



Aus Liebe zum Automobil

# **TSI. A Miracle of Performance.**



**TSI**



TSI



AC R134a  
Substrat  
R134a  
Wichtig: bei demontieren  
Füllmenge 525g  
Distanz Level 175  
Wichtig: bei demontieren  
Wichtig: bei demontieren

**ACHTUNG! WARNING! ATTENTION!**

**ACHTUNG!** Bei Wartungsarbeiten an der Klimaanlage das Gas nicht ablassen. Bei Ablassen des Gases das Gas in eine geeignete Abfallbehälter abgeben. Bei Ablassen des Gases das Gas in eine geeignete Abfallbehälter abgeben. Bei Ablassen des Gases das Gas in eine geeignete Abfallbehälter abgeben.

**WARNING!** When working on the air conditioning system, do not release the refrigerant gas. If the refrigerant gas is released, it must be disposed of in a suitable container. If the refrigerant gas is released, it must be disposed of in a suitable container. If the refrigerant gas is released, it must be disposed of in a suitable container.

**ATTENTION!** Lors des travaux de maintenance de la climatisation, ne pas relâcher le gaz réfrigérant. En cas de relâchement du gaz réfrigérant, celui-ci doit être évacué dans un récipient approprié. En cas de relâchement du gaz réfrigérant, celui-ci doit être évacué dans un récipient approprié. En cas de relâchement du gaz réfrigérant, celui-ci doit être évacué dans un récipient approprié.







