THE EXPERT STEWART SANDERSON

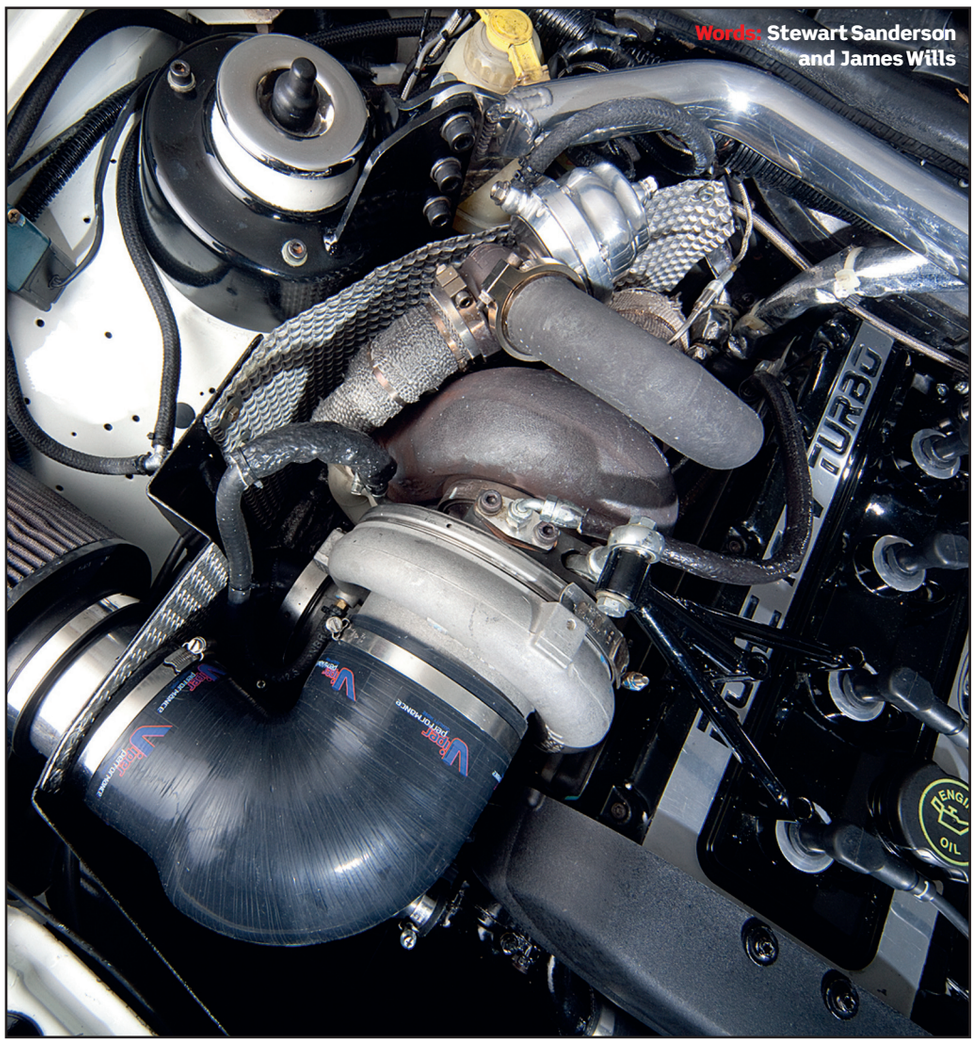
Having worked as a tuner for over 20 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

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.

