Continental
The Future in Motion

White Paper

Tire Testing

For maximum safety in every situation –
testing plays a decisive role in tire development

Contents

Out on the Test Track – Where the Moment of Truth Arrives

On the road from the initial idea to the final product, tire tests are a small but vitally important step.

Following extensive material testing in the laboratory and countless simulations, out on the test track is where the moment of truth finally arrives. Any new tire, whether it's a car, truck or specialized tire, has to conduct an extensive and diverse range of tests ahead of its launch. Before they enter volume production, new tire models cover the equivalent of around 25 million kilometers on roller drum test rigs and test tracks – that's 625 times around the Earth! But this enormous amount of time and effort is more than justified because it is the foundation on which the premium quality of Continental tires is based.

Although numerous steps are performed by means of computer simulations in the tire development process, there is no equivalent for a series of objective measurement data and the subjective assessments of test drivers with their many years of experience. Thanks to ongoing digitalization, however, it is now possible to automate and visualize more and more tests and experiments. In 2012 for example, Continental opened the Automated Indoor Braking Analyzer (AIBA). This one-of-a-kind facility allows the brake performance of tires fitted to fully automated driverless vehicles to be tested on different road surfaces – year round and regardless of the weather. In the U.S.A., autonomous vehicles for performing extremely challenging endurance tests have been in operation since 2018. Sophisticated software like Adams/Car and Adams/Tire now allows test drives to be simulated on a computer. And from 2022, a high-tech vehicle dynamics simulator will allow professional test drivers to perform their work free of the influence of external factors. Objectives of this high-tech campaign include shortening test cycles, significantly improving the reproducibility of the results, reducing the workload on professional test drivers and, last but not least, reducing the environmental impact.

From Test Object to Test Winner

Every test series for a new product always begins with a diverse range of tests with different tread patterns to establish their individual strengths and weaknesses.

The quality of testing depends to a large extent on the test infrastructure and the professional test drivers, who supplement and interpret objective test objects with their own subjective observations. Together with the test hubs in Uvalde in the U.S. state of Texas, Arvidsjaur in Sweden, and Hefei in China, the Contidrom near Hanover is among the most advanced test tracks in the world. Test drives were first performed there back in 1967 and, just one year later, the first driverless vehicle entered service. To this day, the treads on the initial prototypes are often carved by hand. The best treads are chosen, optimized and undergo repeated testing until – finally – a tread pattern is identified that will later enter volume production. Before they enter volume production, new tire models cover 25 million kilometers every year on roller drum test rigs and test tracks – that's 625 times around the Earth! But this enormous amount of time and effort is more than justified because it is the foundation on which the premium quality of Continental tires is based – quality valued by carmakers and customers all over the world.

