Porsche Engineering
MAGAZINE

CUSTOMERS & MARKETS 30 years of successful collaboration with Linde Material Handling
PORSCHE UP CLOSE The new Boxster and the 911 Carrera S Powerkit
ENGINEERING INSIGHTS The challenges of electromagnetic compatibility in product development

ISSUE 2/2012

Speeding up on the test track in southern Italy

NARDÒ!

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Complete Vehicle · Styling · Body & Safety · Engine · Drivetrain · Chassis · Electrics & Electronics · Testing · Industrial Engineering · Production Engineering

We can't predict the future.

But we can work on it every day.

Porsche Engineering
driving technologies

PORSCHE

Malte Radmann and Dirk Lappe,
Managing Directors of Porsche Engineering

About Porsche Engineering

Creating forward-looking solutions was the standard set by Ferdinand Porsche when he started his design office in 1931. In doing so, he laid the foundation for today's engineering services by Porsche. We renew our commitment to that example with each new project that we carry out for our customers.
The scope of Porsche Engineering's activities ranges from the design of individual components to the planning and execution of complete vehicle developments and is also transferred to other sectors beyond the automotive industry.

Dear readers,

_____ We greet you today with a hearty "Buongiorno" in honor of the Nardò Technical Center (in southern Italy), the legendary high-speed test track that we acquired in May of this year as an ideal addition to the Porsche Engineering portfolio. Thus, in the future, we will be able to offer you this extraordinary facility alongside our Porsche engineering expertise. You can read about all of the unique features that this exceptional test facility has to offer in this issue.

As you have already noticed, our magazine has received a new "outfit." But we haven't just given the exterior a facelift; we have also added new content such as customer portraits, industry trends and above all, more technological depth to provide even more valuable information from the world of engineering.

Yet in spite of these changes, we never lose sight of our tradition and origins. The relaunch of our customer magazine is, on the one hand, an expression of our innovative drive and future-oriented direction, yet it also embodies the core values of our company. The proof: 30 years of collaboration with Linde Material Handling. This successful collaboration reflects precisely the qualities that make Porsche Engineering so special: reliability and loyalty to our customers.

You can look forward to fascinating pieces on technology and background information from Porsche combined with news and information from the engineering industry. In addition to the article on Nardò and the Linde customer portrait, we will also—as announced in the last issue—present the technological highlights of the new Porsche Boxster. Moreover, the articles on the Porsche Engineering thermodynamics test bench and the 911 Carrera S Powerkit provide insights into our company's innovative development work. See *Porsche Intelligent Engineering* for yourself.

We wish you fascinating reading
with our new Porsche Engineering Magazine.

30 YEARS OF WORKING TOGETHER WITH LINDE MATERIAL HANDLING

What's behind the success of this longstanding collaboration? Linde's head of pre-development Udo Herrmann and Porsche Engineering Key Account Manager Fritz Müller explain.

COVER STORY

TRENDS & TECHNOLOGIES

CUSTOMERS & MARKETS

PORSCHE UP CLOSE

ENGINEERING INSIGHTS

News

NEW PASSIVE ROLLER DYNAMOMETER

___ Porsche Engineering makes another investment in e-mobility. Since mid-July 2012, the EMC center has had a passive roller dynamometer for vehicle measurements. The new dynamometer enables simulation of "road driving" and measurements under driving conditions. In particular, this allows testers to recreate various operating conditions for hybrid and electric vehicles. The dynamometer is used primarily for EMI (Electro Magnetic Interference) measurements.

Acquisition of the dynamometer takes the solution-oriented approach and flexibility of testing at Porsche Engineering to an even higher level. ■

911 CARRERA MODELS: Fuel consumption combined 11.7–8.2 l/100 km; CO_2 emissions 275–194 g/km

News

PRESENTATIONS AT UNIVERSITIES AND COLLEGES

___ To introduce Porsche Engineering to students and give young talent a more precise look at the world of engineering work, Porsche Engineering experts from various departments give presentations at universities and colleges. In June, for example, Porsche Engineering project engineer Bernhard Mölzer gave a talk on the subject of tolerance management at the University of Stuttgart. And Michael Merklinger, head of Human Resources, lectured on "strategic personnel development at Porsche Engineering" at Pforzheim University.

Employees from the Human Resources department are always on hand to inform interested students about career opportunities at Porsche Engineering. This enables students to make early contacts at Porsche. ■

KEY TECHNOLOGIES FOR ELECTRIC VEHICLES

SUPPORTED BY

Bundesministerium für Bildung und Forschung

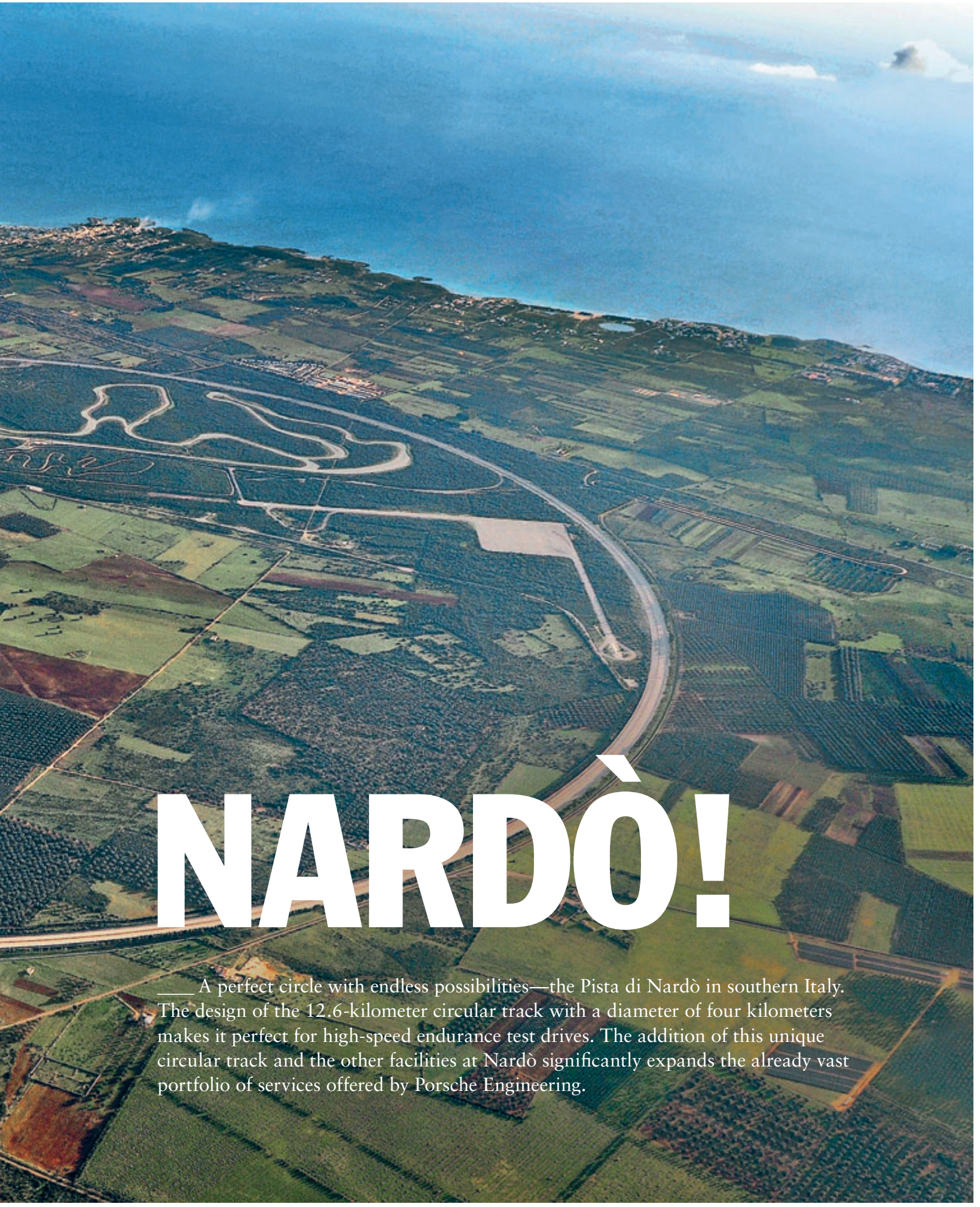
___ In March of this year, Porsche Engineering took over as head of the e-generation research project with the Volkswagen Group research division as an associated partner. In the project, leading German companies and renowned universities are developing a new generation of components for electric vehicles. The objective is to improve the range, costs, and everyday utility of electric vehicles. The project also looks at the potential for cost savings through modularization and component assemblies. This enables a broad-based analysis of research findings. The three-year project is financed to the tune of 45 percent by the Federal Ministry of Education and Research (BMBF). The remaining 55 percent of project costs are borne by the industry partners. ■

PORSCHE ENGINEERING REPRESENTED AT CTI SYMPOSIUM

DECEMBER 3–6, 2012, BERLIN

___ The international CTI Symposium "Innovative Automotive Transmissions, Hybrid & Electric Drives" and the associated "Transmission Expo" is one of the leading events in Europe with regard to the latest technological developments in the field of vehicle transmissions.

Porsche Engineering director Dirk Lappe will give a presentation at the event, this year on the subject of "Potential solutions for modern drives." In the podium discussion, experts from the industry will talk about the challenges, strategies, and latest developments in transmission and drive technologies. And at the Porsche Engineering stand, visitors can check out the latest developments in transmission/drive technology and talk to Porsche engineers. ■



NARDÒ!

A perfect circle with endless possibilities—the Pista di Nardò in southern Italy. The design of the 12.6-kilometer circular track with a diameter of four kilometers makes it perfect for high-speed endurance test drives. The addition of this unique circular track and the other facilities at Nardò significantly expands the already vast portfolio of services offered by Porsche Engineering.

Photos: Gabriele Torsello

Unique climatic conditions enable

TESTING 365 DAYS A YEAR

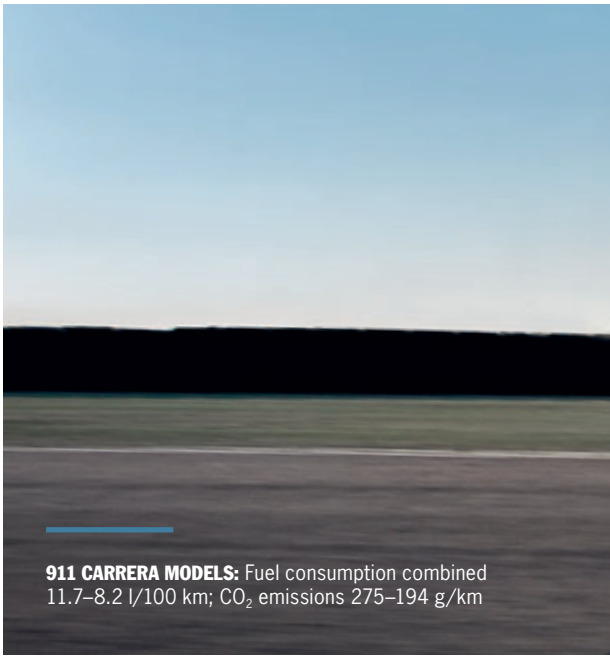
The Apulian sun beats down on the asphalt mercilessly. The air shimmers above the track, which only reveals its curved shape upon a second glance towards the horizon and banks inwards at up to 12 degrees like the rim of a bowl. "La Pista di Nardò"—the place where car legends are made.

