The Jaguar AJ-V8

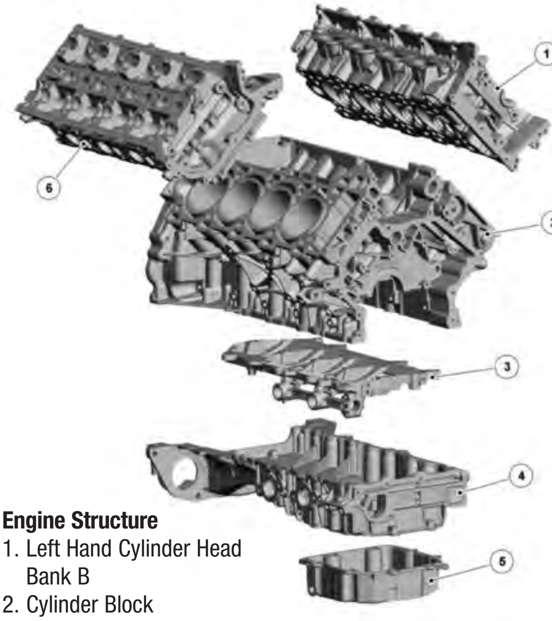
BY **DAVE HAGEN**

The Jaguar 5.0L SC gasoline engine is a liquid cooled V8 unit featuring direct fuel injection, four overhead camshafts and four valves per cylinder and the first designs were made in the late 1990s. These engines are offered in several versions and boast 500 horsepower as delivered to the showroom floor. All four camshafts incorporate VCT (variable camshaft timing). The main structural components of the engine are all manufactured from aluminum alloy. The engine is built around a very stiff, lightweight, enclosed V, deep skirt cylinder block. A structural windage tray is bolted to the bottom of the cylinder block to further improve the block stiffness, minimize NVH (noise, vibration and harshness) and help reduce oil foaming. To further enhance the stiffness of the lower engine structure, a heavily ribbed sump is installed. The sump also helps to reduce engine noise.

The crankshaft is made from spheroidal graphite cast iron, which, compared with grey cast iron, has higher mechanical strength, ductility and increased shock resistance. The undercut and rolled fillets also improve strength. Eight counter-balance weights ensure low vibration levels and the large, cross-drilled main bearing journals are designed to contribute to stiffness.

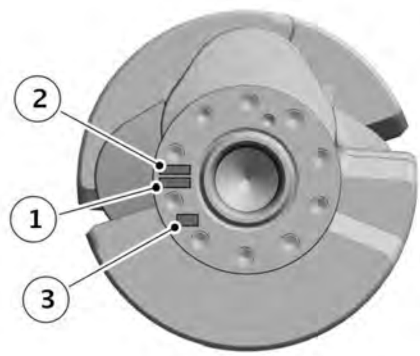
An oil groove in the upper half of each main bearing transfers the oil into the crankshaft for lubrication of the connecting rod bearings. A thrust washer is installed each side of the top half of the center main bearing to control crankshaft end play.

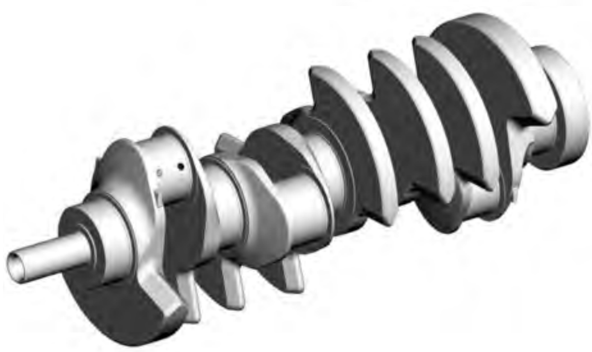
The main bearings are numbered 1 to 5 starting from the front of the engine. There are five grades of standard main bearings available, each being color coded. Journal sizes are marked on the rear of the crankshaft to assist one in select bearing fit to provide desired minimal oil clearance of not less than .00087” (.022 mm) or greater than .0016” (.040 mm).



