The Jaguar V8 Engine Explained (AJ-8)

Although the AJ-V8 engine was hailed a success when it was introduced, later on there were problems due to pre-2000 Nikasil bore coatings, weak timing-chain tensioners and water pump failures.

However, once these early issues were resolved, Jaguar produced a very reliable, class leading power unit with few compromises.

Despite the belief that Jaguar just adapted a Ford designed V8 to create their new power unit, the truth is actually the reverse. Jaguar designed the engine in its entirety, and a simplified variant was shipped to the US where Lincoln installed it in their LS model!

Some Early History

The AJ-V8 was not Jaguars first V8 engine; even discounting the 2.5-litre unit of Daimler origin, as serious work went into designing an eight-cylinder version of the 5.3-litre VI2.

While the 60-degree V angle provided evenly balanced firing pulses as a V12, the vibration from the V8 proved impossible to eliminate completely and the 6 cylinder unit was called upon to soldier on for another decade.

The new V8 of 1996, on the other hand, was designed without the restrictions that come into play when adapting an existing design.

Early Design

Development work on the AJ-V8 began in the early 90s and the new engine was given the green light for production in 1993, with the finished product emerging just 36 months later.

The brief was to deliver as much power as possible alongside the conflicting goals of low emissions and light weight.

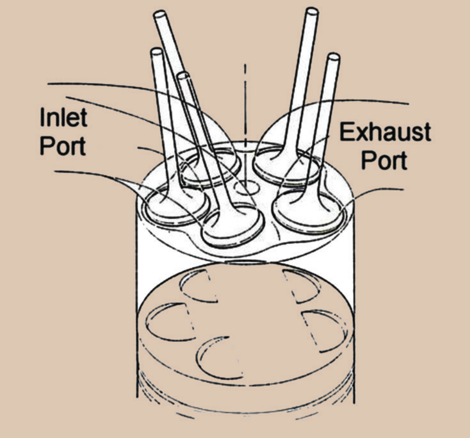
Aluminium block/heads

The weight was taken care of by using a die-cast aluminium block and sand-cast aluminium cylinder heads, while like BMW and Porsche engines, weight was further saved by using a low-friction nickel-silicone carbide plating called Nikasil for the bores and doing without cylinder liners (later abandoned).

The shape of the block casting incorporated a ribbed web cast high into the Vee in order to link the two banks together in the interests of rigidity, while a closed-deck design further improved rigidity and provided a stable face for the head gasket.

The two cylinder heads were 'handed' castings, each a mirror image of the other, and employed a four-valves-per-cylinder layout with a relatively narrow included angle of 28 degrees to provide a compact combustion chamber and a small cylinder head.

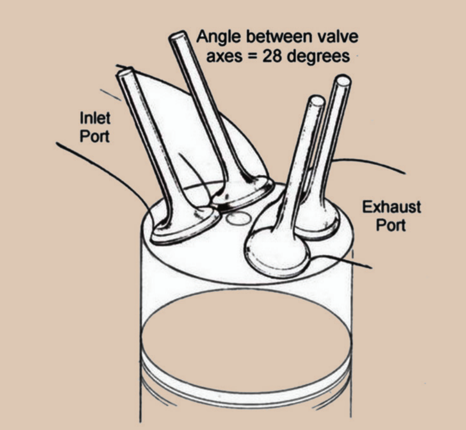
Valve gear



5 Valve Cylinder Head Layout
Tested and rejected for Jaguar V8

Extensive work had gone into the choice of combustion chamber design, with Jaguar even exploring the five-valve layout at one point, but the design chosen for the production engine was an evolution of a single sloping surface four-valve design found in the AJ16.

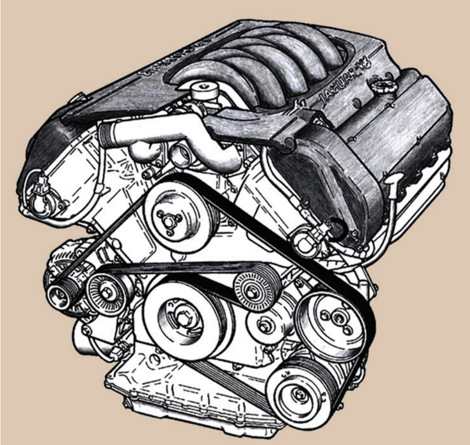
Providing an extremely high volume to surface area ratio, this helped optimise the thermal efficiency of the new engine.



Classic 4 Valve Layout
as used for Jaguar V8

The valve gear itself employed relatively large valves with 35mm heads, but with a stem diameter of just 5mm, making them very light. This brought a measurable improvement in fuel economy due to reduced friction losses and reduced e mechanical stresses in the valve train.

