information to SBA on the proposed waiver of the nonmanufacturer rule for this NAICS code.

Barry Meltz,

Deputy Associate Administrator, Office of Government Contracting.

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. NM81; Notice No. 25–03–04–SC]

Special Conditions: Boeing Model 777 Series Airplanes; Revision to Special Conditions 25–ANM–84

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed special conditions.

SUMMARY: This action proposes to revise Special Conditions 25–ANM–84, applicable to Boeing Model 777 series airplanes. The proposed special conditions revise the extended range operations with two-engine airplanes (referred to as ''ETOPS'') test requirements defined in the existing special conditions. These revisions include changing the airplane demonstration test requirement from a required 1000 flight cycles to a demonstration of capability in ETOPS flight conditions, and allowing more than one airplane to be used for the airplane demonstration test. In addition, the FAA proposes to add post-test inspection requirements for both the engine demonstration test and the airplane demonstration test articles.

DATES: Comments must be received on or before July 28, 2003.

ADDRESSES: Comments on this proposal may be mailed in duplicate to: Federal Aviation Administration, Transport Airplane Directorate, Attention: Rules Docket (ANM–113), Docket No. NM81, 1601 Lind Avenue, SW., Renton, Washington, 98055–4056; or delivered in duplicate to the Transport Airplane Directorate at the above address. Comments must be marked: Docket No. NM81. Comments may be inspected in the Rules Docket weekdays, except Federal holidays, between 7:30 a.m. and 4 p.m.

FOR FURTHER INFORMATION CONTACT: Steve Clark, FAA, ETOPS Project Manager, Seattle Aircraft Certification Office, Propulsion Branch, ANM–140S, Transport Airplane Directorate, 1601 Lind Avenue, SW., Renton, Washington, 98055–4056; telephone (425) 917–6496; facsimile (425) 227–1180.

SUPPLEMENTARY INFORMATION:

Comments Invited

The FAA invites interested persons to participate in this rulemaking by submitting written comments, data, or views. The most helpful comments reference a specific portion of the special conditions, explain the reason for any recommended change, and include supporting data. We ask that you send us two copies of written comments.

We will file in the docket all comments we receive, as well as a report summarizing each substantive public contact with FAA personnel concerning these special conditions. The docket is available for public inspection before and after the comment closing date. If you wish to review the docket in person, go to the address in the **ADDRESSES** section of this preamble between 7:30 a.m. and 4 p.m., Monday through Friday, except Federal holidays.

We will consider all comments we receive on or before the closing date for comments. We will consider comments filed late if it is possible to do so without incurring expense or delay. We may change these special conditions in light of the comments we receive.

If you want the FAA to acknowledge receipt of your comments on this proposal, include with your comments a pre-addressed, stamped postcard on which the docket number appears. We will stamp the date on the postcard and mail it back to you.

Background

Because of concerns over engine and airplane reliability, for many years, 14 CFR 121.161 has generally prohibited operations of two-engine airplanes on routes including segments that are more than one hour flight time from a suitable airport. This regulation contains an exception that allows such operations when specifically authorized by the Administrator. These extended range operations with two-engine airplanes are referred to as ETOPS. Advisory Circular (AC) 120–42A describes a method for obtaining ETOPS authorization if an operator can demonstrate sufficient engine and airplane reliability. This method is based on a combination of various design features and operational and maintenance procedures. The AC states that eligibility for 120-minute ETOPS authorization is normally based on a showing of reliable operation for a minimum of 250,000 engine hours of service in the world fleet. Eligibility for 180-minute ETOPS authorization is normally based on a showing of reliable operation for at least one year in 120-minute ETOPS. The AC also describes an option for reducing the number of hours of service if adequate compensating factors are identified to give a reasonably equivalent database.

On May 18, 1994, the FAA issued Special Conditions Number 25–ANM–84 for the Boeing Model 777 airplane (59 FR 28234). These special conditions define requirements for 180-minute ETOPS approval concurrent with basic type certification of the airplane without the service experience outlined in AC 120–42A that would normally be necessary. These special conditions define additional safety standards that the FAA considered necessary to establish a level of safety equivalent to that provided by the airworthiness standards for non-ETOPS airplanes.

The current 777 ETOPS special conditions consist of five main elements needed to provide adequate compensation for the service experience normally required for 180-minute ETOPS eligibility described in AC 120–42A. No single element is considered sufficient by itself, but the FAA has found that the five elements combined provide an acceptable substitute for actual airline service experience. The five elements are:

1. Design for reliability.
2. Lessons learned.
3. Test requirements.
4. Demonstrated reliability.
5. Problem tracking system.

A description of each of these five elements is contained in the preamble to the 777 ETOPS special conditions.

On December 13, 1999, Boeing Commercial Airplane Group applied for an amendment to Type Certificate No. T00001SE to include the new Model No. 777–200LR and 777–300ER airplanes. The Model No. 777–200LR, which is a derivative version of the existing Model 777–200 series airplanes, has the following differences from the 777–200:

- The wingspan is increased from 199 feet, 11 inches to 212 feet, 7 inches.
- Maximum intended takeoff weight is 750,000 pounds.
- It is capable of carrying from 301 to 440 passengers.
- It has provisions for overhead crew and attendant rest areas.
- Its range capability will be up to 8,800 nautical miles (16,298 kilometers).
- It has 110,100 pounds thrust GE90 engines.
- It has a supplemental electronic tail skid.
- It has provisions for up to 3 auxiliary fuel tanks in the forward area of the aft cargo bay.

The 777–300ER, which is a derivative of the Model 777–300 airplanes, has the following differences from the Model 777–300:

- The wingspan is increased from 199 feet, 11 inches to 212 feet, 7 inches.
- Maximum intended takeoff weight is 750,000 pounds.
- It is capable of carrying from 359 to 550 passengers.
- It has provisions for overhead crew and attendant rest areas.
- Its range capability will be up to 7,250 nautical miles (13,427 kilometers).
- It has 115,300 pound thrust GE90 engines.
- It has a supplemental electronic tail skid.
- It has a semi-levered main landing gear.

Both models are currently approved under Type Certificate No. T00001SE.

For the Model 777–300ER and Model 777–200LR, Boeing has proposed certain changes to the ETOPS special conditions in order to take into account the experience from the original baseline Model 777 engine programs and to eliminate any unnecessary burden from the airplane demonstration testing required by paragraph (e)(7) of those special conditions.

Type Certification Basis

Under the provisions of § 21.101, Amendment 21–69, effective September 16, 1991, for a change to a type certificate Boeing must show that the Boeing Model 777 series airplane, as changed, continues to meet the applicable provisions of the regulations incorporated by reference in Type Certificate No. T00001SE or the applicable regulations in effect on the date of application for the change. The regulations incorporated by reference in the type certificate are commonly referred to as the ''original type certification basis.'' The regulations incorporated by reference in Type Certificate No. T00001SE for the Boeing Model 777 series airplanes include 14 CFR part 25, as amended by Amendments 25–1 through 25–82. The original type certification basis is listed in Type Certificate Data Sheet No. T00001SE.

If the Administrator finds that the applicable airworthiness regulations (*i.e.*, 14 CFR part 25) do not contain adequate or appropriate safety standards for the Model 777 series airplanes because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

In addition to the applicable airworthiness regulations and special conditions, Boeing Model 777 series airplanes must comply with the fuel vent and exhaust emission requirements of 14 CFR part 34 and the noise certification requirements of 14 CFR part 36.