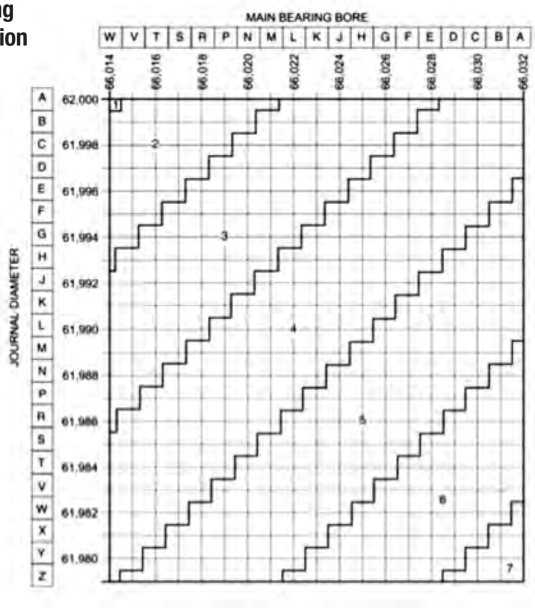
Engine Structure
1. Left Hand Cylinder Head Bank B
2. Cylinder Block
3. Windage Tray
4. Sump
5. Right Hand Cylinder Head Bank A

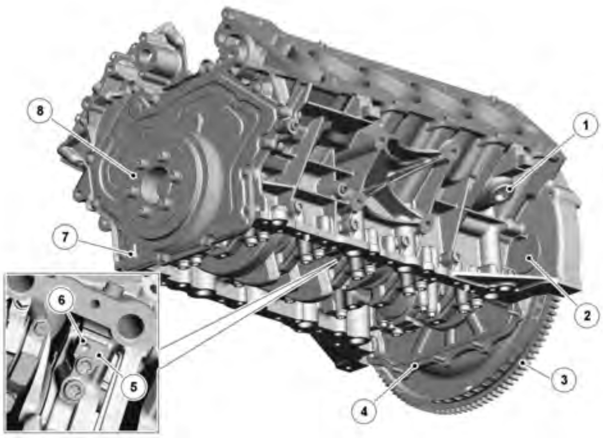
Crankshaft Data Location
1. Connecting Rod Journal Classification and Paint Identification
2. Main Journal Classification
3. Date and Time Code





Main Bearing Selection Chart





Crankshaft Installation

1. Coolant Drain Plug
2. Torque Converter Access Plug
3. Drive Plate
4. Rear Cover
5. Main Bearing Cap
6. Identification Mark
7. Front Cover
8. Front Pulley

The cylinder block is also coded to indicate one of the possible 19 main housing bore gradings. A detailed chart is provided to help select the proper main bearings in conjunction with the possible twenty-two crankshaft main journal diameter gradings.

PISTONS AND CONNECTING RODS

The diameter of each piston is graded and precisely matched to each cylinder bore to help reduce noise. In the vertical plane, the pistons have a slight barrel form, which helps to ensure a reliable oil film is maintained between the piston and the cylinder bore. A solid film lubricant coating is applied to both reaction faces of the piston to reduce wear and improve fuel economy.

A three-ring piston-sealing system is used. The steel top ring is treated with a PVD (physical vapor deposition) peripheral coating. PVD is a coating technique where material can be deposited with improved properties to ensure good cylinder bore compatibility and wear resistance. A Napier center ring helps cylinder pressure and oil management, while the three-piece oil control lower ring is produced from Nitride steel.

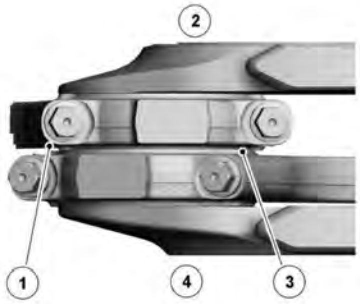
The pistons are cooled with engine oil from four piston cooling jets installed under the valley of the cylinder block. Each piston cooling jet sprays oil onto the underside of the two adjacent pistons, one from each cylinder bank.

The connecting rods are forged from high strength steel. The cap is fracture-split from the rod to ensure precision re-assembly for bearing shell alignment.

Connecting Rod

1. Alignment Marks
2. Connecting Rod
3. Cap
4. Connecting Rod Bearings

The correct alignment of the cap with the connecting rod is indicated by marks on adjacent faces of the two components.



Connecting Rod and Piston Orientation

A. Front of Engine

1. Alignment Marks
2. Left Hand Side Bank B
3. Alignment Marks
4. Right Hand Side Alignment Marks
5. Piston Orientation Front Arrow

The orientation of the connecting rods and pistons on the crankshaft are given below:

- Bank A - The arrow on the piston crown must face the front of the engine and the cap and connecting rod alignment marks must face the rear of the engine.
- Bank B - The arrow on the piston crown must face the front of the engine and the cap and connecting rod alignment marks must face the front of the engine.

