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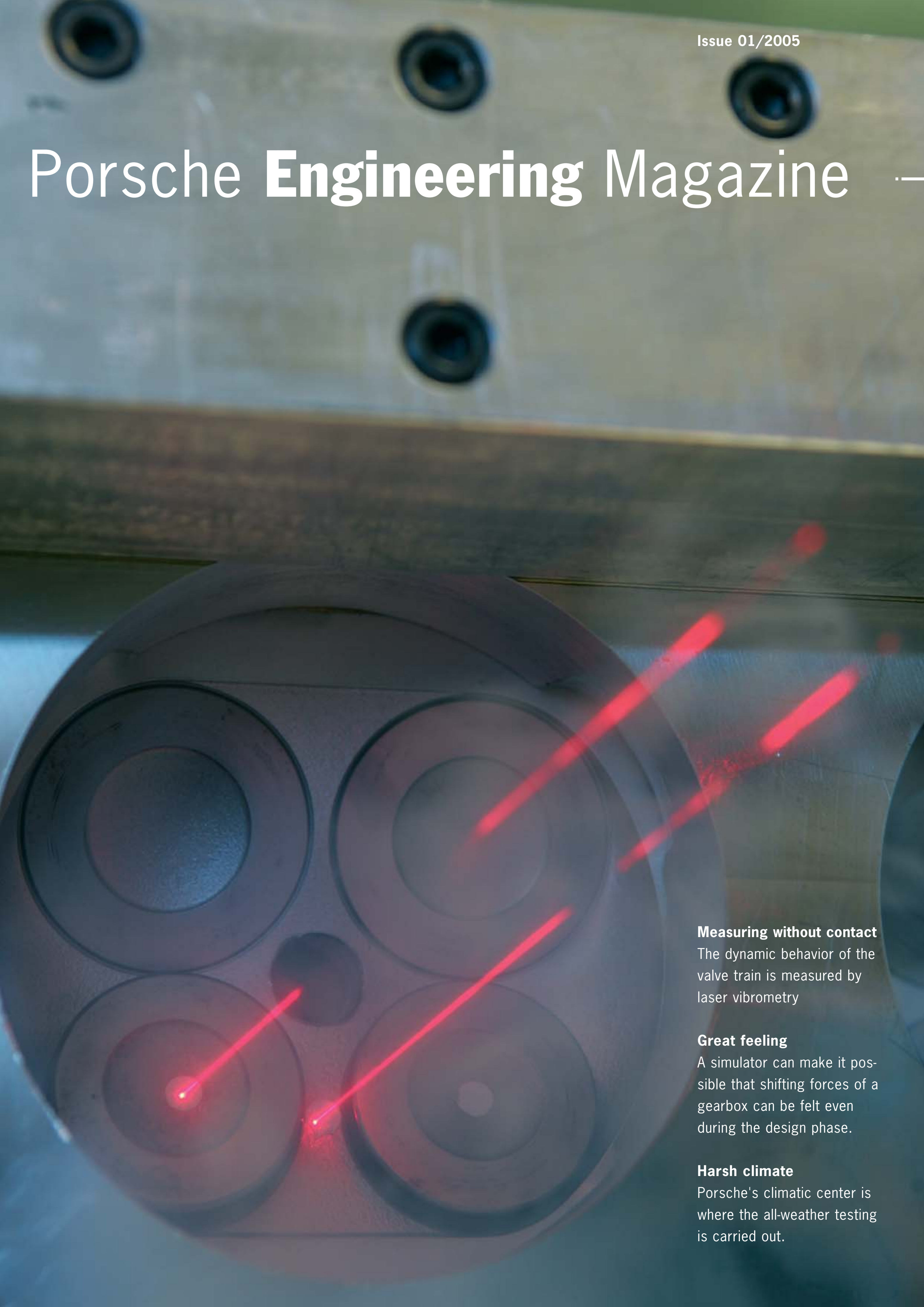
Porsche **Engineering** Magazine



Measuring without contact
The dynamic behavior of the valve train is measured by laser vibrometry

Great feeling
A simulator can make it possible that shifting forces of a gearbox can be felt even during the design phase.

Harsh climate
Porsche's climatic center is where the all-weather testing is carried out.

Porsche Engineering is a Porsche Group subsidiary specializing in contract development services. When contracted to support car manufacturers or original equipment suppliers, we offer design and development services, from individual components through to complex modular systems; we also take on planning and implementation of complete vehicles all the way to series production. What makes our offerings unique ist our proven expertise as a volume vehicle manufacturer.

Whether you require a general automobile developer or specialized system-provider, Porsche Engineering can bring you the best of both worlds.

Our expertise is based in Weissach (Germany) with extensions throughout the world: Troy, USA. Prague in the Czech Republic, or directly on-site with you. Wherever our competence is required, it's always Porsche Engineering.

If you would like to know more about Porsche Engineering, please send an e-mail requesting our image brochure to the following address:
info@porsche-engineering.com

Dear Readers,

In the company's climatic center we try to simulate how vehicles, components or materials behave when exposed to the most varied weather conditions. This service can also be requested from Porsche Engineering.

Very few people know that comprehensive climate control research is also carried out in Porsche's Research and Development Center.

Before the current 911 went into production, it underwent the obligatory hot and cold tests. State-of-the-art technology has helped the new Carrera achieve outstanding performance and dynamics. In this issue we present a few of the sports car's technical highlights.

One of the other topics covered is dynamics: as part of the engine development, Porsche Engineering uses laser vibrometry to investigate the dynamics of the valve train, because only a perfectly-tuned engine guarantees maximum performance with optimum fuel consumption – and that doesn't just apply to sports cars.