Characteristic feature: circular track

This perfect asphalt circle has been the site of many records since it was opened in 1975: There have been hundreds of them in the last few decades. Yet the circular track was never a race track, but has long been used for testing purposes. The ideal conditions for tests on the four lanes of the circle allow speeds that would only be feasible elsewhere with considerably more difficulty. Precisely 387.87 kilometers per hour was the top speed reached by the Koenigsegg CCR—and that at the end of February 2005, the heart of the meteorological winter. And that's not even the limit: In 1979, a Mercedes-Benz C1 topped out at a speed of 403.98 km/h.

Unique conditions

"One of the great advantages of Nardò is the climate: Tests can be run here in Apulia throughout the year; rainy days and frost are extremely rare," explains Francesco Nobile, Managing Director of the Nardò Technical Center. Nobile is well acquainted with the assets of the track regarded by experts as the fastest circuit in the world – as well as those of its other facilities. The circular track with its four parallel lanes plus interior emergency lane allows top speeds with minimal vertical forces and thus low tire wear, enabling cars to drive at a blistering pace while maintaining optimal control: In the outermost lane, lane four—like the other three lanes four meters wide—thanks to the banking cars can drive at up to 240 kilometers per hour without having to steer to stay on course. Lane three allows the same at up to 193 km/h, lane two creates the sensation of a straightaway at up to 140, and the first lane next to the innermost emergency lane allows 100 km/h without touching the steering wheel. This uniform construction



911 CARRERA MODELS: Fuel consumption combined 11.7–8.2 l/100 km; CO_2 emissions 275–194 g/km

with its perfectly maintained radius and slope of the track essentially preclude unidirectional forces during driving. And of course, higher speeds are possible without having to reckon with premature wear of tire materials due to unfavorable track conditions: Up to 500 kilometers per hour are possible.

That the Pista di Nardò was designed and built this way in the 1970s can only be regarded as visionary and forward-looking for its time. Indeed, even today, in 2012, the grounds are still perfectly suited for testing current and future cars of all classes. Experts concur that not even the legendary oval in Fontana, California, the Auto Club Speedway, can compare.

Practically unlimited testing opportunities

The unique circular track is complemented by its auxiliary facilities: A unique handling track that includes hills and compressions to test the limits of the vehicle material is as much a part of the Nardò Technical Center as a vehicle dynamic track, a track with various surfaces, dirt and gravel tracks, as well as a noise test track for a diverse array of testing requirements. And the tracks are supplemented by the necessary infrastructure: Workshops for test teams that have booked track time are available on the 700 hectare grounds.

The grounds have been open to all customers since way back

Opened by Fiat in in 1975, the grounds were sold to Prototipo SpA by the Italian government in 1999 and managed by the company until 2012. Use of the facility has been open to all manufacturers since the beginning. Since May of this year, the complex in the province of Lecce has belonged to the Porsche Group—but continues the tradition of over 80 years of Porsche history in customer projects and remains open to all manufacturers. The facility adds yet a new element to the engineering service portfolio offered by the Porsche Group. Customers that have called on the development skills of Porsche Engineering engineers through computer simulations, on sophisticated test benches and on the test track in Weissach can now have Porsche Engineering engineers test whether their product can withstand the toughest real-world forces on the test tracks at Nardò.

Full speed stability over long distances, the performance of brake systems, the reliability of individual components in real, integrated system deployment, thermal characteristics and many other factors can be tested under ideal conditions at the Nardò Proving Ground. Complete vehicle expertise is constantly being expanded at Porsche Engineering.

E-Mobility testing

Since July 2012, connections with various alternating currents up to 125 amperes have been available. This enables manufacturer-specific charging stations for full-scale testing of electric vehicles. This enables not only e-mobility test drives under extreme climatic conditions in temperatures of up to 40 degrees Celsius. The charging station, which can ›

Not just asphalt: The testing grounds also enable tests on a variety of different off-road tracks

be converted to DC upon request, also enables high-speed battery-driven endurance tests to deliver robust, substantiated data from real driving conditions.

Further investments in the works

The range of possibilities on and around the circular track in Nardò is practically inexhaustible—to the benefit of Porsche Engineering customers, who now have the opportunity to move forward with a service provider that can provide a complete package of development and testing at the very pinnacle of excellence in terms of expertise and testing options. And plans are underway to expand those options in the near future: Surfacing work is planned; the vehicle dynamics course may be enlarged to enable danger-free testing of extreme maneuvers; and a wet handling area is under consideration. The objective is to maintain and expand the commanding lead the Pista di Nardò holds over other test tracks.

Beyond the ring – Apulia

If the Pista di Nardò is a technical masterpiece for the automotive world, the region beyond the track also boasts plenty of attractions: The Pista's surroundings invite visitors to enjoy the ample charms of Apulia after a successful day of testing. The complex is located a mere three kilometers from the Mediterranean. Lodgings of various types and classes are abundant, as is the justly famous cuisine of southern Italy.

100 percent challenged: Test drive on the handling course

And there is no shortage of attractions: Apulia is a cultural hotbed rich in history. From the remnants of the "Magna Graecia," the ancient Greek colonial realm, to buildings from the time of Frederick II or natural phenomena like the "gravine," deep valleys cut into the limestone of the Murge plateau, there is much to see in Apulia. Other attractions include the "trulli," the whitewashed round stone buildings with conical roofs in and around Alberobello. Travel and transport of goods to the Apulia region is quickest and most convenient via the international airport in Brindisi, which is just about 65 kilometers from the testing grounds. Somewhat farther north, the international airport in Bari serves various airlines. ■

Where the grounds are located:

40° 20' 0'' N, 17° 50' 0'' E

1 CIRCULAR TRACKS

CARS

LENGTH: 12.6 km
DIAMETER: 4 km
NO. OF LANES:
4 (+1 emergency lane)
WIDTH PER LANE: 4 m

INDUSTRIAL VEHICLES

LENGTH: 12.5 km
DIAMETER: 4 km
NO. OF LANES:
2 (+1 emergency lane)
WIDTH PER LANE: 4 or 5 m

Thanks to the large radius (2 km), Nardò has a unique ring track allowing top speeds with maximum safety.

The centrifugal force is compensated by the low parabolic profile, with the driving feeling of a straight lane.

Lane	Transversal inclination	Compensation speed [km/h]	Use
III	1°48'	100 km/h	Cars and motorbikes
II	4°30'	140 km/h	
I	8°06'	193 km/h	
0	12°36'	240 km/h	
x	0°54'	84 km/h	Industrial vehicles
xx	3°36'	141 km/h	

2 DYNAMIC PLATFORMS

VEHICLE DYNAMIC TRACK:

- Square with 280 m each side
- Two straight lanes: 700 m length, 20 m width

INDUSTRIAL VEHICLE DYNAMIC TRACK:

- Square with 175 m each side
- Two acceleration lanes: 600 + 170 m length

3 NOISE TRACK

LENGTH: 2,132 m
WIDTH: 4 m
AREA A: 8 mm chipping size surface
AREA B: 14 mm chipping size surface

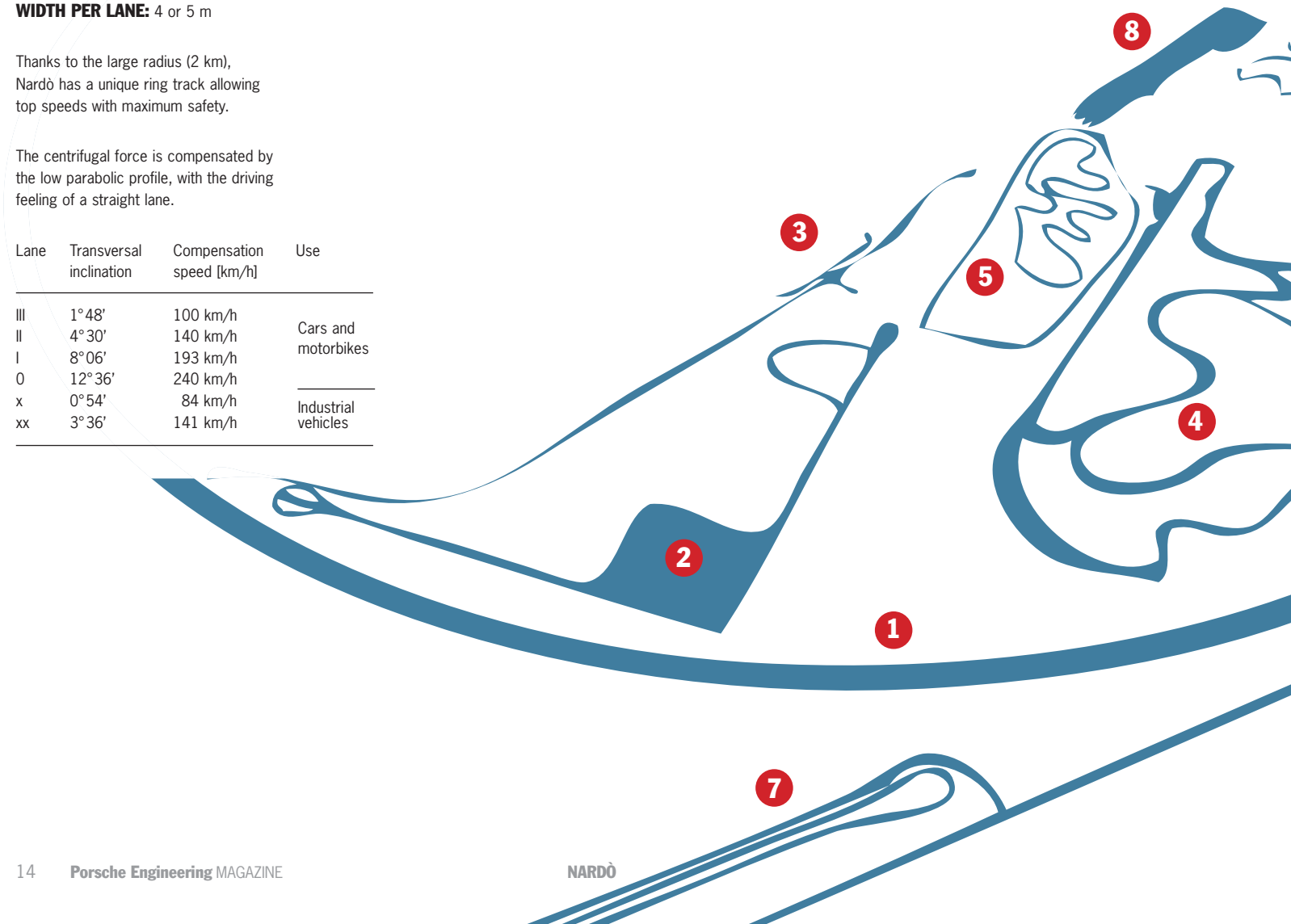
Certified according to ISO 10844

4 HANDLING TRACK

LENGTH OF CIRCUIT: 6,222 m
LENGTH OF STRAIGHT LANE: 1,000 m
WIDTH:
- 15 m straight lane
- 12.50 m remaining parts

BENDS:
- 7 right-hand
- 9 left-hand

BANKING: ≤ 7% (±2.5%) (Longitudinal slopes vary from +5.78% to –6.90%)



5 WHITE ROAD TRACKS

LENGTH “O”: 2,130 m
LENGTH “S”: 2,135 m
WIDTH: 6 m

6 SPECIAL PAVEMENTS TRACK

TOTAL LENGTH: 1,150 m
TOTAL WIDTH: 4+4 m

TWO LANES WITH DIFFERENT SURFACES:

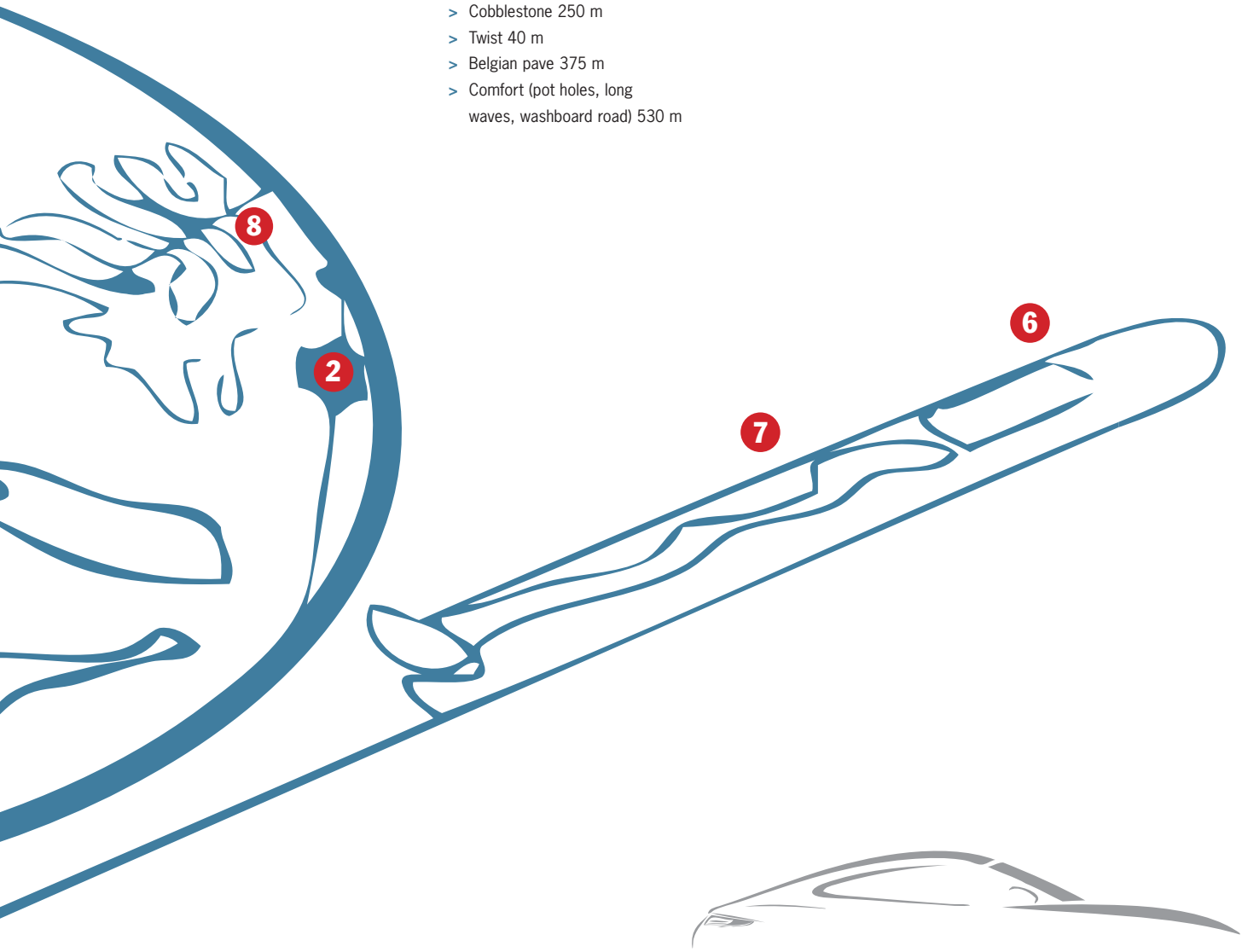
- Cobblestone 250 m
- Twist 40 m
- Belgian pave 375 m
- Comfort (pot holes, long waves, washboard road) 530 m

7 OFF-ROAD TRACKS

- Off-road slopes
- Cross-country track
- Africa track
- Oval off-road track
- Mud track

8 OTHERS

- Slopes
- Curbstone track
- Tire laceration track
- Rolling track
- Low-mu surface



Nardò Technical Center

Porsche Engineering

Interview
Francesco Nobile

_____ Francesco Nobile has been the Managing Director of the Nardò Technical Center as part of Porsche Engineering since May. But his experience at the Nardò Proving Ground goes back to June 2007, when he joined Prototipo SpA as Managing Director and board member. Nobile continues to lead the 120-strong staff on site after Porsche Engineering's acquisition of the Nardò Technical Center. We spoke with him about the opportunities that Nardò has to offer.

Porsche Engineering *Mr. Nobile, what makes the Pista di Nardò so special in your estimation?*

Nobile The special thing is undoubtedly the design of the circuit: a perfect circle 12.6 kilometers in circumference with the ingenious slope of the track allowing speeds of up to 240 kilometers per hour without turning the steering wheel. It's one-of-a-kind. The vertical load on a test vehicle remains low up to this speed, meaning that tires are subject to less stress than on an oval race track. And Nardò has a lot more to offer as well, such as the Formula 1-like handling track with hills and lateral banking. It subjects test vehicles to greater longitudinal and vertical forces than normal, flat Formula 1 tracks. And then there are the standards like the dynamics test track, special pavement tracks, or the noise track.

Are there any other advantages to testing vehicles in southern Italy?

Nobile Our climate is one of the most important factors. Conditions in Apulia are ideal year-round. There are hardly any rainy days and we practically never have frost, so the ring and other tracks can be used 365 days a year. Moreover, the hot summers offer the chance to test the durability of vehicles and components under extreme climatic conditions. The decision to build this kind of track here was visionary in every way—to this day, the Pista di Nardò remains the ideal test track for sports cars. That hasn't changed since the track was opened under the direction of the Fiat group in 1975, nor did it change when the facility was sold to Prototipo SpA in 1999.

What possibilities do you see for the Nardò Technical Center in the future?

Nobile There are many possibilities to expand and optimize the proving ground. We might consider expanding

Francesco Nobile

...knows the automotive industry like the back of his hand, having served as a member of the board at Isringhausen SpA (Italian subsidiary of the German manufacturer of commercial vehicle seats, 1992–1999) and Managing Director at Webasto Italy SpA in Milan (1999–2007). Since 2007 Nobile has directed operations at the Nardò Technical Center. Francesco Nobile spent his youth in Germany and speaks fluent German, in addition to excellent English skills and some command of Spanish. Among other things, he studied mechanical engineering in Mönchengladbach (1982–1984). With his assumption of the directorship of the Nardò Technical Center, he returned to his homeland on the Gulf of Taranto in 2007.

the dynamic platforms, construction of a "straight line" track and a "wet area," or additional workshop areas to improve the options available to our customers. Surface improvements for the ring track are also a consideration. We're not talking about a renovation of the testing grounds—the facility is in excellent condition. The objective is more to expand our lead over other test tracks. For instance, charging stations have been available to our customers for e-mobility tests since July.

Will anything change for Nardò customers due to the acquisition by Porsche Engineering?

Nobile Of course, but only in positive ways: Other vehicle manufacturers are still very welcome to carry out their tests on our tracks. We will also continue to offer our customers tailored workshops, which provide optimal support for work on the test tracks and are adjusted to the customers' needs. Beyond that, they will now have the opportunity to tap the expertise of the Porsche Engineering experts. Development and testing in Nardò will be offered as a complete package with Porsche Engineering. Such a combination of an ideal test track and comprehensive support for customer projects is every bit as unique as the Pista di Nardò itself. ■

ISO 26262

A Safety Standard for Automobile Development

By Anke Schirmer

The electrical and electronic systems in vehicles have become increasingly complex in recent years. They perform a wide range of safety-relevant functions without which a modern vehicle would be unthinkable. To reduce potential hazards posed by these systems in the vehicle for both humans and the environment, the new international standard ISO 26262 was developed and has been in effect for all vehicle manufacturers and their suppliers since November 2011.

The international ISO standard 26262 has been recognized as the official status quo for technology in the automotive industry for some time and is applied by all OEMs and suppliers worldwide for new and ongoing development projects.

The standard applies to all series production developments of electrical and electronic systems in vehicles up to 3.5 metric tons and with four wheels—so it applies to developments at Porsche Engineering as well. All developments are additionally subject to the basic standard IEC 61508, which applies to all E/E systems outside of automotive development. Both standards serve to improve safety in E/E systems. They must also comply with the Product Liability Act.

What is Functional Safety?

Functional Safety involves a clear definition of the requirements and methods as well as the specified work products and safety measures during the development process that are taken in order to reduce functional electrical failures to an acceptable minimum. In other words, the pursuit of safety. The objective is to improve safety for both humans and the environment with regard to risks posed by electrical and electronic failures in vehicles. The standard regards the function of the vehicle as a whole rather than focusing on a particular control device or individual components.

How is the assessment of Functional Safety conducted?

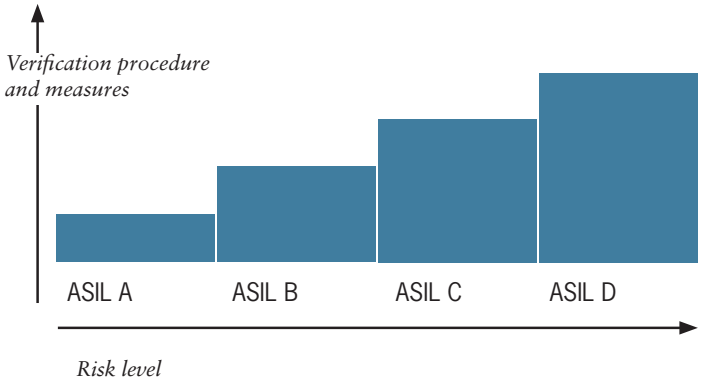
To identify these safety-relevant functions, hazard and risk assessments are conducted for various function groups. The effects and controllability of potential failures in various vehicle situations in road traffic are examined and evaluated. The result is an assessment of the potential failure with regard to Functional Safety. This is expressed in the "Automotive Safety Integrity Level" (ASIL), which rates the criticality of the failure.

Failures with a critical effect on Functional Safety receive an ASIL rating between A and D, where D represents the highest level. If the potential failures are not critical to Functional Safety, they are classified as "QM" (quality management) issues. This means that these functions are developed according to the established development processes and methods (V-model, SPICE/CMMI, etc.) of the respective company.

ASIL LEVELS AND THEIR CHARACTERISTICS

> THE SAFETY RELEVANCE RISES FROM ASIL A TO D
> THE NUMBER OF REQUESTED FAILURE ANALYSIS PROCEDURES RISES FROM ASIL A TO D
> THE NUMBER OF RESTRICTIONS OF PERMISSIBLE DEVELOPMENT METHODS RISES FROM ASIL A TO D
> THE NUMBER OF REQUESTED REVIEWS RISES FROM ASIL A TO D
> THE DEGREE OF REQUIRED REPRODUCIBILITY IN THE REVIEW OF WORK PRODUCTS RISES FROM ASIL A TO D
> LIMIT VALUES OF PERMITTED FAILURE RATES SINK FROM ASIL A TO D

Automotive Safety Integrity Level *ISO 26262*



Overview of ASIL and the degrees of involvement with regard to measures and verification procedures

Examples of Functional Safety-related vehicle functions to be included:

> Functions that can impact the stability of the vehicle
> Functions that generate and draw braking and drive torque
> Functions that enable assistance of and intervention in vehicle control
> Functions that assist and warn the driver

Who is responsible for implementation of the measures, development processes and work products required by ISO 26262?

The entire development team is responsible for implementing ISO 26262. The standard also calls for the role of a "safety manager" responsible for all required process steps, compliance with specifications and the composition of work products as well as their quality and contents.

The know-how from these OEM-specific processes is adapted by Porsche Engineering for other customer projects and applied in their implementation.

How is Functional Safety implemented according to the ASIL level?