11 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

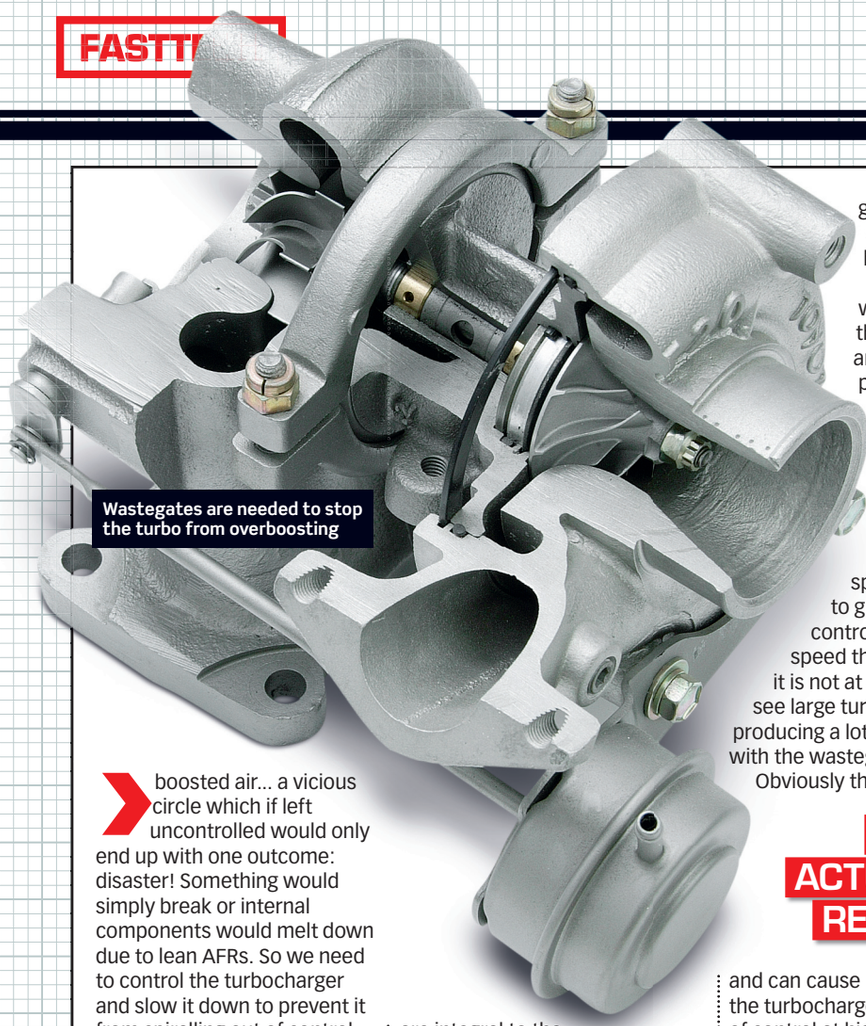
WASTEGATES

THIS ISSUE WE INVESTIGATE WASTEGATES AND SCREAMER PIPES – WHAT ARE THEY, WHAT DO THEY DO AND WHY DO YOU NEED TO KNOW? IT'S ALL HERE.

Hopefully you will have enjoyed the article about air injectors last issue, and the natural progression from air injectors is to look at what item on the engine those air injectors controlled, and that of course is the wastegate. What does it do? Well let's see...

SO, WHAT ARE WASTEGATES? AND HOW DO THEY WORK?

To fully understand the role of a wastegate, we need to look at why one is needed, and for that we need to refresh our memories on how a turbocharger works... Most of you who have followed my technical articles will know that a turbocharger is driven by exhaust gas, and the more exhaust gas that exits the engine, the faster the exhaust turbine is spun, and the more boosted air the wheel at the other end of the shaft, the compressor wheel, pushes into our engine. The problem is, the more air the turbocharger pushes into our engine, the more exhaust gases we create but of course, the more exhaust gas we create, the faster the turbocharger will spin, producing even more



Wastegates are needed to stop the turbo from overboosting

boosted air... a vicious circle which if left uncontrolled would only end up with one outcome: disaster! Something would simply break or internal components would melt down due to lean AFRs. So we need to control the turbocharger and slow it down to prevent it from spiralling out of control, but how can we do that?