We wish you an enjoyable read,

The Editorial Team

Double take on the 911

The current 911 is distinguished by outstanding performance and driving dynamics.

The Porsche 911 has evolved into one of the world's most successful sports cars of the past 40 years. The sixth generation is continuing this long tradition: the outstanding performance and driving dynamics of the current 911 are assisted with the latest technology.

The Porsche 911 is available in two versions with differing engine sizes: the Carrera, the standard version, has a 3.6 liter engine producing 239 kW (325 bhp) at 6,800 rpm; and the Carrera S has a 3.8 liter engine producing 261 kW (355 bhp) at 6,600 rpm.

The new 3.8 liter boxer engine reaches its maximum torque of 400 Nm at 4,600 rpm. This performance power unit accelerates the Carrera S from 0 to 100 kilometers an hour in 4.8 seconds. Its top speed is 293 km/h.


The 3.8 liter engine has a power output of 355 bhp (261 kW) at 6,600 rpm, which brings a top speed of 293 km/h. The Carrera S can accelerate from 0 to 100 km/h in 4.8 seconds.

Aerodynamic coefficients improved

The Porsche 911's new shape is an evolutionary step forward, not only in its design but also in its aerodynamics. All coefficients have again been significantly improved in comparison with its predecessor. For example, the Carrera's drag coefficient dropped from C_d 0.30 to 0.28. Even more significant are the lift forces of 0.05 at the front and 0.02 at the rear. These figures make the Carrera a front runner against the international competition.

Cooling air losses minimized

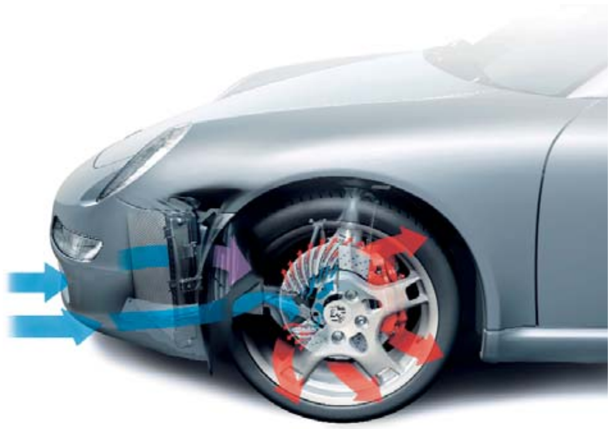
It was possible to reduce cooling air losses mainly by modifying the guidance system design. On the previous model, the extracted air was expelled vertically downward in front of the front wheels. It is now guided directly to the wheel house and directed to the exterior of the vehicle through flaps. Cooling air throughput was increased by a total of 20 percent without increasing drag – which, at around 1.5 percent, was already at an extremely low level in comparison with the competition.

New six-speed transmission

Because of the increased performance of the Carrera S, both 911 coupés have been given new six-speed manual gearboxes with increased torque capacity and shorter gearshift travel, but without adding to the vehicle weight. Tiptronic S, now further optimized in its gearshift program and quality, is still available as an alternative to the new six-speed manual transmission.

Rack-and-pinion steering with variable transmission ratio

The driver's steering input is for the first time on the 911 Carrera by rack-and-pinion steering using a variable ratio which particularly improves agility on winding roads. In urban driving – parking and turning – the variable ratio steering helps with a considerably faster steering response.



The cooling air channel at the front of the vehicle has been further optimized to reduce flow losses.

Active PASM suspension

For the first time, the 911 has an active damping system for the revised suspension. The PASM (Porsche Active Suspension

For the first time, the 911 has an active damping system. The PASM consists of map-controlled dampers, a control module and two acceleration sensors.

A new head airbag is integrated in the door side sill.
In conjunction with the thorax airbag in the front seat back rest it provides a high level of protection against side impacts.

Management), featured as standard on the 911 Carrera S, combines two chassis in one: one with equal measures of sportiness and comfort for long distances, and one entirely dedicated to sportiness for extreme driving.

The PASM system consists of map-controlled dampers with continuously adjustable damping force, a control module and two acceleration sensors for detecting vertical movements of the body. Lateral acceleration, steering angle, speed, brake pressure, engine torque and more are all read in via the CAN bus. The required program (Normal or Sport) is selected via a button on the center console.

In both the Normal and Sport programs, PASM selects the required damping rate for each individual wheel from a precisely co-ordinated map. The possible damper settings range from comfortable to decidedly sporty. This ensures a gain in active driving safety in all driving situations with a noticeable improvement in the level of comfort.

Impeccable brakes

In the case of the Carrera, reinforced four-piston fixed calipers as well as perforated and internally ventilated 318 mm brake disks at the front and 299 mm at the rear (330 mm on all wheels in the case of the Carrera S) guarantee extreme brake performance even under the toughest conditions.

Head airbag underneath the side window

The new 911 Carrera meets all requirements for passive vehicle safety and offers exemplary side-impact protection. A new head airbag is concealed in the door and, in conjunction with the thorax airbag in the front seat back rest, provides a high level of protection against side impacts. Together with the driver and passenger airbags, the new 911 has a total of six airbags. ■

A real sense of the shifting forces

The shifting forces are calculated in real time with the simulation software and replicated by means of servomotors on the gearstick.

In the area of gearbox development every vehicle manufacturer strives to optimize gear-shift efforts. Porsche Engineering has developed a simulator that enables the shifting forces of any gearbox to be felt even at the beginning of the design phase.

