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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 33

[Docket No.: FAA-2018-0568; Amdt. No. 33-36]

RIN 2120–AK83

Medium Flocking Bird Test at Climb Condition

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Final rule.

SUMMARY: This final rule adds new test requirements to the airworthiness regulation addressing engine bird ingestion. The new test requirements ensure that turbofan engines can ingest the largest medium flocking bird (MFB) into the engine core at climb or approach conditions. To obtain certification of a turbofan engine, a manufacturer must show the engine core can continue to operate after ingesting such a bird while operating at a lower fan speed associated with climb or approach.

DATES: Effective [INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

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

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SUPPLEMENTARY INFORMATION:

Authority for this Rulemaking

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

This rulemaking is promulgated under the authority described in Title 49, Subtitle VII, Part A, Subpart III, Section 44701, General requirements. Under that section, the FAA is charged with promoting safe flight of civil aircraft in air commerce by prescribing minimum safety standards required in the interest of safety for performance of aircraft engines. This regulation is within the scope of that authority because it creates new safety-related testing requirements for certification of aircraft turbofan engines.

I. Executive Summary

A. Overview of Final Rule

The FAA is amending the airworthiness regulations related to engine bird ingestion testing in part 33 of title 14, Code of Federal Regulations (14 CFR) (notice of proposed rulemaking (NPRM) published at 83 FR 31479 on July 6, 2018). This final rule revises § 33.76 to create an additional bird ingestion test for turbofan engines. This new test ensures that engines can ingest the largest MFB required for bird ingestion testing into the engine core[1] at climb conditions. If the engine design is such that no bird material would be ingested into the engine core during the test at climb conditions, then the rule requires a different test at approach conditions.

The new testing required by this final rule consists of ingesting one MFB, equivalent to the largest bird required by § 33.76(c), for the engine inlet throat area of the

[1] Turbofan engines have fan and core compressor sections. The fan or low-pressure compressor is at the front of the engine. The core consists of additional compressor stages behind the fan. Each compressor stage consists of a rotating row of blades and a stationary row of vanes.

engine being tested,[2] into the engine core, using either of the following climb or approach test conditions:

(1) <u>Testing for bird ingestion on climb (referred to in this final rule as "climb flocking bird test")</u>. The test bird must be fired at 261-knots (which is 250-knots indicated airspeed (KIAS)), with the mechanical engine fan speed set at the lowest expected speed when climbing through 3,000 feet altitude above mean sea level at International Standard Atmosphere (ISA) standard day conditions (hereafter referred to as MSL). After bird ingestion, the engine must comply with new post-test run-on requirements similar to those in § 33.76(d)(5) for large flocking birds, except that, depending on the climb thrust of the engine, during the first minute after bird ingestion the engine may produce less than 50 percent takeoff thrust.

(2) <u>Testing for bird ingestion on approach (referred to in this final rule as "approach flocking bird test")</u>. If the applicant determines, through testing or validated analysis, that no bird material will enter the core during the test at the climb condition, then the applicant must perform the approach flocking bird test. For the approach flocking bird test, the bird must be fired at 209-knots (which is 200-KIAS), with the mechanical engine fan speed set at the lowest fan speed expected when descending through 3,000 feet MSL on approach. Applicants are required to comply with post-test run-on requirements that are the same as the final six minutes of § 33.76(d)(5) post-test run-on requirements for the large flocking bird (LFB) test. While the FAA based the approach run-on requirements of this final rule on the LFB post-test run-on requirements, only the last six minutes of the test is required, since during approach the airplane will already be lined up with the runway.

Additionally, this final rule allows the climb flocking bird test to be combined with the § 33.76(c) test when the climb first stage (fan) rotor speed is no more than three percent different from the first stage rotor speed, as required by § 33.76(c)(1). This allows

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[2] Section 33.76(c) addresses small and medium bird ingestion requirements.

manufacturers of engines for airplanes, where the pilot does not pull back on the throttle during climb, to perform one fewer ingestion test. Since the fan rotor speed during climb will be the same as the fan rotor speed at takeoff thrust, the amount of bird material ingested into the core during the climb flocking bird test will depend on bird speed and not fan speed.

This final rule also allows the applicant to use objects other than birds to meet the new test requirements.

B. Summary of Costs and Benefits

Over a 27-year period of analysis, the rule will result in present value net benefits of about $9.7 million at a seven percent discount rate with annualized net benefits of about $0.8 million. At a three percent discount rate, the 27-year present value net benefits is about $36.2 million with annualized net benefits of about $1.9 million.

The following table presents estimates of the quantified benefits, costs, and net benefits of the rule.

Summary of Benefits, Costs, and Net Benefits ($Millions)

Impact	**27-year Total Present value** **7% Present Value**	**27-year Total Present value** **3% Present Value**	**Annualized** **7% Present Value**	**Annualized** **3% Present Value**
Benefits	$73.7	$121.6	$6.1	$6.6
Costs	$64.0	$85.4	$5.3	$4.7
Net Benefits	$9.7	$36.2	$0.8	$1.9

II. Background

A. Statement of the Problem

On January 15, 2009, US Airways Flight 1549 (Flight 1549), an Airbus A320, took off from La Guardia Airport in New York City. On climb, at approximately 2,800 feet above ground level (AGL) and approximately 230-KIAS, the airplane struck a flock of migratory Canada geese. Both of the airplane's engines ingested at least two birds, and both engine cores suffered major damage and total thrust loss.

The A320 series of airplanes (i.e., A318/A319/A320/A321) and the similarly sized Boeing 737 series of airplanes are among the airplanes most frequently used by air carriers.[3] Most transport airplanes (including the A320) and many business jets use turbofan engines that are susceptible to bird ingestion damage, which, in some instances, has resulted in loss of greater than 50 percent takeoff thrust. In twin-engine airplanes, this amount of thrust loss in both engines can prevent the airplane from climbing over obstacles or maintaining altitude. Significant loss of thrust by more than one engine is a hazardous condition because it can prevent continued safe flight and landing.

