U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject:: ACTION: Pratt & Whitney (P&W) PW6122A and PW6124A (PW6000A) Engine Certification Program - Request for Review and Concurrence with Equivalent Level of Safety (ELOS) Finding to 14 CFR Part 33, §33.87 Endurance Test, paragraphs (a)(3) and (b)(1)

Date: November 10, 2004

From: Manager, Engine Certification Office, ANE-140

Reply to Attn. of: Antonio Cancelliere
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To: Branch Manager, Engine & Propeller Standards Staff, ANE-111
Manager, Engine and Propeller Directorate, ANE-100

Background

In accordance with the provisions of 14 CFR Part 21, §21.21(b)(1), P&W has requested an alternate method of compliance to the minimum temperature value required by §33.87(a)(3) for the 5-minute time duration at the takeoff thrust portion of §33.87(b)(1) through an Equivalent Level of Safety (ELOS) demonstration. Testing in conjunction with analysis has been chosen as the alternate method of compliance. In particular, P&W proposed to assess creep damage for the most limiting hardware and show by analysis that the cumulative damage will meet or exceed damage demonstrated under direct compliance to §33.87(a)(3). P&W also stated that there would be approximately 6.5% shortfall in physical takeoff thrust for the PW6000A test engine due to the special test equipment. P&W proposed to show by test and analysis that a thrust shortfall would be offset by the cycle effects from elevated internal pressures and temperatures that were due to the special test equipment. This provides compensation for equivalent accrued fatigue damage demonstrated under direct compliance to §33.87(b)(1), for most affected components. For those components where fatigue damage would be slightly higher during direct compliance, P&W will show by analysis that the overall small effect relative to component design capability is negligible. Thus the thrust shortfall for the endurance test has inconsequential effect for the durability of those components as intended in the regulation.

Affected Regulation

The affected regulations in endurance test are §33.87(a)(3) and (b)(1) that are described as follows:

Paragraph (a)(3) states that “Except as provided in paragraph (a)(5) this section, power or thrust, gas temperature, rotor shaft rotational speed, and, if limited, temperature of external surfaces of the engine must be at least 100 percent of the value associated with the particular engine

operation being tested. More than one test may be run if all parameters cannot be held at the 100 percent level simultaneously."

Paragraph (b)(1) states that "*Takeoff and idling.* One hour of alternate five-minute periods at rated takeoff power and thrust and at idling power and thrust. The developed powers and thrusts at takeoff and idling conditions and their corresponding rotor speed and gas temperature conditions must be as established by the power control in accordance with the schedule established by the manufacturer. The applicant may, during any one period, manually control the rotor speed, power, and thrust while taking data to check performance. For engines with augmented takeoff power ratings that involve increases in turbine inlet temperature, rotor speed, or shaft power, this period of running at takeoff must be at the augmented rating. For engines with augmented takeoff power ratings that do not materially increase operating severity, the amount of running conducted at the augmented rating is determined by the Administrator. In changing the power setting after each period, the power-control lever must be moved in the manner prescribed in paragraph (b)(5) of this section."

Compensating Factors

The FAA has determined that compliance with §33.87(a)(3) and (b)(1), relative to takeoff thrust and takeoff EGT limit and duration, using the methods of test and analyses, may be established provided that the supporting data for the following compensating factors:

Demonstrate equivalent or greater creep damage for HPT blades and most limiting LPT components, relative to the test requirements of §33.87(a)(3) and (b)(1). Show that all components affected will have reached the temperatures associated with the temperature and time duration achieved during direct compliance.

Demonstrate equivalent fatigue damage for defined affected components relative to rated takeoff thrust requirements of §33.87(a)(3) and use of agreed to special test equipment. Show for those components where fatigue damage would be slightly higher during direct compliance, that the overall small effect relative to component design capability is negligible.

These compensating factors are applicable to takeoff rating conditions only. Maximum continuous rating and limits will be demonstrated in direct compliance to the applicable requirements defined in §33.87.

Recommendation

The Engine Certification Office (ECO) has reviewed and concurred with the data and analysis provided in P&W Report PWA-7658, "PW6000 Series Turbofan Engine (PW6122A/PW6124A) 150 Hour Endurance Test Report" dated 11/05/2004, submitted to FAA for the certification of the PW6000A. The ECO has determined that the compliance with §33.87(a)(3) and (b)(1), relative to takeoff thrust and EGT limit and duration, using the methods of test and analyses stated previously, was acceptable. The report identified these methods and provided supporting data for the following compensating factors:

To demonstrate equivalent EGT exposure, P&W assessed creep damage for the most limiting hardware, the high pressure turbine (HPT) and low pressure turbine (LPT) blades, and showed that the cumulative damage, including rotor speeds and EGT overshoots, met or exceeded damage that would be demonstrated under direct compliance. In summary, P&W's proposed method for takeoff cycle timing resulted in the following:

Applicable effective hot time was equal to or greater than §33.87(a) (3) requirements.

Limiting hardware affected by hot time was conservatively tested. Thus, P&W demonstrated equivalent or greater creep damage for HPT and LPT second stage turbine blades, relative to the test requirements of §33.87(a)(3).

P&W provided data from load and fatigue damage analyses, to show that the takeoff thrust shortfall is offset by the cycle effects from elevated engine internal pressures and temperatures due to the special test equipment. This results in equivalent fatigue damage and provides compensation for most of the affected components for rated takeoff. P&W stated that for the thrust clevis, rear mount lugs, and the #2 and #3 thrust bearings, the small shortfall in accrued fatigue damage, due to the thrust shortfall, is negligible relative to hardware design capability. Thus, the rated takeoff thrust shortfall for the endurance test has inconsequential effect on engine durability as intended in the regulation.

We therefore recommend the Engine and Propeller Standards Staff concurrence with these findings for an equivalent level safety to the requirements of the §33.87(a)(3) and 33.87(b)(1). Upon concurrence, ELOS number 8040-ELOS-04-NE-03 will be listed on the Type Certificate Data Sheet as part of the certification basis for the PW6122A and PW6124A engine models as follows:

Equivalent Level of Safety Findings:

33.87 (a)(3) & (b)(1)	Endurance Test	ELOS No. 8040-ELOS-04-NE-03

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Robert Guyotte, Manager
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For Concurrence

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