

# Porsche Engineering Magazine



## Carrera model range

Impressive technology

## red dot design award

Success all along the line

## What's around the corner?

Porsche lighting technology

## Sailing into the future

The Porsche Cayenne hybrid is on its way

## Dear Readers,



The future thrives on curiosity. And curiosity is our stock-in-trade. Our thirst for knowledge drives us onward. Our motto: We start off where others stop. We also keep a close eye on our customers' individual goals.

Curiosity certainly got the better of our engineers, for example, when they developed the condensation test stand for ADA. Porsche Engineering made a significant contribution to environmental protection here, which will benefit all the automotive manufacturers involved. Naturally, environmental protection is a particularly important factor in our day-to-day development work.

In the second last issue of the Engineering Magazine, we told you all about the historic Lohner Porsche with its Porsche hybrid technology from the year 1900. And because the Porsche developers have been hard at work since then, we can now present the current Cayenne hybrid in this issue.

The question in relation to the new 911 series was: Is it possible to improve on an already perfect sports car? This appeared to be a real challenge for the developers in Weissach. They set to work. What they came up with is being greeted enthusiastically by international technical publications. Read on to find out why the

new Porsche Doppelkupplung helps to reduce emissions. And just what is behind the technology used in the new Carrera with direct fuel injection.

The latest technology always needs an appealing, attractive look. Shape, colour and function – that's what Porsche Design is all about. In this issue, we also show you where and how the design needs of industrial Porsche customers are met.

And finally, we take a look at a somewhat unusual "complete vehicle development" for Grandhall. Design and engineering have worked hand-in-hand and the result is fantastic. You'll be amazed!

Please join us on a brief journey through our current development work and experience our day-to-day fascination and our idea of performance close-up.

We wish you a pleasant read.

Dr. Peter Schäfer and Malte Radmann  
Porsche Engineering Management

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## About Porsche Engineering

At Porsche Engineering, engineers work meticulously on new, unusual ideas for vehicles and industrial products. At the request of automotive manufacturers and suppliers, we develop a variety of solutions – ranging from the design of individual components and the layout of complex modules to the planning and implementation of complete vehicle developments, including production start-up management. What makes it special is that all this is done with the expertise of a series manufacturer.

Do you need an automotive developer for your project? Or would you prefer to work

directly with a specialised system developer? We can offer both – because Porsche Engineering works right there where these two areas meet.

The extensive knowledge acquired over the years by Porsche Engineering converges in Weissach – and yet it is globally available. Even directly on-site, of course. Regardless of where we work, we always bring a piece of Porsche Engineering with us. To find out more about us, please request our image brochure by contacting us via e-mail:

[info@porsche-engineering.com](mailto:info@porsche-engineering.com)

## New Managers at Porsche Engineering

Dr. Peter Schäfer (48) and Malte Radmann (54) have taken over as managers at Porsche Engineering Group GmbH and Porsche Engineering Services GmbH. Both have worked as general representatives with management responsibility duties at Porsche Engineering since 2005.

Previously both these companies were managed by Wolfgang Dürheimer, Director of Research and Development for Porsche AG.

Dr. Schäfer was appointed chairman of the executive board and technical director. The mechanical engineer moved to Porsche in 2003. Before that, he was Chassis Design Manager for passenger vehicles at Volkswagen.

Mr. Malte Radmann is the commercial director. He has worked in various managerial positions in customer development at Porsche since 1996. Before that, he worked at Daimler-Benz Aerospace Dornier.

## Sailing into the future: The Porsche Cayenne hybrid



The Cayenne hybrid will go into production during this decade. The new concept will not only reduce consumption by up to 25 percent at current rates, but will also improve acceleration and elasticity.

Can you trust this rev counter? The speedometer needle is somewhere between 50 and 60 km/h, the landscape is gliding by, yet the rev counter is at zero. In a Porsche! There is no clearer symbol of unrestrained power and performance. That's a first for either the 911 or the Boxster. Or even for the Cayenne. Except for this Cayenne – a prototype with a hybrid drive. It drives like a Porsche, it sounds like a Porsche, if that's what you

want – but sometimes the rev counter just doesn't play along. Particularly when the hybrid manager (no, not the driver) has "cut off" the combustion engine.

### **25% less fuel for the same driving experience**

The maiden voyage in the Cayenne hybrid promises even more new insights. For example, the silence when you start

the car and the silence when you drive off. Or the continuous display in the cockpit showing which unit is currently being powered and which unit is supplying the power. Or the fact that the warning light for the alternator is completely gone – as is the entire alternator. Or that you can "sail" with this car. But above all, the fact that you can keep driving the way you always drive and still use a good 25% less juice.

## Porsche launches its Parallel Full-Hybrid

For a Cayenne with a 3.6 litre six-cylinder combustion engine with direct fuel injection (206 kW), this means a fuel consumption rate in accordance with the new European driving cycle of significantly less than ten litres per 100 kilometres, compared with the previous rate of 12.9 litres. A rate of eight point something is envisaged by the market launch. During this decade, Porsche will launch a Cayenne on the market in which the combustion engine is just one part of a very complex drive system: In developing the "Parallel Full-Hybrid", Porsche developers are working together with VW and Audi on a concept that has never before been implemented in this form. The Cayenne hybrid features both an internal combustion engine and an electric motor (with 34 kW of mechanical power and 38 kW of electric power), which can be run both independently and together. A second clutch between the two drive units ensures that the electric motor can operate fully independently if necessary. Based on the accelerator pedal position,

the power electronics system then calculates the amount of electrical energy that must flow from the storage battery in the rear to the electric motor in order to get the required drive power. When the second clutch is closed, both the combustion engine and the electric motor can deliver their power to the transmission. Once the electrical power has been used up, the electric motor switches off automatically and the vehicle is powered by the combustion engine alone. The huge challenge here is the interaction between the separating clutch and combustion engine. Depending on the situation, the hybrid manager either "cuts off" the combustion engine or starts it. This is done imperceptibly by the separating clutch, which does both the sensitive and hard work. This includes starting or stopping the combustion engine immediately at any time. The driver of the Cayenne hybrid feels and hears absolutely nothing.

### The hybrid manager: the heart

The complicated interaction between the combustion engine, electric motor and battery is controlled by the hybrid man-

ager – the heart of the car. It obtains all the driving and power information and activates both drives optimally in every driving situation. It ensures that the battery does not run flat and is not charged and discharged too often. The hybrid manager is a real super brain that must work constantly with more than 20,000 defined data parameters. 6,000 data parameters are sufficient for normal engine control.

### 240 cells make up the nickel-metal hybrid battery

The 240-cell nickel-metal hybrid battery (347 x 633 x 291 mm) is really impressive. It is fitted in the spare wheel well (see bottom left illustration) and weighs 69 kg. The high-volt battery (energy: 1.7 kWh, 6 Ah) works with a power of 38 kW, has a voltage of 288 volts and stores the energy, which is charged by the recuperative braking (recuperation potential: around 1 l/100 km) and consumption-optimised load point shifting of the combustion engine while driving. The energy produced in this way can be used for driving exclusively with the electric motor or as a back-up system for the combustion engine. Since it can get extremely hot as a result of charging and discharging, a special air-cooling system is used to keep its temperature below 40 degrees Celsius. The fresh breeze is drawn from the passenger compartment. As a result, the life expectancy of the battery matches that of the entire hybrid vehicle.

