

While opinion and attitudes towards PMA parts are divided, the use of PMAs in engines and engine maintenance continues to grow. The range and sophistication of engine parts is constantly increasing. A survey lists major engine PMA parts suppliers and their products.

PMA engine parts providers survey

Until about a decade ago, aircraft owners and operators were obliged to use airframe and engine parts provided by an original equipment manufacturer (OEM). OEM parts not only have high list prices, but also have high annual price increases applied to them.

Parts manufacturer approved (PMA) parts have become more accepted over the last 10 years, despite having been regulated since 1955, and part of the remit of the Federal Aviation Administration (FAA) since 1965. At the start of 2010 there were more than 300,000 different approved PMA parts for general, corporate, commercial and military aircraft. That number is likely to grow by 35,000 every year (*see PMA parts: the market & major suppliers, Aircraft Commerce, December 2009/January 2010, page 32*). These parts are regulatory body-approved, so they have exactly the same quality and standards as their OEM counterparts, but at a saving of up to 75%.

More airlines are starting to use PMA parts to control costs, although the total number of PMAs in existence accounts for a small percentage of the total part numbers ever conceived. It is therefore not possible for all parts to be replaced with PMA parts.

While many welcome the reduced costs of PMAs, aircraft and engine lessors are less keen on them. They often stipulate that an aircraft or engine is returned with genuine OEM parts, since they are concerned with issues of reduced asset value. Some operators also have a policy of not using PMA parts, which could leave aircraft and engine owners with a large part-swapping exercise after assets have been returned from lease.

Consideration should also be given to the fact that not all parts of an engine are actually made by the OEM in the first

place. An engine OEM typically manufactures 25% or less of the original parts for its engines. Many parts are originally made by other companies under the approval of the engine OEMs. Some of these other parts manufacturers also make PMA parts. These can be the same parts they make for the OEMs, but the PMA parts can be of a similar or even superior quality to the original parts.

PMA acceptance

Non-OEM and PMA engine parts must be approved, primarily by the FAA. This is a two-pronged approval, involving both the design and the manufacture of the part. The FAA has bilateral airworthiness agreements (BAA) with a number of other countries, including many in Europe and the Asia Pacific. This means that FAA-approved PMA parts can also be used in those countries, although there may be further restrictions. An operator in a country with no BAA in place has no alternative but to use original parts. This is especially important to lessors, which may be leasing an engine to an operator in a country that does not recognise PMA parts. The European Aviation Safety Agency (EASA) is also looking at its own approval process, to simplify bilateral approvals and allow the European maintenance, repair & overhaul (MRO) market to compete equally with that in the US.

There are some reciprocal agreements between the two agencies, and their member states. For example, from 2007 EASA accepted FAA-approved PMA parts, provided they are not considered a critical part. There is still some confusion as to what exactly EASA will allow. The BAAs and original FAA regulations are therefore still important for European operators and maintenance facilities.

One important point to note about

PMA parts is that they are always, by the very nature of their approval and testing, equal or superior to their OEM equivalent. In reality the part is unlikely to gain approval, unless it exceeds the performance of the OEM part.

PMA engine market

A specific area of the PMA industry deals with those parts related to aircraft engines. Due to the differing temperatures, stresses and forces that engine parts endure, specialist knowledge and tooling is required, so engine PMA part manufacturers make up a small percentage of PMA suppliers generally.

Engine-related PMAs, despite their precision, were some of the first aircraft-related PMAs to be developed. This was not popular with engine OEMs, which attempted to limit the growth of PMA part use. One of their tactics has been to encourage operators to take up maintenance support contracts provided by the OEMs when they purchase the engines. These contracts will undoubtedly use genuine parts, and have proven to be popular. "Engine OEMs' control engine MRO activities, and few truly independent MROs remain," says Tom Post, director of new product development for ADPma. "As acceptance of PMAs has increased, OEMs have effectively addressed the competitive threat through maintenance agreements, comprehensive engine upgrades and joint ventures, investments and licensing agreements with independent MROs."

As an engine ages and a contract ceases with the OEM, then PMAs become more popular. Used engines are likely to be operated by second- and third-tier operators. The parts and components make up the largest portion of engine maintenance costs. The cost reductions from using PMAs can be immense across



a fleet. As an engine ages, the value decreases, and the use of PMA parts may not have such a negative effect on values and re-marketing.