Special conditions, as defined in § 11.19, are issued in accordance with § 11.38 and become part of the type certification basis in accordance with § 21.101(b)(2), Amendment 21–69, effective September 16, 1991.

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same novel or unusual design feature, or should any other model already included on the same type certificate be modified to incorporate the same novel or unusual design feature, the special conditions would also apply to the other model under the provisions of § 21.101(a)(1).

ETOPS Certification

All two-engine airplanes operating under 14 CFR part 121 are required to comply with § 121.161, which states, in pertinent part, that ''Unless authorized by the Administrator * * * no certificate holder may operate two-engine airplanes * * * over a route that contains a point farther than one hour flying time * * * from an adequate airport.'' Advisory Circular (AC) 120–42A, ''Extended Range Operation With Two-Engine Airplanes (ETOPS),'' provides an acceptable means for obtaining FAA approval for two-engine airplanes to operate over a route that contains a point farther than one hour flying time from an adequate airport. The two basic objectives of this advisory circular are to establish that the airplane and its supporting systems are suitable for the extended range mission and that the maintenance and procedures to be employed in conducting ETOPS operations are adequate. This is accomplished by acquiring a substantial amount of service experience during non-ETOPS operation and then extensively evaluating this experience in the areas of systems reliability, maintenance tasks, and operating procedures. When it is determined that the appropriate reliabilities and capabilities have been achieved, the airplane is found eligible to be considered for use in ETOPS operation by an airline.

When Boeing was developing the Model 777 series airplane, it proposed that the Model 777 be approved for ETOPS operation simultaneously with the issuance of the basic type certificate. At that time procedures did not exist for a finding of this type. The proposed issuance of ETOPS type design approval at certification would have precluded using accumulation of service experience, as outlined in AC 120–42A, as a means to meet ETOPS approval requirements. So an alternative method was devised that provided an adequate level of inherent airplane reliability for ETOPS. It is important to note that the requirements for certification of the airplane regarding the design's suitability for ETOPS operation, as described in those special conditions, relate to type certification approval only. Advisory Circular 120–42A contains guidance regarding operational and maintenance practices criteria that must be met by the operator before ETOPS operations can be conducted. It is incumbent upon the operator to apply for operational approval in accordance with appropriate guidance issued by the FAA for such approvals. Satisfaction of the requirements of these special conditions does not constitute operational approval.

Special Conditions 25–ANM–84 contained the additional safety standards that the Administrator considered necessary to establish a level of safety equivalent to that provided by the airworthiness standards for transport category airplanes for non-ETOPS airplanes. Experience with these special conditions since issuance has provided the FAA with additional data to justify a revision to those special conditions as described in this notice.

Discussion of the Proposed Special Conditions

Boeing has requested the FAA to revise certain parts of the test requirements of Special Conditions 25–ANM–84 defined in paragraph (e). The FAA has concurred that some changes are justified based on an analysis of previous experience applying those special conditions to the original three engine types approved for installation on the Model 777 airplane. The specific changes to those requirements and the justification for each proposed change are discussed below.

Paragraph (e)(6) Engine Demonstration Test

The FAA has concluded from a review of in-service experience of the Model 777 series airplanes that the 3000-cycle engine and propulsion system test required by paragraph (e)(6) of Special Conditions 25–ANM–84 provides an adequate opportunity to discover cyclic-related failure modes associated with the design, provided that an adequate post-test evaluation is conducted to find conditions that could result in an inflight shutdown, power loss, or inability to control engine thrust. An FAA review of the test data from the 3000-cycle tests for the three original engine types installed on the Model 777 series airplanes has shown that most of the early in-service 777 engine failure modes could have been discovered had Boeing and the engine manufacturers conducted a more thorough teardown inspection and analysis of the 3000-cycle test engine and propulsion system hardware. Part conditions noted in the teardown inspection reports for the three baseline 777 engine types did later occur in service, and they resulted in engine inflight shutdowns or airplane diversions. Because the specific condition of those 3000-cycle test parts had been characterized as minor deviations from normal however, no specific investigations into how they might progress in service had been required as a prerequisite for ETOPS approval.

Special Conditions 25–ANM–84 currently do not require a post-test teardown inspection. However, all three engine companies, in cooperation with Boeing, conducted post-test teardown inspections on the original baseline engines installed on the Model 777 series airplanes based on their own experience of what would constitute an adequate evaluation. In order to provide a consistent standard for a post-test evaluation of the 3000-cycle test hardware, the FAA is proposing a change to paragraph (e)(6) to require a complete teardown inspection of the engine and airplane nacelle test hardware after completion of the test. The inspection must include an analysis of any abnormal conditions found. The analysis must consider the possible consequences of similar occurrences in service to determine if they might become sources of engine inflight shutdowns, power loss, or inability to control engine thrust. The intent of this change to paragraph (e)(6) is to require further design analysis to catch potential sources of engine inflight shutdowns or diversions.

For similar reasons, we are proposing to add a new subparagraph (e)(7)(v) to require a post-test external and internal visual inspection of the airplane demonstration test engines and propulsion system hardware. An analysis of the inspection results must identify any potential sources of engine inflight shutdown. Appropriate corrective actions must be performed in accordance with the provisions of the special conditions.

Boeing proposed to delete the word *complete* from the description of the airplane nacelle package required for the 3000-cycle test. The rationale for this proposed change was that without the term *complete,* it is still understood that the test is intended to be a propulsion system test inclusive of the engine buildup items, but some allowance is made for configuration differences necessary to accommodate the test setup. The FAA is concerned that, without this qualifier, it is not clear what nacelle hardware must be installed for this test. It could be misinterpreted in such a way that, for instance, a functioning thrust reverser need not be installed. Therefore, the FAA has concluded that the word *complete* must remain in the requirement. However, we agree with Boeing that those configuration differences associated with test instrumentation and test stand interfaces with the engine nacelle package may be excluded, and we propose to add that qualification to the requirement in order to clarify this intent.

Paragraph (e)(7) Airplane Demonstration Test

Number of Test Airplanes: Boeing has proposed a change to paragraph (e)(7) to allow the use of more than one airplane to comply with the airplane demonstration test requirement (three test airplanes for the current Model 777–300ER program). Boeing's justification includes the argument that using multiple airplanes is an enhancement to the ETOPS validation program that takes into account airplane-to-airplane variation. The value of obtaining ETOPS data on multiple airplanes versus one is the increased sample size. The FAA agrees that increasing the number of test airplanes in the airplane demonstration test would provide a better evaluation of airplane-to-airplane variability. The limited experience obtained during the airplane demonstration test program is not really sufficient to evaluate end-of-life wear-out failure modes, so accumulating all of the time and cycles on one airplane is not really necessary. The main program schedule benefit from using multiple flight test airplanes is that testing can be completed in a shorter period. The FAA is proposing a change to paragraph (e)(7) to require that one or more airplanes must complete the airplane demonstration test required by that paragraph.