### Electric motor integrated in drivetrain

There are many reasons why Porsche opted for this concept. One reason, for



Cayenne hybrid with nickel-metal hybrid battery (NiMH)



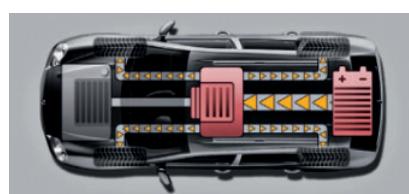
The Cayenne hybrid will have a fuel consumption rate of well under 10 litres per 100 kilometres

example, is because unlike the power-branched hybrid, the electric motor can be integrated into the drivetrain on the "parallel full-hybrid". The hybrid module sits between the transmission and the combustion engine, where it docks with the separating clutch. The hybrid components are thus highly compatible with the existing Cayenne basic platform. This gives more space and minimises the restrictions of the luggage compartment volume and all-wheel technology. It also improves fuel consumption when driving cross-country and on motorways. Unlike other hybrid systems, which offer particular advantages for stop-and-go city driving, the Cayenne hybrid can "cut off" the combustion engine up to a speed of 120 km/h. It then "sails" and glides along the road. Typical Porsche: since the electric motor can not only take over from the combustion engine, but also act as a

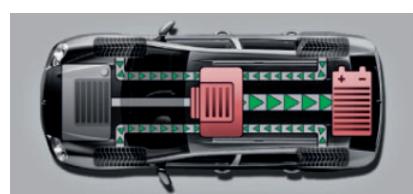
back-up system, acceleration and elasticity are significantly better than on the conventional Cayenne.

Components, which depend on the combustion engine in conventional vehicles, are enhanced or replaced by electrically

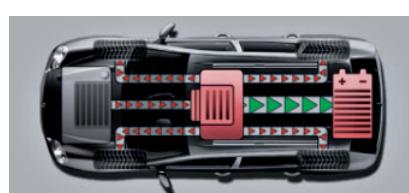
powered units in the Cayenne hybrid. For example, the vacuum pump for the brake booster has been electrified and an electric oil pump now supports the mechanical oil pump for the automatic transmission. For the first time ever in this vehicle class, Porsche is also using



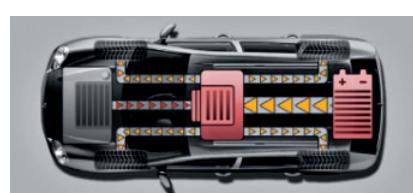
Moving off and driving with an electric motor



Braking while charging the battery



Driving with a combustion engine and hybrid turbocharging



Acceleration with an electric motor via electric motor and combustion engine

electro-hydraulic steering, which reduces energy consumption by 88% compared with hydraulic power steering and still guarantees the precision we have come to expect from Porsche. Even the air conditioning is powered electrically in the Cayenne hybrid. When you add it all up, the vehicle weighs 150 kg more than the conventional vehicle. Since it is much more economical and agile, however, it fits in perfectly with the Porsche philosophy of offering exceptional performance combined with maximum efficiency. That requires hard work, but Porsche developers have always come up with the goods when it comes to reducing fuel consumption. CO<sub>2</sub> emissions have been reduced by 1.7% every year for the last 15 years – an absolute record for the automotive industry. The most recent example is the Cayenne. A brand new generation of engines with direct fuel injection was developed for the new models, which

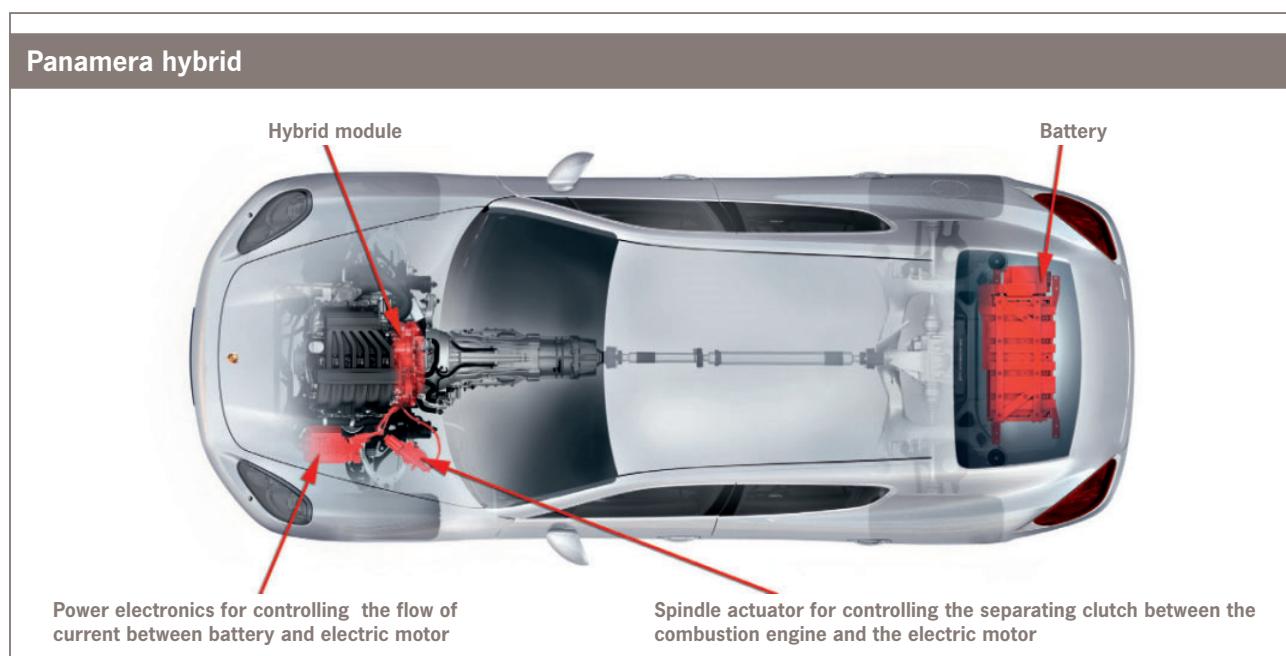
were celebrated at the Detroit Motor-show Premiere in January 2007. With these engines, it proved possible to reduce fuel consumption and emissions by 15% compared to the first generation. And the Porsche developers are quite right to be proud of these figures. The Porsche developments also generated huge interest at IAA 2007, in Frankfurt, Auto China 2008 in Peking and the Geneva Motor Show 2008, where the Cayenne hybrid was presented to a well-informed public. As part of an Engineering Workshop, Porsche presented its new concept to journalists from across the globe in the Research and Development Centre in Weissach in July 2007. The fact that the Porsche developers gave detailed insights into their development work several years before the market launch of a car was a first in the history of the company and is an indication of just how serious they are in Zuffenhausen about reducing fuel consumption.

### The origins of the Porsche hybrid go back more than 100 years

Porsche worked on the hybrid drive over 100 years ago. Back in 1900, Ferdinand Porsche developed the first standard vehicle with a hybrid drive for the Vienna-based k. u. k. Hofwagenfabrik Ludwig Lohner & Co.: The Lohner-Porsche "Mixte" featured both a wheel-hub electric motor and a combustion engine and was able to buffer energy in a battery. The 15-bhp four-cylinder engine was coupled directly with an 80-volt dynamo. This generator powered the wheel-hub electric motors in the front wheels – either directly or via the accumulator, which it powered in parallel.

### Hybrid – also for the Panamera

Porsche is once again making strides in new dimensions – this time with the “parallel full-hybrid” in the new Panamera, which will be available in 2009.



## Product design in keeping with the 911 – behind the scenes



In addition to vehicles, the subsidiary Porsche Design Group is conquering new territory with its innovative luxury products – for its own brand, for industrial customers and for the company. Let's have a look at the Porsche Design Studio in Zell am See.

It is not only the automotive industry that is trying to send the right signals with its product design; other industries have also recognised the importance of having unmistakable products.