PMA manufacturers

Only a small number of the many PMA parts suppliers around offer PMA parts for engines. Most are based in the US, with some also having a presence on other continents.

The major players in the engine PMA market have been surveyed (see table, page 36).

ADpma

When Avio-Diepen of The Netherlands acquired PMA Inc., it formed the subsidiary ADpma. Product development and project management are undertaken at Avio-Diepen's Atlanta offices, and engineering, certification and manufacturing in Tennessee.

Areas of knowledge include Air Transport Association (ATA) Chapters 71-73, 75, 79 and 80 that involve engine parts relating to fuel, air, oil and starting mechanisms. ADpma has built a product development team comprising experienced airline, engineering, manufacturing and operation support professionals.

In 2002 ADpma gained FAA-PMA approval to produce 335 parts for engines and airframes, and now has more than 35 major airline customers worldwide. Nearly half are also maintenance providers.

Aero Kool Corporation

Aero Kool, in Miami, has been a parts

repair and overhaul facility for over 50 years. It also offers FAA-PMA authorised parts through its specific manufacturing division. Capabilities cover a continually expanding list of airframe and engine accessories and line replacement units (LRUs) including valves and air starters.

Aviation Component Solutions

Aviation Component Solutions (ACS) specialises in providing FAA-approved PMA parts. Based in Ohio, USA, it also has a presence in Europe and Asia Pacific.

Taking into account the regulations, it works with an airline or MRO customer to address an issue, and then engineer a solution at a fraction of the OEM cost using typical metals and coatings. It be at least 30% cheaper than current OEM prices, with some parts being as much as 60% cheaper. On average ACS can offer savings of 40%, with most parts relating to ATA Chapters 73 and 75.

Belac

Like ADpma, Belac is a subsidiary of a larger company, with the sole purpose of offering PMA parts. Belac is a joint venture between Chromalloy and a number of major airlines and their maintenance departments (Lufthansa Technik, United Airlines and Alitalia) that started in Florida in 1998.

Belac concentrates on the design and manufacture of high pressure turbine (HPT) blades that meet or exceed FAA specifications. Belac was the first to gain approval for PMA HPT blades in commercial passenger-aircraft engines.

Like ADpma, Belac uses former FAA and industry experts, including metallurgists, software and other

Chromalloy, and its JV Belac, are the largest provider of PMA engine airfoils, particularly HPT blades. HPT blades can be acquired for as little as 40% of OEM's list prices for the equivalent parts.

scientific specialists, to work alongside customers during the manufacturing process. All Belac's blades come with a full warranty and down-stream damage coverage. Over 50,000 HPT blades are currently in operation, having completed about 200 million engine flight hours (EFH).

Belac parts average 40% savings, depending on the type of engine the PMA part is required for.

Chromalloy

Since starting as an airfoil coatings company in the 1950s, Chromalloy has developed into a major manufacturer and repairer of aviation parts, as well as a producer of coatings. As well as dealing with part manufacturing for OEMs, it manufactures FAA-approved PMA parts. Chromalloy produces engine PMA parts in-house and through its joint venture with Belac. It estimates that over 300,000 of its PMA and replacement parts are in operation.

Its capabilities extend to all but the newest engine types. Parts include those for the HPT, low pressure turbine (LPT) and the high pressure compressor (HPC); with concentration on ATA Chapter 72. Advanced capabilities include the use of laser welding and drilling and single crystal technology. No Chromalloy part has ever been subject to an airworthiness directive (AD).

Dixie Aerospace

Dixie Aerospace is also a subsidiary of a major parts player: Wencor. Located in Georgia, USA, Dixie Aerospace has been a leading manufacturer and repairer of aircraft bearings since 1965.

The first PMA part was produced in 1999, with the 500th part approval gained in 2010. The product catalogue was added to in early 2011 with the acquisition of the PMA parts product line of AAR Corp. Not only has Dixie's product list been increased, but new customers have been gained and as part of the agreement, Dixie is now AAR Corp's preferred PMA parts supplier.

