THE EXPERT **STEWART SANDERSON**

Having worked as a tuner for 17 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

A Level 5-trained fuel-injection technician, Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

Eight years ago he joined forces with Kenny Walker and opened up Motorsport Developments near Blackpool (01253 508400, **www.remapping.co.uk**), specialising in engine management live remapping, as well as developing a range of Evolution chips which are now sold all over the world.

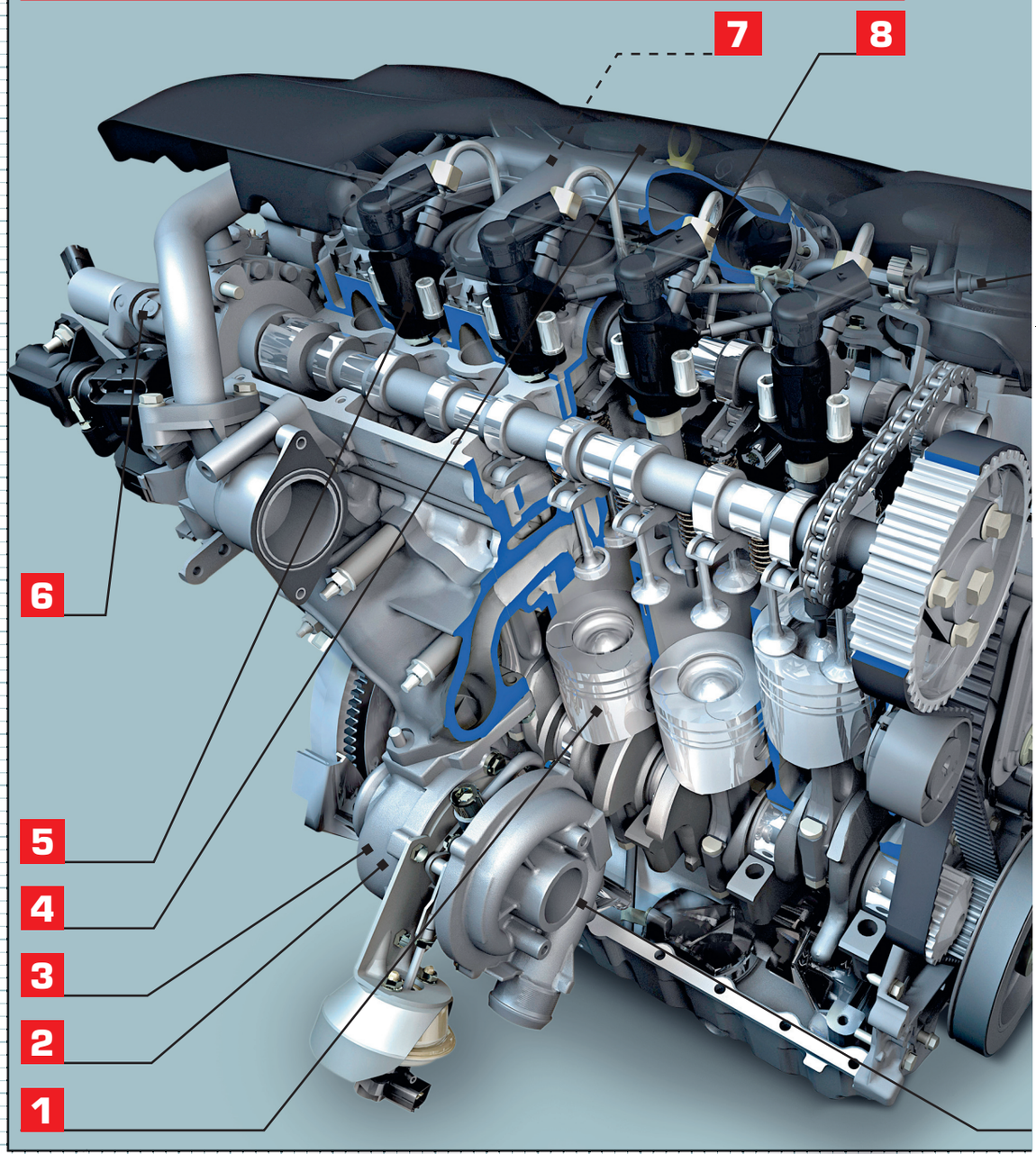
He is the creator and administrator of **www.passionford.com**, which he started in 2003. It has grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web.

