



Federal Aviation Administration

Memorandum

Date: December 19, 2014

To: Manager, Engine Certification Office, ANE-140

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

Prepared by: James Gray, ANE-142

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for International Aero Engines, LLC (IAE, LLC) project on the PW1133G-JM, Engine Model, FAA Project # TC3289EN-E

ELOS Memo#: TC3289EN-E-P-6

Regulatory Ref: 14 CFR 21.21 and 33.78(a)(1)

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 PW1133G-JM engine model.

Background

On August 3, 2012, IAE, LLC submitted an application for Type Certificate to the ECO for the PW1100G-JM series engine model.

Title 14, Code of Federal Regulations (14 CFR) 33.78(a)(1) requires that the ingestion of large hailstones, under defined operating conditions, may not cause unacceptable mechanical damage, unacceptable power or thrust loss after the ingestion, or require the engine to be shut down. Even though compliance to § 33.78(a)(1) does not specifically state that these requirements must be demonstrated by engine test, it is the intent of the rule.

IAE, LLC proposed an ELOS to the large hailstone ingestion requirements of § 33.78(a)(1) using compensating factors in accordance with the provisions of 14 CFR 21.21(b)(1). The ELOS proposal used similarity, validated analysis, and component static rig impact testing to predict damage due to large hailstone ingestion in place of an engine test.

Applicable regulations

14 CFR 21.21, 33.78

Regulation requiring an ELOS finding

14 CFR 33.78(a)(1)

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)

The FAA determined that the following alternative MoC provide an equivalent level of safety with the requirements of § 33.78(a)(1):

1. IAE, LLC performed hail ball impact component bench testing on the air oil cooler, fan blade, and structural guide vane (SGV) to determine the damage threshold capability and structural integrity of engine hardware susceptible to potential hail impact damage. Validated analyses were used to determine that any subsequent thrust loss and mechanical damage was acceptable.
2. Similarity was used to demonstrate the ingestion capability of the fan exit stator (FES) for large hailstones based on the static rig test results of a similar FES.
3. The spinner cap, fan containment case ice liner, inlet guide vane, front center body, and the low pressure compressor first stage blade were assessed by similarity and analysis.

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 § 33.78(a)(1) engine test requirement is intended to show that potential impact damage caused by large hailstone ingestion may not cause unacceptable mechanical damage or unacceptable power or thrust loss. IAE, LLC showed through validated analyses in conjunction with component static rig impact testing and similarity that all PW1100G-JM series engine model components that can be impacted by large hail ingestion will not sustain unacceptable mechanical damage or result in an engine shutdown, or cause sustained power or thrust loss.

All components that potentially could be impacted by hail were assessed. Component testing was done on the parts that could be most susceptible to hail impact: the air oil cooler, fan blade, SGV, and FES. The most critical areas of those components were

tested, as compared to an engine test which could result in more random impacts that would not necessarily challenge the most limiting features of each component. The remaining downstream components were assessed by a combination of similarity and analysis. The most critical features of each of the components were analyzed and a worst case assessment of hail impact damage was used to show compliance. All analyses used to determine thrust loss were validated against results from prior engine certification tests.

FAA approval and documentation of the ELOS finding:

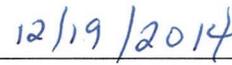
The FAA has approved the aforementioned ELOS findings in PW1100G-JM series engine model issue paper P-6. This memorandum provides standardized documentation of the ELOS findings that are nonproprietary and can be made available to the public. The Engine and Propeller Directorate has assigned a unique 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 has been made for the following regulations:

14 CFR 33.78(a)(1) Large Hailstone Ingestion (documented in ELOS Memo TC3289EN-E-P-6)



Manager, Engine & Propeller Directorate
Aircraft Certification Service



Date

ELOS Originated by ACO:	ACO Manager:	Routing Symbol:
Engine Certification Office	Diane Cook	ANE-140