To implement Functional Safety in the development of the vehicle, a functional and technical safety concept is created. This safety concept forms the basis of:

> Distribution of functions and additional safety functions into hardware and software parts
> Applicable methods
> Failure analysis methods (FMEA, FMEDA, FTA, etc.)
> Required metrics and failure rates
> Processes accompanying the development process
> The scope of reviews, audits and assessments
> Selection and qualification of development tools
> Specifications for production, service and recycling ›

Summary of the process of a development as per ISO 26262

These specifications apply both to the OEM and every supplier and sub-contractor. The safety requirements from one level are passed on to the next.

Abbreviations in the ISO 26262 environment

ASIL	Automotive Safety Integrity Level
E/E	Electrical and Electronic (in this case, generally electrical and electronic systems)
FTA	Fault Tree Analysis
FMEA	Failure Mode and Effects Analysis
FMEDA	Failure Modes, Effects and Diagnostic Coverage Analysis
FuSa	Functional Safety
HRA	Hazard and risk assessment
OEM	Original Equipment Manufacturer (in this case, the vehicle manufacturer)
QM	Quality management

Proof of compliance, however, must be presented by each supplier to the respective buyer and verified.

The final safety documentation of the function in the vehicle is conducted at the OEM and must be demonstrated by an assessment (as of ASIL B).

In its role as "safety manager," Porsche Engineering performs these tasks and ensures that they are carried out in the projects. At the same time, other Porsche Engineering employees take over the moderation of failure analysis methods. This includes system FMEAs for mechatronic systems, fault tree analysis as a verification procedure for Functional Safety and as a method for the identification of "breakdowns" in highly networked systems and all other tasks and roles in the spirit of ISO 26262.

Functional Safety at Porsche Engineering

All of these aspects of Functional Safety are observed and implemented by Porsche Engineering in development projects.

This includes not only the Functional Safety processes of Porsche but also the processes defined specifically for Porsche Engineering customer projects. As previously mentioned, there are some distinctions. Tasks related to Functional Safety are carried out in part from the OEM's perspective, but also—in particular with external customer projects of Porsche Engineering—from the point of view of the supplier.

The tools developed by Porsche Engineering substantially simplify and standardize the application of the ISO 26262 and IEC 61508 standards. This saves time and costs and reduces extra expenditures for critical safety systems.

The tools are intranet-based applications that standardize project structures and their work products within the company on a cross-project basis. They support the implementation of requirements for the development of critical Functional Safety systems.

Range of tasks for Porsche Engineering in relation to ISO 26262

- > DEFINITION OF PROCESSES FROM THE OEM VIEW
- > DEFINITION OF PROCESSES FROM THE SUPPLIER VIEW
- > SAFETY MANAGER
- > FUSA CONSULTANT
- > MODERATOR OF SYSTEM FMEAS
- > MODERATOR OF FAULT TREE ANALYSIS
- > MODERATOR OF HRA
- > REVIEWER
- > PROVISION OF TRAINING
  - · ADAPTED TO THE TARGET GROUP
  - · ADAPTED TO THE DEPARTMENT/COMPANY
- > TOOL DEVELOPMENT

Functional Safety is a central current and future challenge in all areas of electrical and electronic development. Through their consultation services and activities accompanying the development process, employees of Porsche Engineering contribute to significantly reducing the residual risk due to failures in E/E systems. Every customer benefits, whether they are in the automotive industry or another sector of E/E development. ■

Stacking Up Experience – **30 Years of Working Together with Linde Material Handling**

_____ For more than 30 years, Linde Material Handling and Porsche Engineering have cooperated on projects such as the product design of Linde industrial trucks. Fritz Müller, former key account manager at Porsche Engineering, oversaw this cooperation over a period of many years, always in close contact with Udo Herrmann, head of pre-development at Linde Material Handling. To get more detailed insight into this long-term collaboration, we requested an interview with these two gentlemen.

Interview by Frederic Damköhler and Nadine Guhl Photos by Jörg Eberl

Udo Herrmann

Prior to joining Linde Material Handling in 1992, Udo Herrmann, a trained auto mechanic, availed himself of the 'second-chance education' option to study mechanical engineering at Darmstadt University of Applied Sciences. After working in the design department for crankshaft grinding machines at Naxos-Union, Udo Herrmann moved to Linde Material Handling. There he held a number of positions in development and design, including that of department and project leader. Since 2005 Udo Herrmann has been the head of pre-development for vehicles.

Mr. Herrmann, what challenges will the industrial truck and commercial vehicle sectors be facing in the near future?

Herrmann: The challenges for our sector mainly result from the different demands of the markets. Linde's aim is to be a continuous presence in the various market segments all over the world. The biggest challenge here is to meet all of the specific requirements of each market. In low-cost markets, the main considerations are functionality and reduction in costs, while in the high-end market segments, aspects such as performance, design, and ergonomics are critical as well. The challenge is to provide a range of products that meet the standards at Linde while also, of course, fulfilling the expectations of our customers.

To what extent can developers provide support here? Where do they encounter limitations?

Herrmann: At this point, let's take a look at Porsche Engineering. Overall, we're very eager to rely on the experience and momentum from the automotive sector. Just like cars, forklifts usually have four wheels. But this is only one of many similarities: Porsche Engineering and Linde are both positioned internationally, with customers all around the world, and this is very important with regard to the market segments we have mentioned. We have benefited ›

enormously from our cooperation, and, over a short period of time, have been able to incorporate significant developments in the automotive sector into our own industry. This cooperation encompasses the most diverse areas, from styling and IT integration to matters relating to electronics or engines. There are limitations to our cooperation, inasmuch as cost-intensive technological aspects are very difficult to transfer to low-cost markets, where the aim is to keep manufacturing costs as low as possible. Recently, we have been witnessing a certain widening of the gap between the passenger car and forklift sectors. A forklift remains a work machine, while a passenger car is viewed in more emotional terms. Therefore, some topics from the automotive sector cannot be applied to industrial trucks to the same extent.

"What is special about Linde is the combination of a high-performance investment commodity and the highly emotional brand. Passion and pride of ownership are seen as the core components of the brands: a philosophy we share with Porsche."

Dr. Ralf Dingeldein, New Vehicles Sales Manager at Linde Material Handling

Mr. Müller, can you remember your first project in cooperation with Linde Material Handling?

Müller: My first project with Linde Material Handling was the second generation of the H30 – BR393. However, our cooperation goes back even further. The very first cooperation project was the H30 – BR351: a styling project whose aim was to transform a pure work machine into a vehicle with a more pleasing appearance. Since the beginning of the project in 1982, there has been a framework contract between our two companies that is still in force today.

Over this extended period, did you also encounter difficulties in working together? How were they solved?

Herrmann: Readjusting to completely new product generations, such as the 39X, is never easy. This type of process requires considerable patience, endurance, and sensitivity on the part of everyone involved in the cooperation. Continuous effort is necessary, especially in view of the differences between cars and industrial trucks.

Müller: As an engineering services provider, we have to be able to understand and meet our customers' needs and wishes at all times. And although this is part of our day-to-day work, it continually presents us with new situations and challenges. This calls for trusting communication with one another, which of course requires a measure of sensitivity as well as openness. Only then can we complete projects together successfully.

A success factor for long-term customer relationships: open and trusting communication is writ large in all customer projects

How do Linde industrial trucks and Porsche go together?

Herrmann: Analogous to the performance of a Porsche on the road, our forklifts are also high-performance vehicles that move loads quickly—and above all, safely—from one place to another. In addition, Linde and Porsche share high quality standards and a unique product design. As with Porsche, the special design of our vehicles triggers emotions and reflects the values of our company. The vehicle's high performance must be clearly visible; the high quality, sturdiness, and solidity must be given clear expression. Just as is true of Porsche, we do not add artistic touches without substance.

What is particularly special about the long-term customer relationship between Linde Material Handling and Porsche Engineering?

Müller: What's very special is the great mutual trust that has developed over the years. In particular, I appreciate how we've come to work together as though we were colleagues in the same company. Our relationship is not static—we're always learning new things, and contacts change over time, but the high level of trust remains.

Herrmann: In this relationship, we've no inhibitions about bringing up tricky subjects. Even when difficulties or problems arise, they're discussed openly and jointly. ›

“We have benefited enormously from our cooperation with Porsche Engineering, and, over a short period of time, have been able to incorporate significant developments in the automotive sector into our own industry.” Udo Herrmann

Müller: We've always worked together through personal, direct channels between the departments involved—without any other parties acting as intermediaries. This direct link ensures that both sides always know whom they're dealing with, and who their immediate contact person is.

What kind of momentum do you anticipate in the future for Linde Material Handling thanks to your collaboration with Porsche Engineering?

Herrmann: In particular, I hope that we will continue to benefit from an impetus for trends and technical topics from the automotive sector that can be transferred to our industry. I'm thinking of topics such as increasing electrification, communication tools, and displays; these are all becoming more and more important for industrial trucks. This is an area in which the automotive sector is usually a generation ahead. And design language, namely, styling, will continue to play an important role.

Mr. Herrmann, if you could be a developer at Porsche Engineering for a day, what would you like to develop?

Herrmann: One day isn't very long, I'm afraid—a bit limiting, of course ... But I'd really like to try my hand at developing an engine. As a trained mechanic, I've already worked at VW, Audi, and Porsche, so I've got a strong personal relationship with the automotive industry. The engine is the heart of every vehicle, and the sound and performance of a Porsche 911 gives me goose bumps. ■

www.linde-mh.com

30 YEARS OF COOPERATION BETWEEN LINDE MATERIAL HANDLING AND PORSCHE ENGINEERING

In the early 1980s, after Porsche had already designed slewing gear drives and chain drives for Linde, the sports car manufacturer was commissioned to design a new generation of forklifts. Since then, the topic of styling has been an important aspect of their collaboration. By now, Porsche styling for Linde has become a multiple award-winning trademark. For example, once again Linde forklifts have been awarded the "red dot award for product design" by the renowned Design Zentrum Nordrhein-Westfalen: the E20—E50 battery-powered counterbalance forklifts received this award in 2011, adding it to more than 20 design awards since the start of this cooperation.

911 CARRERA MODELS: Fuel consumption combined 11.7–8.2 l/100 km; CO_2 emissions 275–194 g/km

Powerkit

911 Carrera S

___ With the Porsche Exclusive/Tequipment individualization program, customers have the opportunity to customize their vehicles according their wishes. As part of this program, the powerkit for standard naturally aspirated engines is continuing a long tradition in the annals of Porsche history. Customers are given the opportunity to boost the performance of their top-flight standard power units yet another notch without having to dispense with the comfort features of the current Carrera series.

By Dirk Becker, Stephan Hübner Photos by Jörg Eberl, Jürgen Koch

911 CARRERA S WITH POWERKIT: Fuel consumption (in l/100 km)
urban 13.8–12.2 · extra-urban 7.1–6.7 · combined 9.5–8.7; CO_2 emissions 224–205 g/km

The powerkit for the engine of the 3.8-liter Carrera S of the new 911 series has been available since June of this year. Output jumps from 294 kW (400 hp) to 316 kW (430 hp), thereby reaching a level previously reserved for the cars in the GT series.

The power boost is achieved without increasing the engine speed compared to the series or dialing back the high torque of 440 Nm in favor of increased power. Despite the additional power, the philosophy of delivering the Carrera driving characteristic of powerful acceleration even at low rpms is retained.

Like the kit project for the 911 of the preceding series, this powerkit was developed in close cooperation with the corresponding departments of Porsche AG and Porsche Engineering.

Working from the functional base concept defined in concert by the teams involved, the final customer-ready product was developed and implemented by the engineers and technicians at the Bietigheim-Bissingen site, Weissach development center and the Zuffenhausen production plant.

