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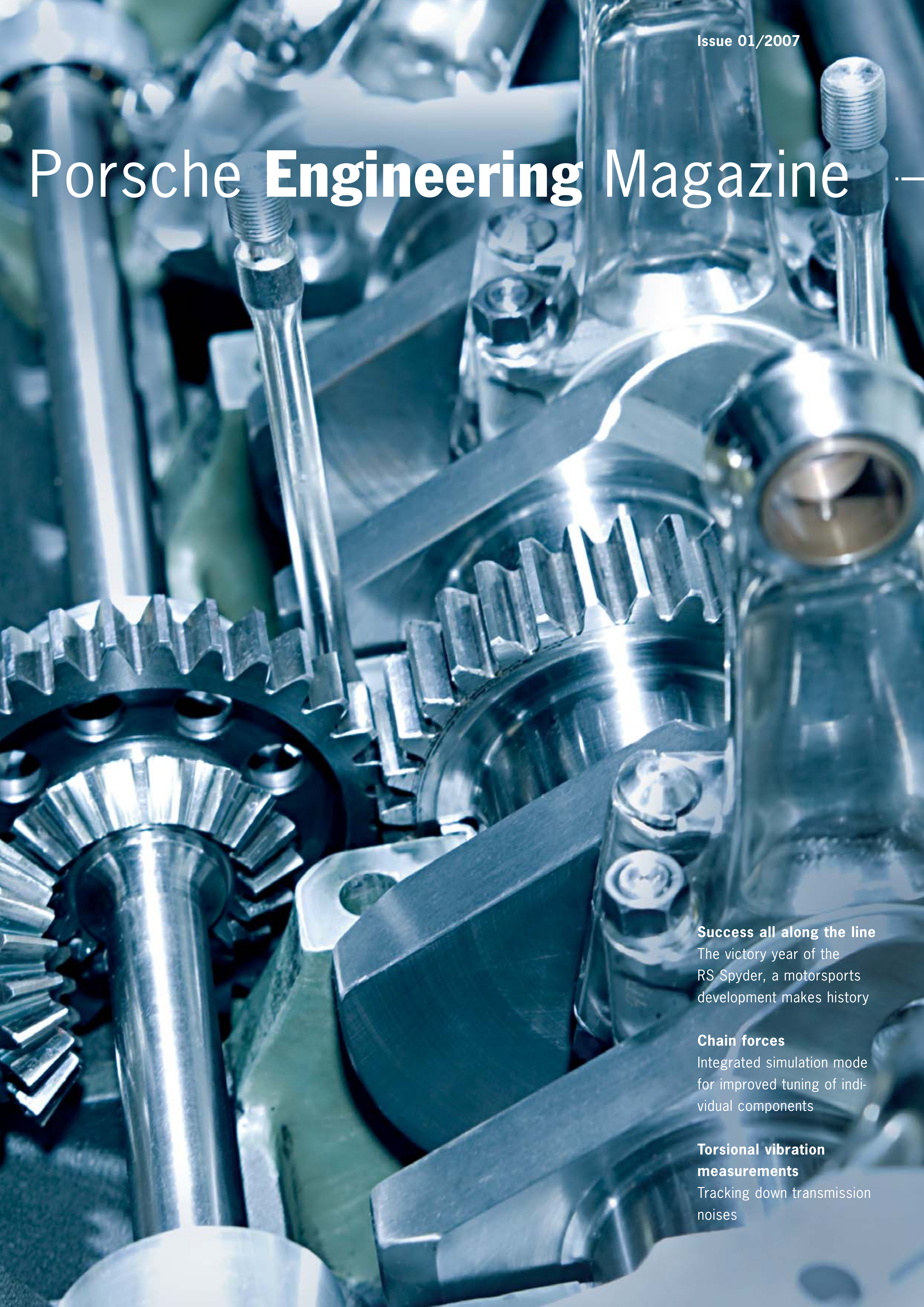
Porsche **Engineering** Magazine



Success all along the line
The victory year of the RS Spyder, a motorsports development makes history

Chain forces
Integrated simulation mode for improved tuning of individual components

Torsional vibration measurements
Tracking down transmission noises

Dear Readers:

Technical progress is made possible by an eye for detail. Driven by unceasing curiosity, it is also the prerequisite for our favorite activities: questioning, researching, inventing.

These three components drive our work. For the customer, we convert them into actual motion. They are the driving forces that help us put into practice scientific findings, for you and your projects. The aspiration to be the driving force that creates the future and enables progress, motivates our engineers, day after day.

In this issue, dear readers, we would like to present to you our work using examples and current developments around the topics of “driving forces” and “drive”.

Our engineers’ tasks include identifying the slightest of influences – such as gearing in wheel drives – thereby perfecting the mechanisms. Their work represents a major contribution to noise optimization in transmissions. Even the sports watercraft Seabob was built with the help of the Porsche Engineering Group. Our experts gave its insides a complete electronic makeover that promises pure driving pleasure.

Driven by an innovative spirit, our employees try to use familiar raw materials in new ways, not limiting their knowledge to just one perspective. The use of aluminum for the doors of the 911 and the development of a solar module provide impressive proof of that.

In engine development, dynamics and drive also play an important role. Porsche Engineering presents the new measuring methods for the dynamic behavior of valve drives. Because only a optimally tuned engine guarantees peak performance – and not just in sports cars.

Finally, we would like to look back and present our achievements for 2007. The RS Spyder is a success model from Porsche and also a driving force in motor sports. The winner of the American Le Mans Series ALMS features convincing advanced technology, outstanding driving performance and unique dynamics. We can without a doubt be proud – of the car and an outstanding racing season 2007!

Please join us on a brief journey through our current development work and discover the driving forces at Porsche Engineering Group.

Enjoy reading, The Editorial Team

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About Porsche Engineering

At Porsche Engineering, engineers work meticulously on new, unusual ideas for vehicles and industrial products. Upon request from automotive manufacturers and suppliers, we develop a variety of solutions – ranging from the design of individual components through the layout of complex modules to the planning and implementation of entire vehicle developments including production start-up management. What makes it special: All this is done with the expertise of a series manufacturer. You need an automotive developer for your project? Or do you prefer a specialized system developer? We offer both - because Porsche Engineering works where both areas interface. The extensive knowledge of Porsche Engineering converges in Weissach – and yet it is globally available. Of course, also directly at your site. But regardless of where we work, we always bring a piece of Porsche Engineering with us.

If you would like to learn more about us, please request our image brochure by e-mail:

info@porsche-engineering.com ■

Porsche Engineering *Insights*

High demand for developments ensures well-filled order books for 2008

The high demand for development services from Porsche Engineering is unrestrained. Short development times, technical innovations and sustainable cost reductions are at the top of the customers' list of requirements. For 2008, the order books of Porsche Engineering are full once again.

