



Federal Aviation Administration

Memorandum

Date: July 12, 2010

To: Thomas Boudreau, Manager, Engine Certification Office (ECO), ANE-140

From: Fran A. Favara, Manager, Engine & Propeller Directorate, ANE-100

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Subject: INFORMATION: General Electric GEnx-2B Engine Certification Program
(Project No. AT2432EN-E) Request for Review and Concurrence with
Equivalent Level of Safety Finding to 14 CFR Part 33, Section (§) 33.77
Foreign Object Ingestion – Ice

Memo No.: 8040-ELOS-09-NE02

Regulatory Reference: 14 CFR § 33.77

This memorandum informs the Engine Certification Office of an evaluation made by the Engine and Propeller Directorate on the establishment of an equivalent level of safety finding for the GEnx-2B engine.

Background

The General Electric Company (GE) proposed to show an Equivalent Level of Safety (ELOS) to the ice slab ingestion requirements of § 33.77(c), under the conditions stipulated in § 33.77(e), using compensating factors in accordance with the provisions of 14 CFR Part 21, § 21.21(b)(1). The proposal used data from the § 33.76(c) medium bird test and analysis as the method of compliance (MOC) instead of showing direct compliance to the requirements of § 33.77(c) by an engine test. GE substantiated the use of this data by demonstrating that a successful § 33.76(c) medium bird ingestion test imposed more severe impact loading conditions on the fan blades than what they would have experienced in the § 33.77 ice slab ingestion test.

Applicable Regulation(s)

§ 33.77, Foreign object ingestion - ice, paragraphs (c) & (e):

(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.
- (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.

Regulation(s) requiring an ELOS finding

§ 33.77 para. (c) and (e)

Description of compensating design features or alternative Methods of Compliance (MoC) which allow the granting of the ELOS (including design changes, limitations, or equipment need for equivalency)

GE proposed to show compliance to the ice ingestion requirements of 14 CFR § 33.77(c) by using data from an analytical model that was validated and calibrated to GE90-115B and GENx-1B medium and large bird ingestion component test data. § 33.76 (c)(1) requires that 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 the V1 minimum speed for airplanes. GE supported this proposal with the results from the validated analytical model that predicted the composite fan blade strains from a medium bird impact exceeded the predicted strains from the ice slab test, and therefore the proposed MOC by means of an ELOS assessment can be used.

Explanation of how compensating design features or alternative Methods of Compliance (MoC) provide an equivalent level of safety to the level of safety intended by the regulation

The safety objectives of § 33.77 para. (c) and (e) are to demonstrate a tolerance to ingesting ice that has accreted and then shed from engine nacelle surfaces, and to establish limits for ice shed from other aircraft surfaces as required by 14 CFR Part 25.

The GE analyses used the most conservative assumptions by selecting the largest ice slab size and worst-case slab orientation as it is ingested into the engine for the ELOS assessment. The predicted fan blade fiber strains from the ice slab analysis were directly compared to the strains resulting from a medium bird (soft body) impact. The comparison showed that the fan blade fiber strains resulting from a worst-case ice slab impact were below the strains from a medium bird strike. The results also showed that

both the medium bird and ice slab strains are below composite fan blade failure threshold (the strain level where fiber failure is predicted). GE has shown by component test and analysis that the medium bird test fan blade fiber strains exceed the ice slab test requirements. Therefore, GE has successfully demonstrated compliance to § 33.77 para. (c) and (e) by a successful medium bird demonstration test.

FAA approval and documentation of the ELOS finding

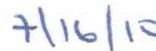
The FAA has approved the aforementioned equivalent level of safety finding in the GENx-2B Issue Paper P-5. This memorandum provides standardized documentation of the ELOS that is non-proprietary and can be made available to the public. The Engine and Propeller Directorate has assigned a unique ELOS Memorandum number, (8040-ELOS-09-NE02), to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number will be listed in the Type Certificate Data Sheet under the certification basis section for the GENx-2B engine models as follows:

Equivalent Level of Safety Findings have been made for the following regulations:

14 CFR §33.77, Foreign object ingestion – ice, para.(c) and (e), (documented in ELOS No. 8040-ELOS-09-NE02).



Fran A. Favara, Manager
Engine & Propeller Directorate, ANE-100



Date