With the cast iron camshafts drilled to save weight, this resulted in the reciprocating weight of the valve gear assembly coming in at just 3.05kg. The valves were operated by shimmed aluminium flat tappets using a single spring to reduce friction while spinning safely over 7000rpm.


Jaguar 4 litre V8

A variable camshaft phasing system was employed using a hydraulic actuator fitted to each inlet camshaft, which was operated by electronically-controlled oil pressure valves activated by the engine management electronics.

This system enabled the timing of the camshafts to be varied a total of 30 degrees from full advance to full retard in just 0.7 seconds, the end result being improved low-speed torque and high-speed power.

Drive to the camshafts was by a single-row chain – one primary and one secondary for each bank, both with hydraulic tensioners.

Crankshaft/Pistons/Conrods

The flat-topped aluminium pistons used a short skirt in the interests of reduced friction and the big-end journals of the con-rods were fracture-split. This process essentially involves splitting the parts in a precise way so that the two halves line up perfectly without the need for further balancing.

Running 5 main bearings, the crankshaft was made from spheroidal graphite cast iron and extensive computer modelling was used to retain its stiffness in operation, alongside large 56mm diameter big end bearings.

Inlet manifold

As was common by the late 90s, the inlet manifold was made from polyamide composite (plastic) for both weight saving and improved hot starting thanks to its superior insulation over a metal unit.

Engine management system

The whole lot was controlled by Jaguar's own engine management system, produced by Nippondenso, which boasted two 16-bit processors and 192k memory – hefty computing power for the era. This was complemented by a drive-by-wire throttle which used a stepper motor to operate the throttle, although a mechanical back-up was provided.

Cooling system

Elsewhere, the cooling system was designed to warm up remarkably quickly. Called a 'split block' system by Jaguar, it used a 'low volume, high velocity' philosophy with the waterways designed to produce a fast coolant flow. It achieved a warm-up within four minutes in the urban test cycle, which enabled good fuel consumption figures as well as ensuring occupants were warmed by the heater sooner.

Final outcome

The end result was a 3996cc engine with a bore of 86mm and stroke of 86mm running a compression ratio of 10.75:1 to produce 290bhp, with an all-up weight of just 200 kg.

Supercharger

In 1998, the normally-aspirated V8 was joined by a 'blown' variant, using an Eaton M112 supercharger driven by belt from the front of the crankshaft with twin air-to-water 'charge coolers', one for each bank. First used in the XJR version of the X308-gen XJ saloon, the supercharged V8 was good for 370bhp at 6150rpm.

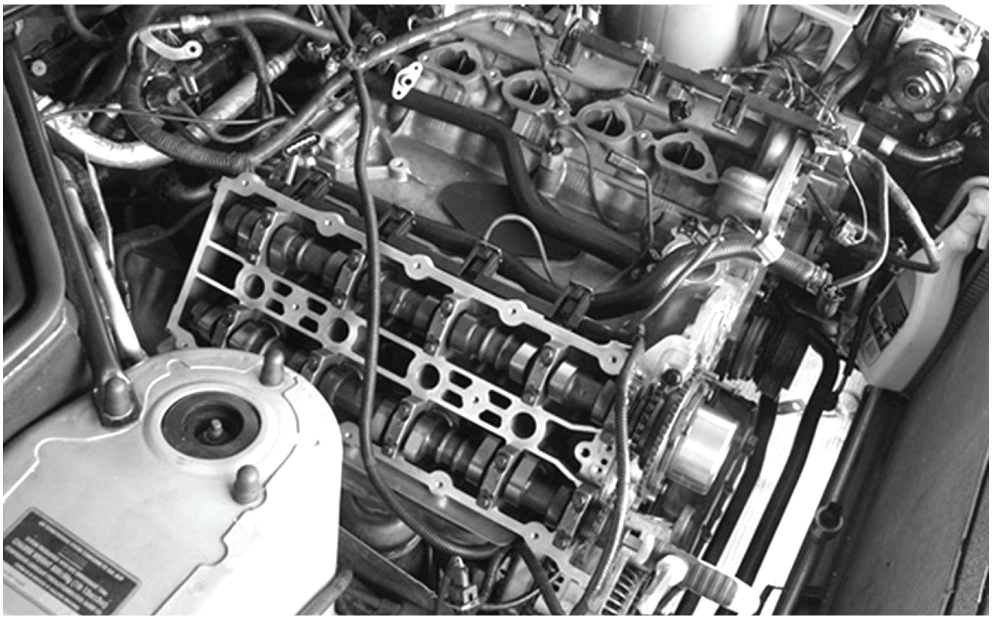
4.0 Litre - Early Design Problems

Nikasil

One significant failing in the design process was the desire to have the both the lightest engine in its class and the highest power-to-weight ratio.

