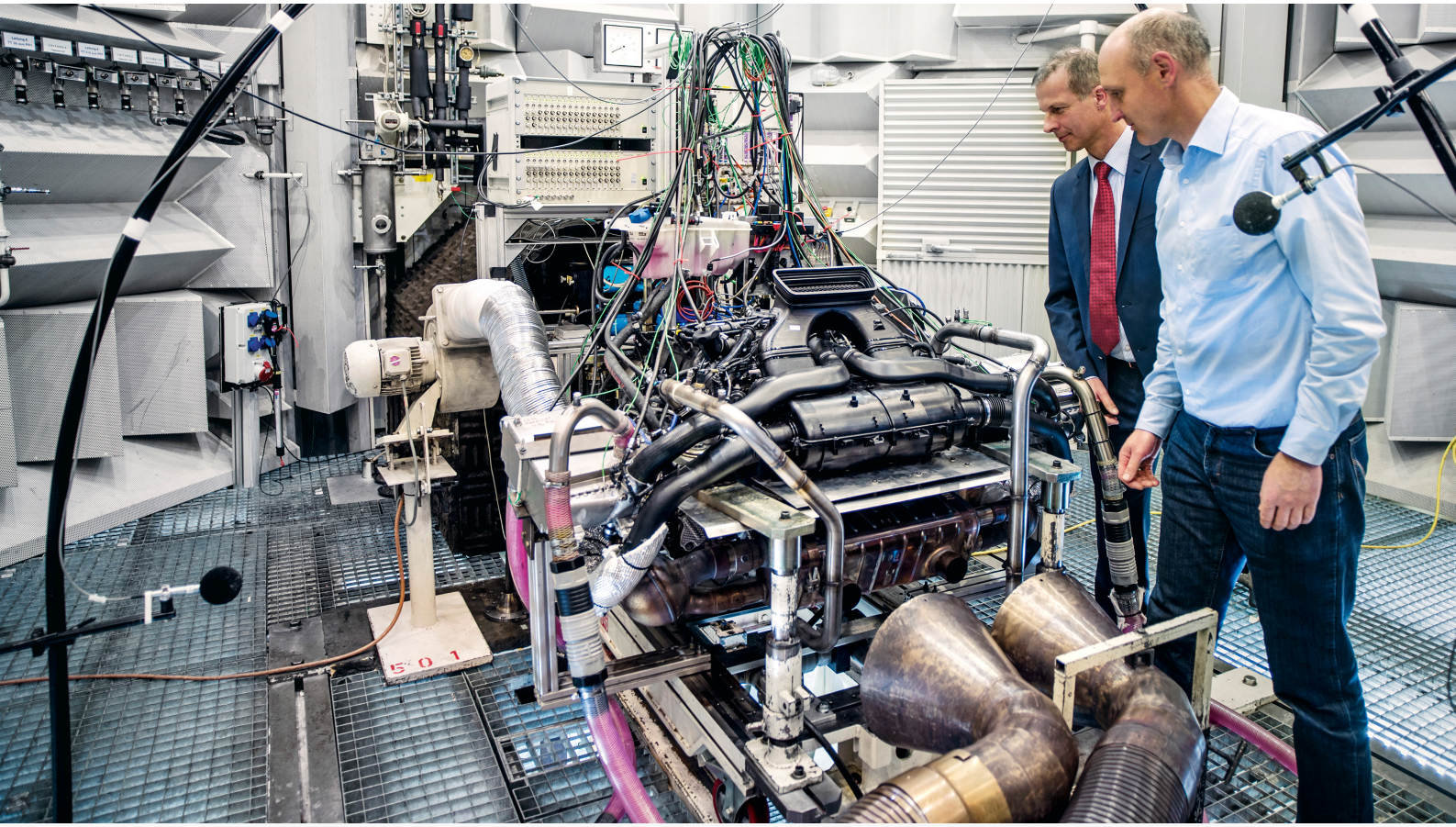


Sound Check

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13/07/2016 To make sure every Porsche truly sounds like a Porsche, acoustics experts compose the right melodies. From the boxer engines of today to the electric cars of tomorrow, Porsche experts in Weissach create individual sound concepts.