In the past, engineers almost exclusively used their experience from previous projects, along with their calculations, to define transmission qualities at the early development stage. However, it wasn't possible to truly experience the gearshift characteristics. This only became feasible once the prototype was built and operating.

The test engineer can take up a position in a true to scale seat construction that replicates the driver's environment for a specific vehicle (here for example the 911 Carrera).

The shifting force simulator: the portable box with manual gearstick, power and control electronics can be used for different types of vehicle.

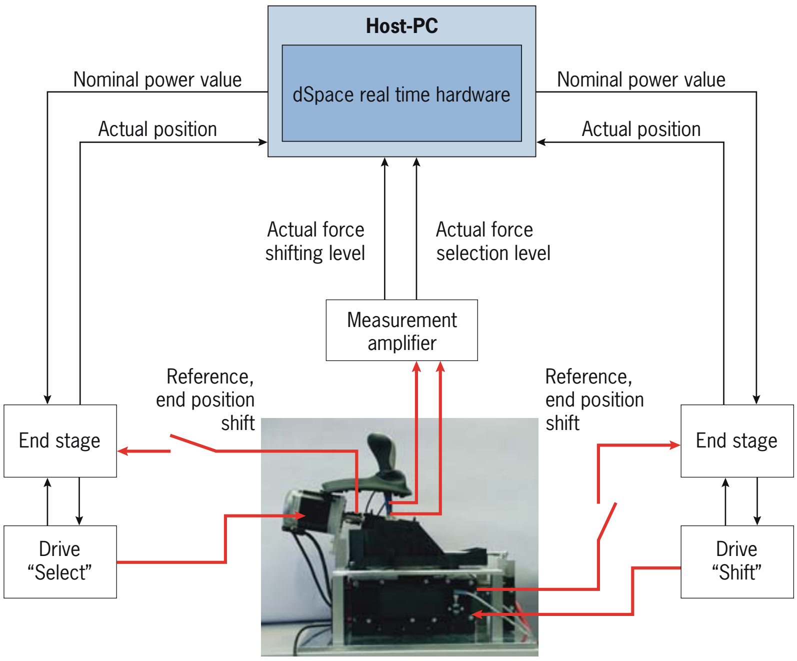
Against this background, Porsche Engineering has developed a virtual gearshift or shifting force simulator. It is now possible to shift gear with all the characteristic properties without the need for an actual gearbox.

The test engineer takes up his position in a true-to-scale seat around which the driver's environment is replicated for a specific vehicle. The shifting force simulator – a portable box with a manual gearstick, power and control electronics – is customized for this environment, and can be used in this way for any number of vehicle types.

A special simulation software package replicates gearshift operations. In addition to gearbox-specific parameters, the dynamic effects of the vehicle on the gearbox are also considered, e.g., engine position or half-shafts arrangement. The shifting forces are calculated in real time and, with the assistance of two servomotors, can be felt on the gearstick. A linear motor generates the shift-direction force specified by the computer, and a rotary motor simulates the force needed for gear selection.

The parameters set up via PC create tangible shifting characteristics on the manual gear lever. If the characteristics experienced do not correspond to requirements, the gearshift forces and travel can be redefined and optimized at the click of a mouse.

The system developed by Porsche Engineering supports vehicle engineers early in the design phase in defining gearshift forces and travel. It allows shift efforts to be assessed in an objective and reproducible way. Furthermore, at each stage of development, checks can be made again under the same conditions – and without building new prototype parts – to ensure that the desired shifting characteristics are maintained through to production. ■



If the shifting characteristics do not correspond to requirements, the gearshift forces and travel can be redefined at the click of a mouse.

The 1:2 scale Cayenne

The small Cayenne for the golf course.

After a development period of just four months, the Porsche Engineering Group has completed two vehicles in "open two-seater" versions. The prototypes have been developed especially for use on golf courses.

This unique and previously unseen golf car not only bears the Porsche logo on the hood, but is reminiscent in much of its detail of the Cayenne SUV – although at a scale of 1:2. For these vehicles measuring 2.7 meters in length and 1.25 meters in width, the engine compartment lid, front wheel arches, headlights, front section and 20-inch wheels have been replicated faithfully following the Cayenne's styling approach.

In addition to two comfortable seats, the golf car also has ample space for two golf bags. Given the open loading space, it was not possible to completely reproduce the styling features of the Cayenne's rear section. However, significant design features, such as the oval exhaust tailpipes, the rear lights and the original stainless steel loading sill, have been incorporated so that the golf car can easily be identified as a mini Cayenne from the rear.

The exhaust tailpipes on the golf car are no more than a design feature. The car is powered by a 3.2 bhp electric motor driving the rear wheels through a direct transmission. The drive technology and the chassis have not been modified by Porsche's engineers, but derive from the basic vehicle developed by Divaco GmbH in Essen. Top speed

The golf car was put through the test run that is obligatory for all Porsche prototypes on the trial circuit at the Research and Development Center.

The Cayenne's headlamps were replicated down to the last detail for the golf car.