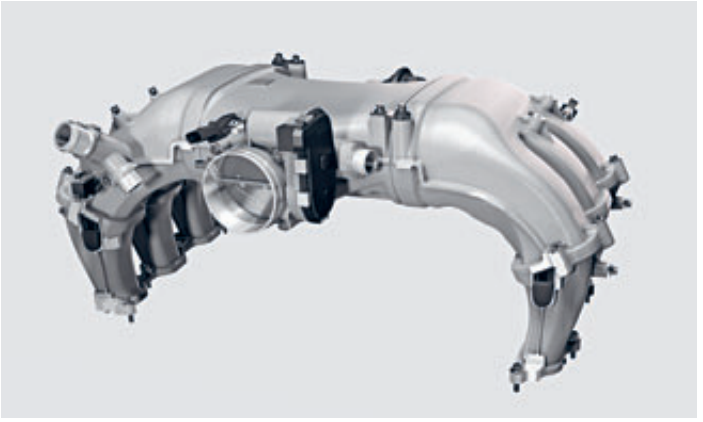
The engine displacement and maximum permissible engine speed adopted from the basic powertrain represent a sensible framework both from a technical and an economic standpoint.

The objective of increasing engine power is thus achieved by increasing the air efficiency, i.e. by enlarging the quantity of air fed into the engine per cycle.

In contrast to an externally charged engine, which uses technical aids (turbochargers, compressors) to pump additional air into the combustion chamber, the powerkit utilizes physical effects, more precisely compression waves, in the intake system to press additional air into the engine with each intake of air.

The powerkit for the Carrera S consists of an extensive package of components:

Flow-optimized cylinder heads with polished channels, a dual-position resonance intake system with enlarged valve lift and adapted valve spring package as well as a sports exhaust system are the primary power components, which are flanked by a range of new peripheral assemblies.



The highlight of the Carrera S powerkit is the newly developed variable resonance intake system with 6 plus 1 switchable valves that switch between power- and torque-optimized geometries.

Last but not least, there is a completely redesigned engine control (mapping) that is the key to converting the additional combustion air into power.

Cylinder heads

In contrast to the series model, the powerkit for the Carrera S has mechanically polished gas exchange channels in the cylinder heads. Prior to polishing there is a local, three-stage channel contour machining procedure that proved its mettle in the predecessor engine kit.

Starting with a series model rough part, after machining the gas exchange channels in the intake port they are deburred and polished by means of a flow grinding procedure. In this procedure, a paste-like grinding medium is pressed through the channels under precisely defined conditions (pressure, temperature, volume flow). Because the motion of the grinding medium is similar to the gas flow, the result is an ideal, uniform polish that cannot be achieved to such perfection through manual reworking. The result finds expression in a further improvement of the dimensionless flow coefficient Alpha K, an indicator of the fluid flow efficiency of the gas cycle channels. In conjunction with the enlarged valve lift and the dual-position resonance intake system, this leads to an increase in the air efficiency. ›

Intake system

A cast aluminum intake system with six coordinated resonance-induction intake ducts is largely responsible for the additional engine charge. For each cylinder bank, three switchable valves create channel activation of the power channel geometry to the torque channel geometry and power channel geometry. Valve control is successfully performed by the engine control mapping utilizing vacuum actuators that are supplied by the engine vacuum pump.

The combination of vibration tube and resonance induction is therefore utilized in full—the flat-six engine is predestined for this like no other engine construction concept.

In addition, the intake system has a tuning flap in the collector volume that enables separation of the two cylinder banks and thus contributes to an even better torque curve during partial load operation.

Compared to the predecessor intake system, lightweight construction measures allowed 25 percent weight savings. The goal of general weight reduction for the vehicle as a whole is achieved in part by an improved casting procedure that enables reduced wall thicknesses (by 2.5–3 millimeters on average) without compromising the durability of the product. Thanks to appropriate construction measures, it was also possible to reduce the time required to mount the intake system on the engine.

Improved torque curve in partial load operation: The cast aluminum intake system has a tuning flap in the receiver volume that enables separation of the two cylinder banks.

Compared to the series version (left), the intake ports of the cylinder heads in the 911 Carrera S powerkit are additionally machined and polished (right).

Inlet camshaft

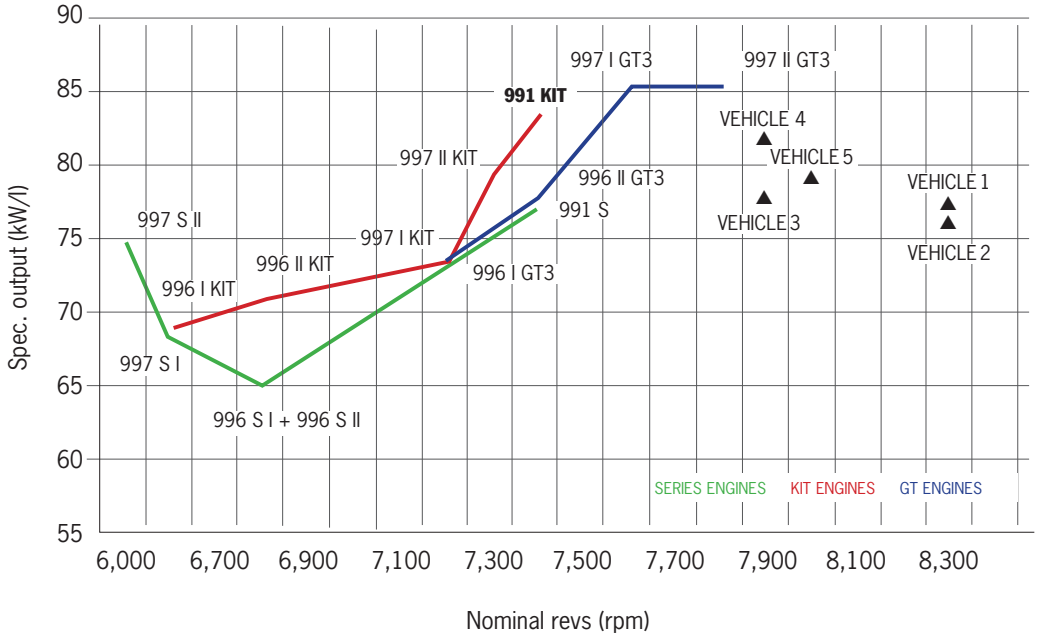
Another component of the powerkit is inlet camshafts with a larger valve lift compared to the series model. At high engine speeds, they display their benefits through an additional quantity of air in the combustion chamber, enabling a power boost at high rpms. The familiar valve-lift shift to a smaller inlet cam for partial load operation from the series model is retained here as well.

Other features

A supplementary part of the kit package is an additional water cooler that safely disperses the increased engine heat and thus ensures a healthy temperature balance. The sports exhaust system de-throttles the exhaust tract and impresses with its gravelly sound. The Sport Chrono package, dynamic engine mount and a kit-specific engine cover round out the package.

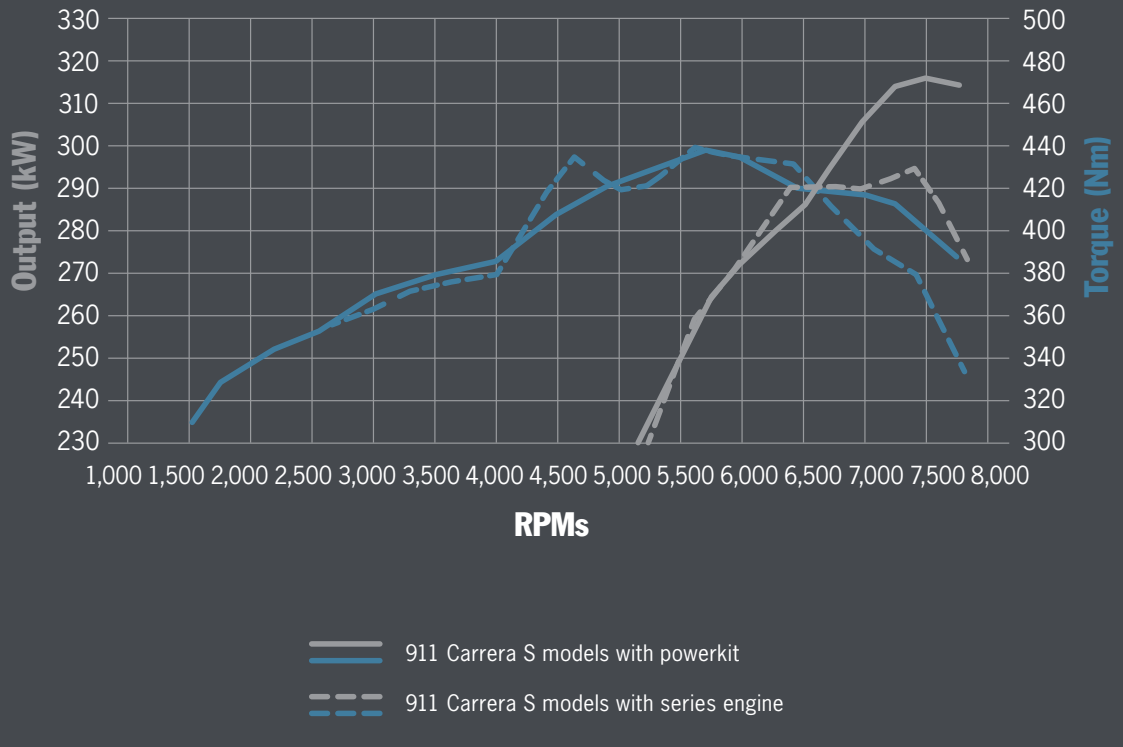
Technology

The engine's power output comes in at 83 kW/liter (113 hp/liter)—a figure that, in light of the required engine speed, amply demonstrates the special character of the kit. As the diagram (next page) shows, the high performance figures are achieved at engine speeds that correspond to those of the series engine. So there's no need to think in terms of high engine speed concepts that can compromise drivability in everyday operation. That these impressive values are attained without higher consumption (in the NEDC) compared to the series engine demonstrates the unique character of the new engine. ›



Development of the power output per liter over the engine speed of the Porsche 911 Carrera generations and in comparison to competitors (vehicle 1–5)

The kit package for the 911 Carrera S (type 991) enabled a power boost particularly in the upper engine speed range.



Historical overview of Porsche powerkits since the Carrera 996

SERIES CARRERA	YEAR	BASE ENGINE	OUTPUT (kW)	OUTPUT DELTA (kW)	ALLOY INTAKE SYSTEM	MODIFIED CYLINDER HEADS	ENGINE SPEED INCREASE	SPORT EXHAUST SYSTEM	VALVES/ INSERTS	CAM SHAFTS	MODIFIED ENGINE APPLICAT.
991	from 06/12	3.8l	294 to 316	22	●	●		●		●	●
997 II	from 06/09	3.8l	283 to 300	17	●	●	●	●			●
997 I	from 08/05	3.8l	261 to 280	19	●		●	●	●		●
996 II	from 01/02	3.6l	235 to 254	19	●	●		●		●	●
996 I	by 12/00	3.4l	221 to 235	14	●	●	●		●	●	●

Project scope

With the new powerkit for the Porsche Carrera S, Porsche engineers and technicians have once again shown that improved performance doesn't have to come at the expense of fuel efficiency. The development of the resonance intake system with switchable valve units, cylinder heads with channel optimization, inlet camshafts with modified valve lift and a series of accompanying peripheral components from concept to production was completed successfully on the tightest of schedules.

In the early phase of the project, the modified valve train concept was verified on dummy cylinder heads. While development was ongoing, a series of complete engines were built and post-trial examinations were carried out.