Nowadays, design is not merely a means – albeit a perfect one – of standing out from the competition, it also builds confidence in the product, because the observer will draw conclusions about the

“inner value” of the product, based on how it looks. Many Porsche Engineering customers therefore decided a long time ago to perfect not only the technical quality of their products, but also the aesthetic. Both Porsche Engineering expertise and the know-how of the Porsche Design Studio are available to assist them in this.

On your behalf, we have gone in search of the roots of Porsche design and found them – in Austria, in a setting that could not be more beautiful.

The birth place is Flugplatzstraße 29, Zell am See – not far from Professor-Ferry-Porsche-Straße, Porscheallee and the new Ferry Porsche Congress Centre. The heart of the Porsche Design Studio beats here in this Austrian town – home to 9,600 people. The headquarters of one of the most famous design houses in Europe radiates transparency and sophistication with its restrained stone façade and huge glass fronts. Clear, unmistakable and timeless – that's how observers see the products that are lovingly placed in a small showroom in the entrance area just to the left. The displays showcase the diversity of the design work: be it yachts, navigation equipment, model trams or water sports equipment. The selection shows that all products have something in common: fine materials, high-quality workmanship and innovative technology. Without a trace of restricted insular thinking, the most varied products line up elegantly side-by-side. Each product is a classic because it defies the spirit of the times.

#### **Product design is a harmonious interaction of various forces**

The shelves showcase the most varied product models – designed exclusively by Porsche Design, with Porsche Engineering playing its part when it comes to technical perfection. It's hard to say which came first – the design or the function. Perhaps the question doesn't even arise because the interaction of designers and engineers is seamless. "When developing the product design, there is always a harmonious interaction between all active forces," confirms a young designer. We look around some more. New-

fangled spring systems on a running shoe catch our eye and the models of small compact vehicles are certainly impressive. We move on to where the designers work. This brings us one storey up into the offices where they are putting their initial visions of products onto paper – simple free-hand drawings, nothing more than a few pen strokes. The birth of a new product. Uninhibited, because Porsche thinking has no limits. And you can take that literally.

The minimalist style is consistent in the interior of the Design Studio. Walls would only get in the way, so only the essential ones remain – and even these serve as ceiling-high cabinets. Birch wood, with its warm feel-good colour, sets the mood. The design determines consciousness. Exchanging ideas, over and above genre limits, becomes an on-going process. Questions are asked, the essence of things is discovered. Designers are essentially problem-solvers.

Everything we see here says just one thing: clarity. "Product design has many functions, e.g. it can showcase high technical standards, innovative skills and the forward-looking nature of products," explains a young designer. Product design turns goods into flagship products – with the job of communicating the corporate culture.

#### **Design eliminates obstacles through creativity**

"First, there's the brainstorming phase. This generally involves doing quite traditional hand sketches, just to get a feel for the subject matter. Once the basic direction is set, the hardest part of the work begins. Because from now on, the designers concentrate only on resolving difficulties. Objections come from all sides – because of the design, production, costs – and the designer must resolve these objections using further creativity," says Roland Heiler, General Manager of the Porsche Design Studio.



New technology and innovative product design for the Pegasus wheelchair



Industrial design by Porsche Design Studio

Following stocktaking and brainstorming, the very latest 3D and 2D software is used to create concrete shapes. The graphic tablet, a kind of virtual drawing pad, is used to bring the project to life on the screen. Just a rough design, which is then rejected and created again from scratch. Intermediate steps are presented and discussed again. A presentation board catches the eye. It is covered in impressive printouts of "our most fascinating projects" (Roland Heiler). Commissioned by the yacht manufacturer "Fearless Yachts" and based on the existing 28-foot boat, further variations are produced, which will be 44-foot, 68-foot and even 125-foot long (1 foot is 30.48 cm). Bold, aesthetic, unmistakable – so very Porsche, down to the very last detail.

### **Reminder of where it all began**

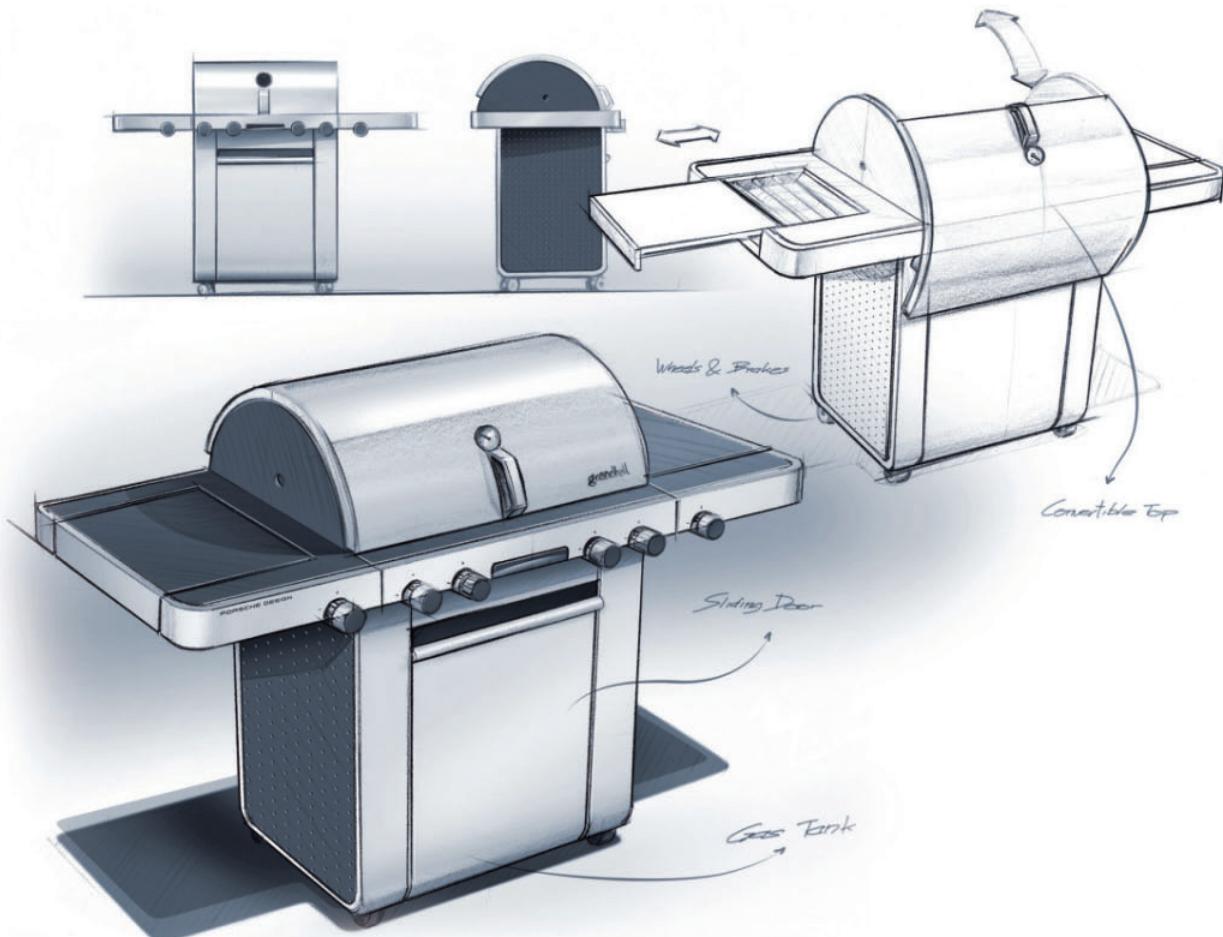
As if to confirm this impression, a 1:18 scale 911 stands on the desk beside it. Not just an ornament, but a reminder of where it all began. One particular office has the job of taking care of these memories. You just take the narrow corridor and already, you feel as if you have been

transported back in time to the workplace of Professor Ferdinand Alexander Porsche, designer of the 911, founder of Porsche Design and honorary chairman of the advisory committee today. The room looks as if the 73-year old has just stepped out – children's drawings hang on the walls, the model car collection is lined up on the shelves and right next to the door – in all its glory – is the golden shovel that was used to turn the first sod for the Porsche plant in Leipzig. The

Product design with the unique  
Porsche Design trademark

large drawing board stands in the middle of the room – as if F. A. Porsche is about to reach for his pen again at any moment. Through the glass front, you have a clear view onto the slope across the street of Hof Schüttgut, ancestral home of the Porsche family, with the white chapel beside it. Company founder Ferdinand Porsche, daughter Louise and son Ferry rest here. Tradition is an important part of the fascination. Designer Christian Schwamkrug calls it the "rather special aura" of the Studio here in Zell am See. Always looking to the past, focusing on the present with sights firmly set on the future.