Over 800 PMA parts are available, with plans for over 200 new PMAs each year. Dixie Aerospace estimates that it

GLOBAL ENGINE PMA PARTS PROVIDERS

Company	Location	PMA part capabilities				Engine types	Potential savings vs. OEM prices	
		Airfoils	LLPs	Cases	Accessories & LRUs			
ADpma	Atlanta, USA Tennessee, USA			Y	Y	Y	CF34-3A/-3B, CFM56-7B, JT8D-200 V2500-A5/-D5	30-50%
Aero Kool Corporation	Florida, USA				Y			
Aviation Component Solutions	Ohio, USA					Y	PW2000, PW4000 CF6-50/-80	30-60%
Belac	Florida, USA	Y					CFM56-3, PW4000 CF6-50/-80	40%
Chromalloy	Various locations in the USA & Europe	Y		Y		Y	CF34-3, CF6-50/80, JT9D CFM56-2/-3/-5/-7, PW2000, PW4000-94/-112, JT8D-200	
Dixie Aerospace	Georgia, USA		Y			Y	CFM Int., GE, IAE, RR, PW	
HEICO	Florida, USA	Y	Y		Y	Y	JT8D, CF34, CF6, CFM56, V2500, PW2000, PW4000	
Jet Parts Engineering	Seattle, WA, USA				Y	Y	CF34, CFM56, CF6-50/-80, V2500, PW2000, PW4000, RB211-524/-535,	30-80%
PW Global Material Solutions	Various locations in the US	Y	Y				CFM56-3	
Wencor	Florida, USA		Y		Y		CFM Int., GE, IAE, RR, PW	25-30%

saves its customers thousands of dollars in procurement costs each time. The parts offered by Dixie cover all commercial engine manufacturers, with specialist capabilities in the area of bearings and ATA Chapters 71, 72, 73 & 75.

Dixie Aerospace, like Chromalloy, manufactures both PMA parts and parts for the OEMs, so it is in a fortunate position to improve on a design.

HEICO Aerospace

HEICO is the largest independent supplier of PMA parts, with over four million engine and aircraft component parts delivered to operators every year. Many major engine types are covered, along with most ATA chapters. In 2007, HEICO launched a management programme to assist customers in finding any PMA part, regardless of the provider.

Jet Parts Engineering

Jet Parts Engineering (JPE), in Seattle, began offering PMA parts in 1994 and now has a global client base that includes

Delta Airlines, Lufthansa, United Airlines and independent repair facilities.

JPE has a vast collection of capabilities covering most areas of an engine and in particular accessories, LRUs and smaller items: those in ATA Chapters 72, 73, 75, 78 and 80. Savings are generally about two-thirds, but can be as high as 80%. JPE's method of storage and production means it aims to have every part in stock at all times, in order to reduce lead times for clients.

PW Global Material Solutions

When Pratt & Whitney (PW) entered the PMA market, a certain respectability fell on this area of the parts industry. PW is still the only OEM offering PMA parts, and only deals with the CFM56-3 in this way. This has been born from the maintenance and repair of these engines, and their parts, for a number of years through a global network of facilities.

PW provides 19 life limited parts (LLPs), as well as eight gas path parts. These are LPT stage blades, LPT vanes, and various HPT components. Due to the

large maintenance network that PW already possesses, these parts are not offered to airlines in quite the same way as other PMAs through parts suppliers.

Wencor

Wencor is one of the largest PMA providers, and started manufacturing PMA parts in 1985, having started in Florida in 1955. The company now has multiple locations in the US; as well as in The Netherlands, Singapore and China.

Most commercial engines are covered, although more parts are available for General Electric (GE) and PW engines. Most of the capabilities are for LLPs and smaller items, especially gears, seals and electrical equipment. There are also the bearings produced by Dixie Aerospace. This brings the Wencor Group's total portfolio to over 4,000 parts. About 500 new parts gain approval each year.

List prices for Wencor PMA products are on average 25-30% less than those of the OEMs. The reduction compares OEM prices with Wencor's list price, so additional discounts might be possible

through long-term agreements or large orders.

PMA engine parts

For regulatory purposes, all engine components and structures are listed between ATA Chapters 70 and 79. Chapter 70 deals with standard practices for engines. Chapter 71 is the powerplant general, and this includes the cowling, mounts, wiring and struts. Chapter 72 is the turbomachinery of the engine. It therefore includes blades and vanes, shrouds and seals.

