aims.

- The draft new rules (without the addition proposed by JAA) retain the same acceptance criteria for single large bird ingestion standard as in the existing rules. Extensive damage leading either to an immediate shutdown or necessitating a shutdown after 15 seconds is permitted, the only limit to the severity of the damage to the fan being safe containment, safe loads and no fire. However, in practice there are very good reasons for the manufacturers to establish that, with respect to containment, loads, fire, etc., the damage is not more severe than occurs with a full fan blade release. That practice is recognized in the draft new rules by a provision for waiving a full

engine test demonstration of compliance with the large bird ingestion standard if it can be demonstrated that compliance with the requirements for containment of a full fan blade is a more severe demonstration.

- Thus, because the minimum design allowed by the draft new rules is actually set primarily by the blade containment requirements, the large bird is allowed to cause extensive damage equivalent to that which results from the release of one entire fan blade. The increase of the weight of the large bird in the draft new rules, from 4 lb. to 6 lb. or 8 lb., will not improve the safety level if engines are designed to the minimum allowed by those new rules because it is a lower minimum that was demonstrated during certification of many, possibly most, of the current in-service engines. Further, it does not automatically follow that designing for a "safe" shutdown with a 6 lb. or 8 lb. bird results in a higher safety level than designing for a "safe" shutdown with a 4 lb. bird.

- The certification tests on most of the types of large engines currently in service demonstrated that the 4 lb. bird certification ingestion test did not result in extensive damage to their fan blades. Therefore, the service experience which is the basis for the aims of the draft new rules is derived mainly from engines which were better during certification than required by the existing rules and better than can be allowed under the draft new rules without the JAA proposed addition.

- The draft new rules require the large engines to retain a run-on and a 75% thrust capability when subjected to a multiple 2.5 lb. bird ingestion test but, as mentioned previously, the 6 lb. or 8 lb. bird ingestion is allowed to result in such extensive fan damage as to necessitate an immediate shutdown. In this case no information would then be available on the behavior of the fan in the event of a 4 lb. bird ingestion because the draft new rules do not address either medium (flocking) birds heavier than 2.5 lb. or large birds lighter than 6 lb. or 8 lb.. The ingestion of a 4 lb. bird could, with some fan designs, also result in an immediate unavoidable engine shutdown.

- There is already an example of a new engine which complies with the draft new rules for 2.5 lb. and 8 lb. bird ingestion's but the 8 lb. bird was shown to cause extensive damage commensurate with an immediate unavoidable shutdown. It would not have been possible, from only that damage, to make any reasonable assessment of what damage would have resulted from a 4 lb. large bird certification test. Economic pressure could lead to an increased use of fan blades which are designed to the minimum allowed by the draft new rules because it provides an opportunity to reduce the weight of the fan blades, disc and containment ring.
- Allowing new fan designs to be less capable than current in-service designs to withstand the ingestion of a 4 lb. bird would not be a concern if the multi-engine ingestion threat did not include birds weighing up to, and more than, 4 lb.. However, the service experience supporting the draft new rules shows that the multiple engine ingestion rate for birds larger than 2.5 lb. is greater than 1E-7. With current in-service engines these events have resulted in a marginally acceptable risk of multi-engine shutdown. If no certification data is available to show that new designs are equal to, or better than, current designs at withstanding those birds, it must be assumed that such encounters will result in unavoidable multi-engine shutdowns at a rate of roughly 1E-7 which is in excess of the declared aim of 1E-8. The JAA proposed additional requirement is intended to provide such certification data.
- All parties involved in the development of the draft new rules recognize that flocking birds larger than 2.5 lb. may be encountered and the JAA does not disagree totally with the position that mitigation of this risk to 1E-8 or better per airplane departure cannot be economically provided entirely by available engine technology. However, the JAA believes that future engine fan technology must not be allowed to be less capable at mitigating that risk than current in-service engines.
- Consequently the JAA concluded that the draft new rules are not achieving the stated aims by an amount that is more than necessary and not ensuring an achievable retention or improvement to the safety level by not ensuring that new fan designs are equal to, or better than, current designs at retaining their integrity when subjected to the ingestion of a 4 lb. bird under the

conditions applicable to large bird ingestion requirements. The additional 4 lb. bird consideration proposed by JAA is intended to do no more than to provide some assurance of parity with current in-service fan designs, it is not intended to ensure a full run-on capability after the ingestion of a 4 lb. bird. “

The remaining EHWG members have reviewed the JAA position statement, and offer the following comments:

The JAA Position Statement above contains two major concerns; (1) that flocking birds larger than 2.5 lb. are a significant enough threat to require an evaluation for run-on capability; and (2) that the proposed rule may allow a lesser capable engine than those certified to the current rule with respect to medium flocking and single large bird ingestion.

With respect to JAA’s first major concern:

The majority of EHWG members believe the proposed rule adequately addresses the flocking bird threat within the stated goal of this rulemaking. That improvement goal is to reduce the risk of a dual engine power or thrust loss greater than fifty percent (50%) from current in-service rates, to approximately 1E-8 or better per aircraft departure.

The worldwide bird ingestion threat database used for the medium and large engine portion of this rulemaking includes substantial data from 1970 through 1995, and encompasses approximately 85 million aircraft flights. The database includes data for engine models with fan inlet diameters from 60” to 100”. This database shows the rate of multi-engine ingestions of birds larger than 2.5 lb. to be approximately 1E-7 per aircraft departure. The probability of a dual engine shutdown is predicted to be approximately 1E-8 per aircraft departure. This probability is based on the observed multi-engine ingestion rate and demonstrated rate of engine shutdown for ingestion of birds in this size range. The above rates/probabilities are for engines certified to the current 1.5 lb. medium flocking and 4 lb. single large bird standards which are less severe than the proposed rule.

The JAA Position Statement notes that the dual engine power loss/shutdown rate is marginally acceptable today. The proposed rule requires 2.5 lb. medium flocking and 6-8 lb.

(function of inlet size) large single birds which are more severe demonstrations, and which the majority of EHWG members believe can only improve the overall world fleet ingestion capability of engines certified thereto. This is especially true when considering the additional run-on requirements of the proposed medium bird test. Therefore, the majority of EHWG members do not believe that additional run-on evaluation requirements for flocking birds larger than 2.5 lb. is necessary.

With respect to JAA's second major concern:

Concerning medium flocking birds, the current marginally acceptable dual engine power loss rate relates primarily to engines certified to a 1.5 lb. bird requirement for 5 minutes of run-on. The proposed rule is for a 2.5 lb. bird with a 20 minute run-on requirement. This is obviously a much more severe design and test requirement than for engines certified to the current rule, and should yield a more capable engine, not a less capable one. This is supported by a test that is run to worst case conditions of fan speed, target location, number of birds, and new run-on profile. In the original review of historical data used in consideration of the development of the proposed rule, it was noted that single large birds (greater than 2.5 lb.) resulted in significant powerloss about 50% of the time, mostly due to mechanical damage to the fan. It is difficult to see how an argument could be made that these earlier certified engines have a greater capability than that demonstrated by a minimum engine that passes both the 2.5 lb. medium flocking run-on and 6-8 lb. single large bird safe shutdown tests.

With respect to single large birds, the current marginally acceptable dual engine power loss rate relates primarily to engines certified to a 4 lb. single large bird safe shutdown requirement. With identical test criteria, it can only be expected that an engine passing the proposed test will be at least as capable of a large bird safe shutdown as a current engine. Engine models that are tested using these larger birds will have greater axial loads and greater local stresses on the impacted blades than for the 4 lb. requirement. Therefore, the blades must have greater capability with respect to a safe shutdown criteria. The majority of EHWG members do not believe the proposed large bird criteria allows sufficient latitude such that an engine can pass

a 6-8 lb. test but not a 4 lb. test. The NPRM has not altered the current objective of a safe shutdown after a large bird ingestion.

The JAA Position Statement also argues another point they consider significant to this rulemaking: That economic pressures could reduce the margin above the stated pass/fail criteria that engines may be designed for, and therefore result in less costly and less capable new designs of reduced margin when compared to engines currently in service. The majority of EHWG members do not believe it is appropriate to consider the margin with which any particular engine model demonstrates compliance, and that discussion of economic pressure has no place in objective evaluations of safety. The purpose of the rule is to set forth minimum requirements below which it is considered unsafe. Everything that meets the minimum is considered safe. In other words, either the regulatory criteria is appropriate, or it is not. Margin is not an issue for properly chosen criteria. The majority of EHWG members consider the proposed rule criteria as appropriate, and therefore demonstrated margin above that criteria is not necessary. With respect to engines certified to the current 4 lb. single large bird safe shutdown test standard, some fan designs have exhibited blade fragmentation during the test while others have not. It is incorrect, however, to infer continued run-on capability simply from lack of fan blade fragmentation during the 15 second "hands-off" period of the large bird test. Secondary damage and operability effects of continued high power operation with mechanical and/or aerodynamic unbalance would have to be taken into consideration. It is also true that previously certified designs which have experienced fan blade fragmentation in large bird tests have accumulated well over 50 million hours in revenue service with a satisfactory bird ingestion record. The fact that these engine designs, certified to the current standard, have continued to operate and produce greater than 50% thrust in a significant percentage of revenue service large bird ingestion events, is attributable more to the combination of ingestion conditions being less severe than the certification test than the robustness of the fan design. The majority of the EHWG conclude this same mixed result will continue to occur in the single large bird certification test. It is also concluded that such mixed results relative to fan blade fragmentation are not significant relative

to this rulemaking effort's stated goal of improving the world fleet rate of dual engine power loss.

The majority of EHWG members also do not agree with the JAA statement that the proposed rule has a lower design minimum than the current rule, and believe that the proposed rule significantly increases the certification standards for medium and large bird ingestion by increased severity of bird size, run-on, and target location. The test criteria of the current rule is less severe than that specified for under the proposed rule, therefore, it can not be described as providing "greater margin" when compared to a marginally compliant engine under the proposed rule. Furthermore, no evidence has been offered to demonstrate that engines certified under the current rule would always have margin for run-on following the ingestion of a 4 lb. flocking bird. Thus, the arguments of current vs. proposed are considered subjective and unproven as indicators of future performance in service.

Consequently, for the reasons stated above, the majority of EHWG members have concluded that evaluation of run-on capability for birds larger than 2.5 lb. is not necessary to meet the stated rulemaking objective, and therefore the JAA proposal does not need to be incorporated into the proposed rule.

General Discussion of the Proposals

Section 23.903 (a)(2) and 25.903 (a)(2)

This proposal revises the part 23 and part 25 requirements associated with foreign object ingestion into turbine engines to be consistent with the proposed part 33 changes.

Section 33.76.

Proposed new section 33.76 would contain the bird ingestion requirements. Bird ingestion standards are currently found in section 33.77. This proposal was developed by the engine harmonization working group, and contains substantial common language that will be reflected both in Part 33 and JAR-E. The only significant difference between Part 33 and JAR-E is an additional large bird ingestion

criteria in JAR-E (JAR-E 800 (b)(5) as proposed by JAA P NPA-E-20, dated 12 July 1996). Also, the proposed new section adopts the approximate metric equivalents for certain test parameters to further commonality between Part 33 and JAR-E.

Section 33.77.

This proposal would remove the bird ingestion standards now specified in section 33.77 (a) and (b); these new proposed bird ingestion standards would appear in a new section 33.76. Paragraphs (a) and (b) will be held in reserved. Paragraphs (d) and (e) have been revised to eliminate any reference paragraphs to (a) and (b).

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.), there are no record keeping or reporting requirements associated with this proposed rule.

Regulatory Evaluation Summary

.....(FAA to Provide).....

International Trade Impact Analysis

.....(FAA to Provide).....

Regulatory Flexibility Determination

.....(FAA to Provide).....

Federalism Implications

The regulations proposed herein would not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed above, including the findings in the Regulatory Determination and the International Trade Impact Analysis, the FAA has determined that this proposed regulation is not a significant regulatory action under Executive Order 12866. In addition, the FAA certifies that this proposal, if adopted, will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. This proposal is considered significant under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979). An initial regulatory evaluation of the proposal, including a Regulatory Flexibility Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

List of Subjects in 14 CFR Part 33

Air transportation, Aircraft, Aviation safety, Safety.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend Parts 23, 25 and 33 of the Federal Aviation Regulations (14 CFR Part 23, 25, 33) as follows:

PART 23- AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES

1. The authority citation for Part 23 continues to read as follows:

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

2. Section 23.903 is amended by revising paragraph (a)(2) to read as follows:

ξ 23.903 Engines

* * * * *

(a) ***

(2) Each turbine engine and its installation must either -

(i) Comply with section 33.77 and 33.76 of this chapter in effect on

[**Insert effective date of final rule**], or as subsequently amended; or

(ii) Comply with section 33.77 of this chapter in effect on October 31, 1974, or as subsequently amended prior to [**Insert effective date of final rule**]; unless that engine's foreign object ingestion service history has resulted in an unsafe condition; or

(iii) Be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition.

* * * * *

PART 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

3. The authority citation for Part 25 continues to read as follows:

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

4. Section 25.903 is amended by revising paragraph (a)(2) to read as follows:

ξ 25.903 Engines

* * * * *

(a) ***

(2) Each turbine engine must either -

(i) Comply with section 33.77 and 33.76 of this chapter in effect on [**Insert effective date of final rule**], or as subsequently amended; or

(ii) Comply with section 33.77 of this chapter in effect on October 31, 1974, or as subsequently amended prior to [**Insert effective date of final rule**]; unless that engine's foreign object ingestion service history has resulted in an unsafe condition; or

(iii) Be shown to have a foreign object ingestion history in similar installation locations which has not resulted in any unsafe condition.

* * * * *

PART 33 - AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

5. The authority citation for Part 33 continues to read as follows:

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

6. Section 33.76 is added to Subpart E, to read as follows

§ 33.76 Bird Ingestion.

(a) General. Compliance with paragraphs (b) and (c) of this section shall be in accordance with the following:

(1) All ingestion tests shall be conducted with the engine stabilized at no less than 100 percent takeoff power or thrust, for test-day ambient conditions prior to the ingestion. In addition, the demonstration of compliance must account for engine operation at sea-level takeoff conditions on the hottest day that a minimum engine can achieve maximum rated takeoff thrust or power.

(2) The "engine inlet area" as used in this section to determine the bird quantity and weights will be established by the applicant and identified as a limitation on the inlet throat area in the installation instructions required under section 33.5.

- (3) The impact to the front of the engine from the single large bird and the single largest medium bird which can enter the inlet must be evaluated. It must be shown that the associated components when struck under the conditions prescribed in paragraphs (b) or (c) of this section, as applicable, will not affect the engine to the extent that it cannot comply with the requirements of paragraphs (b)(3) and (c)(6) of this section.

(4) For an engine that incorporates an inlet protection device, compliance with section 33.76 shall be established with

the device functioning. The engine approval will be endorsed to show that compliance with the requirements has been established with the device functioning.