A soloist extraordinaire enters the stage. A hush of silence fills the air, as the audience hardly dares to breathe. Suddenly the voice is heard, its virtuoso quality immediately evident with one coloratura, then another, while a layer of tension builds in the quiet bass tones. A crescendo sets in a few bars later as the voice accelerates through nearly every musical pitch, from bass and tenor to soprano. The finale erupts in an unbridled furioso, and all who hear it are left with goose bumps. Then the recording stops, and Dr. Bernhard Pfäfflin smiles. “Marvelous, isn’t it?”

That short soundtrack of a 911 solo displays a number of qualities that every Porsche has to have. First of all, the sound is not one-dimensional, but instead covers a broad range of frequencies. This attribute distinguishes a Porsche from a humming American or a high-strung Italian. Second, both the sound and

the volume vary with the load—that is, with the throttle. “This gives the driver an additional point of orientation,” explains Pfäfflin, 49, who is the head of development for vibrational technology and acoustics. In other words, he is in charge of the Porsche sound.

A GT3 has to rock

Each model should have a sound that matches its character. A GT3 has to rock, that's for sure. Another important criterion, according to Pfäfflin, is that “the car has to sound like its output.” No synthetic pop music, therefore, but real tones from genuine instruments. Nevertheless, the sound bodies are mixed in such a way that a harmonious pattern emerges for every style of driving. In order to achieve this, Pfäfflin doesn't wait until the automotive engineers and engine developers build the first prototypes. The quest for good sound begins much earlier.

While both the powertrain and the car are still in the digital creation process, acoustics specialist Bernd Müller is already calculating countless variants of exhaust systems and mufflers—or, to be precise, the effects of different combinations on the sound of the car. Müller is responsible for the gas exchange acoustics at Porsche, and he generates hundreds of sound files. “This lets you hear a car before it actually exists as a physical prototype,” he says, describing the wonders of digitization. Working together with other experienced colleagues, he distills three or four variants from the multitude of possibilities.

Parameters for the perfect sound

These variants are presented to the board—where, as Müller can attest, they are debated with an intensity usually reserved for the car's design. Once the decision is made, Müller starts working on the specifications for the exhaust system. From the diameter of the pipes to the dimensions of the muffler, he lays out crucial parameters that will ultimately ensure the perfect sound.

For someone like Müller, who has lived and breathed acoustics for two decades now, the work would be done were it not for the company's drivetrain developers, who keep coming up with major new engine innovations. They have introduced a broad range of turbocharged engines, the first four-cylinder engine in many years, and plug-in hybrid cars, and soon there will even be an all-electric sports sedan. These steps are of great significance for the Porsche brand and also bring fascinating challenges.

Two turbocharges enable a rapid buildup of torque

The new turbocharged boxer engines with 3.0 liters of displacement give the new 911 Carrera even more performance. Even the standard Carrera sprints from 0 to 200 km/h in 14.8 seconds—nearly a second faster than its predecessor (Combined fuel consumption: 8.3-7.4 l/100 km; CO2 emissions 190-169 g/km). The two turbochargers, each of which respirates a cylinder bank, enable a rapid

buildup of torque. While this engine concept delivers an enthralling level of power for drivers, it represents a twofold task for Müller. For one thing, the exhaust gases from the engine now flow into the turbine first, which changes the flow speed and therefore the sound pattern. It shifts the entire frequency range, because certain pitches are dampened more strongly than others.

Moreover, the turbochargers, which spin at up to 200,000 rpm, develop their own very specific sound effect: the well-known turbo whistle. This is not bad in itself, because it alerts drivers to the imminent boost. But it's important to prevent annoying prolonged tones at high speeds on the freeway. Müller has mastered these two challenges with the help of some technical measures. For example, the wastegate, which regulates the flow of exhaust to the charger, is adjusted in certain respects to meet acoustic demands.

The basic tone of the engine is largely determined by its number of cylinders

The Porsche sound experts also had the thorny task of fulfilling a desire frequently expressed by customers. They wanted the sports exhaust system—an additional configuration option—to sound even more pronounced, despite the tendency of the turbochargers to dampen it. Müller's team has found the solution. A special design for the final muffler, combined with moving the tailpipes to the rear middle of the car, provides additional bass tones. These changes make it possible to achieve a desired length in the pipe between the catalytic converter and the end of the exhaust system. Similar to a tuba, the length of the instrument will vary the pitch.