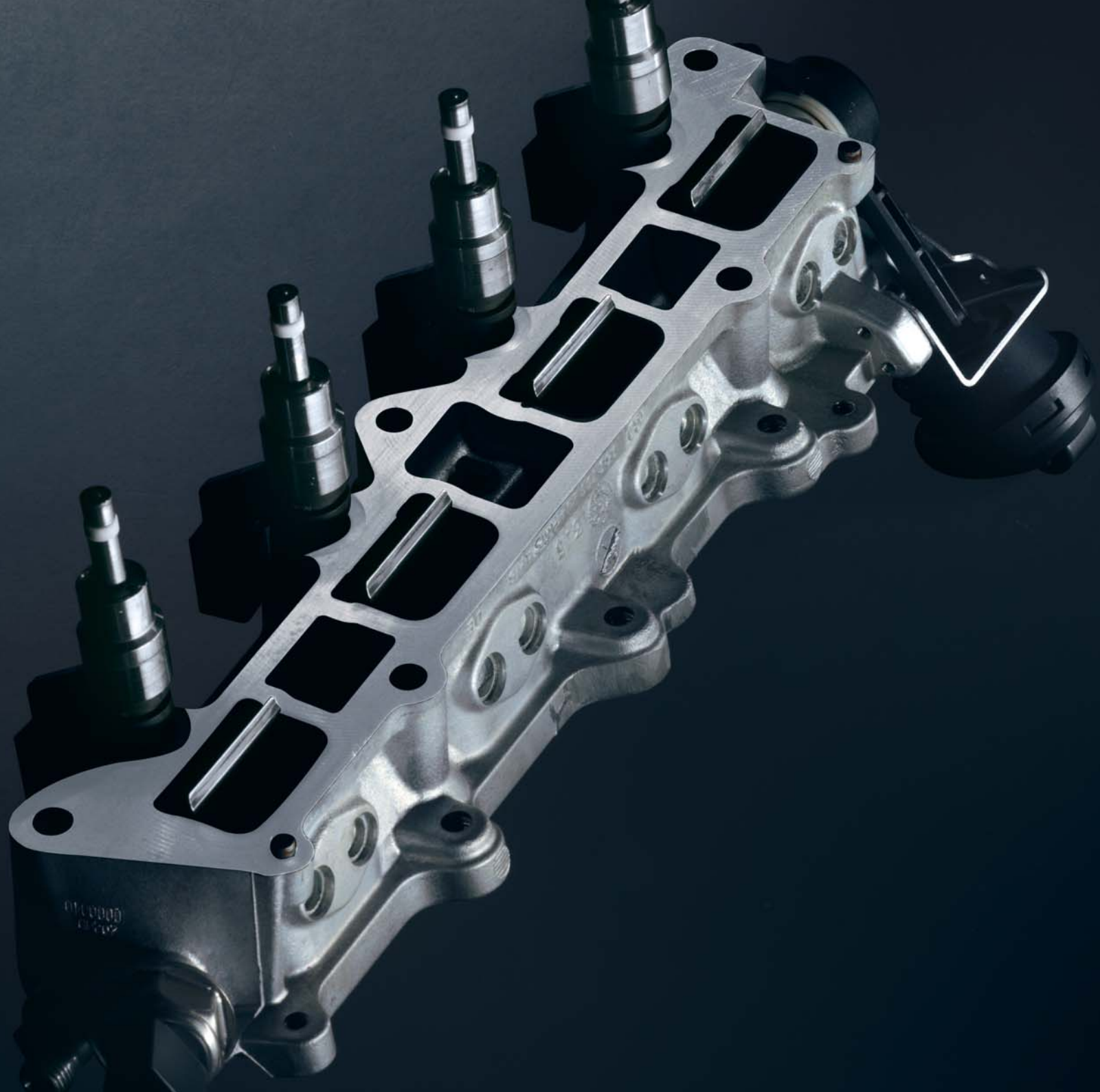
## Driving the miracle



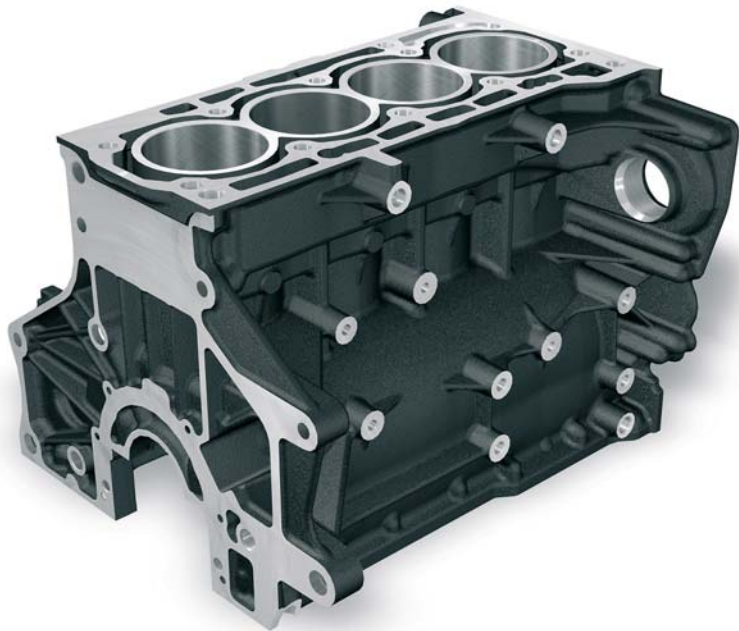
True automotive breakthroughs that successfully challenge laws and shake up the rulebook come along only once every so often. Like today.

Introducing Volkswagen's innovative twincharger TSI engine: a powerplant so remarkably advanced that it garnered numerous accolades even before its launch, including the highly-coveted 'Best New Engine of the Year' title at the International Engine of the Year Awards 2006.

**Introducing the twincharger TSI petrol engine.  
The first engine in history to combine turbocharging,  
supercharging and direct fuel injection.**



**125kW (170bhp)**  
**240Nm torque**  
**7.2l/100km (13.9km/l)**



The result? Maximum power with minimum fuel consumption.

The numbers speak for themselves. The TSI engine pumps out a class-leading 125kW (170bhp) and 240Nm of torque. Volkswagen has chosen an ultra-efficient Roots-type supercharger that delivers strong boost right from idle, so the engine produces more than 200Nm of torque from just 1,250rpm.

The turbocharger quickly spools up as the revs climb, and by 3,500rpm the supercharger can be disconnected for optimum engine efficiency. From the driver's seat, all you feel is one continuous, exhilarating surge.