(5) Objects that are acceptable to the Administrator may be substituted for birds when conducting the bird ingestion tests required by paragraphs (b) and (c) of this section.

(6) If compliance with the requirements of this section is not established, the engine type certification documentation will show that the engine shall be limited to aircraft installations in which it is shown that a bird cannot strike the engine, or be ingested into the engine, or adversely restrict airflow into the engine.

(b) Large birds. Compliance with the large bird ingestion requirements shall be in accordance with the following:

(1) The large bird ingestion test shall be conducted using one bird of a weight determined from Table 1 aimed at the most critical exposed location on the first stage rotor blades and ingested at a bird speed of 200 knots for engines to be installed on airplanes, or the maximum airspeed for normal rotorcraft flight operations for engines to be installed on rotorcraft.

(2) Power lever movement is not permitted within 15 seconds following ingestion of the large bird.

(3) Ingestion of a single large bird tested under the conditions prescribed in this section may not cause the engine to:

(i) catch fire;

(ii) release hazardous fragments through the engine casing;

(iii) generate loads greater than those ultimate loads specified under Section 33.23(a); or

(iv) lose the ability to be shut down.

(4) Compliance with the large bird ingestion test requirements of this paragraph may be waived if it can be demonstrated that the containment requirements of section 33.94(a) constitutes a more severe demonstration than the requirements of section 33.76(b).

Table 1
Large Bird Weight Requirements

Engine Inlet Area (A) square meters (square inches)	Bird Weight kg. (lb.)
1.35 (2,092)> A	1.9 (4.2) minimum, unless a smaller bird is determined to be a more severe demonstration.
1.35 (2,092)≤ A< 3.90 (6,045)	2.8 (6.2)
3.90 (6,045)≤ A	3.7 (8.2)

(c) Small and Medium birds. Compliance with the small and medium bird ingestion requirements shall be in accordance with the following:

(1) Analysis or component test, or both, acceptable to the Administrator, shall be conducted to determine the critical ingestion parameters affecting power loss and damage**.** Critical ingestion parameters shall include, but are not limited to, the effects of bird speed, critical target location, and first stage rotor speed. The critical bird ingestion speed should reflect the most critical condition within the range of airspeeds used for normal flight operations up to 1500 feet above ground level, but not less than V_1 minimum for airplanes.

(2) Medium bird engine tests shall be conducted so as to simulate a flock encounter, and will use the bird weights and quantities specified in Table 2. When only one bird is specified, that bird will be aimed at the engine core primary flow path; the other critical locations on the engine face area must be addressed, as necessary, by appropriate tests or analysis or both. When two or more birds are specified in Table 2, the largest of those birds must be aimed at the engine core primary flow path, and a second bird must be aimed at the most critical exposed location on the first stage rotor blades. Any remaining birds must be evenly distributed over the engine face area.

(3) In addition, except for rotorcraft engines, it must also be substantiated by appropriate tests or analysis or both, that when the full fan assembly is subjected to the quantity and weights of birds from Table 3, that the engine can comply with the acceptance criteria of FAR 33.76(c).

(4) A small bird ingestion test is not required if the prescribed number of medium birds pass into the engine rotor blades during the medium bird test.

(5) Small bird ingestion tests shall be conducted so as to simulate a flock

encounter using one 85 gram (0.187 lb.) bird for each 0.032 square meters (49.6 square inches) of inlet area, or fraction thereof, up to a maximum of 16 birds. The birds will be aimed so as to account for any critical exposed locations on the first stage rotor blades, with any remaining birds evenly distributed over the engine face area.

(6) Ingestion of small and medium birds tested under the conditions prescribed in paragraph (c) of this section may not cause:

(i) more than a sustained 25 percent power or thrust loss;

(ii) the engine to be shut down during the required run-on demonstration prescribed in paragraphs (c)(7) or (c)(8) of this section;

(iii) the conditions defined in paragraphs (b)(3) of this section.

(iv) unacceptable deterioration of engine handling characteristics.

(7) Except for rotorcraft engines, the following test schedule shall be used:

(i) ingestion so as to simulate a flock encounter, with approximately 1 second elapsed time from the moment of the first bird ingestion to the last.

(ii) followed by 2 minutes without power lever movement after the ingestion.

(iii) followed by 3 minutes at 75 percent of the test condition.

(iv) followed by 6 minutes at 60 percent of the test condition.

(v) followed by 6 minutes at 40 percent of the test condition.

(vi) followed by 1 minute at approach idle.

(vii) followed by 2 minutes at 75 percent of the test condition.

(viii) followed by stabilizing at idle and engine shut down.

The duration specified are times at the defined conditions with the power lever being moved between each condition in less than 10 seconds.

(8) For rotorcraft engines, the following test schedule shall be used:

(i) Ingestion so as to simulate a flock encounter within approximately 1 second elapsed time between the first ingestion and the last.

(ii) followed by 3 minutes at 75 percent the test condition.

(iii) followed by 90 seconds at descent flight idle.

(iv) followed by 30 seconds at 75 percent of the test condition.

(v) followed by stabilizing at idle and engine shut down.

The duration specified are times at the defined conditions with the power being changed between each condition in less than 10 seconds.

(9) Engines intended for use in multi-engine rotorcraft are not required to comply with the medium bird ingestion portion of this section, providing that the appropriate type certificate documentation is so endorsed.

(10) If any engine operating limit(s) is exceeded during the initial 2 minutes without power lever movement [reference section 33.76(c)(7)(ii)], then it shall be established that the limit exceedance(s) will not result in an unsafe condition.

Table 2
Medium Flocking Bird Weight & Quantity Requirements

Engine Inlet Area (A) square meters(square inches)	Bird Quantity	Bird Weight kg.(lb.)
0.05 (77.5)> A	none	------
0.05 (77.5)≤ A < 0.10 (155)	1	0.35 (0.77)
0.10 (155)≤ A < 0.20(310)	1	0.45 (0.99)
0.20 (310)≤ A < 0.40 (620)	2	0.45 (0.99)
0.40 (620)≤ A < 0.60 (930)	2	0.70 (1.54)
0.60 (930)≤ A < 1.00 (1,550)	3	0.70 (1.54)
1.00 (1,550)≤ A < 1.35 (2,092)	4	0.70 (1.54)
1.35 (2,092)≤ A < 1.70 (2,635)	1 plus 3	1.2 (2.65) 0.70 (1.54)
1.70 (2,635)≤ A < 2.10 (3,255)	1 plus 4	1.2 (2.65) 0.70 (1.54)
2.10 (3,255)≤ A < 2.50 (3,875)	1 plus 5	1.2 (2.65) 0.70 (1.54)
2.50 (3,875)≤ A < 3.90 (6045)	1 plus 6	1.2 (2.65) 0.70 (1.54)
3.90 (6045)≤ A < 4.50 (6975)3	3	1.2 (2.65)
4.50 (6975)≤ A	4	1.2 (2.65)

Table 3
Additional Integrity Assessment

Engine Inlet Area (A) square meters(square inches)	Bird Quantity	Bird Weight kg.(lb.)
1.35 (2,092)> A	none	------
1.35 (2,092)≤ A < 2.90 (4,495)	1	1.2 (2.65)
2.90 (4,495)≤ A < 3.90 (6,045)	2	1.2 (2.65)
3.90 (6,045)≤ A	1	1.2 (2.65)
	plus 6	0.70 (1.54)

7. Section 33.77 is amended by revising paragraphs (d) (3) and (e) to read as follows:

ξ 33.77 Foreign object ingestion

* * * *

(a) Reserved

(b) Reserved

(d) *** (3) The foreign object, or objects, 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 required by paragraph (c) of this section.

(e) Compliance with paragraph (c) of this section must be shown by engine test under the following ingestion conditions:

Foreign object	Test quantity	Speed of foreign objec	Engine operation	Ingestion
Ice.....	Maximum accumulation on a typical inlet cowl and engine fa resulting from a 2-minute dela in actuating anti-icing system, or a slab of ice which is com-parable in weight or thickness for that size engine.	Sucked in.....	Maximum cruise...	To simulate a continuous maximum icing encounter at 25 degrees F.
Hail (0.8 to 0.9 specific gravity	For all engines: With inlet are of not more than 100 square inches: one 1-inch hailstone. With inlet area of more than 1(square inches: one 1-inch and one 2-inch hailstone for each 1 square inches of inlet area or fraction thereof.	Rough air flight speed of typical aircraft.	Maximum cruise a 15,000 feet altitude	In a volley to simulate a hailstone encounter. One-half the number of hail-stones aimed at random are over the face of the inlet an the other half aimed at the critical face area.
	For supersonic engines (in add tion): 3 hailstones each having a diameter equal to that in a straight line variation from 1 inch at 35,000 feet to 1/4 inch at 60,000 feet using diameter corresponding to the lowest supersonic cruise altitude expected.	Supersonic cruise velocity, Alternatively use subsonic velocitie with larger hailstones give equivalent kineti energy.	Maximum cruise...	Aimed at critical engine fac area.
Water.....	At least 4 percent of engine air flow by weight.	Sucked in.....	Flight idle, accel-eration, takeoff, deceleration.	For 3 minutes each at idle and takeoff, and during acceleration and deceleration in spray to simulate rain.

Note. - The term "inlet area" as used in this section means the engine inlet projected area at the front face of the
It includes the projected area of any spinner or bullet nose that is provided.

Issued in Washington, DC, on

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BIRD INGESTION RULE
ADVISORY MATERIAL
DRAFT

NOTE: It is intended that this advisory material will replace the current material on bird ingestion requirements located in AC33.2.

(1) General:

(a) The front of the engine is defined as any part of the engine which can be struck by a bird. This includes, but is not limited to, the following components, nose cone, spinner (centerbody) on the fan or compressor rotor, engine inlet guide vane assemblies, and any engine protection device. Ingestion is defined as the passage of a bird into the rotating blades.

The applicant should assess the bird impact to components at the front of the engine relative to the critical parameters of the component. For example, the ability of the spinner to withstand a bird impact should be assessed for the most critical parameters of the spinner, which would include; bird size, bird velocity, target location , and spinner rotational speed.

(b) Artificial birds or devices which simulate the mass, shape, and density of birds, and which are acceptable to the Administrator, may be used for the ingestion tests.

(c) For substantiating derivative engine models , the engine tests should be performed under the conditions of section 33.76, unless alternative equivalent demonstration evidence, acceptable to the Administrator, is provided. This substantiation evidence may come from the applicant's experience on engines of comparable size, design, construction, performance, and handling characteristics, obtained during development, certification or operation. Any parametric analysis used to substantiate derivative engines should fall within 10% variation in the critical impact parameters used to substantiate the original engine certification basis.

(d) In conducting the analysis or component tests, or both, to determine the critical ingestion parameters, the applicant should consider related

experience for the type and size of engine being evaluated, with particular attention to the types and causes of failures in that related experience.

(e) Engine tests should be conducted with a fully operational engine which is representative of the Type Design. The normal functioning of any automatic systems not requiring pilot intervention is acceptable (including automatic power lever movement), provided that a time limited dispatch (TLD) or similar analysis acceptable to the Administrator is submitted. Automatic systems may be required for dispatch if a suitable analysis is not provided. The Applicant may also conduct the test(s) with any automatic systems in a functionally degraded state, if this does not constitute a less severe test.

(f) The object of the test is to cover all the defined impact zones. The test facility should be appropriately calibrated to ensure that the controlling parameters defined by the analysis of the critical conditions (e.g. bird speed, aiming locations) are within an acceptable tolerance. This tolerance band should be derived from an analysis of the sensitivity of the critical impact parameter to variations in the controlling parameters. The band should be such that variations in the critical impact parameter are not more than 10% resulting from any combination of the controlling parameters.

Certain test facilities and installations may affect or reduce the stability margin of the engine due to airflow distortion attributed to the close proximity bird gun(s) to the engine inlet. These effects must be identified prior to the test.

(g) If turboprop or turboshaft engines are tested using an alternative load device which could induce different engine response characteristics than when the engine is coupled with a propeller or installed in the aircraft, the interface with the test facility, other aircraft or propeller systems should be monitored during the test and should be used for determining how the engine would respond in a representative installation and for ensuring that the engine would then comply with the requirements.

Input and output data across the engine interfaces with the aircraft systems should be provided by the engine manufacturer in the installation manual regarding the expected interaction of the engine with these systems during ingestion events. Of particular interest would be dynamic interactions such as auto surge recovery, propeller auto feather.

(h) For the purpose of FAR 33.76, a minimum engine is defined as a new engine that exhibits the type design's most limiting operating parameter(s), with respect to the bird ingestion conditions prescribed in this section. These operating parameters include, but are not limited to, power or thrust, turbine temperature, and rotor speed.

(i) The term "first stage rotating blades" includes the first of the exposed stages of any fan or compressor rotor which are susceptable to a bird strike or bird ingestion. These first stage rotating blades are considered to be part of the front of the engine, as defined in paragraph (1)(a) above. This definition encompasses ducted, unducted and aft fan engine designs. In these latter cases, blading on multiple rotors (i.e., primary and secondary airflow paths) should be considered separately when complying with section 33.76.

(2) Large bird:

(a) For the purpose of the section 33.76 test, the complete loss of engine power or thrust after ingestion will be accepted.

(b) The most critical location on the first stage rotating blades may be determined from analysis or component tests, or both. Determination of the most critical location to be considered in 2 (c) above should include evidence, where necessary, on:

(i) the effect of the bird strike on rotating ~~and static~~ components,
(ii) the compressor casing strength,
(iii) the possibility of multiple blade failures,
(iv) the strength of the engine structure and main shafts relative to the unbalance and excessive torque likely to occur.

(c) When compliance with the containment requirements of section 33.94(a) is used in lieu of the large bird ingestion test, the determination that the 33.94(a) test constitutes a more severe demonstration should consider the engine dynamic response to a large bird ingestion event, and include, but not be limited to, the effects of engine unbalance loads, engine torque loads, surge related loads, and axial loads, resulting from the bird impact which are transmitted to the front of the engine.

(3) Small and medium birds:

(a) The Applicant will identify the critical target locations for the small and medium bird ingestion tests required by section 33.76(c), and appropriately consider potential effects of assumed installations in aircraft. After targeting one bird for the most critical exposed location, applicants should target any remaining birds in proportion to the fan face area, including the centerbody if applicable, to achieve an even distribution of birds over the face of the engine. The even distribution of remaining birds should also include consideration of any additional critical locations. Any critical locations not targeted may be evaluated separately by analysis or component testing, or both.

(b) In the tests performed under section 33.76(c), the engine is required to produce at least 75% of takeoff power or thrust after ingestion of small and medium birds. Nevertheless, a momentary power or thrust drop below this value may be acceptable as long as its duration does not typically not exceed 3 seconds.

(c) The purpose of the sea-level hot day corner point assessment under 33.76(a)(1) is to address both the basis for loss of performance margins (exhaust gas temperature, measured gas temperature, etc.) and also the influence on available power or thrust of engine control system limiters or controlling parameters at a common critical hot day break point condition. This post test analysis approach permits conduct of tests at takeoff power or thrust for actual test day conditions and provides a uniform assessment of power loss against rated levels independent of the actual tests ambient conditions.

