U.S. Department of Transportation
**Federal Aviation Administration**

# Memorandum

Subject: **ACTION**: Pratt & Whitney (PW) PW6124A and PW6122A Engine Certification Program – Request for Review and Concurrence with Equivalent Level of Safety (ELOS) Finding to 14 CFR Part 33, §33.77 Foreign Object Ingestion, paragraph (e)

Date: 22 October, 2004

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

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To: Branch Manager, Engine and Propeller Standards Staff, ANE-111
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**Background**

In accordance with the provisions of 14 CFR Part 21, §21.21(b)(1), PW has requested an alternate method of compliance to the requirements of §33.77(e), ice slab ingestion test, through an ELOS demonstration for the PW6124A and PW6122A engine models, herein called PW6000A. Analysis and similarity have been chosen as the alternate method of compliance. In particular, by analysis PW proposed to comply with the ice slab ingestion test using their "Fan Blade Damage Methodology for Ingestion of Ice Slab," Ref 1, which was used to certify the PW6124 and PW6122-1D engine models, herein called PW6000 baseline. PW proposed to demonstrate that similarity exists between the design and installation considerations for the PW6000A and the PW6000 baseline, such that their damage methodology still applies and can be used to show compliance to §33.77(e) for the new PW6000A.

**Affected Regulation**

§33.77, "Foreign Object Ingestion "paragraph (e):

(e) Compliance with paragraph (c) [included below for reference] 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.

(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.

PW is proposing compliance by means of an analytical methodology, in lieu of direct compliance through an engine test.

**Compensating Factors**

The PW6000 baseline ELOS finding showed that the

- ice slab thickness and fragment size,
- blade geometry, and
- inlet geometry

fell within the boundaries of test experience such that PW's damage methodology, Ref 1, was applicable and shown to be an equivalent means of compliance to the requirements of §33.77(e). Fan blade near leading edge thickness and the normal component of the kinetic energy of a ½ inch ice slab are assumed as the critical parameters to calculate fan blade damage limits. These limits are used to predict whether the fan blade damage resulting from the ice slab and/or fragment impact would result in a sustained power or thrust loss, or require the engine to be shut down. PW's damage methodology predicted no damage to the PW6000 baseline fan blades.

PW showed that similar inlet geometries are used for both the PW6000A and PW6000 build up configurations. Due to this similarity the same ice slab thickness and fragment size, 12" by 12" by ½", used in the PW6000 baseline analysis determination, applies to the PW6000A. In addition, the PW6000A has the same fan blades, identified as "AERO 3C," as those certified in the PW6000 baseline.

Thus, the FAA concurred with the use of PW's damage methodology, for the PW6000A based on the same fan blade design and similar installation considerations between the PW6000 baseline and the PW6000A.

**Recommendation**

The Engine Certification Office (ECO) has reviewed the data and the analysis provided in report PWA-7682 Rev 2, "PW6000 Series Turbofan Engine (PW6124A/PW6122A) Ice Slab Ingestion", Ref 2, submitted to FAA for the certification of the PW6000A and assessed that similarity between the two engine configurations exists. Effect on thrust, due to different fan speed (44 RPM) at the maximum cruise condition between the two engine configurations, was assessed to be insignificant. Therefore, the ECO has approved PWA-7682 Rev 2, which shows that the PW6124A and PW6122A engine models inlet, fan blade geometry and operating conditions fall within the boundaries of PW's test experience, based on similarity to the PW6000 baseline, and the analysis predicts no damage.

We therefore recommend the Engine and Propeller Standards Staff concurrence with this finding for an equivalent level safety to the requirements of the §33.77(e). We also recommend that the ELOS number 8040-8-1-002, issued for the PW6124 and PW6122-1D engine models, be considered applicable to the PW6124A and PW6122A due to the use of similarity between these models to determine applicability and use of PW's "Fan Blade Damage Methodology for Ingestion of Ice Slab," Ref 1.

Upon concurrence, ELOS number 8040-8-1-002 will be listed on the Type Certificate Data Sheet as part of the certification basis for the PW6124A and PW6122A engine models as follows:

Equivalent Level of Safety Findings:

| | | |
|---|---|---|
| 33.77, para. e) | Foreign Object Ingestion-Ice | ELOS No. 8040-8-1-002 |

References :
Ref 1 : PWA 7129 "Fan Blade Damage Methodology for Ingestion of Ice Slab,".
Ref 2 : PWA-7682 Rev 2, "PW6000 Series Turbofan Engine (PW6124A/PW6122A) Ice Slab Ingestion".

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For Concurrence

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