Chapter 73 is the engine fuel and control system. Chapter 74 is the engine's electrical and ignition systems. Chapter 75 relates to the engine's bleed air system, and all accessories related to cooling.

Chapter 76 is for the engine's controls, and includes the autothrottle. Chapter 77 is the engine's indicating and instrumentation. This includes characteristics such as engine speed, fuel flow, temperature and vibration.

Chapter 78 relates to the engine's exhaust, thrust reversers and related indicators. Chapter 79 relates to the engine's oil system, including oil storage and distribution, indication and warning system. Chapter 80 is related to engine starting.

The most expensive parts, due to their complexity, are the blades and vanes as included in ATA Chapter 72. Complexity can mean that many manufacturers may choose not to make them, although the expense will mean that they are possibly the most interesting for aircraft operators, since they provide the biggest cost savings.

Parts alone can represent up to 70% of a total shop visit cost. If it were possible to utilise PMA parts throughout a shop visit, with a conservative 50% cost reduction expected through the use of PMA parts, then the total shop visit (parts and labour) could be reduced by at least 20%. A CFM56 shop visit, for example, can cost about \$2 million, with OEM parts and materials costing \$1.2 million. Calculated across an operator's whole fleet, the saving can amount to millions of dollars, although it has to be measured against the potential reduction in the value of the engine.

Even if an operator or engine owner were happy with the use of PMA parts, not every part, as yet, is available as both an OEM and PMA part. Most importantly, there are critical areas of an engine that many stakeholders might not want PMA parts used in. "Engineers and lessors view gas path parts as critical," says Gordon Harker, sales director, Europe and Africa for Aviation Component Solutions, an airframe & engine accessory component piece-part PMA manufacturer. "The FAA and EASA

also see rotating engine parts as critical. Critical parts are less likely to be accepted by airline engineers for obvious reasons." The obvious reason being that precision is even more important and failure of a part has a greater impact.

The capabilities shown (see table, page 36) have been split into specific sections of an engine: airfoils; LLPs; cases; accessories and line replacement units (LRUs); and smaller items such as brackets, hoses, and clips. Most engine PMA suppliers will specialise in a certain engine type, or engine OEM, or certain sections of an engine or category of parts such as accessories or airfoils.

Airfoils

PMA providers can discount OEM prices significantly, with Belac currently offering HPT airfoils at list prices up to 40% less than the equivalent OEM parts.

The main two PMA providers are HEICO and Chromalloy.

HEICO offers many types of PMAs, including the blades and vanes for the CFM56, CF6, CF34, PW2000, PW4000, V2500, JT8D, and JT9D engines. In addition, HEICO offers PMA fan exit guide vanes and rotating airfoils. Capabilities cover both the hot and cold sections blades in the turbine and compressor.

Hot section airfoils are the blades and vanes of the turbine. The high temperature of turbines requires these parts to be made from specialist metals, as well as having intricate cooling holes and advanced thermal coatings. Belac concentrates on HPT blades, having recently passed the 50,000 mark for blade deliveries. Some airlines have reported that post-flight maintenance shows the Belac blade to be superior, at times, to those of the OEMs. This is

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Belac manufactures first-stage HPT blades for the CFM56-3, CF6-80A2, CF6-80C2, CF6-50, and most recently the PW4000. Despite the PW4000 being a relatively new offering, Belac has already sold over 1,000 of these blades with service experience of over 2.5 million EFH.

This is compared to more than 9,000 blades sold for each CF6-80 engine series; with the CF6-80A and CF6-80C2 each flying for over 70 million EFH.

The first stage HPT blades for the CFM56-3 are the most prolific offering by Belac, with about 20,000 sold (over 250 sets) since approval was gained in 2002.

In addition to first stage blades, Belac offers second stage blades for the CF6-80C2 and the CF6-50, with over 5,000 sold in total and nearly 30 million service hours. Although Belac blades are PMA parts, they are completely interchangeable with OEM blades, both new and repaired.

Belac calculates that its HPT blades have saved operators about \$200 million over the past nine years. Despite its customer base being traditionally the US and Europe, growth over the past few years has predominantly been in the Asia Pacific.

Belac's parent company, Chromalloy, also produces HPT vanes: stage one for the CFM56-2/-3/-5A/-5B/-5C; stage one and two for the PW2000; stage one for the JT9D-7Q; and stage one and two for the CF6-80A/-80C2.