Even the engine compartment lid and wheel arches are identical to the original - although at a scale of 1:2.

is 24 km/h, which it can reach within 10 meters. The vehicle's range is approximately 30 kilometers – without the headlights switched on. Before the two Cayenne-look alike golf cars were delivered, they were put through their paces on the test track at the Porsche Research and Development Center in Weissach. Not until the development engineers were satisfied with their exceptional test subjects were they cleared for delivery to Mallorca. Beginning in the spring of 2005, they will be used by Hans-Peter Porsche, who initially commissioned the vehicle conversion for use, on the Alcanada golf course. No decision has been taken yet as to whether the Porsche Engineering Group will be building more mini Cayenne golf cars to market to other golf courses around the world. ■

Technical data

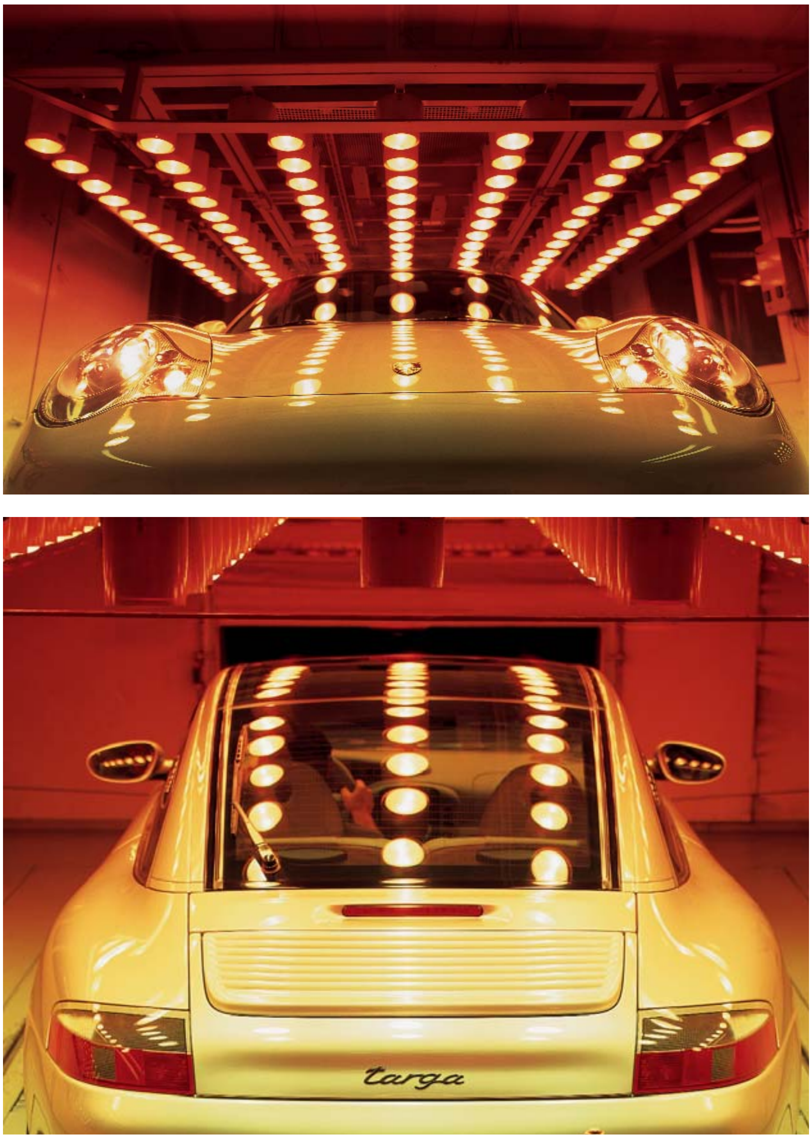
Engine	electric, 48 volt, DC
Output	3.2 bhp
Transmission unit	fully synchronized
Length	2.70 meters
Width	1.25 meters
Height	1.75 meters
Empty weight	224 kilograms
with batteries	404 kilograms
Load capacity	approx. 200 kilograms
Range	approx. 30 kilometers (without lights)
Acceleration	24 km/h over 10 meters

Bracing climate in Research and Development Center

Porsche's Climatic Center is able to carry out a whole host of climatic tests on how long a vehicle, individual components or new materials can withstand daily stresses caused by heat, cold, sun or rain.

The sun beats down on the 911 Targa; the thermometer is creeping towards 60 degrees Celsius. Humidity is just 10 percent. It might sound as if the sports car is standing in Death Valley, the lowest point below sea level in North America, but in fact the Targa has gone no further than Weissach – and more specifically, the Climatic Center at Porsche's Research and Development Center. Here investigations are carried out into how vehicles, individual components and materials behave when exposed to extreme weather conditions every day.

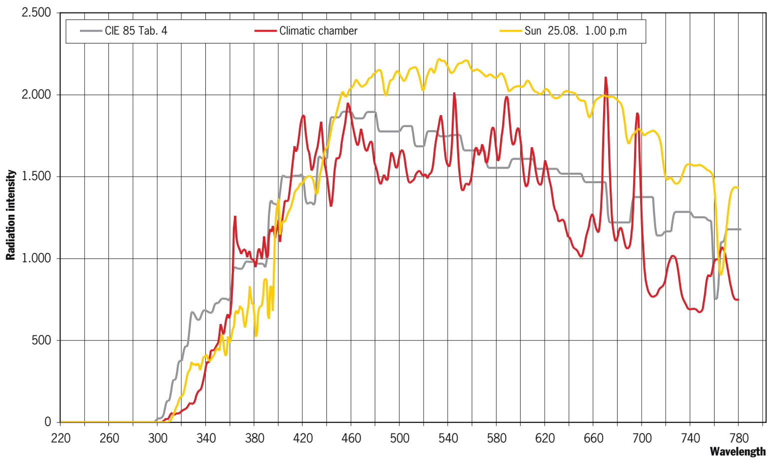
The Climatic Center is specially equipped for automobile and supplier industry simulations. A total of three test chambers with varying special facilities are available in addition to a basic climatic chamber and a climatic wind tunnel.



In the climatic wind tunnel, solar simulation can also provide sun-load to the Targa interior.