## Complete vehicle development – something entirely different



The engineers at Porsche Engineering cannot conceal their origins, even when it comes to industrial developments – including speed counters. A search for development parallels for a somewhat unusual “vehicle”.

Admittedly, the development of a “grill car” is somewhat of an exception for Porsche Engineering. With the result that this grill has little in common with its commercially available cousins and far more in common with a Porsche car, because colleagues from Porsche Design had a hand in designing it. And what about the mechanics? They came from Porsche Engineering. When we were done, even we had a little respect. Not only does the new outdoor kitchen offer

beauty, style and excellent functionality, which you expect from Porsche Design Studio, it also features the Crossray® burner technology developed and patented by Grandhall. The resulting “grill car” is a masterpiece – highly functional and stylistically pure.

### Parallels with the sports car

And since this is Porsche, we specifically looked for parallels with the sports car

for our development project. And we found them. Even the first sketches by Porsche Design opened up a new era for the Grandhall outdoor kitchen. When you’re the Porsche of barbecues, you need the mechanics of the sports car maker too. Our engineers from Porsche Engineering used a slim stainless-steel body as the bodyshell. The modular-designed system means that the kitchen trolley can be used both as a mobile cooking station and a mini-kitchen.

## New framework structure for greater hold

With a new inner framework structure, we have given it a secure hold – stability for guaranteed roadholding. The eye is drawn straight to the domed sheet-metal sliding roof giving rise to an immediate open-top feeling. After all it is, in fact, still summer. The perfect time for our outdoor kitchen. The lever mechanism of the “cabriolet hood” reminds us of something. It opens smoothly, quietly, almost silently. It is a succinct lesson in elementary physics. The calculation of spring strength and paths, friction calculations and materials all combined to produce a perfect, force-optimised system for opening the top. Under the sliding roof, we see a grill – we ask ourselves: how long does our steak have to sit still here until it is perfect? Temperatures had to be taken for this and the engineers pushed the small mobile kitchen to its limits time and time again. Once satisfied, we nod in approval: a job well done!

## Speed range – including display

We play with the centre console and are delighted with the simple, elegant knobs. The switch panel shows which speed range is currently active – in other words: whether or not the burners are in top form. There's also a clock for the cook. Time to chance looking at the side: surprisingly, our Grandhall has a “trailer hitch” on both sides. Just like our Exclusive/Tequipment range, there's also a wide choice of attachment options here. The gleam of silver stainless steel shines on all components, be it the cooking drawer or other details. Fine, black stone elements further highlight the Porsche Design trademark. Almost straightaway, the stone look reminds us of a freshly asphalted section of race-track. And we wouldn't be Porsche if we weren't fond of “stepping on the gas” here at least. And look there, under the grill, we find the engine, the heart of the new master grill. The heart is behind a sliding door. It beats faster and hotter and you wonder a little why these burn-

ers don't need cooler grills. With the Crossray® infrared burner technology patented by Grandhall, the outdoor kitchen boasts the most sophisticated system available today – darting flames and choking smoke are a thing of the past. Unlike traditional burners, which lie directly under the cooking zone, the infrared burners at the sides heat the complete grill area evenly. Outdoor cooking is now child's play for everyone!

## Efficient processes for more added value

We look down under the Grandhall. We see small wheels fitted with the finest brakes. The Porsche engineer had mobility in mind here. Freedom of movement – even for a kitchen. Certainly, it is a compact kitchen, but because of this, the passion for detail was particularly important. The wheels are break-proof and weather-resistant. And that ends our comparison with Porsche development, where engineers work passionately every day developing something new for you.



Switch panel, side and front view of the Grandhall mobile cooking station

Hold on! One more thing: As at Porsche, our outdoor kitchen was optimised for production, which makes the fitters at Grandhall Production happy because they now have less to do thanks to leaner, more efficient processes. Wilbert Kroes, Sales Manager at Grandhall Europe: "Working together with Porsche Design Studio and Porsche Engineering was an immensely inspiring experience for us. It was exciting to see how perfect design and engineering skills were combined to form one product that we are so familiar

with." Our conclusion: With its finely polished granite surfaces and electronic instruments, the new outdoor kitchen is an utterly elegant and functional innovation, which is as much at home in the finest gardens of the world as it is a large roof terrace. The developers at Porsche Engineering are very happy.

And now? We're hungry and have just called our Porsche colleague Regina Schaen, two-time German master griller, who has the following recipe for you:



## It's what's inside that counts



Is it actually possible to make a seemingly perfect sports car even better? The new 911 generation – with technical highlights designed specifically for greater power using less fuel. Improved efficiency for a superior look.

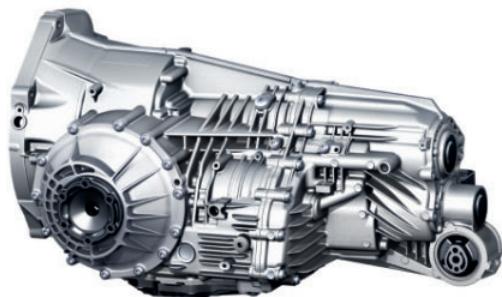
The new Porsche 911 taps into the long tradition of the 911 model series. Its design has been carefully enhanced, without changing the classic shape. It reflects the quality of the further technological development of the drive system. The

slightly larger, outer air intakes give the 911 a superior look and highlight the high performance potential of the new generation. Its looks will certainly catch your eye. And the technology? It makes our engineers' heart beat faster and leaves

nothing to be desired. What's new, for example, is the unique Porsche Doppelkupplung (PDK). Another highlight: the completely redesigned engines with direct fuel injection enable a significant improvement in performance while at

the same time reducing fuel consumption and emissions.

### You don't have to increase displacement to get more power



The Porsche Doppelkupplung (PDK)

The first-ever use of direct fuel injection in Porsche sports cars and the optional Porsche Doppelkupplung (PDK) makes the new 911 more sporty and considerably more efficient. The Carrera Coupé with PDK, for example, has an excellent fuel consumption rate of 9.8 litres per 100 kilometres. All new Carrera models can now boast fuel consumption rates well below the limit of 11 litres per 100 kilometres. CO<sub>2</sub> emissions are also up to 15% lower.