As a result of the Flight 1549 accident, the FAA began studying how to improve engine durability related to core engine bird ingestion.[4] In response to a tasking from the FAA to review and study bird ingestion standards and guidance, the Aviation Rulemaking Advisory Committee (ARAC) established the Engine Harmonization Working Group (EHWG) under the Transport Airplane and Engine subcommittee. The EHWG developed a report, subsequently accepted by the ARAC, titled "Turbofan Bird Ingestion Regulation Engine Harmonization Working Group Report" (ARAC report), dated February 19, 2015.[5] The ARAC report concluded that modern fan blades (such as those on the Flight 1549 airplane engines) have relatively wider fan blade chords than those in-service when the FAA implemented the MFB ingestion test in 14 CFR 33.76(c) (65 FR 55848, September 14, 2000). The ARAC report also pointed out that the § 33.76(c) test is conducted with the

[3] https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2019-39_FAA_Aerospace_Forecast.pdf, pp 31-32, "U.S. Commercial Aircraft Fleet."

[4] The FAA used the following studies to begin the review: FAA Technical Center Report DOT/FAA/AR-TN03/60, "Study of Bird Ingestions Into Aircraft Turbine Engines (December 1968-December 1999)," September 2003, and the "Aerospace Industries Association (AIA) Bird Ingestion Working Group Interim Report – January 2012," produced after the Flight 1549 accident. The AIA report contains the latest bird ingestion data available through January 2009, including data from the Flight 1549 accident. The FAA included both reports in the docket for this rulemaking.

[5] The FAA included the ARAC report in the docket for this rulemaking. This rulemaking is consistent with the recommendations in the report.

engine operating at 100 percent takeoff power or thrust. This setting is ideal for testing the fan blades but does not represent the lower fan speeds used during the climb and approach phases of aircraft flight.

When an engine ingests a bird, the amount of bird material that enters the engine core depends on: (1) the width of the fan blade chord, (2) the airplane's speed, and (3) the rotational speed of the fan blades. The wider the chord of the fan blade and the lower the speed of the airplane, the longer the bird will remain in contact with the fan blade. As airplane speed increases, the bird spends less time on the fan blade. With higher fan speed, the bird will move radially faster away from the core. Thus, the longer the time in contact with the fan blade, from wider blades and lower airspeed, and increased centrifugal forces from a higher fan speed, the further outboard and away from the core the bird material will move. Therefore, a higher fan speed makes it less likely that bird material will enter the core during the § 33.76(c) test compared to the new climb flocking bird test. Conversely, a lower fan speed and higher airspeed, for a given fan blade width, make it more likely that the bird material will enter the core.

The § 33.76(c) test is conducted using 100 percent power or thrust and the most critical airspeed up to 1,500 feet AGL. Consequently, the § 33.76(c) test does not simulate lower fan speed phases of flight (such as climb and descent) during which a bird, if ingested, is more likely to enter the engine core. In addition, the higher airspeed in climb is not covered by the § 33.76(c) test. Therefore, the small and medium flocking bird test prescribed in § 33.76(c) does not fully provide the intended demonstration of core durability against bird ingestion for the climb and approach conditions.

B. National Transportation Safety Board (NTSB) Recommendations

As part of its report[6] on Flight 1549, the NTSB issued two relevant engine-related safety recommendations to the FAA:

(1) A–10–64: Modify the small and medium flocking bird certification test standard to require that the test be conducted using the lowest expected fan speed, instead of 100 percent fan speed, for the minimum climb rate.

(2) A–10–65: During re-evaluation of the current engine bird-ingestion certification regulations by the Bird Ingestion Rulemaking Database working group, specifically re-evaluate the large flocking bird certification test standards to determine if they should:

(a) Apply to engines with an inlet area of less than 2.5 square meters (3,875 square inches).

(b) Include an engine core ingestion requirement.

If re-evaluation determines the need for these requirements, incorporate them into 14 CFR 33.76(d) and require that newly certificated engines be designed and tested to these requirements.

The ARAC report addressed both NTSB safety recommendations. In response to NTSB safety recommendation A-10-64, the ARAC report recommended the test adopted in this final rule. The ARAC report found that its recommendation would also address the intent of NTSB safety recommendation A-10-65 since the kinetic energy of the bird in this final rule is of the same magnitude as a LFB test.

III. Discussion of Public Comments and Final Rule

The FAA received comments on the NPRM from 12 commenters. Specifically, the FAA received comments from Pratt & Whitney U.S.A. (Pratt & Whitney); Honeywell International; Pratt & Whitney Canada Corporation (Pratt & Whitney Canada); The Boeing

[6] Loss of Thrust in Both Engines After Encountering a Flock of Birds and Subsequent Ditching on the Hudson River, US Airways Flight 1540, Airbus A320-214, N106US, Weehawken, New Jersey, January 15, 2009, Aircraft Accident Report NTSB/AAR-10/03 (Washington, DC: NTSB, 2009) (hereinafter "NTSB report AAR-10/03" available at https://www.ntsb.gov/investigations/Pages/DCA09MA026.aspx

Company; General Electric (GE); Aerospace Industries Association (AIA); Rolls-Royce; Air Line Pilots Association, International (ALPA); the National Transportation Safety Board (NTSB), and three individuals. The FAA received supportive comments on the NPRM from the NTSB and one individual. While a number of commenters requested changes, commenters generally supported the proposal. The NTSB expressed general support for the NPRM and noted the proposed rule, when implemented, would satisfy the intent of NTSB Safety Recommendation A-10-64.[7]

A. Fan Speed Difference Criteria for Combining the Existing MFB Test (§ 33.76(c)) and the New Climb Flocking Bird Test (§ 33.76(e)(1))

In the NPRM, the FAA proposed allowing applicants to combine the new climb flocking bird test with the existing § 33.76(c) test if the fan speed at climb is within 1 percent of the fan speed at takeoff. The purpose of the proposed 1 percent limit on the difference between the climb and takeoff fan speed was to ensure the combined test would apply only to engines designed such that the typical operational practice will be to maintain the throttle in the takeoff position through the climb phase. However, even with the throttle in the same position, both fan and core rotor speeds will change to some extent with altitude and aircraft speed.

