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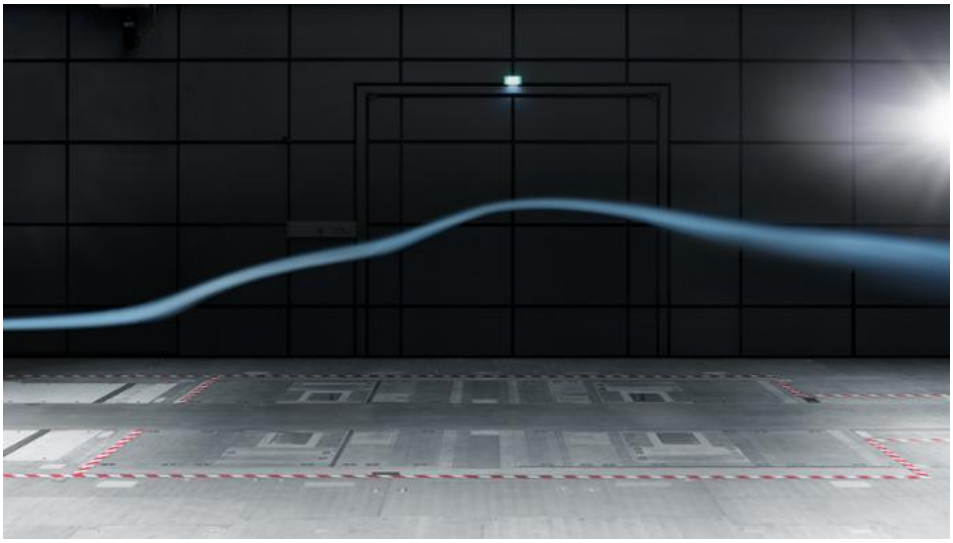
Winds of Change

The new aero-acoustic wind tunnel at the Weissach Development Center is helping Porsche engineers find the path of least resistance with even greater precision.



Three hundred km/h. That is a magical figure, above which is a realm inhabited only by super sports cars and race cars. An airplane would take off at this speed. But not the 911 Turbo Cabriolet. In addition to the weight that rests on its axles, the car's aerodynamics are such that the headwind presses it down onto the road and contributes to its extremely high track and directional stability. Generating sufficient downforce at high speeds, and at the same time keeping drag to a minimum, is the task of the aero-dynamics experts at the Weissach Development Center.
That is a challenge, because even the smallest modifications to the car's contours can affect both the drag and the downforces. Therefore, every new model version has to be tested in the wind tunnel. "It is primarily a matter of precision," explains test rig director Dr. Hauke Stumpf, who together with his team is in charge of the new wind tunnel that was opened in the spring of 2015.
"We have to be able to measure forces of a single newton." One newton is the weight force that a mass of approximately 100 grams brings to the scale. This force is essentially nothing when compared to a car that weighs about one and a half tons, moving at 300 km/h, in addition to the mutually reinforcing effect of vehicle weight and aero-dynamic downforces.

Belt system simulates the relative motion of the car

The previous wind tunnel in Weissach, which was built in the mid-1980s, was already very good. But "very good" is never good enough for Porsche engineers, so the company invested in the construction of a new tunnel that can do everything even better. "Our measurements now come considerably closer to reflecting real conditions on the road," says Stumpf. In large part this is because the prototypes now move in the tunnel, whereas before they did not. The car doesn't really move, of course, but rather is secured above a belt system that runs at up to 300 km/h. It simulates the relative motion of the car vis-à-vis the road. That is important because it is the only way to approximate a realistic flow of air underneath the car.
If the floor of the wind tunnel is stationary, a not inconsiderable boundary layer forms. In other words, the air near the floor moves more

slowly and even comes to a standstill right at floor level. But precisely here, in the area around the car's underbody and wheelhouses, is where there is considerable potential to increase efficiency and stability by enhancing the aerodynamics.