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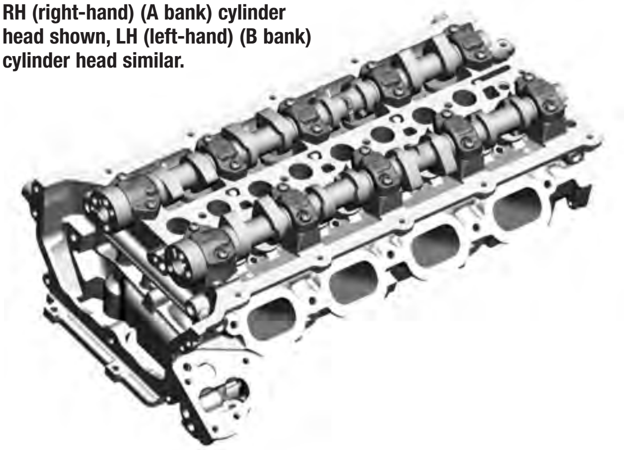
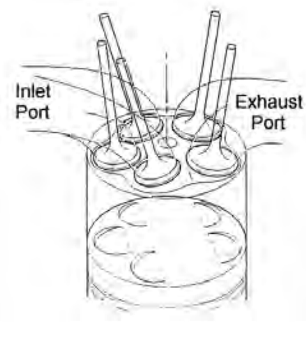
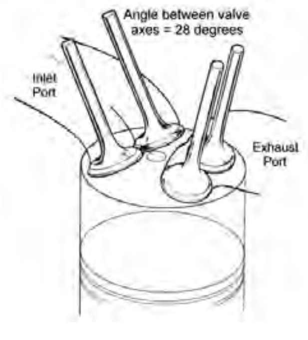
RH (right-hand) (A bank) cylinder head shown, LH (left-hand) (B bank) cylinder head similar.





5 Valve Cylinder Head Layout Tested and rejected for Jaguar V8



Classic 4 Valve Layout as used for Jaguar V8

There are three grades of large end bearing available, each being color coded.

CYLINDER HEADS

The cylinder heads are manufactured in gravity die cast aluminum alloy and are unique for each cylinder bank. Deep-seated cylinder head bolts reduce distortion while securing the cylinder heads to the cylinder block.

Each cylinder is served by four valves. To help achieve the required gas-flow characteristics, the valves are arranged asymmetrically around the cylinder bore. Each cylinder has a centrally mounted fuel injector and spark plug. The cylinder head gasket is of a multi-layer steel construction.

Jaguar's engineers had also considered alternative arrangements like the five valve configuration used so successfully by Yamaha on their high performance motor cycle engines. No real advantage could be found that way so progress continued with a more conventional four valve layout. A very efficient and compact combustion chamber was achieved by closing up the angle between the valves from the 47 degrees of the AJ6 and AJ16 engines to a more ideal 28 degrees, accepting the slight drawback that the head bolts were situated right under the camshafts so the heads could not be totally pre-assembled. An incidental advantage of the narrower valve angle is that it helps to keep the cylinder heads compact, so minimizing the weight and package size of the complete power unit.

EXHAUST MANIFOLD

The high SiMo (silicon molybdenum) cast iron exhaust manifolds are unique for each cylinder bank. Each exhaust manifold installation includes two metal gaskets and two heat shields. Spacers on the securing bolts allow the manifolds to expand and contract with changes of temperature while maintaining the clamping loads.

VALVE TRAIN

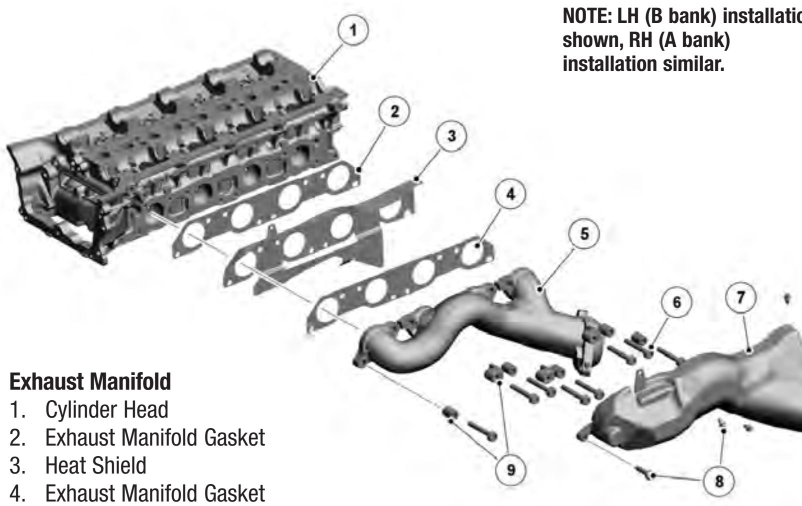
The lightweight valve train provides good economy and noise levels and is chain driven from the crankshaft.