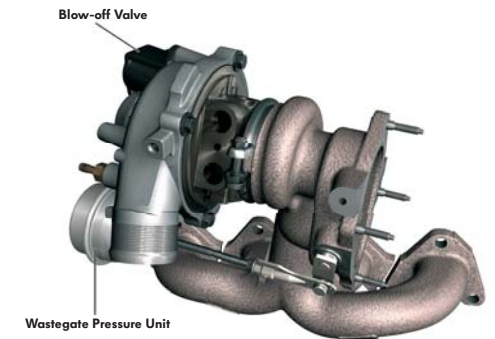
Volkswagen engineers have also managed to consign the dreaded 'turbo lag' to the past. With the TSI engine, there's absolutely no delay between stepping on the accelerator pedal and the power being delivered.

This instantaneous engine response gives better control when driving hard on challenging roads. What's more, you can continue driving all day because if there's one thing the TSI engine hates, it's petrol stations. With a fuel consumption figure of just 7.2 litres per 100km in the combined cycle, it's as economical as many engines with half as much power.

## The 1.4-litre TSI engine manages to do the work of a 2.5-litre engine

The first thing to note is that the 1.4-litre TSI engine is very small in capacity relative to its output. We all know how ants can lift objects many, many times their own body weight. In much the same way, with a capacity of just 1.4-litre, the TSI engine manages to do the work of a 2.5-litre powerplant. It accomplishes this feat by being very, very good at something called 'efficiency'.

'Efficiency' basically refers to how much air you can actually get into an engine compared to that engine's static capacity. More air means more power. High efficiency means being able to get nearly as much air into an engine as its static capacity permits. But Volkswagen's TSI technology goes one big step further. It allows an engine to achieve more than 100 percent efficiency right through the rev range.



“If this is the future for the petrol engine, the trend in Europe towards diesel powerplants could already have hit its peak. The Twincharger really is that good.”

Greg Kable, Autocar magazine, UK



# More air = more power

The easiest way to get more air into an engine is to pressurise it with a special sort of pump. There are two types you can use: supercharger or turbocharger. But there are problems.

Turbochargers run off an engine's exhaust gases, which means they don't sap engine power. Unfortunately, this also means they don't get to work instantly. There's a delay before the exhaust gas pressure gets high enough to work the turbo, and this is commonly called turbo lag. In powerful cars, turbo lag can be either undesirable or extremely thrilling depending on your point of view.

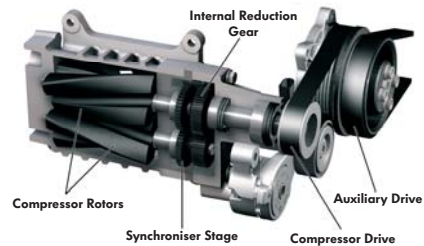
On the other hand, superchargers run directly on engine power, so they work