Stu's enviable knowledge of the workings of modern-day Ford performance engines means that every month he's just the man to explain how and why things work, and importantly how they can be improved.

Words: Stewart Sanderson and James Wills

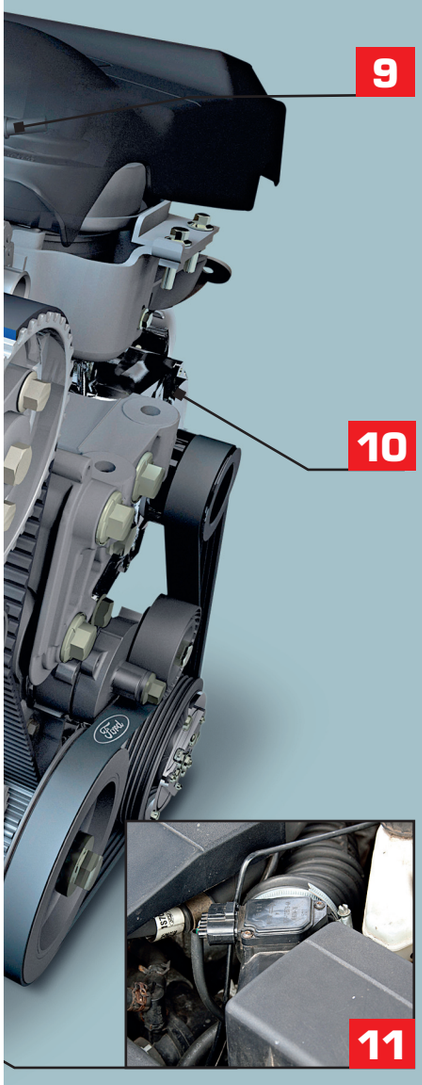
DIESEL ENGINE MANAGEMENT SENSORS.

WHY DO MODERN DIESELS NEED SO MANY SENSORS? WHAT DO THEY DO? STU TELLS ALL



All engine management systems use accurate sensors to measure the engine's functions and temperatures. Without these, the ECU would have no idea how the engine is performing or what the driver is asking it to do, so they are almost as important as the ECU itself!

New sensors are designed all the time to give the ECU more information so it can make tiny adjustments to the running of the engine to improve performance and economy. And if a sensor fails, rather than shut down the engine, most modern ECUs will make up figures for the faulty sensor using data from others. This keeps the engine running to get the driver home before needing the specialist. Let's look at the most common sensors on modern diesels.



1 KNOCK SENSOR (KS)

This sensor is usually mounted on the engine block and it allows the ECU to reference how much knock (or detonation) the engine is producing. On new common rail diesels this is very important and the ECU can make a whole range of adjustments to its pre, post and main injection processes to reduce the amount of knock to a minimum.

Some systems will use more than one knock sensor to allow the ECU to measure more accurately. The ECU will use this information gained from multiple engine sensors to determine not only if the engine is knocking, but also which cylinder has the problem.

2 EXHAUST GAS TEMPERATURE SENSOR (EGT)

Mounted in the exhaust system, the purpose of the exhaust gas temperature sensor is to accurately monitor the temperature of the exhaust gases flowing through the exhaust itself.

Again, this is important for DPF function because the correct exhaust gas temperatures must be reached to ensure the regeneration process can be completed. Fuelling will be accurately adjusted by the ECU to ensure these temperatures meet the desired level.

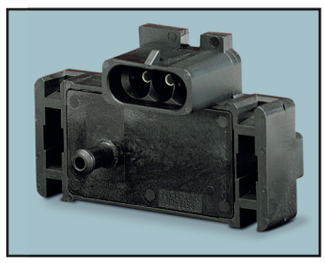
3 EXHAUST PRESSURE SENSOR (EPS)

Mounted in the front exhaust section, the exhaust pressure sensor is fitted to monitor the back pressure in the exhaust system. Excessive exhaust pressure can be a sign of clogged silencers, catalysts or on more modern machines, particulate filters. In the case of the latter, this pressure increase signals the need for a regeneration process to clean the filter.

THROTTLE POSITION SENSOR (TPS)

This sensor allows the ECU to reference the throttle position and any throttle movements made by the driver so it can respond accordingly.