This spring, Porsche is also presenting a new generation of four-cylinder engines in the 718 Boxster. After production of the 968 ended in the mid-1990s, Porsche had not been active in this field for two decades. The 718's boxer engine is now a completely new instrument in the Porsche orchestra. The basic tone of this engine is largely determined by its number of cylinders. A four-cylinder engine fires twice for each revolution of the crankshaft, so what initially dominates the acoustics is what is known as the second engine order.

A much rounder and more pleasant sound

Left to its own devices, this type of engine would sound somewhat rough, which is why the Weissach acoustics experts, together with the engine designers, came up with an elegant trick. They have given the exhaust manifold—which channels the exhaust first into the turbocharger—a deliberately asymmetrical design. This creates overtones (secondary orders) that generate a much rounder and more pleasant sound.

The 718's exhaust system refines the sound further. After passing through the catalytic converter, the exhaust mass flow is split between two pipes of unequal length. The shorter one ends in a classic

muffler, which primarily lowers the overall volume. The longer one leads first to a Helmholtz resonator, named after Hermann Ludwig Ferdinand von Helmholtz, who lived and worked in Berlin in the nineteenth century. Like many of his contemporaries, he was a polymath. His particular interests included nerve cells, the conservation of energy, and magnetic fields. One of his most important discoveries was the resonator that bears his name.

The air inside the container starts to vibrate and generates a tone

This air-filled container has a single opening. When airwaves—or sound—flow past the opening, the air inside the container starts to vibrate and generates a tone. Depending on its geometry and dimensions, the natural frequency of the resonator can add or eliminate certain tones—so precise adjustments can be made to achieve sophisticated sound. The result is what emerges from the two tailpipes to meet the human ear.

Developing the Mission E for production has also changed the goal of Porsche's acoustics team. As fascinating as the acceleration and torque of a purely electric car are, the sound created is extremely quiet and dominated by high frequencies. True, the sound of silence has its advantages in certain situations—for example, when leaving the house early in the morning. But in urban traffic, pedestrians and cyclists benefit from being able to hear cars before they see them. In some countries, including the United States, laws are already being drafted which stipulate a minimum volume for cars. So a new sound is needed—but what kind?

Artificial sound à la Star Wars

The first question that Pfäfflin and Müller asked themselves was how to reflect the character of the car. It's a given that whatever they compose, they will not violate Porsche philosophy and create something that has nothing to do with the brand. This means an absolute ban on artificial sound à la Star Wars. "Customers will not be able to download newsounds for electric Porsches like ringtones for their smartphones," says Pfäfflin. The Porsche experts also don't think it makes sense to gather a wide range of opinions at the start of development for such a completely new product and technology.

"Every customer has a very individual approach," says Pfäfflin. "But how can you assess a symphony that you haven't yet heard? Our customers also always expect Porsche to provide direction." The decision has not yet been made as to what the production version of the Mission E will sound like. One thing is certain, however: the acoustics experts will play an even more important role in vehicle development. Despite amplification by interior and exterior loudspeakers, the absolute volume level will be lower, so it is essential to eliminate any acoustic interference from mechanical components or headwinds at high speed.

Closely work with the development colleagues

Pfäfflin and Müller will therefore work closely with their development colleagues, both in the wind tunnel and elsewhere, to ensure that the resulting sound will be in line with Porsche standards. If the testing phase should give them an auxiliary mission, they have a miracle cure at the ready that they have already used on cars with combustion engines: an acoustic camera. Its combination of photo sensors and directional microphones lets the two specialists pinpoint hidden sources of sound in the depths of car bodies.

Porsche's acoustics experts are not artists, but rather engineers and physicists. They deal with engine orders, flow calculations, and frequency analyses. Yet an emotional moment can suddenly interrupt their otherwise sober routine—such as stumbling across the sound of a historic Le Mans race car while searching for inspiration in their very own acoustic database. "It gives me goose bumps," says Pfäfflin. Da capo, please—another refrain for every new Porsche model, regardless of which powertrain will be driving it in the future!

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