

The PW4000 100"

Technical Development

In 1991 Pratt & Whitney (P&W) took the decision to offer an engine variant for the A330 aircraft, at that time the biggest commercial twin engine aircraft, in competition with the other major engine manufacturers, to increase their market share. The first engine entered service in 1994.

Because of the need to increase thrust, P&W increased the engine diameter from 94" to 100" – the thrust now ranges from 64,000lb to 70,000lb. The design is very similar to the 94": all engine versions are FADEC-controlled and, in common with all P&W products, is engine pressure ratio controlled. The main data are:

LPC	• 1 fan stage • 5 primary stages
HPC:	• 15 stages • 5 stages of variable vanes
Combustor:	• Anular combustion chamber
HPT:	• 2 stages
LPT:	• 5 stages

IASG believes the main technical problems for this engine variant are concentrated in the engine hot section. The most important issues a lessor or operator needs to be aware of are associated with the high pressure turbine stage 1 blades and the high pressure turbine stage 2 vanes.

HPT stage 1 blades have shown a faster than expected deterioration: a greater than normal EGT margin deterioration can be an indication that the engine is experiencing this problem. Despite this indication stage 1 blade deterioration is still the primary reason for aborted take-offs.

The HPT stage 2 vanes can also show distress. This problem is not leading to IFSD events as it can be easily detected and monitored through borescope inspections, but remains the first cause for engine removal. P&W is actively working to solve this problem and new parts have been promised to operators in 2006.

All 100" version engines have the ring case modification on the high pressure compressor stator incorporated during production. Nevertheless some surge events have been already experienced in the fleet, even though the problem is much less critical than in the 94" family.

IASG has noted that for engines operated on long routes, the deterioration rate is 15 degrees of EGT margin lost every 2,000 cycles, but for engines operated at high weights and on shorter routes, the

deterioration can reach 25 degrees of EGT margin lost in 1,800 cycles.

Application and operators

The PW4000 100" is for the A330 aircraft only, with thrust ratings as follows:

Engine Model	Thrust	Aircraft Model
PW4164	64,000lb	A330-300
PW4168	68,000lb	A330-300
PW4168A	70,000lb	A330-200

The engine is certified as 180 minutes ETOPS and has accumulated in excess of five million hours and 1,400,000 cycles.

Currently about 20 airlines are operating the engine in its various variants.

A total of 278 engines are currently flying. The fleet leader has accumulated 35,000 flight hours and 12,000 flight cycles. Thai Airways is the only airline operating the engine at 64,000lb, all other operators are operating at higher thrust.

In addition to the civil application, Airbus is proposing a tanker version of the aircraft, with orders yet to be made public.

Maintenance Costs

Because of the installed base of engines and its familiarity with the smaller model, several engine shops in the world are certified to repair this engine model. At present, P&W, SR Technics, Korean Air and GE Engine Services Malaysia have overhaul capabilities on this engine model.

Except for Korean Air, using the aircraft for Korea-Japan flights, all aircraft are used on long-haul flights. The typical flight to cycle ratio is 4.9:1. The basic average engine shop visit rate is close to 12,000 flight hours, with first run engines reaching 15,000 flight hours. The typical first shop visit is a core performance restoration in the range of \$1.9m. The second engine on wing time is 11,000 flight hours on average and the subsequent engine shop visit is a full refurbishment, in the range of \$2.5m. Shop visits are highly dependent upon engine thrust utilisation, environment and engine standard.

Operators or lessors interested in buying an engine or repairing the engine need to carefully evaluate the HPT stage 1 blades and vanes configuration.

Maintenance reserves do not change significantly between the engine variants as the repair costs are not deeply dependant on the thrust utilisation. Since P&W is proposing several modifications to be

Operator	Number of aircraft	Number of engines
Asiana	2	5
Air Caraibes	2	4
Air Greenland	1	2
Air Luxor	2	4
Air Madrid	1	2
Austrian	4	9
Al Etihad	3	7
Eurofly	3	6
Iberworld	1	2
Korean Air	19	43
Lufthansa	2	5
LTU	11	24
Malaysia	16	38
Northwest	17	35
Novair	1	2
Swiss	9	19
TAM	2	5
Thai	12	28
US Airways	9	21
ABN AMRO	3	6
Lessors	–	10

introduced to the engine at shop visit level, the standard is a very important factor and needs to be carefully evaluated when the engine is being repaired. Maintenance reserves for life limited parts (LLP) are \$290 per cycle. A full set of new LLP is in the range of \$4.4m.

Ownership and Leasing

Several leasing companies have this engine in their portfolio. The engine traded very well in 2005 and IASG was involved in several transactions. P&W Engine Leasing has some engines in their portfolio, mainly being used to support operators.

The PW4000 100" engine is quite successful with operators and it is not suffering any major problems. There is a market demand for spare engines because the installed fleet is continuously growing and still quite young. IASG believes this trend will continue for the next three years, when the engine will be more mature and the installed base will not be growing at today's rate. IASG expects the market to increase, with good opportunities for new investors.

Currently engines can be leased for as little as \$2,300 per day for long term lease; however IASG anticipates this number to increase over the next 12 months.

This article is an abbreviated version from Paolo Lironi of IASG Powerplant Support Services.

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