(d) Any analysis used in place of a fan rig or engine test for demonstrating compliance with section 33.76 should be substantiated by evidence based on tests and should have demonstrated its capability to predict full fan rig or engine tests results.

(e) Rig tests may be used to determine if a particular bird size will pass through the inlet and into the rotor blades.

(f) Thrust or power should be measured by a means which can be shown to be accurate throughout the test to enable the thrust or power to be set without undue delay and maintained to within plus or minus 3 percent of the specified levels.

If a sustained high vibration condition exists after the first 2 minutes of operation after the bird ingestion, then thrust or power may be varied as a protective measure within plus or minus 3 percent of the specified levels. Alternative load devices of some test facilities such as waterbrakes, may be unable to control power within the plus or minus 3% tolerance. This should be identified and approved prior to the test.

(g) Exceedences of engine operating limits are not expected to occur. However, exceedances may be permitted to occur only during the first 2 minutes [reference section 33.76(c)(7)(ii)] following the ingestion of the birds in the 20 minute run-on test. Any limit exceedence(s) should be recorded, and it must be shown by evidence acceptable to the Administrator, that the limit exceedance(s) will not result in an unsafe condition [reference 33.76(c)(10)]. This evidence may come from previous test or service experience, or analysis thereof. Also, under such circumstances, the operating instructions, installation manual, and maintenance manual should be reviewed to assure that appropriate instructions are included within those documents, and that any such instructions are appropriately validated.

FAA Action: (1) Airworthiness Standards; Bird Ingestion; NPRM -- FAA-1998-4815 and
(2) Final rule -- FAA-1998-4815

(3) Advisory Circular; Bird Ingestion Certification Standards 33.76-1 – Regulatory and Guidance Library

109346

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Part V

Department of Transportation

Federal Aviation Administration

14 CFR Parts 23, 25, and 33
Airworthiness Standards; Bird Ingestion; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 23, 25, 33

[Docket No. FAA–1998–4815; Amendment No. 23–54, 25–100 and 33–20]

RIN 2120–AF84

Airworthiness Standards; Bird Ingestion

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This amendment revises the bird ingestion type certification standards for aircraft turbine engines to better address the actual bird threat encountered in service. This amendment also establishes nearly uniform bird ingestion standards for aircraft turbine engines certified by the United States under FAA standards and by the Joint Aviation Authorities (JAA) countries under JAA standards, thereby simplifying airworthiness approvals for import and export.

EFFECTIVE DATES: December 13, 2000.

FOR FURTHER INFORMATION CONTACT: Marc Bouthillier, Engine and Propeller Directorate, Engine and Propeller Standards Staff, ANE–110, Federal Aviation Administration, New England Executive Park, Burlington, Massachusetts 01803–5299; telephone (781) 238–7120; facsimile (781) 238–7199.

SUPPLEMENTARY INFORMATION:

Availability of Final Rules

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the FedWorld Electronic bulletin board service (telephone: (703) 321–3339) or the Government Printing Office's (GPO) electronic bulletin board service (telephone: (202) 512–1661).

Internet users may reach the FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the GPO's web page at http://www.access.gpo.gov/nara for access to recently published rulemaking documents.

Any person may obtain a copy of this document by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Communications must identify the amendment number or docket number of this final rule.

Persons interested in being placed on the mailing list for future rulemaking documents should request from the above office a copy of Advisory Circular No. 11–2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996, requires the FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. Therefore, any small entity that has a question regarding this document may contact their local FAA official. Internet users can find additional information on SBREFA on the FAA's web page at *http://www.faa.gov/avr/arm/sbrefa.htm* and may send electronic inquiries to the following Internet address: 9–AWA–SBREFA@faa.gov.

Background

Statement of the Problem

In 1976, the National Transportation Safety Board (NTSB), in response to an accident involving a wide-bodied aircraft that may have experienced multiple bird ingestion into the engines, issued Safety Recommendation A–76–64, recommending that the FAA, "amend 14 CFR 33.77 to increase the maximum number of birds in the various size categories required to be ingested into turbine engines with large inlets." Safety Recommendation A–76–64 also stated, "these increased numbers and sizes should be consistent with the birds ingested during service experience of these engines." In response to the recommendation, the FAA sponsored an industry wide study of the types, sizes, and quantities of birds that had been ingested into aircraft turbine engines of all sizes, and the resulting affects on engine performance. Subsequently, the FAA requested that the Aerospace Industries Association (AIA) analyze the data, and report back to the FAA. Based on the AIA report, the FAA determined the actions to be taken, as well as the disposition of the NTSB safety recommendation A–76–64. The FAA concluded that the regulations contained in § 33.77 should be modified to increase the severity of the bird ingestion testing requirements regarding large, high bypass ratio engines. In addition, the FAA found that it should update the design and testing requirements for all engine sizes to reflect the actual numbers and bird sizes being ingested. This effort was adopted as a part 33 and Joint Aviation Regulations for engines (JAR–E) harmonization project and was selected as an Aviation Rulemaking Advisory Committee (ARAC) project.

Industry Study

There are three separate data collection efforts within the industry study. The largest and most comprehensive collection is the data for large commercial transport engines with fan diameters between 80 and 100 inches and spanning a time period from entry into service through 1987. This collection includes FAA sponsored contracts which are summarized in report number DOT/FAA/CT–84/13, dated September 1984. A less extensive collection effort involving engines with inlet areas less than 1000 square inches was also performed. Data for this class of engine is less comprehensive in that it involves reporting from a very diverse aircraft operator base including General Aviation operators as well as some commuter and part 121 operators. The third collection effort was an extension of the first, but includes only data for ingestion of birds weighing greater than 2.5 pounds, for the time period from entry into service through September 1995 for large commercial transport engines with fan diameters 60 inches and larger.

The results of the first two data collections were compared to the historical design standards and certification bases for the family of engines comprised in the database. The study group identified bird ingestion threats both more and less severe than were addressed in either engine design practices of the time, or in part 33. A proposal for a change in the medium bird ingestion rules was presented by the AIA to the FAA in AIA report dated October 17, 1986.

The FAA then asked for expansion of the database to include both heavier birds and coordination of the data and proposed rules with the European Association of Aerospace Industries (AECMA). This coordination effort included consensus between the two industry groups on the completeness and accuracy of the data, and validation of the analytical approach by independent statisticians from Allied Signal, Boeing, General Electric, Pratt & Whitney, Rolls-Royce, and Snecma. The AIA and AECMA delivered a report to the FAA on November 10, 1988. This data collection has become known as the "AIA database." The substance of the latter report is a primary basis for the current NPRM.

Three additional bird ingestion studies were contracted by the FAA to corroborate the findings of the collections described above. The results of these studies may be found in reports

numbered DOT/FAA/CT–90/13, "Study of Bird Ingestions Into Small Inlet Area Aircraft Turbine Engines," dated December 1990, DOT/FAA/CT–91/17, "Bird Ingestion Into Large Turbofan Engines," dated May 1992, and DOT/FAA/CT–91/32, "Engine Bird Ingestion Experience of the Boeing 737 Aircraft—Expanded Data Base", dated July 1992. The data contained in these reports supports the data summaries of the related industry studies.

Subsequently, a further review of the data for birds heavier than 2.5 pounds (lb) was requested of industry by the FAA and JAA. The resulting data is contained in an AIA/AECMA report dated March 29, 1996 which includes all relevant reports of bird ingestions for commercial transport engines with fan diameters 60 inches and greater, for the time period from entry into service through September 30, 1995.

Aviation Rulemaking Advisory (ARAC) Project

In December 1992, the FAA requested the ARAC to evaluate the need for new bird ingestion standards. The task, in turn, was assigned to the Engine Harmonization Working Group (EHWG) of the ARAC on Transport Airplane and Engine (TAE) Issues on December 11, 1992. On April 9, 1997, the TAE issues group recommended to the FAA that it proceed with rulemaking and associated advisory material even though one working group member disagreed with a portion of the proposal. The FAA published a notice of proposed rulemaking (NPRM) on December 11, 1998 (63 FR 68636). This rule reflects the ARAC recommendations.

Discussion of Comments

All interested persons have been afforded an opportunity to participate in this rulemaking. Due consideration has been given to all comments contained in the nine comment letters received, which represent domestic and foreign industry, and foreign airworthiness authorities. Nine comments generally supported publication of the rule as a benefit over the existing regulations.

One commenter notes that the companion Advisory Circular (AC) has not been published for comment.

The FAA agrees in part. An extensive AC has been drafted that provides one method, but not the only method, for showing compliance with this new rule for bird ingestion. The FAA expects that the AC will be available for comment prior to the effective date of the new rule. The FAA does not agree that this final rule should be delayed pending completion of that AC.

Two commenters state that the safety intent and justification of the proposed rule should be clarified.

The FAA disagrees. The NPRM preamble clearly states that the objective of the proposed rule is to provide a freedom from risk of hazard due to bird ingestion at least equal to ten to the minus eighth power (1E–8) per aircraft cycle. The objective is further defined for single large birds and both small and medium flocking birds. Justification for various aspects of the rule is given throughout the preamble section of the NPRM.

Several comments were received concerning bird control programs at airports. One commenter states that additional actions are necessary to better control bird populations on and around airports. Two commenters state that airport bird control programs and flight crew awareness training are not effective in mitigating the bird threat, and should not be considered relative to this rulemaking. One commenter states that airport bird control programs and flight crew awareness training programs are generally being decreased in scope.

The FAA disagrees that airport controls programs and flight crew awareness training are ineffective in mitigating the bird ingestion threat. The FAA believes airport bird control programs are effective in mitigating the bird ingestion threat on and around airports. It must be noted that the overall bird ingestion experience base of commercial aircraft is a combination of aircraft capability, airport and environ controls, air traffic control, and flight crew awareness. Only by a combination of efforts will the bird ingestion threat to aircraft be kept to acceptable levels. It should be noted that the proposal did not specifically consider airport controls, air traffic controls, or flight crew effects in the design of the rule, other than assuming current levels of effectiveness will be maintained. Also, airport wildlife controls themselves are beyond the scope of this rulemaking effort.

It should also be noted that the FAA has recently published a number of policy and guidance related documents pertaining to airport wildlife control plans, land use practices, and aircraft bird strike reporting. The FAA also participates in various government and industry focus groups related to wildlife hazards on and around airports, maintains a bird strike database, and has contracted with the Smithsonian institution to provide a service to identify and size birds involved in aircraft strike events. As a result of these efforts, the emphasis on wildlife hazard identification and control measures is expanding industry wide.

One commenter states that fan blade containment after a bird ingestion event is a concern.

The FAA agrees in part. The FAA agrees that containment of hazardous fragments after a bird strike present a serious concern, however containment requirements are beyond the scope of this rulemaking effort. The proposed rule, for large, small and medium birds has the same requirement, meaning the applicant must show that release of hazardous fragments through the engine casing following a bird strike is precluded. Also, § 33.19 requires that the energy levels and trajectories of fragments resulting from rotor blade failure that lie outside the engine cases must be defined (*e.g.*, fragments exiting through inlet structure). The FAA does not agree, however, that this concern warrants delay in issuing this final rule.

One commenter states that a full flight engine configuration should be utilized for certification tests.

The FAA agrees in principle. The test engine configuration must be fully representative of a type design engine insofar as bird ingestion requirements are concerned. Also, it is standard practice to use flight type inlets, cowls, and primary nozzles, or equivalents for these tests. The use of such flight type aircraft components are needed to evaluate the energy and trajectory of fragments which lie outside the engine type design cases. No changes to the proposed rule are required since compliance with the requirements will dictate the use of appropriate inlet and cowl hardware for any given design.

One commenter states that a 10-percent tolerance band on certification test controlling parameters is excessive.

The FAA does not agree. The 10-percent tolerance band addresses the Critical Ingestion Parameter (CIP), which is the parameter for a particular bird ingestion scenario that is most critical relative to the pass/fail criteria contained in the rule. The other controlling parameters must be maintained such that the CIP itself does not vary more than 10-percent. In practice, most controlling parameters can be maintained to a relatively tight tolerance, and this practice will not change. The AC will contain further guidance on one method, but not the only method, to show compliance with this requirement.

One commenter states that the makeup of the rulemaking database is not clearly described within the NPRM.

The FAA agrees in part. The database could be described in more detail. The database is made up of known revenue-

service engine bird ingestion events from the time period from entry into service through September 1995. Data collections included International Civil Aviation Organization (ICAO) data, airframe manufacturer data, engine manufacturer data, FAA data and any other data presented that could be cross referenced to an actual engine ingestion. The data comes from a cross section of engine types, and for transport category aircraft engines it encompasses approximately 90 million aircraft flights. The data points utilized are those which were identified as actual engine ingestion events, where an engine ingestion event was defined as the presence of bird debris within the engine inlet or engine flow paths. Bird debris was defined as feathers, flesh, or body fluids that could be identified as having come from a bird. Techniques used for identification of debris were visual identification of feathers, forensic laboratory methods, and black light identification of body fluid smears on the engine inlet flow path and engine structure. If the evidence positively indicated an ingestion, but a positive identification of the bird species could not be made, the data was entered as an ingestion without an associated weight. Data representing bird strikes to the aircraft structure (other than engines) was not utilized in the design of this rule. Simple bird species distribution data (*i.e.*, population and size distributions occurring in nature) was also not utilized in the design of the rule.

A series of bird ingestion data collection efforts, as described above, collated data for a variety of engine sizes and types. Three parameters were estimated from the data collection for events where the bird size, bird type, aircraft model, engine model, flight regime, and outcome where reasonably known. These were the single engine ingestion rate versus bird weight; multiple engine ingestion rate versus bird weight; and the ratio of the number of engine power loss events to the number of ingestion events versus bird weight. The probability of a dual engine power loss on a twin engine aircraft was computed by multiplying the square of the power loss ratio by the multiple engine ingestion rate for twin engine positions. Twin engine positions were defined as the inboard positions on four engine airplanes, the wing positions of three engine airplanes, and the wing positions on two engine airplanes. For the purpose of the above data reduction, a power loss was defined as 50-percent or more loss of power or thrust. The data was collected and evaluated in a manner which would provide a good representation of the bird ingestion threat to aircraft engines in service during that time period.

The FAA does not agree, however, that the description of the database contained in the NPRM was deficient, or that this final rule should be delayed.

Two commenters state that this rulemaking database does not reflect actual service experience, and is not accurate or complete.

The FAA disagrees. As discussed in the paragraph above, the rulemaking database is comprised of data from actual engine bird ingestion events where the bird species, bird size, bird number, aircraft model, engine model, regime of flight, and outcome where all reasonably known. Also as noted above, for transport category aircraft engines, the database reflects known bird ingestion events encompassing approximately 90 million aircraft flights of experience covering a broad cross-section of aircraft types. This rulemaking database is a good representation of what aircraft engines have actually experienced over the past 25 years. Lastly, since this is the actual experience of the fleet, it also includes whatever effects there might be from increased bird populations in this time period.