AIA, Pratt & Whitney, Pratt & Whitney Canada, Honeywell International, The Boeing Company, GE, and one individual commented on the proposed allowance for combining the new test with the § 33.76(c) test. These commenters stated the proposed one percent difference in fan rotor speed at takeoff and climb conditions in § 33.76(e)(4) is too restrictive. Commenters further stated the in-service difference between climb and takeoff fan rotor speeds is in the range of three percent to five percent, and recommended the FAA

[7] NTSB further stated in its comment that, "Recommendation A-10-65 was classified "Closed—Acceptable Action" on March 1, 2016, in part because the ARAC found that the new climb condition MFB test will further assure the robustness of the engine core."

allow applicants to combine the tests when the fan rotor speed difference was no greater than three percent.

This final rule allows combining the MFB test and the new test at climb condition when the difference in the climb and takeoff fan rotor speeds is no more than three percent. The NTSB accident report for the Flight 1549 accident states that Flight 1549 impacted birds at approximately 2,800 feet altitude AGL and ~82 percent fan speed; well below the maximum takeoff setting.[8] The ARAC report states that many air carriers operating transport category airplanes use reduced thrust or derated takeoff power settings. Operators may use reduced thrust or derated takeoff power settings because they may provide substantial benefits in terms of engine reliability, maintenance, and operating costs, while operating at lower fan speeds than the maximum takeoff thrust rating. Climb power settings on large transport airplanes are also significantly lower than maximum takeoff settings. Smaller jet aircraft with small throat inlets are not typically certified to perform reduced thrust or derated takeoffs (i.e., all takeoffs are completed at max rated takeoff thrust), and climb power settings on most smaller corporate aircraft are typically close to the maximum takeoff thrust rating.

The FAA agrees with the commenters' recommendation to allow combining the new climb flocking bird test with the existing MFB test in § 33.76(c) when the difference between climb and takeoff fan rotor speeds is no more than three percent. It would be overly restrictive to limit the allowable variation to one percent when the in-service difference between climb and takeoff fan rotor speeds, with no change in throttle position, is typically in the range of three percent to five percent. As a result, § 33.76(e)(4) allows applicants to combine the existing MFB and new climb flocking bird tests if the engine's climb fan rotor speed is within three percent of the fan rotor speed required in the MFB test under § 33.76(c). Combining the tests when the fan rotor speed is within 3 percent will

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[8] NTSB report AAR-10/03 at paragraph 2.8.1, page 98, and paragraph 1.16.1, page 47.

have no effect on the efficacy of the test because the bird for the test at climb condition will be fired at the higher bird speed and a fan rotor speed consistent with actual operations.

B. Consistent Usage of Bird Airspeed and Altitude Units (§ 33.76(e)(1)(i)(C) and (e)(2)(i)(C))

The NPRM proposed a bird speed of 250-knots for the new climb flocking bird test and 200-knots for the new approach flocking bird test. Honeywell International, The Boeing Company, AIA, Pratt & Whitney, and GE stated that the NPRM used "knots" and "knots indicated airspeed" (KIAS) inconsistently. Knots, KIAS, and knots true airspeed (KTAS) can refer to different physical speeds. The commenters also stated that the ARAC working group intended for the bird in the climb flocking bird test to be fired at the equivalent of 250-KIAS at an altitude of 3,000 feet MSL using ISA conditions, and 200-KIAS at an altitude of 3,000 feet MSL using ISA conditions for the approach flocking bird test. Therefore, to achieve consistency with the ARAC working group recommendation, the commenters concluded the climb and approach flocking bird tests should be performed with fan speeds representative of the lowest possible fan rotor speed at these conditions, and the bird velocities should be 261-KTAS for the climb flocking bird test, and 209-KTAS for the approach flocking bird test.

KIAS measures airspeed modified to account for the altitude pressure effect. KTAS is the speed of the aircraft relative to the air mass through which it is flying. During a bird ingestion event, KTAS is the effective speed of the bird relative to the aircraft. The NPRM did not specify the altitude at which KIAS was based. For the climb flocking bird test, 250-KIAS at 3,000 feet MSL equates to a bird speed of 261-KTAS at sea level. For the approach flocking bird test, 200-KIAS at 3,000 feet MSL equates to a bird speed of 209-KTAS at sea level. In this final rule, the FAA has revised the proposed § 33.76(e)(1)(i)(C) from "Ingestion must be at 250-knots bird speed," to "Ingestion must be at 261-knots true airspeed." The FAA also revised the proposed § 33.76(e)(2)(i)(C), from "Ingestion must be at 200-knots bird speed" to "Ingestion must be at 209-knots true airspeed."

In the NPRM, the agency proposed that the engine must be stabilized during the test at the mechanical rotor speed of the first exposed fan stage or stages that, on a standard day, produce the lowest expected power or thrust required during climb through 3,000 feet AGL. MSL will establish more consistent test conditions than AGL because the flight conditions for the engine using AGL may vary based upon the ground level altitude above sea level. For example, 3,000 feet above Denver International Airport (5,434 feet above sea level) is 8,434 feet MSL; 3,000 feet above Boston Logan International Airport (19 feet above sea level) is 3,019 feet MSL. Using MSL defines the engine conditions consistent with the commenters' request that the standard refer to 3,000 feet at ISA conditions. The FAA has revised § 33.76(e)(1)(i)(A) for the climb flocking bird test to require the fan rotor speed to be set to the lowest expected power or thrust required during climb through 3,000 feet MSL instead of 3,000 feet AGL.

