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

INSTRUMENTATION

NOT JUST THERE TO LOOK GOOD, STU EXPLAINS WHAT YOU NEED TO KNOW ABOUT GAUGES.

When asked if the battery voltage was OK on a gauge or if the max EGT on the gauge was safe, many of our customers reply, 'I have no idea mate, I don't know what all the numbers mean!'

That got me thinking how we have become a nation of flashing light worshippers that has started spending a lot of money on items we don't understand purely because we think they look good. So, let's look at some common aftermarket instruments and see exactly what they are supposed to indicate and why.

WATER TEMP GAUGE

These have been fitted in most vehicles for years now. They are one of the simplest indications of a potential engine problem caused by overheating.

Why do I need one? Even if you have a water temperature gauge in your vehicle from the factory, how accurate do you believe it to be? How accurately is it scaled? The answer sadly a lot of the time is 'not very'. Water temperature is a key element in how safely your engine is running, if the water temperatures are rising then the integrity of the head gasket is at risk, as well as many other areas of the engine and cooling system.

How to fit one: Water temperature senders should be installed either into the top hose from the thermostat housing to the radiator with a hose adaptor, or fitted directly into the thermostat housing. Depending on the material the housing is made from, it is sometimes possible just to drill and tap a thread to fit the sender into.

What to look for: Normal operating temperatures are around 80-90degrees. Some vehicles inherently run a little hotter than this, but the key is identifying your normal operating temperature and looking for climbing temperatures.

Sometimes it's best to be normal!

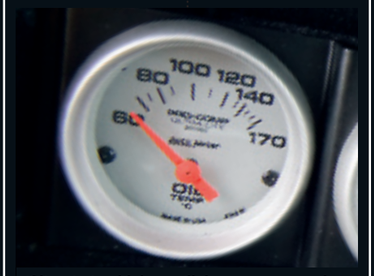
OIL TEMP GAUGE

Regularly found in the domain of factory performance cars, an oil temperature gauge is a good addition for any vehicle, whether it be road or race based.

Why do I need one? If the oil temperature gets too high and the oil starts to break down, the protection it offers will be reduced. An oil temperature gauge lets you check when you've reached the safe thermal limit of your oil.

How to fit one: As with the oil pressure gauge sender installation (see page 126), a sandwich plate can be used between the block and the oil filter to install the sender. To give a more accurate reading, the oil temp sender can be installed into the oil sump pan. This can be done either by welding a boss onto the sump and drilling and tapping if the sump is off the vehicle at the time, or by installing the temperature sender into the drain plug in the sump.

What to look for: The safe operating temperature of your oil will vary depending on what grade you are using and its composition. However, I personally don't like to see oil temperatures in excess of 130degrees Celsius for any prolonged period of time. High oil temperatures will also result in lower than normal oil pressure. It is also worth using your oil temperature gauge to ensure your oil is up to normal operating temperature (approximately 90degrees Celsius) prior to subjecting it to hard use.



If it gets too high, you'll damage your engine

EGT GAUGE

This gives an insight into how hot the gases are within your exhaust system. These gauges are found more often in competition or track focused vehicles, but they should not be excluded from road cars.

Why do I need one? Exhaust Gas Temperature gauges will allow you to see whether excessive heat is posing a risk to your engine. In addition, if you are running race fuel with lead content then there is a high risk of damaging or even destroying Lambda sensors. As such, EGT gauges are the only way to know exactly what is going on, both for your tuner and you.

How to fit one: On a turbocharged vehicle the sensor should ideally be placed in the exhaust manifold collector by welding a mounting boss on or drilling and tapping through the manifold. However, some people prefer to mount the sensor after the turbocharger to avoid turbine wheel damage in the event of the EGT sensor breaking off under hard use.

What to look for: Normally, on a turbocharged vehicle around 900 degrees Celsius is safe when measured before the turbocharger, if you do choose to measure after the turbo, then the gases will have cooled a little and will normally be in the 800-850 degrees Celsius region.

EGTs can reach over 1000degrees C!

There are several different types of Pectel monitors

PECTEL AND IAW MONITORS

This one is mainly used for monitoring Sierra and Escort Cosworth Level 6, Level 8 and P8 ECUs that are equipped with a tuner's chip that outputs a data stream of information. There are a few types of Pectel monitor with various different inputs on them to allow monitoring of a variety of information that the ECU sends out as standard, so prices vary. There is also a PC-based version that's excellent and called the IAW monitor. We use ours almost every day and wouldn't tune a Cosworth without it.

Why do I need one? If you want to see what your ECU is seeing this is the gauge for you. A Pectel monitor or IAW monitor will show you things such as engine rpm, MAP sensor pressure, air temperature, water temperature, throttle position, injection duty, ignition advance and boost valve duty, plus knock level and Lambda correction on some P8 software. The obligatory error codes are also available if your ECU spots a fault and decides to tell you about it. You can also data log all this data on both systems, allowing you to play it all back later. It's great for finding intermittent problems.