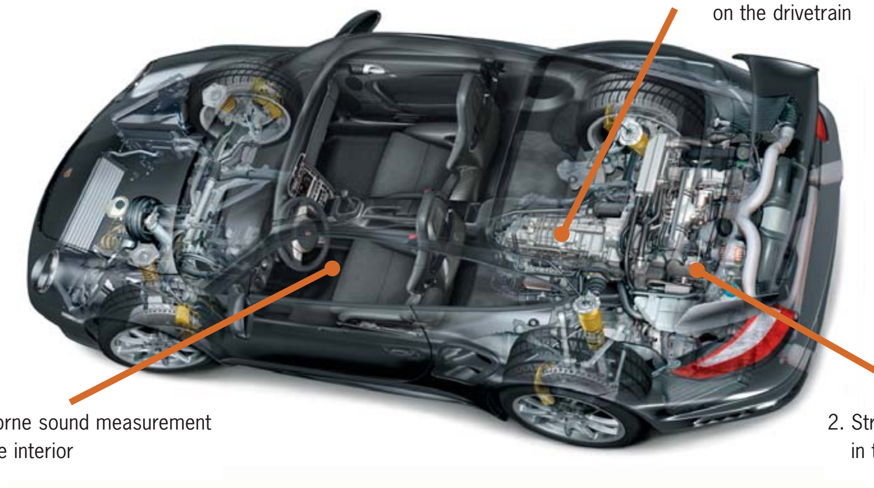
Customized solutions for automotive manufacturers and suppliers, but also companies in other industries, are the objective of the development work. We would like to thank our customers for their trust and look forward to an innovative new year. ■

Focus on alternative technologies, such as hybrid and electric drives

Forward-looking innovations are the objective of all development engineers at Porsche Engineering Group GmbH. New drive concepts are a focal point of the development work of Porsche Engineering Group. The engineers have been very active in the area of alternative drives, such as hybrid and electric engines and have specialized even further in this field.

In 2008, there will also be projects concerning further improvements of the new drive technologies – as always strictly confidential, for the benefit of our customers. ■

Torsional vibration measurements are a reliable method for finding noise in the drivetrain



All Dr. Ing. h.c. F. Porsche AG vehicles are developed and manufactured according to the highest quality standards. This includes the acoustics, a topic that is an important focus for our development departments.

Dominant sources of noise that the driver can hear are – besides body and chassis – the drivetrain and the transmission. Minimizing these transmission noises has for many years been an important challenge for the development engineers of Porsche Engineering.

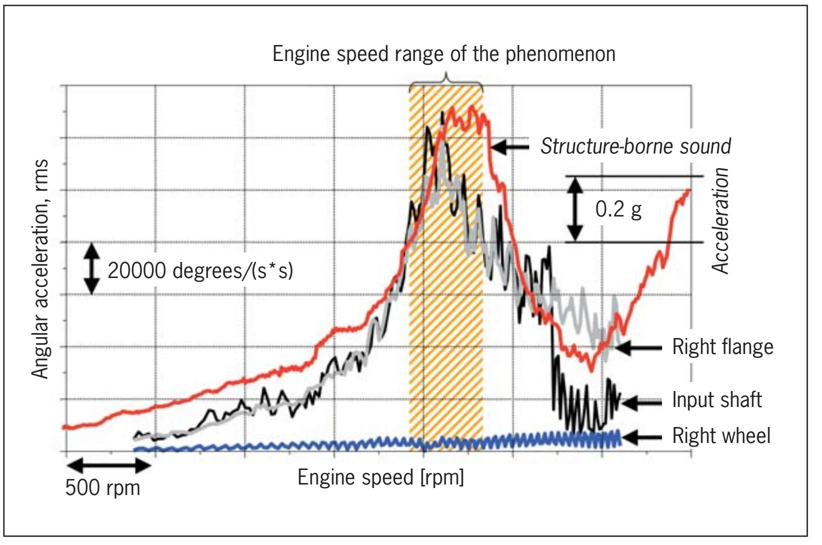
The knowledge about modern measuring methods that can localize and ultimately minimize these noises is thus gaining importance. Only if noise can be located with suitable measurements can the mechanical causes of undesirable drivetrain noises and vibration (such as whining or whistling in the transmission) be eliminated.

Mechanical causes of transmission noise

Transmission noise is caused mainly by loads on the intermeshing teeth. In particular, rigidity fluctuations during meshing are responsible for this. These fluctuations cause rotational irregularity during the transmission of the rotary motion. If the rotational irregularities caused by the gearing are introduced into the drivetrain, they can be transmitted to the vehicle in the form of structure-born vibration. Therefore, they are often audible in the interior. Depending on the frequency of these relatively tonal noises, they resemble “whining” or “whistling”.

In order to measure noise, air-borne sound measurements (point 1, Fig. above) are performed in the interior of the vehicle, where the noises perceived by the passengers can be measured. However, the measured noises may be superimposed by other noises of a similar order (e.g., engine noises). To obtain the amplitudes of a vibration directly at the engine, structure-borne sound measurements are performed on the engine (point 2, Fig. above).

However, these two measuring methods alone do not satisfy the experts at Porsche Engineering, since they do not yield a thorough root cause analysis of a transmission noise. Therefore, they developed a system for measuring the root causes of gearing noises directly on the drivetrain – in the smallest of installation spaces and at high temperatures (point 3, Fig. p. 5).



Angular acceleration at different engine speeds and measuring points for accurate localization of engine noises.

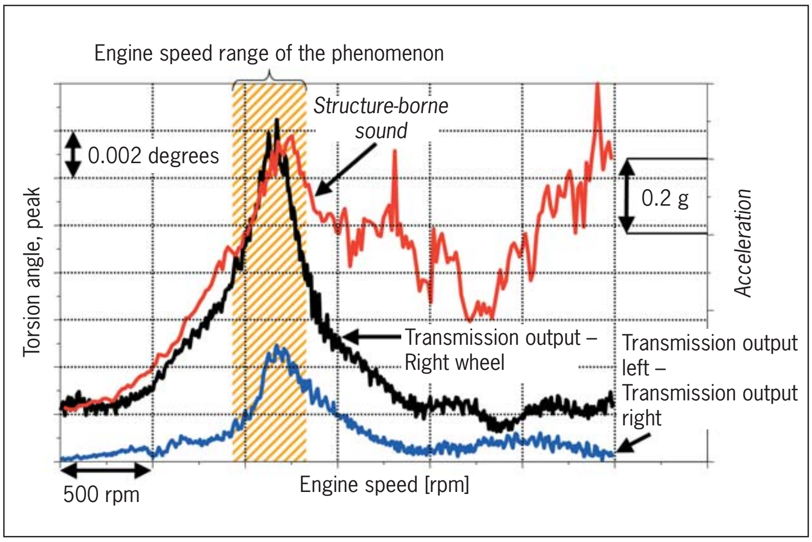
High-resolution torsional vibration measurement on the drivetrain

Torsional vibration measurements provide information about vibration that is superimposed on a regular rotational movement. This allows the transmission noises caused by the meshing to be measured.

The high-resolution torsional vibration measurement is performed in the anechoic chambers of the Development Center in Weissach. The analyses make the measurements reproducible, especially for air-borne sounds. The measurements can therefore be performed on a test stand under free-field conditions. This is necessary, since only the slightest sound reflection occurs here. Under constant measuring conditions, it is thus possible to both use the particular degrees of freedom of the rolling test stand for special studies and to simulate the on-road operation of the vehicle.

Over several measurement series, the parameters load, driving gear and transmission oil temperature are varied. Furthermore, the effect of a component can be examined (e.g., axle shafts with different mass moments of inertia). In addition, traction and overrun (full load) load conditions can be tested on the road, using the existing measurements. The use of torsional vibration measurements combined with simultaneous air-borne and structure-borne sound measurements can prove the correlation of noise and meshing of the transmission (or final drive) in the drivetrains.

