CFM56-5A/5B series specifications

The CFM56-5A/-5B series has many variants and sub-variants. A complete description of the family is given, together with their thrust ratings, flat rating temperatures & EGT margins.

The CFM56-5A and -5B series followed the development of the -3 series. The -5A and -5B are one of two engine options available for the A320 family. The CFM56-5A was the original engine on the A320, which gave the CFM56 a market lead over the V.2500 series. The first engines were -5A series powerplants that went into service in 1987, and continued to be manufactured up to 2003. The -5B was developed to provide higher thrust ratings for all A320 family members. The first engines entered service in 1993 and are now the only CFM56-5B series available for the A320 family. To date 3,500 A320 family aircraft have been ordered, and about 2,000 of these have had CFM56-5A/-5B engines specified.

Configuration

The CFM56-5A/-5B have a two-shaft design, and overall have four and eight different thrust ratings between 21,600lbs and 32,000lbs thrust *(see table, page 9)*.

-5A series

The CFM56-5A has a 68.3-inch diameter intake fan, a three-stage low pressure compressor (LPC) booster, a single-stage high pressure turbine (HPT), and four-stage low pressure turbine (LPT). The engine also has a full authority digital engine control (FADEC) as standard. The -5A series engines have red line exhaust gas temperatures (EGT) of 890 and 915 degrees centigrade, depending on modification status. The -5B series have red line EGTs of 950 and 940 degrees centigrade, depending on their sub-variant.

The -5A series has four ratings. The first variant introduced into service was the -5A1, rated at 25,000lbs thrust. This was used to power the A320-100, and also powers the higher gross weight A320-200 model. The -5A1 is flat rated to an outside air temperature (OAT) of 30 degrees centigrade.

This flat rating temperature is significant, because the engine is allowed to operate at maximum thrust for all OATs up to this flat rating temperature. The -5A1's EGT increases by 3.1 degrees for every one degree increase in OAT when operating at maximum thrust. The engine's FADEC and engine control unit then maintain the engine's EGT at a constant level by reducing thrust as OAT increases beyond the flat rating temperature. This reduction in thrust for OATs higher than the flat rating or 'corner point' temperature means that the aircraft may suffer take-off weight and payload penalties.

The other -5A variant for the A320 is the -5A3 rated at 26,500lbs thrust. This also has a flat rating temperature of 30 degrees. The engine's EGT increases at a rate of 3.1 degrees for every one degree increase in OAT below the corner point temperature.

The two variants available for the A319 are the -5A4 rated at 22,000lbs thrust and the -5A5 rated at 23,500lbs thrust. The lower rated -5A4 is flat rated to 45 degrees centigrade, and this higher corner point temperature is beneficial to airlines operating in hot environments. The engine's EGT increases by 2.9 degrees for every one degree increase in OAT. The -5A5 has a corner point temperature of 37 degrees centigrade. EGT increases by 3.0 degrees for every one degree increase in OAT.

A modification programme was developed for three of the -5A series variants, denoted by a /F suffix. This allows the engine to run hotter, via hot section modifications, and so provides it with an increase in EGT certification from 890 to 915 degrees centigrade, thereby increasing the EGT margin by up to 25 degrees centigrade.

-5B series

The -5B series was developed to power all proposed variants of the A320 family, because the -5A series did not have the growth potential that the A321 required. The -5B's configuration is similar to the -5A, but the -5B features a fourth LPC stage which allowed the engine to be developed to provide up to 32,000lbs thrust, and to increase coreflow. The engine could also be de-rated to power all other members of the A320 family.

The -5B series has nine different variants with eight different thrust ratings *(see table, page 9)*. The -5B3 is the highest rated at 32,000lbs thrust, used to power the highest gross weight models of the A321, while the -5B8 is the lowest rated at 21,600lbs thrust for the lighter A318 model. All nine variants share the same hardware for the eight different ratings, and thrust rating is changed by using the data entry plug. The engine can therefore easily and quickly be re-rated, which facilitates its management and can be used to extend removal intervals between shop visits. This means that the engine can first be used on the A321 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 A320 and A319. This process allows it to regain some EGT margin that will enable it to operate for an extended period.

There are three main variant groups of the -5B series. Each one of these has sub-groups. The first of these three main groups comprises the 'classic' -5B engines. This was the first group of -5Bs manufactured between 1993 and 1996, and fewer than 300 were produced. There are only six variants: the -5B1, -5B2, -5B4, -5B5, -5B6 and -5B7. The highest rated -5B3 and lowest rated - 5B8 and -5B9 were not available at the time. These engines are recognisable by the absence of a suffix on their variant name.

The -5B2 powers the A320. It has the highest rating in this group of 31,000lbs thrust, and a corner point temperature of 30 degrees *(see table, page 9)*. The -5B1 also powers the A321, has a rating of 30,000lbs thrust and a corner point temperature of 30 degrees. This relatively low corner point temperature could mean that the A321 will be performance limited on some routes when operating in hot climates.