Double overhead camshafts on each cylinder head operate the valves. For each cylinder head, an inverted tooth timing chain transfers drive from the crankshaft to the VCT (variable camshaft timing) unit on the front of each camshaft. Graded tappets enable setting of inlet and exhaust valve lash clearances.

Each timing chain has a hydraulic tensioner operated by engine oil pressure. The chain tensioners incorporate a ratchet mechanism, which maintains tension while the engine is stopped to eliminate start-up noise. The chains are lubricated

(continued)

NOTE: LH (B bank) installation shown, RH (A bank) installation similar.



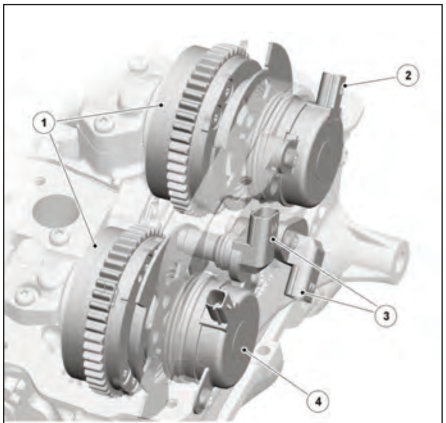
Exhaust Manifold
1. Cylinder Head
2. Exhaust Manifold Gasket
3. Heat Shield
4. Exhaust Manifold Gasket
5. Exhaust Manifold
6. 8 Mounting Bolts
7. Heat Shield
8. 4 Mounting Bolts
9. Spacers, 8 Total

with engine oil from jets located at the front of the engine block. Nylon chain guides control chain motion on the drive side.

The VCT system varies the timing of the intake and exhaust camshafts to deliver optimum engine power, efficiency and emissions. The timing of the intake camshafts has a range of 62 degrees of crankshaft angle. The timing of the exhaust camshafts has a range of 50 degrees of crankshaft angle.

In the base timing position:
- The intake camshafts are fully retarded.
- The exhaust camshafts are fully advanced.

The system consists of a VCT unit and a VCT solenoid for each camshaft. The ECM (engine control module) controls the system using PWM (pulse width modulation) signals to the VCT solenoids. The torsional energy generated by the valve springs and the inertia of the valve train components are used to operate the system.

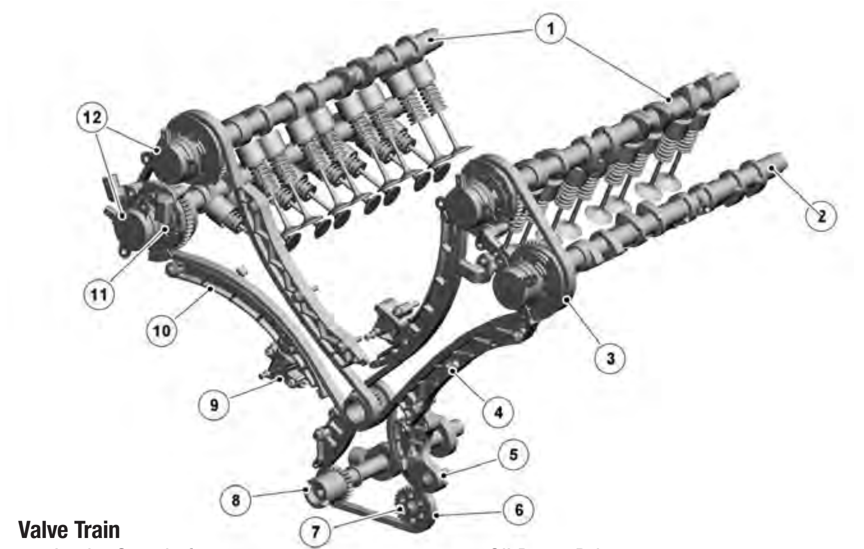


Variable Camshaft Timing
1. VCT Units
2. Intake Camshaft VCT Solenoid
3. Camshaft Position Sensor
4. Exhaust Camshaft VCT Solenoid

Variable Camshaft Timing Units
The VCT units change the position of the camshafts in relation to the timing chains.