"This enables us to make especially precise measurements"

The heart of the new wind tunnel thus consists of its belt system and scale. A special feature of the Weissach tunnel is that it offers test engineers a choice between two different belt systems. One system has five steel belts: one runs below each of the four wheels and a larger one down the middle below the vehicle floor. "This enables us to make especially precise measurements," says Stumpf.
The other is the one-belt system, which, as its name suggests, consists of a single steel belt that runs below the test object. It reflects real conditions more closely, but yields measurements that are somewhat less precise. Porsche followed the motto. "Take two!" in its decision to incorporate both measurement systems in one facility. With the use of an industrial freight crane, it takes just a few hours to switch the systems, which weigh more than 20 tons.
Another crucial benefit of the belt systems is that they allow the engineers to measure the forces that the wind exerts on the car. Linked with a precision scale that stands on its own foundation, the belt system can measure minimal changes in the wind forces on the car or their distribution among the wheels. This measurement in turn enables the engineers to calculate the drag and the up- or downforces on the front and rear axles.

The fan's motor has an output of 7,000 kW.

The wind is generated by a huge fan with carbon vanes and a diameter of about eight meters. It has a peak output of around seven megawatts, or 9,300 horsepower, generated by an electric motor the size of a small bus. The wind tunnel is not terribly loud, however, and at 200 km/h is considerably quieter than its predecessor. Consequently, certain acoustic measurements can now be done in Weissach which used to be sent to external service providers.

Certain acoustic measurements can now be done in Weissach

Of interest here is not so much the absolute noise level, but some detailed detective work. For example, how does a certain mirror shape or a new door seal affect the sound pattern? Several hundred microphones are set up on the car in the test section, allowing a computer to generate a three-dimensional representation of the sound propagation from the car.
Many of the measurements, such as those to determine drag, will also be done later on freeways at the usual European speed of 130 km/h. However, it is important to be able to generate considerably higher wind speeds, in order to test the structural strength, for example, or to contribute to developments in racing. One of Porsche's classic strengths is the ability to exhaust the scope of the regulations and still find a small competitive edge by means of sophisticated aerodynamics. Its long-distance racing cars of previous

decades, for example, have all been known for their good downforces—from the legendary 956 to the current 919 Hybrid.

Almost all components are custom-made

The new wind tunnel in Weissach is not set apart, but rather is integrated into an ensemble of buildings that includes design studios, workshops, and aero-dynamics development facilities. Deliberately so, as Stumpf confirms: “Spatial proximity enables the aerodynamics developers to test design studies very quickly under the strictest secrecy conditions.” At Porsche, aesthetics and favorable aerodynamics should not be mutually exclusive. “Spatial proximity,” Stumpf adds thoughtfully, “encourages not only the exchange of technical information among specialists from different disciplines, but also helps develop close interpersonal relations.” After the board gave the green light for the wind tunnel, it took about four years before it went into operation. That's a long time, but, considering the construction requirements, not so long. Almost all of its components are custom-made, and there are only a few suppliers worldwide. Not least of all, the tunnel itself had to undergo precision tests and careful adjustments.

A lot of effort “just” for air

“A wind-tunnel needs to be prepared for its job in the same way a musical instrument has to be tuned for a concert,” explains Stumpf. For instance, a team of experts spent weeks checking the distribution of the air flow in the test section, or “plenum,” which has a cross-section of 22 square meters. In order for the results from this space to be viable, any fluctuations in the wind speed have to be less than one percent. “We’re well below that,” says Stumpf.
This is a lot of effort “just” for air. But it’s worth it. The mission of the wind tunnel specialists will be accomplished when the next model to hit the roads consumes a little less fuel, when a Porsche is the first car to see the checkered flag at the finish line, and when the next Turbo clocks a faster time on the North Loop of the Nürburgring.

Circuit flow

Porsche’s new wind tunnel has what is known as a Göttingen design. A powerful turbine generates an air flow in a closed circuit, which means that less energy is required. A jet upstream from the actual test section accelerates the wind by a factor of six, and a downstream collector decelerates it again. A powerful heat exchanger removes the heat generated by air friction.
See a graphic of the wind tunnel (download, left column).

Info

Text first published in the Porsche customer magazine Christophorus, No. 371
By Johannes Winterhagen // Photos by Rafael Krötz

Consumption data

911 Turbo Cabriolet (TYPe 991): CO2 emissions (combined): 231 g/km, Fuel consumption combined: 9.9 l/100 km

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