One commenter states that recent events have shown that the proposed requirements, relative to bird mass and flock size, are less severe than occur in nature.

The FAA agrees in part. Events can occur that are beyond the severity of the proposed requirements. This was stated in the NPRM preamble. The proposed rule was not designed to encompass the worst possible combination of all factors, as this is impossible to predict, and would be beyond the capability of current engine technology. The FAA believes the proposed requirements are reasonable relative to the state goal of reducing the bird threat hazards to aircraft by an order of magnitude. It should also be noted that a number of new engine models have been designed and evaluated to these proposed standards, and have generally performed well in revenue service.

The FAA does not agree that the possibility of a bird ingestion event more severe than already contemplated in the proposed rule should warrant a delay in issuing a final rule.

One commenter states that there has been significant growth in some bird populations over the past 10 years.

The FAA agrees in part. The FAA acknowledges that certain species of birds have experienced significant population and distribution increases over the past several years, and should be monitored for any effect on the bird threat to aircraft engines in service. The FAA does not believe, however, that this warrants a delay in issuing this final rule.

Two commenters state that this rulemaking database focused only on past experience, and made no attempt to predict future changes to the bird threat.

The FAA agrees in part. While this rulemaking database focused only on actual events which have occurred in revenue service, the rule was not designed to meet predicted future changes in the bird threat environment. The FAA believes it would be impossible to accurately predict threat changes, more or less in severity, as the overall experience base is a function of bird population, bird distribution, aircraft capability, engine capability, airport and airport environmental control measures, air traffic control operational requirements, air traffic control alert reports, and flight crew awareness. The FAA believes it is impossible to integrate these various factors into an accurate prediction of bird threat changes suitable for rulemaking, and believes that the possibility of such changes does not warrant delay in issuing this final rule. However, the FAA agrees that the factors noted above should be reviewed at periodic intervals to assure that the bird ingestion certification standards are adequate to meet the overall threat of bird ingestion, and that no individual factor is allowed to worsen to a significant degree.

One commenter states that the large bird requirement should be 12–15 lbs.

The FAA does not agree. While birds larger in size than the standard for "large birds" in the proposed rule can occur in revenue service, a review service data indicates that the proposed sliding scale (4–8 lbs. as a function of inlet area) for the single large bird requirement is reasonable relative to the stated goal of reducing the hazards to aircraft by an order of magnitude. The FAA does not agree the large bird standard needs to be changed.

One commenter states that the proposed requirement for § 33.76(c)(2) needs to be revised to allow the use of certification data from previous programs.

The FAA disagrees. It is not necessary for a rule to contain language allowing the use of existing certification data. Any certification data held by the applicant may be utilized provided that the data is applicable to the product in question, and approved by the FAA. The AC will contain a discussion on what sources of data could be

acceptable for the purpose of compliance findings.

One commenter states that the proposed requirements for §§ 23.903 and 25.903 are not clear.

The FAA disagrees. The text changes were required only to provide reference to new § 33.76, and uses the same format as the previous rule.

One commenter states that the proposed requirements for §§ 23.903 and 25.903 will allow inappropriate use of previous engine bird ingestion certification requirements instead of new § 33.76 when determining engine model eligibility for new aircraft applications.

The FAA disagrees. The proposed text is consistent with current §§ 23.903 and 25.903, and allows flexibility for installation of pre § 33.76 certification basis engines into new aircraft applications at the FAAs discretion. The FAA believes it would be inappropriate to preclude by regulation the installation of pre § 33.76 engines which have demonstrated acceptable bird ingestion capabilities in revenue service. For transport category aircraft, the existing requirements under §§ 21.21(b)(2), 25.903(a) and 25.1091(d)(2)/(e) have been identified as providing for the evaluation of proposed installations relative to bird ingestion service history. The FAA will review the application of these regulations to assure that they provide for the necessary level of evaluation of any proposed installation utilizing pre § 33.76 model aircraft engines. Lastly, as part of this review, it was observed that current § 25.1091 must be revised to include an appropriate reference to the new requirements of § 33.76. Therefore, § 25.1091 is also revised by this final rule action.

One commenter states that the FAA air traffic control (ATC) operational procedures are now allowing high speed operations below 10,000 ft. altitude, and this should be considered with respect to these bird ingestion requirements.

The FAA agrees in part. This rule is based on the expectation that the majority of operations below 10,000 ft. would be at less than 250 knots. However, studies into changing ATC operational procedures have allowed unrestricted operation at speeds above 250 knots near some Class B airports, and at altitudes where bird encounters are most likely to occur. The new small and medium bird requirements are structured to account for higher speeds. However the large bird requirement utilizes a 200-knots default bird speed value. Higher aircraft speeds at low altitudes could also result in shallower climb profiles, possibly resulting in an aircraft spending more time in a higher risk bird threat environment then previously assumed. Therefore, the FAA will institute a follow-on rulemaking action to determine whether additional changes to the bird requirements are necessary based on these operational considerations. Also, the FAA will include material in the AC to address this subject relative to the large bird test requirements. The FAA does not believe, however, that this operational consideration warrants delaying this final rule.

One commenter states that the NPRM explanation for choosing the 200 knots over a 250 knots bird speed value for large bird tests needs clarification.

The FAA agrees in part. For a given turbine engine design, a specific bird speed will provide the least margin to the pass/fail criteria of § 33.76. For critical static structure (*e.g.*, inlet guide vane), the higher speed will generally be more severe due to simple momentum transfer at impact. However for critical rotating stages of blades, there will be an optimum bird speed which results in maximum damage to that rotating stage. Bird speeds faster or slower than this optimum will result in less severe damage. This is due to the combined effects of bird speed, rotor blade tangential velocity, and blade twist angle. The worst case combination of these factors will result in the highest bird since mass absorbed by the blade at the worst impact angle, and therefore results in the highest blade stresses at the blade's critical location. For example, most conventional high bypass turbofan designs will have critical speeds in the 150–220–knots range, depending upon specific fan blade design characteristics. While the FAA plans further review of this aspect of the large bird certification test, the FAA does not believe that this warrants delay in issuing this final rule.

Five commenters state that the FAA should reconsider the JAA position of including a requirement addressing intermediate flocking birds greater than 2.5 lbs.

The FAA agrees in part. The FAA agrees to reconsider the overall JAA position as part of future rulemaking study, and still believes that the Joint Aviation Requirements (JAR) and the FAA regulations should eventually be harmonized in this regard. The FAA does not agree, however, that the difference between this final rule and the JAA's current position warrants delay in issuing this final rule pending further study.

Two commenters state that the FAA does not understand the JAA position on intermediate flocking birds.

The FAA disagrees. The FAA understands that the rationale for the additional JAA intermediate flocking bird requirement is to ensure that new engines will have the same level of capability (for flocking birds greater than 2.5 lbs.) as current in-service engines have demonstrated. The FAA does believe that the new requirements of § 33.76, overall, will provide a fleet of engines of overall increased capability when compared to the fleet of engines based on current § 33.77 requirements.

Three commenters state that the FAA and JAA should consider alternatives to the JAA intermediate flocking bird requirement of JAR–E 800(b)(2), as it does not meet its stated objective.

The FAA agrees in part. The FAA agrees to participate in a new rulemaking study to develop a meaningful alternative to the JAR intermediate flocking bird requirement. The FAA does not agree that the 12-percent unbalance requirement of proposed JAR–E 800(b)(2) can be relied upon to achieve the stated intent of the JAR–E rule as described. The FAA also does not believe that this final rule should be delayed pending any study of this issue.

Three commenters state that the proposed requirements do not adequately cover the flocking bird range of 2.5–8 lbs.

The FAA disagrees. The proposed requirements have taken into account flocking birds in this category based on (1) the historical performance of engines currently in service, and (2) based on the overall increased severity of the new requirements. The FAA believes that the new requirements of § 33.76, overall, will provide a fleet of engines of increased capability in this regard when compared to be fleet of engines based on current § 33.77 requirements. However, since the flocking bird capability in this bird size range may not be directly evaluated for each individual design at the time of certification, the FAA agrees to participate in a new rulemaking study of evaluate this comment further. The FAA does not agree, however, that this final rule should be delayed pending any study of that issue.

One commenter states that the proposed requirements meet the flocking bird objections for conventional designs (*e.g.*, for designs which the database directly represents).

The FAA agrees that the rulemaking database and related assumptions which are part of this rule are most closely to the conventional designs which make up the database. Therefore, for each designs, there is a high degree of

confidence that this new rule's stated objective can be met.

Two commenters state that the proposed requirements may not meet the flocking bird objectives for new unconventional design technologies which have no historical data from which to evaluate capability.

The FAA agrees in part. The database on which this rule finds support, is made up of primarily conventional designs, and that the assumptions made when developing this rule most closely relate to those designs. However, it must be noted that the new § 33.76 is generally a more severe set of requirements then currently § 33.77, and that the overall effect of the new rule will be a world fleet of increased capability when compared to the world fleet based on current § 33.77 requirements. Therefore, the overall rule objective of decreasing the risk from bird ingestion events by an order of magnitude will be met at the world fleet level. Also, since the new requirements do not include specific test requirements for flocking birds greater than 2.5 lbs., the possibility exists for disparities in engine capability from one model series to another, regardless of conventional or unconventional designs. The FAA believes it prudent to address this concern by further review of available service data to determine whether the chosen standards sufficiently cover the level of safety desired for this rule, and to assure that the specific level of safety demonstrated by each engine model certified is acceptable. The FAA agrees to participate in a new rulemaking study to evaluate this comment further, but does not agree that this final rule should be delayed pending that study.

Two commenters state that the proposed requirements do not provide any improvement in power loss rate over current requirements.

The FAA disagrees. It must be noted that the new § 33.76 is generally a more severe set of requirements then current § 33.77, and that the overall effect of the new rule will be a world fleet of increased capability when compared to the world fleet based on current § 33.77 requirements, of which power loss rate is one measure.

One commenter states that there is no need for expanded flocking bird requirements beyond this proposal.

The FAA agrees that new § 33.76 will be beneficial to overall world fleet capability. The FAA also believes, however, that a new review of available is prudent to evaluate the current state of the bird threat in service, and that additional rulemaking action could result.

Two commenters state that a new rulemaking study should be implemented to develop additional standards for run should be not be delayed pending further study.

Finally, the FAA has made the following minor editorial changes to better clarify this rule. These changes do not affect the scope of the rule or change the intent of these sections.

§ 33.76(a)(2) text was modified slightly to more clearly state the intent of the rule. There are no changes to the requirements.

§ 33.76(b)(4) was revised to more clearly state the intent of the rule, which does not include an actual "waiver" of the large bird requirements as stated in the NPRM, but was intended to specify an additional method of showing compliance to these requirements using § 33.76(a) certification data when appropriate. Therefore the actual certification substantiation requirements of this section are unchanged from the NPRM proposal, with the only change being a more accurate description of the compliance option under this subsection that is available to the applicant.

It was determined that the title of § 33.77 should be revised to specify the one remaining foreign object retained within this section (ice), and that for clarity and brevity the table of § 33.77(e) is deleted, and the table's remaining pertinent information is included directly into the text of existing paragraph (e). No changes to the requirements have resulted from these additional format changes.

Section 25.1091 was revised to include reference to § 33.76. It was determine that the part 33 references within § 25.1091 needed to be updated to account for this rulemaking action.

After careful review of all the comments, the FAA has determined that air safety and the public interest require the adoption of the rule with the changes described.

Paperwork Reduction

There are no new requirements for information collection associated with this rule that would require approval from the Office of Management and Budget pursuant to the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)).

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommends Practices to the maximum extent practicable. The FAA determined that there are no ICAO Standards and Recommended Practices that correspond to these regulations.

Regulatory Analyses and Assessments

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

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

Regulatory Evaluation Summary

Cost—this rule is the result of ARAC recommendations. Moreover, public comments were not received on the preliminary economic evaluation. Costs of the rule include one-time certification costs and recurrent fuel costs due to reduced fan efficiency. The FAA estimates that the rule will add $250,000 to $500,000 to each new engine model's certification costs, depending on engine inlet area. These certification costs will be incurred primarily in two areas. First, additional analysis required to verify the affects of a large bird impact on the front of the engine could necessitate a component test costing $250,000. Second, the rule

will require additional analysis or testing on the full fan assembly for engines with inlet areas greater than 2,092 square-inches. Such testing is estimated to cost approximately an additional $250,000 for those engines.

In addition, the revised bird test weights could necessitate strengthening fan components, thereby affecting fan performance. The FAA estimates that reduced fan efficiency will result in a 0.2-percent increase in fuel consumption. On average, the FAA estimates that this will increase annual fuel costs by $4,770 per airplane, for airplanes equipped with new engines certificated to the standards of this rule.

Benefits—Benefits associated with this rule include: (1) Averted fatalities and injuries, (2) averted property damage (primarily hull losses), and (3) reduced maintenance and repair costs. Based on historical accident information, the FAA estimates that the expected annual per-airplane benefit from averted airplane damage or loss is approximately $657. The expected annual benefit per-airplane from averted fatalities and injuries is $654 and $75, respectively.

The estimated value of maintenance/repair savings associated with the rule is based on an analysis of the relationship between bird ingestion weight and the probability of damage. The FAA estimates that, on average, the rule will save operators approximately $4,654 per airplane per year.

To compare the lifecycle costs and benefits of the rule, the evaluation utilizes a hypothetical representative engine certification. The engines are assumed to be installed on a notional twin-engine jet transport with a seating capacity of 161 (the average seating capacity of jet transports in commercial service in 1996). In addition, this analysis assumes the following: (1) Incremental engine certification costs equal $250,000 in year 0 and $250,000 in year 1; (2) production of engines commences in year 2, (3) engines are installed in aircraft and enter service beginning in year 3, (4) each engine has a 15-year service life, (5) 24 engines are produced per year for 10 years so that there are 240 total engines and 120 airplanes per certification, and (6) the discount rate is 7 percent. Under these conditions, the expected discounted benefits, at $4.333 million, exceed the discounted costs of $3.906 million.

Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) of 1980, 5 U.S.C. 601–612, directs the FAA to fit regulatory requirements to the scale of the business, organizations, and governmental jurisdictions subject to the regulation. We are required to determine whether a proposed or final action will have a "significant economic impact on a substantial number of small entities" as defined in the Act. If we find that the action will have a significant impact, we must do a "regulatory flexibility analysis."

This final rule will not have a significant economic impact on a substantial number of small entities. The final rule will apply only to newly designed turbine aircraft engines certificated in the future. Each new engine certification could affect two types of small entities: manufacturers of turbine engines and operators of aircraft.