### First Porsche Doppelkupplung for the series

A huge challenge in developing the Porsche Doppelkupplung was to combine the high input torques of Porsche engines in an extremely compact transmission with excellent day-to-day usability and low losses while at the same time keeping the weight to a minimum. The new seven-speed Porsche Doppelkupplung meets these requirements. The developers combined the dynamics of a manual gearbox

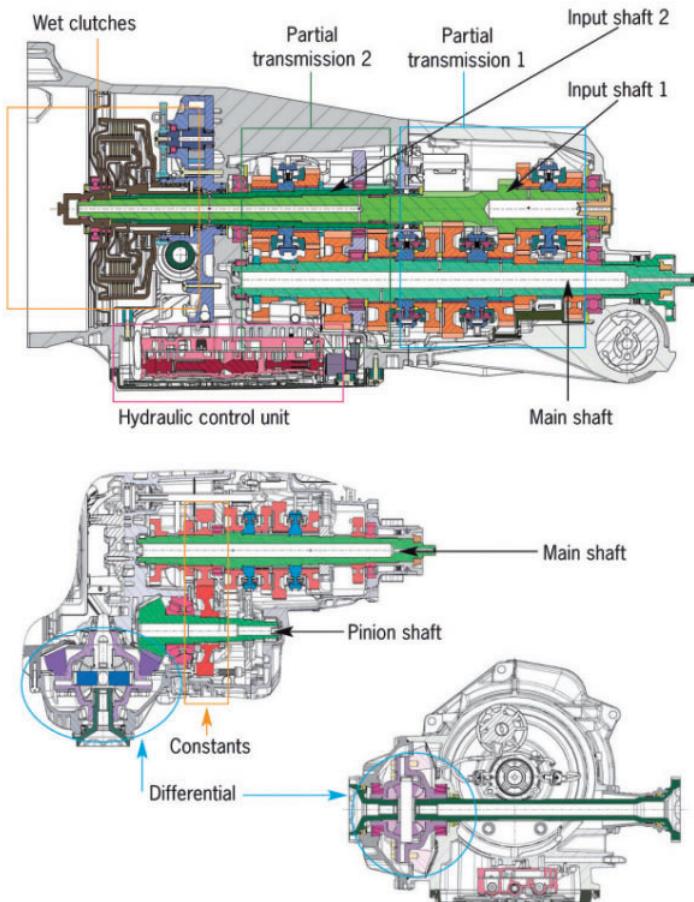
with the comfort of an automatic, thereby combining the advantages of both systems. The automatic transmission allows shifting without interruption in traction, automatic drive-off and shifting and exceptional comfort, while the manual system offers low losses, excellent efficiency, high transmission-ratio flexibility and a low weight. And what's more, the 911 Carrera models are now recording new best times for acceleration with PDK thanks to the fast gearshift time without interruption in traction. For example, the Coupé with a 3.6 litre engine makes the

sprint from 0 to 100 kilometres per hour in just 4.7 seconds, two tenths of a second faster than the extraordinarily fast manual transmission version. Two tenths of a second also separate the Carrera S Coupés, with just 4.7 seconds for the manual transmission and 4.5 seconds with PDK.

### Gear changes without interruption in traction

PDK for standard sports cars combines the very latest technology and decades

### Porsche Doppelkupplung (PDK)

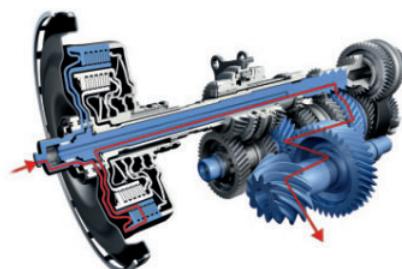


of experience – because Porsche Doppelkupplung technology has actually been around for 25 years. Back in 1983, the racing department pioneered and used this type of transmission in the 956 long-distance racing car. In the following year, the successor model, the 962, had its first victory in the Supercup at the Nürburgring. The greatest success was in 1986 with the Triumph at the World Championships in Monza.

The new Porsche Doppelkupplung provides the driver with seven forward gears and one reverse gear. As the name suggests, the Porsche Doppelkupplung actually comprises two transmissions in one housing. One controls 1st, 3rd, 5th and 7th gear as well as reverse, while the other controls 2nd, 4th and 6th gear. Both transmissions are driven by a shared input shaft. A hollow shaft for the relevant transmission runs to clutch No. 1, while a full shaft goes to clutch No. 2. All gear wheels are constantly rotating, but run without force. An operating sleeve then provides power transmission. Essentially, the individual gears are selected via shift forks, in the same way as in a mechanical manual gearbox, except that in the PDK these are actuated electrohydraulically. The transmission can even be customised using modern electronics. There are three customisation variants available: "Normal" position is designed with both fuel consumption and comfort in mind. The gears are screwed out further in "Sport" position, resulting in losses in both areas. All comfort is thrown overboard as soon as the "Sport plus" switch is pressed. "Launch control" is the ultimate when it comes to the emotions, however. Press

the brake, give it full throttle and then take your foot off the brake – the 911 shoots forward without slip and without interrupting tractive power.

#### Gear changes with preselection



Power flux in 1st gear of Porsche Doppelkupplung



Power flux in 2nd gear of Porsche Doppelkupplung

The PDK operating principle can be described based on a drive-off manoeuvre: when you accelerate in first gear, second gear is already preselected in the (no-load) second transmission while clutch II is still open. This takes only a few milliseconds and is imperceptible for the driver. When you shift up to second gear, the first clutch opens and the second clutch closes at the same time. This means that the torque is transferred even at full throttle from one clutch to the other in a controlled way without interrupting propulsive power. The procedure is basically the same for upshifts and downshifts. In manual mode, only



Porsche Doppelkupplung gear selector

load changes from odd to even gears and vice versa are possible. However, PDK has an option that allows you to shift down several gears very quickly using shift commands in quick succession. Individual gears can be skipped in automatic mode so that you can shift directly from 7th to 2nd gear, for example. If you want to shift from 6th to 2nd gear in one transmission, for example, 5th gear will be engaged temporarily. In the meantime, 2nd gear is selected in the other gear channel and synchronisation of the engine and transmission speed is adapted by a short rev.

#### First ever direct fuel injection

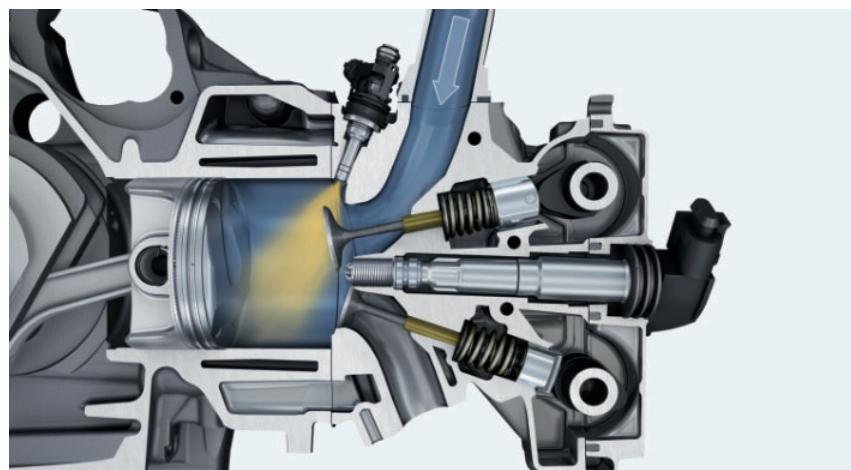
The new direct fuel injection (DFI) system used in the new flat engines is designed for homogeneous operation. The mixture of air and fuel is distributed evenly in the combustion chamber, thus facilitating perfect combustion. The fuel is injected into the combustion chamber with up to 120 bar pressure, depending on load and engine speed.