The measuring technology used here has been validated, the time resolution and the number of measurement sensors is sufficient to detect even very small rotational variations. Using a system that accurately detects the time intervals between the measurement points of the sensors on rotating axles and gears allows an analysis with precise separation of frequencies. By optimizing the sensor elements for high resolution, rotational deviations in the time range can be plotted very accurately. If necessary, both the order analysis and the phase-related analyses in the time range can provide drivetrain-related data for the fine-tuning of calculation models. In particular, the analysis of a drivetrain measurement in the time range can be



Torsion angle analyses are compared with vibration measurements to better understand the phenomenon.

used to study non-continuous vibrations result from combustion irregularities.

Angular acceleration and torsion angle are criteria for the analysis.

The sample diagram (see Fig. on p. 6) shows the angular accelerations at different engine speeds and different measuring points. Compared with the structure-borne sound signal, angular acceleration can be used to accurately localize transmission whining, since the signal has a unique identifiable global maximum. Besides analyzing the different measuring points with angular acceleration, the amplitude of the torsion angle can be observed (see Fig. above), a further criterion for clarifying the “axle whining” noise phenomenon. Using a difference analysis of the different engine speed measuring locations, the relative angle of the torsion in a vibrating system can be determined.

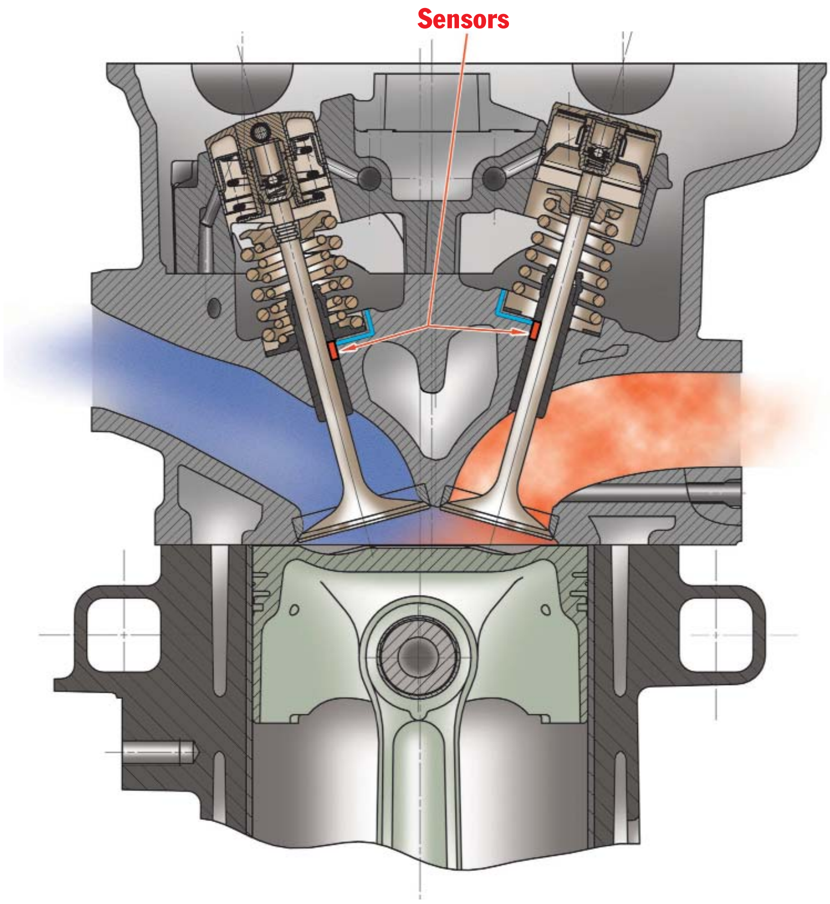
By studying the angular acceleration at suitable measuring points, it is also possible to obtain proof of the correlation with structure-borne sound measurements. It can be ensured that the “whining” phenomenon correlates with the torsional vibration measurement. Furthermore, the torsional vibration measurement creates an understanding of the vibration system, which in contrast to the acceleration measurement provides an explanation for the engine speed/load interdependence of the phenomenon: Depending on the torque applied in traction, the output is perceived as vibrating in-phase. Depending on the torque applied in traction, the output vibrates in-phase. In overrun, however, the unlocked differential allows antiphase vibration.

The measuring technology described here can also be used without modification under operating conditions, to study the meshing quality in a single-flank test. Porsche Engineering uses this method successfully for customer projects.

Valve drive measurements with running engine

With valve drive measurements on the running engine, Porsche Engineering is using a new measuring method for engine development purposes, with the goal of optimizing the dynamic behavior of valve drives.

High performance is one thing, efficient fuel use another. Both require a perfectly tuned engine. Of primary importance within a long chain of components is the valve drive. Especially in sports car engines, it holds great potential for improvement, since the components are subjected to very high wear. To achieve optimum aspiration of the cylinders, large opening cross-sections with the shortest possible open period and high engine speeds are necessary. The optimization of the dynamic properties of valve drive and timing gear are at the top of the improvement list of the engineers.

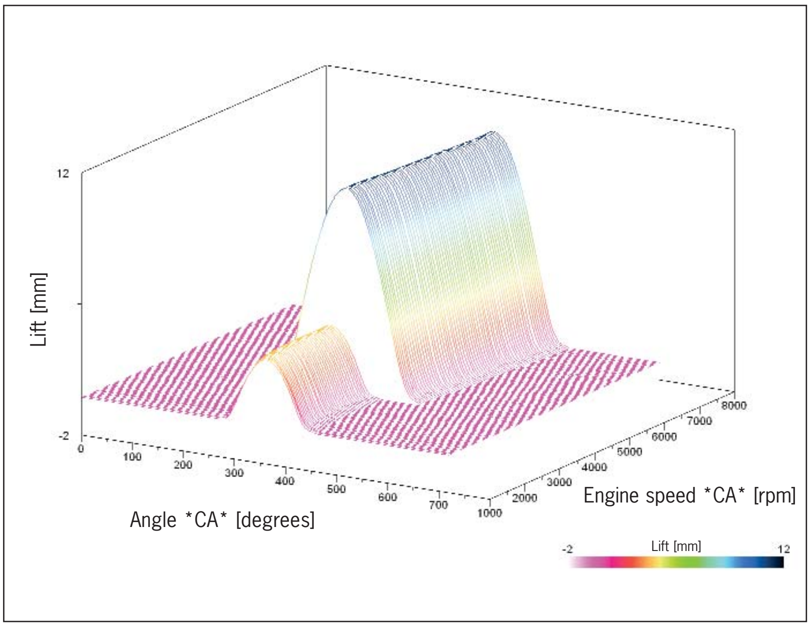


A small sensor stands for great progress

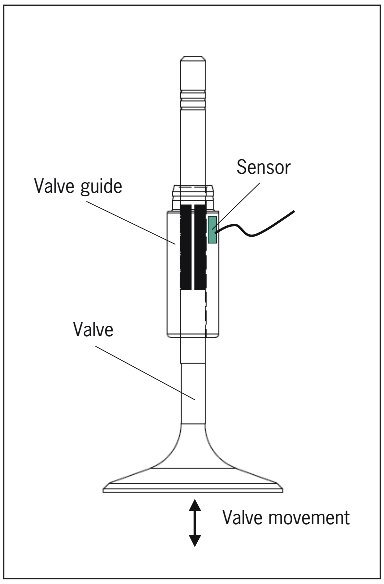
A sensitive measuring method is imperative for improving the valve drive. While some years ago laser vibrometry, an optical measuring method using a laser beam on a dummy test stand, brought with it great progress (Porsche Engineering Magazine, edition 1/2005), the engineers of Porsche Engineering now made a quantum leap in this field. Thanks to their ideas, all measurements can be performed independently on a running engine.