Manufacturers will be required to perform additional analysis or testing to demonstrate that the new bird ingestion requirements are met. There are nine turbine aircraft engine manufacturers with headquarters in the U.S. (this count includes subsidiaries of foreign entities and consortiums of domestic and/or foreign entities). Information available to the FAA indicates that only one—a U.S. manufacturer of small turbine engines has less than 1,500 employees, and therefore qualifies as a small business under SBA employment criteria. One entity is not considered a substantial number by the FAA. If all certification costs are assumed to be borne by the manufacturer, the FAA would conclude that with only one manufacturing firm being classified as "small," there is not an impact on small business.

In addition, the FAA analyzed the small business impact with a tougher criterion. The FAA assumes that all manufacturing costs will be borne by their customers who purchase new equipment. The rule is estimated to add about $250,000 for a small engine type produced by the single small entity: these are one-time certification costs. The FAA estimates that the rule will impose no incremental manufacturing costs. Aircraft operators will incur slightly higher engine prices and will pay increased operating or fuel costs due to the small decrease in engine efficiency (described in the full regulatory evaluation). According to FAA data, there are about 3,000 air carriers having less than 1,500 employees: approximately 100 air carriers operating under part 121 (or both part 121 and part 135), and 2,900 air carriers operating under part 135.

Assuming conservatively that: (1) All incremental certification costs are passed on to the buyer/operator, (2) the manufacturer recovers incremental certification costs by applying a uniform price increase to engines produced during a 10-year production run, and (3) that the discount rate is 7 percent; then the FAA estimates that average new engine prices will increase by approximately $3,070 per larger engine and $1,587 per smaller engine. When these costs are amortized over the 15-year life of an engine (again, assuming a 7-percent discount rate), the incremental annualized cost per new engine is approximately $315 and $163 for larger and smaller engines, respectively. Therefore, assuming a typical airplane has two engines, the incremental annualized costs for a large airplane is approximately $630 and the incremental annualized cost for a smaller airplane is approximately $326.

For larger engines, the rule will also increase annual airplane operating costs as a result of the new medium bird ingestion requirements due to higher fuel consumption and, thus, costs. These requirements will have a negligible effect on smaller engines. On average, annual operating costs per large airplane, with engines newly certificated to the standards of this rule, are estimated to increase by approximately $4,770. However, the reduction in average annualized maintenance costs associated with the more damage-resistant engines is expected to approximately offset the incremental operating costs.

Therefore, total annualized costs for operators of larger and smaller airplanes with new engines will be approximately $630 and $326 per airplane, respectively. Consequently, the FAA certifies that the rule will not have a significant economic impact on a substantial number of small entities.

International Trade

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards of related activity that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In addition, consistent with the Administration's belief in the general superiority and desirability of free trade, it is the policy of the Administration to remove or diminish, to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and barriers affecting the import of foreign goods and services into the U.S.

Turbine engines are produced by United States and foreign companies. The FAA has assessed the potential

effect of this rule and has determined that it will impose the same costs on domestic and international entities, and will thus have a neutral trade impact.

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (2 U.S.C. 1532–1538) requires the FAA to assess the effects of Federal regulatory actions on state, local, and tribal governments, and on the private sector of rules that contain a Federal intergovernmental or private sector mandate that exceeds $100 million in nay one year. This action does not contain such a mandate.

Executive Order 13132, Federalism

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

Plain Language

In response to the June 1, 1998, Presidential Memorandum regarding the use of plain language, the FAA re-examined the writing style currently used in the development of regulations. The memorandum requires federal agencies to communicate clearly with the public. We are interested in your comments on whether the style of this document is clear, and any other suggestions you might have to improve the clarity of FAA communications that affect you. You can get more information about the Presidential memorandum and the plain language initiative at *http://www.plainlanguage.gov.*

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment or environmental impact statement. In accordance with FAA Order 1050.ID, appendix 4, paragraph 4(j), this rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the notice has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Public Law 94–163, as amended (43 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the final rule is not a major regulatory action under the provisions of the EPCA.

List of Subjects

14 CFR Part 23

Air transportation, Aircraft, Aviation safety, Safety.

14 CFR Part 25

Air transportation, Aircraft, Aviation safety, Safety.

14 CFR Part 33

Air transportation, Aircraft, Aviation safety, Safety.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends parts 23, 25 and 33 of Title 14, Code of Federal Regulations as follows:

PART 23—AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES

1. The authority citation for part 23 continues to read as follows:

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

2. Section 23.903 is amended by revising paragraph (a)(2) to read as follows:

§ 23.903 Engines.

(a) * * *

(2) Each turbine engine and its installation must comply with one of the following:

(i) Sections 33.76, 33.77 and 33.78 of this chapter in effect on December 13, 2000.

(ii) Sections 33.77 and 33.78 of this chapter in effect on April 30, 1998, or as subsequently amended before December 13, 2000; or

(iii) Section 33.77 of this chapter in effect on October 31, 1974, or as subsequently amended before April 30, 1998, unless that engine's foreign object ingestion service history has resulted in an unsafe condition; or

(iv) Be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition.

* * * * *

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

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

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

4. Section 25.903 is amended by revising paragraph (a)(2) to read as follows:

§ 25.903 Engines.

(a) * * *

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

(i) Sections 33.76, 33.77 and 33.78 of this chapter in effect on December 13, 2000, or as subsequently amended; or

(ii) Sections 33.77 and 33.78 of this chapter in effect on April 30, 1998, or as subsequently amended before December 13, 2000; or

(iii) Comply with § 33.77 of this chapter in effect on October 31, 1974, or as subsequently amended prior to April 30, 1998, unless that engine's foreign object ingestion service history has resulted in an unsafe condition; or

(iv) Be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition.

* * * * *

5. Section 25.1091 is amended by revising paragraph (e) to read as follows:

§ 25.1091 Air induction.

* * * * *

(e) If the engine induction system contains parts or components that could be damaged by foreign objects entering the air inlet, it must be shown by tests or, if appropriate, by analysis that the induction system design can withstand the foreign object ingestion test conditions of §§ 33.76, 33.77 and 33.78(a)(1) of this chapter without failure of parts or components that could create a hazard.

PART 33—AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

6. The authority citation for part 33 continues to read as follows:

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

7. Section 33.76 is added to read as follows:

§ 33.76 Bird ingestion.

(a) *General.* Compliance with paragraphs (b) and (c) of this section shall be in accordance with the following:

(1) All ingestion tests shall be conducted with the engine stabilized at no less than 100-percent takeoff power or thrust, for test day ambient conditions prior to the ingestion. In addition, the demonstration of compliance must account for engine operation at sea level takeoff conditions on the hottest day that a minimum engine can achieve maximum rated takeoff thrust or power.

(2) The engine inlet throat area as used in this section to determine the bird quantity and weights will be established by the applicant and identified as a limitation in the installation instructions required under § 33.5.

(3) The impact to the front of the engine from the single large bird and the single largest medium bird which can enter the inlet must be evaluated. It must be shown that the associated components when struck under the conditions prescribed in paragraphs (b) or (c) of this section, as applicable, will not affect the engine to the extent that it cannot comply with the requirements of paragraphs (b)(3) and (c)(6) of this section.

(4) For an engine that incorporates an inlet protection device, compliance with this section shall be established with the device functioning. The engine approval will be endorsed to show that compliance with the requirements has been established with the device functioning.

(5) Objects that are accepted by the Administrator may be substituted for birds when conducting the bird ingestion tests required by paragraphs (b) and (c) of this section.

(6) If compliance with the requirements of this section is not established, the engine type certification documentation will show that the engine shall be limited to aircraft installations in which it is shown that a bird cannot strike the engine, or be ingested into the engine, or adversely restrict airflow into the engine.

(b) *Large birds.* Compliance with the large bird ingestion requirements shall be in accordance with the following:

(1) The large bird ingestion test shall be conducted using one bird of a weight determined from Table 1 aimed at the most critical exposed location on the first stage rotor blades and ingested at a bird speed of 200-knots for engines to be installed on airplanes, or the maximum airspeed for normal rotocraft flight operations for engines to be installed on rotocraft.

(2) Power lever movement is not permitted within 15 seconds following ingestion of the large bird.

(3) Ingestion of a single large bird tested under the conditions prescribed in this section may not cause the engine to:

(i) Catch fire;

(ii) Release hazardous fragments through the engine casing;

(iii) Generate loads greater than those ultimate loads specified under § 33.23(a); or

(iv) Lose the ability to be shut down.

(4) Compliance with the large bird ingestion requirements of this paragraph may be shown by demonstrating that the requirements of § 33.94(a) constitute a more severe demonstration of blade containment and rotor unbalance than the requirements of this paragraph.

TABLE 1 TO § 33.76.—LARGE BIRD WEIGHT REQUIREMENTS

Engine Inlet Throat Area (A)—Square/meters (square-inches)	Bird weight kg. (lb.)
1.35 (2,092)> A	1.85 (4.07) minimum, unless a smaller bird is determined to be a more severe demonstration.
1.35 (2,029)≤ A< 3.90 (6,045).	2.75 (6.05)
3.90 (6,045)≤ A	3.65 (8.03)

(c) *Small and medium birds.* Compliance with the small and medium bird ingestion requirements shall be in accordance with the following:

(1) Analysis or component test, or both, acceptable to the Administrator, shall be conducted to determine the critical ingestion parameters affecting power loss and damage. Critical ingestion parameters shall include, but are not limited to, the affects of bird speed, critical target location, and first stage roto speed. The critical bird ingestion speed should reflect the most critical condition within the range of airspeeds used for normal flight operations up to 1,500 feet above ground level, but not less than V_1 minimum for airplanes.

(2) Medium bird engine tests shall be conducted so as to simulate a flock encounter, and will use the bird weights and quantities specified in Table 2. When only one bird is specified, that bird will be aimed at the engine core primary flow path; the other critical locations on the engine face area must be addressed, as necessary, by appropriate tests or analysis, or both. When two or more birds are specified in Table 2, the largest of those birds must be aimed at the engine core primary flow path, and a second bird must be aimed at the most critical exposed location on the first stage rotor blades. Any remaining birds must be evenly distributed over the engine face area.

(3) In addition, except for rotorcraft engines, it must also be substantiated by appropriate tests or analysis or both, that when the full fan assembly is subjected to the ingestion of the quantity and weights of bird from Table 3, aimed at the fan assembly's most critical location outboard of the primary core flowpath, and in accordance with the applicable test conditions of this paragraph, that the engine can comply with the acceptance criteria of this paragraph.

(4) A small bird ingestion test is not required if the prescribed number of medium birds pass into the engine rotor blades during the medium bird test.

(5) Small bird ingestion tests shall be conducted so as to simulate a flock encounter using one 85 gram (0.187 lb.) bird for each 0.032 square-meter (49.6 square-inches) of inlet area, or fraction thereof, up to a maximum of 16 birds. The birds will be aimed so as to account for any critical exposed locations on the first stage rotor blades, with any remaining birds evenly distributed over the engine face area.

(6) Ingestion of small and medium birds tested under the conditions prescribed in this paragraph may not cause any of the following:

(i) More than a sustained 25-percent power or thrust loss;

(ii) The engine to be shut down during the required run-on demonstration prescribed in paragraphs (c)(7) or (c)(8) of this section;

(iii) The conditions defined in paragraph (b)(3) of this section.

(iv) Unacceptable deterioration of engine handling characteristics.

(7) Except for rotorcraft engines, the following test schedule shall be used:

(i) Ingestion so as to simulate a flock encounter, with approximately 1 second elapsed time from the moment of the first bird ingestion to the last.

(ii) Followed by 2 minutes without power level movement after the ingestion.

(iii) Followed by 3 minutes at 175-percent of the test condition.

(iv) Followed by 6 minutes at 60-percent of the test condition.

(v) Followed by 6 minutes at 40-percent of the test condition.

(vi) Followed by 1 minute at approach idle.

(vii) Followed by 2 minutes at 75-percent of the test condition.

(viii) Followed by stabilizing at idle and engine shut down.

The durations specified are times at the defined conditions with the power lever being moved between each condition in less than 10 seconds.

(8) For rotorcraft engines, the following test schedule shall be used:

(i) Ingestion so as to simulate a flock encounter within approximately 1 second elapsed time between the first ingestion and the last.

(ii) Followed by 3 minutes at 75-percent of the test condition.

(iii) Followed by 90 seconds at descent flight idle.

(iv) Followed by 30 seconds at 75-percent of the test condition.

(v) Followed by stabilizing at idle and engine shut down. The duration specified are times at the defined conditions with the power being changed between each condition in less than 10 seconds.

(9) Engines intended for use in multi-engine rotorcraft are not required to comply with the medium bird ingestion portion of this section, providing that the appropriate type certificate documentation is so endorsed.

(10) If any engine operating limit(s) is exceeded during the initial 2 minutes without power lever movement, as provided by paragraph (c)(7)(ii) of this section, then it shall be established that the limit exceedence will not result in an unsafe condition.

TABLE 2 TO § 33.76.—MEDIUM FLOCKING BIRD WEIGHT AND QUANTITY REQUIREMENTS

Engine Inlet Throat Area (A)—Square-meters (square-inches)	Bird quantity	Bird weight kg. (lb.)
0.05 (77.5)> A	none	
.05 (77.5)≤ A <0.10 (155)	1	0.35 (0.77)
0.10 (155)≤ A <0.20 (310)	1	0.45 (0.99)
0.20 (310)≤ A <0.40 (620)	2	0.45 (0.99)
0.40 (620)≤ A <0.60 (930)	2	0.70 (1.54)
0.60 (930)≤ A <1.00 (1,550)	3	0.70 (1.54)
1.00 (1,550)≤ A <1.35 (2,092)	4	0.70 (1.54)
1.35 (2,092)≤ A <1.70 (2,635)	1	1.15 (2.53)
	plus 3	0.70 (1.54)
1.70 (2,635)≤ A <2.10 (3,255)	1	1.15 (2,53)
	plus 4	0.70 (1.54)
2.10 (3,255)≤ A <2.50 (3,875)	1	1.15 (2.53)
	plus 5	0.70 (1.54)
2.50 (3,875)≤ A <3.90 (6045)	1	1.15 (2.53)
	plus 6	0.70 (1.54)
3.90 (6045)≤ A <4.50 (6975)	3	1.15 (2.53)
4.50 (6975)≤ A	4	1.15 (2.53)

TABLE 3 TO § 33.76.—ADDITIONAL INTEGRITY ASSESSMENT

Engine Inlet Throat Area (A)—square-meters (square-inches)	Bird quantity	Bird weight kg. (lb.)
1.35 (2,092)> A	none	
1.35 (2,092)≤ A <2.90 (4,495)	1	1.15 (2.53)
2.90 (4,495)≤ A <3.90 (6,045)	2	1.15 (2.53)
3.90 (6,045)≤ A	1	1.15 (2.53)
	plus 6	0.70 (1.54)

8. Section 33.77 is amended by revising the section heading, removing and reserving paragraphs (a) and (b), and by revising paragraphs (c), (d)(3), and (e) to read as follows:

§ 33.77 Foreign object ingestion—ice.

(a) [Reserved]

(b) [Reserved]

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

(1) Cause a sustained power or thrust loss; or

(2) require the engine to be shutdown.