Capability Demonstration vs. Reliability Demonstration: The 1000-cycle airplane demonstration test requirement was developed with the intent of exposing the airplane to the conditions where the greatest numbers of inflight shutdowns occur. Most inflight shutdowns occur during takeoff and climb. The failure modes associated with these takeoff- and climb-related shutdowns tend to be cyclic in nature for a couple of reasons.[1] For failure modes where the risk of failure increases with engine thrust, 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 test to be the most appropriate airplane validation test for the original 777 ETOPS special conditions. However, as stated above, we now consider that the 3000-cycle engine and propulsion system test required by paragraph (e)(6) provides an adequate opportunity to discover cyclic-related failure modes associated with the design when the test hardware goes through an appropriate level of post-test teardown and inspection.

For inflight shutdowns where improper maintenance is a main causal factor, the 1000-cycle airplane demonstration test provides multiple opportunities for these types of failures to occur. However, the maintenance procedure validation program required by paragraph (d)(2) is intended to minimize the probability of these occurrences. The airplane demonstration test airplane provides opportunities to demonstrate those maintenance tasks associated with the normal operation of the airplane. The FAA considers that these demonstrations can be accomplished in fewer than 1000 cycles.

Although the fewest inflight 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 inflight 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 inflight shutdowns, the overall integrity of the propulsion system is assured. Since adequate cyclic exposure would be evaluated by an enhanced 3000-cycle engine demonstration test, as proposed for paragraph (e)(6) of these special

[1] Data provided to the Aviation Rulemaking Advisory Committee (ARAC) ETOPS Working Group confirm that the inflight shutdown rate during the takeoff flight phase is on the order of 6 to 16 times the fleet average inflight shutdown rate and during the climb phase is 2.5 to 4.5 times the fleet average.

conditions, the FAA has concluded that the airplane validation program should emphasize exposure to the cruise phase of flight. During the three 1000-cycle tests conducted for the original 777 engine installation certification programs, only 91 of the total 1000 cycles were of durations of two hours or more. Since the intent of paragraph (e)(7) is to simulate an actual airline operation, this would better be accomplished through longer duration flight cycles. Long duration flight exposure provides additional confidence in the design against those 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-range flight, and a number of single engine diversions. As such, the FAA proposes that the airplane demonstration test requirement of paragraph (e)(7) be revised to more clearly state the objectives of the test program. Those objectives include demonstrations that the aircraft, its components, and equipment are capable of and function properly during long-range operations and airplane diversions, including engine-inoperative diversions. This change in focus constitutes a significant departure from the original purpose of the 1000-cycle airplane demonstration test requirement, as discussed in the preamble to special conditions 25–ANM–84.

Reliability of 777

In order to further justify this change in philosophy for the airplane demonstration test requirement from being a demonstration of ''reliability'' to a demonstration of ''capability,'' the FAA reviewed the original intent of Special Conditions 25–ANM–84, as documented in the preamble to those special conditions. The purpose of this review was to assess whether the assumptions we made in justifying the special conditions are still valid, or whether they should be revised based on ETOPS certification experience since their issuance in June 1994.

In the preamble to Special Conditions 25–ANM–84, the FAA stated that: ''existing practices to achieve airplane certification safety objectives have involved definition of performance requirements, incorporation of safety margins, and prediction of failure probabilities through analysis and test. However, historical evidence, in general, indicates that a period of actual revenue service experience is necessary to identify and resolve problems not observed during the normal certification process. Successful achievement of this experience has been a prerequisite for granting ETOPS type design approval for a specific airplane engine combination. However, several recent airplane engine combinations incorporating new or substantially modified propulsion systems have demonstrated a high level of reliability consistent with ETOPS operation upon entry into revenue service. In addition, this high level of reliability was demonstrated by the small number of problems encountered during basic certification activity.'' Based on these successful airplane and engine development and certification programs, the special conditions were designed to ''result in a level of airplane reliability that is equivalent to the level of reliability previously found to be acceptable based upon service experience.''

The basic premise behind the engine and airplane demonstration tests required by paragraphs (e)(6) and (e)(7) of the special conditions was that those tests would provide a final validation of an ''inherent'' level of reliability that was the product of an enhanced design and test process. This is similar to the purpose of the function and reliability testing required by § 21.35(b)(2). The FAA's expectation for these tests was that no significant failures would occur. The probability of significant design failures occurring on a one-airplane flight test is so low that if any DO occur, that would be indicative of a design that is not suitable for ETOPS approval. This expectation is contained in the ''type and frequency'' requirement of special conditions paragraph (h)(1). Statistical reliability studies have shown that a much larger database would be required to validate a design's true reliability with a significant degree of confidence.

No major engine failures occurred during the 1000-cycle airplane demonstration tests for any of the three engine types certified on the Model 777 series airplane, although several engine design problems were discovered during other certification testing that affected the start and conduct of those tests. The Reliability Assessment Board (RAB) evaluated each of these design problems in compliance with paragraph (g) of the special conditions, and found the 777 to be suitable for ETOPS type design approval with the incorporation of corrective actions identified in Appendix 1 of the RAB final recommendation reports for the three engine types. There were hardware similarities between engines with the original certified thrust ratings and follow-on higher-thrust-rated engines, and the FAA certified each of those follow-on engine derivatives for ETOPS in consideration of those hardware similarities. The FAA accepted the original baseline engine test programs as showing compliance to the 3000-cycle propulsion system ground test and 1000-cycle airplane demonstration test requirements for the follow-on derivative engines. Although the 3000-cycle and 1000-cycle tests were not repeated for those follow-on derivative engines, Boeing and the engine companies completed reduced ground and flight test demonstrations tailored to the design changes being introduced in compliance with the ''Test Features'' requirement of special conditions paragraph (c)(4). Therefore, the follow-on engine derivatives are not included in this analysis of the 1000-cycle airplane demonstration test requirement.

The Boeing Model 777–200 series airplane powered by Pratt & Whitney PW4077 engines was approved for ETOPS on May 30, 1995 and entered service in June 1995. By all accounts, it was a very successful new model introduction. This was followed by ETOPS approval of the 777–200 powered by General Electric GE90–77B and Rolls-Royce RB211–Trent 877–17 engines in October 1996. The inflight shutdown (IFSD) rate for all three engine types was zero for at least the first year in service. The Pratt & Whitney PW4000 reached a peak 12-month rolling average engine IFSD rate of .018/1000 hours in October 1996. The General Electric GE90 reached a peak of .021 for one month in July 1998 and the Rolls-Royce Trent reached a peak of .016 in December 1997. Although the inflight shutdown rates stayed within the allowable .02/1000 hour standard for 180-minute ETOPS, significant design problems were discovered on each engine type after ETOPS approval.

During the first two years after ETOPS approval of each engine type on the Model 777 series airplanes, the FAA was concerned that the design problems being discovered may have indicated a failure of the early ETOPS process to identify those failure modes before they occurred in service. Some failure modes had the potential to result in inflight shutdowns had they occurred under different circumstances or had they not been detected during maintenance for unassociated reasons. A summary of the actual problem reports for these inflight shutdowns and other events, which were submitted in compliance with paragraph (f) of these special conditions, is contained in Table 1. Had every one of those events resulted in an engine inflight shutdown, the resulting IFSD rates for each engine type would have been significantly higher. Boeing, the engine manufacturers, the FAA, and other regulatory authorities worked together to prevent additional inflight occurrences of these failure types. The actual inflight shutdown rates prove that these early in-service problems were successfully managed to maintain the safety of 777 ETOPS operations worldwide.