A small sensor is the important component; it can be attached to the valve stem. This non-contact, non-reactive measuring technology is so compact that it can be installed in the smallest of spaces. Although the sensor is very small, its measuring capabilities are extensive. It logs valve lift, speed, acceleration and overlap, intake and outlet media and seating speed.

For the first time, it is possible to record the significant parameters that affect the engine characteristics over the entire engine speed range. For example, a certain amount of noise is associated with the speed at which the valve contacts its seat. However, if the noise generated by the valve drive is reduced, performance is affected. While acoustics play a minor role in the eight-cylinder engine of the successful Porsche RS Spyder ALMS race car, performance was the highest priority in the technical specification. In an emergency power unit, on the other hand, a low noise level during operation is desirable.



The diagram shows the valve lift curve in partial load operation.



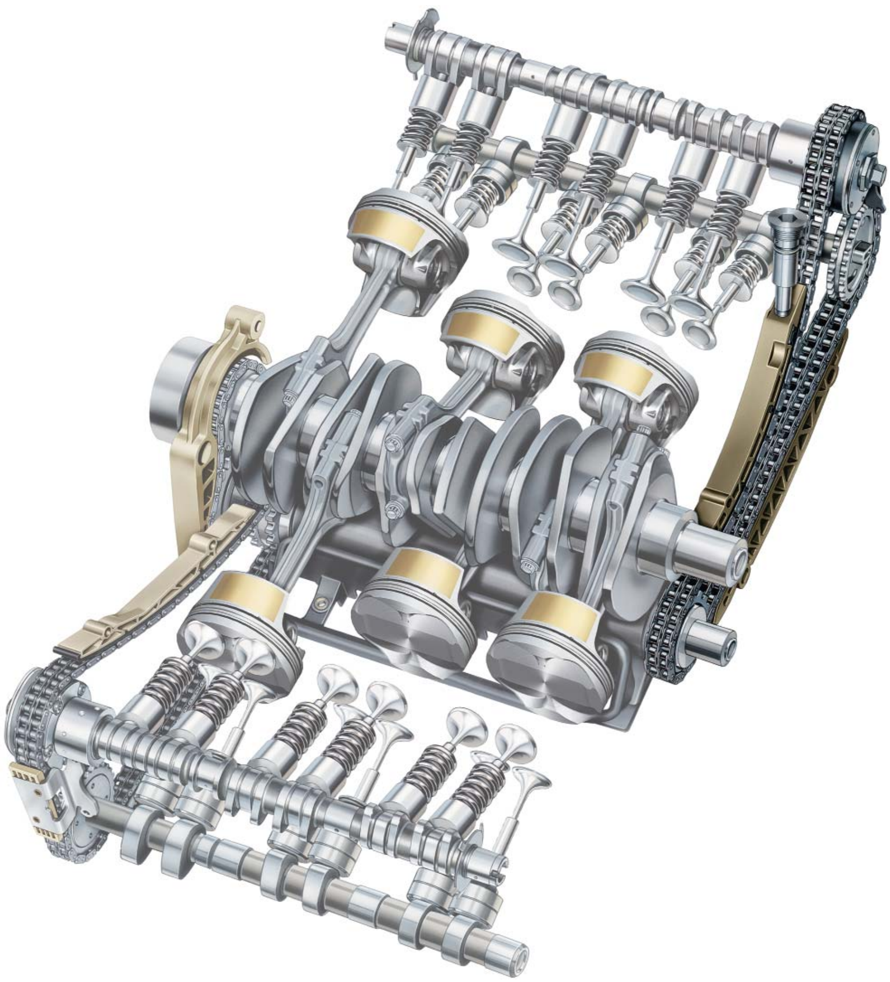
The sensor is suited for the smallest installation spaces.

The common goal in all cases is to get as close to the optimum as possible in an early phase of development. The effects of different cam contours, valve drive weights, or spring stiffnesses or progressions can be studied this way. But this new measuring method can also be used to obtain additional findings.

It is currently not yet known whether and how different ignition pressures deform the valve. In light of more complex valve drives and simultaneously shorter development times, valve drive analysis is gaining importance. With the measuring techniques used at Porsche Engineering – laser vibrometry and valve lift measurements on the running engine – the effects of different parameters on the valve drive can be studied in an early development phase with regard to kinematics, dynamics and loads in the desired engine speed range. Ultimately, this also guarantees high performance and efficient fuel consumption.

Integrated simulations from Porsche Engineering make calculating chain forces possible

A wholistic approach is required when it comes to engine development. If individual components are not properly matched, the harmonious interaction of different components is easily disrupted.

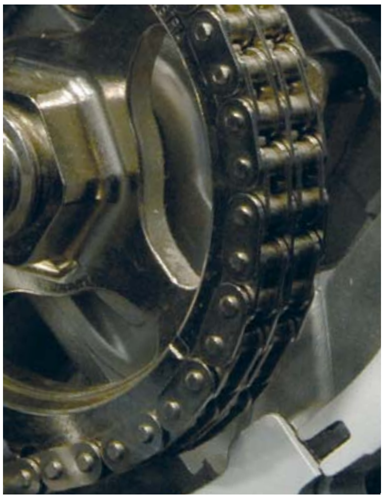


A major goal of the development work of Porsche Engineering is the elimination of undesirable interactions between the different systems. Especially in timing gears, preventing mutual excitation has been the object of numerous tests, since they are an important link between different engine assemblies. The timing gear and the timing chain in particular, drive the camshafts. These, in turn, are part of the valve drive, which in itself is a dynamic system. Thus, mutual interactions occur.

Integrated simulation models

The engineers at Porsche Engineering are working intensively on the phenomenon of mutual interactions. They rely in particular on a simulation model that can plot several systems and their interactions. The experts were successful in realizing such a simulation of the dynamic behavior of the chain drive and the valve drive. This way, the different effects of the chain drive can be taken into consideration.

While in the past it took several separate calculations – with many associated error sources – all calculations can now be performed on a single simulation model. In the calculations for the dimensions of the timing chain, it is possible not only to simulate excitation with a flexible crankshaft, but also to plot the complete valve drive. In an isolated view of the systems, mutual excitations were not taken into consideration. Conseqently, excessive



The timing chain of the valve drive as an important link between engine parts.