The main advantage is that the fuel is now injected directly into the combustion chambers via six fuel injectors instead of into a central intake port. The 911 is thus perfectly equipped for the future because both the 3.6 litre engine in the Carrera (345 bhp/254 kW) and the 3.8 litre engine in the Carrera S (385 bhp/

283 kW) already satisfy the Euro 5 guidelines, which don't come into force until September 2009. The injector is located between the two intake valves and injects fuel directly into the two air streams that are drawn in. This eliminates so-called 'wall heat losses', produced when the fuel mist settles on the

intake port walls in conventional systems. The air and fuel are mixed better in the cylinder – an important prerequisite for clean and complete combustion. Since the evaporating fuel lowers the temperature in the combustion chamber, more air can be drawn in, thereby improving cylinder filling and performance. At the same time, the cooler mix increases the compression ratio, resulting in greater efficiency and thus, higher performance with lower fuel consumption. In all cylinders in both types of engine, the combustion chamber is now designed to achieve a maximum compression ratio of 12.5:1 – this was 11.8:1 for the 3.8 litre engine and 11.3:1 for the 3.6 litre engine in earlier versions.

The significantly improved efficiency of the two Porsche high-performance engines with 3.6 and 3.8 litre displacement is apparent from the important key figures:



Cut-away diagram of direct fuel injection system

#### Porsche 911 Carrera (values in brackets: with Tiptronic S/PDK)

	Power output kW/bhp	Torque Nm	Fuel consumption Coupé l/100 km	NEFZ total Cabriolet l/100 km
Previous	239/325	370	11.0 (11.2)	11.2 (11.4) in accordance with Euro 4
New	254/345	390	10.3 (9.8)	10.4 (9.9) in accordance with Euro 5*
	+ 6.2 %	+ 5.4 %	- 6.4 % (- 12.5 %)	- 7.1 % (- 13.2 %)

#### Porsche 911 Carrera S (values in brackets: with Tiptronic S/PDK)

	Power output kW/bhp	Torque Nm	Fuel consumption Coupé l/100 km	NEFZ total Cabriolet l/100 km
Previous	261/355	400	11.5 (11.7)	11.6 (11.7) in accordance with Euro 4
New	283/385	420	10.6 (10.2)	10.8 (10.3) in accordance with Euro 5*
	+ 8.5 %	+ 5 %	- 7.8 % (- 12.8 %)	- 6.9 % (- 12 %)

## red dot design award: Success all along the line



The red dot design award is an internationally recognised award, which is highly regarded in specialist circles as the seal of quality for excellent design. Even Porsche designers get excited about this one.

This seal of quality for excellent design is awarded annually by an international jury of recognised design experts. Numerous products from Porsche Engineering, Porsche Design and even Porsche AG have been honoured for their innovative design in the past in the red dot design award competition. For industrial design, e.g. Linde forklifts, the 911 model series, a premium running shoe and a kitchen – the many distinctions for design quality are significant.

### **Delight among designers**

Porsche would not be Porsche if design didn't matter. We are delighted to be honoured such a prestigious award because it shows our designers and engineers that perfection pays off in the end. Achieving an ideal interaction between function and design requires not just creative ideas – it's more a matter of having the free spirit to take new paths and eliminate existing mental barriers. That's why we compete with the best internationally.

### **Porsche has enjoyed great success in the world's greatest design competition**

With almost 7,000 entries from a total of 52 countries every year, the red dot design award is one of the greatest design competitions in the world. The competition has three different categories "product design", "communication design" and "design concept". The excellent work of the jury, among other things, ensures the international accept-



## reddot design award

ance of the design award. The line-up of jurors changes from year to year and guarantees a high degree of objectivity. It includes renowned designers and design experts from around the globe, with new jurors selected each year to ensure the greatest possible objectivity in the selection of the winning products. The jury independently decides which of the numerous product proposals submitted will get a red dot. It evaluates the products submitted based on various criteria, e.g. innovation, functionality, formal quality and ergonomics. Both

designers and manufacturers can enter their work in the annual competition. The award-winning products are exhibited for at least a year in the red dot design museum in Germany (Essen).

Porsche has won numerous awards in the past and has impressed with its competence in the area of innovative design. The illustration shows some examples of the many awards Porsche has received in the most diverse categories: for industrial design as well as for its own model series.

### "red dot product design award"- winning products from Porsche

						
Aluminium Sled	Bike FS	Golf Bag Set	Mythos Sink	Porsche GT Ski	DIVA Workstation Light	Helit Office and Service Trolley
<b>2002</b>				<b>2003</b>		

					
"Solitaire" Compact Toaster for Bosch Hausgeräte GmbH	Shakepen P 3100	Porsche 911 Targa 4	Linde Electric Forklift, E12-E20	Zumtobel Lighting GmbH, Light P 7111	SN 911 Espresso Machine, BSH Bosch Siemens Haushaltsgeräte
<b>2005</b>		<b>2006</b>		<b>2007</b>	

### History: From Red Dot to the red dot design award

The red dot design award was first announced for the first time in 1955, but did not emerge in its current form until much later. It first appeared as the renowned red dot in 1992. The name of the award and the competition was born. Since then, the red dot has stood for excellent, top-class design quality. To distinguish between the Design Centre logo and the actual name of the competition award, the award symbol the red

dot was revised in 1994. The competition has since gone from strength to strength across the globe. Companies in Asia as well as North and South America and Europe compete for this award with various industrial products. The new logo portrays its succinctness and dynamic nature, particularly in the new media. Companies and designers use the red dot both nationally and internationally for their excellent products as a necessary instrument for communication and to successfully position themselves as quality and design leaders.

					
Grand Piano, Model 214	Alber Power Wheelchair	911 Carrera (997)	Pallet truck for Linde AG, T20	Sunglasses P8404, Rodenstock	Playing Desk and Manuals for the Leipzig Ladegast Organ
<b>2004</b>		<b>2005</b>			

					
Navigation System P'9611	Bounce S Running Shoe, Adidas AG	Poggenpohl Kitchen P 7340	Linde Forklift H80-900 BR 396	Porsche Design Worldtimer Watch, P'6750, Eterne SA	Völker Supply Bar
<b>2008</b>					

## What's around the corner? Porsche lighting technology



More active safety. Less energy consumption. Longer service life. A forward-looking lighting concept that leaves nothing to be desired.

The new generation of Carreras offers a forward-looking lighting concept for even more active safety: The 911 models with 3.6 litre engine now come with Bi-Xenon headlights and daytime driving lights in LED technology as standard. As a technically sophisticated enhancement, a new dynamic cornering light now lights every road up perfectly on request. The new lighting technology proved successful almost a year ago in the Cayenne models.

Light-emitting diodes (LEDs) are not only particularly bright, they only use a fraction of the power that bulbs need and they are designed to last for the entire

life of the vehicle. In addition to the automatic dynamic headlight levelling system, the gas discharge lighting system includes the headlight cleaning system, in which a modified stroke and perfect placement of the nozzles ensure even better cleaning power. The clear-glass cover on the headlights gives a perfect view of the state-of-the-art gas-discharge lighting system. Compared with conventional halogen headlights, the Bi-Xenon light used for dipped beams provides exceptional lighting and good colour vision thanks to the high colour temperature. In addition, the Xenon lamps have about two-and-a-half times the luminous power of halogen headlights.

### New design for front lights

A horizontally arranged front light assembly in the new design, which houses the LED daytime driving light, the position light and the indicators with conventional bulbs, extends over the side air intakes. The position light comprises an LED-powered light guide, which extends over the entire width of the light assembly. Each daytime driving light consists of six LEDs, which are clearly visible.