TABLE 1

Date occurred	EE–1 #	Engine type	Affected system	Event description
10/1/1995	101	PW	ENGINE—OIL PUMP.	Airplane diversion due to low oil quantity. Engine not shut down, but oil quantity indication went to zero. Related to LP01 problem.
5/19/1996	179	PW	ENGINE	Takeoff aborted due to EGT exceedance. A loose B-nut was found on the PS3 line to the 2.95 bleed valve, which caused erratic operation.
5/30/1996	181	PW	ENGINE	Air turnback due to high oil consumption. Oil wetness noted and corrected from previous flights. Consumption continued to be high.
8/24/1996	233	PW	ENGINE	IFSD—Inflight shutdown due to low oil pressure indication. Plastic shipping cap was left in the LPO1 oil line during installation as part of fleet upgrade.
10/5/1996	254	PW	ENGINE	IFSD—Engine was shut down due to low oil quantity and low oil pressure. Loose main oil line at filter housing. Repeat of oil line shipping cap problem.
10/11/1996	261	PW	ENGINE	Air turnback. Engine experienced high vibration during cruise. Vibration indication exceeded EICAS "Pop-up" level at 4.06.
3/26/1997	385	PW	ENGINE	Twelve quarts of oil lost after a series of training flights due to a leak of an oil line to the fuel/oil cooler. Oil loss took place over approximately 3 hours of flight time.
2/24/1997	G–65	GE	ENGINE GEARBOX.	Air turnback due to loss of right backup generator followed by engine oil filter EICAS message. Root cause was a failed gearbox backup generator pad bearing.
11/4/1997	G–84	GE	ENGINE	IFSD—Engine experienced a power loss during approach. A restart attempt was unsuccessful. Root cause was a sticking bypass valve in the hydromechanical unit (HMU).
11/9/1997	G–87	GE	ENGINE	Flight crew heard a surge toward the end of the takeoff roll and tower reported seeing flames from the engine. At 600 feet, the engine surged again. The flight crew reduced power and returned to the airport.
3/12/1998	G–96	GE	ENGINE	Pilot heard a bang and a tower reported fire from the tailpipe after power was set for takeoff. The takeoff was aborted. Metal was found in the tailpipe.
6/22/1998	G–108	GE	ENGINE	IFSD—After takeoff, the pilot received low oil pressure and low oil quantity indications. The pilot shut down the engine. Two of four oil filter cover bolts were loose due to inserts pulling out of the filter housing casting.
7/1/1998	G–110	GE	ENGINE	IFSD—Uncommanded engine inflight shutdown during cruise at flight level 370. Flight crew noted a rapid loss of oil pressure and N2. Root cause was a Number 3 bearing failure.
7/22/1998	G–112	GE	ENGINE	IFSD—During cruise, EICAS indication of low oil quantity. Pilot shut down the engine. Oil filter housing cover bolts were over-torqued resulting in stripped threads in the oil filter housing inserts.
11/20/1998	G–120	GE	IDG installation	IFSD—Crew started return to departure airport due to indication of complete oil loss. Engine was subsequently shut down when oil pressure dropped to 10 psi. The integrated drive generator (IDG) packing was damaged during installation.
10/11/1996	R–63	RR	ENGINE—RADIAL DRIVE SHROUD.	Flight diverted after crew observed right engine oil quantity loss approx. 5 hours into flight. Found cracked upper radial drive shroud.
10/11/1996	R–64	RR	ENGINE—FUEL NOZZLE.	Fuel found leaking from Zone 2 during investigation of R–63 oil loss. Source of fuel leak was a cracked weld on the No. 24 fuel nozzle (top dead center).
10/25/1996	R–65	RR	ENGINE—RADIAL DRIVE SHROUD.	After engine shutdown at the gate, the right engine oil quantity indicated 9 qts. Upper radial drive shroud found cracked.
11/12/1996	R–67	RR	ENGINE	"ENGINE OIL PRESS R" EICAS message displayed after landing. Engine shut down. Oil pump drive shaft found sheared.
1/26/1997	R–91	RR	ENGINE—STEP ASIDE GEARBOX.	Low oil quantity caused by crack in step aside gearbox housing approximately 4 to 5 inches long.
5/24/1997	R–109	RR	ENGINE	Engine was shut down on takeoff following high power surge. Subsequent borescope inspection revealed HPC rotor 1 blade failure caused by foreign object damage that was consistent with blade damage noted on 5/20/97 inspection.
7/7/1997	R–112	RR	ENGINE	Aircraft diversion caused by excessive oil leakage due to incorrectly installed lower bevel box O-ring seal following radial drive shaft replacement.
7/26/1997	—	RR	ENGINE	Aircraft diversion due to high oil consumption. Not related to step aside gearbox housing cracking problem.

TABLE 1—Continued

Date occurred	EE–1 #	Engine type	Affected system	Event description
9/16/1997	R–113	RR	ENGINE	IFSD—Engine shutdown at 400 feet after takeoff due to high- pressure compressor failure.

Reliability of 737NG

As part of the process of reviewing existing methods for ETOPS approval, the FAA also analyzed data from the initial in-service period for Boeing Models 737–600, 737–700, and 737–800 powered by CFM56–7 engines. As a group, these variants of the 737 were referred to as the 737 Next Generation, or ''737NG.'' Even though early ETOPS special conditions were not issued, the 737NG was chosen for this analysis because it followed an ETOPS approval process program that was very similar to what Boeing is proposing for the 777–300ER. Several months after entry into service, however, the 737NG did not exhibit an acceptable level of propulsion system reliability for ETOPS approval. Early ETOPS special conditions were intended to identify a design not suitable for ETOPS approval prior to type certification.

Boeing proposed in 1994, prior to the 777's type certification, that the 737NG be certified as an early ETOPS airplane in a manner similar to the 777, but without all of the testing required in the 777 special conditions. Since the success of the 777 program was still an unknown at the time of Boeing's request for the 737NG, the FAA did not agree to Boeing's proposed changes to the airplane demonstration test requirement. Early ETOPS special conditions for the 737NG were never issued. Even so, Boeing proceeded with those elements of the 777 special conditions that the company had proposed to accomplish. These included the relevant experience assessment, design requirements assessment, 3000-cycle propulsion system ground test, and enhanced problem reporting and resolution.

Although the FAA never issued special conditions for the 737NG program, we agreed that the elements from the 777 special conditions that Boeing did accomplish justified a reduction in the service experience normally required for ETOPS type design approval, as outlined in AC 120–42A. Boeing presented the following information in support of its request for a reduction in service experience required for ETOPS certification.

- ''Design involved lessons learned, similar to 777 Early ETOPS process.
- ''APU most thoroughly tested in Allied Signal history—more than 3000-cycle ground test, including hot/cold exposure.
- ''Propulsion system subjected to 3000-cycle ground test, intentionally unbalanced, with three 180-minute diversion cycles.
- ''Flight testing included a Southwest Airlines 50-cycle demonstration, using airline crews and maintenance. During the Function and Reliability testing, 61 ETOPS cycles were conducted with three single engine 180-minute diversions.
- ''A proposed ETOPS problem tracking and resolution system, similar to that used on the 777 that will remain in effect until the fleet attains 250,000 engine fleet hours.''