The NPRM proposed in § 33.76(e)(2)(i)(A) that the engine must be stabilized during the test at the mechanical rotor speed of the first exposed fan stage or stages when on a standard day the engine thrust is set at approach idle thrust when descending 3,000 feet AGL. The FAA also revised § 33.76(e)(2)(i)(A) for the approach flocking bird test to require the fan speed be set to the lowest expected power or thrust required during descent through 3,000 feet MSL instead of 3,000 feet AGL, based on the same rationale as the climb flocking bird test.

Finally, changing AGL to MSL will not result in different test conditions than those proposed in the NPRM. For turbofan engines, power or thrust is proportional to fan speed. The lowest fan speed for a given climb thrust at standard day conditions and 3,000 feet AGL is equivalent to 3,000 feet MSL. In addition, changing the altitude units to MSL makes the altitude reference consistent with the requirement to have the lowest fan speed at standard day conditions.

C. Removal of Reference to Approach Flocking Bird Test (§§ 33.76(e)(4))

The NPRM preamble discussed the circumstances under which applicants could combine the proposed climb flocking bird test with the existing § 33.76(c) test; however, the proposed regulatory text in § 33.76(e)(4)(ii) provided that the proposed approach flocking bird test could also be combined with the § 33.76(c) test. Honeywell International and GE commented that proposed § 33.76(e)(4)(ii) should not be included in the final rule. Honeywell International further explained that there is no scenario where the fan speed at the approach condition will be within one percent, or even the recommended three percent, of the max takeoff thrust fan speed. The FAA agrees that applicants may only combine the climb flocking bird test with the § 33.76(c) test since the conditions of the approach flocking bird test are not consistent with the § 33.76(c) test. Therefore, in this final rule, § 33.76(e)(4) does not include a reference to the approach flocking bird test.

D. Proposal to Exclude Engine Inlets Greater than 3.90 Square Meters

In the NPRM, the FAA proposed that either the climb or approach flocking bird test would be required for all turbofan engines in addition to the existing § 33.76(c) test. GE commented that engines with inlet areas of 3.90 square meters (6,045 square inches) or greater, known as Class A size engines, should be excluded from the requirement to perform the new test. Specifically, GE asserted that engines should be excluded when the applicant can show that the proposed type design for an engine has design features and functions consistent with the applicant's successful MFB ingestion based on field service experience and core ingestion compliance demonstrations with previously certified engine types. GE reasoned that the ARAC report shows that the data in the Aerospace Industries Association Bird Ingestion Working Group Interim Report contained no reported loss of power events associated with core bird ingestion into Class A size turbofan engines between 1999 and 2009. GE also stated that its recent compliance testing results provide clear evidence of core ingestion. Therefore, compliance with the MFB ingestion requirements found in § 33.76(c) will present an appropriate and operationally relevant MFB ingestion challenge for the largest size class of engines.

The FAA notes that between 2000 and 2009, there were between 12 and 20 million airplane flight cycles (a flight cycle includes a takeoff and landing) per year with Class D size engines (1.35m^2–2.5m^2 inlet areas, the same size as the engines on the US Airways Flight 1549 airplane). During that same time, there were less than 2 million airplane flight cycles with Class A size engines per year. Along with the low overall number of engine power loss events, this low number of airplane flight cycles makes it difficult to statistically establish that the prior service history of Class A size engines between 2000 and 2009 is sufficient to prove that the airplane is protected from hazards due to engine core ingestion during climb, based on the engine inlet area alone.

Additionally, the ARAC report did not make an exception for Class A size engines or other engine sizes with relatively few core power loss events. Instead, section 5 of the ARAC report indicates that the § 33.76(c) core ingestion demonstration criteria did not adequately represent the most critical flight phase with respect to core ingestion due to the combination of high fan rotor speed and low aircraft speed. The ARAC report discusses the effects of rotor speed and low aircraft speed on core ingestion in paragraph 3.2.

With respect to GE's comment that signs of bird material are consistently found on the spinner or in the core inlet area after the § 33.76(c) test and therefore are a reliable indicator of the core flow path, the FAA does not concur. The ARAC report addressed this topic in paragraph 4.3, Differentiating Between Core Induced Power Loss vs. Material in the Core. The ARAC report stated:

> It is believed that the presence of bird remains within the engine core is not a reliable indicator of significant core ingestion because bird strikes on aircraft

structure other than the core intake area, such as the inlet lip, spinner cap, and radome, regularly result in some amount of avian material entering the core.[9]

Based on the information in the ARAC report, the FAA determined that during a certification test, it is not possible to accurately measure the amount of bird material that entered the core, as opposed to bypassing the core. Testing the engine at the climb condition is the best way to ensure significant bird material enters the core. Therefore, consistent with the NPRM, this final rule does not except Class A engines.

E. Using MFB Test to Meet Core Ingestion Requirement

The NPRM proposed that either the climb or approach flocking bird test would be required for all turbofan engines in addition to the existing § 33.76(c) test, regardless of the results of the § 33.76(c) test. GE commented that the approach flocking bird test proposed in the NPRM should not be required if bird material entered the core during the § 33.76(e)(1) climb flocking bird test or the § 33.76(c) test, because ingestion of bird material during the § 33.76(c) test would demonstrate sufficient core robustness against bird ingestion. In addition, GE commented that based on its experience, the core capability could be demonstrated using the § 33.76(c) test.

The ARAC found that bird velocity is predicted to have the greatest influence on the amount of bird ingested into the core for a given design.[10] Also, generally, for a given bird velocity, the amount of ingested bird material into the core is inversely proportional to the fan rotor speed. Therefore, the new climb flocking bird test in the new § 33.76(e)(1) will provide a more representative demonstration of core capability than the § 33.76(c) test due to the higher bird velocity and lower rotor fan speed required by the climb flocking bird test.

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[9] ARAC report at p. 25.

[10] ARAC report at p. 17, 18.