Another plus for the new lighting technology concept is the optionally available dynamic cornering light, which is particularly effective at lighting up the road. It is integrated into the front lights and switches on automatically at a vehicle speed of 10 kilometres per hour. The dynamic cornering light uses Xenon technology. The headlight covers are made of clear glass and allow a direct view of the new system with its pivoting dipped beam module and the high beam positioned underneath. On winding country roads or in long motorway bends, the cornering light provides excellent illumination into the bend, thus significantly contributing to added safety.

### Dynamic cornering light comes on automatically

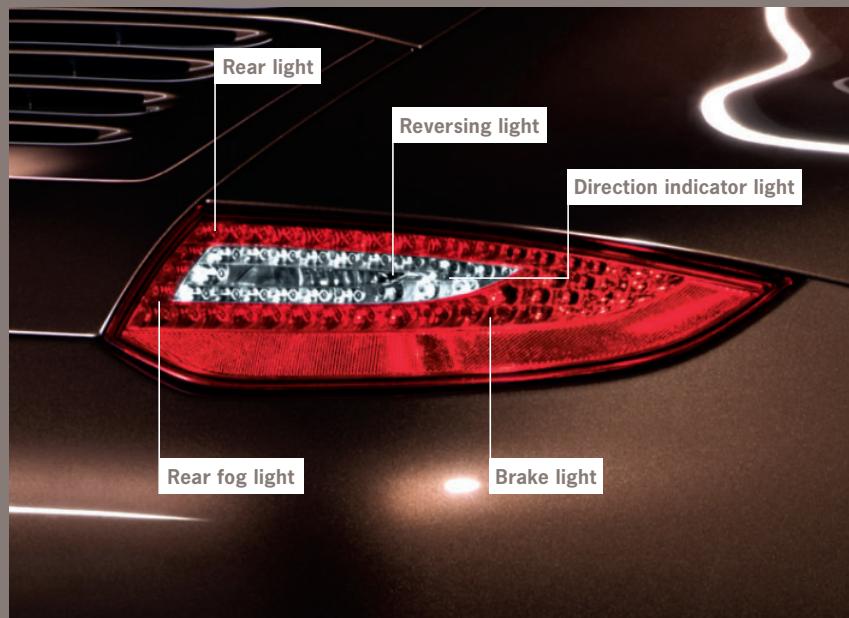
The dipped beam light in the Bi-Xenon headlights follows the driver's steering movements and adapts continually to the speed of the vehicle. Sensors continuously record the vehicle speed, lateral acceleration and steering angle and calculate the extent of the corner based on this. A control mechanism then uses the

recorded data to work out the perfect angle for controlling the dynamic cornering light. The dynamic cornering light is activated once a vehicle speed of five kilometres per hour is reached. The maximum adjustment angle of the headlight at the inside of the bend is 15 degrees, while the maximum adjustment angle at the outside of the bend is 7. The different adjustment angles of the light units at the inside and outside of the bend help to achieve the widest possible illumination on the road because the two light cones lie side-by-side and their light is not focused on one point. The cornering light also remains active when the high beam is switched on, thereby giving the driver a better view.

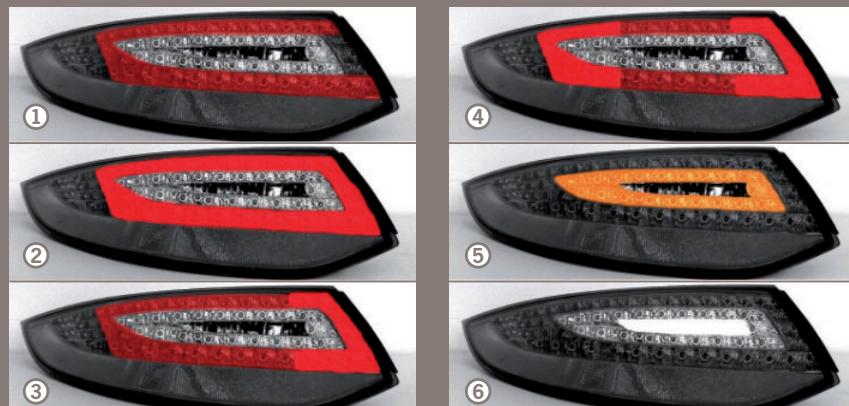
### Striking night design: Taillights with 60 LEDs

The redesigned taillights in LED technology are not only another visual highlight, they also help to reduce energy consumption and improve safety. Besides having a long service life, the main advantage of LED technology is its short response time. While the response time for conventional bulbs is around 100 milliseconds, it is only about 0.1 milliseconds for LEDs. At a speed of 100 kilometres per hour, the time you save is equivalent to a distance of about three metres. When you brake, traffic driving behind is therefore warned much faster.

The shape of the taillights merges harmoniously into the design of the vehicle. The lights get narrower from the outside in, thus giving the vehicle an elegant, yet sporty look. The one-piece taillights accommodate the direction indicator lights,



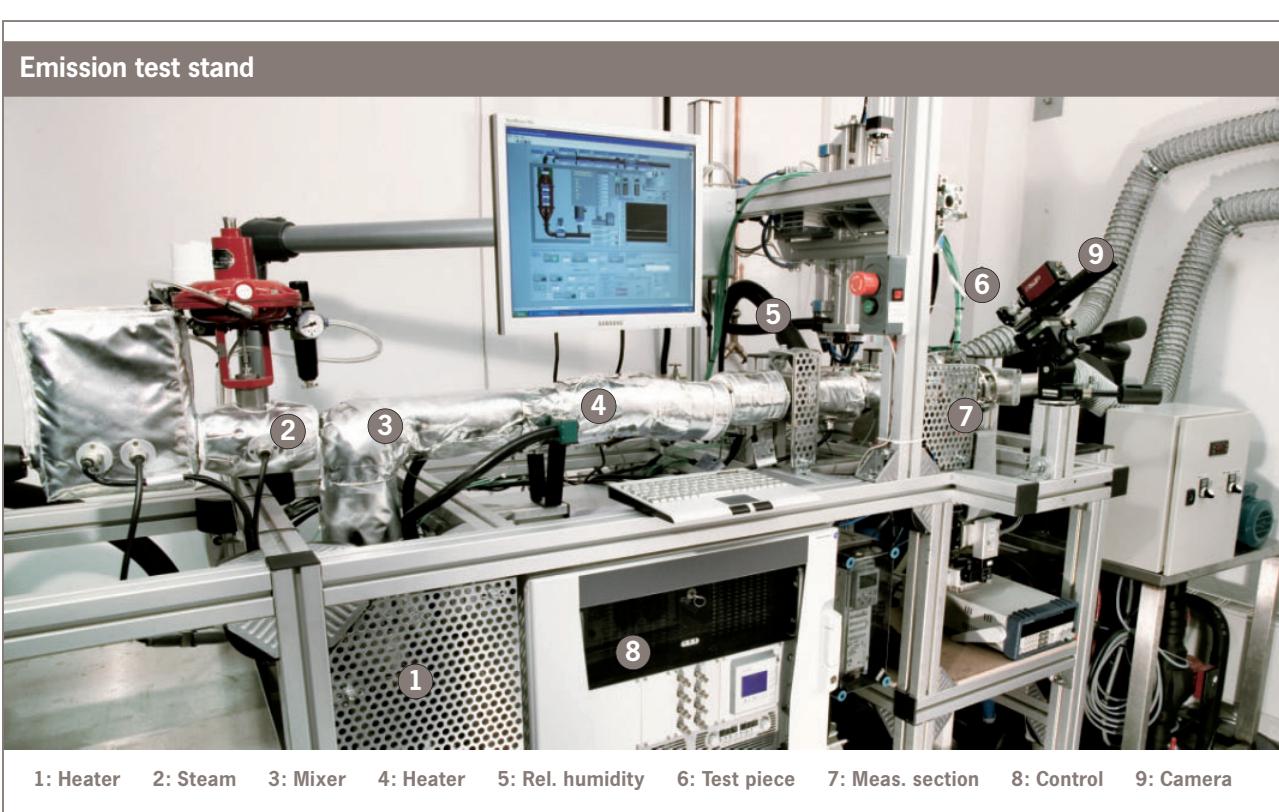
Taillight with 60 LEDs



1: Rear light, 2: Brake light, 3: Rear fog light with rear light, 4: Rear fog light with rear light and small brake light, 5: Direction indicator light, 6: Reversing light

rear fog lights, reversing lights, brake light, marker light and the reflector in one housing. Each of the two tail light units has 60 LEDs, some of which are activated for a number of different functions. For example, the rear light has 37 LEDs. If the rear fog light, which has nine LEDs, is switched on, the brake light group is reduced to 17 LEDs. A 16 Watt bulb is used for the reversing light.