That is where the wastegate comes into action, by opening a valve in the exhaust manifold and allowing excess exhaust gas to bypass the exhaust turbine of the turbocharger we can limit how fast it is rotated. In a nutshell we use a diverter valve to stop more exhaust gas going through the turbocharger than we require. The unrequired exhaust gas can be termed 'waste' hence the term 'waste' 'gate'.

However, rather than just open and close, it is required to regulate, as to maintain any given turbine speed we would have to bypass far more exhaust gas at 9000rpm than we would at 4000rpm. So the wastegate is actually a device used to regulate exhaust gas rather than just a device that is either open or closed. There are two main types of wastegate, so let's take a look at them.

INTERNAL WASTEGATES

Internal wastegates are housed in the exhaust housing of the turbocharger itself and, as their name suggests, are integral to the turbocharger design. Visually they actually resemble a valve in a cylinder head but it is on a flap, rather than a stem, so for the sake of your visualisation, they open pretty much like a garden gate. The gate controls a port that is located just before the turbocharger turbine scroll and when the gate to this port is open, it allows exhaust gas to travel directly from the exhaust manifold into the exhaust downpipe, totally bypassing the turbocharger's turbine wheel, having no effect on its rotational speed.

ANY COMMON PROBLEMS?

It is not exactly uncommon for the wastegate lever to snap, as the metal has a torturous time of being heated and cooled regularly in its life. Thankfully it is easily fixed with a spot of weld. A more common problem is the wastegate not seating properly against its face and causing lag and response problems due to the fact the wastegate is always partially open, bypassing exhaust gas that initially shouldn't have been bypassed.

One thing well worth noting is that any wastegate and corresponding port must be designed so as to be large enough to bypass enough volume of exhaust gas at high engine speeds to be able to give us the required control over turbine speed that we need. Sadly, it is not at all uncommon to see large turbochargers still producing a lot of boost even with the wastegate wide open! Obviously this is far from ideal and can cause massive issues if the turbocharger becomes out of control at high revs. The first sign of this issue to an end user (yes, you...) is that the higher you rev your engine in fourth and fifth gears, the more boost your turbocharger generates. This means your wastegate cannot bypass enough gas from the turbine under high load and engine speed situations and the turbocharger's boost level is actually out of your control and under gas control.

It is common practice on some turbochargers like the big Garrett T4 to have to enlarge the wastegate port sizing so that the wastegate can bypass enough exhaust gas to slow the turbocharger down to an acceptable level. I have seen T4s on a standard size wastegate with the wastegate wide open still want to produce over 25psi of boost pressure which is far from ideal on a car running small 403 Grey injectors that could only fuel 20psi at high revs or worse still, we have seen the same problem on little 803 greens as well.

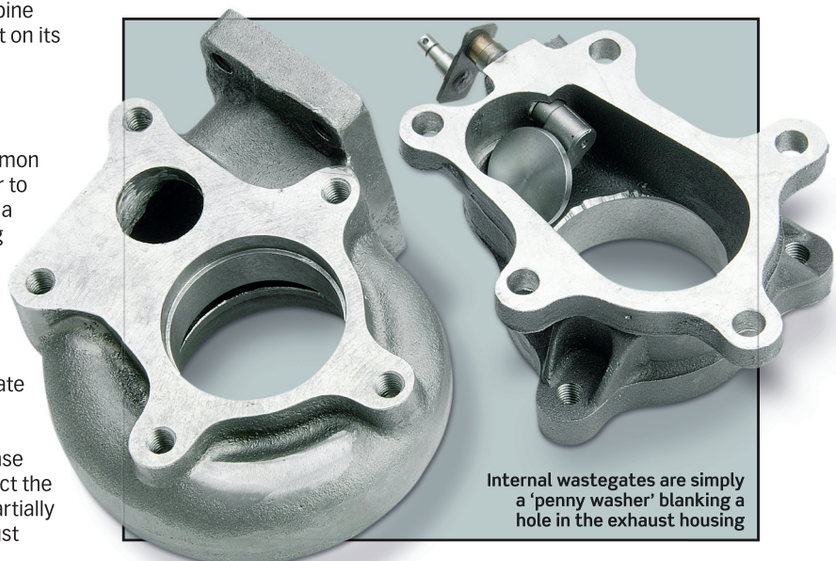
Interestingly, Ford themselves had this problem with the RS500 so as a last resort they restricted the downpipe of those 500 cars to create a large exhaust back pressure to keep boost down. Owners coming along and fitting a nice big Mongoose or Magnex back in the day were usually flummoxed as to why the car now hit a boost limiter.