How to fit one: These just plug into the Cosworth's standard diagnostic port. Sometimes they don't come with a plug so you connect the wires direct.

What to look for: Apart from the obvious error codes, you are looking for data that is incorrect. If you have just come back from a long drive and the monitor is telling you the engine coolant temperature is only 5degrees C you will know that is wrong and can then investigate the coolant sensor and its wiring. Other than that you are looking for trends, or a change from normal. Often it's worth data-logging a run while the engine is running fine, that way you can compare the readings under the same conditions when things go wrong later on.

OBD DATA STREAM MONITOR

There is a data stream present in most ECU-controlled fuel injection vehicles produced after the mid to late-'80s. In some vehicles it is more advanced than others and the more modern the vehicle, the more data can be accessed.

Data stream monitors check the information coming from the ECU as a stream and then display it on a single screen. There are a number of variations on this theme; there are now full digital dashes that interrogate the RS232 or CAN (Controlled Area Network) data streams on both factory and aftermarket ECUs. There are also display gauges that simply plug into the OBD (On Board Diagnostic) port.

Why do I need one? A gauge of this type will normally allow you to see rpm, MAP sensor pressure, air temperature, water temperature, throttle position, injection duty, ignition advance and sometimes more!

As you can imagine, there would be an enormous amount of individual gauges on your dash to see all of this in any other way. Keeping an eye on this information will allow quick diagnosis of faults. Some of these devices even report fault codes to you!

How to fit one: Depending on which display you use, each will have specific installation instructions. However, as a generalisation for use on older vehicles it is normal to have to solder wires onto the ECU wiring loom to interrogate the data. The next generation could to be connected directly to the vehicle's diagnostic connector within the wiring loom, normally plugging straight in with a mating connector.

From there we are on to OBD versions that plug in to the OBD connector. The very latest versions use the RS232/CAN data stream only found on very recently produced vehicles and aftermarket engine management ECUs.

What to look for: Every vehicle will run differently, the main thing to look for with this type of monitor is repeatability and consistency. After a period of familiarising yourself with temperatures/values you should be easily able to spot something out of the ordinary.

Scan Gauges are popular, and also display fault codes

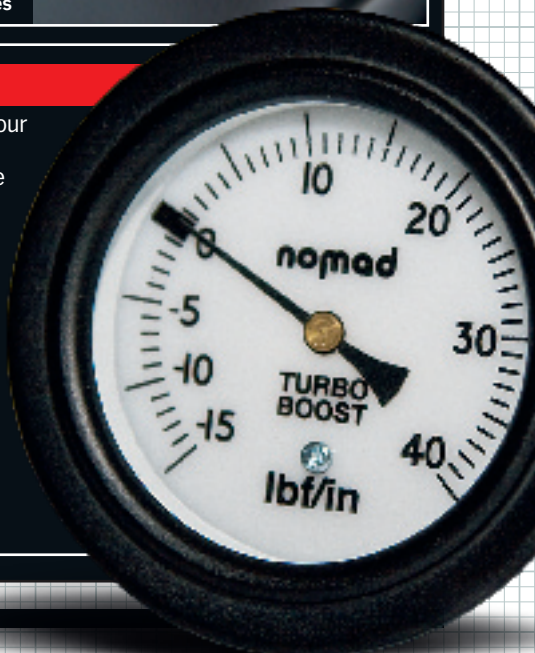
BOOST GAUGE

The most commonly found gauge in any forced-induction performance car. It provides an indication of how much pressure is being generated by your turbo or supercharger. Most boost gauges also allow you to see the vacuum depression present in the inlet manifold when the throttle butterfly is shut.

Why do I need one? It will tell you whether your turbo/supercharger is making the correct boost pressure and confirm that it is making its way into your inlet manifold.

How to fit one: You'll need to access a pressure and vacuum signal from the inlet manifold. If you cannot connect directly onto the manifold it may be necessary to fit a T-piece and share the signal. It is good practice not to take the signal from either the MAP sensor or the fuel pressure regulator as if the reading to either of these two components is compromised then damage can occur.

What to look for: Your tuner will advise you as to what the appropriate peak and held boost pressure values are for your vehicle. You need to look for abnormalities in these values. If the vehicle is under boosting then performance will be affected, while over boosting can lean the fuelling out and cause terminal damage. Vacuum readings will vary depending on your head porting and cam selection, but again abnormalities should be easy to spot.



FUEL PRESSURE GAUGE

Usually found in track and race cars, fuel pressure gauges are an addition for those who want to see that their fuel supply is working correctly.

Why do I need one? This gauge allows you to ensure that your fuel injectors are being supplied with fuel at the right pressure, enabling you to spot a failing fuel pump or a leaking line before it costs you an engine.

Most forced induction cars rely on the fuel pressure to rise in relation to the boost pressure to ensure suitable fuel delivery. A fuel pressure gauge allows you to check that the base fuel pressure is correct and that the required rise in pressure is occurring.