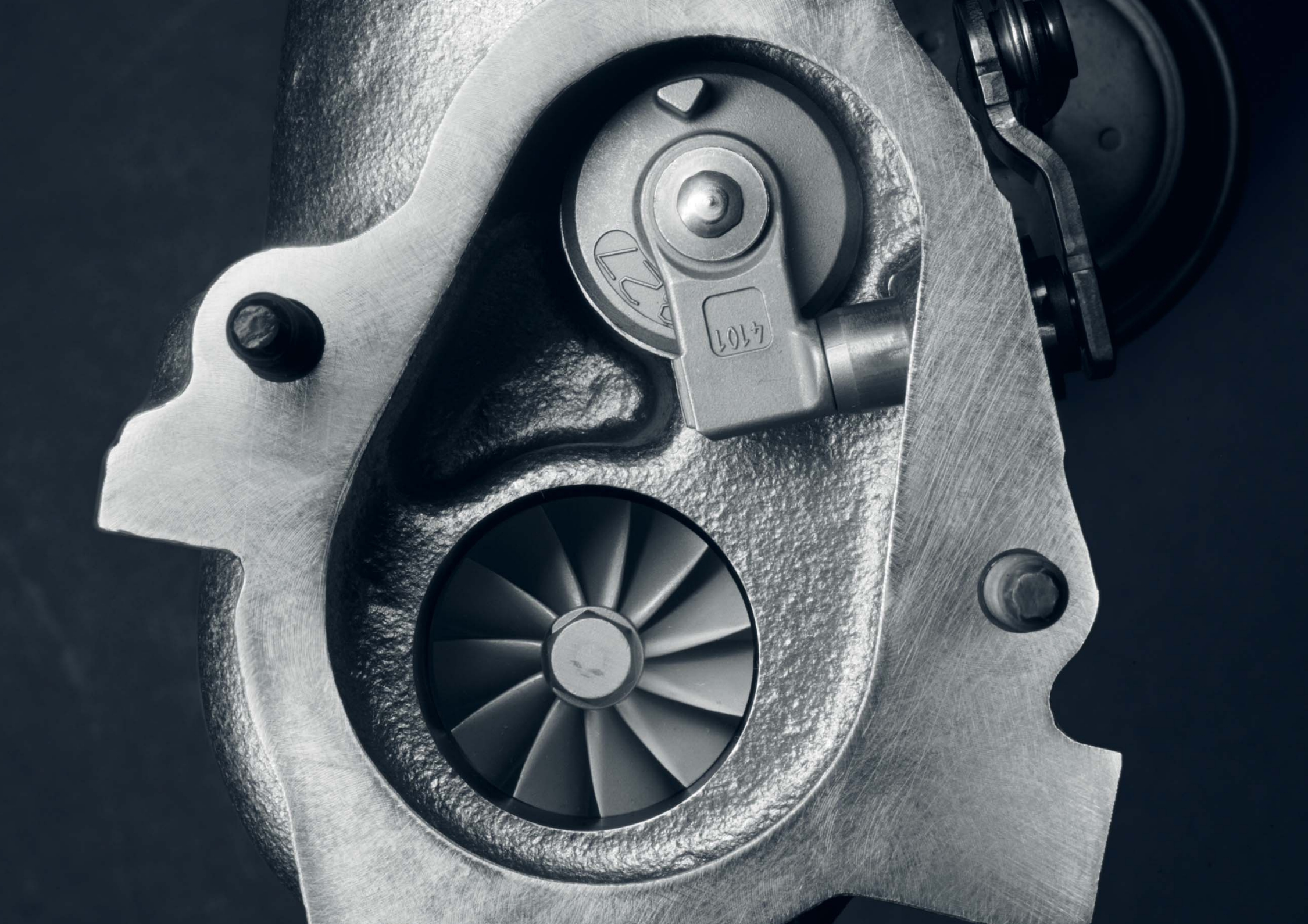
immediately. The disadvantage is that they constantly soak up some engine power, so they aren't all that efficient. What's worse is that this extra load from the supercharger increases as you build up speed.

The best would be to combine the advantages of both supercharger and turbocharger but leave their respective disadvantages behind. And that's exactly what TSI technology does.

The TSI uses a supercharger for low engine revs and a turbocharger when it gets to higher revs. It almost sounds too simple really. Then again, the most elegant solutions often are.

Gear ratio crankshaft to water pump	i1	=0,75
Gear ratio water pump to compressor	i2	=0,52
Gear ratio compressor reduction gearset	i3	=0,52
Total gear ratio	iges	=0,20





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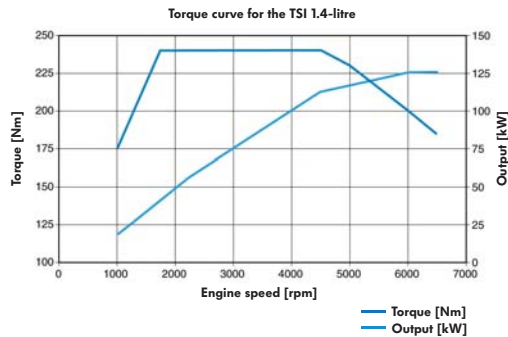




# The TSI engine averages 7.2l/100km (13.9km/l). Compare that with 10l/100km (10km/l) from a 2.5-litre petrol engine.

Perhaps the best thing about the TSI engine is its fuel economy. It averages 7.2l/100km (13.9km/l) in the combined cycle. In comparison, a 2.5-litre petrol engine only manages to achieve a markedly lower consumption figure of about 10l/100km (10km/l) on average.