Traditionally it has always been mounted on the throttle body itself, but more frequently on the common rail diesels it is mounted on the throttle pedal because these systems are normally 'drive-by-wire', so there is no direct link between the throttle pedal and the engine. Drive-by-wire systems essentially have the throttle pedal connected to the ECU, and then the ECU tells the pump what to do based on what the driver is doing with his foot.



4 MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

Usually mounted separately from the engine, this sensor reads manifold absolute pressure. Its reference hose will be piped to the inlet manifold somewhere, usually behind the throttle body if fitted. When the throttle is closed the manifold will be in vacuum, and when on boost the manifold will be filled with pressure, so this sensor needs to have a wide range of pressure sensing ability.

The signal from this sensor will determine many important adjustments including which load sites the ECU will reference in the main fuel table.

5 FUEL INJECTOR NEEDLE LIFT SENSOR

Due to the high pressures involved in these systems, any tiny differences between injector lift can cause a large difference in the amount of fuel delivered by that injector. Most modern common rail fuel injectors have a needle lift sensor built in place, which can accurately relay information back to the ECU regarding each injector needle and how far it has moved.

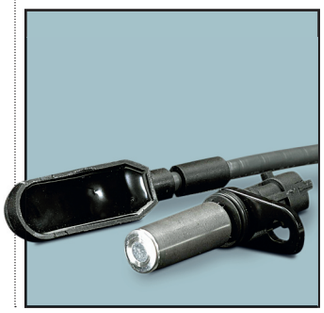
This allows the ECU to make tiny adjustments individually to each injector to keep the fuelling as accurate as possible across all cylinders.

6 CRANKSHAFT CAMSHAFT POSITION SENSORS (CPS)

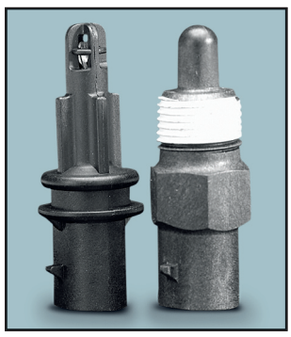
These sensors usually pick up a signal from lugs on the pulleys or the camshaft/crankshaft itself. As the indicator lug passes the sensor an electronic signal is sent to the ECU. This signal allows the ECU to keep a track on engine position and speed, so it knows when and where to inject fuel and can perform any other speed or position dependant functions that it may need to do.

If the ECU detects a misfire, it can even work out what cylinder the misfire occurred on by using data from these specific sensors as they will indicate a speed fluctuation in the engine's rotation. This data will usually be stored in a memory which a fault code reader can later retrieve, making diagnosis of random misfires much easier for the technician than in earlier years.

Likewise, any issues or timing differences between camshaft and crankshaft can either be accounted



for, or flagged up as an error if they are deemed to be excessive.



7 AIR CHARGE TEMPERATURE SENSOR (ACT)

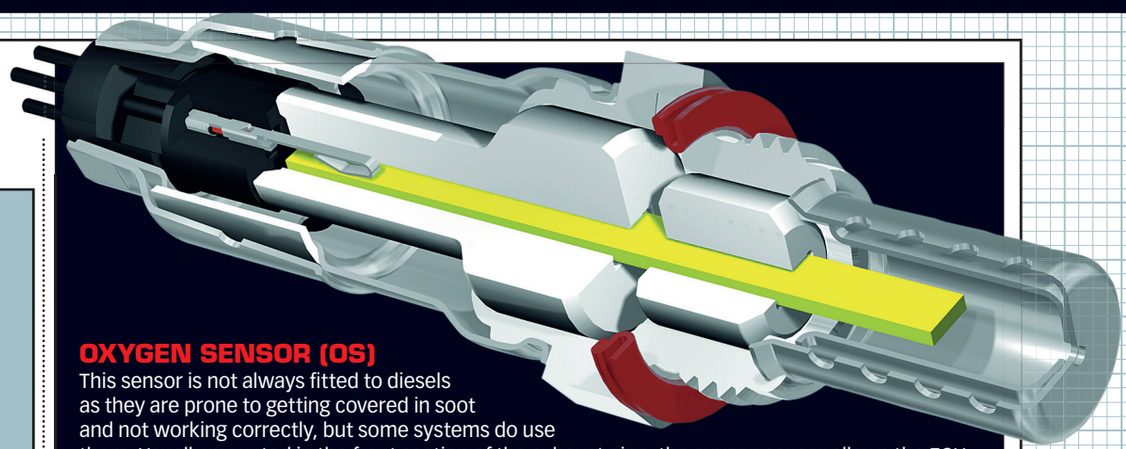
Usually mounted in the inlet plenum, the air charge temperature sensor's function is, as the name suggest, to measure the temperature of the air entering the engine.