HPT blade offerings include stage one on the CFM56-2/-3, stage one and two on the CF6-50/-80A/-80C2, stage one on the JT8D-200 & PW4000-94, and stage two on the JT9D-3/-20J.

Stators are also offered on the JT9D for stages nine to 14. Stage one LPT vanes are made for the CFM56-2/-3/-5B/-7, while LPT blades are offered for the JT8D-200.

LLPs

LLPs are the disks and shafts, and other rotating parts. LLPs include the combustor, the main bearings and parts of the fan & booster module.

HEICO are a major supplier of PMA shafts, as well as bearings and combustion chambers. Every engine module, from the fan to the engine exhaust, can potentially have a HEICO PMA part, HEICO says, with capability covering the CFM56, CF6, CF34, PW2000, PW4000, V2500, JT8D and JT9D. One of its strong points is the provision of parts that would otherwise be obsolete and hard to source.

PW offers 18 LLPs for the CFM56-3 in association with its engine shops.

A major ball-bearings producer is Dixie Aerospace, with customers including all the engine OEMs, as well as the PMA parts market. Dixie's parent company, Wencor, also deals with LLPs, and has capabilities for the shafts of most commercial engines.

Cases

There are a number of cases within an engine as well as the actual engine cowls and nacelles. The main cowlings are the outer covers from the forward part of the

HEICO is another main provider of PMA engine airfoils. It provides blades and vanes for the CFM56, CF6, CF34, PW2000, PW4000, V2500, JT8D and JT9D engines.

engine; the fan, with the C-duct in the middle covering the exhaust.

Cases are less common as PMA parts, but ADPma offers nacelle PMA parts, such as the engine and nacelle brackets; in particular for the CFM56-5. It also provides hot section cases at a 30-50% cost saving. Alternative or PMA nacelles are also on offer from airframe parts manufacturers. For example, Spirit Aerosystems offers engine nacelles for Boeing aircraft, through its licensing agreement with the airframe manufacturer and through FAA PMA approval.

Chromalloy offers HPT shrouds for the CFM56-2/-3/-5/-7, CF34-3, CF6-50/-80, as well as a baffle for the HPT shroud on the CF6-50. Additionally shrouds are made for the PW4000-112 and the LPT of the CF6-80C2.

Accessories & LRUs

Accessories and LRUs are mounted outside the engine casings. These include the starter, fuel and lube pumps, the gear box, control units, valves, sensors, full authority digital engine control (FADEC) and throttle.

ADPma offers a PMA part for the CF34-3A/3B starter at a 50% reduction on the OEM price. It also offers CFM56-7B HPT CC valves with the same savings. "ADPma specialises in non-rotating engine parts, engine component parts and engine QEC/nacelle parts," says Post. Other capabilities include the shut-off valve, lube pump and fuel control.

JPE offers a number of different engine accessories. The relief valve for the lube and scavenge pump component of the PW2000, and the sleeve and piston of the fuel pump component on the CF6-80 are a few examples. Valves are also on offer, such as a fuel valve for the CFM56-5. It offers additional parts for these engines; as well as for the CF34, PW4000, CFM56-3/-5/-7, CF6-50, RB211 and V2500.

Aero Kool Corporation's speciality is accessories, in particular lube/oil scavenge pumps, various valves, controls and air starters for many different engines.

HEICO again has a lot to offer in this area with capabilities for fuel pumps, gears, valves and starters. Again these can be for the CFM56, CF6, CF34, PW2000,

PW4000, V2500 and JT8D.

The gears and electrical connectors for most engines are offered as PMA parts by Wencor.

Smaller items

There are a number of smaller items that are essential to an engine, and which are often also the most likely to be offered as a PMA part. These items can be as basic as a bracket, hose or clip, but also include seals and heat shields.

Another major business area for ADpma is smaller items offered for the CF43-3A/-3B, JT8D-200 and V2500-A5/-D5. A saving of 50% can be expected with the CF34 and JT8D, while a smaller saving of 35-40% is found with the V2500 parts. Parts include seals, pins and seal rings. Another pins producer is Dixie Aerospace, which also deals with rod ends and bushings, clevises and ducts for most commercial engines. Wencor adds to this product line with seals and electrical connectors.