To achieve this required coated aluminium bores instead of steel liners, the substitution of plastic for metal in several key areas and simplex timing chains when all previous Jaguar engines had used duplex for strength and reliability.

As has been well publicised, the Nikasil bore coating proved susceptible to the high sulphur used in much of the world's low-quality petrol's used throughout the late 1990s. In the UK it is estimated that at least half of all Nikasil engines failed, with many replaced under warranty.



Jaguar XK8 AJV8 engine – without valve cover and intake track

Water pump/timing chain tensioners

Collapsed plastic water pump impellers have caused overheating while the plastic tensioners for the upper timing chains become brittle with age, loose their slipper covers, and allow destructive metal to metal contact with the chain.

A reversion to conventional steel liners in late 2000 cured the Nikasil problem, while the 3.5 & 4.2-litre engines of 2003 rectified just about all of the other issues.

New 4.2 Litre Engine

The more powerful 4.2-litre engine was introduced in 2002 for the 2003 model year and replaced the 4.0-litre unit, marking the first significant change from the original design with improvements to the block casting to further improve rigidity and refinement.

The capacity increase retained the 86mm bore but used a 90.3mm stroke for a total of 4296cc – and rather impressively, the revised engine was even lighter than the original at just 194kg.

Other revisions were mainly detail in their nature, including branched exhaust manifolds, new multi-hole fuel-injectors and further improved emissions systems.

The variable cam phasing also gained more ability, now able to operate over a total of 48 degrees.

The supercharged variant now gained helical rotor gears to reduce noise and a coating on the rotors for improved efficiency, with the supercharger itself spinning 5% faster. The result was 300bhp for the normally-aspirated engine and a hefty 400bhp for the supercharged unit in the S-Type R.

Engine & Model Summary

4.0 Litre (1997-2003)

The AJ26 was updated in 1998 as the AJ27 with continuously variable valve timing.

The AJ-V8 was updated again for the S-Type in 2000 as the AJ28.

3.2 Litre (1997-2003) (XJ8)

The 3.2 litre variant was the second to be introduced. It reduces the stroke to 70 mm and power fell to 240 hp.

3.5 Litre (2002 -2007) (XJ8)

The 3.6 litre, marketed as "3.5", was used in the XJ series. The stroke was 76.5 mm. Output was 262 bhp.

4.2 Litre (2002-2010)

The 4.196 litre AJ33 and AJ34 versions retained the 86 mm bore with 90.3 mm stroke.

AJ133 Gen III 5.0 (2009-2024)

An all new direct injection 5.0 litre engine family was introduced in 2009 (all new engine block).

Now featuring: spray-guided direct-injection, continuously variable intake and exhaust camshaft timing. The naturally aspirated engines also feature cam profile switching and variable track length inlet manifold. Supercharged engines made use of a sixth-generation TVS (Twin Vortices Series) supercharger.

The engine was controlled by Denso's Generation 1.6 Engine Management System. Later switching to Bosch for the F-Type and other mid-2010 models going forward. ■

AJ-8 General Maintenance

Regular oil changes

This high-performance engine has complex lubricating passages and, in non-supercharged 4.0-litre form, hydraulic operation of the Variable Valve Train (VVT) units. As such it not only requires a good quality oil, but with a significantly reduced sump capacity compared to earlier Jaguar engines, regular changes of both oil and filter.

Cooling system

The cooling system efficiency is critical and that means regular checks of the radiator and oil cooler for blockages and corrosion.

Apart from regular changes of coolant, using the correct coolant is also vital as from VIN 87827400 (XJ) and 042635(XK), Jaguar began using the special Ford type red coolant, which if mixed with conventional glycol will react and form a thick sludge through the entire system. It goes without saying that even the slightest twitch of the temperature needle should be investigated immediately.

Air filter cartridge

With Nikasil engines it pays to keep a close eye on the air filter cartridge, as a build-up of oil here will normally be a precursor to loss of compression.

Avoid multiple cold starts

Of particular importance is the need to allow an engine to warm fully before switching off. If the car is started, pulled out of the garage and then stopped, not only will all that extra fuel (necessary for initial starting) be sloshing around the bores and washing the oil away, but also when the car is started again a few minutes later the ECU will think it's another completely cold start and will pump in even more fuel.