Additionally, the FAA proposed that the approach flocking bird test would only be required if testing or validated analysis shows that no bird material will be ingested into the engine core during the § 33.76(e)(1) climb flocking bird test. As stated in the NPRM, testing at the 200-KIAS (209-KTAS) approach condition would ensure that, if the engine is designed to centrifuge all bird material away from the core flow path at takeoff and climb conditions (which is beneficial), then engine core capability to ingest bird material would still be tested. This is because an engine that centrifuges bird material away from the core at the 250-KIAS (261-KTAS) climb condition may not be able to centrifuge away the same amount of bird material at the lower speed approach condition. The NPRM stated that the approach flocking bird test would only be required if testing or validated analysis shows that no bird material will be ingested into the engine core during the § 33.76(e)(1) climb flocking bird test. Consequently, the FAA did not change the rule as a result of comments seeking to exclude the approach flocking bird test if material entered the core during the § 33.76(c) test.

F. Approach Flocking Bird Test Run-On Requirement Wording

In the NPRM, the FAA proposed post-test bird ingestion run-on requirements for the new climb and approach flocking bird tests. Rolls-Royce, Honeywell International, The Boeing Company, AIA, Pratt & Whitney, and GE suggested the NPRM preamble description of the engine run-on requirements for the approach flocking bird test was confusing. The NPRM preamble stated that applicants would be required to comply with the same post-test run-on requirements as those for the final six minutes of the existing § 33.76(d)(5) post-test run-on requirements for LFB. The NPRM preamble also stated that the post-test run-on requirements for the proposed approach flocking bird test would consist of the final seven minutes of the existing LFB 20-minute post-ingestion run-on requirement.

The FAA clarifies that the phrase "final seven minutes" in the NPRM preamble included a 1-minute period after ingestion when the engine throttle must not be manipulated, followed by the final six minutes of the LFB run-on requirement. Consistent with the preamble discussion, the proposed regulatory text in § 33.76(e)(2)(iii) included a total of both the 1-minute delay after ingestion and the final six minutes of the LFB run-on. Therefore, in this final rule, the FAA adopts § 33.76(e)(2)(iii) as proposed.

G. MFB Bird Speed (§ 33.76(c))

Honeywell International, The Boeing Company, AIA, Pratt & Whitney, and GE commented that the NPRM preamble improperly described the § 33.76(c) bird speed requirement. The NPRM preamble stated that the MFB test is conducted using 100 percent power or thrust and 200-knots airspeed, simulating takeoff conditions. However, § 33.76(c) states that 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 AGL, but not less than V_1 minimum for airplanes. Therefore, while the NPRM preamble's description of the § 33.76(c) bird speed requirement was inaccurate, the proposed regulatory text was correct.

H. Number of Required Tests

The NPRM preamble stated that it was unlikely that manufacturers would need to run multiple tests to meet the proposed test requirements. GE questioned the accuracy of this assertion, requesting that the FAA acknowledge the possibility that the proposal could result in two additional ingestion tests.

The FAA has determined that manufacturers are unlikely to have to run two additional tests because the agency expects that manufacturers will evaluate the design of their engines before testing and should be able to determine whether engines will centrifuge all bird material away from the engine core. In this final rule, a manufacturer may perform either the climb or approach test; however, they would perform the approach test only if testing or a validated analysis shows that no bird material will enter the engine core. By performing a validated analysis to determine whether an engine will centrifuge all bird material away from the engine core during the climb flocking bird test, a manufacturer will be able to know ahead of time whether to run either the climb or the approach flocking bird test.[11] Therefore, while it is possible that the final rule could result in two additional ingestion tests, it remains unlikely.

The FAA notes that the ARAC report found that various engine manufacturer simulation results have shown that, in general for a given bird velocity, the amount of ingested bird material into the core is inversely proportional to the fan rotor speed.[12] During the ARAC working group study, at least three different engine manufacturers who had conducted these simulations presented engineering analyses predicting how much bird material would enter the core after ingestion (See Figure 3.2.2 of the ARAC report). This indicated that industry has the capability to determine before the test, whether engines will centrifuge all bird material away from the engine core.

I. Canada Geese

As noted by Honeywell International, AIA, and Pratt & Whitney, the NPRM incorrectly referred to the birds ingested into the engines of Flight 1549 as "Canadian geese" rather than "Canada geese." The preamble to this final rule uses the term "Canada geese," reflecting the proper bird identification.[13]

J. Regulatory Evaluation Costs

The NPRM summarized the results of the FAA evaluation of the costs and benefits associated with the proposal. GE disagreed with the total benefits and costs of the proposed rule as described in the NPRM. The commenter expressed that the cost and benefit analyses

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[11] Advisory Circular 33.76-1B, published with this final rule, provides guidance for using a validated core ingestion prediction analysis.
[12] ARAC report at p. 17, 18.
[13] NTSB report AAR-10/03 at section 1.18.1.2, "Canada Goose Information."

do not include the additional incremental cost to develop and mature the technology to pass the additional certification test(s) and to conduct and pass the additional certification test(s).

The commenter's costs discussion shows that it is possible that the cost to design and develop engine blades and vanes to comply with the new rule could be significantly different from those estimated in the preliminary regulatory impact analysis. While the new test is intended to increase the amount of bird material entering the engine core relative to the existing § 33.76(c) test, the fundamental requirement for blades and vanes behind the fan to withstand foreign object damage from bird ingestion has not changed. Since § 33.76 at Amendment 20 (65 FR 55848, September 14, 2000), applicants have been required to aim the largest MFB at the engine core primary flow path. In addition, other regulations (such as § 33.78(a)(1) for hailstone ingestion) have also required applicants to account for potential impact damage when designing their core engine blades and vanes. The need for new engineering analysis, development tools, and methods when developing a new blade to meet this final rule's new test requirement will vary among manufacturers depending on the physical design of their engines, their development philosophy, and their tolerance for risk during the certification process. For example, an engine manufacturer who designs its engine so no material would enter the engine core during either the climb or approach condition could have zero developmental costs due to the new regulation. Others might desire or require additional developmental work to ensure a future engine would meet the new requirement. The FAA has revised the regulatory analysis to address the potential for pre-certification developmental costs.