## Exhaust gas sensors now faster and more accurate



The eco-friendliness of vehicles is set to increase dramatically. The ultimate goal here, of course, is to reduce CO<sub>2</sub> emissions.

In order to meet the strict legal requirements, car manufacturers worldwide are working not only on reducing consumption, but also on even more effective emission control. To this end, Porsche is using the latest technologies in the form of an exhaust probe test stand, which is stationed in the Porsche Engineering workshops in Bietigheim-Bissingen (Ludwigsburg). The catalytic converter plays a significant role in emission control. Yet, this purifying component requires specific conditions in order to

work successfully. The keyword here is "lambda 1".

### The lambda sensor is essential for mixture control

This sensor ensures that the air drawn in by the engine is mixed with the exact amount of fuel that can be combusted fully. Ideally, this air/fuel ratio (lambda) is 1. If too much fuel is present during combustion, the excess would be released into the environment in the form

of uncombusted hydrocarbons. Too little fuel, on the other hand, significantly increases poisonous nitrogen oxides in the exhaust gas. The lambda sensor works out the correct ratio by determining how much oxygen is still in the exhaust gas and then passes this information on to engine control so that the fuel quantity can be adapted.

To optimise hydrocarbon conversion, the lambda sensor uses a saw-tooth profile for rich/lean peaks. This technology is not new – quite the opposite in fact. It has been used successfully in motor engineering for more than 30 years. What still needs to be improved? The optimum working temperature of the sensor only starts at above 550 degrees

Celsius. But for cold-starting, or even in modern combustion engine/electric motor combinations (hybrids), the exhaust system remains below this working temperature for a long time.

The solution involves heating the sensor electrically. In the cold environment, the hot combustion gases produce a water condensate, which drops down on to the walls of the exhaust system and in the sensor and is often carried along in drop form by the exhaust gases that are flowing in at great speed. However, if a drop of this water reaches the ceramic measuring element in the sensor, this produces high thermal stress that causes small hairline cracks in the sensor element, thus preventing it from working properly.

### **Huge challenge still facing the automotive industry**

An emission test, which is required by law, monitors compliance with strict emission limits. During emission testing, between 30 and 50 percent of the uncombusted hydrocarbons (HC) is emitted in the first seconds of the cold-start phase. This represents a particular challenge for automobile manufacturers. HC emission in the cold-start phase could be reduced to a minimum if the lambda sensor were activated as early as possible. Risk-free operation of the sensor is only possible, however, after the heat-up phase, i.e. at the end of what is called "dew point". This means that there must be no more water in liquid form in the exhaust system. This, in turn, takes time – precious time. The objective, therefore, is to develop a sensor that will

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### **The development of the test stand focused on six main questions:**

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- Where in the exhaust sensor does condensation start to form?
  - How long does it take?
  - Where does it last longest?
  - How much condensation can actually form?
  - Are the drops bigger than a critical size that can damage ceramics?
  - What path do the drops take inside the sensor?
- 

start working early, despite the extreme conditions during cold-starting.

#### **Reproducible framework conditions are crucial**

With the new condensation test stand, it is now possible to recreate these framework cold-start conditions so that the condensation and evaporation processes can be reproduced exactly and examined.

#### **The ADA is driving development onward**

The ADA, the automotive industry's Exhaust Emission Centre in Germany, commissioned Porsche Engineering to develop the condensation test stand. The ADA is a joint venture involving the five car manufacturers Audi, BMW, VW, Daimler and Porsche and is based in the Porsche Development Centre in Weissach.

The ADA manages the pre-competition cooperation in the area of the post-treatment of exhaust gases from petrol and diesel cars. The special test stand, owned by the ADA, is available not only to the five equal partners, but also gives

sensor manufacturers the opportunity to test their sensors. The test stand has undergone intensive testing and has been continuously adapted to suit special requirements over the last six months. Previous measurements have unearthed impressive details from the sensor micro cosmos.

The heart of the sensor test stand is the visible measuring section. The test probe, which sits in a screw-type fixture, can be cooled to minus 20 degrees using coolant. To prevent condensation from forming even before the test begins, the measuring section is closed off via valves and rinsed out with nitrogen.

To achieve the same conditions you would have in reality, the air is sent through two consecutively switched heaters. There is a steam injection valve between the two electric heaters. This creates various humidity levels just like in the actual exhaust system. The entire pipe is fitted with temperature sensors so that the test conditions can be set perfectly and the test can be repeated later under the same conditions. Pipe heating in the form of heater mats was installed to ensure that condensation only forms in a controlled way at the

required position, namely on the lambda sensor.

A special feature of the test stand is the gas switch, which was developed specifically for this purpose by Porsche Engineering. The pneumatically operated valve in the switch is activated in a fraction of a second. The pre-cooled gas, which is initially released into the air via a by-pass valve, is suddenly diverted into the measuring section. This is the only way to achieve the high temperature gradients that occur under real conditions.

#### Real-life testing of sensors under laboratory conditions

Until now, these tests have been performed on various engines either in air-conditioning chambers or as part of field-testing. Either an engine or an entire vehicle had to be mounted on the test stand in order to test a sensor. The new condensation test stand can now be used to test sensors individually in the lab. Important advantages of the test stand are that it accurately reproduces the starting (cold-starting) conditions required for testing and that it is fast. This takes one or two hours on the engine test stand and only between 5 and 15 minutes on the laboratory test stand.

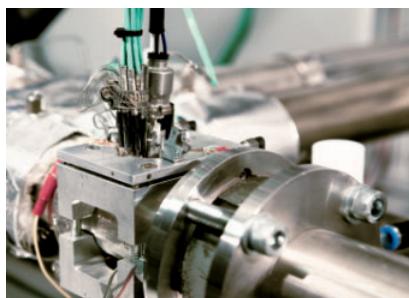
Physical questions first had to be clarified before the technical implementation of the extensive requirements listed in the specifications. Still, the mechanics and engineers at Porsche Engineering, who are working closely with the ADA, saw no obstacles whatsoever to the elaborate and costly implementation of the



Moisture regulator



Measuring section and gas switch



Lambda sensor with thermo couples



Precision balance 0.1 mg

condensation test stand project. Close cooperation between all those involved has meant that all requirements could be met satisfactorily. The technology and control system has undergone continuous improvements along the way and the automation of individual processes has made the test stand operator's job much easier.

#### Advantages of the new test stand

- Faster development times
- Lower costs
- Not engine-dependent
- Various ambient conditions can be set up for anywhere in the exhaust system

#### Straightforward prototyping

With the new condensation test stand, engine mechanics now have a tool they can use to precisely determine the release time for lambda sensing. The suitability of new prototypes from sensor manufacturers can now be examined quickly and easily in order to meet the demands of future emission requirements more efficiently and more effectively.



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