Sunshine at the press of a button

The climatic chamber with solar simulation can generate temperatures from minus 40 to more than 70 degrees Celsius. Vehicle and component behavior and aging processes can be observed over time using a UV spectrum similar to the sun, but much more intense. It is also possible to conduct DIN 75220 tests “Aging Automobile Components in Solar Simulation Units”.



The climatic chamber with solar simulation is able to reproduce solar radiation and considers norm values (CIE85) at the same time.

Special climatic cabinets, known as Solarclimatics, can also be used in this test rig for testing individual components. The behavior of materials beneath a windshield, for example, is tested at temperatures of up to 80 degrees Celsius and humidity of up to 95 percent. In controlled testing, Porsche engineers can simulate in 25 days how leather and adhesive properties might change when exposed to a couple of years of Arizona or Florida sunshine.

During driving simulations or as in this case cold start tests a special system draws off the exhaust gases.

Heat wave chamber

The high temperature climatic chamber can almost boil water. Tests can be conducted at temperatures of up to 90 degrees Celsius. Here, the behavior of filled fuel tanks is simulated at various and especially high temperatures. Therefore this climatic chamber has explosion protection.

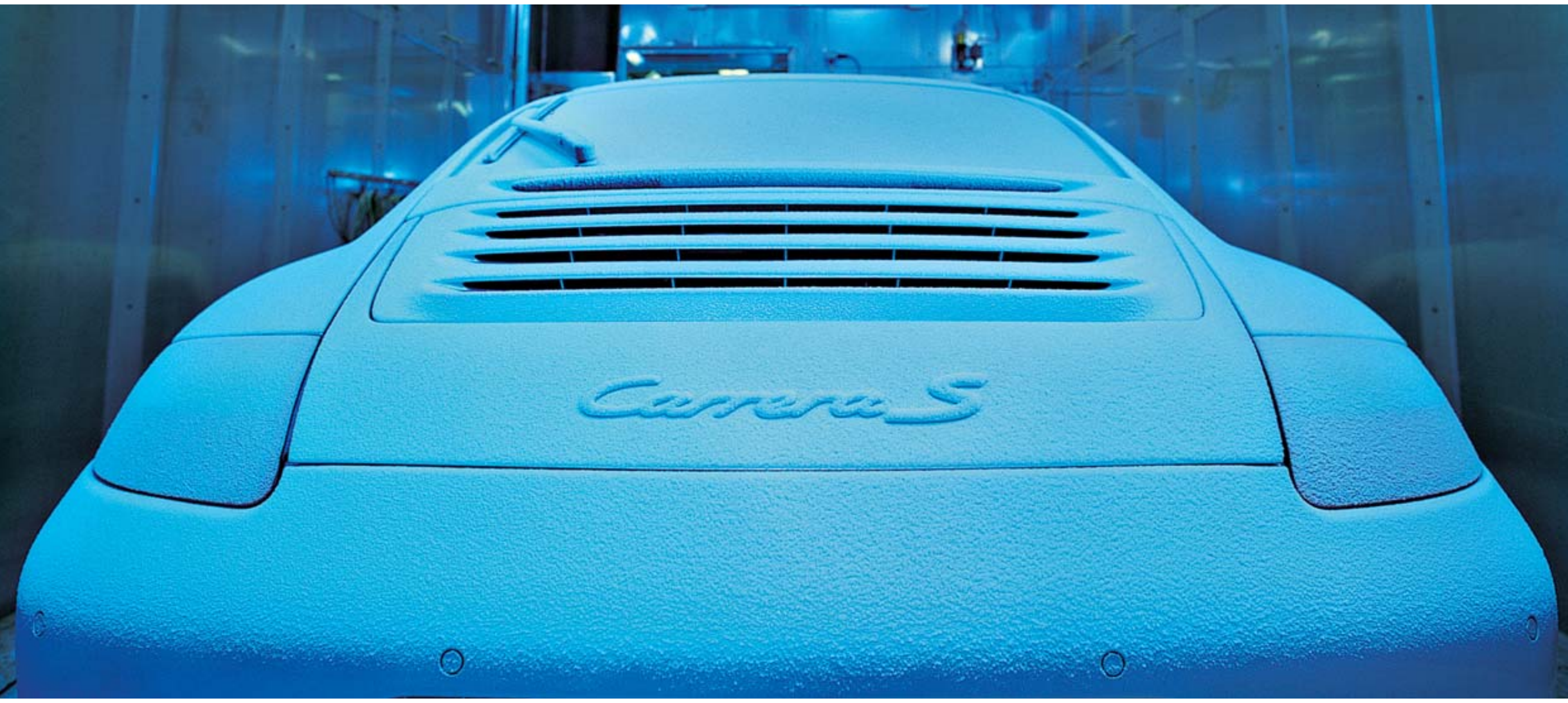
In this chamber, too, we can life-test a cabriolet top by cycling it opened and closed, at various temperatures, several thousand times.

The 911 Carrera S under a sheet of ice: tests can be carried out at temperatures as low as minus 40 degrees celsius in the climatic chambers.

Testing the air conditioning of a prototype of the Carrera GT in the climatic wind tunnel.

Climatic chamber with single axle roller

We can investigate the behavior of engine and engine components during a cold or warm start, followed by a trip, in the climatic chamber (minus 40 to over 70 degrees Celsius) with the single-axle roller. The double-roller set can be fitted to front- or rear-wheel drive vehicles and can be operated at speeds of up to 200 km/h. A turbine, which either operates at a fixed speed or in relation to the roller speed, simulates the wind blast at up to 160 km/h.