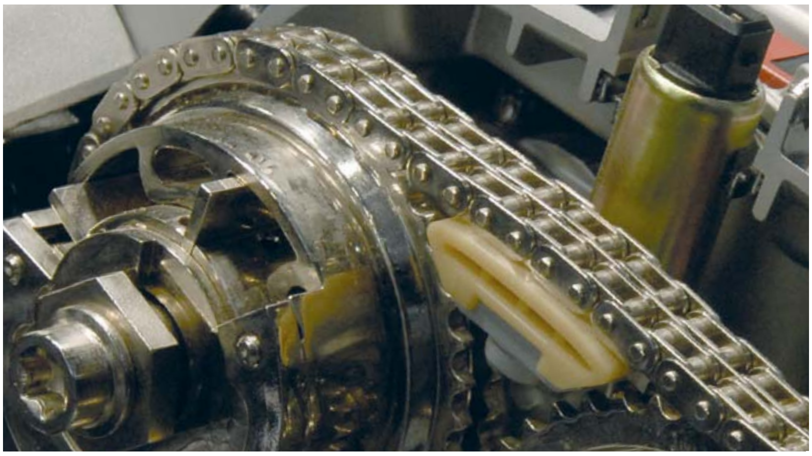
forces in the valve drive went undetected; yet, they are a major cause of damage to engine components.

Timing chains in diesel engines

Another area of application for the new simulation models is the dimensioning of the timing chain in diesel engines. In these engines, the fuel pump is often activated by the chain drive. In order to improve emission and consumption values, the injection pressure is continuously increased. The result is higher drive torques and thus higher chain forces. The new simulation models also introduce the dynamic increase of chain forces into the layout phase, thereby ensuring greater safety at the concept phase.

System optimization through integrated simulation

Thanks to the integrated simulations performed at Porsche Engineering, extensive improvement work can be prevented early on in the development. It is thus possible to determine the loads on the timing gear and – by optimizing the dynamic behavior of the valve drive – improve the entire system. In their new simulation models, the Porsche experts can take into consideration excitations from the crankshaft, the dynamics of the valve drive, fuel pump torques, moments of inertia of the chain sprockets and transmission gears, the dynamic behavior of the chain tensioner, dynamic chain rigidity, circumferential backlash of gears and much more. In addition to other parameters, the natural frequencies of the chain drive can be determined and the chain vibrations calculated. This is the basis for targeted measures to reduce the arising forces and optimize the systems involved. ■



The natural frequencies of the chain drive and the chain vibrations can be calculated.

Aluminum – a weighty decision made easy

It is hard to conceive vehicle design without aluminum. Although this material is competing against materials such as carbon and magnesium, it plays a significant role in development and production due to its unbeatable price-performance ratios and outstanding material properties. Thanks to its light weight, the material creates seemingly endless design possibilities. Good forming and tensioning properties combined with high strength are just a few of its benefits. Special alloys can further improve its already very good corrosion properties. They enable a long service life of components and parts that can withstand even extreme conditions.

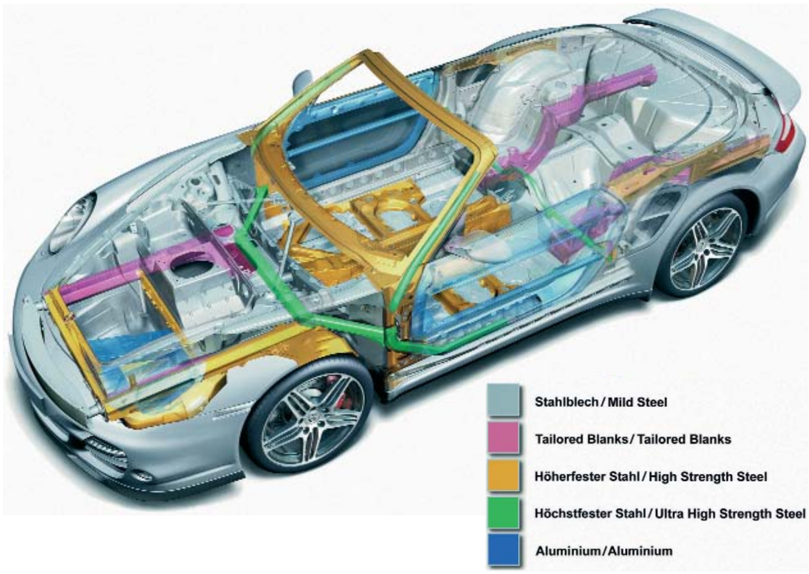
Mainly because of its light weight, aluminum still plays an important role in the automotive sector. The developers at Porsche Engineering have been using their expertise regarding aluminum for years to optimize vehicles, as well as other areas.

Engineers use their knowledge not just for the doors of the new 911 Turbo convertible. As a simple solar module for BP shows, the material is also used successfully in order developments for customers from other industries.

Intelligent lightweight construction for the 911 Turbo

The striking silhouette of the 911 is one of the major characteristics of this classic sports car. Since its debut in 1963, it has barely changed. Moreover, the basic data of the flat-six engine have remained constant over the years. For example, the distance between two combustion chambers is still 118 millimeters. Displacement and power, however, have increased continuously. The unique dynamics and the associated emotion and driving pleasure never fall by the wayside. Yet, the Porsche engineers did not foster this increase in power just

Aluminum door of the 911 Turbo



The aluminum door of the 911 Turbo convertible is 7 kilograms lighter than the steel door.

for its own sake. Over time, the 911 has gained weight due to the improved safety equipment, such as airbags and stability systems, as well as the enhanced comfort packages, for example with A/C systems and power windows. While the first version weighed 1080 kilograms, the current 997 model tips the scales at 1395 kilograms. However, this moderate gain is not something the sports car needs to be ashamed of. Vehicles in the same class have put on much more weight in a shorter time.

Against the background of exhaust emissions discussions, however, the days when “extra pounds” went unpunished are gone forever. After all, each additional pound increases fuel consumption and thus CO_2 emissions. In the eyes of the Porsche developers, the future will be intelligent lightweight construction with new materials. While the raw material steel, which has been used for many decades, has reached its limits, the cost of new, lighter alloys have increased drastically. Aluminum, however, will play an important role in the future, thanks to its convincing cost-benefit ratio. This advantage can be demonstrated using the doors of the Porsche 911 as an example, where the material was changed from steel to aluminum.

The obvious, simple approach of material substitution in a shell construction was unsuitable due to the high material costs. Only by integrating reinforcement parts into a complex die cast large-area door interior part could the costs be lowered significantly. Considerable cost advantages were achieved through determination of the load paths with simultaneous optimization of topology and wall thicknesses, combined with savings in tooling expenditure, production and assembly times. Depending on the production volumes, they can even over-compensate for the additional casting process and material costs. At the same time, it was ensured that if necessary, both steel and aluminum doors could be installed on the same assembly line. Therefore, it was necessary that the joining geometry for the doors from both materials be identical.

Another specification for the layout of the aluminum doors was that all assembly parts such as door mirrors and handles could be accepted without changes. This was achieved by designing the frame as a die cast part. In the body, it was even possible to drastically reduce the number of components. Instead of 15 sheet metal parts, five bolted connections and 85 welding spots, which are required for the steel door, the aluminum counterpart only needs five aluminum parts and ten bolted connections. The length of the bonded raised edging seam and the adhesive beads between door channel and safety reinforcement closely matches the length of the welding spot connections. The success on the scales was also enormous: 17.5 kilograms of steel door on the body structure versus 10.3 kilograms of the aluminum part.

