



U.S. Department
of Transportation

Federal Aviation
Administration

Memorandum

Subject: **ACTION:** Review and Concurrence, Equivalent
Level of Safety

Date: May 5, 2005

From: Manager, Chicago Aircraft Certification Office, ACE-115C

Reply to
Attn. of: K. Hosny
847-294-7134

To: Manager, Engine and Propeller Directorate, ANE-100

We are requesting that your office review and provide concurrence with the proposed FAA Equivalent Level of Safety (ELOS) finding for the FJ44-1AP turbofan engine. This ELOS finding is for the heater electrical power supply of the combined total temperature/total pressure sensor. Title 14 of the Code of Federal Regulations, Section 33.28(b) requires that no failure of aircraft-supplied power will result in an unacceptable change in thrust or prevent continued safe operation of the engine. The control system of the FJ44-1AP is essentially the same system used on the FJ33-4A and FJ44-3A turbofan engines.

Background:

The FJ44-1AP turbofan engine is controlled by a dual channel Full Authority Digital Electronic Control (FADEC) that utilizes total temperature (TT2) and total pressure (PT2) sensors as control inputs. This data is used to schedule engine thrust as well as to determine engine acceleration and deceleration schedules. Each of the two FADEC channels receive TT2 and PT2 signals from an independent pair of sensors housed in a single probe which is mounted in the airframe inlet forward of the engine fan. The TT2/PT2 probe is electrically heated to provide de-ice and anti-ice capability necessary for demonstrating compliance with §33.68, Induction System Icing. Electrical power (nominal 28 VDC) is supplied to the probe by the aircraft electrical bus (es). Consequently, literal compliance with the 33.28(b) requirement that the engine "Be designed and constructed so that any failure of aircraft-supplied power or data will not result in an unacceptable change in power or thrust, or prevent continued safe operation of the engine." cannot be shown.

Applicable Regulations:

Section 33.28(b) (Electrical and electronic engine control systems) requires that the control system be designed and constructed so that any failure of aircraft-supplied power or data will not result in an unacceptable change in power or thrust, or prevent continued safe operation of the engine.

Section 33.68 (Induction system icing) requires that each engine must operate both on the ground at idle and throughout the flight power range in icing conditions without adverse effects on engine operation and without serious loss of thrust.

FAA Position:

The FJ44-1AP engine can show an equivalent level of safety to the literal requirements of 33.28(b) by working with the airframe manufacturer and requiring a minimum satisfactory level of system reliability for the power and data systems.

Discussion:

Regarding airframe supplied power, the FJ44-1AP engine is being certified for single or multiple engine installations. (Note, the probes on the aircraft are referred to TT/PT probes. The engine inlet mounted probes are referred to as TT2/PT2 probes.) The engine Installation Instructions provided by Williams International will require the following limitations be met:

In the case of multiple engine installations:

- The reliability of the aircraft supplied power to the two (or more) TT2/PT2 probe heaters is limited to a failure rate of not more than 1×10^{-8} per flight hour. To accomplish this, it is acceptable to utilize two main electrical buses with a failure rate of not more than 1×10^{-4} per flight hour each, with each bus supplying power to one TT2/PT2 probe heater under normal operating conditions.
- If there are two buses, an additional limitation requires that any single bus be capable of supplying power to all (two or more) probe heaters in the event of failure of the remaining bus (es).

In the case of single engine installations:

- The reliability of the aircraft supplied power to the TT2/PT2 probe heater is limited to a failure rate of not more than 1×10^{-6} per flight hour. To accomplish this, it is acceptable to utilize two main electrical buses with a failure rate of not more than 1×10^{-3} per flight hour each, with automatic switching (in the event of bus failures) providing continuous power to the probe heater under normal operating conditions. The failure rates discussed in this paragraph should not include the engine in-flight shut down rate when calculating the reliability of aircraft power.

If the TT2/PT2 probe heaters are shed from the electrical bus when all power generation has failed then the following aircraft air data requirements apply to the installation.

For air data availability, the FJ44-1AP engine FADEC is equipped to receive air data from the airframe via an ARINC 429 data link. It is assumed that the engine TT2/PT2 probes lose heat with loss of all aircraft generated power. The Installation Instructions require that following failure of all aircraft generated power the following limitations must be met:

- At least one aircraft TT/PT probe must be powered by the battery to account for the condition where all engine generators are inoperative.
- If required for proper and correct total temperature information, the heater circuits for the aircraft's static pressure pickup ports should also be placed on battery power during (both) engine generator inoperative conditions.

- The aircraft is not considered dispatchable when the heater circuit for the aircraft TT/PT probe powered by the aircraft battery is inoperative, and if required for proper and accurate operation, the heater circuits for the aircraft static pressure ports are inoperative. A No Dispatch message must be obvious to the flight crew under this condition. Therefore, if the aircraft's master minimum equipment list allows dispatch with an aircraft TT/PT heater circuit inoperative, it should only allow the heater circuit to the probe, which is NOT on the aircraft's battery bus to be inoperative. If required for proper and correct operation, the heater circuits for the static pickup ports associated with the PT/TT probe heater, which is on the battery, must be available for all dispatches.
- The air data system receiving TT/PT probe information from the probe on the battery must be powered by the aircraft's battery.
- Hence, it is a requirement that the engine FADEC systems must be able to receive a set (i.e., total temperature, and total pressure) of correct aircraft environmental information on an aircraft/engine digital data bus when both engine generators are inoperative.

ACO Recommendation: The Chicago ACO concludes that the above power and data reliability limitations imposed on the airframe installation are sufficient to assure an equivalent level of safety to the requirements of 33.28(b).

Upon concurrence, ELOS number 8040-ELOS-05-NE-01 will be listed on the Type Certificate Data Sheet as part of the certification basis for the FJ44-1AP engine model as follows:

Equivalent Level of Safety Findings:

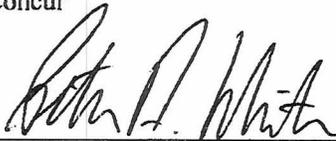
33.28 para. (b) Electrical and Electronic
Engine Control Systems

ELOS No. 8040-ELOS-05-NE-01



Royace H. Prather
Manager, Chicago Aircraft
Certification Office

Concur



Manager, Engine & Propeller Standards Staff,
ANE-110

Date: 5/5/05

Concur



Manager, Engine & Propeller Directorate,
ANE-100

Date: 5/9/05