Climatic wind tunnel with four-wheel roller test rig

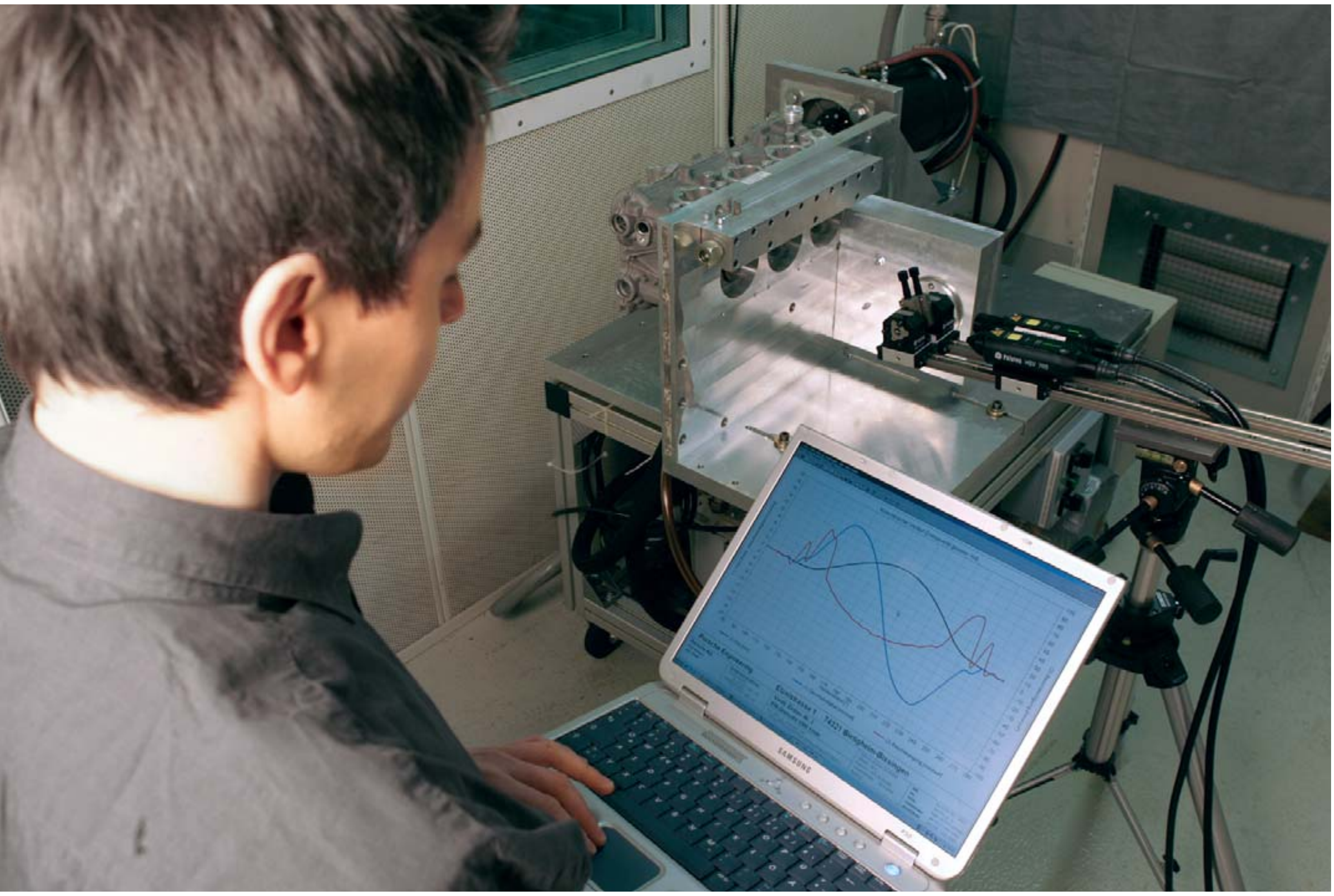
The climatic wind tunnel with four-wheel roller test rig is available for testing vehicle performance, brake cooling behavior, or the performance of air conditioning and heating systems at temperatures from minus 40 to more than 55 degrees Celsius. The four-wheel rollers can absorb up to 750 kW and are designed for speeds of up to 400 km/h, which allows us to simulate driving two- and four-wheel drive vehicles along real routes such as Townes Pass in the USA, or the Großglockner High Alpine Route in Switzerland. Simulation of the wind blast (up to 200 km/h) is either controlled according to the roller speed or is random. Standard test programs – idle simulation, stop-and-go traffic, urban driving, journeys on mountain roads – may also be carried out on this test rig.

The rainy journey simulation is used to develop windshield wiper systems to work quickly and cleanly during drizzle or cloudbursts; the rain can be supplemented with a solar array to simulate Germany's April weather.

Recording and evaluation

The data from each climatic chamber and test are recorded and evaluated using a modular measuring system developed by Porsche. The engineer may view the test results online and in many different formats. ■

Valve Train dynamics: Measuring by laser



Integrated software packages enable fast analysis of the data obtained.

Laser vibrometry has taken a firm place in the automotive sector over the past few years. This non-contact measuring process is used at Porsche Engineering to investigate and improve the dynamic behavior of the valve train during engine development.

Top performance with optimum fuel consumption assumes a perfectly-tuned engine. The valve train, at the foundation of such tuning, always offers the potential for improvement. Heavy demands are placed on these components, particularly in the case of sports car engines, from offering the largest possible opening cross-sections in combination with short valve opening periods at high rpm. It is for this reason that developers in this area are constantly striving to further optimize the dynamic properties of valve and timing drive.