A large part of JPE's inventory is seals, with specialist seals and seal assembly designs produced for the CFM56-3/-5A/-5B/-7. It also offers gaskets, strips, bushing, containment rings, retaining lock tabs, piston rings and poppets for the above engines and for the PW2000, PW4000, CF34 and JT8D.

Similar engine types are catered for by HEICO. It offers PMA nuts and bolts, rings, spacers, heat shields and insulation blankets. Other miscellaneous items are shrouds, thrust reversers, acoustic panels and nozzles.

ACS offers many accessories and smaller parts, in particular for the PW2000, PW4000 and CF6-50/-80. This includes the spring-helical compression for the number 4 bearing front and rear seal assembly on the PW2000. The same spring for the PW2000's number one and three bearing seal support assembly is offered, as well as for the number one bearing seal assembly on the PW4000. The CF6 part is the bushing core for the thrust reverser.

Chromalloy also deals with seals and rings. Stage seven to 14 airseals are produced for the JT9D-7, as well as the stage two and three airsealing rings for the JT8D-200 and PW2000. For the CFM56-2/-3/-5/-7, Chromalloy also manufactures the HPC stator retainer seal for stages three to seven.

Developments

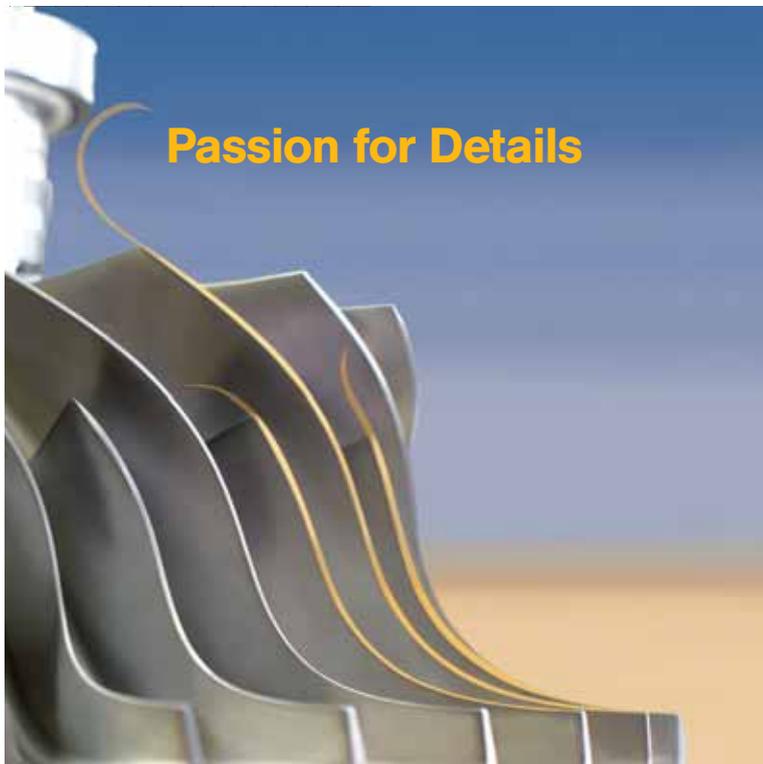
PMA parts are gaining popularity and not just for civilian aircraft and engines. The US military has recently taken note of the cost benefits, and the US Air Force has chosen Belac to produce HPT blades for the military version of the CFM56.

Timken, which deals with PMA parts for the PT6 turboprop engines, also offers parts for smaller jet engines used by the military.

With more operators needing to reduce their costs, and with PMA parts increasing in acceptance, the future for PMA parts looks favourable. It is likely that providers which already offer PMAs will increase both the number of parts and the engines they deal with. "The potential lies with minor parts and expendables, engine components and accessories, and nacelle/engine QEC parts not controlled by the top-tier OEMs. Critical and rotating core gas path parts of the engine will likely remain a battle between the OEMs and Belac and other designated engineering representative (DER) repair schemes," says Post.

PMA parts have a low failure rate and this is likely to aid the growth of the PMA market. PMA providers will choose parts that are cost-effective to make, meaning that no immediate problems with the design have been seen. They may even take parts that can be improved upon, but they are unlikely to reproduce parts that have suffered problems, with no easy solution. This results in a parts industry with few failures and defects. **AC**

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