Another issue that causes exactly the same symptoms is when someone puts so much preload on a wastegate actuator (usually in a vain attempt to get more boost), that the wastegate itself no longer opens properly as there is no travel left in the actuator. This we see at least once a month.

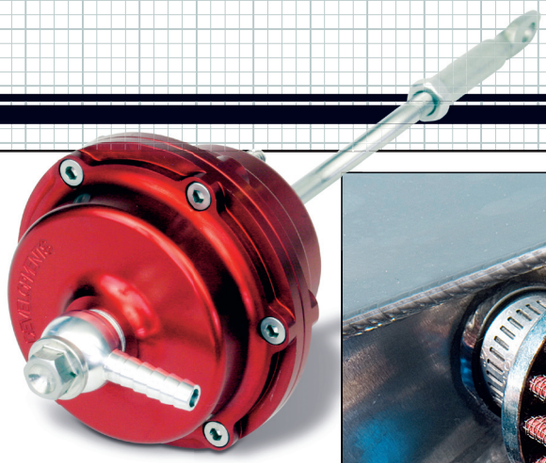
"THE WASTEGATE IS ACTUALLY A DEVICE USED TO REGULATE EXHAUST GAS"

WHAT CONTROLS THIS WASTEGATE FLAP?

Internal wastegates are controlled by a device called



Internal wastegates are simply a 'penny washer' blanking a hole in the exhaust housing



a wastegate actuator. This is simply bolted to the turbo itself. It consists of a metal canister with a spring and diaphragm inside it connected to a rod which is in turn connected directly to the wastegate arm. Inside the canister, the incoming boost signal pushes on the diaphragm and compresses the spring. The more pressure (boost) that enters the actuator, the further out the rod is pushed and the further the wastegate opens. Simple.

EXTERNAL WASTEGATES

An external wastegate is rarely fitted to the turbocharger itself at manufacture, it is almost always a nice, self-contained aftermarket item sized to suit your power output and then fitted into a suitable location to do its job.

It is a pretty simple device, having only two ports. It will have an inlet port which must be fed with exhaust gas from before the turbine scroll on the turbocharger's exhaust housing, and an exit port that will need to direct exhaust gas to the downpipe, after the turbo, or into a 'screamer pipe' which we will look at a little later. As you can see, it does exactly the same job as the internal wastegate but in a more customisable manner with regards size and location.

The most critical aspect to an external wastegate installation, and the one most commonly ignored by over keen DIYers is the fact that the wastegate must bypass an equal amount of exhaust gas from each cylinder. If it were not to do so, we would end up with an engine efficiency imbalance between cylinders that would cause all manner of problems, not to mention some unusual pulses reaching the turbine wheel which, again, will cause all manner of issues.

WHAT CONTROLS THE EXTERNAL WASTEGATE?