Whether the engineers and technicians of Porsche are working on a sports car or some other project, the result is always the same: Porsche Intelligent Performance. ■

Powerkit

911 Carrera S

Technical Specifications:
Increased output from 294 kW (400 hp) to 316 kW (430 hp). Improved acceleration to 4.0 seconds from 0–100 km/h for Carrera S Coupé with PDK in Sport-Plus mode. Increased top speed to up to 308 km/h (depending on vehicle variant). Fuel consumption remains unchanged despite higher output (in NEDC).

BOXSTER (TYPE 981): Fuel consumption combined 8.8–7.7 l/100 km; CO_2 emissions 206–180 g/km

The Boxster Revolution

_____ Never before in Porsche's storied history has the transition from one generation to the next been so stark and evident at a glance. The new Boxster astounds with its lightness, which is reflected not only in its weight and fuel consumption but also in its speed and agility.

The redesigned rear end of the Boxster: striking and expressive

Despite its comparatively meager consumption of less than 8 liters with the Porsche double-clutch transmission (PDK), the new Boxster nevertheless manages to put even more power on the pavement. The Porsche Intelligent Performance principle has been implemented in full.

5,69 kg/kW

The new Boxster is the lightest sports car in its class

Intelligent lightweight construction and design

Thanks to intelligent lightweight construction, the new Boxster weighs in at an impressive 35 kilograms lighter than its predecessor despite more demanding safety and torsional rigidity requirements. The Boxster is thus the lightest sports car in its class, with a power-to-weight ratio of just 5,69 kg/kW (Boxster S).

Substantial changes to the design have also been carried out. The Boxster's rear end has been completely redesigned. You'll search in vain for the old hood compartment. The modern rear wing with integrated tail lights unites a striking ridge across the entire width of the rear with the central light unit just below it. With a shape that stretches around the edge of the car, the new, completely LED technology-based tail lights are perfectly integrated in the Boxster's rear end. The rear end is rounded out by the redesigned tailpipe, which sits low and centrally. Typical of the new design is the shoulder line, which flows out of the starkly arching wing into the rear side section. Particularly characteristic is the new dynamic indentation in the door, which directs the intake air to the striking inlet in the rear side section. It's plain to see where the roadster's heart beats. The proportions have changed forever. The wheelbase has grown by 60 millimeters and the track width in front by up to 40 and in the rear up to 18 millimeters, with the wheels sitting flush with the body.

Engine and transmission

The new Porsche Boxster ushers in the third generation of the mid-engine roadster. The classic flat-six engine makes the two-seater the perfect embodiment of performance and efficiency. Yet the downsizing impulse is irresistible, and the displacement has been reduced to yield more power with less consumption. The drives of the two currently available Boxster models both feature direct fuel injection, thermal management, brake energy recuperation, and automatic start-stop function. They are thus more powerful ›

The large air intakes give the Boxster a powerful look

The new chassis enables greater agility and driving stability

than ever before—and more than 15 percent more fuel-efficient as well.

They also employ the "coasting" feature from the new 911 Carrera. The principle of only drawing engine power when it is really necessary is performed by the Boxster in conjunction with the PDK transmission. Thanks to disengaged rolling or "coasting," in which the engine runs in neutral with correspondingly low consumption, the Boxster can save up to a liter of fuel over 100 kilometers.

Chassis and brakes

The Boxster's agility and sportiness are in its mid-engine genes. But the new chassis raises that level yet another notch. The wider track and bigger wheelbase bring greater driving stability and agility, as test and comparison drives on the Nordschleife of the Nürburgring have shown time and again. The new Boxster posts a 12-seconds-faster time than a similarly equipped predecessor model and at 7:58, cracks the 8-minute barrier for the first time. First-class driving performance is ensured by the improved Porsche Active Suspension Management system, the dynamic engine mount and Porsche Torque Vectoring. The intelligent interplay of the rear-differential lock with wheel-selective braking intervention, an additional function of Porsche Stability Management, enables improved steering behavior and increased steering precision of the vehicle through targeted braking of the inner rear wheel when cornering.

A more capable chassis also requires an optimized brake system—a matter of course at Porsche. The new Boxster features new, stiffer brake calipers on the front axle, improved brake pad guidance, and a larger braking surface. The brake disc cooling was optimized and a pulsating brake light installed for improved traffic safety that activates automatically whenever the ABS system kicks in.

Changes in the performance data with the new generation of the Boxster

Boxster	**New (Type 981)**	**Previously (Type 987)**	Δ
Displacement	2,706 cm^3	2,893 cm^3	–187 cm^3
Power	195 kW (265 hp) at 6,700 rpm	188 kW (255 hp) at 6,700 rpm	+7 kW (10 hp)
Torque	280 Nm at 4,500–6,500 rpm	290 Nm at 4,400–6,000 rpm	–10 Nm
Fuel consumption with PDK	7.7 l/100 km	9.1 l/100 km	–1.4 l/100 km (–15.4 percent)

911 CARRERA MODELS: Fuel consumption combined 11.7–8.2 l/100 km; CO_2 emissions 275–194 g/km

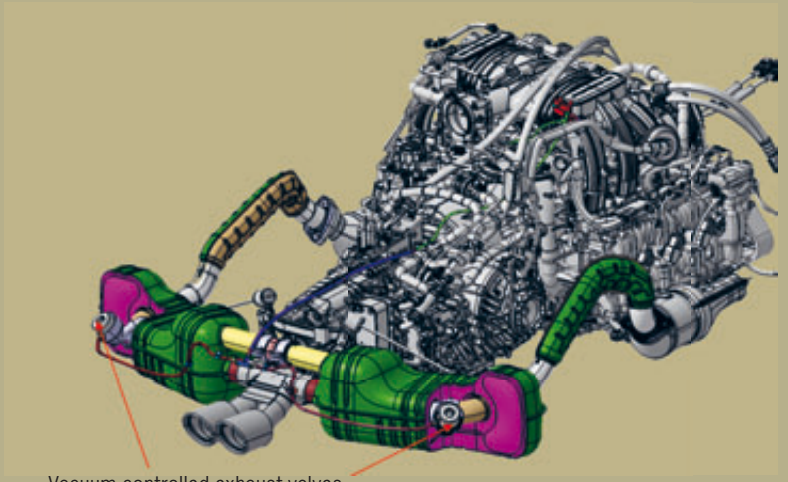
Convertible top

The new fully automatic hood operation system makes things even more convenient. The roof opens and closes fully electronically using two electric motors in less than nine seconds at speeds of up to 50 km/h. And thanks to the new roof material in a special acoustics edition, interior noise was reduced from roughly 75 decibels to 71 decibels at 100 km/h, which corresponds to a reduction in the perceived noise level by half. As part of the new roof geometry, the front magnesium roof frame was enlarged such that when open, it completely covers the hood compartment, which in turn enabled omission of the convertible top compartment lid—once again, consistent with the principle of intelligent lightweight construction. ■

www.porsche.com/Boxster

Porsche (Sound) Engineering and the new Boxster

The exhaust valves largely responsible for sound generation are vacuum-controlled via the engine



The sports exhaust system being offered optionally either factory-installed or as a retrofit package was developed by Porsche Engineering in close collaboration with the exhaust and acoustics experts from the development center in Weissach. In this sports exhaust system, the exhaust flow is regulated according to the driving system (vehicle speed, engine speed, gear) and if necessary is not completely directed through the respective rear silencer as in the standard version but partially through an accordingly designed piping system circumventing the attenuator and emitted directly into the air. The appropriate distribution and channeling of the attenuated and unattenuated exhaust flow play a decisive role in achieving the typical Porsche sound. The sound effect is regulated by map-controlled exhaust valves in the exhaust flow activated by means of vacuum control by the engine vacuum system (see illustration). By pressing the sport button on the vehicle console, the valves can also be opened or closed mechanically while driving, according to the driver's wishes. A specially designed valve map ensures that statutory noise threshold values are observed. Thus, opening the valve system in the city or when idling is not possible, even if the driver presses the button on the console.

Innovative Test Bench – Flexible Service

Intelligent Thermodynamic Testing

_____ The thermodynamic test bench from Porsche Engineering is the product of years of testing for a wide variety of customer projects. The thermodynamic specialists at Porsche and their versatile test bench now offer companies in different business sectors comprehensive testing services.

Photos by Jörg Eberl

The new Porsche Boxster being analyzed on the flexible thermodynamic test bench

What was the initial spark for the development of this thermodynamic test bench? It came from a variety of sources: development work on e-mobiles and hybrid vehicles, HVAC (heating, ventilation, and air-conditioning) projects, vehicle cooling systems, and thermal management. Each new task meant new requirements specifications; in consequence, a three-year project working with the test bench became three years devoted to developing the test bench itself. The end result was a very flexible test bench incorporating in-depth testing expertise in the areas of heating, cooling, and maintaining temperatures.

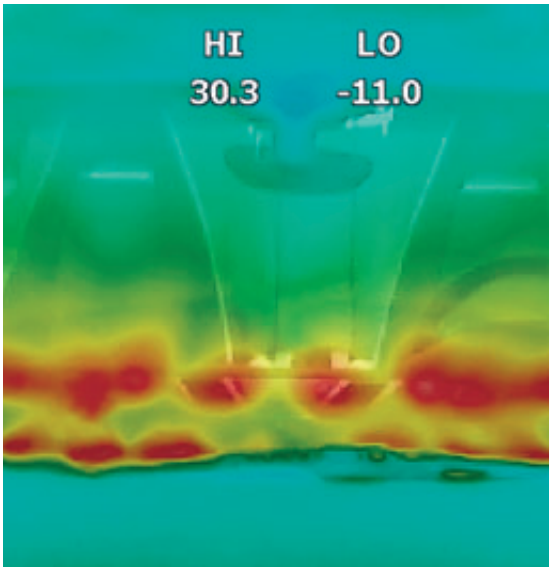
"As an engineering services provider we are offering the Porsche know-how and expertise in the field of thermodynamics to a large variety of customers, who are often confronted with similar problems in their development work," notes Björn Pehnert, development engineer at Porsche Engineering. "Our thermodynamic test bench has been configured for use in various sectors." ›

BOXSTER (TYPE 981): Fuel consumption combined 8.8–7.7 l/100 km; CO_2 emissions 206–180 g/km

One test bench – three media

The test bench offers a demonstration of the options Pehnert is referring to: the test bench conditions air, coolants, and refrigerants with equal aplomb—flexibility available as needed.

All of the systems and components these media flow through can be analyzed on the test bench—and not only in terms of thermodynamics, for the thermodynamic test bench can be connected to a battery test bench as well. For this type of testing, the Porsche engineers simulate the overall vehicle in which the battery would be installed, including any relevant environmental conditions. At the same time that the test battery is loaded as though it were in operation, it is possible, for instance, to represent the complex interaction of cooling and heating, and the control electronics.



The heat distribution is analyzed to ensure that the windshield is defrosted evenly (shown here: the Porsche Panamera)

One test object – hundreds of test points

The thermodynamic test bench is no less accomplished when working alone. All of the pertinent thermodynamic behaviors of a component or system can be tested; depending on the factor and test object, this can add up to 200 test points or more.

The test bench can be run in hot or cold mode, which means that pressure, volume flow rate, and flow behavior can be tested; heat distribution and temperature differences can be tested separately or in combination. On customer request, the test bench can be adapted from R134a refrigerant to its possible replacement, R1234yf. As Pehnert sums up, "The problem itself and how to solve it most efficiently are what guide us in selecting media." One problem that continues to challenge Porsche Engineering customers is the phenomenon of cavitation, which can occur in any component in which there is a rapid increase in the flow rate. In the event of unfavorable pressure and temperature conditions, vapor bubbles can form—and implode—in the fluid. If this happens, microjets strike the inner wall of the component at the speed of sound. Whether we're looking at tubing, heat exchanger accumulators, or cylinder heads, this leads to undesirable results, ranging from the surface being subjected to a high compressive load to its being mechanically damaged. In cases such as these, Porsche Engineering's task is to pinpoint the trouble spots, analyze them, and redesign the flow of coolants so that cavitation can be reliably prevented.