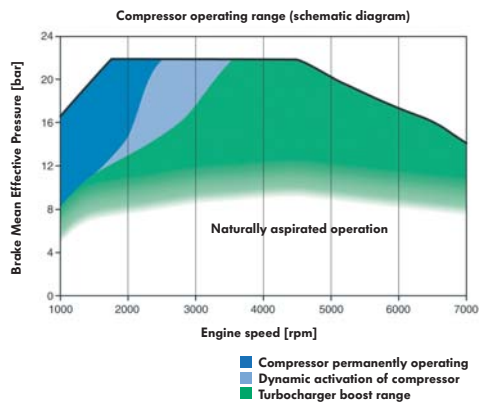
Continued dependence on crude oil is not the way of the future. At present a viable solution to managing today's skyrocketing fuel costs is what's needed most. The TSI engine represents one.



The TSI engine embodies Volkswagen's passion for innovation and its pursuit of technological perfection. But it also serves a greater purpose. While there's no doubt that you will enjoy more power and improved fuel economy, in broader terms, the technology employed in the TSI engine is also in aid of sustainability.

The TSI engine's groundbreaking ability to deliver maximum performance with minimum consumption is just one part of Volkswagen's broader blueprint for sustainability. Towards this end, Volkswagen has also embarked on a concept project to develop a Compressed Natural Gas powered TSI engine, thereby taking us closer to realising a future independent of crude oil.

More crucially, the TSI engine also produces 240Nm of torque. To put this figure into some perspective, most 2.5-litre cars only produce somewhere in the region of 220Nm to 230Nm.





Dr. Rudolf Krebs

# Meet the father of TSI development

We catch up with the head of Volkswagen's engine development department - Dr Rudolf Krebs - to gain further insight into the TSI engine.

“Only when both the compressor and the exhaust turbocharger complement one another optimally can the driver experience maximum torque and driving pleasure without worrying about fuel consumption.”



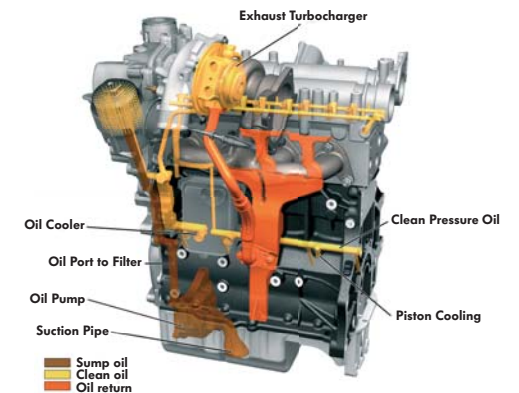
The TSI Team

## 1. What inspired the TSI engine?

Our goal was to reduce fuel consumption and at the same time offer better performance. The most effective measure was to “downsize” the cylinder capacity, while balancing the limited power with the innovative double charging technology. The result is Volkswagen's groundbreaking TSI engine.

## 2. In a few words, describe the TSI.

The TSI is the world's first twincharged FSI engine. It offers drivers a miracle of performance, delivering maximum power and driving pleasure with minimum consumption.



### 3. What was the biggest challenge in developing the TSI engine?

One of our biggest challenges was to achieve the best possible interplay between the turbocharger and supercharger. Only when both complement each other optimally can the driver experience maximum torque and driving pleasure – without worrying about fuel consumption.

### 4. How do you think the TSI engine will change the future of petrol engines?

There is no question that the TSI marks the technology of the future. The petrol engine is going to be a real alternative to the diesel engine with additional cost savings.

“Our motto: Only fuel economy combined with the fun-to-drive element sells! Moving forward, this will guide Volkswagen in the way we develop and optimise our engines.”

### 5. Would you say that the TSI engine is one of the greatest achievements in Volkswagen gasoline engine development?

Yes. Our aim was to disprove the generally held belief of either economy or performance.

### 6. What made you first think of combining the supercharger with the turbocharger?

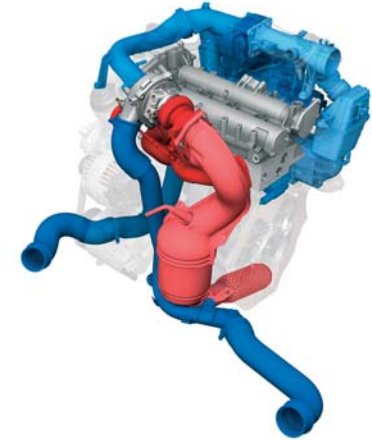
Our TDI engines with their tremendous torque characteristics were the role models. Our quest was to copy their success factors, i.e. direct injection and turbo charging, to gasoline engines. After we successfully developed the FSI engine, the next natural step in improving efficiency was to turn to engine-charging technology. To achieve best performance on the highly downsized engine, we realised early on that it was necessary to support the turbocharger with a mechanically driven supercharger.