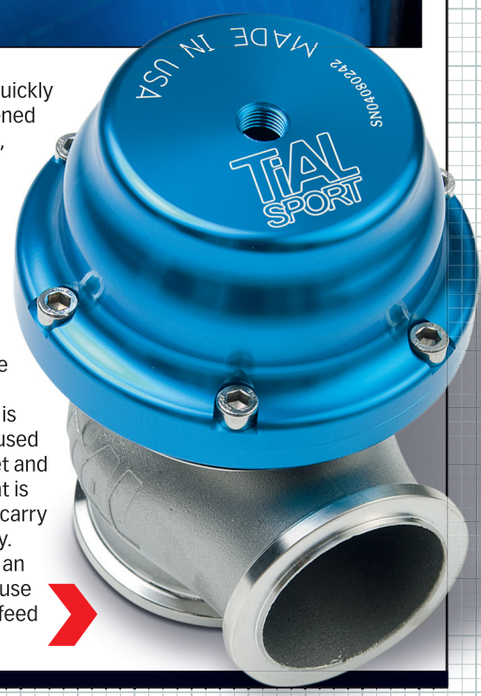
An external wastegate incorporates its own actuator system, which is very similar to the separate wastegate actuator component that we mentioned when discussing the internal wastegates, but instead of being a separate unit, it is integral to the design of the external wastegate. The springs in the unit can be changed very easily, allowing us to achieve the boost pressure and control that is required on any manner of different installations.

ANY COMMON PROBLEMS?

As per the internal gate, sizing must be perfect of course especially as it's easy to go too big with an external wastegate. If a wastegate is too large, the boost can drop too quickly when the gate is opened even a small amount, making smooth boost control very difficult to achieve, especially if you only need to knock a few PSI off the boost level.

Other than that, the only problems we ever really see with external wastegates is when someone has used pipe work on the inlet and outlet of the gate that is too small to actually carry the exhaust gas away. In fact, we once saw an alleged professional use some 10mm pipe to feed a 50mm waste gate!

Air injectors can be used to precisely control the actuator



CONTROL SIGNAL HOSES

Whether the wastegate is internal or external, its actuation system will usually be fed with a boost reference hose, directly from your chosen boost controller.

These hoses are generally rubber... Now most of you reading this will spot an instant potential for disaster there. 900degC exhaust manifolds and rubber in close proximity. Just remember without this reference boost signal actually reaching the wastegate to push it open, the wastegate may not open at all meaning the turbocharger will simply keep on making pressure until something breaks or melts!

"MANIFOLDS AND RUBBER IN CLOSE PROXIMITY IS INSTANT POTENTIAL FOR DISASTER."

The quality, routing and insulation of these hoses is absolutely critical. If they melt or get damaged then it could mean the end of the engine! Internally gated turbochargers usually have the wastegate actuator mounted on the compressor housing which is on the coolest part of the turbo making it very easy to route the boost control hoses forward and away from heat and possible damage.

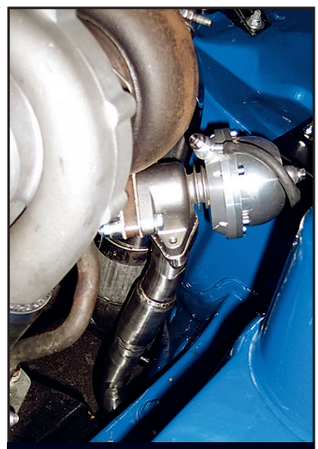
External wastegates on the other hand are mounted on the exhaust manifold which is the hottest part possible! So it is critical that the boost control reference hoses are well heat wrapped, routed away from heat and kept clear of any contact with the exhaust or turbocharger itself. It is recommended that Aeroquip-type hose and fittings are used here as they can take a lot more heat than standard rubber hose and the chances of a boost control hose failure is dramatically reduced when using this type of hose. It may cost more at the outset, but long term can end up a whole lot cheaper!

WHAT IS A SCREAMER PIPE?

A screamer pipe is essentially an alternative to directing the waste exhaust gas from the outlet of our wastegate into the main exhaust system. Instead, it can be directly dumped to atmosphere through a screamer pipe. As the name suggests they can be very noisy as they are usually unsilenced.