(d) * * *

(3) The foreign object, or objects, 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 required by paragraph (c) of this section.

(e) Compliance with paragraph (c) of this section must be shown by engine test under the following ingestion conditions:

(1) Ice quantity will be the maximum accumulation on a typical inlet cowl and engine face resulting from a 2-minute delay in actuating the anti-icing system; or a slab of ice which is comparable in weight or thickness for that size engine.

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

(3) Engine operation will be maximum cruise power or thrust.

(4) The ingestion will simulate a continuous maximum icing encounter at 25 degrees Fahrenheit.

Issued in Washington, DC, on September 5, 2000.

Jane F. Garvey,

Administrator.

[FR Doc. 00–23175 Filed 9–13–00; 8:45 am]

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Federal Register

Thursday,
September 14, 2000

Part V

Department of Transportation

Federal Aviation Administration

14 CFR Parts 23, 25, and 33
Airworthiness Standards; Bird Ingestion; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Parts 23, 25, 33

[Docket No. FAA–1998–4815; Amendment No. 23–54, 25–100 and 33–20]

RIN 2120–AF84

Airworthiness Standards; Bird Ingestion

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This amendment revises the bird ingestion type certification standards for aircraft turbine engines to better address the actual bird threat encountered in service. This amendment also establishes nearly uniform bird ingestion standards for aircraft turbine engines certified by the United States under FAA standards and by the Joint Aviation Authorities (JAA) countries under JAA standards, thereby simplifying airworthiness approvals for import and export.

EFFECTIVE DATES: December 13, 2000.

FOR FURTHER INFORMATION CONTACT: Marc Bouthillier, Engine and Propeller Directorate, Engine and Propeller Standards Staff, ANE–110, Federal Aviation Administration, New England Executive Park, Burlington, Massachusetts 01803–5299; telephone (781) 238–7120; facsimile (781) 238–7199.

SUPPLEMENTARY INFORMATION:

Availability of Final Rules

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the FedWorld Electronic bulletin board service (telephone: (703) 321–3339) or the Government Printing Office's (GPO) electronic bulletin board service (telephone: (202) 512–1661).

Internet users may reach the FAA's web page at http://www.faa.gov/avr/arm/nprm/nprm.htm or the GPO's web page at http://www.access.gpo.gov/nara for access to recently published rulemaking documents.

Any person may obtain a copy of this document by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680. Communications must identify the amendment number or docket number of this final rule.

Persons interested in being placed on the mailing list for future rulemaking documents should request from the above office a copy of Advisory Circular No. 11–2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure.

Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996, requires the FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. Therefore, any small entity that has a question regarding this document may contact their local FAA official. Internet users can find additional information on SBREFA on the FAA's web page at *http://www.faa.gov/avr/arm/sbrefa.htm* and may send electronic inquiries to the following Internet address: 9–AWA–SBREFA@faa.gov.

Background

Statement of the Problem

In 1976, the National Transportation Safety Board (NTSB), in response to an accident involving a wide-bodied aircraft that may have experienced multiple bird ingestion into the engines, issued Safety Recommendation A–76–64, recommending that the FAA, "amend 14 CFR 33.77 to increase the maximum number of birds in the various size categories required to be ingested into turbine engines with large inlets." Safety Recommendation A–76–64 also stated, "these increased numbers and sizes should be consistent with the birds ingested during service experience of these engines." In response to the recommendation, the FAA sponsored an industry wide study of the types, sizes, and quantities of birds that had been ingested into aircraft turbine engines of all sizes, and the resulting affects on engine performance. Subsequently, the FAA requested that the Aerospace Industries Association (AIA) analyze the data, and report back to the FAA. Based on the AIA report, the FAA determined the actions to be taken, as well as the disposition of the NTSB safety recommendation A–76–64. The FAA concluded that the regulations contained in § 33.77 should be modified to increase the severity of the bird ingestion testing requirements regarding large, high bypass ratio engines. In addition, the FAA found that it should update the design and testing requirements for all engine sizes to reflect the actual numbers and bird sizes being ingested. This effort was adopted as a part 33 and Joint Aviation Regulations for engines (JAR–E) harmonization project and was selected as an Aviation Rulemaking Advisory Committee (ARAC) project.

Industry Study

There are three separate data collection efforts within the industry study. The largest and most comprehensive collection is the data for large commercial transport engines with fan diameters between 80 and 100 inches and spanning a time period from entry into service through 1987. This collection includes FAA sponsored contracts which are summarized in report number DOT/FAA/CT–84/13, dated September 1984. A less extensive collection effort involving engines with inlet areas less than 1000 square inches was also performed. Data for this class of engine is less comprehensive in that it involves reporting from a very diverse aircraft operator base including General Aviation operators as well as some commuter and part 121 operators. The third collection effort was an extension of the first, but includes only data for ingestion of birds weighing greater than 2.5 pounds, for the time period from entry into service through September 1995 for large commercial transport engines with fan diameters 60 inches and larger.

The results of the first two data collections were compared to the historical design standards and certification bases for the family of engines comprised in the database. The study group identified bird ingestion threats both more and less severe than were addressed in either engine design practices of the time, or in part 33. A proposal for a change in the medium bird ingestion rules was presented by the AIA to the FAA in AIA report dated October 17, 1986.

The FAA then asked for expansion of the database to include both heavier birds and coordination of the data and proposed rules with the European Association of Aerospace Industries (AECMA). This coordination effort included consensus between the two industry groups on the completeness and accuracy of the data, and validation of the analytical approach by independent statisticians from Allied Signal, Boeing, General Electric, Pratt & Whitney, Rolls-Royce, and Snecma. The AIA and AECMA delivered a report to the FAA on November 10, 1988. This data collection has become known as the "AIA database." The substance of the latter report is a primary basis for the current NPRM.

Three additional bird ingestion studies were contracted by the FAA to corroborate the findings of the collections described above. The results of these studies may be found in reports

numbered DOT/FAA/CT–90/13, "Study of Bird Ingestions Into Small Inlet Area Aircraft Turbine Engines," dated December 1990, DOT/FAA/CT–91/17, "Bird Ingestion Into Large Turbofan Engines," dated May 1992, and DOT/FAA/CT–91/32, "Engine Bird Ingestion Experience of the Boeing 737 Aircraft—Expanded Data Base", dated July 1992. The data contained in these reports supports the data summaries of the related industry studies.

Subsequently, a further review of the data for birds heavier than 2.5 pounds (lb) was requested of industry by the FAA and JAA. The resulting data is contained in an AIA/AECMA report dated March 29, 1996 which includes all relevant reports of bird ingestions for commercial transport engines with fan diameters 60 inches and greater, for the time period from entry into service through September 30, 1995.

Aviation Rulemaking Advisory (ARAC) Project

In December 1992, the FAA requested the ARAC to evaluate the need for new bird ingestion standards. The task, in turn, was assigned to the Engine Harmonization Working Group (EHWG) of the ARAC on Transport Airplane and Engine (TAE) Issues on December 11, 1992. On April 9, 1997, the TAE issues group recommended to the FAA that it proceed with rulemaking and associated advisory material even though one working group member disagreed with a portion of the proposal. The FAA published a notice of proposed rulemaking (NPRM) on December 11, 1998 (63 FR 68636). This rule reflects the ARAC recommendations.

Discussion of Comments

All interested persons have been afforded an opportunity to participate in this rulemaking. Due consideration has been given to all comments contained in the nine comment letters received, which represent domestic and foreign industry, and foreign airworthiness authorities. Nine comments generally supported publication of the rule as a benefit over the existing regulations.

One commenter notes that the companion Advisory Circular (AC) has not been published for comment.

The FAA agrees in part. An extensive AC has been drafted that provides one method, but not the only method, for showing compliance with this new rule for bird ingestion. The FAA expects that the AC will be available for comment prior to the effective date of the new rule. The FAA does not agree that this final rule should be delayed pending completion of that AC.

Two commenters state that the safety intent and justification of the proposed rule should be clarified.

The FAA disagrees. The NPRM preamble clearly states that the objective of the proposed rule is to provide a freedom from risk of hazard due to bird ingestion at least equal to ten to the minus eighth power (1E–8) per aircraft cycle. The objective is further defined for single large birds and both small and medium flocking birds. Justification for various aspects of the rule is given throughout the preamble section of the NPRM.

Several comments were received concerning bird control programs at airports. One commenter states that additional actions are necessary to better control bird populations on and around airports. Two commenters state that airport bird control programs and flight crew awareness training are not effective in mitigating the bird threat, and should not be considered relative to this rulemaking. One commenter states that airport bird control programs and flight crew awareness training programs are generally being decreased in scope.

The FAA disagrees that airport controls programs and flight crew awareness training are ineffective in mitigating the bird ingestion threat. The FAA believes airport bird control programs are effective in mitigating the bird ingestion threat on and around airports. It must be noted that the overall bird ingestion experience base of commercial aircraft is a combination of aircraft capability, airport and environ controls, air traffic control, and flight crew awareness. Only by a combination of efforts will the bird ingestion threat to aircraft be kept to acceptable levels. It should be noted that the proposal did not specifically consider airport controls, air traffic controls, or flight crew effects in the design of the rule, other than assuming current levels of effectiveness will be maintained. Also, airport wildlife controls themselves are beyond the scope of this rulemaking effort.

It should also be noted that the FAA has recently published a number of policy and guidance related documents pertaining to airport wildlife control plans, land use practices, and aircraft bird strike reporting. The FAA also participates in various government and industry focus groups related to wildlife hazards on and around airports, maintains a bird strike database, and has contracted with the Smithsonian institution to provide a service to identify and size birds involved in aircraft strike events. As a result of these efforts, the emphasis on wildlife hazard identification and control measures is expanding industry wide.

One commenter states that fan blade containment after a bird ingestion event is a concern.

The FAA agrees in part. The FAA agrees that containment of hazardous fragments after a bird strike present a serious concern, however containment requirements are beyond the scope of this rulemaking effort. The proposed rule, for large, small and medium birds has the same requirement, meaning the applicant must show that release of hazardous fragments through the engine casing following a bird strike is precluded. Also, § 33.19 requires that the energy levels and trajectories of fragments resulting from rotor blade failure that lie outside the engine cases must be defined (*e.g.*, fragments exiting through inlet structure). The FAA does not agree, however, that this concern warrants delay in issuing this final rule.

One commenter states that a full flight engine configuration should be utilized for certification tests.

The FAA agrees in principle. The test engine configuration must be fully representative of a type design engine insofar as bird ingestion requirements are concerned. Also, it is standard practice to use flight type inlets, cowls, and primary nozzles, or equivalents for these tests. The use of such flight type aircraft components are needed to evaluate the energy and trajectory of fragments which lie outside the engine type design cases. No changes to the proposed rule are required since compliance with the requirements will dictate the use of appropriate inlet and cowl hardware for any given design.

One commenter states that a 10-percent tolerance band on certification test controlling parameters is excessive.

The FAA does not agree. The 10-percent tolerance band addresses the Critical Ingestion Parameter (CIP), which is the parameter for a particular bird ingestion scenario that is most critical relative to the pass/fail criteria contained in the rule. The other controlling parameters must be maintained such that the CIP itself does not vary more than 10-percent. In practice, most controlling parameters can be maintained to a relatively tight tolerance, and this practice will not change. The AC will contain further guidance on one method, but not the only method, to show compliance with this requirement.

One commenter states that the makeup of the rulemaking database is not clearly described within the NPRM.

The FAA agrees in part. The database could be described in more detail. The database is made up of known revenue-

service engine bird ingestion events from the time period from entry into service through September 1995. Data collections included International Civil Aviation Organization (ICAO) data, airframe manufacturer data, engine manufacturer data, FAA data and any other data presented that could be cross referenced to an actual engine ingestion. The data comes from a cross section of engine types, and for transport category aircraft engines it encompasses approximately 90 million aircraft flights. The data points utilized are those which were identified as actual engine ingestion events, where an engine ingestion event was defined as the presence of bird debris within the engine inlet or engine flow paths. Bird debris was defined as feathers, flesh, or body fluids that could be identified as having come from a bird. Techniques used for identification of debris were visual identification of feathers, forensic laboratory methods, and black light identification of body fluid smears on the engine inlet flow path and engine structure. If the evidence positively indicated an ingestion, but a positive identification of the bird species could not be made, the data was entered as an ingestion without an associated weight. Data representing bird strikes to the aircraft structure (other than engines) was not utilized in the design of this rule. Simple bird species distribution data (*i.e.*, population and size distributions occurring in nature) was also not utilized in the design of the rule.

A series of bird ingestion data collection efforts, as described above, collated data for a variety of engine sizes and types. Three parameters were estimated from the data collection for events where the bird size, bird type, aircraft model, engine model, flight regime, and outcome where reasonably known. These were the single engine ingestion rate versus bird weight; multiple engine ingestion rate versus bird weight; and the ratio of the number of engine power loss events to the number of ingestion events versus bird weight. The probability of a dual engine power loss on a twin engine aircraft was computed by multiplying the square of the power loss ratio by the multiple engine ingestion rate for twin engine positions. Twin engine positions were defined as the inboard positions on four engine airplanes, the wing positions of three engine airplanes, and the wing positions on two engine airplanes. For the purpose of the above data reduction, a power loss was defined as 50-percent or more loss of power or thrust. The data was collected and evaluated in a manner which would provide a good representation of the bird ingestion threat to aircraft engines in service during that time period.

The FAA does not agree, however, that the description of the database contained in the NPRM was deficient, or that this final rule should be delayed.

Two commenters state that this rulemaking database does not reflect actual service experience, and is not accurate or complete.

The FAA disagrees. As discussed in the paragraph above, the rulemaking database is comprised of data from actual engine bird ingestion events where the bird species, bird size, bird number, aircraft model, engine model, regime of flight, and outcome where all reasonably known. Also as noted above, for transport category aircraft engines, the database reflects known bird ingestion events encompassing approximately 90 million aircraft flights of experience covering a broad cross-section of aircraft types. This rulemaking database is a good representation of what aircraft engines have actually experienced over the past 25 years. Lastly, since this is the actual experience of the fleet, it also includes whatever effects there might be from increased bird populations in this time period.

One commenter states that recent events have shown that the proposed requirements, relative to bird mass and flock size, are less severe than occur in nature.

The FAA agrees in part. Events can occur that are beyond the severity of the proposed requirements. This was stated in the NPRM preamble. The proposed rule was not designed to encompass the worst possible combination of all factors, as this is impossible to predict, and would be beyond the capability of current engine technology. The FAA believes the proposed requirements are reasonable relative to the state goal of reducing the bird threat hazards to aircraft by an order of magnitude. It should also be noted that a number of new engine models have been designed and evaluated to these proposed standards, and have generally performed well in revenue service.

The FAA does not agree that the possibility of a bird ingestion event more severe than already contemplated in the proposed rule should warrant a delay in issuing a final rule.

One commenter states that there has been significant growth in some bird populations over the past 10 years.