### 7. You've tackled the problem of balancing fuel economy and power. What do you think is the next big area of development for engines?

Our motto: Only fuel economy combined with the fun-to-drive element sells! Moving forward, this will guide Volkswagen in the way we develop and optimise our engines.

### 8. What's your vision for the TSI?

That customers will say they've never had so much fun saving money with a Volkswagen!



### 9. What are the next big projects you're working on?

The biggest challenge now is to balance customers' expectations and preferences, with the constraints of broader political and social issues impacting the automotive industry. Such as rising fuel prices.

This means we're working on a wide number of projects concurrently. Top of the list are:

- Further fuel efficiency optimisation
- Emissions reduction
- Maximising performance
- Improving acoustics
- Expanding our research on bio fuels
- Strengthening the DSG (Direct Shift Gearbox) strategy

And what sort of results are we expecting? Just wait and see!



# TSI FAQ's

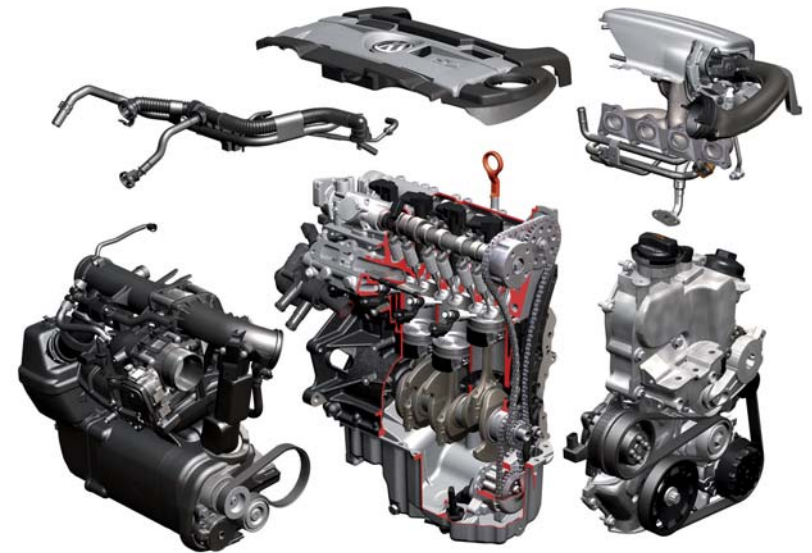
Know the TSI inside out.

## What's a Twincharger?

It's more a system than a thing. Think of an engine as a device that consumes air. The more air you get into it, the more fuel you can combust with it and produce more power. As the name suggests, the TSI's Twincharger is a dual charging system, meaning there are two components which increase the charge density – or the amount of oxygen per unit of volume of air – of the air consumed by the TSI engine. Namely, the system includes a Roots-type supercharger as well as a turbocharger.

## What does a supercharger do?

It's basically an air compressor. A mechanical device driven off the engine's crankshaft, it employs rotating vanes which spin in opposite directions to compress air in the engine's intake system. Because the TSI's supercharger is geared to spin five times faster than the engine, it's effective from very low rpms. In fact at idle, the supercharger is already pushing air into the engine at 1.8 times atmospheric pressure! That's why the TSI is capable of generating such terrific low-end response, and why the driver simply feels that he has a much bigger engine.



**Since the supercharger works best at low rpms, and the turbo at high rpms, why not combine the two?**

# There are equally powerful engines out there but is there one which delivers the goods with such a low appetite for fuel?

## What does a turbocharger do?

Essentially the same thing as a supercharger but in a very different way. While a supercharger is driven by the engine, a turbocharger gets its energy from the exhaust gases leaving the engine. This flow of gas is harnessed to spin a turbine (hence the 'turbo' prefix), which in turn drives vanes which compress the intake air. This use of 'free' energy from the flowing exhaust gases makes the turbocharger an attractively efficient means to boost engine performance.