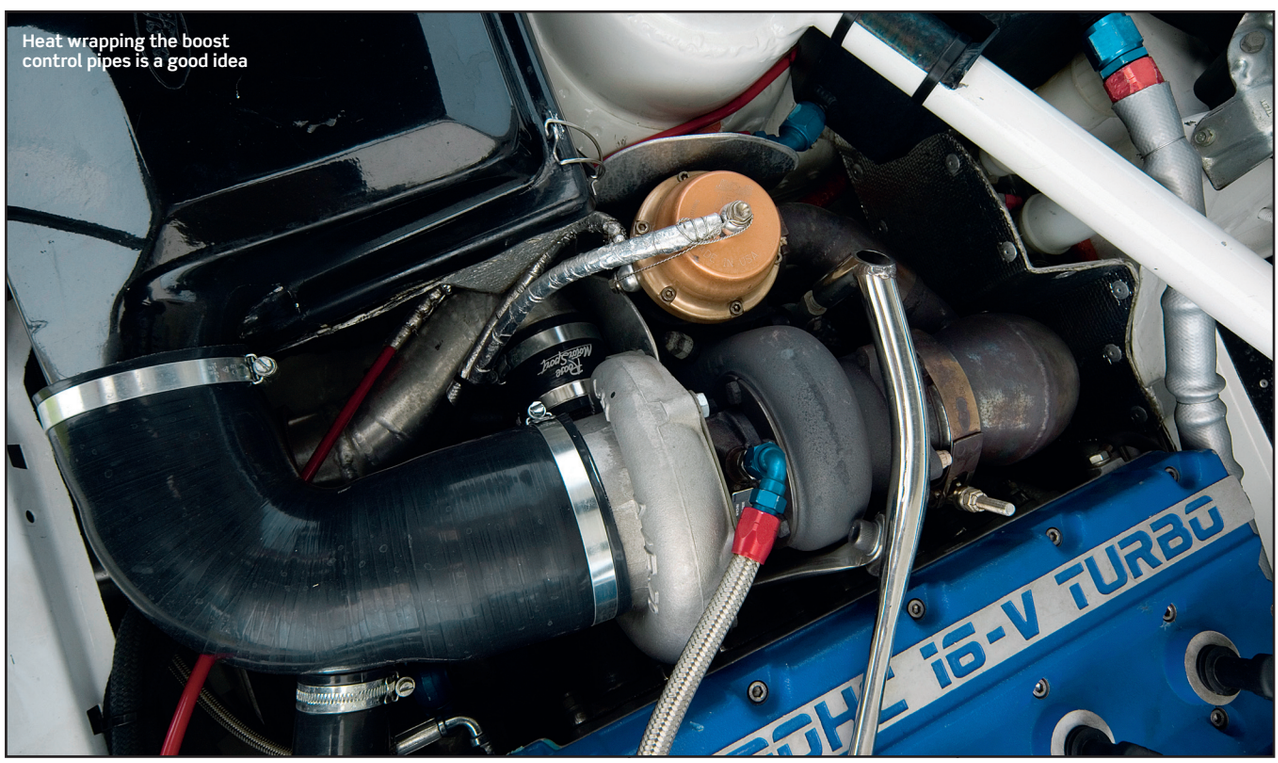
A screamer pipe can actually pick up some power if the exhaust system is in any way restrictive as it will remove a large amount of gas flow from the exhaust system under wide open throttle conditions when the wastegate is open, decreasing the bottleneck presented by the exhaust system.

The positioning of the screamer pipe itself, and specifically its outlet end, is very important, the pipe itself can become very hot so good heat management is critical. The vent point is also extremely important as the screamer pipe will dump flames and seriously hot exhaust gases. So, pointing it at the front tyre would obviously be pretty stupid right? Well I have seen a few just like that! In fact I have seen a number of screamer pipes that have melted or set fire to various suspension and drivetrain components like CV boots and rubber brake lines, simply because they are not directed to a suitable area. So think carefully when having one fitted and exercise some common sense. A screamer pipe is a flamethrower... please treat it like one.