The FAA agrees in part. The FAA acknowledges that certain species of birds have experienced significant population and distribution increases over the past several years, and should be monitored for any effect on the bird threat to aircraft engines in service. The FAA does not believe, however, that this warrants a delay in issuing this final rule.

Two commenters state that this rulemaking database focused only on past experience, and made no attempt to predict future changes to the bird threat.

The FAA agrees in part. While this rulemaking database focused only on actual events which have occurred in revenue service, the rule was not designed to meet predicted future changes in the bird threat environment. The FAA believes it would be impossible to accurately predict threat changes, more or less in severity, as the overall experience base is a function of bird population, bird distribution, aircraft capability, engine capability, airport and airport environmental control measures, air traffic control operational requirements, air traffic control alert reports, and flight crew awareness. The FAA believes it is impossible to integrate these various factors into an accurate prediction of bird threat changes suitable for rulemaking, and believes that the possibility of such changes does not warrant delay in issuing this final rule. However, the FAA agrees that the factors noted above should be reviewed at periodic intervals to assure that the bird ingestion certification standards are adequate to meet the overall threat of bird ingestion, and that no individual factor is allowed to worsen to a significant degree.

One commenter states that the large bird requirement should be 12–15 lbs.

The FAA does not agree. While birds larger in size than the standard for "large birds" in the proposed rule can occur in revenue service, a review service data indicates that the proposed sliding scale (4–8 lbs. as a function of inlet area) for the single large bird requirement is reasonable relative to the stated goal of reducing the hazards to aircraft by an order of magnitude. The FAA does not agree the large bird standard needs to be changed.

One commenter states that the proposed requirement for § 33.76(c)(2) needs to be revised to allow the use of certification data from previous programs.

The FAA disagrees. It is not necessary for a rule to contain language allowing the use of existing certification data. Any certification data held by the applicant may be utilized provided that the data is applicable to the product in question, and approved by the FAA. The AC will contain a discussion on what sources of data could be

acceptable for the purpose of compliance findings.

One commenter states that the proposed requirements for §§ 23.903 and 25.903 are not clear.

The FAA disagrees. The text changes were required only to provide reference to new § 33.76, and uses the same format as the previous rule.

One commenter states that the proposed requirements for §§ 23.903 and 25.903 will allow inappropriate use of previous engine bird ingestion certification requirements instead of new § 33.76 when determining engine model eligibility for new aircraft applications.

The FAA disagrees. The proposed text is consistent with current §§ 23.903 and 25.903, and allows flexibility for installation of pre § 33.76 certification basis engines into new aircraft applications at the FAAs discretion. The FAA believes it would be inappropriate to preclude by regulation the installation of pre § 33.76 engines which have demonstrated acceptable bird ingestion capabilities in revenue service. For transport category aircraft, the existing requirements under §§ 21.21(b)(2), 25.903(a) and 25.1091(d)(2)/(e) have been identified as providing for the evaluation of proposed installations relative to bird ingestion service history. The FAA will review the application of these regulations to assure that they provide for the necessary level of evaluation of any proposed installation utilizing pre § 33.76 model aircraft engines. Lastly, as part of this review, it was observed that current § 25.1091 must be revised to include an appropriate reference to the new requirements of § 33.76. Therefore, § 25.1091 is also revised by this final rule action.

One commenter states that the FAA air traffic control (ATC) operational procedures are now allowing high speed operations below 10,000 ft. altitude, and this should be considered with respect to these bird ingestion requirements.

The FAA agrees in part. This rule is based on the expectation that the majority of operations below 10,000 ft. would be at less than 250 knots. However, studies into changing ATC operational procedures have allowed unrestricted operation at speeds above 250 knots near some Class B airports, and at altitudes where bird encounters are most likely to occur. The new small and medium bird requirements are structured to account for higher speeds. However the large bird requirement utilizes a 200-knots default bird speed value. Higher aircraft speeds at low altitudes could also result in shallower climb profiles, possibly resulting in an aircraft spending more time in a higher risk bird threat environment then previously assumed. Therefore, the FAA will institute a follow-on rulemaking action to determine whether additional changes to the bird requirements are necessary based on these operational considerations. Also, the FAA will include material in the AC to address this subject relative to the large bird test requirements. The FAA does not believe, however, that this operational consideration warrants delaying this final rule.

One commenter states that the NPRM explanation for choosing the 200 knots over a 250 knots bird speed value for large bird tests needs clarification.

The FAA agrees in part. For a given turbine engine design, a specific bird speed will provide the least margin to the pass/fail criteria of § 33.76. For critical static structure (*e.g.*, inlet guide vane), the higher speed will generally be more severe due to simple momentum transfer at impact. However for critical rotating stages of blades, there will be an optimum bird speed which results in maximum damage to that rotating stage. Bird speeds faster or slower than this optimum will result in less severe damage. This is due to the combined effects of bird speed, rotor blade tangential velocity, and blade twist angle. The worst case combination of these factors will result in the highest bird since mass absorbed by the blade at the worst impact angle, and therefore results in the highest blade stresses at the blade's critical location. For example, most conventional high bypass turbofan designs will have critical speeds in the 150–220–knots range, depending upon specific fan blade design characteristics. While the FAA plans further review of this aspect of the large bird certification test, the FAA does not believe that this warrants delay in issuing this final rule.

Five commenters state that the FAA should reconsider the JAA position of including a requirement addressing intermediate flocking birds greater than 2.5 lbs.

The FAA agrees in part. The FAA agrees to reconsider the overall JAA position as part of future rulemaking study, and still believes that the Joint Aviation Requirements (JAR) and the FAA regulations should eventually be harmonized in this regard. The FAA does not agree, however, that the difference between this final rule and the JAA's current position warrants delay in issuing this final rule pending further study.

Two commenters state that the FAA does not understand the JAA position on intermediate flocking birds.

The FAA disagrees. The FAA understands that the rationale for the additional JAA intermediate flocking bird requirement is to ensure that new engines will have the same level of capability (for flocking birds greater than 2.5 lbs.) as current in-service engines have demonstrated. The FAA does believe that the new requirements of § 33.76, overall, will provide a fleet of engines of overall increased capability when compared to the fleet of engines based on current § 33.77 requirements.

Three commenters state that the FAA and JAA should consider alternatives to the JAA intermediate flocking bird requirement of JAR–E 800(b)(2), as it does not meet its stated objective.

The FAA agrees in part. The FAA agrees to participate in a new rulemaking study to develop a meaningful alternative to the JAR intermediate flocking bird requirement. The FAA does not agree that the 12-percent unbalance requirement of proposed JAR–E 800(b)(2) can be relied upon to achieve the stated intent of the JAR–E rule as described. The FAA also does not believe that this final rule should be delayed pending any study of this issue.

Three commenters state that the proposed requirements do not adequately cover the flocking bird range of 2.5–8 lbs.

The FAA disagrees. The proposed requirements have taken into account flocking birds in this category based on (1) the historical performance of engines currently in service, and (2) based on the overall increased severity of the new requirements. The FAA believes that the new requirements of § 33.76, overall, will provide a fleet of engines of increased capability in this regard when compared to be fleet of engines based on current § 33.77 requirements. However, since the flocking bird capability in this bird size range may not be directly evaluated for each individual design at the time of certification, the FAA agrees to participate in a new rulemaking study of evaluate this comment further. The FAA does not agree, however, that this final rule should be delayed pending any study of that issue.

One commenter states that the proposed requirements meet the flocking bird objections for conventional designs (*e.g.*, for designs which the database directly represents).

The FAA agrees that the rulemaking database and related assumptions which are part of this rule are most closely to the conventional designs which make up the database. Therefore, for each designs, there is a high degree of

confidence that this new rule's stated objective can be met.

Two commenters state that the proposed requirements may not meet the flocking bird objectives for new unconventional design technologies which have no historical data from which to evaluate capability.

The FAA agrees in part. The database on which this rule finds support, is made up of primarily conventional designs, and that the assumptions made when developing this rule most closely relate to those designs. However, it must be noted that the new § 33.76 is generally a more severe set of requirements then currently § 33.77, and that the overall effect of the new rule will be a world fleet of increased capability when compared to the world fleet based on current § 33.77 requirements. Therefore, the overall rule objective of decreasing the risk from bird ingestion events by an order of magnitude will be met at the world fleet level. Also, since the new requirements do not include specific test requirements for flocking birds greater than 2.5 lbs., the possibility exists for disparities in engine capability from one model series to another, regardless of conventional or unconventional designs. The FAA believes it prudent to address this concern by further review of available service data to determine whether the chosen standards sufficiently cover the level of safety desired for this rule, and to assure that the specific level of safety demonstrated by each engine model certified is acceptable. The FAA agrees to participate in a new rulemaking study to evaluate this comment further, but does not agree that this final rule should be delayed pending that study.

Two commenters state that the proposed requirements do not provide any improvement in power loss rate over current requirements.

The FAA disagrees. It must be noted that the new § 33.76 is generally a more severe set of requirements then current § 33.77, and that the overall effect of the new rule will be a world fleet of increased capability when compared to the world fleet based on current § 33.77 requirements, of which power loss rate is one measure.

One commenter states that there is no need for expanded flocking bird requirements beyond this proposal.

The FAA agrees that new § 33.76 will be beneficial to overall world fleet capability. The FAA also believes, however, that a new review of available is prudent to evaluate the current state of the bird threat in service, and that additional rulemaking action could result.

Two commenters state that a new rulemaking study should be implemented to develop additional standards for run should be not be delayed pending further study.

Finally, the FAA has made the following minor editorial changes to better clarify this rule. These changes do not affect the scope of the rule or change the intent of these sections.

§ 33.76(a)(2) text was modified slightly to more clearly state the intent of the rule. There are no changes to the requirements.

§ 33.76(b)(4) was revised to more clearly state the intent of the rule, which does not include an actual "waiver" of the large bird requirements as stated in the NPRM, but was intended to specify an additional method of showing compliance to these requirements using § 33.76(a) certification data when appropriate. Therefore the actual certification substantiation requirements of this section are unchanged from the NPRM proposal, with the only change being a more accurate description of the compliance option under this subsection that is available to the applicant.

It was determined that the title of § 33.77 should be revised to specify the one remaining foreign object retained within this section (ice), and that for clarity and brevity the table of § 33.77(e) is deleted, and the table's remaining pertinent information is included directly into the text of existing paragraph (e). No changes to the requirements have resulted from these additional format changes.

Section 25.1091 was revised to include reference to § 33.76. It was determine that the part 33 references within § 25.1091 needed to be updated to account for this rulemaking action.

After careful review of all the comments, the FAA has determined that air safety and the public interest require the adoption of the rule with the changes described.

Paperwork Reduction

There are no new requirements for information collection associated with this rule that would require approval from the Office of Management and Budget pursuant to the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)).

International Compatibility

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommends Practices to the maximum extent practicable. The FAA determined that there are no ICAO Standards and Recommended Practices that correspond to these regulations.

Regulatory Analyses and Assessments

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

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

Regulatory Evaluation Summary

Cost—this rule is the result of ARAC recommendations. Moreover, public comments were not received on the preliminary economic evaluation. Costs of the rule include one-time certification costs and recurrent fuel costs due to reduced fan efficiency. The FAA estimates that the rule will add $250,000 to $500,000 to each new engine model's certification costs, depending on engine inlet area. These certification costs will be incurred primarily in two areas. First, additional analysis required to verify the affects of a large bird impact on the front of the engine could necessitate a component test costing $250,000. Second, the rule

will require additional analysis or testing on the full fan assembly for engines with inlet areas greater than 2,092 square-inches. Such testing is estimated to cost approximately an additional $250,000 for those engines.

In addition, the revised bird test weights could necessitate strengthening fan components, thereby affecting fan performance. The FAA estimates that reduced fan efficiency will result in a 0.2-percent increase in fuel consumption. On average, the FAA estimates that this will increase annual fuel costs by $4,770 per airplane, for airplanes equipped with new engines certificated to the standards of this rule.

Benefits—Benefits associated with this rule include: (1) Averted fatalities and injuries, (2) averted property damage (primarily hull losses), and (3) reduced maintenance and repair costs. Based on historical accident information, the FAA estimates that the expected annual per-airplane benefit from averted airplane damage or loss is approximately $657. The expected annual benefit per-airplane from averted fatalities and injuries is $654 and $75, respectively.

The estimated value of maintenance/repair savings associated with the rule is based on an analysis of the relationship between bird ingestion weight and the probability of damage. The FAA estimates that, on average, the rule will save operators approximately $4,654 per airplane per year.

To compare the lifecycle costs and benefits of the rule, the evaluation utilizes a hypothetical representative engine certification. The engines are assumed to be installed on a notional twin-engine jet transport with a seating capacity of 161 (the average seating capacity of jet transports in commercial service in 1996). In addition, this analysis assumes the following: (1) Incremental engine certification costs equal $250,000 in year 0 and $250,000 in year 1; (2) production of engines commences in year 2, (3) engines are installed in aircraft and enter service beginning in year 3, (4) each engine has a 15-year service life, (5) 24 engines are produced per year for 10 years so that there are 240 total engines and 120 airplanes per certification, and (6) the discount rate is 7 percent. Under these conditions, the expected discounted benefits, at $4.333 million, exceed the discounted costs of $3.906 million.

Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA) of 1980, 5 U.S.C. 601–612, directs the FAA to fit regulatory requirements to the scale of the business, organizations, and governmental jurisdictions subject to the regulation. We are required to determine whether a proposed or final action will have a "significant economic impact on a substantial number of small entities" as defined in the Act. If we find that the action will have a significant impact, we must do a "regulatory flexibility analysis."

This final rule will not have a significant economic impact on a substantial number of small entities. The final rule will apply only to newly designed turbine aircraft engines certificated in the future. Each new engine certification could affect two types of small entities: manufacturers of turbine engines and operators of aircraft.

Manufacturers will be required to perform additional analysis or testing to demonstrate that the new bird ingestion requirements are met. There are nine turbine aircraft engine manufacturers with headquarters in the U.S. (this count includes subsidiaries of foreign entities and consortiums of domestic and/or foreign entities). Information available to the FAA indicates that only one—a U.S. manufacturer of small turbine engines has less than 1,500 employees, and therefore qualifies as a small business under SBA employment criteria. One entity is not considered a substantial number by the FAA. If all certification costs are assumed to be borne by the manufacturer, the FAA would conclude that with only one manufacturing firm being classified as "small," there is not an impact on small business.

In addition, the FAA analyzed the small business impact with a tougher criterion. The FAA assumes that all manufacturing costs will be borne by their customers who purchase new equipment. The rule is estimated to add about $250,000 for a small engine type produced by the single small entity: these are one-time certification costs. The FAA estimates that the rule will impose no incremental manufacturing costs. Aircraft operators will incur slightly higher engine prices and will pay increased operating or fuel costs due to the small decrease in engine efficiency (described in the full regulatory evaluation). According to FAA data, there are about 3,000 air carriers having less than 1,500 employees: approximately 100 air carriers operating under part 121 (or both part 121 and part 135), and 2,900 air carriers operating under part 135.