In its analysis of the 737NG approval process, the FAA noted that these program elements, at the time, had been accomplished with good results. The engines and airplane system had performed well during the test programs, with results comparable to the 777 test fleet (all engines). The in-service 737NG airplanes had achieved a 98.96% dispatch reliability rate after 45 days in service, better than any previous Boeing airplane. Boeing's proposal included an accumulation of 15,000 fleet engine hours of service experience before requesting ETOPS approval. At that time, there would be three airplanes with more than 1000 flight cycles, the total 737NG fleet would have accumulated more than 20,000 flight cycles, and the high-time airplane/engines would have more than 2000 flight cycles. During the 737 NG approval process, the FAA concurred with Boeing's proposal to require 15,000 hours of service experience based on the following:

- ''The FAA has agreed to the concept that ETOPS at entry into service can be achieved by appropriate design and testing as evidenced by the 777 special conditions, which have now been validated through actual service experience,
- ''The 737NG/CFM56–7B airframe/engine configuration is a derivative/evolution of the existing 737–300/400/500 which through extensive service experience has demonstrated exceptional reliability, and, is approved for 120-minute ETOPS,
- ''Except for the lack of a dedicated 1000-cycle ETOPS test program, design and testing of the 737NG/CFM56–7B mirrors what was done on the 777 to satisfy Early-ETOPS approval.
- ''The additional 15,000 engine hour in-service evaluation plus the fact that three 180-minute single engine diversions were performed during Function and Reliability testing more than compensates for the omission of a 1000-cycle test,
- ''The satisfactory performance of the 737NG/CFM56–7B airframe/engine configuration during the certification testing, and
- ''The proven ability of Boeing to satisfactorily manage ETOPS airworthiness of the 777 fleet in the face of problems encountered in service. The 737NG proposal includes a problem tracking and resolution system that will remain in effect for a full 250,000 engine hours.''

The Model 737–700 was the first variant of the 737NG to enter service, in December 1997. Section 4.2 of the FAA-approved 120-minute ETOPS Airplane Assessment Report for the 737–700, Boeing Document Number D033A003, Revision B, states that the Model 737–700 was designed, manufactured, and tested for extended range operations at entry into service. The following additional supporting statements were also made.

a. ''The 737–700 airplanes have been designed and manufactured based on regimented application of lessons learned from other ETOPS program experience as well as the in-service experience of earlier 737 models.

b.''The 737–700 airplane was subjected to a rigorous test program as described in following paragraphs. Production equivalent equipment where appropriate, was used to support test objectives. Equipment was production equivalent as defined at the time of the test.''

No significant propulsion system design problems occurred during any of the testing described above. Two inflight shutdowns did occur during certification flight testing. One was caused by an indication fault within the electronic engine control that was corrected with a simple software change. The other was caused by an inappropriate flight test condition.

Boeing stated in the 737–700's 120-minute ETOPS Airplane Assessment Report that the fleet reached the 15,000-hour mark during the month of April 1998. At that time, there had been no inflight shutdowns in service. However, on May 9, 1998, before the FAA had completed its assessment of the airplane for ETOPS approval, the first inflight shutdown occurred. A second inflight shutdown occurred during the month of May, and the fleet exceeded the accepted 120-minute ETOPS standard of .05 inflight shutdowns per 1000 engine hours. Three inflight shutdowns occurred in June 1998, and one in July 1998. The peak inflight shutdown rate during this period was .085/1000 hours at the end of June 1998, which clearly did not meet the minimum standard for ETOPS type design approval.

The six engine inflight shutdowns were caused by three different failure root causes. Boeing and CFMI, the engine manufacturer, undertook aggressive actions to correct each of these design problems as they occurred. The high rate of fleet hourly accumulation during this period, however, resulted in new ETOPS reportable events occurring faster than the known problems could be corrected. This delayed FAA consideration of the 737–700 for ETOPS approval until the problems were brought under control. A consequence of the high rate of fleet hourly accumulation was that, with no additional inflight shutdowns, the inflight shutdown rate decreased rapidly and was within the ETOPS type design approval standard by the end of 1998. The FAA approved the 737–600/–700/–800 (737NG) for 120-minute ETOPS approximately one year after entry into service with over 300,000 engine-hours of service experience and an inflight shutdown rate of .020/1000 hours.

Conclusions From Comparison of 777 and 737NG

In comparing the 737NG experience with that of the 777, the FAA observes that there is a fleet hourly accumulation rate above which aggressive problem management to qualify for early ETOPS certification may become resource prohibitive. Therefore, when certifying an airplane/engine combination that will be entering service with a high production rate resulting in a rapid accumulation of engine hours, manufacturers may find it more cost-effective to use the service experience criteria of AC 120–42A than to follow the rigorous requirements of the early ETOPS process.

As stated earlier, the 777 ETOPS special conditions were designed to "result in a level of airplane reliability that is equivalent to the level of reliability previously found to be acceptable based upon service experience." As previously noted, the current 777 ETOPS special conditions consist of five main elements needed to provide adequate compensation for the service experience normally required for 180-minute ETOPS eligibility described in AC 120–42A. No single element is considered sufficient by itself, but the FAA has found that the five elements combined provide an acceptable substitute for actual airline service experience. The five elements are:

1. Design for reliability.
2. Lessons learned.
3. Test requirements.
4. Demonstrated reliability.
5. Problem tracking system.

Even though the overall objective is a level of airplane and propulsion system reliability that is equivalent to that achieved through service experience, we considered the uncertainty of actually achieving that goal in the development of these special conditions. The first three elements focus on designing an airplane to eliminate sources of engine inflight shutdowns and diversions to the greatest practical extent. This is accomplished by an overall design philosophy to preclude sources of engine inflight shutdowns and diversions using the manufacturer's experience with earlier designs to identify successful and unsuccessful design features. The additional testing required by the special conditions focuses on exposing the design to conditions that in the past have contributed to engine failures, such as high engine vibration or repeated exposure to humid and inclement weather on the ground followed by long-range operation at the extreme cold temperatures at high altitude. These design and test elements do not assure a level of reliability that is equivalent to that based on service experience. Instead, they result in an acceptable level of inherent design reliability from which we can successfully manage ETOPS fleet safety once the airplane enters service.

The fourth element, "demonstrated reliability," provides the FAA with a standard by which to judge a design against existing ETOPS-approved airplanes. This gives the FAA a standard from which to withhold ETOPS approval from airplanes that experience significant failures during certification testing, demonstrating that they are not suitable for ETOPS. However, it does not by itself guarantee that designs showing no significant failures during flight testing will have adequate reliability for ETOPS.

To manage fleet safety after ETOPS approval, we rely on the fifth element of the ETOPS special conditions. Paragraph (f) of the special conditions requires a problem tracking system for the prompt identification of those problems that could impact ETOPS safety. The FAA uses this enhanced problem reporting system to work with the airplane and engine manufacturers to aggressively manage and correct significant design problems identified after ETOPS approval. This requirement is the "catch-all" for those design flaws that are not caught by the other special conditions elements during airplane design and testing.

The first in-service inflight shutdown of the 737–700 variant of the 737NG did not occur until the fleet had accumulated approximately 30,000 engine-hours. The FAA could not have expected that a complete 1000-cycle airplane demonstration test would have had a better chance of discovering the types of problems that occurred in service on the 737NG than the nearly 30,000 hours accumulated on multiple airplanes and engines prior to the first inflight engine shutdown. While significant propulsion system failures occurring during type certification testing, including the additional testing required by the ETOPS special conditions, may indicate that a design is not yet ready to enter ETOPS service, the 737NG experience shows that the reverse cannot be stated with a significant degree of confidence. A lack of significant failures during certification testing does not in itself assure an ETOPS-suitable design at entry into service.