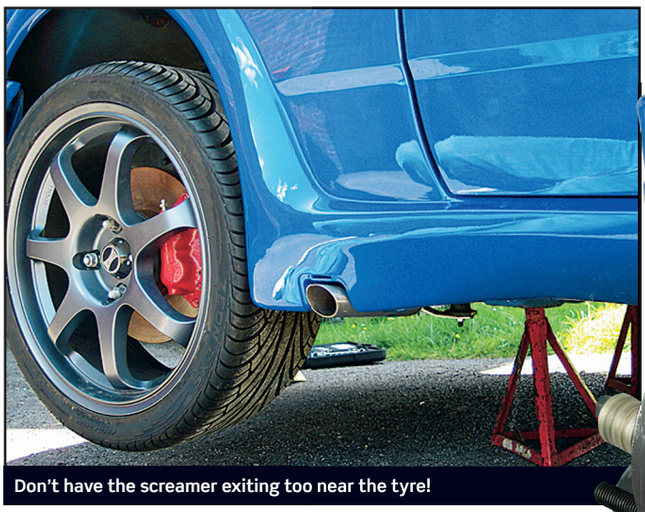


Screamer pipe vents the excess exhaust gas to atmosphere

If the screamer pipe is to be mounted to the body of the car in the usual manner it would be advisable to use some form of flexible joint on the pipe to allow the engine to move around without cracking or stressing the pipe itself and also the wastegate unit. This is another failing we see regularly.



Heat wrapping the boost control pipes is a good idea


Don't have the screamer exiting too near the tyre!

WASTEGATE MYTHS

There is really only one myth surrounding wastegates and that is the much spoken about but totally misunderstood term 'wastegate chatter'.

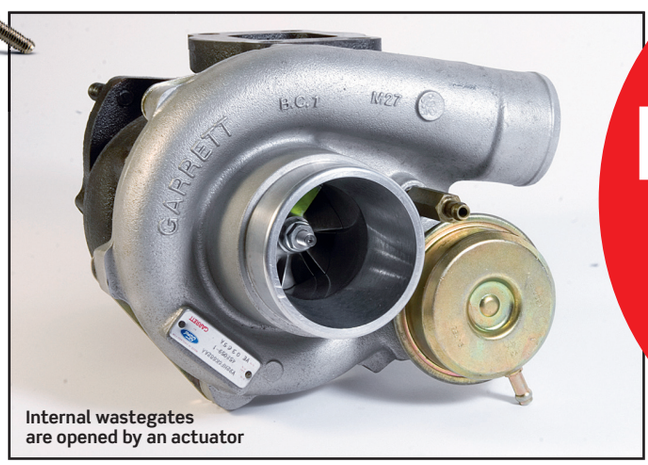
The term is given to that very hard to describe but easily recognised sound that high power turbocharged cars make when the driver lifts off the accelerator under power. It is most often likened to a very loud 'pigeon call' or a warbling sound and it has become a bit of a myth that it is the sound of the wastegate bouncing open and closed off its seat, hence the term wastegate chatter.

It is in fact nothing of the sort, it is the sound made by air that was travelling at very high speed through an inlet system and then suddenly came across a closed throttle butterfly. The resulting pressure wave is forced to reverse and travel backwards through the high speed turbocharger's compressor; this sound pressure wave then clashes with the compressor which is still trying to send air the other way and this clash makes a very distinctive warbling sound. This sound is much louder when a cone filter is fitted as the standard airbox on all cars works as a silencer.

Of course, you now know why you generally have to take your dump valve off to make this sound happen... the dump valve, by design, stops that pressure wave from having to go backwards at all, which is why we fit them as close to the throttle body as possible. Some manufacturers call the standard vehicle's dump valve a 'noise suppressor'... Now you know why.

SUCK OR BLOW?

It's worth mentioning that some actuators on modern cars are operated by a vacuum instead of pressure. This overcomes a failing pipe causing too much boost pressure as they start off fully open and then get closed, instead of the other way round. The rest of the explanation is the same.



Internal wastegates are opened by an actuator

NEXT MONTH

THE DIFFERENCES BETWEEN TURBOS AND SUPERCHARGERS