BREATHE EASIER

This month Stu explains all about crankcase breather systems.

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

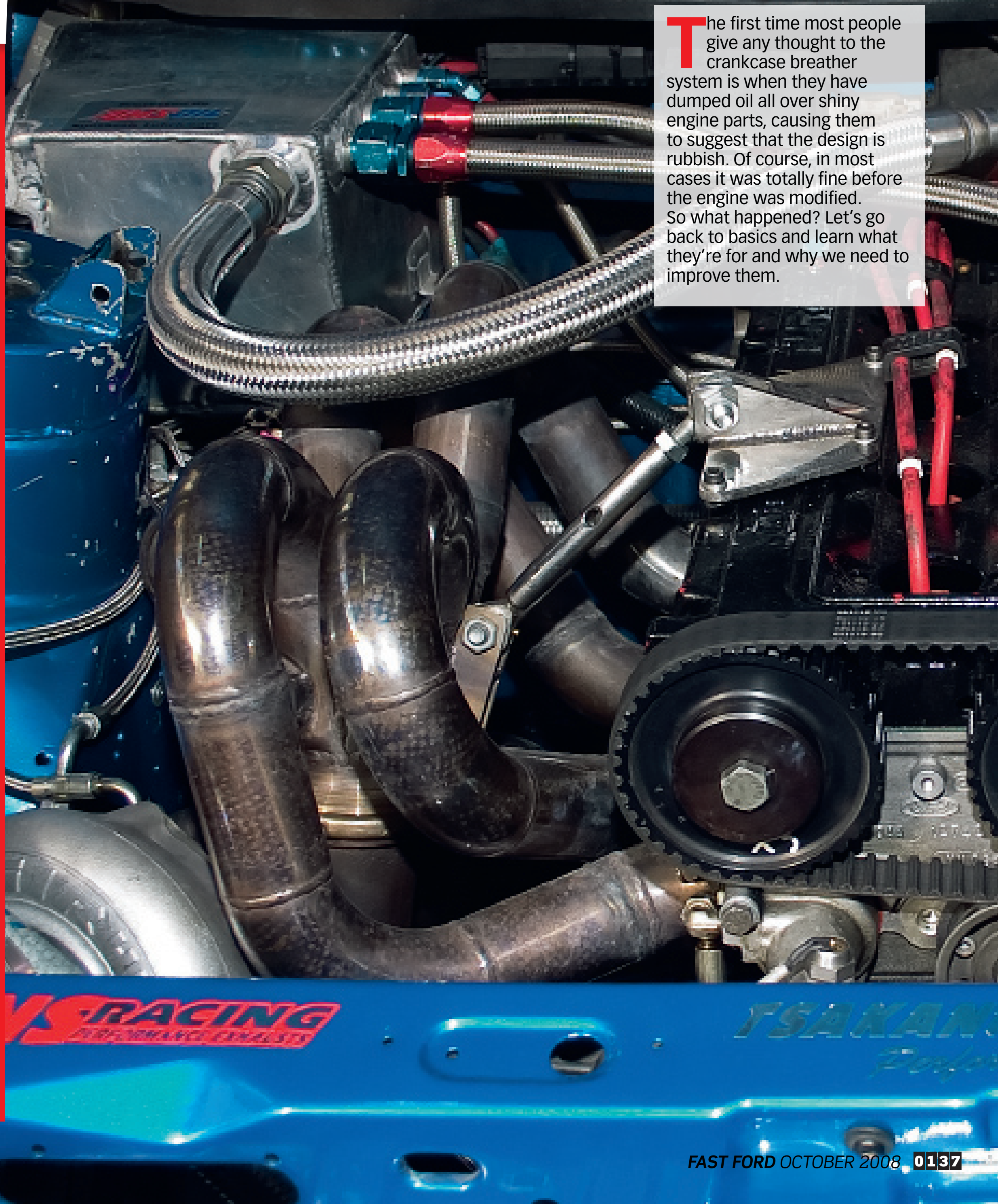
A Level 5-trained fuel-injection technician, Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

Seven 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.

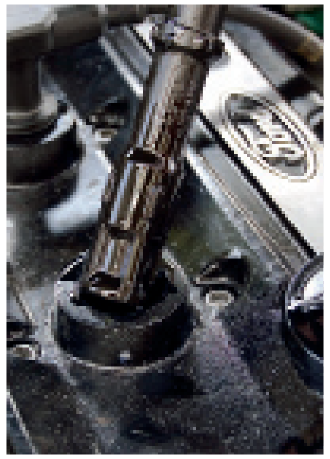
He's jointly responsible for **www.passionford.com**. Started in 2003, it's grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web. His new forum, **www.fordrsforums.co.uk**, is running too.