The 777 experience shows that a relatively small fleet can be managed successfully during the initial service period based on the data provided by the enhanced problem tracking system required by special conditions paragraph (f). The 737NG experience shows that a larger fleet may require a much more resource-intensive fleet management program. However, had the 737NG received its ETOPS approval as originally proposed prior to its first inflight shutdown in service, the problem reporting system that Boeing had in place gave the FAA timely identification of the problems causing inflight shutdowns so that we could have required appropriate corrective action through the airworthiness directive process to maintain ETOPS safety. Such airworthiness directives could have required the operators to incorporate design changes prior to further ETOPS flight or withdrawn ETOPS approval.

Since we cannot be certain that an airplane approved for ETOPS under the special conditions will have the same maturity at original type certification as an airplane that we have approved based on service experience, our experience with the 777 and 737NG confirms that the five elements of the special conditions, in conjunction with the FAA's normal safety oversight processes, adequately compensate for that uncertainty.

The changes we propose for the engine demonstration test and the airplane demonstration test, including enhanced post-test inspection requirements, are intended to address our experience with the existing ETOPS special conditions, which identified several shortcomings in the original test requirements. We are proposing these changes to more clearly focus the testing on the objective of exposing the engines and airplane to those operating conditions that give us the best chance of identifying underlying major design flaws that could jeopardize ETOPS safety in service. These proposed changes would provide a better evaluation of the design than the existing requirements, including the 1000-cycle airplane flight test as previously conducted.

The FAA therefore proposes to change the purpose of the airplane demonstration test requirement of paragraph (e)(7) from being a demonstration of reliability to a demonstration of airplane capability under the types of ETOPS operational and diversion scenarios being proposed in this notice. The requirements of that airplane demonstration test have been changed accordingly.

Aged Engine Requirement

In response to Boeing's request, the FAA is proposing to delete paragraph (e)(7)(ii), which currently requires the installation of the engine and propulsion system from the 3000-cycle engine demonstration test required by paragraph (e)(6), or another suitable aged engine, on the 1000-cycle demonstration test airplane for a minimum of 500 cycles. Boeing provided the following information in support of its request for deleting the aged engine requirement:

Review of the aged engine data from the baseline 777 program showed that the nature of the findings, which occurred on the aged engines, was not related to the aging of the engines. The findings were related to the variation that occurs during manufacturing, assembly, etc. This lesson learned on the aged engines is consistent for each engine manufacturers' baseline 777 ETOPS test program.

The lack of findings related to the aging of an engine in the ETOPS flight test program has been demonstrated three times. Based on this consistent demonstration, there is no further need to maintain the requirement for an aged engine in the flight test program. Additionally, flying more airplane/engine combinations will provide increased opportunities for evaluating potential problem areas.

Boeing reported nine events (EE–1 Reports) which occurred during the ''aged'' engine portions of the 1000-cycle tests for the three baseline engine types, with an explanation of why the aged engine requirement was not necessary in order to identify each failure. Boeing stated that the lack of any EE–1 reports from the post-test inspections is an indication that there were no significant findings from the aged engine testing.

FAA Analysis of Boeing's Proposal: The original intent of the aged engine requirement was to expose the 3000-cycle test engine, or equivalent, to inflight conditions that cannot be simulated in a ground test environment. This would further validate the propulsion system design out to an age beyond 3000 cycles. Boeing data available at the time the ETOPS special conditions were developed indicated that 95% of all new significant failure modes occur on airplane propulsion systems with 3000 cycles or less. That concept is still valid. The lack of specific findings on the aged engine during the 1000-cycle airplane validation test only confirms the validity of the Reliability Assessment Board's conclusion that those baseline 777 engine installations were suitable for 180-minute ETOPS. A number of significant events during the 1000-cycle test program would have jeopardized that conclusion.

The question that the FAA considers to be more relevant is whether or not a greater benefit would come from a more thorough teardown inspection and analysis of the 3000-cycle test engine and propulsion system hardware than from this additional level of validation. In this regard, the FAA agrees with Boeing that other test articles may provide sufficient experience to uncover the majority of age-related problems independent of the additional exposure provided by the 1000-cycle test inflight exposure.

In consideration of the need to perform a detailed analysis of the 3000-cycle test engine and the extra expense of using a parallel 3000-cycle test engine as ''another suitable aged engine,'' the FAA agrees that the requirement for installation of an aged engine on the ETOPS test airplane can be eliminated provided significantly improved processes are used to analyze the condition of the 3000-cycle test and airplane demonstration test engines at the conclusion of these tests, as being proposed for paragraph (e)(6).

Miscellaneous Amendments

We are also proposing the following revisions.

Re-identification of paragraph (e)(7)(iii) as (e)(7)(iv) and revision of the requirement that the 1000-cycle test airplane be operated and maintained using the recommended operations and maintenance procedures to recognize that more than one test airplane may be used.

Replacement of the reference to the ''1000-cycle ETOPS test'' with ''Airplane Demonstration Test'' in paragraph (g)(2) in order to be consistent with the changes being proposed for paragraph (e)(7).

Replacement of the reference to the ''1000-flight-cycle ETOPS test'' with ''Airplane Demonstration Test'' in paragraph (h)(1) in order to be consistent with the changes being proposed for paragraph (e)(7).

Applicability

As discussed above, these special conditions are applicable to Boeing Model 777 series airplanes. Should The Boeing Company apply at a later date for a change to the type certificate to modify any model included on Type Certificate No. T00001SE to incorporate the same novel or unusual design feature, the special conditions would apply to that model as well under the provisions of § 21.101(a)(1), Amendment 21–69, effective September 16, 1991.

Conclusion

This action affects only certain novel or unusual design features on Boeing Model 777 series airplanes. It is not a rule of general applicability, and it affects only the applicant who applied to the FAA for approval of these features on the airplane.

List of Subjects in CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The authority citation for these special conditions is as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

The Proposed Special Conditions

Accordingly, the Federal Aviation Administration (FAA) proposes the following revisions to Special Conditions 25–ANM–84 as part of the type certification basis for Boeing Model 777 series airplanes. The existing special conditions are printed in their entirety for clarity. Your comments are invited on the proposed revisions: Sections (e)(6), (e)(7), and the word substitutions in sections (g)(2) and (h)(1).

In addition to the airworthiness requirements of 14 CFR part 25, the Model 777 airplane must comply with the following requirements in order to be eligible for Extended Range Operation with Two-Engine Airplanes (ETOPS) without the requisite operating experience specified in Advisory Circular (AC) 120–42A:

(a) *Introduction.* An approved ETOPS Type Design Assessment Plan covering the engine and each applicable airplane system must be established. The specific methods that will be used to substantiate compliance with the requirements of these special conditions must be defined in the plan. Specific systems that will undergo the complete analysis, testing, and development program tracking defined in paragraph (c) of these special conditions must be identified. Other airplane systems that may contribute to the overall safety of an ETOPS operation, but that do not warrant the rigorous type design requirements and relevant experience assessments defined in paragraph (c) of these special conditions, must be identified and agreed to by the FAA. Compliance must be shown for these other systems with all provisions of these special conditions, except paragraph (c). In showing compliance with these special conditions, tests and analyses conducted to substantiate compliance with the basic airworthiness standards of part 25 may be referenced, if applicable.