How to fit one: The fuel pressure sender needs to be installed either into the fuel rail or into a dedicated port on an aftermarket fuel pressure regulator. Some fuel pressure gauges available are mechanical in operation and so are intended for the gauge to reside outside of the cabin. If you want a fuel pressure gauge inside the vehicle it is best to use one with an electric sender. The vacuum/pressure reference pipe will need to be connected to the inlet manifold as per a boost gauge installation.

What should I look for? Check that your base fuel pressure is correct. Your tuner should be able to confirm what pressure the vehicle/regulator should be running and this is normally set at atmospheric pressure, ie with the reference pipe disconnected. You should see the fuel pressure reduce with the vehicle at idle and a vacuum depression present in the inlet manifold. When on boost, you should see the fuel pressure rise in relation to the boost pressure, normally at a 1:1 ratio. So, for every 10psi of boost pressure, you should see another 10psi of fuel pressure.

OIL PRESSURE GAUGE

A lot of vehicle manufacturers fit these as standard to performance vehicles as it is one of the most important areas to monitor.

Why do I need one? Oil is the life-blood of your engine, it needs to move around at suitable pressure to ensure everything is lubricated correctly, and it requires pressure to make it do so. This gauge monitors that pressure.

How to fit one: There are a couple of places to install the oil pressure sensor, one of which is into a sandwich plate that sits between the block and the oil filter, the other is into an oil gallery in the block. The oil gallery can be accessed either by fitting an adaptor between your existing oil pressure warning switch, or by removing one of the gallery blanking screws and accessing it directly with an adaptor fitting.

What to look for: Every engine will make different oil pressure. However, the following points should apply: oil pressure should be high on start up from cold as the oil is thicker when cold. As it warms up, pressure should drop. When the engine speed is raised, the oil pressure should rise as the oil pump speed is normally directly related to crankshaft speed.

You should familiarise yourself with 'normal' readings on your engine and look for abnormalities. Worst case scenario, if oil pressure falls to zero shut the engine down to avoid causing any terminal damage

"WE HAVE BECOME A NATION OF FLASHING LIGHT WORSHIPPERS."

AFR GAUGE

AFR (Air Fuel Ratio) is the measurement used to establish what ratio the mass air and injected fuel were combusted in the engine. A Lambda sensor monitors the exhaust gases and provides readings to a gauge.

Why do I need one? An AFR gauge is an excellent way to know how safe your engine is running. You can confirm at a glance whether the fuelling is lean, rich or safe.

How to fit one: The Lambda sensor will need to be installed into a boss in the downpipe approximately 6in after the turbo or in the collector area of a naturally-aspirated vehicle.

What to look for: Your tuner will advise you of your required under load AFR. However, 11.5-12.0:1 is deemed 'safe' for forced induction vehicles, 12.0-12.6:1 or leaner for N/A vehicles. 14.7:1 is deemed to be stoichiometric, where the most chemically efficient burn occurs, also known as 'Lambda 1.00'. Lambda 1 is normally the target mixture for idling and low load cruising on modern cars, as this is the least poisonous mixture for a catalyst.

BATTERY LEVEL GAUGE

Found on many vehicles both as factory fitted items and aftermarket additions. It allows you to keep an eye on your alternator charging rate.

Why do I need one? A battery level gauge will allow you to see whether the vehicle's charging circuit is operating correctly. It is not uncommon for alternators to stop working correctly when exposed to excessive heat or vibration.

How to fit one: Installation is very easy, simply requiring a wire to be connected to the positive and negative terminal of the battery.

What to look for: This varies from car to car and manufacturer to manufacturer, but generally the alternator needs to maintain a regulated charging voltage of approximately 14.00 volts. If it is producing more than 15.00 volts or less than 13.00 volts there is usually a problem and you need to be aware.

AIR TEMP GAUGE

Another commonly found gauge amongst owners of forced induction vehicles. It's fine having all that boost but do you know how hot your engine is?

Why do I need one? A key to getting more power out of your engine is to get more oxygen into it. If the air going in is hot, its oxygen content is reduced. At best hot air will reduce the power your engine produces, at worst it can lead to detonation. An air temp gauge will let you see how hot or cold the air entering your engine is.

How to fit one: Installation is normally done in one of two ways. The first involves securing the air temp sensor into the inlet manifold by drilling and tapping a hole or by bonding it in. The other (normally used for thermocouple wires) is to insert them under a silicone hose used to join boost pipes so that the wires protrude into the air stream. The sensor needs to be as close to the throttle body as possible, or in the inlet manifold to give an accurate reading of the air entering your engine.

What to look for: Air temps should be below 40degrees Celsius to ensure good oxygen content, below this shows an efficient air charge temp cooling system. High air temperatures can lead to detonation, and if you are seeing air temperatures in excess of 60degrees Celsius regularly, investigate alternative cooling and airflow options.

For optimum performance keep this under 40degrees C