## So why do you need both systems?

Naturally, each type of charger has its drawbacks. The supercharger, while effective from very low engine speeds, also tends to consume some of the engine's energy at high rpms. The turbocharger, on the other hand, is a lovely device at high rpms. Since the supercharger works best at low rpms, and the turbo at high rpms, why not combine the two? That's the singularly brilliant concept behind the TSI. It breathes hearty flows of compressed air from the supercharger until about 3,500rpm, at which point the turbocharger picks up the ball, driven by a powerful flow of exhaust gas. Meanwhile, the supercharger is disconnected from the engine by a small clutch, just to keep it from consuming engine power.

## Will I be able to feel the engine switching between the supercharger and turbocharger?

Given how the computer-controlled transition between both charging systems happens seamlessly, most likely not.



## Why not apply TSI technology to larger engines for even more power and performance?

In one word – efficiency. In a few more – because there really isn't a need for it. Larger engines usually produce enough gas flow to enjoy efficiency and power gains from a turbocharger alone. A smaller engine means less weight, lower levels of internal friction and other advantages. There are equally powerful engines out there but is there one which delivers the goods with such a low appetite for fuel?

# Key facts about the TSI engine

Knowledge is power, and the Volkswagen engineers know all about that. Soak up these key facts about the TSI, and you will too.

## First of its kind.

### With no less than 320 patents.

The TSI engine is the world's first double charge direct injection petrol engine in production. The TSI technology is so innovative that, along with the FSI system in Volkswagen's other petrol engines, it's protected by 320 patents.



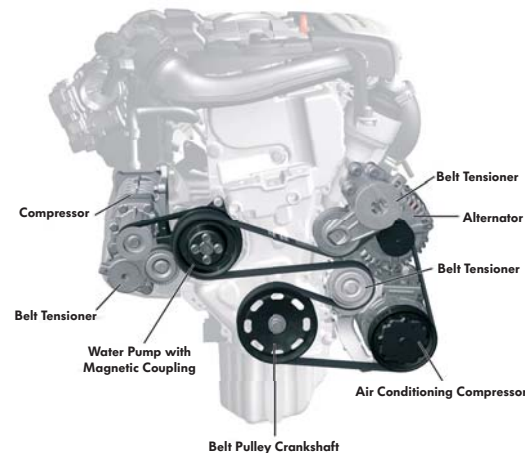
## Most awarded engine in the world.

Winner of the Auto Motor Sport 'Paul Pietsch Prize', the 'Innovation Award' from Popular Science magazine and the much-coveted 'Best New Engine' in the International Engine of the Year Awards 2006, the 1.4 TSI is currently the most decorated engine in the world. It also grabbed full honours in the 1.0 to 1.4-litre class of the International Engine of the Year Awards.



## 240Nm torque from 1,750rpm to 4,500rpm. On just 1.4-litre.

The TSI engine produces 125kW (170bhp), enough to power a Volkswagen Golf GT to 220km/h (136mph). Along the way, 100km/h is reached in just 7.9 seconds. It helps to have 240Nm of torque from just 1,750rpm all the way to 4,500rpm. And it's just a 1.4-litre.



## Excellent fuel economy at 7.2l/100km (13.9km/l).

The 1.4 TSI delivers fuel economy of 7.2l/100km (13.9km/l) in the Golf GT. A standard engine would have to be 2.3-litre in size to perform as well as the 1.4 TSI, but would end up consuming approximately 20 percent more fuel.

## Bye bye turbo lag.

Turbochargers deliver plenty of torque, but you have to wait – they operate best at high engine speeds. A supercharger boosts torque from very low engine speeds, so adding one to a turbocharger means goodbye turbo lag.

From as little as 1,500rpm, the TSI's supercharger is already providing 2.5 bar of boost pressure. And it keeps providing boost up to 3,500rpm, at which point it is disengaged from the engine to prevent it from consuming too much power. By then the turbocharger is providing plenty of boost pressure, allowing the driver to enjoy plenty of torque everywhere in the engine's speed range.