(b) *Engine Assessment.*

(1) The ETOPS eligibility of the engine must be determined specifically for the airplane installation for which early ETOPS type design approval is requested.

(2) Procedures for an engine condition monitoring program must be defined and validated at the time of ETOPS type design approval. The engine condition monitoring program must be able to predict when an engine is no longer capable of providing, within certified engine operating limits, the maximum thrust required for a single engine diversion.

(c) *ETOPS Type Design Assessment.*

(1) *Design Requirements Assessment.* 14 CFR part 25, including applicable amendments, defines most of the requirements necessary to design an airplane that is suitable for ETOPS operation, as long as the ETOPS mission is considered in applying these requirements for all anticipated dispatch configurations. In addition to these requirements, the propulsion system must be designed to preclude failures or malfunctions that could result in an engine inflight shutdown. The applicant must identify and list methods of compliance for each of the applicable ETOPS requirements, including those specific part 25 requirements for which methods of compliance relative to the ETOPS mission are different from those traditionally used for two-engine airplanes. Paragraph (c)(3) of these special conditions lists certain design feature categories that may be affected by a consideration of the ETOPS mission in the design of these systems. The effects of the applicable ETOPS requirements on the design of any of those design feature categories listed in paragraph (c)(3) must be specifically addressed by this assessment.

(2) *Relevant Experience Assessment.* For each system covered by the ETOPS Type Design Assessment, there must be an assessment of the relevant design, manufacturing, and operational problems experienced on previous airplanes built by the applicant. The assessment must include the applicable relevant service experience of vendor supplied systems or, to the extent possible, the service experience of components on aircraft built by other manufacturers. Specific corrective actions taken to preclude similar problems from occurring on the new airplane must be identified.

(3) *Design Features.*

(i) The applicant must define any design features implemented to comply with the design requirements listed in paragraph (c)(1). Consideration of the following design feature categories must be specifically addressed:

(A) Airplane capabilities and capacities of the ETOPS mission;

(B) Fuel system integrity, including consideration of uncontained main engine rotor burst and fuel availability as affected by cross-feed capability and electrical power to pumps and other components;

(C) Fuel quantity indication to the flightcrew, including alerts that consider the fuel required to complete the mission, abnormal fuel management or transfer between tanks, and possible fuel leaks between the tanks and the main engines;

(D) Communication systems for the ETOPS environment;

(E) Navigation systems for the ETOPS environment;

(F) Minimum single engine cruise altitude capability; and

(G) Failure tolerant designs of cockpit indicating systems or avionics systems to prevent unnecessary airplane diversions.

(ii) The applicant must define the specific design features used to address problems identified in the relevant service experience assessment of paragraph (c)(2).

(4) *Test Features.* The applicant must define specific new tests, or enhanced tests, that will be used to assure engine and airplane system design integrity. These test features may be derived from the requirements assessment of paragraph (c)(1) and the relevant service experience assessment of paragraph (c)(2).

(5) *Analysis Features.* The applicant must define specific new analyses, or enhanced analyses, that will be used to assure engine and airplane system design integrity. These analysis features may be derived from the requirements assessment of paragraph (c)(1) and the relevant service experience assessment of paragraph (c)(2).

(6) *Manufacturing, Maintenance, or Operational (Other) Features.* The applicant must define specific new, or enhanced, manufacturing processes or procedures, and maintenance or operational procedures that are being implemented to assure engine and airplane system integrity. These ''other'' features may be derived from the requirements assessment of paragraph (c)(1) of this section and the relevant service experience assessment of paragraph (c)(2).

(d) *Additional ETOPS Analysis Requirements.*

(1) *Performance and Failure Analyses.* Engine and airplane performance and failure analyses required for certification must be expanded to consider ETOPS mission requirements, including exposure times associated with a 180-minute single-engine diversion and a subsequent 15-minute hold in the terminal airspace at the diversion airport. Consideration must be given to crew workload and operational implications of continued operation with failure effects for an extended period of time. The rationale and all assumptions used in the analyses must be documented, justified, and validated, including maintenance interval and maintainability assumptions.

(2) *Maintenance and Flight Operations Evaluation.* The Type Design Assessment Plan must contain a program to systematically detect and correct problems occurring as a result of improper execution of maintenance or flight operations. Corrective actions for any problems found must be identified and implemented through the Problem Tracking and Resolution System required by paragraph (f).

(3) *Manufacturing Variability.* The Type Design Assessment Plan must contain a program to minimize potential manufacturing problems. The plan should address early validation of tooling and procedures, as well as any related problems, as identified in paragraph (c)(2). Corrective actions for problems that impact the safe operation of the airplane must be identified and implemented through the problem tracking and resolution system required by paragraph (f).

(e) *Additional ETOPS Test Requirements.* As part of, or in addition to, the testing identified in paragraph (c)(4), the following specific test requirements apply:

(1) *Configuration Requirements.* All testing defined in paragraph (e) must be conducted with the configuration proposed for certification, and must include sufficient interfacing system hardware and software to simulate the actual airplane installation.

(2) *Completion of Applicable Failure Analyses.* Failure analyses required for ETOPS type design approval must be submitted to the FAA prior to the start of the testing defined in paragraph (e).

(3) *Vibration Testing.* Vibration testing must be conducted on the complete installed engine configuration to demonstrate that no damaging resonances exist within the operating envelope of the engine that could lead to component, part, or fluid line failures. The complete installed engine configuration includes the engine, nacelle, engine mounted components, and engine mounting structure up the strut to wing interface.

(4) *New Technology Demonstration Testing.* Testing must be conducted to substantiate the suitability of any technology new to the applicant, including substantially new manufacturing techniques.

(5) *Auxiliary Power Unit Demonstration Test.* If requesting credit for APU backup electrical power generation, one auxiliary power unit (APU), of the type to be certificated with the airplane, must complete 3000 equivalent airplane operational cycles.

(6) *Engine Demonstration Test.* One engine of each type to be certificated with the airplane must complete 3000 equivalent airplane operational cycles. The engine must be configured with a complete airplane nacelle package for this demonstration, including engine-mounted equipment except for any configuration differences necessary to accommodate test instrumentation and test stand interfaces with the engine nacelle package. At completion of the engine demonstration test, the engine and airplane nacelle test hardware must undergo a complete teardown inspection. This inspection must be conducted in a manner to identify abnormal conditions that could become potential sources of engine inflight shutdown. An analysis of any abnormal conditions found must consider the possible consequences of similar occurrences in service to determine if they may become sources of engine inflight shutdowns, power loss, or inability to control engine thrust. Any potential sources of engine inflight shutdown identified must be corrected in accordance with paragraph (g)(2).

(7) *Airplane Demonstration Test.* In addition to the function and reliability testing required by 14 CFR 21.35(b)(2), for each engine type to be certificated with the airplane, one or more airplanes must complete flight testing which demonstrates that the aircraft, its components, and equipment, are capable of and function properly during long range operations and airplane diversions, including engine-inoperative diversions.

(i) The flight conditions must expose the airplane to representative operational variations based on the airplane's system and equipment design and the intended use of the airplane including:

(A) Engine inoperative maximum length diversions to demonstrate the airplane and propulsion system's capability to safely conduct a diversion.

(B) Non-normal conditions to demonstrate the airplane's capability to safely divert under worst case probable system failure conditions.

