



Federal Aviation Administration

Memorandum

Date: July 29, 2013

To: Manager, Engine Certification Office, ANE-140

From: Manager, Engine & Propeller Directorate, ANE-100

Prepared by: Carlos Fernandes, ANE-141

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for General Electric Company's (GE's) project on GENx-2B67/P Engine Model, FAA Project # AT3138EN-E

ELOS Memo #: AT3138EN-E-P-3

Regulatory Ref: 14 CFR 21.21 and 33.77

This memorandum informs the Engine Certification Office (ECO) of an evaluation made by the Engine & Propeller Directorate on the establishment of an equivalent level of safety finding for the GENx-2B67/P engine model.

Background

On October 6, 2010, General Electric Company (GE) submitted an application to the ECO to amend the GENx series Type Certificate to include a new derivative model, the GENx-2B67/P.

Title 14, Code of Federal Regulations (14 CFR) 33.77(c) requires that the ingestion of ice, under the conditions stipulated in § 33.77(e), may not cause a sustained power or thrust loss, or require the engine to be shut down.

GE proposed an ELOS to the ice slab ingestion requirements of Title 14, Code of Federal Regulations (14 CFR) 33.77(c), under the conditions stipulated in § 33.77(e), using compensating factors in accordance with the provisions of 14 CFR 21.21(b)(1). The ELOS 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.

Applicable regulations

14 CFR 21.21 and 33.77

Regulation requiring an ELOS finding

14 CFR 33.77(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 the §33.76(c) medium bird test and validated analysis as the method of compliance instead of the required engine test.

GE validated and calibrated their analytical model with instrumented component test data from the GEnx-1B and GE90-115B. The model is used for both the ice slab and medium bird impact predictions. The resulting data from this model is combined with medium bird certification testing to show compliance to ice slab ingestion requirements.

GE ran a full engine bird test for the baseline GEnx-2B, which shares the same fan and low pressure compressor design. The compensating factors that allow granting the equivalency to §33.77(c) and (e) are:

- Using a validated analytical model, the composite fan blade strains from a medium bird impact exceed the predicted strains from the ice slab test requirements.
- The predicted strains from both the medium bird impact and ice slab strains are below the composite failure threshold (point above which fiber fracture is predicted).
- The maximum predicted ice slab size and most critical orientation is used in the analysis.
- An assessment of engine thrust loss must show it to be less than 1.5% and any damage will not result in unacceptable power or thrust loss within 100 cycles.
- The analysis must show that any damage will not result in:
 - Adverse effects on engine operability (that is, surge, shut down flameout, or prevent transient operation), or
 - Failure or a performance loss that would prevent continued safe operation for a conservative flight cycle scenario, or
 - Any other anomaly that may cause the engine to exceed operating or structural limitations.

Explanation of how 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(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(c) and (e) by a successful medium bird demonstration test.

FAA approval and documentation of the ELOS finding:

The FAA has approved the aforementioned ELOS findings in GENx-2B67/P issue paper P-3. This memorandum provides standardized documentation of the ELOS findings that are nonproprietary and can be made available to the public. The Engine & Propeller Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate archiving and retrieval of these ELOS. This ELOS Memorandum number must be listed in the Type Certificate Data Sheet under the Certification Basis section (TCs & ATCs) or in the Limitations and Conditions section of the STC. An example of an appropriate statement is provided below.

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

14 CFR 33.77(c) and (e), Foreign object ingestion - ice (documented in ELOS Memo AT3138EN-E-P-3)

//Original Signed by Robert Ganley for ANE100//

November 22, 2013

 Manager, Engine & Propeller Directorate
 Aircraft Certification Service

 Date

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