Jaguar injection systems in general tend to run rich and two successive starts within a couple of minutes can be enough to flood the engine and stop it running at all.

AJ-8 Running Repairs

Chain tensioners and guides

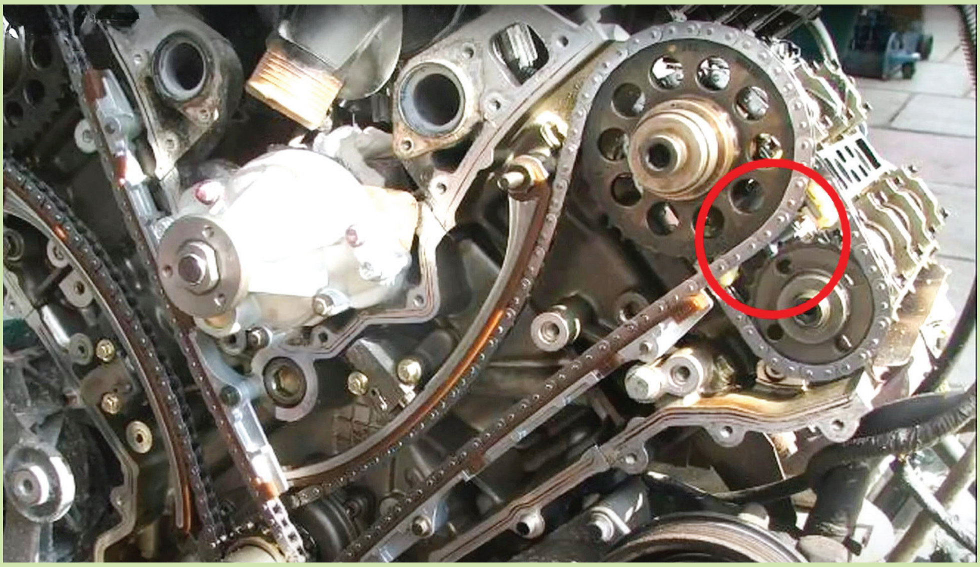
The general rule here is simple, if a 3.2 or 4.0-litre engine has not been updated to the 3.5/4.2-litre type chain tensioners and guides, it should be done as soon as is practically possible; some cars have been updated over the years to a revised plastic tensioner, but these too can fail and so only the metal cased tensioner should be used.

To check if the later tensioners have been fitted, a cam cover will have to come off to confirm this.

With any operation that requires removal of the front pulley, always replace the crank bolt and tension to the correct specification as the bolts have been known to come loose, allowing the pulley to move back and forth on the woodruff key, ruining the crankshaft.

Water pump

One other item which needs to be replaced for peace of mind is the water pump, the original type having a plastic impeller prone to losing its vanes, especially if the engine runs hot for a period.



The AJ26/AJ27/AJ28 has 4 chains, two 2 large primary chains from the crankshaft to the cams and two smaller chains inking the two cams together. The weak point and rattle at start up comes from the secondary chain tensioner. (Circled in red). If that chain jumps one tooth you will get rough idle, and if it jumps two tooth's the valves will hit the pistons. Special tools are required to replace the tensioners and guides .

This reduces coolant flow, eventually leading to overheating and ultimately blown head gasket(s). Again, the later 4.2 unit should be used, it can be identified by the bolts securing the two halves together, earlier pumps were a single casting. Whenever a new pump is fitted the thermostat should also be changed.

On non-supercharged cars, the plastic from which the thermostat tower and bridge pipe are made will degrade over time, becoming brittle and eventually crumbling away around the O-ring recesses. A replacement tower in alloy and a bridge pipe are available.

Coolant usages

Should an engine start to use coolant without a visible leak, one of the head gaskets will most likely be leaking but on an XJ first check that the header tank pipes are connected in the correct order as it is easy to mistakenly transpose a bleed pipe with the overflow, venting the entire system to the atmosphere.

In the case of a blown head gasket the key to a successful repair is to catch it before any subsequent damage is done to the bottom end of the engine.

Never replace a head gasket without pressure testing the heads, as internal cracks are quite common.

AJ-8 Replace or Rebuild

Major engine issues

There are three main reasons to write off a V8 engine. Loss of compression due to Nikasil failure, extensive internal damage caused by chain tensioner collapse leading to a snapped secondary timing chain and gross overheating due to water pump failure. In extreme cases this can fuse the engine components together which then cannot be dismantled.

In the case of a 3.2-litre engine, obtaining a second-hand unit remains the preferred option.

This is because they are still plentiful and the lower (relative) value of these cars rules out a rebuilt on financial grounds.