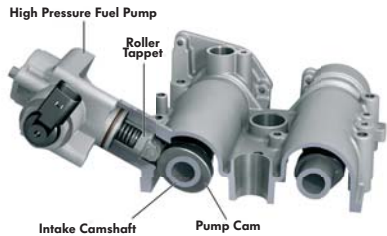
## Sips like a diesel, revs like a petrol.

The 1.4 TSI's 125kW (170bhp) output and wide spread of torque – plus its low appetite for fuel – might mean its performance is comparable to a 2.0-litre TDI diesel engine. But there's one key difference: unlike a turbodiesel, the 1.4 TSI will rev to a frantic 7,000rpm, which keen drivers are likely to do over and over...



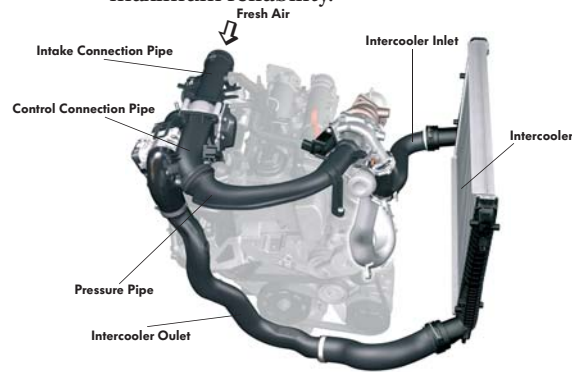
### Best in a small package.

With a tiny but tough 1.4-litre engine as its base, the TSI is able to realise important efficiencies. For example, the low displacement engine experiences lower friction losses than a larger one. It's also lighter.



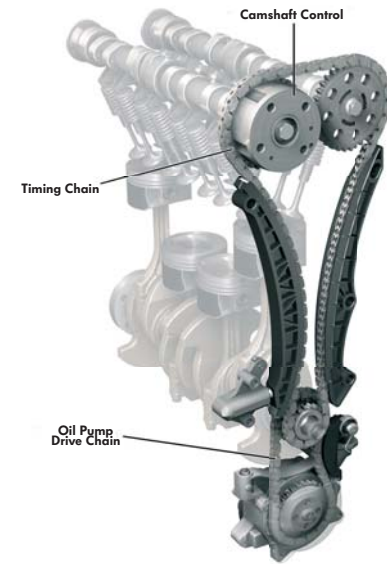
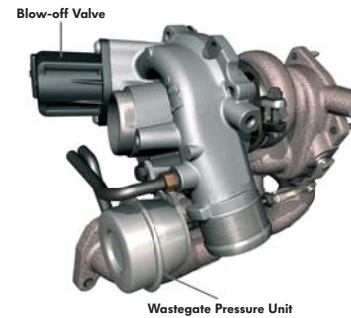
### Built to last.

The TSI is as sophisticated as it is robust, and it's built to endure the toughest running conditions. Volkswagen has subjected the TSI engine to over 50,000 hours of torturous testing to ensure maximum reliability.



### Rage like a tornado.

All Volkswagen TSI and FSI engines incorporate small 'tumble flaps' to induce air entering the combustion chambers to swirl into a vortex. This results in clean, uniform and above all, fast combustion.



## 50,000 hours of torturous testing to ensure maximum reliability.

### Geared for efficiency and flexibility.

Plentiful low-end torque enables tall gearing, and in sixth gear the Golf GT cruises at 100km/h with the engine humming along at a little over 2,700rpm, helping it to consume petrol at a sip. The 1.4 TSI's ample spread of torque also means that it offers amazing in-gear flexibility. The Golf GT accelerates from 60km/h to 100km/h in just 8.0 seconds in fifth gear, beating a 2.0-litre FSI-powered Golf by about a second and a half.

### Lean, mean and green.

The 1.4 TSI is just the sort of engine you would expect from the car company named the industry's most environmentally friendly automaker, according to J.D. Power and Associates' 2006 "Alternative Powertrain Study".

### More mind-numbing numbers.

There are ordinary petrol engines, well-tuned petrol engines, and then there's the 1.4 TSI. Its ability to do more with less is best summed up by its horsepower-per-litre figure of 121. Some truly remarkable cars come close, like the Porsche 911 GT3 RS, which delivers 85kW/l (115bhp/l)!

# The TSI Engine