A clear view of hot spots

In order to identify problem spots, the thermodynamic specialists visualize flow processes. One variant that they recommend and implement in the case of extremely short, rapid processes in complex components that are out of sight—cylinder blocks or cylinder heads, for example—is to reproduce the test object on transparent plastic in a rapid prototyping process. Next, the sample part can be flushed with a dyed fluid; a high-speed camera can then be used to film it and capture tens of thousands of high-resolution images per second—and every detail of the flow behavior. When these images are played back over a period of several minutes, even lightning-fast cavitation processes and convoluted flow movements become visible to the human eye, enabling the engineers to document and analyze them.

Demisting and defrosting tests

In case of demisting and defrosting tests the thermography reveals what is essential for cooling, heating, and air-conditioning systems for vehicles: this is the uniform distribution of warm air flowing onto the windshield and into the interior to ensure a mist-free view and rapid defrosting. Here, too, the thermodynamic specialists incorporate a wide variety of customer requests; they adapt individual components—for example, a new dashboard that is to be installed above a pre-existing air-conditioning system. Or they might model a complete passenger compartment as a mock-up for the best possible design of the discharge nozzles for all relevant systems.

Full service and troubleshooting

The thermodynamic test bench has been designed with flexibility in mind, and can be combined with an environmental chamber, a vibration test bench, or a shaker test bench. This wide spectrum makes any imaginable type of customer-oriented cooperation possible. "We offer support to companies throughout the development process, starting with the concept and component design; working with suppliers; prototyping and testing; all the way to the start of production," explains Pehnert. "Or we assist on short notice, for example if individual components need to be optimized before series start-up."

Energy follows efficiency

Customer projects don't always revolve around vehicles rolling off the production line. Sometimes the goal is to improve the production: more units produced in less time, no waste, and with low power consumption. The bottom line: fully automated production at the limit of what is technically feasible. This is a challenge confronting companies in a number of business sectors.

Thus, for example, blanks are often heated at the start of a production process; the semi-finished parts or final products are then cooled down at the end. There is generally a historical reason for the separation of industrial heating and cooling cycles, as that was the traditional practice. The Porsche thermodynamic experts are bringing two processes together where they belong: they use heat pumps to collect heat extracted during the cooling process and supply it to the heating unit. And that's just one example of many energy-efficient solutions from Porsche Engineering. ■

Test bench media in figures

Coolant supply	
Type of coolant	Water/glycol
Temperature range	–5°C to +105°C
Flow rate	80 l/min
Cooling efficiency	20 kW
Pressure range	up to 4 bar
Air supply	
Temperature range	–5°C to +80°C
Volume of air flow	1,000 l/s
Cooling/heating efficiency	20 kW
System pressure	45 mbar at 1,000 l/s
Upstream flow cross-section	800 mm x 500 mm
Refrigerant supply	
Type of refrigerant	R134a
Temperature range	–10°C to +10°C
Refrigerating capacity	0 kW to 15 kW

A thermodynamic test bench for a variety of customer requirements

Available media

> Air
> Refrigerant
> Coolant

Available test procedures

> Cold-water testing
> Hot-water testing
> Demisting/defrosting tests

Flexible use

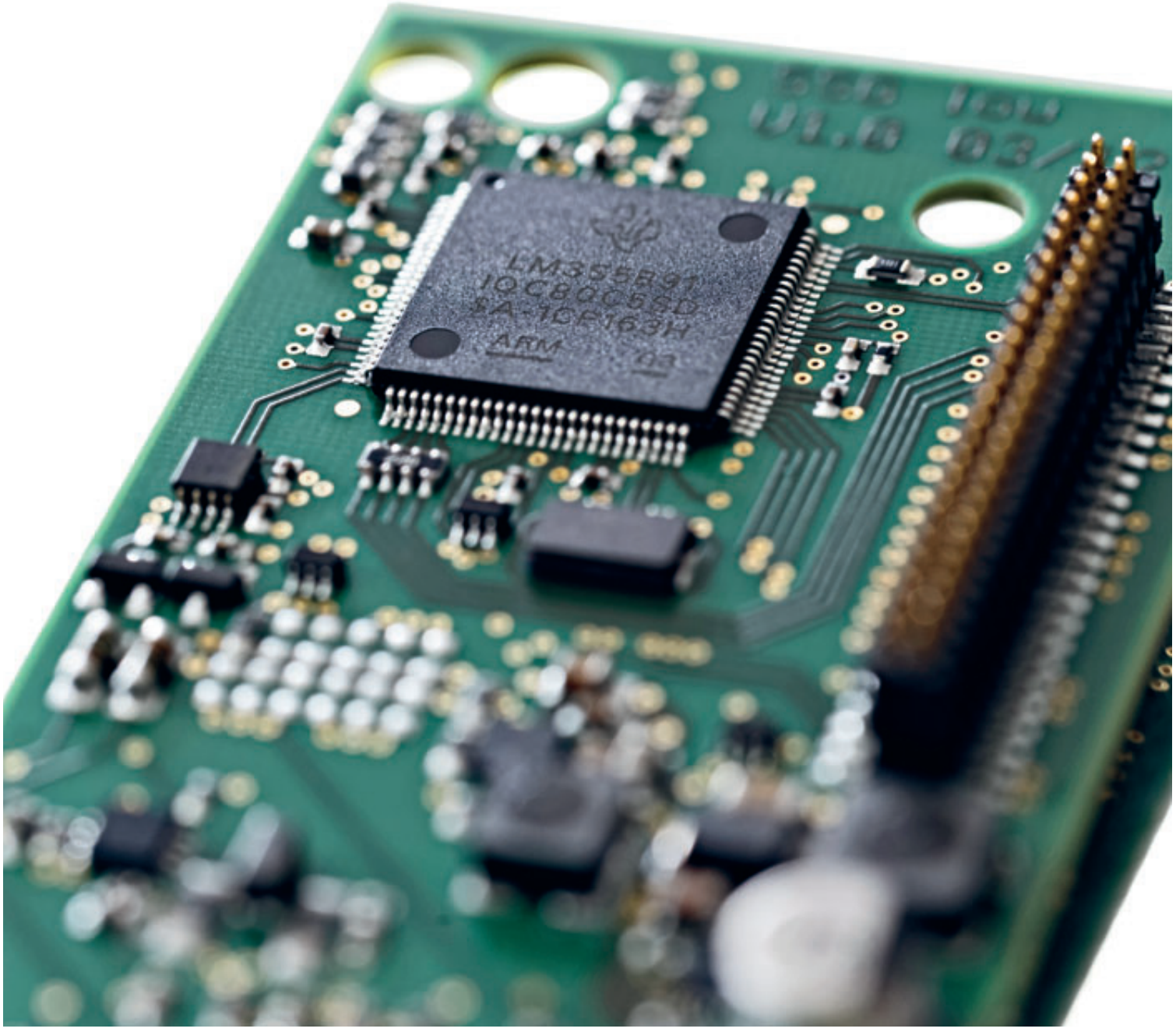
> May be coupled to an electric test bench
> Modular integration with other test benches is feasible

PANAMERA: Fuel consumption combined 12.5–6.3 l/100 km; CO_2 emissions 293–159 g/km

Prototype Controller

In the automotive industry, the use of prototype controllers for developing new vehicles and products is standard practice. Porsche Engineering offers a requirements-based hardware and software platform that provides just the right solution, whatever the application.

By Norbert Nentwig, Ulf Schlieben, Jens Müller, Andreas Müller Photos by Jörg Eberl



In order to remain ahead of the competition, it is important for a company to keep developing innovations for vehicles as quickly as possible, and to make them ready for series production. The implementation of this approach requires an efficient product development process and appropriate tool chains. In the future, with its modular prototype controllers, Porsche Engineering will be able to provide a flexible, economical, and robust solution for every application.

Why does Porsche Engineering have its own prototype hardware platform?

Electronic controllers in vehicles ensure improved comfort and safety, and reduce the impact on the environment. In order to be able to apply all of these functions, more and more controllers are required, and the need for exchanging information increases.

During the development process, a large number of tests, simulations, and measurements are performed in the prototype phase, so that the desired functions can then be mapped in a number of iteration steps on the target hardware created by the supplier. To shorten this process and to be able to perform a verification of the simulation in the vehicle under real conditions as soon as possible, the development of cost-efficient prototype platform was started.

What are the benefits of prototype controllers from Porsche Engineering?

> Cost-efficient hardware
> Complete solutions: "All from a single source"
> Flexible and open architecture through the use of standard components

What does the modular structure of the platforms look like?

The basis of the controllers is the ARM Cortex processor series, which provides a large range of services and functions. The basic software, drivers, and interfaces are the same for all processors, and this simplifies the development process considerably. The areas of application are grouped according to performance, handling, safety, and environmental parameters.

The table below provides an overview of the various properties of the interface controllers (referred to below as ICs) of the types IC LOW, IC MID and IC HIGH. The following example uses the IC LOW to explain the properties and special features and thus clarify the hardware and software structures.

Interface controller LOW

The IC LOW covers the lower performance spectrum of the controller platform, which includes topics such as sensor evaluation, sensor simulation, simulation of LIN nodes, logger functions, and simulation of diagnostic/tester functions. This also provides the option to implement customer-specific hardware extensions. A version with an on-board diagnostics (OBD) connector housing is currently finished and in use. ›

FUNCTION	IC LOW	IC MID	IC HIGH
Basic IO	■	■	■
Individual software	■	■	■
Matlab/Simulink	—	■	■
HMI/Display	—	■	—
Ambient conditions	Interior	Interior	Engine compartment
Safety			IEC 61508 SIL-3 ISO 26262 ASIL-D
Application	Sensors, HW Gateway, Diagnostics	Logger, Network Gateway, HMI, Simulations	Transmission, Engine, Battery Management, Electric Vehicle Manager

Hardware description

The IC LOW consists of a motherboard and an extension board (see figure below). The motherboard contains the processor, the hardware inputs and outputs, and the voltage supply. The current extension board for the OBD connector housing (see figure at upper right on right-hand page) contains a Bluetooth module for communication and a micro SD card slot for mapping logging functions. The extension board is connected via a 50-pin connector and can be adjusted to meet specific customer needs. A version for implementation in an aluminum housing is currently under development.