4.0-litre engines are much harder to come by second-hand. They do pop up from time to time but rarely when needed and so many of the Jaguar specialists are now arranging for unserviceable Nikasil units to be steel sleeved and overhauled.

Please note: If buying a replacement engine, take great care to ensure it is the correct specification for the car.

As well as differing significantly between XJ/XK & S-TYPE and disregarding the accessories such as throttle housing for example, engines can also vary in the number of oil pressure switches and cam sensors.

In the case of the latter, while it is possible to adapt a twin sensor engine into a single sensor car (by swapping the trigger on the RH camshaft), a single sensor engine cannot be fitted to a twin sensor car.

AJ-8 Nikasil or Steel

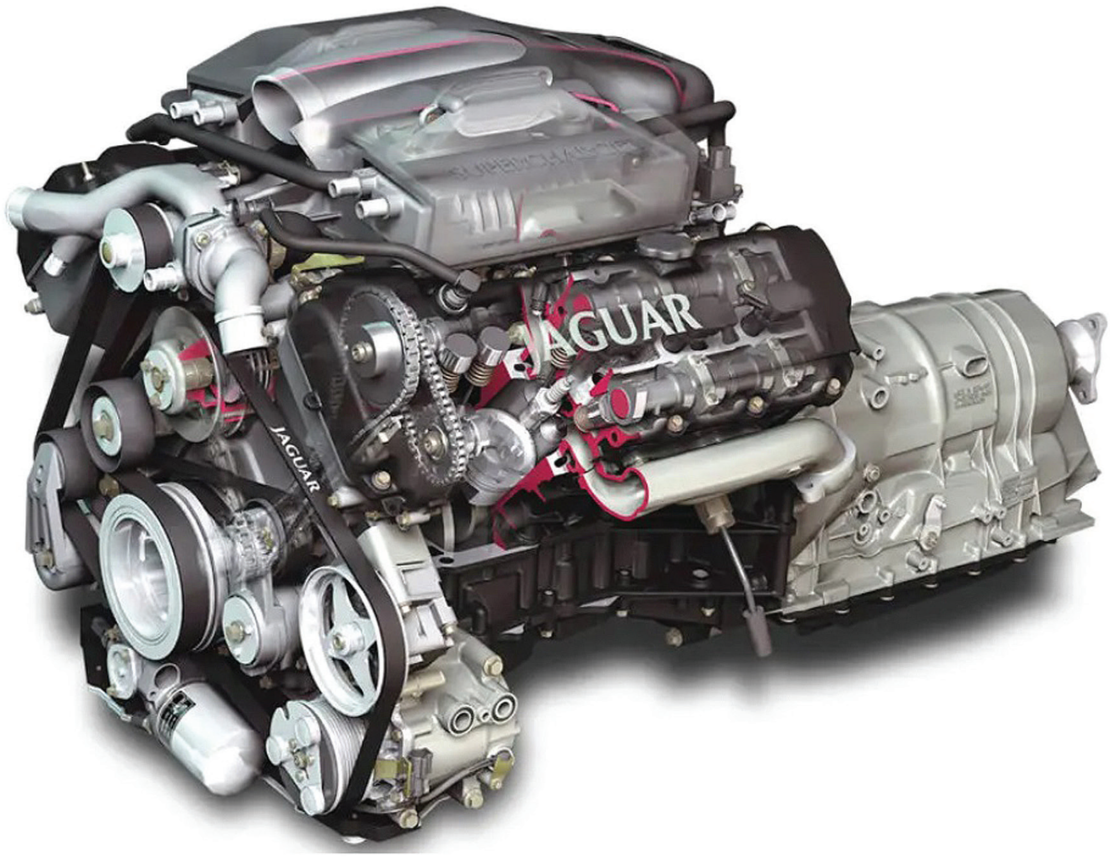
Jaguar reverted to steel liners from engine number 000818: 1043 with the number based on the build date and time, which translates to 10.43am on 18 August 2000. Until existing supplies of Nikasil engines were exhausted both types were fitted side by side. That is, the VIN number cannot be used as an accurate indicator of engine build.

Of course, this information is only of relevance where high sulphur petrol has been an issue.

In markets such as Australia, Nikasil failure is almost unheard of and the low friction coating remains an advantage with lower noise levels and higher efficiency.

Finally, the cost of production tooling to build the V8 was huge, the Bridgend AJ-V8 plant cost Jaguar (Ford) £125 million in 1997.

Editor: Information for this article sourced from Prestige & Performance Cars, Jaguar World, AJ6 Engineering, and AROnline.



Jaguar is traditionally known for its straight-six and V12 engines but the AJ-V8 was arguably one of its best