The -5B4 and -5B7 are both rated at 27,000lbs thrust, power the A320 and have a corner point temperature of 45 degrees *(see table, page 9)*. The -5B7 can also be used to power the A319.

The -5B6 is rated at 23,500lbs thrust, and can be used to power the A320 and A319. It also has a corner point temperature of 45 degrees. The -5B5 is rated at 22,000lbs thrust, has a corner point temperature of 45 degrees centigrade, and can also be used to power the A320 and A319 *(see table, page 9)*.

These six original variants of the -5B have an EGT of 950 degrees centigrade.

The second main group of -5B variants is recognised by the /P suffix following their variant nomenclature. The

The -5B series has nine variants. The series is also split into three sub-variants. These are the original or 'classic' engines, the -5B/P engines and the -5B/3 engines. There are less than 200 classic engines in the fleet, which is dominated by the -5B/P, accounting for more than 2,000 engines in operation. The -5B/3 will be the standard production engine from the fourth quarter of 2007.

/P suffix was used to designate an improved performance modification. The main features were a redesigned HPC compressor that used 3-D aerodynamic blades, a new HPT blade that had increased cooling, and a redesigned LPT stage 1 nozzle.

This was included as standard on the production line, but was also available as a modification that could be incorporated in a shop visit. The majority of classic engines were upgraded to /P engines, leaving only 48 in their original configuration.

The /P engines had about 3% lower specific fuel consumption (sfc) over the classic -5B engines.

This group includes all nine variants. The first of these was the -5B3, the highest rated -5B variant. It is rated at 32,000lbs for the A321, and has a corner point temperature of 30 degrees.

This group also includes the two lowest rated variants. The first is the -5B8, the lowest rated -5B variant, rated at 21,600lbs thrust. It is used to power the A318, and has a corner point temperature of 45 degrees centigrade *(see table, page 9)*. There is also the -5B9, rated at 23,300lbs thrust and used to power the A318 Elite, which is the corporate version of the A318.

The nine /P variants in this group are certified with an EGT of 940 degrees centigrade, 10 degrees lower than the classic engines.

The third group of engines has a /3 suffix. These will be standard production engines from late 2007, and the /3 designates a 'Tech Insertion' standard, which is a modification that offers several improvements to reduce sfc and NOx emissions, and provide a higher EGT red line limit and overall better durability.

The main features include redesigned and more aerodynamic stage 1-9 HPC blades, an upgraded single annular combustor (SAC) that will meet CAEP6 NOx emissions standards, improved cooling for durability, and redesigned HPT blades that will assist in lowering sfc *(see CFM56-5A/-5B Modification programmes, page 10)*. The /3 'Tech Insertion' modification can also be installed on existing engines during a shop visit.

Sub-variants

In addition to the three main groups of -5B variants, there are also several sub-variants. The first of these sub-groups comprises the engines with the dual annular combustor (DAC). These are denoted by the /2 suffix. The DAC was designed to reduce NOx emissions, and airlines operating in areas that impose specific penalties related to emissions have specified the DAC. The standard specification of the -5A and -5B engines is the SAC.

Of the six variants of the classic engines, four were available as DAC engines: the -5B1, -5B2, -5B4 and -5B6. The majority of classic engines were specified with the SAC, but Swissair and Austrian Airlines ordered classic DAC engines.

The other main specification feature of -5B engines is the 'thrust bump'. As described, the engine's thrust is reduced from maximum thrust when operating in OATs above its corner point temperature. This can restrict an aircraft's performance by limiting its take-off weight and payload on certain routes. Thrust bump is achieved by extending the engine's corner point by a few degrees, so that the engine's FADEC will allow the maximum thrust rating to be provided to a higher corner point temperature. This facility could be useful not only for aircraft operating in hot environments, but also for those using high airfields or short runways, or where steep climb capability is required.

Of the /P engines, the -5B3 and -5B4, which are the highest rated engines for the A321 and A320, are available with thrust bump capability. This is provided via programme changes to the engine's FADEC, but it incurs penalties in cycle times counted on the engine's life limited parts (LLPs).

Airlines can choose from several combinations of specification. Besides the regular /P, the -5B3 and -5B4 are available as the /P1, which is the /P with the thrust bump capability.

Six of the /P variants are available with the DAC combustor. These are the -5B1, -5B2, -5B3, -5B4, -5B6 and -5B9, and are denoted with the /2P suffix. Finnair ordered /P engines with the DAC combustor.

The -5B3 and -5B4 are also available with the DAC combustor and thrust bump, and are denoted with the /2P1 suffix.

The third main variant group of /3 engines includes the option of a thrust bump for the -5B3 and -5B4 engines. These are the -5B3/3B1 and -5B4/3B1.

Life limited parts

The -5A series has 18 LLPs, which have a total list price of $1.75 million. These are split between three in the fan/booster module with a list price of $375,000, five in the HPC module with a list price of $460,000, four in the HPT

with a list price of $419,000, and six in the LPT with a list price of $500,000.

