

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 with 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 Model 777-200 series airplanes 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 series engines reached a peak 12-month rolling average engine IFSD rate of .018/1000 hours in October 1996. The General Electric GE90 series engines reached a peak of .021 for one month in July 1998 and the Rolls-Royce Trent series engines 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.