GE also criticized the analysis as significantly underestimating production costs. The commenter stated that, for example, a production rate of nearly 3,000 engines per year should be used instead of the FAA estimate of 220 engines per year. The FAA contacted the commenter to clarify whether its comment was based on the belief that the FAA was estimating 220 affected engines would be produced per year in total. The FAA asked if the commenter believed that instead, the total number of engines produced by all engine manufacturers in one year should be closer to 3,000. The commenter responded that it thought the 220 engines produced per year were for all manufacturers. The commenter mentioned the CFM International LEAP engine production rate is nearly 3,000 engines per year as an example. Therefore, the commenter believes the total of 220 engines given in the benefits and costs analysis of the NPRM is too low.

The FAA clarifies that the 220 engines in its economic analysis are per new engine certification (i.e., one certification for each manufacturer). More specifically, in the regulatory evaluation, the FAA estimated that three engines would be certified every year and two additional engines would be certified every three years. Additionally, the FAA assumed production of the engines would begin one year after certification. Finally, the FAA estimated that, on average, 220 engines would be produced per year, per certification. To calculate engines in-service that would be affected by this final rule, the FAA assumes the estimated average service life of an engine is about 16 years.

Therefore, in the first year of compliance, the FAA estimated five engines would be certified with 1,100 engines produced. In the second year, three more engines are certified, and in the following year, an additional 660 engines would be produced. In the third year, another three certifications occur with an additional 660 engines produced. In the fourth year, five engines would be certified with another 1,100 engines produced. After 10 years, the engines produced from the tenth year would be installed the following year and continue in-service for 16 years. The number of affected engines reach a maximum in the twelfth year and, with no attrition, there are 8,360 engines in-service until year 18 when the engines in operation begin to retire. After 27 years, all the affected engines would be retired. See "Table 1. Engine Certifications and Aircraft in Service Forecast" of the Regulatory Evaluation for details.

The FAA's estimate of 220 engines produced per year, per certification, is based on the average production rate per year, from 1989 to 2015, for the V2500 engine. The V2500 engine is installed on the Airbus A320 airplane and the MD-80 airplane. Larger engines like the GE90 (installed on the Boeing 777) would be produced at a lower average rate and smaller engines like the CF34 (regional jet) would be produced at a higher average rate.

The FAA compared the estimate of 220 engines per year against the data for engines previously certified to determine if the 220 estimate is too low. This rule only affects engines with a certification date of application after the effective date of the final rule and does not affect the CFM International LEAP engine. The data shows that the average production rate per year from 2008 to 2017 for the V2500 engine is 182 engines per year. Furthermore, the average production of certified engines from 2008 to 2017 is even less (108 engines per year). For this reason, the FAA's use of 220 engines per certification to estimate the operating cost of this rule is justified.

K. Miscellaneous Changes Between the NPRM and the Final Rule

In the NPRM, proposed § 33.76(e)(1)(iii)(D) included the allowance that "Power lever movement in this condition is unlimited" for that segment of the climb flocking bird test. The FAA inadvertently omitted a similar allowance in proposed § 33.76(e)(2). To correct this omission and make the approach flocking bird test schedule consistent with the climb flocking bird test schedule, the FAA added "Power lever movement in this condition is unlimited" to the end of § 33.76(e)(2)(iii)(C) in this final rule.

The FAA modified the proposed test requirements in paragraphs (e)(1)(i)(B) and (e)(2)(i)(B) to § 33.76, to clarify that only one bird is required for the climb flocking bird test and approach flocking bird test added by this final rule.

Section 33.76(a)(5) allows applicants to substitute objects that are accepted by the Administrator for birds when conducting the existing bird ingestion tests. The FAA amended § 33.76(a)(5) by adding a reference to new § 33.76(e) for consistency with the allowance for other bird ingestion tests.

In order to be consistent with the existing wording in § 33.76(b) through (d), the FAA does not use the word “fan” in this final rule when describing the first exposed rotor stage in § 33.76(e)(1)(i)(A) and (D), (e)(2)(i)(A) and (D), and (e)(4).

IV. Regulatory Notices and Analyses

A. Regulatory Evaluation

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 and Executive Order 13563 direct that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Public Law 96-354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Public Law 96-39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, the Trade Agreements Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules, that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation with base year of 1995; current value is $155 million). This portion of the preamble summarizes the FAA’s analysis of the economic impacts of this final rule. The FAA suggests readers seeking greater detail read the full regulatory evaluation, a copy of which is available in the docket for this rulemaking.

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

Total Benefits and Costs of this Rule

The FAA is amending certain airworthiness regulations to add a new test requirement to the airworthiness regulation addressing engine bird ingestion. This final rule ensures that engines can ingest the largest MFB into the engine core at climb or approach conditions. The ingestion of MFB can cause thrust loss from core engine bird ingestion if enough bird mass enters the engine core, which in turn can cause an accident or flight diversion. This rule adds to the certification requirements of turbofan engines, a requirement that manufacturers must show that their engine cores can continue to operate after ingesting an MFB while operating at a lower fan speed associated with climb or approach. Engine manufacturers have the capability of producing such engines.

The FAA estimates the annualized cost of the rule to be $5.3 million, or present value $64.0 million over 27 years (discounted at 7 percent).[14] The FAA estimates the annualized benefits of the rule to be $6.1 million, or present value $73.7 million over 27 years (discounted at 7 percent). The following table summarizes the benefits and costs of this final rule. The FAA has revised the analysis of costs for the final rule based on information received during the public comment period (for details see section J. Regulatory Evaluation Costs).