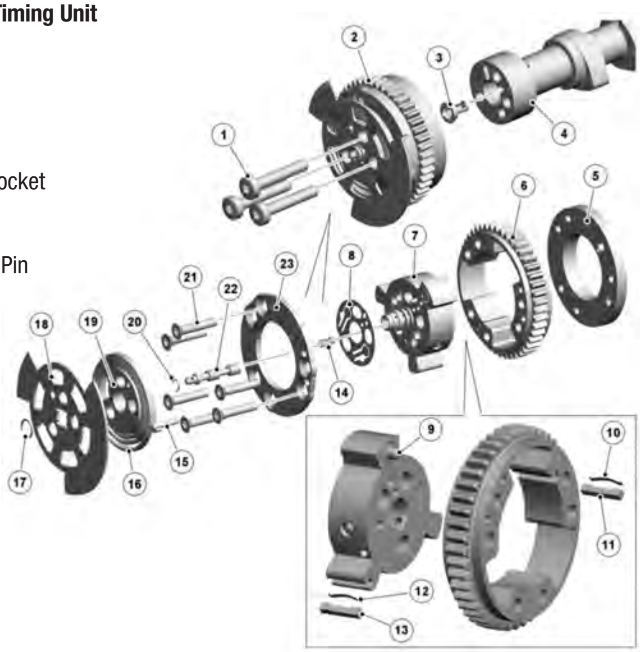
Each VCT unit is attached to the camshaft by three bolts. A rotor assembly and a reed plate are installed inside a sprocket housing, which consists of a sprocket, an outer plate and an inner plate held together by six screws.

A reluctor ring, for the CMP (camshaft position) sensor, a center plate and a bias



Valve Train
1. Intake Camshafts
2. Exhaust Camshafts
3. Inverted Tooth Timing Chain
4. Nylon Chain Guide
5. Auxiliary Chain Tensioner
6. Auxiliary Drive Chain
7. Oil Pump Drive
8. Auxiliary Drive Camshaft
9. Timing Chain Tensioner
10. Tensioner Lever
11. VCT Unit
12. VCT Solenoids

Variable Camshaft Timing Unit
1. Bolt 3 Total
2. VCT Unit
3. Filter
4. Camshaft
5. Inner Plate
6. Housing and Sprocket
7. Rotor Assembly
8. Reed Plates
9. Spring and Lock Pin
10. Spring 3 Total
11. Tip Seal 3 Total
12. Spring 2 Total
13. Tip Seal 2 Total
14. Spring
15. Dowel Pin
16. Bias Spring
17. Snap Ring
18. Reluctor Ring
19. Center Plate
20. Snap Ring
21. Screw 6 Total
22. Spool Valve
23. Outer Plate



VCT Operating Ranges

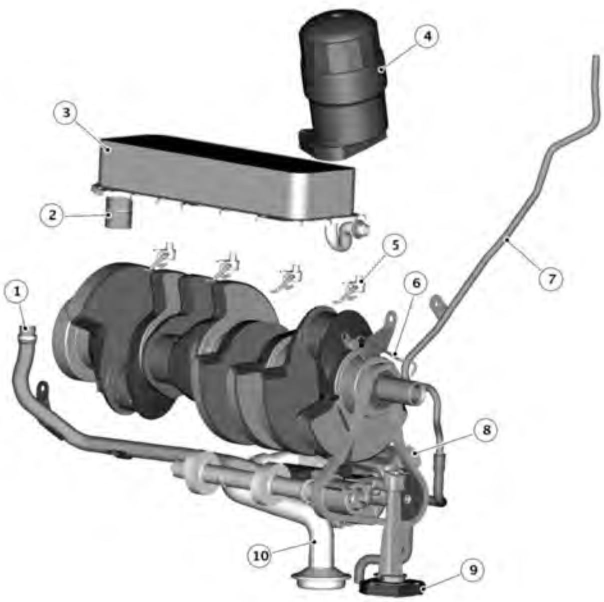
Camshaft	Valve Opens	Valve Closes
Intake	29 degrees BTDC (before top dead center) to 33 degrees ATDC (after top dead center)	207 to 269 degrees ATDC (after top dead center)
Exhaust	244 to 194 degrees BTDC (before top dead center)	6 to 56 degrees ATDC (after top dead center)