The aluminum door achieves the same crash characteristics as the steel version. This was made possible by using extruded profiles for the three-dimensionally bent channel reinforcement and the crimped-on safety reinforcement. In an offset crash at 64 km/h, the middle load paths guide the impact forces via channel and safety reinforcement to the rear section. At the same time, they stabilize the door aperture, which is subjected to the load from the engine mass being pushed forward during an accident. Thus the passengers remain protected in the passenger compartment. It also passed the requirements of the side crash test with flying colors.

Door acoustics

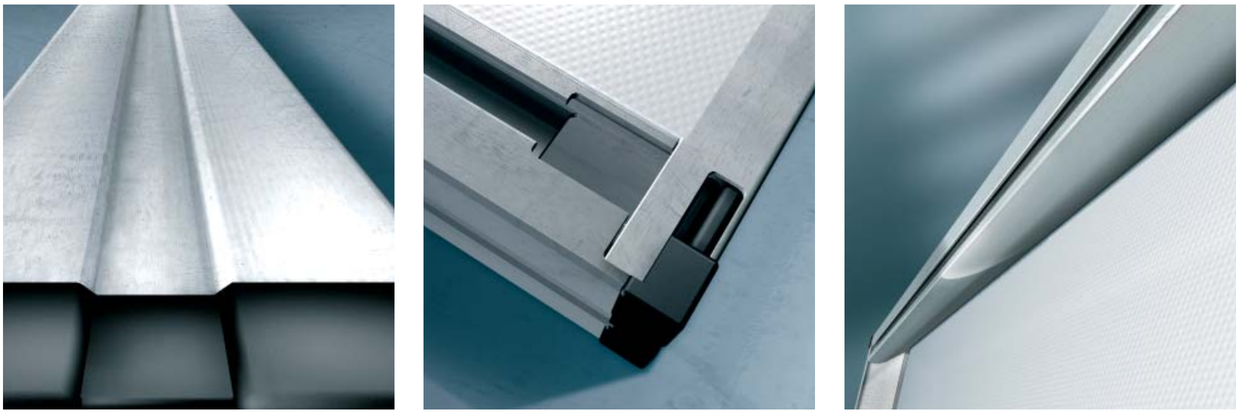
Another important aspect for the Porsche developers was the acoustics when closing the door. A solid sound and low vibration are a must to satisfy the high comfort demands of the customers. An acoustic measurement with an artificial head on the driver's seat shows that the metal also meets all acoustic requirements.

In the end, 14 kilograms were saved by switching from steel to aluminum doors – 14 kilograms that significantly reduce fuel consumption and exhaust emissions. Applying these findings to other vehicle parts could result in further improvements. The Porsche engineers know that lightweight construction still holds a lot of potential. They are already using their expertise successfully in the development of new models and customer development projects. ■

Built for eternity and equipped for extreme situations. In the new solar module generation, everything stays within the frame.

With the development of the modular frame of the new solar module generation of BP Solar, the engineers at Porsche Engineering have proven that they are immensely knowledgeable in the area of industrial development. They were able to build the frame so that it can even withstand significantly increased loads despite its low module weight.

The unusually light and extremely torsionally rigid aluminum frame, which was developed in collaboration with Porsche Engineering, equips the modules of "Generation Endura" sustainably for extreme situations. The tested load bearing capacity under snow and wind is beyond all standards and reaches over 600 kg/m^2. This is the equivalent of six meters of new snowfall on the solar module – even with the so-called insertion system and bracket on the front side. In combination with modern clamped or bolt-

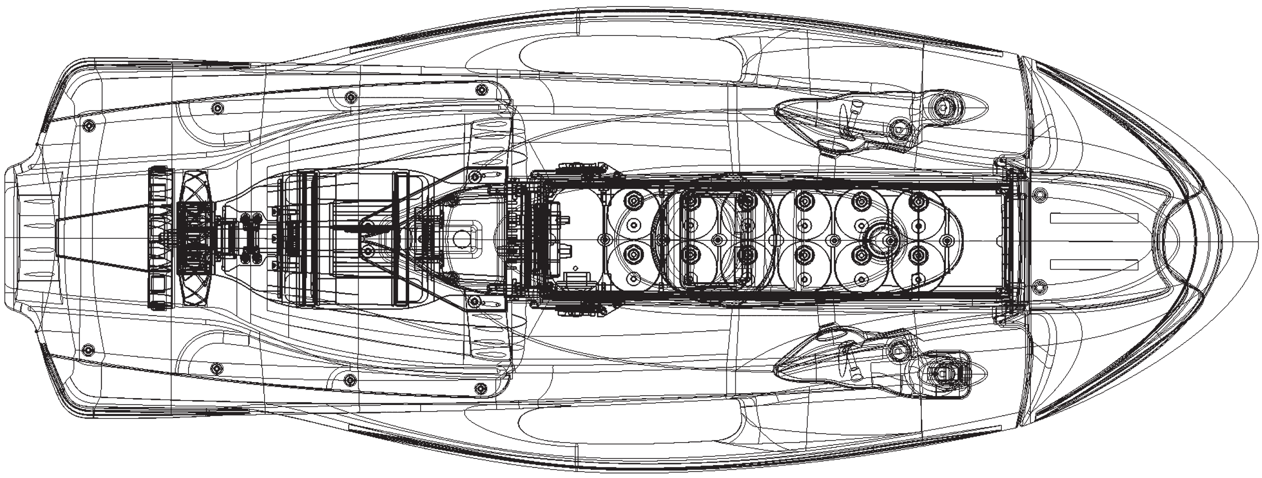


The aluminum frame of the module – equipped for extremes.

ed brackets, this value may even be exceeded. Thanks to these outstanding properties, the module has easily passed standard IEC 61215. From now on, impact-damping corners protect the module even in the event of rugged handling. The frame is made of silver anodized aluminum, which allowed weight optimization. The new module is not only technically state-of-the-art, but the new properties also reduce assembly times on the roof. Besides Porsche Engineering, Porsche Design contributed considerably to the appearance. Thus, the new frame looks good from any angle. ■

The solar module from BP. Stable even under very high loads.

Even on the water, Porsche Engineering ensures environmentally friendly driving pleasure



Agile and maneuverable like a fish in water, on the surface or deep down – a ride on the SEABOB makes it possible.

This unusual, sporty watercraft is easy to steer by simply shifting your body weight. The speed is regulated at the control grip. But it's not all driving pleasure and good looks with the SEABOB from Rotinor. Thanks to the development work that went into it, its technology is quite impressive, too. The engineers gladly accepted the challenge and developed three electronic components for the patented sports watercraft: the battery manager, the motor control system and the control panel with graphic display.

With the electronics, Porsche Engineering developed the heart of the SEABOB

The SEABOB, which weighs approx. 60 kg and has a 5 HP (3.7 kW) electric jet drive, can reach speeds of 15 to 20 kilometers per hour and could dive up to 40 meters deep. For safety reasons, however, the standard presetting only allows a diving depth of 2.5 meters.

With a PIN entry, it can be set to a lower value. It receives its propulsion by means of the jet stream principle. The powerful, rotating impeller suctions in water and pushes it at a high pressure through the jet duct to the outside. This thrust propels the SEABOB forward.

