CFM56-7B series specifications

The CFM56-7B has six main variants, with thrust ratings between 19,500lbs and 27,300lbs. These variants and the families features are described.

The CFM56-7B series has six main variants, each of which has several sub-variants. A description of the family is given, together with their thrust ratings, flat rating temperatures and exhaust gas temperature (EGT).

The CFM56-7B for the 737NG family is closely related to the CFM56-5B, which powers the Airbus A320 family. The first -7B engines went into service in 1997 on the first 737-700 with Southwest Airlines. There are almost 2,560 737NGs powered by these engines in service. There are another 2,200 CFM56-7B-powered 737NGs on firm order.

Model groupings

The CFM56-7B series uses a standard two-shaft design with a 61-inch diameter fan. Behind the fan is a three-stage low pressure compressor (LPC), a nine-stage high pressure compressor (HPC), a one-stage high pressure turbine (HPT), and a four-stage low pressure turbine (LPT) to drive the fan and LPC.

The CFM56-7B series has six thrust ratings ranging from 19,500lbs to 27,300lbs thrust *(see table, page 12)*. Bypass ratios vary from 5.5 for the lowest-thrust-rated version, to 5.1 for the highest-rated model.

There are essentially two hardware-differentiated groups: engines that were built prior to the Tech56 modification, and those that have the Tech56 modification. Engines with the Tech56 modification all have a '/3' suffix at the end of their model designation.

The Tech56 engines incorporate an improved-emissions single-annular combustor, a re-designed compressor, and re-designed HPT rotor. Both main production groups include sub-variants covering the six available thrust options.

The thrust version is indicated by a two-digit number immediately following 'CFM56-7B'. The pre-Tech56 thrust variants are therefore as follows: CFM56-7B18 (19,500lbs thrust); CFM56-7B20 (20,600lbs thrust); CFM56-7B22 (22,700lbs thrust); CFM56-7B24 (24,200lbs thrust); CFM56-7B26 (26,300lbs thrust); and CFM56-7B27 (27,300lbs thrust) *(see table, page 12)*. The post-Tech56 model designations and thrusts are exactly the same, except for addition of the '/3' suffix.

Within the two groups, the thrust rating is determined by the data entry plug of the full-authority digital engine control (FADEC) unit. The engine can therefore be easily and quickly re-rated, which facilitates its management and means that it can be used to extend removal intervals between shop visits. This means that the engine can first be used on the 737-900 with one of the highest thrust ratings, and when its EGT margin has been exhausted it can be re-rated to a lower thrust rating as used by the 737-800, -700, and -600. This process allows it to regain some EGT margin that allows it to operate for an extended period.

Additionally, there are sub-variants with modified take-off power management and EGT capabilities for specific applications, such as the Boeing Business Jet. These options are indicated by additional suffixes (after the '/3') such as: 'A'; 'B1'; 'B2'; 'B3'; 'B1F'; and 'B2F'. For example, a 'CFM56-7B27/B1' is the same as -7B27, but with optimised power management at take-off. A 'CFM56-7B26/B1' is the same as a -7B26, but optimised for a business jet mission. Another example is the 'CFM56-7B27A' which is the same as the -7B27, except that it has increased capability for gearbox power extraction. Meanwhile a 'CFM56-7B26/3B2F' is the same as the -7B26/3B2, except for increased EGT limits, which are facilitated by modifications to the FADEC programming.

It should be noted that, unlike its CFM56-5B counterpart on the A320 family, the -7B series does not include an engine variant with a '/P' suffix. The '/P' engine incorporated a redesigned HPC compressor with '3-D aero' blades, a new HPT blade with increased cooling, and a redesigned LPT stage 1 nozzle. The equivalent modifications were already incorporated in baseline -7B engines. Today the '/P' standard has been superseded by the Tech56's '/3' enhancements, which were standard in production engines for the A320 and 737NG from 2007.

For the sake of completeness, it is also worth mentioning a rare '/2' variant which had earlier been offered on the CFM56-7 series. This uses a dual-annular combustor (DAC) for reduced NOx emissions. This option did not prove

There are six main variants of the CFM56-7B. Within each one there are several sub-variants, but the two main groups of engines are the original non-Tech56 modified engines and more recent Tech56 engines. The -7B26 is the most numerous in the global fleet of about 5,100 engines.