This can vary for many reasons, including varied boost pressures, varied ambient temperatures, intercooler efficiency, and EGR function to name but a few. As the temperature changes it alters the resistance through the sensor, the signal from this sensor is then fed to the ECU which will accurately reference a correction table and adjust fuel injection time and amount to ensure and correct running.

8 FUEL TEMPERATURE SENSOR (FTS)

Compressing the fuel to increase its pressure to such a high level as mentioned earlier dramatically increases the fuel temperature.

Therefore a sensor is fitted in the fuel line which can measure and keep a close eye on the fuel temperature, allowing the ECU to make the required adjustments to compensate for this change in temperature.



OXYGEN SENSOR (OS)

This sensor is not always fitted to diesels as they are prone to getting covered in soot and not working correctly, but some systems do use them. Usually mounted in the front section of the exhaust pipe, the oxygen sensor allows the ECU to reference the amount of oxygen present in the exhaust gases, which will relate to the AFR (Air to Fuel Ratio). The ECU can then adjust the diesel injected as necessary to keep these AFR levels constant. These sensors only work correctly when around 800 degrees, and for this reason most have internal heaters to increase the sensor temperature quickly.

9 FUEL PRESSURE SENSOR (FPS)

The fuel pressure in the new diesel injection systems is very high: over 1600 Bar in some cases! The fuel pressure sensor sits in the fuel rail and accurately reads the pressure, allowing the ECU to control and adjust the regulator valve as required to keep the fuel pressure at the correct level.

These sensors have to be very reliable, as the pumps are capable of making so much pressure that various components could be damaged and mechanical failure could occur if the pressure got out of control. Imagine a fuel leak at over 1800 Bar, that is hypodermic pressure and can pierce bone!

10 COOLANT TEMPERATURE SENSOR (CTS)

Usually mounted within the cylinder head itself, the coolant temperature sensor's function is to measure the temperature of the engine's coolant, and therefore its operating temperature.

As the temperature changes it alters the resistance through the sensor. This information is fed to the ECU which again references a correction table, and adjusts the fuel amount and time to suit. This sensor is also responsible for lots of other functions like cold start and all emission based components which are all temperature dependant.

11 MASS AIR FLOW SENSOR (MAF)

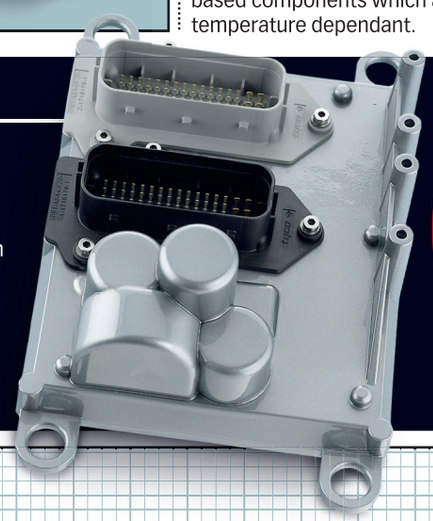
The mass air flow sensor takes its signal from the engine's intake tract, usually near the air filter unit. It accurately measures the mass of air entering the engine, similarly to the map sensor but the MAF sensor is far more accurate and gives a much more detailed analysis of the engine's air consumption.

As the air passes by the sensor it cools a heated wire. The ECU calculates the amount of air going through the meter by measuring the current required to maintain the temperature of this wire. These sensors do suffer badly from getting fouled and dirty, and can require regular cleaning. Incidentally, when you see MAF and MAP sensors on the same engine, the MAP is normally only measuring boost pressure so the ECU can limit it if required.

CONCLUSION

So there you have it – the basic modern diesel engine sensors covered in some detail. Hopefully you can now understand a little bit about how this intricate system works and how the various sensors actually relate to each other and how the car drives.

When you see the basics of how these systems work, you can see how the ECU uses this data to make the engines as efficient as possible, and in some cases even take care of fault diagnoses for the owner too!



NEXT MONTH

WE WILL TAKE A LOOK AT ENGINE MANAGEMENT, IN PARTICULAR NEW VS OLD