The battery manager monitors the installed lithium ion batteries

With a capacity of 42Ah per 4V cell, the battery manager monitors the functionality of the lithium ion batteries installed in the craft; these batteries are also used in space technology. Each cell weights approx. 1 kg and has a volume of $^{1}/_{2}$ liters. Since lithium ion batteries can be very sensitive, special electronics were developed for monitoring each cell voltage separately. The battery manager also controls the current monitoring and shut-off for charging and discharging the battery.

In addition, several sensors monitor the operating temperature. Through active cell balancing, each cell is loaded to the point that all cell voltages are the same. This prevents the series-connected battery voltages from drifting apart.

The electric high-performance drive mechanism is an exemplary innovation

The SEABOB's motor is emission-free and almost silent. Its control system works with a digital signal processor (DSP) and generates 3-phase sinusoidal current from the battery voltage. The intermediate circuit voltage of up to 60 V generates phase currents of up to 200 amps. Its high-power phase is even designed for 250 A. The rated power of the motor is up to 7.5 kW and can be overloaded to twice that value. The rotor position is sensed by three hall sensors. The mechanism used is a high-torque synchronized drive unit. Using cutting-edge technology, this motor develops the ideal amount of torque with an extraordinary efficiency of 96 percent. And all this in a compact overall design. During an endurance test over 10,000 hours of operation at full load, the drive mechanism demonstrated absolutely no breakdowns or reduction in performance.

The Seabob – a next generation sports watercraft.

Keeping your perspective under water – with the illuminated LCD display

The illuminated LCD display shows all important technical data on motor electronics in an easy-to-read format. This includes the current driving performance, remaining operating time and the charge status of the battery. In addition, the driver receives information about the diving depth and water temperature via the display. The integrated infrared interface can also read in software updates and read out diagnostic data. Likewise, necessary programming functions are easy to control via the LCD display. All control units are networked in a bus system and exchange information.

Optimized processes and assured quality standards

Besides developing the electronic system, the experts from Porsche Engineering also supported manufacturer Rotinor in the optimization of production processes. Aided by the experts, the first step was to stabilize the output volume. By identifying outsourcing potentials and improvement measures during work preparation, it was possible to significantly increase both unit volumes and quality. Among other things, potential production time improvements were identified and implemented on the basis of a time study according to the REFA (German Association for Work Studies) standard. By optimizing the commissioning concept and material provision, transport times could be reduced by up to 50 percent.

Parallel to production optimization, innovations were made in terms of supplier management: One of the first measures was the introduction of an inquiry system that includes the requirements for development, production, purchasing, quality and logistics. Production optimization was simultaneous with improvements in supplier and quality management. Experts from Porsche Engineering also supported Rotinor in the development of the successor model. Here, a wholistic approach was also taken in order to assure maintenance of performance, cost and quality objectives early on in the development phase. ■

The RS Spyder conquers the American Le Mans Series

Seldom before has a racing vehicle dominated a championship the way the Porsche RS Spyder dominated the American Le Mans Series (ALMS).

The RS Spyder, which was developed and built in Weissach, sets new AMLS standards. In twelve races, the sports prototypes achieved 11 class victories in the LMP2 category (Le Mans Prototype 2). Eight times, a RS Spyder secured the overall victory. The Porsche factory drivers Timo Bernhard and Romain Dumas won the driver title with confidence. Likewise, the titles for engine and chassis went to Porsche. Proof of the outstanding technology of the RS Spyder, which had been overhauled considerably for the 2007 season.

Successful conclusion of the first racing season 2006

Already in the first full racing season of the first generation RS Spyder in 2006, Porsche won the LMP2 title in the engineering class. The RS Spyder team Penske Motorsports secured the team championship. In addition, Porsche factory drivers Sascha Maassen and Lucas Luhr won the driver title in the LMP2 class. In the race in Mid-Ohio, their teammates Timo Bernhard and Romain Dumas earned the first overall win for the RS Spyder. The second place of Sascha Maassen and Lucas Luhr completed this success.

RS Spyder model year 2007 – improvement through fine-tuning

Despite outstanding successes during the first racing year, technical preparations for 2007 started shortly after the last 2006 race. Here, the extremely light and rigid body was completely overhauled by Porsche Engineering, especially with regard to improved ease of maintenance and assembly. In addi-

Almost unstoppable: the RS Spyder 2007 with powerful 478 HP output

tion, the aerodynamics were optimized and improved tuning was implemented for the different race tracks.

The sequential six-speed constant-mesh countershaft transmission is actuated using gearshift paddles at the steering wheel. The electro-pneumatic shifting actuator system allows the driver to shift under full load – that is, without using the clutch or taking his foot off the accelerator. Furthermore, the RS Spyder features traction control and a mechanical locking differential, which is optionally assisted by a viscous coupling.

In weight optimization, too, the engineers of Porsche Engineering and Porsche Motorsport demonstrated their expertise by reaching the minimum permissible weight of 775 kg. Likewise, the heat balance of the vehicle was thermodynamically optimized by a new design of the air inlet and outlet ducts.

The driving force

At the beginning of the 2007 season, the 90-degree, V8 long-distance racing engine, limited by an air volume restrictor, had a power output of 503 HP at 10,300 rpm. After the overall wins in four of the first six races and the triumph over vehicles with more powerful engines in the LMP1 class, the engine power was limited further after the 6th race, due to a change in rules, to 478 HP at 9,800 rpm. The torque is now 370 Nm at 7,500 rpm.

Victory in series

After the initial 2006 success, the objective for 2007 was clear: to continue the success of the first season and to build on it. The two Porsche RS Spyders of the Penske Motorsports team got support from two other vehicle types, which started under the flag of Dyson Racing. With the additional participation of Acura and the Mazda and Lola vehicles, the LMP2 class is now the ALMS category with the toughest competition.

Already at the start of the 2007 season, the RS Spyder continued its previous year's success with a double win in the LMP2 class in the St. Petersburg, Florida, race. The Porsche factory drivers Sascha Maassen and Ryan Briscoe were not only class winners, but were also placed third in the overall result.

Triple victory – the greatest success for Porsche in the ALMS

In the following race in Long Beach, California, the RS Spyder made motorsports history: Against LMP1 vehicles with 200 HP more and were clearly superior based on performance weight, Timo Bernhard and Romain Dumas earned the first overall victory in 2007. Sascha Maassen and Ryan Briscoe won the second overall victory. With their third place, Andy Wallace and Butch Leitzinger of the Dyson Racing team ensured a historical event.

