

V2500 family specifications

The V2500 family has nine variants in three sub-families. A description of the engines' design & capabilities is given.

The V2500 is the product of International Aero Engines (IAE), a multi-national consortium led by senior shareholders Rolls-Royce (RR) and Pratt & Whitney (PW), with JAEC and MTU Aero Engines. The engine is a dual-rotor, axial-flow family of high bypass turbofans with: a single stage fan; three- or four-stage low-pressure compressor (LPC); 10-stage high-pressure compressor (HPC); annular combustor, two-stage high-pressure turbine (HPT); and a five-stage low-pressure turbine (LPT).

The V2500 is available for the A319, A320, A321 family of jetliners, and the Airbus Corporate Jetliner (ACJ) aircraft of these same types. It also powers the now out-of-production Boeing MD-90.

One V2500 is being produced a day, rising to 400 a year by the end of 2008, and even more for 2009. FlightGlobal's ACAS aircraft fleet database says there are 1,600 V2500-powered aircraft in operation. A small number have been parked, retired or destroyed.

The V2500 incorporates technologies developed by IAE's partner companies,

like the RR RB211's hollow wide-chord fan blades and the PW PW4000's 'floatwall' combustor. Technology for the 10-stage HPC was derived from the RR RC34B research compressor programme in the 1960s. The partners in the JAEC originally collaborated with RR in the late 1970s to develop the 20,000lbs thrust RJ500 for the Boeing 737-300, but the programme was cancelled in the early 1980s after the rig testing of two engines.

In 1982, attention was focused on developing an engine in the 25,000lbs-thrust class for the 150-seat market. The engine was initially called the RJ500-35, but when PW, MTU and FIAT joined the consortium, the engine was renamed the V2500. The 'V' prefix denoted the five original partners, and '2500' the original thrust level of 25,000lbs. FIAT later withdrew from the consortium.

The V2500 is more advanced than the RJ500 demonstrator, with a larger diameter of 63.0 or 63.5 inches. Three booster or LPC stages raise the overall pressure ratio. There are two extra LPT stages to drive the larger fan mass-flow and support the higher bypass ratio.

V2500-A1

The first version of the V2500 to be developed, V2500-A1, was FAA-certified in June 1988 for use on initial models of the A320-200. This engine was rated at 24,800lbs thrust at ISA+15°C and has a bypass ratio of 5.4:1 (see table, page 12). No A320-100s were equipped with the V2500-A1. These aircraft were all CFMI-powered. Of the 143 original V2500-A1-powered A320s built, 136 are still in active service. Air India operates the largest fleet, with 48.

In 1994 IAE replaced the original V2500-A1 with the -A5 series. This was more capable, had higher thrust ratings and significantly improved EGT margin. It also achieved longer removal intervals.

In total, 362 -A1 model engines were manufactured before production switched to the -A5.

The -A5 added a fourth LPC booster stage and a larger main fan. The fan-diameter increased from 63 inches on the -A1, to 63.5 inches on the -A5. The -A5 series has five thrust ratings of 23,040lbs, 24,480lbs, 24,800lbs, 29,900lbs and 31,600lbs with corresponding bypass ratios of 4.9, 4.8, 4.6 and 4.5:1 (see table, page 12). All future deliveries of V2500-powered A319, A320 and A321 aircraft will therefore have engines with identical turbomachinery.

V2522-A5 and V2524-A5

The V2500-A5 family has five variants, with a nominal thrust rating of 22,000-33,000lbs (see table, page 12). For the actual thrusts listed it is assumed that the engine inlet air has: a temperature of 59 degrees Fahrenheit and a density of 29.92 inches of Hg; no fan or compressor air bleed or load on accessory drives; ideal inlet pressure recovery; and a mixed exhaust system with no internal pressure losses and a mixed primary nozzle velocity coefficient equal to 1.0. Under these conditions, the V2522-A5 and V2524-A5, as offered on the A319, are FAA-certified at 23,040lbs and 24,480lbs respectively (both at or below ISA+40°C).

The V2522-A5 powers 127 delivered aircraft. United has the largest fleet of V2522-A5 powered A319s with 55 in service and 23 on order. Its sibling, the V2524-A5, powers 188 A319s in active service, with 87 still on order. US Airways flies the largest fleet of 39 aircraft.

The V2500 is now dominated by the -A5 series for the A320 family. The V2500 has been designed for fuel efficiency, and features a two-stage HPT. The engine also has a reputation for good EGT margin retention.



V2500 SERIES THRUST RATING & SPECIFICATION DATA

Engine model	Aircraft application	Take-off thrust lbs	Maximum EGT take-off Deg C	Maximum EGT continuous Deg C	Bypass ratio
V2500-A1	A320-200	24,800	650/635	625/610	5.4
V2522-A5	A319	23,040	625/635	610/610	4.9
V2524-A5	A319	24,480	635/635	610/610	4.9
V2527M-A5	A319	24,800	645/635	610/610	4.8
V2527-A5	A320	24,800	645/635	610/610	4.8
V2530-A5	A321	29,900	650/650	610/610	4.6
V2533-A5	A321	31,600	670/650	610/610	4.5
V2528-D5	MD-90	28,000	635/635	610/610	4.7
V2525-D5	MD-90	25,000	620/620	610/610	4.9

V2527-A5

The V2527-A5 for the A320's three maximum take-off weight (MTOW) variants is certified at 24,800lbs thrust at or below ISA+31°C (see table, this page). The V2527-A5 is the most popular variant of the V2500, powering 607 A320s in service, and with an order backlog of 468 aircraft. The largest sub-fleet is operated by jetBlue Airways with 103 A320-200s powered by these engines, with another 73 on order.