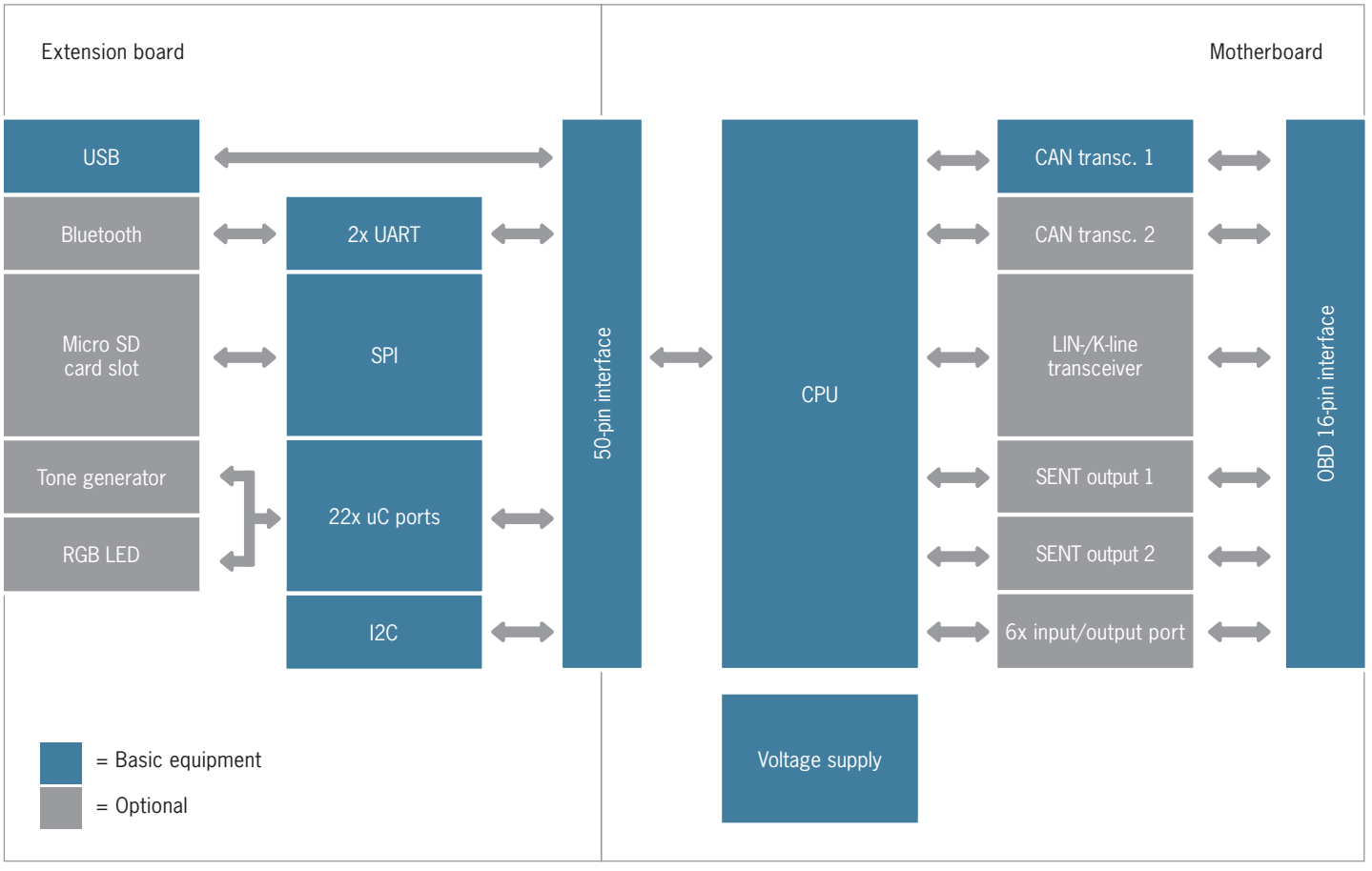
Software description

Due to the complexity of modern microprocessors and the significantly increased demands on the software, flexible and modular software architecture is needed that can meet the following requirements:

> Structured software design
> Reusability of components
> Hardware-independent function design (separate behavior from the hardware architecture)
> Portability of the functions to different hardware platforms without changing code
> Use of manufacturer libraries

The software for the ARM Cortex M3 processor of the IC LOW has been developed based on the software library principle. Every hardware module has its own initializations and functions, so that the required hardware can be addressed as required. With this step, it is possible to take existing functions and use them for future developments with the same process architecture without any problems.

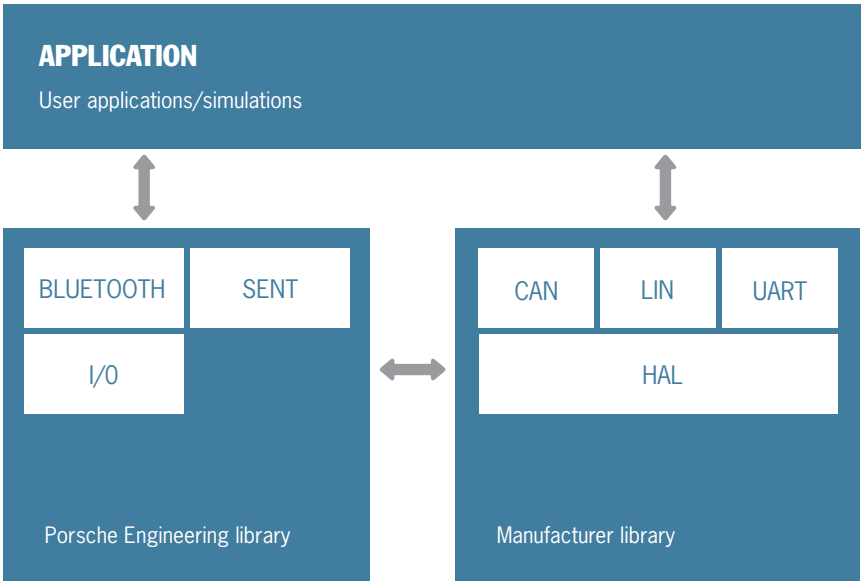
The modular hardware means that the motherboard, together with the voltage supply, CAN, LIN, SENT, and processor, can also be used in other hardware developments. Using the software library, basic functions can be implemented quickly, and the actual function development can be prioritized.



Block diagram of the IC LOW, consisting of a motherboard and an extension board

OBD housing and interior

Software architecture



As each project accesses the library developed specifically for the IC LOW, changes are effective immediately across the board. This preliminary work makes it very easy to incorporate new projects.

Thanks to the variety of implementation options of the IC LOW, in parallel with the embedded software there is also a Windows interface for managing the individual software versions and documenting the devices already in use.

An integrated boot loader enables an older software version to be updated at any time. Other functions of the Windows interface include function tests, monitoring processes, and displaying operating statuses.

In its current development phase, five different projects have been implemented with the IC LOW. These include starting the fuel feed pump with a diagnostic command, activating/deactivating the dynamometer mode for all-wheel and rear-wheel drive, simulating a controller, and also incorporation into the "TargetSetupCenter" software. ■

911 CARRERA MODELS: Fuel consumption combined 11.7–8.2 l/100 km; CO_2 emissions 275–194 g/km

Electromagnetic Compatibility – a Product Development Issue

At its site in Bietigheim-Bissingen, Porsche Engineering has its own center for electromagnetic compatibility (EMC Center), which provides diverse options for EMC-oriented developments. Beyond the automotive sector, tests are performed for customers from different areas such as industrial, medical, and household technology.

By Jan Spindler, Ralf Fanz, Florian Dietze Photos by Jörg Eberl

Due to the rising number of electronic components and radio communication services in everyday life, electromagnetic compatibility (EMC) has become significantly more important in the last few years. For electronic systems, there are legal and customer-specific requirements to ensure that, first, they do not interfere excessively with their electromagnetic environment, and second, that they are resistant to interference from other systems and installations. Depending on the application environment and the customer, threshold values must be fulfilled with regard to interference emissions and requirements for the checking level for interference input.

Seeing EMC as a strength

The acceptance test is a criterion for release onto the market. To ensure that a product is launched onto the market punctually and without any problems, the corresponding requirements and criteria should be considered from the beginning of the development process. This is to avoid time-consuming rectifications and verification tests, and it can also provide competitive advantages. When problems are only identified in later stages of the development process, it is difficult to implement changes. ›

EMC vehicle measurement

One of the everyday measurement procedures is the interference emission vehicle measurement. From the Porsche Communication Management to the GPS antenna and the TV module, everything is looked at closely. For this, Porsche Engineering uses two state-of-the-art measuring stations. The roller dynamometer can be used to perform tests at speeds of up to 50 km/h.

An interference emission measurement is performed in the anechoic chamber

Ideally, EMC disturbances can be reduced by means of shielding measures and filters. If these measures are not effective, redesigns are required. The comprehensive adjustments and additional measurements lead to costs that were not factored in, and experience shows that these increase exponentially the later an EMC problem is discovered.

Integration into the development process

In the development process, the focus is usually on functionality. At the start of the development it is often not clear which requirements apply to the target market and what scope must be fulfilled. However, the EMC topic should be considered from the beginning. Aside from the applicable threshold values, basic aspects can be considered. These include the PCB layout and structure, the selection of the components, and a comprehensive grounding concept. Intensive preparation can often reveal shortcomings in this early phase. The scope, the applicable standards, threshold values, and requirements should be defined as early as possible. Ideally, these are set down in the form of a specification set or a catalog of requirements. In the long term, the knowledge gained over time is employed in various projects and can ultimately contribute to all-round improvement.

Porsche Engineering as a development partner

The Porsche Engineering EMC Center has already proved itself a reliable and flexible partner in a multitude of projects. The goal of the center is to discover and document problems and then develop the corresponding measures for optimization or resolution. The approaches used here in disruptor analysis do not have to adhere to a standard. To find interference sources and detect switching paths, measuring equipment is sometimes used that has been modified by Porsche engineers to meet their own individual requirements. Additionally, special constructions can be used for application-relevant scopes. The comprehensive repertoire of interference-suppressing materials can be used for a wide range of approaches, the effect of which can be tested immediately in the anechoic chamber.

The distinguishing feature is the long-term support for customer projects.

The Porsche Engineering EMC Center can perform classic layout consulting, provide a review relating to the test plan, or provide support to clients building up their own EMC expertise.

For the employees at the EMC Center, individual consulting with customers and fast, solution-oriented processing of projects are the focus of their day-to-day work. What distinguishes the EMC Center in Bietigheim-Bissingen is the long-term support for customer projects. From the initial idea to the qualification and series production—the entire spectrum can be provided by a single source. ■

The new generation of the 911 Carrera Cabriolet is tested on the roller dynamometer

An engineer evaluates measurement results

EMC Engineering Seminar

Analyzing the interference sources and testing the switching paths for a vehicle component

In March 2012, Porsche Engineering staged the first in-house seminar on the topic of electromagnetic compatibility (EMC), which was carried out in close co-operation with Würth Elektronik eiSos GmbH & Co. KG. With 28 developers from all areas of the electrical and electronic development sectors, a whole day was dedicated to EMC. The goal of the event was to give visitors an insight into EMC-oriented development and to present approaches that they can implement on an everyday basis.

Basic principles of EMC

Various practical examples were used to explain to the seminar participants the theoretical aspects of EMC and interference suppression, and the corresponding measures were presented. In a series of short presentations, the employees at Porsche Engineering illustrated the main differences between EMC in the industrial and automotive sectors. For the latter, a distinction was also made between the component level and the vehicle as a whole.

In the workshop that followed, the seminar participants were challenged to put into practice what they had learned in theory. They had to pass through three stations within the EMC laboratory. In

Key questions in preparing for a successful EMC measurement

- > Does a clear testing plan exist?
- > Have the operating conditions for the procedure been defined?
- > How can the operating conditions be achieved?
- > How should the interference resistance tests be monitored, and how can this be implemented?
- > What equipment is required for the measurement (cable harnesses, monitoring tools, periphery)?
- > How does the test setup have to be defined?
- > How is the grounding concept implemented?

the process, various tips and tricks were explained for measuring constructions for the industrial and vehicle sectors. The "structured procedure for interference suppression" station generated particular interest. Here the test object was used to present the structured procedure for disruptor analysis, along with the measuring equipment used.

Though this may appear time-consuming, dealing with these points often considerably reduces the time for passing through the EMC laboratory.

Feedback

The seminar enabled an intensive exchange between EMC experts and developers. Beyond the presentations and the workshop, there was plenty of time for personal conversations, to answer questions directly on site, and to discuss particular challenges with which participants have already been confronted. Due to the positive feedback received, a repeat of the seminar is being planned. ■

Porsche Engineering
MAGAZINE

ISSUE 2/2012

PUBLISHER
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Porsche recommends Mobil 1

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