CFM56-7B SERIES THRUST RATING & SPECIFICATION DATA

Engine model	Thrust lbs	Flat rate temp	EGT redline (Indicated)	EGT redline (Actual)	Notes	737NGs in service
CFM56-7B18	19,500	30	950	857	Base 19,500lbs model	0
CFM56-7B/3	19,500	30	950	857	Tech56 insertion model	0
CFM56-7B20	20,600	30	950	884	Base 20,600lbs model	125
CFM56-7B20/2	20,600	30	950	894	Dual annular combustor model	0
CFM56-7B20/3	20,600	30	950	884	Tech56 insertion model	0
CFM56-7B22	22,700	30	950	886	Base 22,700lbs model	509
CFM56-7B22/2	22,700	30	950	896	Dual annular combustor model	0
CFM56-7B22/B1	22,700	36	950	886	Extended take-off flat temperature	0
CFM56-7B22/B2	22,700	50	950	920	Extended high altitude and temperature above corner point temperature	0
CFM56-7B22/3	22,700	30	950	886	Tech56 insertion model	4
CFM56-7B22/3B1	22,700	36	950	886	CFM56-7B22/B1 with Tech56	0
CFM56-7B22/3B2	22,700	50	950	920	CFM56-7B22/B2 with Tech56	0
CFM56-7B24	24,200	30	950	908	Base 24,200lbs model	481
CFM56-7B24/2	24,200	30	950	918	Dual annular combustor	0
CFM56-7B24/B1	24,200	41	950	908	Extended take-off flat temperature	0
CFM56-7B24/3	24,200	30	950	908	Tech56 insertion	24
CFM56-7B24/3B1	24,200	41	950	908	CFM56-7B24/B1 with Tech56	0
CFM56-7B26	26,300	30	950	920	Base 26,300lbs model	919
CFM56-7B26/2	26,300	30	950	930	Dual annular combustor	1
CFM56-7B26/B1	26,300	30	950	920	Extended take-off flat temperature	35
CFM56-7B26/B2	26,300	35	950	920	Extended high altitude and temperature above corner point temperature	0
CFM56-7B26/3	26,300	30	950	920	Tech56 insertion	53
CFM56-7B26/3B1	26,300	30	950	920	CFM56-7B26/B1 with Tech56	0
CFM56-7B26/3B2	26,300	35	950	920	CFM56-7B26/B2 with Tech56	0
CFM56-7B26/3F	26,300	30	950	940	CFM56-7B26/3 except for increased EGT limits	0
CFM56-7B26/3B2F	26,300	30	950	940	CFM56-7B26/3B2 except for increased EGT limits	0
CFM56-7B27	27,300	30	950	920	Base 27,300lbs model	314
CFM56-7B27/2	27,300	30	950	930	Dual annular combustor	0
CFM56-7B27/B1	27,300	30	950	920	Optimised power management take-off	78
CFM56-7B27/B3	27,300	30	950	920	Optimised power management take-off	2
CFM56-7B27A	27,300	30	950	920	Increased gearbox extraction	0
CFM56-7B27/3	27,300	30	950	920	Tech56 insertion	9
CFM56-7B27/3B1	27,300	30	950	920	CFM56-7B27/B1 with Tech56	0
CFM56-7B27/3B3	27,300	30	950	920	CFM56-7B27/B3 with Tech56	0
CFM56-7B27/3F	27,300	30	950	940	CFM56-7B27/3 except for increased EGT limits	0
CFM56-7B27/3B1F	27,300	30	950	940	CFM56-7B27/3B1 except for increased EGT limits	0

popular, however, and only one aircraft is listed with these engines, according the ACAS fleet database.

The specifications of all engine models are summarised *(see table, this page)*.

Flat rating and EGT calibration

Engine ratings are based on calibrated stand performance (sea level static). Take-off thrust is nominally independent of ambient temperature (or 'flat rated') up to ambient temperatures of International Standard Atmosphere (ISA) + 15ºC (30ºC) for all models, with some exceptions. The -7B22/B1 and -7B24/B1 are flat rated up to ISA + 21ºC (36ºC), the -7B24/B1 and -7B24/3B1 are flat rated up to ISA + 26ºC (41ºC), the -7B26/B2 is flat rated up to ISA + 20ºC (35ºC), and the -7B22/B2 and -7B22/3B2 are flat rated up to ISA + 35ºC (50ºC).

Furthermore, while the 'indicated' maximum permissible take-off EGT for all -7B series engines is 950ºC, these take-off EGT redlines are accomplished in the engine control unit (ECU) software via an EGT 'shunt' and an EGT 'trim' applied to the actual value. The actual EGT and indicated take-off EGT redline value of 950ºC for each of the models are summarised *(see table, this page)*.

The EGT shunt adds 30ºC to actual measured engine EGT on CFM56-7B and -7B/3 series engines, while it adds 10ºC to actual measured engine EGT on the CFM56-7B/3F series engines, and adds 20ºC to the actual measured engine EGT on the CFM56-7B/2 series engines to provide an indicated EGT level.

This EGT shunt is triggered above a core speed of 8,500RPM for all CFM56 series engines. In addition, EGT 'trim', which is applied only under certain operating conditions, adds specific values to the indicated EGT levels. This EGT trim is only triggered from Mach 0 to 0.40, and when the core speed is greater than 11,200RPM. This function is only applicable for certain models.

It should also be noted that maximum continuous thrust, which is higher than take-off thrust, is nominally independent of ambient temperature (or flat rated) up to an ambient temperature of ISA + 10ºC (25ºC) for all models. Actual EGT is again adjusted using the shunting technique to realise the indicated maximum permissible maximum continuous EGT of 925ºC for all engines. This EGT shunt is triggered above 8,500RPM core speed for all CFM56 series engines.