CFMI's policy is to set target lives of 30,000 engine flight cycles (EFCs) for the three fan/booster LLPs, a target life of 20,000EFC for the nine HPC and HPT LLPs, and a target life of 25,000EFC for the six LPT LLPs.

There are several part numbers for each LLP, and some part numbers have had their lives limited to less than their target lives. Other part numbers have been issued as a consequence, so there is now a range of lives for each LLP. The fan disk and booster spool part numbers for the -5A series have lives of 23,000-30,000EFC. All parts for the fan shaft have a life of 30,000EFC. Most part numbers for all LPT LLPs have lives of 25,000EFC, and all part numbers of HPC LLPs have lives of 20,000EFC. The module with the most life restrictions is the HPT. The rotating forward air seal in particular has some part numbers that are restricted to lives of 11,000EFC in the -5A1, 7,700EFC in the -5A3 and 9,100EFC in the -5A5. There are other part numbers used in the HPT whose lives are also limited to several thousand EFC fewer than the target life of 20,000EFC.

The -5B has 18 LLPs with a total list price of $1.83 million. CFMI has the same target lives for the four main modules as the -5A series. The three parts in the fan/booster module have a list price of $406,000, the five parts in the HPC have a list price of $447,000, the four parts in the HPT have a list price of $474,000, and the six parts in the LPT have a list price of $503,000.

Part numbers for the fan disk are limited to 20,000-25,000EFC, while the other two LLPs in the module have lives of 30,000EFC. Five of the six LPT part numbers have lives of 25,000EFC, and the sixth LLP has lives of 15,000-25,000EFC. Most part numbers for the HPC have lives of 15,600-20,000EFC. Like the -5A, the HPT has part numbers with the most limitations. These have lives between 6,400EFC and 20,000EFC. The worst affected part numbers in this module are those used in -5A engines. Part numbers used in the HPT of -5B engines have lives of 12,400-20,000EFC. Moreover, only a minority of engines have parts with lives as short as 12,400EFC. There are a larger number of engines, however, with parts that have lives as short as 15,300EFC and 17,600EFC.

The /3 engines with the Tech Insertion programme will, however, have all LLPs with lives certified at the target lives.

EGT margin

As described, the engine's FADEC is programmed to keep the engine up to its maximum thrust rating up to the corner point temperature. The EGT increases at a rate of about 3 degrees per one degree increase in OAT. The EGT therefore rises to a maximum allowable level, which is lower than the engine's red line EGT. This is the exhaust temperature between 890 and 950 degrees centigrade, which must never be exceeded. The difference between the engine's actual EGT and the red line temperature is the EGT margin. The EGT margin is measured at the reference point of the corner point temperature. The engine will actually have a higher EGT margin for OATs below the corner point.

For OATs higher than the corner point temperature, the FADEC is programmed to keep the engine's EGT constant, so that the difference between the EGT and the red line temperature is the same. The engine's EGT margin is thus the same for all temperatures above the OAT, but the EGT margin increases by about 3 degrees for every one degree drop in OAT below the corner point temperature.

As the engine's condition deteriorates as a result of operation, the EGT gradually rises and the EGT at the corner 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 EGT margin at OATs lower than the corner point temperature.

The engine's EGT is highest for the highest rated -5B3 engines, which therefore have the lowest EGT margin. The -5B3, as well as the -5B1 and -5B2, also has a low corner point temperature of 30 degrees centigrade. Conversely, the lowest rated -5B8 has the highest EGT margin, as well as a higher corner point temperature of 45 degrees.

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 -5B3 and -5B1 engines can therefore expect to have the shortest removal intervals. Moreover, EGT margins of engines following shop visits are only 60-80% of original levels, which means that second and subsequent removal intervals are shorter than the first intervals.

The high EGT margins and high corner point temperatures of lower rated engines therefore enable engines to achieve lower maintenance costs and allow aircraft to operate with fewer performance restrictions in high ambient temperatures than the higher rated family members. AC

CFM56-5A & -5B EGT MARGINS

Engine variant	-5A3	-5A1/ -5A1F	-5A5/ -5A5F	-5A4/ -5A4F
Thrust lbs	26,500	25,000	23,500	22,000
Application	A320	A320	A319	A319
Red line EGT (deg C)	915	890/915	890/915	890/915
Initial EGT margin (deg C)	71	57/82	50/75	55/80
Corner point temperature (deg C)	30	30	37	45

Engine variant	-5B3	-5B2	-5B1	-5B7	-5B4	-5B6	-5B5	-5B8
Thrust lbs	32,000	31,000	30,000	27,000	27,000	23,500	22,000	21,600
Application	A321	A321	A321	A320	A320	A319	A319	A318
Red line (deg C)	940	950/ 940	950/ 940	950/ 940	950/ 940	950/ 940	950/ 940	940
Initial EGT margin (deg C)	66	95	115	109	109	145	163	180
Corner point temperature (deg C)	30	30	30	45	45	45	45	45