spring are installed at the front of the VCT unit. The ends of the bias spring locate on the center plate assembly and the sprocket housing, to give a turning moment to the camshaft in the advance direction. A snap ring locates the reluctor ring on to a sleeve installed in the center of the rotor assembly. The opposite end of the sleeve locates in a bore in the front face of the camshaft, which contains a filter.

A spring and spool valve are installed in the rotor assembly sleeve and retained by a snap ring. The spring keeps the spool valve in contact with the armature of the related VCT solenoid.

Each VCT unit is supplied with engine oil from an oil gallery in the cylinder head, through the camshaft front bearing cap and a bore in the center of the camshaft.

Lubrication System
1. Oil Pump Outlet Tube
2. Anti-Drain Valve
3. Oil Cooler
4. Oil Filter
5. Piston Cooling Jets (4 Total)
6. Timing Chain Lube Jet (2 Total)
7. Oil Evacuation Tube
8. Oil Pump
9. Oil Pick-up Tube
10. Oil Temperature and Level Sensor



Variable Camshaft Timing Solenoids

The VCT solenoids control the position of the spool valves in the VCT units.

The VCT solenoids are installed in the front upper timing covers, immediately in front of their related VCT units. Each VCT solenoid is secured with two screws and sealed with an O-ring. A two pin electrical connector provides the interface with the engine harness.

Each VCT solenoid incorporates a spindle that acts on the spool valve in the related VCT unit to advance and retard the camshaft timing. The VCT solenoids operate independently and are controlled by a PWM signal from the ECM (engine control module).

Variable Camshaft Timing Basic Operation

When the engine is running, the compression and expansion of the valve springs causes momentary increases and decreases in the torque acting on the camshafts. These momentary changes of torque are sensed in the VCT (variable camshaft timing) units and used to change the camshaft timing.

LUBRICATION SYSTEM

The oil pump is attached to the underside of the windage tray. The input shaft of the oil pump is driven from the front of the crankshaft, by the auxiliary chain, at 0.87 engine speed. The oil pump draws oil from the sump through a centrally mounted pick-up pipe. The oil is pressurized and pumped through an output tube to the cylinder block. After passing through an anti-drain valve and a plate type oil cooler, the oil is filtered by a replaceable cartridge installed on the front of the RH (right-hand) cylinder head. The output from the oil filter is distributed through oil galleries in the cylinder heads and cylinder block. All moving parts are lubricated by pressure or splash oil. Pressurized oil is also provided for the VCT (variable camshaft timing) system, the timing chain tensioners, the piston cooling jets and the timing chain lubrication jets.

The oil returns to the oil pan under gravity. Large drain holes through the cylinder heads and cylinder block ensure the rapid return of the oil to the sump. System replenishment is through the oil filler cap on the LH (left-hand) cylinder head cover. An oil evacuation tube is installed to allow oil to be drawn from the sump. The upper end of the oil evacuation tube is located under the oil filler cap. An oil drain plug is installed in the RH (right-hand) side of the sump.

Oil Level Monitoring & Oil Level and Temperature Sensor Systems

Oil level monitoring is provided by an oil level and temperature sensor that measures the oil level in the sump. The oil level can be displayed in the message center of the instrument cluster. The oil level and temperature sensor supplies the ECM (engine control module) with a signal containing the level and temperature of the oil in the sump. The oil level and temperature sensor is secured to the bottom of the sump with three screws and sealed with a gasket.

The oil level and temperature sensor sends an ultrasonic pulse vertically upward and measures the time taken for the pulse to be reflected back from the top surface of the oil. This time is compared with the time taken for an ultrasonic pulse to travel a reference distance within the oil level and temperature sensor to determine the oil level. The oil level reading is combined with the oil temperature reading and transmitted in a PWM (pulse width modulation) signal to the ECM (engine control module). Unusual signals will automatically shut the engine down or prevent it from starting.

AERA Technical Specialist Dave Hagen has over 41 years of experience in our industry. As an ASE-certified Master Machinist, Dave specialized in cylinder head work and complete engine assembly for the first 17 years of his career.