Tech56: 'Tech Insertion'

The major upgrade and new production standard of the CFM56-7B series is the 'Tech Insertion' (TI) upgrade, which entered into service in the middle of 2007. The package includes a new '3D-Aero' compressor blade design, an enhanced single-annular combustor, and an improved blade and low pressure nozzle design, which result in lower interaction losses between high and low pressure turbines.

According to Stephane Garson, general manager of product marketing Commercial Engines for the CFMI partner Snecma, TI aims to reduce

The six main CFM56-7B variants have the same basic hardware, and thrust rating is only changed through programming of the engine's FADEC unit. Engines rated with high thrusts can be re-rated down to lower thrusts after EGT margin is eroded to increase on-wing life.

maintenance costs by up to 12% (from better durability and time-on-wing). The improved engine will also burn up to 1% less fuel and exhibit a reduced performance deterioration rate. The newer standard is fully intermixable and interchangeable with existing configurations, and will also reduce NOx emissions by 20-30% (CAEP VI compliance certified).

Garson explains that the TI upgrade has created a new engine model called the '/3'. "At the time of entry into service, the catalogue price was the same as that of the previous model for the same thrust rating," explains Garson. "Moreover, when a customer wants to upgrade his engine to the /3 standard during a shop visit, the price of the new parts is the same as the price of the previous standard. For example, the price of the life limited parts (LLP) set remains unchanged whenever you buy a /3 standard or the previous standard."

According to Snecma, LLP lives for the TI package are as follows: the fan disc, booster spool and shaft are all 30,000EFC; in the HPC section, the front shaft, stage 1-2 spool, stage 3 disc, stage 4-9 spool and CDP seal are all 20,000EFC; in the HPT, the front shaft, front air seal, disc, and rear shaft are all 20,000EFC; and in the LPT section, the shaft, conical support, and stage 1-4 discs (each) are life-rated at 25,000EFC. In addition, the life-limits for the LPT stator LLPs (turbine rear-frame and LPT case) are dependent on the specific thrust variant.

EGT margin & OAT

As with other models of the CFM56, the -7B's FADEC is programmed to allow the engine to deliver its maximum thrust rating up to, but not exceeding, the 'flat-rate' corner point temperature. For all these engines, their EGTs increase at a rate of about 3.5 degrees per one degree increase in outside air temperature (OAT). The EGT therefore rises to a maximum allowable level, which is lower than the engine's red-line EGT. The latter is the actual EGT redline which varies between 857 and 940 degrees centigrade, and which must never be exceeded *(see table, page 12)*. The difference between the engine's actual EGT and the red-line temperature is the EGT margin, and is measured at the reference point of the corner point temperature. The engine will actually have a higher EGT margin for OATs lower than the corner point.

For OATs higher than the corner point temperature, the FADEC is programmed to keep the engine's EGT constant by reducing thrust output. This maintains a constant margin between the actual EGT and the certified red-line temperature, despite the higher OAT. The engine's EGT margin is therefore constant for all temperatures above the OAT. The engine's thrust is reduced, however, for OATs higher than the corner point temperature.

The EGT margin increases by about 3.5 degrees for every one degree drop in OAT below the corner point temperature, however.

Moreover, as the engine's condition deteriorates as a result of operation, the EGT, up to the corner point temperature, also gradually increases. The EGT margin therefore decreases by the same amount. The engine can remain in operation until the EGT margin has reduced to zero. The engine will still actually have some available EGT margin at OATs lower than the corner point temperature.

EGTs in operation are highest for the highest rated -7B27 engines, which therefore have the lowest EGT margin. Conversely, the lowest rated -7B18 has the highest EGT margin. It should be noted that to suit certain operations, particularly for the BBJ's low-cycle, high-thrust business-jet mission requirements (for short take-off field length and rapid hot-and-high climb-rate), CFMI offers versions of the -7B which have extended EGT capabilities, that is, maximum take-off thrust above the nominal flat-rate temperature of 30°C for the passenger applications. Examples of these extended flat-rate corner points include: CFM56-7B22/B1 with 36°C; CFM56-7B22/B2 with 50°C; CFM56-7B24/B1 with 41°C; CFM56-7B26/B2 with 35°C.

In general, EGT margins are at their highest levels when the engines are new. The rate at which EGT margins decline with engine deterioration determines life on-wing. The highest rated -7B27 models on the heaviest 737-900s can logically expect to have the shortest removal intervals. "The removal interval will depend on the thrust of the engine," says Garson. "-7B18 to -7B24 engines, with the lower ratings, will most likely see their removal interval driven by flight cycles on-wing when they reach their LLP life limit.

"The -7B26 and -7B27 engines, with the higher ratings, will in all probability see removal intervals driven by flight hours on-wing and EGT margin loss, when performance restoration will be requested. It obviously also depends on flight hours:flight cycle ratio," continues Garson.

Moreover, since the EGT margins of engines following shop visits are typically 60-80% of original levels, second and subsequent removal intervals are therefore shorter than the first intervals. High EGT margins of lower-rated variants allow engines to achieve lower maintenance costs, and allow aircraft to operate with fewer performance restrictions in high ambient temperatures compared to their higher-rated family members. AC