



Federal Aviation Administration

Memorandum

Date: November 21, 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-5

Regulatory Ref: 14 CFR 21.21 and 33.78

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) 33.78(a)(2) defines the airworthiness certification test requirements for rain and hail ingestion. In part, it requires that each engine is capable of acceptable operation throughout its specified operating envelope when subjected to sudden encounters with certain concentrations of rain and hail, as defined in Appendix B to Part 33.

GE proposed an ELOS to the rain and hail ingestion test requirements of §33.78(a)(2) using compensating factors in accordance with the provisions of 14 CFR 21.21(b)(1). The ELOS proposal used comparative analysis validated by §33.78(a)(2) compliance test of the GENx-1B/P2 series engine models.

GE proposed to combine the results from testing conducted on a GENx-1B/P2 series engine model with comparative analysis data. The analysis demonstrated that the GENx-2B67/P engine model would not experience unacceptable sustained power or thrust loss, flameout, rundown, loss of acceleration or deceleration capability, non-recoverable stall or surge, unacceptable mechanical damage, or other engine anomalies when exposed to extreme concentrations of rain or hail.

Applicable regulations

14 CFR 21.21, 33.78

Regulation requiring an ELOS finding

14 CFR 33.78(a)(2)

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)

To address the use of comparative analysis in lieu of test for compliance with § 33.78(a)(2) by an ELOS, GE proposed and the FAA concurred with the following compensating factors for the ELOS finding:

1. The analytical methodology must be validated based on previous testing of similar geometry, materials and relevant operating characteristics. The engine to be certified must have the same or greater adverse operation margins than the tested engine when subjected to sudden encounters with certification standard concentrations of rain and hail, as defined in Appendix B to Part 33.
2. The validated analytical methodology must be capable of accurately predicting engine operating characteristics throughout its specified operating envelope when subjected to conditions defined by the rule.
3. The validated analytical methodology must have the ability to accurately predict mechanical damage, either from direct impact or internal accretion.
4. The engine similarity to prior certification tests must support the identified pass/fail criteria.

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

GE based the calibration and validation of the analytical technique on prior rain and hail ingestion test data. The comparative analysis used prior approved GENx-1B/P2 series engine model test data from compliance engine test to validate the analytical model that was then used to generate new data to represent any new design features and new

operating environments or operating characteristics of the GENx-2B67/P engine model. The assumptions made during the comparative analysis were conservative. The GENx-1B/P2 series and GENx-2B67/P engine models share a common engine core, i.e., high pressure compressor and turbine, and combustor. However, there are certain differences between the GENx-1B/P2 series and GENx-2B67/P engine models. The design differences pertinent to rain and hail ingestion capability include fan geometry, low pressure compressor (booster) geometry, full authority digital engine control (FADEC) schedule differences and customer bleed from the high pressure compressor case. The difference in horsepower extraction was also found pertinent to rain ingestion capability. The validated analysis addressed the design differences.

The FAA has found that the compliance test configuration and data for GENx-1B/P2 series engine models, in conjunction with the comparative analysis performed, is fully applicable to GENx-2B67/P engine model. The FAA has made the compliance finding.

FAA approval and documentation of the ELOS finding:

The FAA has approved the aforementioned ELOS findings in GENx-2B67/P issue paper P-5. This memorandum provides standardized documentation of the ELOS finding that is nonproprietary and can be made available to the public. The Accountable Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate archiving and retrieval of this 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 33.78 Rain and Hail Ingestion (documented in ELOS Memo AT3138EN-E-P-5)

//Original Signed By Robert Ganley for ANE100//

November 22, 2013

 Manager, Engine & Propeller Directorate
 Aircraft Certification Service

 Date

ELOS Originated by ACO: Engine Certification Office	ACO Manager: Thomas Boudreau	Routing Symbol: ANE-140
--	---------------------------------	----------------------------