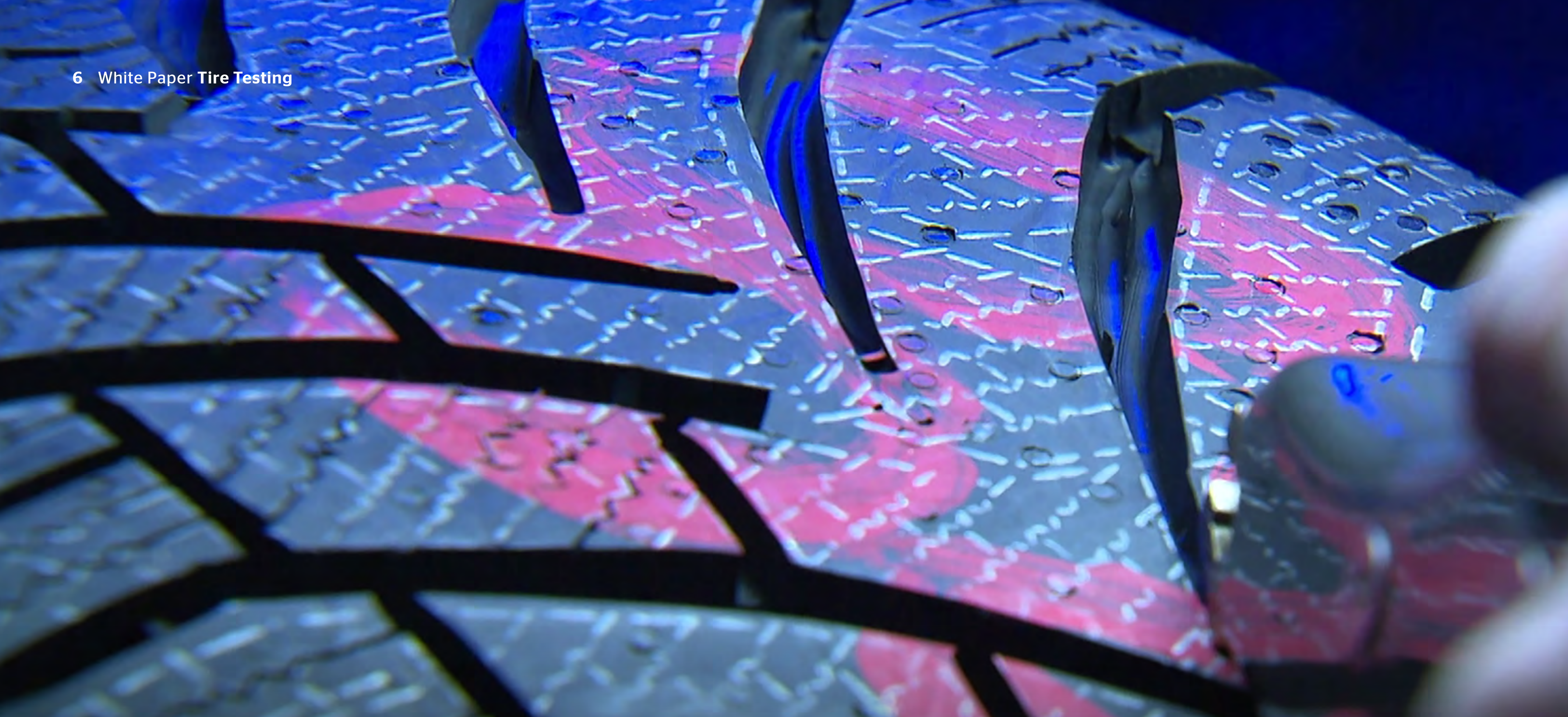
A Long and Proven Track Record

Carmakers all over the world trust in the quality of the products developed by Continental.

In addition, Continental tires frequently clinch the top spots in the comparison tests conducted by car magazines all over the world. Out of 830 participations in independent tire tests worldwide over the past 10 years, Continental tires have emerged with top marks in almost 8 out of 10 cases. Among the numerous honors are the “Overall Winner of 50 Years of Tire Tests” title, which is awarded by the German specialist magazine Auto Motor und Sport, as well as regular top rankings in the important tire tests performed by the German automobile association ADAC. This incredible success story is the result of the company’s unique development expertise as well as the outstanding test infrastructure and critical judgment of experienced test drivers.

Every new tire development process begins with what’s known as a “performance specification”, which details all the objectives regarding tire performance and, to a much lesser extent, appearance (e.g. directionally orientated tread pattern) that the project team or, in the OEM sector the customer, is expected to have achieved at the end of the process. The performance specification is the result of numerous engineers and chemists pooling their expertise, finding solutions to conflicting goals, and identifying potential contour designs as a result. The initial tread variants are then developed on the basis of this process.

Following extensive material testing in the laboratory and countless simulations, out on the test track is where the moment of truth finally arrives. Only then is it possible to see just how effective these new ideas and designs truly are. Although numerous steps are performed by means of computer simulations in the tire development process, there is no equivalent substitute for original measurement data and the subjective assessments of test drivers with their many years of experience. Every test series for a new product always begins with a diverse range of tests with different tread patterns to establish their individual strengths and weaknesses.



Hand-Carved Early Prototypes

What is remarkable about these early test phases is that no prototypes from the hot tire mold have been produced yet. Instead, the vehicles are fitted with prototypes featuring treads carved by hand or by a robot.

Every assignment begins with an engineering drawing, which is then transferred to a template from which the tread grooves are milled. With the template as a guide, the pattern is transferred to the blank tire. A series of precise number codes indicates the required depth for the sipes. A tire carver takes around six hours to create a summer tire, while the more complex winter treads take longer to carve – sometimes up to 40 hours. This may be a long and complicated process, but it's worth all the effort. The best treads are chosen, optimized and undergo repeated testing until – finally – a tread pattern is identified that will later enter volume production. Only then can the initial tire be produced in a series mold.

Tire Testing at the Contidrom Since 1967

Continental performs most of its tire testing for the European, Middle Eastern and African markets at the Contidrom.

The company's own test track in Jeversen, a small town in the Südheide Nature Park, was its first. It was opened back in 1967 and has been continuously modernized ever since to handle ever more stringent tire testing requirements. Today, the Contidrom is among the most technologically advanced test tracks in the world and, in 2013, received with the title "Proving Ground of the Year" from the international jury of the Automotive Testing Technology International Awards. No wonder so many customers in the automotive sector consider it to be the industry benchmark. Over a total area of 160 hectares, the proving ground covers every conceivable need when it comes to tire testing. Around the various sections of track, which add up to around 10 km and offer a wide variety of road surfaces – some of them specially wetted with sprinklers – and include the legendary full circuit with its steep banking, vehicles can reach speeds of more than 250 km/h. The grounds also include sections specially designed for testing chassis elements. More than 100 employees – including test drivers, fitters, technicians, engineers, data processors, firefighters and a catering team – help to ensure that everything runs smoothly and according to plan at all times.

http://contidrom.com/

Combination of Subjective Assessments and Standard Tests

The tests performed here fall into two categories: vehicle dynamics analysis and grip testing.

For example, during grip testing, the drivers perform a subjective assessment of the tire's wet and dry handling performance, ride comfort and noise.