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.

The first time most people give any thought to the crankcase breather system is when they have dumped oil all over shiny engine parts, causing them to suggest that the design is rubbish. Of course, in most cases it was totally fine before the engine was modified. So what happened? Let's go back to basics and learn what they're for and why we need to improve them.



WHY WE NEED THE CRANKCASE TO BREATHE



All internal combustion engines leak a little combustion gas past the piston rings. How much leaks past depends on engine design and the bore/piston ring wear, but the older the engine the more gas will leak past.

This 'piston ring blow by,' will create a little crankcase pressure, and this pressure needs to be vented out of the crankcase one way or another to relieve the pressure, ie allowed to breathe. An engine can also 'breathe' through the valve guides, although to a lesser extent. (Breathe = air into crankcase/air out of the crankcase.)

PROBLEMS

If the crankcase breather system becomes blocked, or is of insufficient proportions to deal with the blow by, this will lead to various problems:

1 A host of oil leakage problems as the pressurised oily mixture forces its way out of any available orifice. Common leakage areas include dipstick, oil filler cap, cam cover gaskets, sump gaskets and crank and camshaft oil seals.

2 The oil control rings will be overloaded, allowing oil into the combustion chamber. This will not only increase oil consumption, it will also cause poor idling quality and power loss, and can lead to engine-destroying detonation in severe cases.

3 The oil will become contaminated by combustion by-products such as excess fuel and carbon, which will then accelerate engine wear as the lubricating qualities of the oil will then be compromised.

4 Turbocharged engines will start to lose oil via the turbocharger's turbine oil control ring as the differential pressure at the crankcase and oil return line is affected. This is seen as blue smoke from the tailpipe in most cases.

5 The engine will run low on oil and suffer failure due to the amount of oil lost through the inadequate breather system.

OVERLOADED

The standard engine's breather system is adequate, if not overkill for the standard power level. When we increase power or engine speed the levels of blow by are increased, and increased exponentially if we use higher turbo or supercharger boost levels.

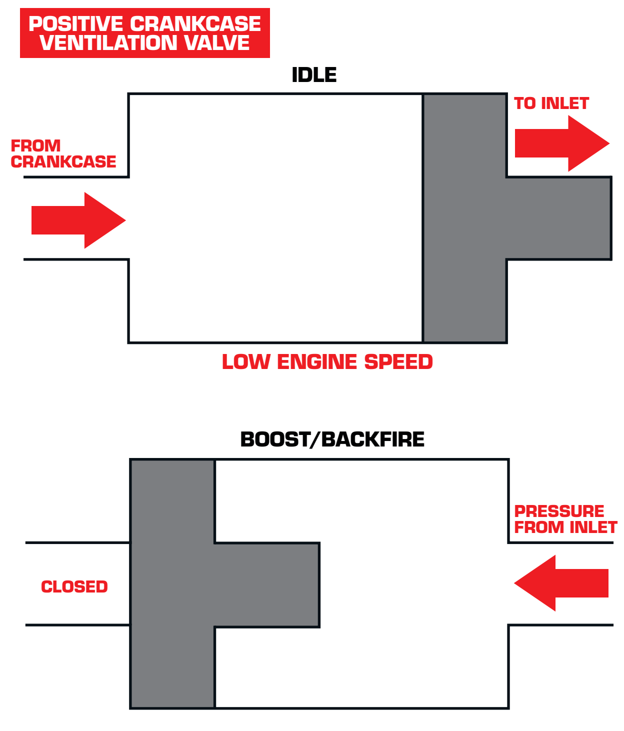
It's also worth noting that radical cam profiles can affect the breather system quite dramatically due to the inlet having less depression available to scavenge the crankcase of blow by gas.

The standard pipe work is often the first restriction as it is invariably a thick wall tube designed for long life and oil/heat resistance, thus its internal diameter can be quite small. The separator boxes and one-way valves further restrict the airflow if the blow by levels increase to such a point as to require larger diameter ports and pipes.

If the vehicle has good chassis and/or power improvements, it's possible that the cornering and acceleration forces generated by the car will create oil surge in the sump, which will overload the standard breather ports by immersing them in hot oil. The positive pressure in the crankcase will force that oil into the breather system. When it happens, oil's usually dispelled into the air filter housing and inlet manifold.

Sierra Cos drivers will be the fast Ford owners most likely to have seen oil pouring out of the air filter on their standard systems after a spirited drive.

