

electrical power supply system requirements of paragraph I(a)(2) of this proposed appendix.

Explanation

This paragraph would codify paragraph (e)(5) of the Boeing Model 777 ETOPS special conditions.

As we stated in the section on APU design for proposed paragraph I(b)(2), current twin engine airplanes approved for ETOPS only comply with the proposed requirement for electrical system reliability contained in this notice by having three independent electrical generators. On these airplanes, the third independent electrical generator is normally powered by an auxiliary power unit. To assure that an APU would have the proper reliability at entry into service, the proposed rule would require the applicant to conduct an APU endurance test in a similar manner to that proposed in paragraph II(b)(4) for the main engines. The phrase "equivalent airplane operational cycles" requires the applicant to test the APU in an environment that the APU would be operating in an airline ETOPS operation. In most cases this would include starting and operating the APU in extremely cold temperatures representative of high altitude operation or ground operations in extremely cold climates. This would also include operation in high temperature environments, and with simulated pneumatic and electrical loads. Further amplification of the interpretation of "equivalent airplane operational cycles" is found in the draft part 25 advisory circular.

II(b)(7) Airplane Demonstration Test

This paragraph would require the applicant to conduct an airplane flight test to demonstrate that the airplane, its components and equipment are capable of and function properly during ETOPS and ETOPS diversions. This flight test may be coordinated with, but would not be in place of the function and reliability flight testing required for compliance with § 21.35(b)(2).

The proposed requirement includes several conditions that the applicant would have to comply with in conducting this test. Among these are:

- (1) The flight test program would have to include:
 - (i) Flights simulating actual ETOPS operation;
 - (ii) demonstration of maximum normal flight duration with maximum diversions;
 - (iii) maximum time engine inoperative diversions;
 - (iv) non-normal conditions to demonstrate the airplanes

capability to safely; conduct an ETOPS diversion,

- (v) diversions into representative operational diversionary airports; and
 - (vi) repeated exposure to humid and inclement weather on the ground followed by long-range operations at normal cruise altitude.
- (2) The flight testing would have to validate the adequacy of the airplane's flying qualities, performance and the flight crew's ability to deal with adverse operating conditions.
 - (3) The engine-inoperative diversions would have to be evenly distributed among the number of engines in the applicant's flight test program.
 - (4) The test airplane would have to be operated and maintained using the recommended operations and maintenance manual procedures during the test.
 - (5) At the completion of the test, the ETOPS Group 1 significant systems would have to undergo an airplane visual inspection and the engines would have to also undergo an internal gas path inspection.

Explanation

This paragraph would codify the airplane demonstration test requirement of paragraph (e)(7) of the Boeing Model 777 ETOPS special conditions. The original version of the special conditions effective July 1, 1994 required the applicant to fly one complete airplane for at least 1,000 flight-cycles simulating an actual airline operation.

The FAA developed the 1,000-cycle airplane demonstration test requirement with the intent of exposing the candidate airplane to the conditions where the greatest numbers of in-flight shutdowns occur. Most in-flight shutdowns occur during takeoff and climb. Failures that tend to occur only during certain portions of a flight are known as "cyclic" failures. An example of a cyclic failure would be a tire failure where exposure to the high tire speeds that could lead to a tire failure would only occur during takeoff or landing. These are in contrast to failures that are more likely to occur as components age, which are known as "hourly" failures. An example of an hourly failure is an electric cooling fan failure where the fan runs continuously to cool electronic components.

The failure modes associated with takeoff- and climb-related in-flight shutdowns tend to be cyclic in nature for a couple of reasons. In cases where the loads and stresses on engine or airplane hardware increase as engine

power or thrust increases, the takeoff portion of the flight is most critical. Failure modes that occur due to improper maintenance or engine servicing, for instance loss of engine oil due to improper assembly of an oil tube connection, also tend to occur early in the flight. A larger number of airplane flights increases the exposure to these types of failures. Therefore, the FAA considered a cyclic type of test to be the most appropriate airplane validation test for the original 777 ETOPS special conditions.

Although the fewest in-flight shutdowns occur during cruise, this is the phase of flight that is most important to an ETOPS operation. Traditionally, the FAA and industry have avoided trying to differentiate between those in-flight shutdowns that may occur during cruise from those that would only occur in a non-ETOPS environment. The main reason for this approach in existing ETOPS policy is that by correcting all causes of in-flight shutdowns, we gain confidence in the overall integrity of the propulsion system design. Since an enhanced 3,000-cycle engine demonstration test proposed for paragraph II(b)(4) of Appendix L and § 33.200(c) would provide adequate cyclic exposure, the FAA has concluded that the airplane validation program should emphasize exposure to the cruise phase of flight.

During the three 1,000-cycle tests conducted for the original 777 engine installation certification programs, only 91 of the total 1,000 cycles were of durations of two hours or more. Since we intend for the airplane demonstration test to simulate an actual airline operation, this would better be accomplished through longer duration flight cycles. Long duration flight exposure provides additional confidence that the design accounts for cruise-related failure modes that cannot be evaluated in a cyclic test environment. Such failure modes could include freezing of entrapped water condensation or binding of propulsion system components, neither of which would likely occur in a sea level test facility.

Based on these considerations, the FAA has determined that the airplane demonstration test requirement should be refocused on those conditions that are most prevalent in an ETOPS operating environment. Those conditions include long flights to a variety of airports with broad variations of airport elevation, temperature, and humidity. It is also important that these flights expose the airplane to several enroute climbs, such as may occur with a fully loaded 777-300ER on a long-