(C) Simulated airline operations including normal cruise altitudes, step climbs, and maximum expected flight durations out of and into a variety of departure and arrival airports.

(D) Diversions to worldwide airports representative of those intended as operational alternates.

(E) Repeated exposure to humid and inclement weather on the ground followed by long-range operation at normal cruise altitude.

(ii) The flight testing must validate expected airplane flying qualities and performance considering engine failure, electrical power losses, etc. The testing must demonstrate the adequacy of remaining airplane systems and performance and flightcrew ability to deal with an emergency considering remaining flight deck information following expected failure conditions.

(iii) The engine-inoperative diversions must be evenly distributed among the number of engines in the applicant's flight test program.

(iv) The test airplane(s) must be operated and maintained using the recommended operations and maintenance manual procedures during the airplane demonstration test.

(v) At completion of the airplane demonstration test, the test engines and engine-mounted equipment must undergo a complete external on-wing visual inspection. The engines must also undergo a complete internal visual inspection. These inspections must be conducted in a manner to identify abnormal conditions that could become potential sources of engine inflight shutdowns. An analysis of any abnormal conditions found must consider the possible consequences of similar occurrences in service to determine if they may become sources of engine inflight shutdowns. Any potential sources of engine inflight shutdown that are identified must be corrected in accordance with paragraph (g)(2).

(f) *Problem Tracking System.* An FAA-approved problem tracking system must be established to address problems encountered on the engine and airplane systems that could affect the safety of ETOPS operations.

(1) The system must contain a means for the prompt identification of those problems that could impact the safety of ETOPS operations in order that they may be resolved in a timely manner.

(2) The system must contain the process for the timely notification to the responsible FAA office of all relevant problems encountered, and corrective actions deemed necessary, in a manner that allows for appropriate FAA review of all planned corrective actions.

(3) The system must be in effect during the phases of airplane development that will be used to assess early ETOPS eligibility, and for at least the first 250,000 engine-hours of fleet operating experience after the airplane enters revenue service. For the revenue service period, this system must define the sources and content of in-service data that will be made available to the manufacturers in support of the problem tracking system. The content of the data provided must include, as a minimum, the data necessary to evaluate the specific cause of all service incidents reportable under § 21.3(c) of part 21, in addition to any other failure or

malfunction that could prevent safe flight and landing of the airplane, or affect the ability of the crew to cope with adverse operating conditions.

(4) Corrective actions for all problems discovered during the development and certification test program that could affect the safety of ETOPS operations, or the intended function of systems whose use is relied upon to accomplish the ETOPS mission, must be identified and implemented in accordance with paragraph (g)(2). If, during the certification program, it is discovered that a fault has developed that requires significant rework of manufacturing, maintenance, and/or operational procedures, the FAA will review the ETOPS suitability of the affected system and interfacing hardware and identify any additional actions to be accomplished to substantiate the corrective actions.

(5) For each engine type to be certificated with the airplane, the system must include provisions for an accelerated engine cyclic endurance test program that will accumulate cycles on one representative production-equivalent propulsion system in advance of the high-cycle revenue fleet engine. This test program will assist the applicant and the FAA in identifying and correcting problems before they occur in revenue service. This program must be in place for, at a minimum, the first 250,000 engine-hours of fleet operating experience after the airplane enters revenue service. The representative production-equivalent propulsion system may, at the manufacturer's discretion, be used for other fleet support activities.

(g) *Reliability Assessment Board.*

(1) An FAA Reliability Assessment Board will be formed to evaluate the suitability of the airplane for ETOPS approval and make a recommendation to the Manager, Transport Airplane Directorate, regarding the adequacy of the type design for 180-minute ETOPS operation. The purpose of this board will be:

(i) To periodically review the development and certification flight test program accomplishments from both type design and operational perspectives;

(ii) To ensure that all specific problems, as well as their implications on the effectiveness of the Early ETOPS process, are resolved; and

(iii) To assess the design suitability for ETOPS. The board will consider design, maintenance, manufacturing, and operational aspects of the type design when finding suitability for ETOPS approval.

(2) The FAA Reliability Assessment Board will review and evaluate the data from the problem tracking and resolution system to establish compliance with the requirements of paragraph (h). The board will evaluate the overall type design for ETOPS suitability as demonstrated in flight test, and the *Airplane Demonstration Test*, considering all resolutions of problems. The following suitability criteria will be applied:

(i) Sources of engine shutdown/thrust loss, engine anomalies, or airplane system problems that have a potential significant adverse effect on in-service safety will be resolved.

(ii) Resolutions are identified for all items in paragraph (i) with analysis and/or testing to show all resolutions are effective. These resolutions may be accomplished through one or more of the following categories: Design change, Operating procedure revision, Maintenance procedure revision, Manufacturing change.

(iii) The resolutions of paragraphs (i) and (ii) will be incorporated prior to entry into service.

(iv) The engine shutdown history of the test program indicates that the engine reliability of the configuration is suitable for the ETOPS approval being considered.

(v) Where interim resolutions having operational impact are defined, the cumulative effect must be determined to be acceptable.

(vi) System or component failures experienced during the program are consistent with the assumptions made in the failure analyses.

(h) *Reliability Demonstration Acceptance Criteria.*

(1) For the engine and airplane systems, the type and frequency of failures that occur during the airplane flight test program and the *Airplane Demonstration Test* must be consistent with the type and frequency of failures or malfunctions that would be expected to occur on presently certified 180-minute ETOPS airplanes. The failures to be considered are those associated with system components that conform to the type design requested for certification. The Reliability Assessment Board will determine compliance with this requirement based on an evaluation of the problem reporting system data, considering system redundancies, failure significance, problem resolution, and engineering judgment.

(2) Corrective action for any of the following classes of problems occurring during the testing identified in paragraph (h)(1) that requires a major system redesign would delay ETOPS type design approval, or result in approval of a reduced single-engine diversion time, unless corrective action has been substantiated to, and accepted by, the FAA Reliability Assessment Board:

(i) Any source of unplanned inflight shutdown or loss of thrust.

(ii) Any problem that jeopardizes the safety of an airplane diversion.

(3) The FAA Reliability Assessment Board must determine that the suitability criteria of paragraph (g)(2) have been met.

(i) *Demonstration of Compliance.* In order to be eligible for 180-minute ETOPS type design approval, the following conditions apply:

(1) The engine assessment has been completed and eligibility for ETOPS operation has been approved by the FAA Engine Certification Office.

(2) All design, manufacturing, maintenance, operational, and other features necessary to meet the ETOPS requirements of paragraph (c)(1), and to resolve the problems identified in paragraph (c)(2), have been successfully implemented.

(3) The identified test and analysis features in paragraph (c)(4) and (c)(5) have been shown to be effective in validating the successful implementation of the features in paragraph (i)(2).

(4) The additional analysis requirements of paragraph (d) have been completed and the results have been approved.

(5) The additional test requirements of paragraph (e) have been successfully completed.

(6) All significant problems identified in accordance with paragraph (f) have been resolved, and fixes substantiated to be effective have been implemented.

(7) The accelerated engine cyclic endurance test program of paragraph (f)(5) must be in place.

(8) Compliance with the reliability demonstration acceptance criteria of paragraph (h) has been found by the Reliability Assessment Board.

Issued in Renton, Washington on June 4, 2003.

Kalene C. Yanamura,

Acting Manager, Transport Airplane Directorate, Aircraft Certification Service.

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