HOW IT WORKS



All crankcase ventilation systems work in a similar way. Up until around 1960 they used to just dump the vapours and oil out to the atmosphere via the filler cap, but due to strong pressure from environmental groups the systems were redesigned to find a way to keep all the vapours and waste oil inside the engine compartment, thus the PCV (Positive Crankcase Ventilation) system was born.

Most breather systems will have a pipe that connects the crankcase to the air filter housing. As well as the route to the air box, most manufacturers also fit a connection to the pipe work that will connect the breather system into the inlet manifold in such a way as the inlet depression at low throttle openings will actually draw the blow by gas into the inlet manifold and burn it in the normal combustion process. This connection is often in the form of a one-way valve and exists to perform three very important functions:

PCV VALVE

1 Effectively stops blow by gas passing out of the air filter housing intake pipes if the engine isn't consuming sufficient air levels to create a depression level high enough to draw it into the engine from the air filter housing.

2 It regulates the amount of gas allowed to enter the combustion process at low engine speeds, as the engine run quality is most susceptible to mixture changes at low speeds.

This regulation is achieved in most systems by having a special one-way valve that varies in aperture depending on the manifold depression applied to it. At high depressions it flows very little air and at low ones it flows more.

3 In the event of a backfire, the one-way valve would close when it saw pressurised air, thus protecting the breather system from the backfire temperatures and potentially raw fuel.

SEPARATOR BOX

When the blow by gas is en route to the air filter housing, it will normally be passed through an oil separator box containing some kind of gauze designed to trap the oil suspended in the vapour. This means that only the waste air is taken all the way back to the air filter housing and then recycled back into the engine and combusted within the normal combustion cycle.

The trapped oil in the separator box will then drain back down to the sump via a specially designed drainage channel. If the oil was not separated from the vapour and returned to the sump, two bad things would happen:

1 The engine could potentially run low on oil and be damaged due to the engine burning it.

2 The burning oil will lower the octane of the fuel and cause running problems and potentially, engine damage.

HOW WE MODIFY THEM

This depends how good the factory system is. Pretty much every modern engine design will have a breather system that can cope with cylinder blow by for all moderate stages of engine tune, while still controlling the emissions perfectly well. However, even quite recent cars will need their breather systems looking at carefully with a view to replacing any perished-looking pipe work and ensuring that any oil separator boxes are clear and not gummed up with old oil and tar. Improving the system will require some serious planning.

First, you need to ascertain what breather ports the engine has and then decide if they are good enough. For example, a single 17mm port on the crankcase is often seen and, in my opinion, is insufficient for most engines that are expected to work very hard. I would far prefer to see two of them at that kind of diameter. Even if the engine has a 25mm one on the crankcase, I feel it would benefit from an additional smaller diameter one on the cam cover somewhere too.

If the crankcase only has one port on one side, as per most breather systems, you need to consider what will happen if this port becomes covered with oil due to cornering or acceleration forces while the sump is under pressure. Oil will be forced into the breather system and dumped into the air box and the inlet manifold. The only way to alleviate this problem is to release the pressure in the crankcase under this situation. We would usually do this by adding another breather to the crankcase, normally on the opposite side to the standard one so that you will never have both breather ports covered in oil at the same time due to cornering or acceleration force induced oil surge. If the cam cover doesn't have a breather port to start with, consider adding one.

When adding breather ports to your engine, pay attention to the fact that any rotating parts will throw a lot of oil around. Any breather connection near a rotating part will need to have some form of baffle plate fitted to ensure that oil isn't forced directly into your breather ports by high speed rotating parts. Failure to do so is a very common mistake!

Let's assume we have three breather ports connected to our engine, two in the crankcase and one in the cam cover. We need to send them all to a unified collector in order to separate the suspended oil from the waste air. This collector is commonly known as the oil separator and is readily available via the aftermarket and comes in all shapes and sizes. Essentially, it's a canister with three inlets for your breather connections, one big outlet to expel the waste blow by gas and ideally an oil return and a drain tap.

The internal channels are often filled with some form of baffle material that will stop the oil from making it all the way out of the canister and ultimately back into the air box or inlet manifold. Good canisters route the gas through a series of turns and twists while flowing through filter media to ensure as much oil as possible is removed from suspension in the air.

Once the canister is mounted and your breather connections are plumbed in, you only have two more hurdles to overcome. The first is what to do with the waste oil. For this there are two options:

WASTE OIL

1 Leave it in the bottom of the canister and drain it out by hand periodically to return it to the sump. While this system works, it does mean oil is left there for long periods of time, and it tends to degrade quickly due to the condensation found in these cool underbonnet-mounted tanks that never really get hot. In reality, the oil can actually be rendered useless in no time at all.