Despite fast racing tracks, which should be an advantage for vehicles of the LMP1 class, the winning streak continued. The Porsche drivers stood atop the victory podium a total of eight times. For the double wins in Lime Rock and Mid-Ohio, the

Racing Calendar of the American Le Mans Series 2007

Racing track	LMP2	Total	RS Spyder driver teams
1. Sebring	**3rd**	**5th**	**Dumas, Bernhard/ Penske Motorsports**
(12 hours)	5th	9th	Leitzinger, Wallace/ Dyson Racing
36 starters -	6th	10th	Dyson, Smith/ Dyson Racing
10 in LMP2 class	8th	23rd	Maassen, Briscoe/ Penske Motorsports
2. St. Petersburg	**1st**	**3rd**	**Maassen, Briscoe/ Penske Motorsports**
(2 3/4 hours)	2nd	4th	Dumas, Bernhard/ Penske Motorsports
25 starters -	5th	11th	Leitzinger, Wallace/ Dyson Racing
8 in LMP2 class	6th	18th	Dyson, Smith/ Dyson Racing
3. Long Beach	**1st**	**1st**	**Dumas, Bernhard/ Penske Motorsports**
(1 2/3 hours)	2nd	2nd	Maassen, Briscoe/ Penske Motorsports
26 starters -	3rd	3rd	Leitzinger, Wallace/ Dyson Racing
8 in LMP2 class	5th	5th	Dyson, Smith/ Dyson Racing
4. Houston	**1st**	**1st**	**Dumas, Bernhard/ Penske Motorsports**
(2 3/4 hours)	3rd	4th	Maassen, Briscoe/ Penske Motorsports
24 starters -	5th	6th	Dyson, Smith/ Dyson Racing
8 in LMP2 class	6th	7th	Leitzinger, Wallace/ Dyson Racing
5. Salt Lake City	**1st**	**1st**	**Maassen, Briscoe/ Penske Motorsports**
(2 3/4 hours)	2nd	3rd	Dumas, Bernhard/ Penske Motorsports
26 starters -	3rd	4th	Leitzinger, Wallace/ Dyson Racing
8 in LMP2 class	4th	5th	Dyson, Smith/ Dyson Racing
6. Lime Rock	**1st**	**1st**	**Maassen, Briscoe/ Penske Motorsports**
(2 3/4 hours)	2nd	2nd	Dumas, Bernhard/ Penske Motorsports
26 starters -	4th	4th	Dyson, Smith/ Dyson Racing
9 in LMP2 class	5th	6th	Leitzinger, Wallace/ Dyson Racing
7. Mid-Ohio	**1st**	**1st**	**Dumas, Bernhard/ Penske Motorsports**
(2 3/4 hours)	2nd	2nd	Maassen, Briscoe/ Penske Motorsports
28 starters -	4th	6th	Leitzinger, Wallace/ Dyson Racing
9 in LMP2 class	5th	7th	Dyson, Smith/ Dyson Racing
8. Road America	**1st**	**1st**	**Dumas, Bernhard/ Penske Motorsports**
(4 hours)	2nd	4th	Maassen, Briscoe/ Penske Motorsports
27 starters -	4th	6th	Dyson, Smith/ Dyson Racing
8 in LMP2 class	5th	7th	Leitzinger, Wallace/ Dyson Racing
9. Mosport	**1st**	**1st**	**Dumas, Bernhard/ Penske Motorsports**
(2 3/4 hours)	2nd	3rd	Maassen, Briscoe/ Penske Motorsports
26 starters -	5th	7th	Dyson, Smith/ Dyson Racing
9 in LMP2 class	7th	9th	Leitzinger, Wallace/ Dyson Racing
10. Detroit	**1st**	**1st**	**Dumas, Bernhard/ Penske Motorsports**
(2 3/4 hours)	2nd	4th	Leitzinger, Wallace/ Dyson Racing
27 starters -	5th	7th	Dyson, Smith/ Dyson Racing
8 in LMP2 class	7th	9th	Maassen, Briscoe/ Penske Motorsports
11. Road Atlanta	**1st**	**2nd**	**Dumas, Bernhard/ Penske Motorsports**
(10 hours)	2nd	3rd	Dyson, Smith/ Dyson Racing
32 starters -	4th	5th	Leitzinger, Wallace/ Dyson Racing
9 in LMP2 class	5th	7th	Maassen, Briscoe/ Penske Motorsports
12. Laguna Seca	**1st**	**2nd**	**Dumas, Bernhard/ Penske Motorsports**
(4 hours)	2nd	4th	Maassen, Briscoe/ Penske Motorsports
32 starters -	5th	7th	Dyson, Smith/ Dyson Racing
9 in LMP2 class	6th	8th	Leitzinger, Wallace/ Dyson Racing

driver duos Sascha Maassen/Ryan Briscoe and Timo Bernhard/Romain Dumas took turns atop the podium.

At the 12-hour race of Road Atlanta, two of the four RS Spyders finished among the top three in the overall rankings. With a double victory at the season finale in Laguna Seca, Porsche crowned its most successful AMLS season. The team around Timo Bernhard/ Romain Dumas could once again secure a spot on the podium, thereby confirming its continuous first-class performance in the 2007 season. And teammates Sascha Maassen/ Ryan Briscoe ended the racing year by finishing second in the LMP2 class.

The carbon fiber monocoque of the RS Spyder is cutting edge technology and provides the highest level of safety.

The driver pairings of the Dyson Racing team Butch Leitzinger/ Andy Wallace and Chris Dyson/ Guy Smith also achieved good results with the Porsche RS Spyder in their first season. The two second-place finishes in the overall ranking and second and third places in the class, as well as permanent places in the top 10, resulted in second position for Dyson Racing in the LMP2-class team rankings. The RS Spyder was unstoppable in the AMLS 2007.

Already after the eighth race in Elkhart Lake, Penske Motorsport was able to secure the team championship early on. At the race in Detroit, Porsche won the engineering championship for chassis and engine, also ahead of time. In the driver class, Timo Bernhard and Romain Dumas triumphed ahead of their teammates Sascha Maassen and Ryan Briscoe in the next-to-last race.

The body of the RS Spyder is made of carbon fiber – well thought out down to the smallest detail.

Professionalism and strength down to the smallest detail – Porsche proved it impressively with its two teams in the ALMS 2007 season. The consistent overall victories of the RS Spyder against the clearly more powerful LMP1 race cars have shown one thing very clearly: the competence of Porsche and Porsche Engineering in vehicle development.

The first hybrid car in the world – a Porsche

As early as 1900, Ferdinand Porsche developed a hybrid gasoline-electric drive.

More than 100 years ago, when climate discussions were not yet on the agenda, the young inventor Ferdinand Porsche developed vehicles at k.u.k.-Hofwagen-Fabrik Jakob Lohner & Co., Vienna-Floridsdorf, which had a hybrid gasoline-electric drive – the first hybrid automobiles in the world.

This was preceded by the introduction of the first Lohner-Porsche at the world trade fair in Paris on April 14, 1900. The front wheels of this electric vehicle were driven by so-called wheel hub motors, which the then 24-year-old Ferdinand Porsche had developed as the chief engineer at k.u.k.-Hofwagen-Fabrik Jakob Lohner & Co., Vienna-Floridsdorf.

The wheel hub motor worked without a transmission or drive shafts because the wheel, which acted as the rotor of the DC motor, revolved around a stator, which was permanently fastened to the wheel suspension. The drive thus worked without mechanical friction losses and a fantastic efficiency of 83 percent.

In the same year, a prototype of the Lohner Porsche "Mixte" followed; besides a combustion engine, it also had an electric motor and could temporarily store energy in a battery.

The vehicle was driven by a four-cylinder engine, which was coupled directly to an 80-volt dynamo. The generator supplied power to the wheel hub motors installed in the front wheels. This vehicle was – so to speak – the first series production car with a hybrid drive.

In addition to a prototype, a racing version of the Lohner Porsche was also built.

Incidentally: The idea of the electric wheel hub motor was later used by NASA to get their moon vehicle rolling.

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