There are two supplementary options for the V2527-A5: the V2527E-A5 and V2527M-A5. The first is the 'enhanced take-off' model which provides increased take-off thrust for A320s at higher airport elevations than the V2527-A5 base model. The V2527M-A5 provides 'enhanced' climb thrust for the A319 and the A319-based Airbus Corporate Jetliner (ACJ). There are 63 V2527E-A5-powered A320s in service; TACA International Airlines is the largest operator with 22. The V2527M-A5 subvariant accounts for another 31 A320s.

V2530-A5 and V2533-A5

The V2530-A5 and V2533-A5, certified at 29,900lbs and 31,600lbs thrust both at or below ISA+15°C (see table, this page), are available for the A321's five MTOW options. The V2530-A5 powers 60 A321 aircraft. Lufthansa is the largest operator with 20. The V2533-A5 with greater thrust powers 156 A321 aircraft, and has an order backlog of 102 A321s. The largest operator is China Southern Airlines, with 23 aircraft.

V2500-D5

The Boeing MD-90, a derivative of the JT8D-200-powered MD-80, was

powered by the V2500-D5. This has internally identical turbomachinery to the V2500-A5 powering the Airbus aircraft.

The -D5's main external differences relate to the fan case and its rear-fuselage-mounted configuration for the MD-90. Take-off thrusts are 25,000lbs and 28,000lbs both at ISA+15°C (see table, this page). Of 116 delivered MD-90s, 115 are still active, powered by the V2525-D5 (56 aircraft) and V2528-D5 (59 aircraft). The largest MD-90 operator is Saudi Arabian Airlines with 29 aircraft.

Thrust and EGT capabilities

From 1994, the -A5 replaced the -A1 for all models of the A320 family, which includes the smaller A319 whose engines are derated to 22,000lbs or 24,480lbs thrust. Unsurprisingly, even at the higher of these two ratings the engine is, for all practical purposes, unlimited in terms of EGT margin at the highest operating temperatures an aircraft is ever likely to experience. This is borne out by its ability to operate at full A319 thrust levels at temperatures of up to ISA plus 40 degrees.

The EGT margins on the lower rated variants are high, and these engines are flat rated at outside air temperatures of 55 degrees. This is because flat-rating is normally required with engines to preserve some EGT margin at take-off at high ambient temperatures, but these variants' EGT margin of 120 degrees centigrade is more than high enough for flat rating to be unnecessary.

For the same ambient take-off ISA conditions of ISA plus 15 degrees, the V2500-A5's higher core airflow and EGT margins permit higher thrust ratings up to 31,600lbs, higher than the V2500-A1's maximum permissible thrust of 24,800lbs. When the V2500-A5 is

operating in de-rated mode at the same 24,800lbs thrust achieved by the V2500-A1 at ISA plus 15 degrees, the -A5 can still deliver this thrust even under 'hot and high' conditions of ISA plus 31 degrees, and with a superior EGT margin.

For operational redline temperatures, full authority digital engine control (FADEC) software is capable of biasing indicated versus actual EGT values to provide consistent displayed EGT limit values to the aircraft. The actual versus indicated EGT values are controlled by a combination of the software, and data entry plug (DEP) wiring scheme. Engine EGT limits are controlled by the FADEC and DEP, and are only implemented by specific service bulletin instructions. The engine data plate also reflects the engine's thrust limits. The maximum permissible approved EGT values for individual engine models (see table, this page) may not be implemented on all models. The Installation and Operating Manual, document No. IAE-0174(D5) or IAE-0043(A5) fully defines the EGT limit values assigned to specific engine models.

Life limited parts (LLPs) in the V2500-A1's fan, LPC and LPT modules all have lives of 20,000 engine flight cycles (EFC). Those in the HPC and HPT have lives of 12,000-17,000EFC.

The improved V2500-A5 (and -D5) series has 25 LLPs. All current LLPs have lives of 20,000EFC for all thrust ratings, with one exception. Earlier part numbers of the stage 3-8 HPC drum had lives limited to 10,000-16,000EFC. A newer part number 6A7705 increases the life to 20,000EFC in line with the rest of the set.

Major upgrades

There were operational concerns about the EGT margin capability and time on-wing of the baseline V2500-A1 configuration (due to hot-section deterioration) especially when operated from hot-and-high airports like Phoenix, Arizona. IAE therefore offered a hot-section and booster upgrade for existing V2500-A1 engines, dubbed the 'Phoenix Standard', with obvious reference to the hot and dusty conditions there. In 1999, the first V2500-A1 Phoenix Standard engine entered service, updating the original -A1 with the latest hot-section technology from the -A5 engine, to extend the on-wing life of the -A1 and lower maintenance costs by 25%.

The new V2500-A5 build standard, SelectOne, will enter service in the second half of 2008 and, with the V2500Select aftermarket package, will offer more fuel savings and time on-wing, and lower emissions and maintenance costs. **AC**

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