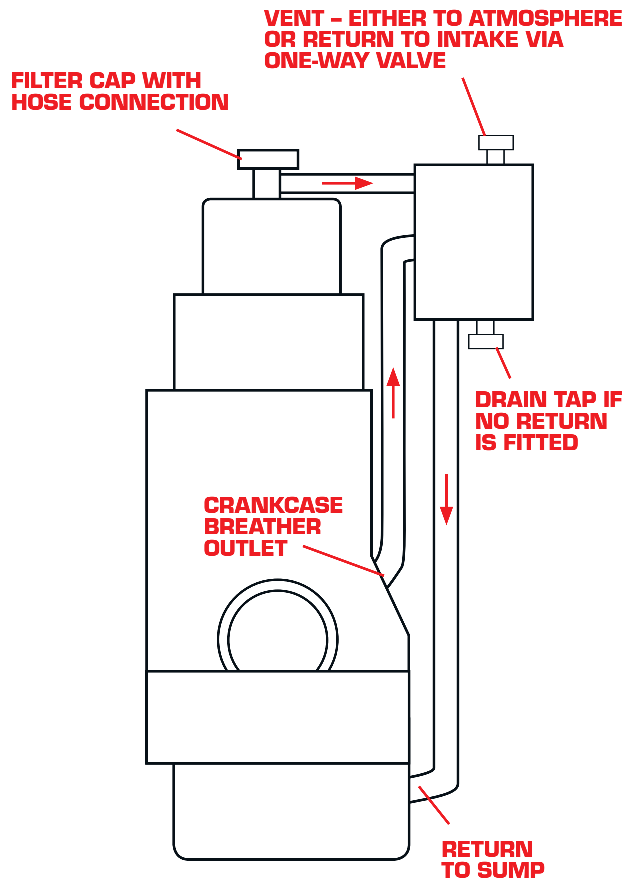
2 The correct thing to do is to drill and tap the sump and return the oil down a drain channel so it is always returned automatically to the sump, thus maintaining oil level and quality. If you are going to do this, ensure your oil drain tapping is fitted below oil level in the sump so that this return line is not subject to crankcase pressure that would otherwise slow or stop the oil from returning down the line.

BLOW BY GAS

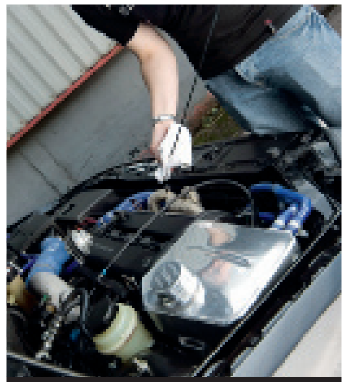
The second and last problem is what to do with the waste blow by gas. Again you have two options here:

1 You can pipe it up correctly like the OE manufacturer did and ensure that the air is routed back to the inlet system to be consumed by the engine.

2 Sadly the most common option. Most people opt to just leave this waste air being expelled into the atmosphere. While this may seem like a great idea, it has two major drawbacks. Firstly, any oily residue is deposited onto the tarmac to become an ice-like mixture once mixed with rain. Not what any biker needs as he is leaning into a fast bend... Secondly, when driving at slow speed, the fumes from the systems are invariably drawn back into the cockpit by blower motors, and it can be very poisonous indeed.



A MODIFIED BREATHER SYSTEM



CONCLUSION

That's pretty much it for this month, but I will warn you about two common problems with breather systems and modifying them. First of all, you must remember that all engines with engine management fitted will be programmed to take the air metered into the inlet manifold via the breather. Any change to the amount of air coming in will affect the emissions and so the way the engine runs. In some circumstances this may even lead to MoT failure.

Finally, beware of over filling your sump with oil in the mistaken belief that the more is always safer. It is categorically not safer; in fact it's less safe than running near minimum.

Excess oil in the sump means that the crank will start throwing the oil around the sump at high speed. This will not only lead to loss of power due to increased drag on the crank and rods but also lead to the oil control rings on the pistons being overloaded. The engine will start to burn oil as a result. The top rings will become less efficient and the rings will leak more gas down into the crankcase than usual. This will normally overload the breather system and oil may start filling the separator box and air filter housing. We just run round in circles with one problem feeding another once this cycle starts.

The vehicle manufacturer did not put a maximum fill line on the engine's dipstick for a laugh; it was done because that is the maximum amount of oil needed to fill the engine, so take note to avoid any trouble.

NEXT MONTH

Spark plugs: what they are and what they do.