Whether or not the valve train can actually offer the characteristics indicated in a specification document, and whether it will be able to withstand the demands placed on it as a result, can be ascertained at the early stages of development on the test bench. To do this, the engi-

In order to take measurements, the laser beam is positioned to meet the valve head vertically.

neers at Porsche Engineering use special lasers to examine the valve drive dynamics with no physical contact and therefore, no interference. This allows the behavior of the valve to be measured at different speeds.

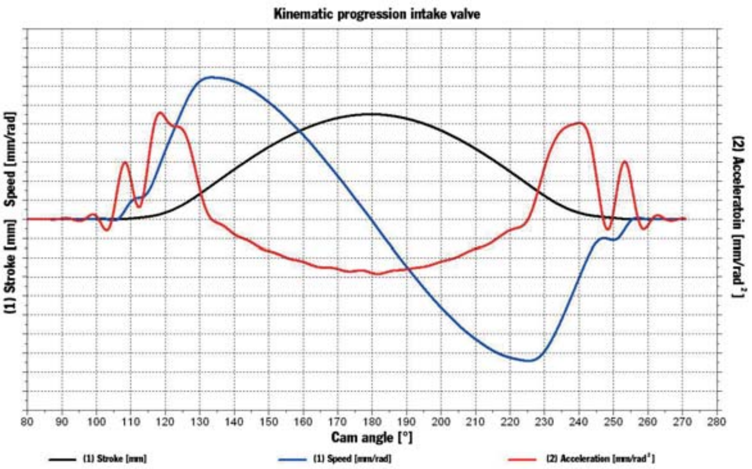
To take measurements, the cylinder head is pressurized with oil just as in normal operation on a mock-up test bench. The oil temperature and oil expansion can be adjusted accordingly. These parameters are specified in an electronic database and monitored .

A second laser beam is positioned as a reference measurement beam parallel to the first and adjacent to the valve seat to measure the relative movement of the valve.

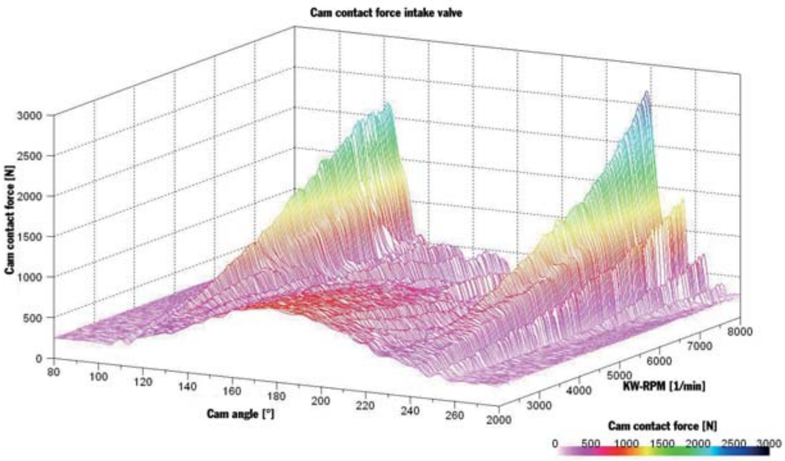
A high-performance electric asynchronous motor drives the entire timing assembly and can be programmed to simulate actual operation.

The chain drive is replicated in full with all intermediate gears, guides and tensioning rails including the chain tensioner. In this way the valve train dynamics can be examined along with all the external influences and reactions such as the chain drive polygon effect, damping influence of the hydraulic chain tensioner, and variable camshaft moments.

In order to take measurements, the laser beam is positioned to meet the valve head vertically. A second laser beam is positioned as a reference measurement beam parallel to the first and adjacent to the valve seat. With the reference established, the relative movement between the two measurement points is then measured and can therefore show the isolated movement of the valve without the influence of sprung mass vibrations. In this way, the valve lift and valve speed can be recorded exactly.



With laser vibrometry it is possible to examine the valve drive for kinematic properties, dynamics, and stress in the desired RPM range at an early stage of development.



Porsche Engineering uses a laser that has been developed especially for measuring Formula 1 engines. This laser is able to record speeds of up to 30 m/s as well as displacements (strokes) up to 160 mm.

The data acquired during measuring are recorded and saved in a time synchronous way. The Rotec RAS system used by Porsche Engineering can record analog signals at a resolution of 16 bits and a sampling rate of 400 kHz. Speed signals up to a frequency of 1 MHz and a resolution of 40 bits can be recorded. An integrated software package enables rapid analysis of the data obtained.

Deploying this system enables Porsche to measure the effects of different cam contours, spring stiffnesses, spring progressions and valve drive masses for example. The influence of these modifications can then be assessed by examining valve closure speeds and valve accelerations and by calculating contact power processes and Hertzian stresses. Additionally, analyses of torsional vibration can provide further information on operational behavior.

Owing to increasingly complex valve trains now being coupled with ever shorter development periods, valve train analysis is gaining more and more significance. By using laser vibrometry at an early stage of development, Porsche Engineering is examining the valve drive for kinematic properties, dynamics, and stress in the desired RPM range. With the Porsche Carrera GT V-10 engine, the necessary valve train development modifications were targeted and evaluated through the use of laser vibrometry, and thus avoided cost and time-intensive development loops. ■

Prize awarded for use of new materials

The Society of Plastic Engineers, one of the most highly respected associations in materials technology, has awarded the Engineering Excellence Award to the Porsche Carrera GT.

The Carrera GT has been honored with the Engineering Excellence Award.