Assuming conservatively that: (1) All incremental certification costs are passed on to the buyer/operator, (2) the manufacturer recovers incremental certification costs by applying a uniform price increase to engines produced during a 10-year production run, and (3) that the discount rate is 7 percent; then the FAA estimates that average new engine prices will increase by approximately $3,070 per larger engine and $1,587 per smaller engine. When these costs are amortized over the 15-year life of an engine (again, assuming a 7-percent discount rate), the incremental annualized cost per new engine is approximately $315 and $163 for larger and smaller engines, respectively. Therefore, assuming a typical airplane has two engines, the incremental annualized costs for a large airplane is approximately $630 and the incremental annualized cost for a smaller airplane is approximately $326.

For larger engines, the rule will also increase annual airplane operating costs as a result of the new medium bird ingestion requirements due to higher fuel consumption and, thus, costs. These requirements will have a negligible effect on smaller engines. On average, annual operating costs per large airplane, with engines newly certificated to the standards of this rule, are estimated to increase by approximately $4,770. However, the reduction in average annualized maintenance costs associated with the more damage-resistant engines is expected to approximately offset the incremental operating costs.

Therefore, total annualized costs for operators of larger and smaller airplanes with new engines will be approximately $630 and $326 per airplane, respectively. Consequently, the FAA certifies that the rule will not have a significant economic impact on a substantial number of small entities.

International Trade

The Trade Agreement Act of 1979 prohibits Federal agencies from engaging in any standards of related activity that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and where appropriate, that they be the basis for U.S. standards. In addition, consistent with the Administration's belief in the general superiority and desirability of free trade, it is the policy of the Administration to remove or diminish, to the extent feasible, barriers to international trade, including both barriers affecting the export of American goods and services to foreign countries and barriers affecting the import of foreign goods and services into the U.S.

Turbine engines are produced by United States and foreign companies. The FAA has assessed the potential

effect of this rule and has determined that it will impose the same costs on domestic and international entities, and will thus have a neutral trade impact.

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (2 U.S.C. 1532–1538) requires the FAA to assess the effects of Federal regulatory actions on state, local, and tribal governments, and on the private sector of rules that contain a Federal intergovernmental or private sector mandate that exceeds $100 million in nay one year. This action does not contain such a mandate.

Executive Order 13132, Federalism

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

Plain Language

In response to the June 1, 1998, Presidential Memorandum regarding the use of plain language, the FAA re-examined the writing style currently used in the development of regulations. The memorandum requires federal agencies to communicate clearly with the public. We are interested in your comments on whether the style of this document is clear, and any other suggestions you might have to improve the clarity of FAA communications that affect you. You can get more information about the Presidential memorandum and the plain language initiative at *http://www.plainlanguage.gov.*

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment or environmental impact statement. In accordance with FAA Order 1050.ID, appendix 4, paragraph 4(j), this rulemaking action qualifies for a categorical exclusion.

Energy Impact

The energy impact of the notice has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) Public Law 94–163, as amended (43 U.S.C. 6362) and FAA Order 1053.1. It has been determined that the final rule is not a major regulatory action under the provisions of the EPCA.

List of Subjects

14 CFR Part 23

Air transportation, Aircraft, Aviation safety, Safety.

14 CFR Part 25

Air transportation, Aircraft, Aviation safety, Safety.

14 CFR Part 33

Air transportation, Aircraft, Aviation safety, Safety.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends parts 23, 25 and 33 of Title 14, Code of Federal Regulations as follows:

PART 23—AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES

1. The authority citation for part 23 continues to read as follows:

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

2. Section 23.903 is amended by revising paragraph (a)(2) to read as follows:

§ 23.903 Engines.

(a) * * *

(2) Each turbine engine and its installation must comply with one of the following:

(i) Sections 33.76, 33.77 and 33.78 of this chapter in effect on December 13, 2000.

(ii) Sections 33.77 and 33.78 of this chapter in effect on April 30, 1998, or as subsequently amended before December 13, 2000; or

(iii) Section 33.77 of this chapter in effect on October 31, 1974, or as subsequently amended before April 30, 1998, unless that engine's foreign object ingestion service history has resulted in an unsafe condition; or

(iv) Be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition.

* * * * *

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

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

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

4. Section 25.903 is amended by revising paragraph (a)(2) to read as follows:

§ 25.903 Engines.

(a) * * *

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

(i) Sections 33.76, 33.77 and 33.78 of this chapter in effect on December 13, 2000, or as subsequently amended; or

(ii) Sections 33.77 and 33.78 of this chapter in effect on April 30, 1998, or as subsequently amended before December 13, 2000; or

(iii) Comply with § 33.77 of this chapter in effect on October 31, 1974, or as subsequently amended prior to April 30, 1998, unless that engine's foreign object ingestion service history has resulted in an unsafe condition; or

(iv) Be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition.

* * * * *

5. Section 25.1091 is amended by revising paragraph (e) to read as follows:

§ 25.1091 Air induction.

* * * * *

(e) If the engine induction system contains parts or components that could be damaged by foreign objects entering the air inlet, it must be shown by tests or, if appropriate, by analysis that the induction system design can withstand the foreign object ingestion test conditions of §§ 33.76, 33.77 and 33.78(a)(1) of this chapter without failure of parts or components that could create a hazard.

PART 33—AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

6. The authority citation for part 33 continues to read as follows:

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

7. Section 33.76 is added to read as follows:

§ 33.76 Bird ingestion.

(a) *General.* Compliance with paragraphs (b) and (c) of this section shall be in accordance with the following:

(1) All ingestion tests shall be conducted with the engine stabilized at no less than 100-percent takeoff power or thrust, for test day ambient conditions prior to the ingestion. In addition, the demonstration of compliance must account for engine operation at sea level takeoff conditions on the hottest day that a minimum engine can achieve maximum rated takeoff thrust or power.

(2) The engine inlet throat area as used in this section to determine the bird quantity and weights will be established by the applicant and identified as a limitation in the installation instructions required under § 33.5.

(3) The impact to the front of the engine from the single large bird and the single largest medium bird which can enter the inlet must be evaluated. It must be shown that the associated components when struck under the conditions prescribed in paragraphs (b) or (c) of this section, as applicable, will not affect the engine to the extent that it cannot comply with the requirements of paragraphs (b)(3) and (c)(6) of this section.

(4) For an engine that incorporates an inlet protection device, compliance with this section shall be established with the device functioning. The engine approval will be endorsed to show that compliance with the requirements has been established with the device functioning.

(5) Objects that are accepted by the Administrator may be substituted for birds when conducting the bird ingestion tests required by paragraphs (b) and (c) of this section.

(6) If compliance with the requirements of this section is not established, the engine type certification documentation will show that the engine shall be limited to aircraft installations in which it is shown that a bird cannot strike the engine, or be ingested into the engine, or adversely restrict airflow into the engine.

(b) *Large birds.* Compliance with the large bird ingestion requirements shall be in accordance with the following:

(1) The large bird ingestion test shall be conducted using one bird of a weight determined from Table 1 aimed at the most critical exposed location on the first stage rotor blades and ingested at a bird speed of 200-knots for engines to be installed on airplanes, or the maximum airspeed for normal rotocraft flight operations for engines to be installed on rotocraft.

(2) Power lever movement is not permitted within 15 seconds following ingestion of the large bird.

(3) Ingestion of a single large bird tested under the conditions prescribed in this section may not cause the engine to:

(i) Catch fire;

(ii) Release hazardous fragments through the engine casing;

(iii) Generate loads greater than those ultimate loads specified under § 33.23(a); or

(iv) Lose the ability to be shut down.

(4) Compliance with the large bird ingestion requirements of this paragraph may be shown by demonstrating that the requirements of § 33.94(a) constitute a more severe demonstration of blade containment and rotor unbalance than the requirements of this paragraph.

TABLE 1 TO § 33.76.—LARGE BIRD WEIGHT REQUIREMENTS

Engine Inlet Throat Area (A)—Square/meters (square-inches)	Bird weight kg. (lb.)
1.35 (2,092)> A	1.85 (4.07) minimum, unless a smaller bird is determined to be a more severe demonstration.
1.35 (2,029)≤ A< 3.90 (6,045).	2.75 (6.05)
3.90 (6,045)≤ A	3.65 (8.03)

(c) *Small and medium birds.* Compliance with the small and medium bird ingestion requirements shall be in accordance with the following:

(1) Analysis or component test, or both, acceptable to the Administrator, shall be conducted to determine the critical ingestion parameters affecting power loss and damage. Critical ingestion parameters shall include, but are not limited to, the affects of bird speed, critical target location, and first stage roto speed. The critical bird ingestion speed should reflect the most critical condition within the range of airspeeds used for normal flight operations up to 1,500 feet above ground level, but not less than V_1 minimum for airplanes.

(2) Medium bird engine tests shall be conducted so as to simulate a flock encounter, and will use the bird weights and quantities specified in Table 2. When only one bird is specified, that bird will be aimed at the engine core primary flow path; the other critical locations on the engine face area must be addressed, as necessary, by appropriate tests or analysis, or both. When two or more birds are specified in Table 2, the largest of those birds must be aimed at the engine core primary flow path, and a second bird must be aimed at the most critical exposed location on the first stage rotor blades. Any remaining birds must be evenly distributed over the engine face area.

(3) In addition, except for rotorcraft engines, it must also be substantiated by appropriate tests or analysis or both, that when the full fan assembly is subjected to the ingestion of the quantity and weights of bird from Table 3, aimed at the fan assembly's most critical location outboard of the primary core flowpath, and in accordance with the applicable test conditions of this paragraph, that the engine can comply with the acceptance criteria of this paragraph.

(4) A small bird ingestion test is not required if the prescribed number of medium birds pass into the engine rotor blades during the medium bird test.

(5) Small bird ingestion tests shall be conducted so as to simulate a flock encounter using one 85 gram (0.187 lb.) bird for each 0.032 square-meter (49.6 square-inches) of inlet area, or fraction thereof, up to a maximum of 16 birds. The birds will be aimed so as to account for any critical exposed locations on the first stage rotor blades, with any remaining birds evenly distributed over the engine face area.

(6) Ingestion of small and medium birds tested under the conditions prescribed in this paragraph may not cause any of the following:

(i) More than a sustained 25-percent power or thrust loss;

(ii) The engine to be shut down during the required run-on demonstration prescribed in paragraphs (c)(7) or (c)(8) of this section;

(iii) The conditions defined in paragraph (b)(3) of this section.

(iv) Unacceptable deterioration of engine handling characteristics.

(7) Except for rotorcraft engines, the following test schedule shall be used:

(i) Ingestion so as to simulate a flock encounter, with approximately 1 second elapsed time from the moment of the first bird ingestion to the last.

(ii) Followed by 2 minutes without power level movement after the ingestion.

(iii) Followed by 3 minutes at 175-percent of the test condition.

(iv) Followed by 6 minutes at 60-percent of the test condition.

(v) Followed by 6 minutes at 40-percent of the test condition.

(vi) Followed by 1 minute at approach idle.

(vii) Followed by 2 minutes at 75-percent of the test condition.

(viii) Followed by stabilizing at idle and engine shut down.

The durations specified are times at the defined conditions with the power lever being moved between each condition in less than 10 seconds.

(8) For rotorcraft engines, the following test schedule shall be used:

(i) Ingestion so as to simulate a flock encounter within approximately 1 second elapsed time between the first ingestion and the last.

(ii) Followed by 3 minutes at 75-percent of the test condition.

(iii) Followed by 90 seconds at descent flight idle.

(iv) Followed by 30 seconds at 75-percent of the test condition.

(v) Followed by stabilizing at idle and engine shut down. The duration specified are times at the defined conditions with the power being changed between each condition in less than 10 seconds.

(9) Engines intended for use in multi-engine rotorcraft are not required to comply with the medium bird ingestion portion of this section, providing that the appropriate type certificate documentation is so endorsed.

(10) If any engine operating limit(s) is exceeded during the initial 2 minutes without power lever movement, as provided by paragraph (c)(7)(ii) of this section, then it shall be established that the limit exceedence will not result in an unsafe condition.

TABLE 2 TO § 33.76.—MEDIUM FLOCKING BIRD WEIGHT AND QUANTITY REQUIREMENTS

Engine Inlet Throat Area (A)—Square-meters (square-inches)	Bird quantity	Bird weight kg. (lb.)
0.05 (77.5)> A	none	
.05 (77.5)≤ A <0.10 (155)	1	0.35 (0.77)
0.10 (155)≤ A <0.20 (310)	1	0.45 (0.99)
0.20 (310)≤ A <0.40 (620)	2	0.45 (0.99)
0.40 (620)≤ A <0.60 (930)	2	0.70 (1.54)
0.60 (930)≤ A <1.00 (1,550)	3	0.70 (1.54)
1.00 (1,550)≤ A <1.35 (2,092)	4	0.70 (1.54)
1.35 (2,092)≤ A <1.70 (2,635)	1	1.15 (2.53)
	plus 3	0.70 (1.54)
1.70 (2,635)≤ A <2.10 (3,255)	1	1.15 (2,53)
	plus 4	0.70 (1.54)
2.10 (3,255)≤ A <2.50 (3,875)	1	1.15 (2.53)
	plus 5	0.70 (1.54)
2.50 (3,875)≤ A <3.90 (6045)	1	1.15 (2.53)
	plus 6	0.70 (1.54)
3.90 (6045)≤ A <4.50 (6975)	3	1.15 (2.53)
4.50 (6975)≤ A	4	1.15 (2.53)

TABLE 3 TO § 33.76.—ADDITIONAL INTEGRITY ASSESSMENT

Engine Inlet Throat Area (A)—square-meters (square-inches)	Bird quantity	Bird weight kg. (lb.)
1.35 (2,092)> A	none	
1.35 (2,092)≤ A <2.90 (4,495)	1	1.15 (2.53)
2.90 (4,495)≤ A <3.90 (6,045)	2	1.15 (2.53)
3.90 (6,045)≤ A	1	1.15 (2.53)
	plus 6	0.70 (1.54)

8. Section 33.77 is amended by revising the section heading, removing and reserving paragraphs (a) and (b), and by revising paragraphs (c), (d)(3), and (e) to read as follows:

§ 33.77 Foreign object ingestion—ice.

(a) [Reserved]

(b) [Reserved]

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

(1) Cause a sustained power or thrust loss; or

(2) require the engine to be shutdown.

(d) * * *

(3) The foreign object, or objects, 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 required by paragraph (c) of this section.

(e) Compliance with paragraph (c) of this section must be shown by engine test under the following ingestion conditions:

(1) Ice quantity will be the maximum accumulation on a typical inlet cowl and engine face resulting from a 2-minute delay in actuating the anti-icing system; or a slab of ice which is comparable in weight or thickness for that size engine.

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

(3) Engine operation will be maximum cruise power or thrust.

(4) The ingestion will simulate a continuous maximum icing encounter at 25 degrees Fahrenheit.

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Jane F. Garvey,

Administrator.

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