



Federal Aviation Administration

Memorandum

Date: February 23, 2006

To: Manager, Engine & Propeller Standards Staff, ANE-110
Manager, Engine & Propeller Directorate, ANE-100

From: Manager, Engine Certification Office (ECO), ANE-140

Prepared by: Mark Riley (ECO), ANE-142

Subject: **ACTION:** Engine Alliance - Pratt & Whitney GP7200 Engine
Certification Program – Request for Review and Concurrence with
Equivalent Level of Safety Finding to 14 CFR Part 33, § 33.78, Rain and
Hail Ingestion

Memo No.: 8040-ELOS-05-NE-06

Background

In accordance with the provisions of 14 CFR Part 21, § 21.21(b)(1), Engine Alliance – Pratt & Whitney (EA-PW) proposed an Equivalent Level of Safety (ELOS) to the requirements of the large hailstone test of § 33.78(a)(1) through the use of compensating factors for the GP7270 and GP7277 engine models (herein called GP7200). The proposed method of compliance is based on analysis and component testing that demonstrated that, when accounting for the operating environment, the GP7200 fan blade has the same resistance to damage from large hailstones as a similar, previously certified fan blade that successfully completed a hail ingestion engine test.

Applicable Regulation(s)

§ 33.78, Rain and hail ingestion, paragraph (a)(1):

- (a) *All engines.* (1) The ingestion of large hailstones (0.8 to 0.9 specific gravity) at the maximum true air speed, up to 15,000 feet (4,500 meters), associated with a representative aircraft operating in rough air, with the engine at maximum continuous power, may not cause unacceptable mechanical damage or unacceptable power or thrust loss after the ingestion, or require the engine to be shut down. One-half the number of hailstones shall be aimed randomly over the inlet face area and the other half aimed at the critical inlet face area. The hailstones shall be ingested in a rapid sequence to simulate a hailstone encounter and the number and size of the hailstones shall be determined as follows:

- (i) One 1-inch (25 millimeters) diameter hailstone for engines with inlet areas of not more than 100 square inches (0.0645 square meters)
- (ii) One 1-inch (25 millimeters) diameter and one 2-inch (50 millimeters) diameter hailstone for each 150 square inches (0.0968 square meters) of inlet area, or fraction thereof, for engines with inlet areas of more than 100 square inches (0.0645 square meters).

Regulation(s) requiring ELOS

§ 33.78(a)(1)

Description of compensating factors or alternate standards that allows the granting of the ELOS (including design changes, limitations, or equipment need for equivalency)

The EA-PW proposed method of compliance is by means of a P&W analytical methodology for large hailstone ingestion and a comparative component bench test, in lieu of direct compliance through an engine test.

1) Pratt & Whitney (P&W) Analytical Methodology - The P&W analytical methodology, which utilizes results from prior engine certification tests, predicts potential damage to fan blades due to impact by large 1-inch and 2-inch diameter hailstones. Estimates of hailstone kinetic energy and knowledge of fan blade design features are used to identify the critical spans of the fan blade and predict the potential for airfoil damage. Results from the analysis are then used to determine whether the damage resulting from large hailstone impact would cause unacceptable mechanical damage or unacceptable power or thrust loss after the ingestion or would require the engine to be shut down.

2) Comparative component bench testing – EA-PW performed ice impact component bench testing to determine the damage threshold capability of the GP7200 fan blade compared to a similar certified fan blade that successfully completed a hailstone ingestion engine test. Results showed that the GP7200 fan blade has equivalent resistance to ice impact damage at the critical spans as the previously certified fan blade.

Explanation of how compensating factors or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation

Results from the analytical methodology predicted no fan blade damage due to ingestion of large hailstones. Results from the comparative ice impact bench test demonstrated that the GP7200 fan blade has equivalent resistance to damage due to hailstone ingestion. Therefore, the combined results from the analyses and component test show that the GP7200 fan blade will not sustain unacceptable mechanical damage that could result in an engine shutdown, or cause sustained power or thrust loss, thus meeting the criteria of § 33.78(a)(1).

FAA approval and documentation of the ELOS

The FAA approved the proposed Equivalent Level of Safety finding as documented in GP7200 Issue Paper E-4. 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-05-NE-06, to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number will be listed in the Type Certificate Data Sheet as part of the certification basis for the GP7200 engine models as follows:

Equivalent Level of Safety Findings:

33.78, Rain and Hail Ingestion, para.(a)(1), ELOS No. 8040-ELOS-05-NE-06

ELOS memo issue date discrepancy

This memo documents that the FAA has concluded that a finding of compliance for the proposed ELOS for § 33.78(a)(1) has been made, and that the Engine & Propeller Directorate concurred with this finding prior to issuance of the GP7200 Type Certificate on December 29, 2005.

(Original signed by Thomas Boudreau)

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For Concurrence

(Original signed by Robert J. Ganley for Peter A. White)

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