This prize, awarded for the first time in 2004, demonstrates the high regard in which these automotive experts hold the Carrera GT for being the world's first standard production application of carbon fiber reinforced plastic (CFRP) for the chassis and engine sub-frame, as well as the ceramic clutch PCCC (Porsche Ceramic Composite Clutch).

Essentially CRFP consists of carbon fibers as used in aircraft construction and the aerospace industry. Porsche opted for this material for high performance components as it is the only product that meets all the requirements of maximum strength, stiffness and durability with minimum weight. The Carrera GT’s use of CRFP brings the highest possible level of flexural and torsional rigidity and thus outstanding occupant safety for a standard production vehicle.

The PCCC has been completely redesigned by Porsche's engineers: the clutch disk diameter is just 169 millimeters thus allowing a very low center of gravity for the engine and transmission. A further advantage is the low inertia that has a positive effect on the engine dynamics. The ceramic clutch has been developed to be both durable and easy to use in everyday driving. ■

Both the monocoque as well as the entire sub-frame are constructed from carbon fiber reinforced plastic (CFRP).

More sporty, more powerful and more confident

> A new generation: after more than eight years of production and more than 160,000 vehicles, the new Boxster is now available in two versions.

The base 2.7 liter six cylinder engine has a power output of 176 kW (240 bhp). The Boxster S that is being introduced at the same time generates 206 kW (280 bhp) from a displacement of 3.2 liters. The Boxster accelerates from 0 to 100 km/h in 6.2 seconds and the Boxster S in 5.5 seconds. The base model can reach 256 km/h and fuel consumption is 9.6 liters of Super Plus per 100 km in accordance with the EU standard. The top speed of the S version is 268 km/h with average fuel consumption of 10.4 liters (EU standard).

From the side, noteworthy features include enlarged air inlets in front of the rear axle, precisely crafted door sills, a larger window area between the B-pillar and the roof, as well as newly designed and enlarged wheels. The base 2.7 liter version is now equipped with standard 17 inch wheels, while the Boxster S rolls off the production line with 18 inch wheels.

With 280 bhp, the Boxster S is particularly powerful and has a top speed of 268 km/h.

The front now characteristically displays the new lighting design, separating the main headlamps from the front lamp unit that houses an integrated fog lamp.

A redesigned five-speed manual transmission transfers torque in the new base Boxster, while the S model receives a new six-speed gearbox.

For both versions, the shift action has been redesigned to provide faster gear travel. A five-speed Tiptronic S is also available on both vehicles. The Boxster is the world's first roadster to protect occupants with a head airbag to counteract side impact collisions. The airbag inflates from side sills on the doors and is supported by a thorax airbag located in the outer side of the back rest. ■

Fresh air fascination

Since April 2005 the new 911 cabriolet is available as an alternative to the coupé. The open-top 911 series car offers two engine variations: a 239 kW (325 bhp) rated 3.6 liter boxer engine and a S model 3.8 liter engine and 261 kW (355 bhp).

The cabriolets also possess the outstanding driving dynamics that characterize the coupés. Thanks to excellent lightweight designs, the basic version weighs just 1,480 kilograms empty (S version: 1,505 kilograms) and therefore takes a leading position in its market segment. Both cabriolets weigh just 85 kilograms more than the corresponding coupé versions. Coupled with a favorable power-to-weight ratio and a typical Porsche chassis, the two open-top sports cars excel with exemplary agility and dynamics on corners. With the PASM chassis (Porsche Active Suspension Management) supplied as standard (available optionally for the 3.6 liter Carrera), the Carrera S Cabriolet is establishing new benchmarks.

Both models attain exactly the same top speeds as the coupés – 285 km/h and 293 km/h respectively – thus highlighting their exemplary aerodynamics. They have a C_d value of 0.29 and are therefore front runners against international competition. With its 3.6 liter engine, the open-top Carrera (with manual transmission) accelerates from 0 to 100 km/h in 5.2 seconds whereas the Carrera S Cabriolet takes 4.9 seconds.

The soft-top is fully automatic and can be opened or closed in just 20 seconds at the push of a button. Once folded in a Z configuration, it is placed in the cover retainer with the outside facing upwards. Opening and closing the top is possible at speeds of up to 50 km/h. ■

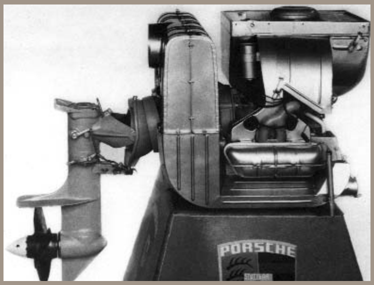
The 911 Carrera Cabriolet's fully-automatic soft-top opens in just 20 seconds.

Porsche – on land and water

Porsche took to the water for the first time in the mid-1950s. The first, fast trial circuits were conducted on Max-Eyth Lake near Stuttgart in a boat driven by a detuned 356 engine.

First trial circuits conducted on the Max-Eyth Lake near Stuttgart.

Because the Porsche 356 was so successful, its engine – slightly modified – was also used to power boats.



The engine of the Porsche 356 was modified for the use in water.

Then, in 1959, a 356 engine detuned from 60 to 52 bhp and designated the Type 729 was introduced to the public as a boat engine. A particular feature of the construction was the engine's special sheet-metal housing which ensured a supply of cooling air and protected the drive from overheating. Furthermore a heat exchanger captured the engine's exhaust heat to also heat the boat if it was necessary. At a top speed of 46 km/h, the wind blast can be quite chilly… ■

In 1959 the first boat with Porsche engine was introduced to the public.


Carrera GT

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