Summary of Benefits and Costs ($Millions)

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[14] The FAA uses a 27-year period of analysis since it represents one complete cycle of actions affected by the rule. One life cycle extends through the time required for certification, production of the engines, engine installation, active engine service, and retirement of the engines.

Impact	27-year Total Present value 7% Present Value	27-year Total Present value 3% Present Value	Annualized 7% Present Value	Annualized 3% Present Value
Benefits	$73.7	$121.6	$6.1	$6.6
Costs	$64.0	$85.4	$5.3	$4.7
Net Benefits	$9.7	$36.2	$0.8	$1.9

1. This rule addresses two engine-related safety recommendations that the NTSB issued to the FAA: (1) A-10-64 and (2) A-10-65.

2. Who is Potentially Affected by this Rule?

Aircraft operators and engine manufacturers.

3. Assumptions

The benefit and cost analysis for the regulatory evaluation is based on the following assumptions:

- The analysis is conducted in constant dollars with 2020 as the base year.
- The FAA calculated the present value of the potential benefits by discounting the monetary values following the Office of Management and Budget guidance using a 7 percent and a 3 percent interest rate.
- The analysis period is 27 years with 10 years of new engine certifications.
- Based on the actual production numbers of a common airline engine, the FAA estimates that about 220 engines are produced per year per certification.
- Because of this final rule, the average fuel consumption will increase by $821 per year per aircraft.

B. Regulatory Flexibility Determination

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

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

Two groups will be affected by this rule: aircraft operators and engine manufacturers.

The FAA has determined that this final rule will not have a significant economic impact on small aircraft operators. Operators will incur higher fuel burn costs due to an increase in engine weight (heavier blading, components, etc.), and consequently, an increase in total aircraft weight. The FAA estimates fuel burn costs of $750 per year per aircraft, which the FAA has determined will not result in a significant economic impact for small aircraft operators.

Similarly, the FAA has determined that this final rule will not have a significant economic impact on engine manufacturers. The FAA identified one out of five engine manufacturers that meet the Small Business Administration definition of a small entity. The annual revenue estimate for this manufacturer is about $75 million.[15] The FAA then compared this manufacturer's revenue with its annualized compliance cost. The FAA expects that the manufacturer's projected annualized cost would be 0.3 percent of its annual revenue,[16] which the FAA has determined is not a significant economic impact.

If an agency determines that a rulemaking will not result in a significant economic impact on a substantial number of small entities, the head of the agency may so certify

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[15] Source: http://www.manta.com.

[16] Ratio= annualized cost/annual revenue = $220,355/$74,800,000 = 0.3%.

under section 605(b) of the RFA. Therefore, as provided in section 605(b), the head of the FAA certifies that this rulemaking will not result in a significant economic impact on a substantial number of small entities.

C. International Trade Impact Assessment

The Trade Agreements Act of 1979 (Public Law 96-39), as amended by the Uruguay Round Agreements Act (Public Law 103-465), prohibits Federal agencies from establishing standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to these Acts, the establishment of standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such as the protection of safety, and does not operate in a manner that excludes imports that meet this objective. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards. The FAA has assessed the potential effect of this final rule and determined that it has legitimate domestic safety objectives. Therefore, this final rule is in compliance with the Trade Agreements Act.

D. Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (in 1995 dollars) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a “significant regulatory action.” The FAA currently uses an inflation-adjusted value of $155 million in lieu of $100 million. This final rule does not contain such a mandate; therefore, the requirements of Title II of the Act do not apply.

E. Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. The FAA has determined that there is no new requirement for information collection associated with this final rule.

F. International Compatibility

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

G. Environmental Analysis

FAA Order 1050.1F identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 5-6.6 and involves no extraordinary circumstances.

H. Regulations Affecting Intrastate Aviation in Alaska

Section 1205 of the FAA Reauthorization Act of 1996 (110 Stat. 3213) requires the Administrator, when modifying 14 CFR regulations in a manner affecting intrastate aviation in Alaska, to consider the extent to which Alaska is not served by transportation modes other than aviation, and to establish appropriate regulatory distinctions. The FAA has determined that this rule would not affect intrastate aviation in Alaska.

V. Executive Order Determinations

A. Executive Order 13132, Federalism

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

B. Executive Order 13211, Regulations that Significantly Affect Energy Supply, Distribution, or Use

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

C. Executive Order 13609, International Cooperation

Executive Order 13609, Promoting International Regulatory Cooperation, (77 FR 26413, May 4, 2012) promotes international regulatory cooperation to meet shared challenges involving health, safety, labor, security, environmental, and other issues and reduce, eliminate, or prevent unnecessary differences in regulatory requirements. The FAA has analyzed this action under the policy and agency responsibilities of Executive Order 13609, Promoting International Regulatory Cooperation. The agency has determined that this action will eliminate differences between U.S. aviation standards and those of other civil aviation authorities by ensuring that § 33.76 remains harmonized with European Union Aviation Safety Agency Certification Specification CS-E 800.

VI. How To Obtain Additional Information

A. Rulemaking Documents

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

1. Search the Federal eRulemaking Portal (*www.regulations.gov*);

2. Visit the FAA's Regulations and Policies web page at *www.faa.gov/regulations_policies/*; or
3. Access the Government Printing Office's web page at *www.GovInfo.gov*.

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

B. Small Business Regulatory Enforcement Fairness Act

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

List of Subjects in 14 CFR Part 33

Bird ingestion.

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends chapter I of title 14, Code of Federal Regulations as follows:

PART 33--AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

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

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

2. Amend § 33.76 by revising the introductory text to paragraph (a) and paragraphs (a)(1) and (5) and adding paragraph (e) to read as follows:

§ 33.76 Bird ingestion.

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

(1) Except as specified in paragraphs (d) and (e) of this section, all ingestion tests must 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.

* * * * *

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

* * * * *

(e) Core flocking bird test. Except as provided in paragraph (e)(4) of this section, for turbofan engines, an engine test must be performed in accordance with either paragraph (e)(1) or (2) of this section. The test specified in paragraph (e)(2) must be conducted if testing or validated analysis shows that no bird material will be ingested into the engine core during the test under the conditions specified in paragraph (e)(1).

(1) Climb flocking bird test. (i) Test requirements are as follows:

(A) Before ingestion, the engine must be stabilized at the mechanical rotor speed of the first exposed stage or stages that produce the lowest expected power or thrust required during climb through 3,000 feet above mean sea level (MSL) at standard day conditions.

(B) The climb flocking bird test shall be conducted using one bird of the highest weight specified in table 2 to this section for the engine inlet area.

(C) Ingestion must be at 261-knots true airspeed.

(D) The bird must be aimed at the first exposed rotating stage or stages, at the blade airfoil height, as measured at the leading edge that will result in maximum bird material ingestion into the engine core.

(ii) Ingestion of a flocking bird into the engine core under the conditions prescribed in paragraph (e)(1)(i) of this section must not cause any of the following:

(A) Sustained power or thrust reduction to less than 50 percent maximum rated takeoff power or thrust during the run-on segment specified under paragraph (e)(1)(iii)(B) of this section, that cannot be restored only by movement of the power lever.

(B) Sustained power or thrust reduction to less than flight idle power or thrust during the run-on segment specified under paragraph (e)(1)(iii)(B) of this section.

(C) Engine shutdown during the required run-on demonstration specified in paragraph (e)(1)(iii) of this section.

(D) Any condition specified in § 33.75(g)(2).

(iii) The following test schedule must be used (power lever movement between conditions must occur within 10 seconds or less, unless otherwise noted):

Note 1 to paragraph (e)(1)(iii) introductory text. Durations specified are times at the defined conditions in paragraphs (e)(1)(iii)(A) through (I) of this section.

(A) Ingestion.

(B) Followed by 1 minute without power lever movement.

(C) Followed by power lever movement to increase power or thrust to not less than 50 percent maximum rated takeoff power or thrust, if the initial bird ingestion resulted in a reduction in power or thrust below that level.

(D) Followed by 13 minutes at not less than 50 percent maximum rated takeoff power or thrust. Power lever movement in this condition is unlimited.

(E) Followed by 2 minutes at 30-35 percent maximum rated takeoff power or thrust.

(F) Followed by 1 minute with power or thrust increased from that set in paragraph (e)(1)(iii)(E) of this section, by 5-10 percent maximum rated takeoff power or thrust.

(G) Followed by 2 minutes with power or thrust reduced from that set in paragraph (e)(1)(iii)(F) of this section, by 5-10 percent maximum rated takeoff power or thrust.

(H) Followed by 1 minute minimum at ground idle.

(I) Followed by engine shutdown.

(2) <u>Approach flocking bird test</u>. (i) Test requirements are as follows:

(A) Before ingestion, the engine must be stabilized at the mechanical rotor speed of the first exposed stage or stages that produce approach idle thrust when descending through 3,000 feet MSL at standard day conditions.

(B) The approach flocking bird test shall be conducted using one bird of the highest weight specified in table 2 to this section for the engine inlet area.

(C) Ingestion must be at 209-knots true airspeed.

(D) The bird must be aimed at the first exposed rotating stage or stages, at the blade airfoil height measured at the leading edge that will result in maximum bird material ingestion into the engine core.

(ii) Ingestion of a flocking bird into the engine core under the conditions prescribed in paragraph (e)(2)(i) of this section may not cause any of the following:

(A) Power or thrust reduction to less than flight idle power or thrust during the run-on segment specified under paragraph (e)(2)(iii)(B) of this section.

(B) Engine shutdown during the required run-on demonstration specified in paragraph (e)(2)(iii) of this section.

(C) Any condition specified in § 33.75(g)(2).

(iii) The following test schedule must be used (power lever movement between conditions must occur within 10 seconds or less, unless otherwise noted):

Note 2 to paragraph (e)(2)(iii) introductory text. Durations specified are times at the defined conditions in paragraphs (e)(2)(iii)(A) through (H) of this section.

(A) Ingestion.

(B) Followed by 1 minute without power lever movement.

(C) Followed by 2 minutes at 30-35 percent maximum rated takeoff power or thrust. Power lever movement in this condition is unlimited.

(D) Followed by 1 minute with power or thrust increased from that set in paragraph (e)(2)(iii)(C) of this section, by 5-10 percent maximum rated takeoff power or thrust.

(E) Followed by 2 minutes with power or thrust reduced from that set in paragraph (e)(2)(iii)(D) of this section, by 5-10 percent maximum rated takeoff power or thrust.

(F) Followed by 1 minute minimum at ground idle.

(G) Followed by engine shutdown.

(H) Power lever movement between each condition must be 10 seconds or less, except that any power lever movements are allowed within the time period of paragraph (e)(2)(iii)(C) of this section.

(3) Results of exceeding engine-operating limits. Applicants must show that an unsafe condition will not result if any engine-operating limit is exceeded during the run-on period.

(4) Combining tests. The climb flocking bird test of paragraph (e)(1) of this section may be combined with the medium flocking bird test of paragraph (c) of this section, if the climb first stage rotor speed calculated in paragraph (e)(1) of this section is within 3 percent of the first stage rotor speed required by paragraph (c)(1) of this section. As used in this paragraph (e)(4), ‘‘combined’’ means that, instead of separately conducting the tests specified in paragraphs (c) and (e)(1) of this section, the test conducted under paragraph (c) of this section satisfies the requirements of paragraph (e) of this section if the bird aimed

at the core of the engine meets the bird ingestion speed criteria of paragraph (e)(1)(i)(C) of this section.

Issued under authority provided by 49 U.S.C. 106(f), 44701(a), and 44704 in Washington, DC, on or about March 23, 2023.

Billy Nolen,
Acting Administrator.

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