Grip characteristics are measurable variables. These include:

- Wet and dry brake performance
- Aquaplaning resistance during straight-line driving and cornering
- Cornering performance on a wet stationary skid pad
- Traction, braking and directional control on snow and ice

All these findings are needed so that a comprehensive evaluation of the new tire can be prepared later. The extent to which the different procedures complement each other is demonstrated, for example, when the evaluation of tire road noise is analyzed. While the values measured both in the laboratory and on the Contidrom noise-measuring track might indicate that a tire more than fulfills the legal requirements, the test driver's subjective assessment may tell a very different story. Whether a tire develops unpleasant tire road noise that is annoying to the driver cannot be fully determined using objective measurement methods. The subjective impression, hearing and experience of the test driver are indispensable here. Other tire characteristics, however, can be determined only objectively or only subjectively. A vehicle's braking distance, for example, is an objective test result. When it comes to handling, however, results can vary even if the lap times are identical, which is why it is important for a tire to have a broad critical range to give the driver time to react. A tire with a narrower critical range might perform better in terms of lap times but still be considered not as good by the test driver.

The Enormous Effort Involved in Test Drives

Despite highly standardized procedures, the time and effort put into testing tires are immense – and this is especially true when it comes to winter tires because, in addition to the same tests that summer tires undergo, they have to be put through a whole range of further trials.

These tests also include analyzing the tire's ability to start on snowy ground, which involves well over 60,000 individual measurements annually. And when you include all the braking distance tests, such as braking from 40 km/h on snow and braking from 30 km/h on ice, that's another almost 800 kilometers that winter tires have to cover. And to assess directional control, the individual tire prototypes undergo 18,000 cornering maneuvers on ice and snow, covering a total of around 700 kilometers. To eliminate the effect of random factors, each individual test is conducted multiple times. Each test and tire type requires dozens of sets of four tires. All of this does not exactly add up to an easy task, so it's no wonder that testing can last for many months – and sometimes even many years. It's also hardly surprising that adverse weather conditions can sometimes make it impossible for testing at the Contidrom to continue. But even in situations like that, every effort must be made to ensure that the tire tests can still be performed within their very tight schedule, so the entire crew will take a flight to a different test track (always accompanied, of course, by at least some of the 25 metric tons of tires, test equipment and test vehicles). If necessary, this alternative test track might even be on another continent. Continental uses similar proving grounds in places like Spain, Asia, and the U.S.A., or hires out a test track in wintry New Zealand during the northern hemisphere's summer months. To ensure that testing can be resumed without any problems and because the engineers need reproducible measurement methods to assess the individual stages of development, the conditions on these alternative test tracks have to be comparable to those at the Contidrom. This is why the facilities and road surface characteristics of the Corporation's test tracks are as close to identical as it is possible to get. If necessary, the test drivers use other test tracks like the high-speed circuit in Nardò in southern Italy or, in exceptional cases, the Nürburgring Nordschleife. To put winter tires through their paces, Continental operates its own test center in Arvidsjaur, just south of the Arctic Circle.

1968: The First Driverless Test Vehicle

Given the highly complex, time-consuming process of driver-based tire testing, developers were constantly seeking ways to shorten test cycles through simulation and innovative automation methods.

More than 50 years ago, Continental was already doing groundbreaking work in preparing for the future of mobility. On September 11, 1968, Continental's first electronically controlled driverless car took to the Contidrom test track, to the amazement of the public in attendance. "The Future Is Here" and "Around the Banked Turn with a Ghost at the Wheel" were among the headlines. More than 400 newspapers, magazines, radio stations and television channels reported on the event. The actual purpose of this visionary project was to determine how tires could be tested precisely using scientific methods under programmed conditions. However, the Continental engineers were pushing the limits of what was technically possible at the time and, in a sense, were paving the way for the future of driving.

In the Mercedes-Benz 250 Automatic (also known as the "Stroke Eight"), the engineers installed a range of equipment including electro-mechanical steering, an electro-mechanical throttle regulator and a radio system for reporting measurements – cutting-edge technology at the time. In addition, the bumpers were adorned with an array of antennas, with the control electronics and an electro-pneumatic braking system housed in the trunk.

Via the wire to the car, the control station next to the test track sent commands telling it to brake, accelerate or sound the horn. The benefit of the completely new test system was that ruling out the possibility of human influence resulted in a considerable increase in the accuracy of the measurements. Meanwhile, the tests meant that the Contidrom, which had opened the year before, was being used to its full capacity for the first time.

Increasing Influence of Digitalization and Test Facilities

Engineers later started to utilize the benefits of increasing digitalization.

As early as the 1980s, computers were systematically deployed for a whole range of design, testing and optimization tasks. These simulations initially had little impact on the practical tire tests performed on the track, but they helped to cut the number of potential tire designs down to a manageable amount for actual testing. The more powerful computers and programs became, however, the more valuable they became in tire development and, in turn, the greater their impact on tire testing. For example, in 2012, developers at the technology hub in Stöcken, Hanover, used for the first time ever a method that had until then been used primarily in healthcare for diagnosing illnesses. High-tech tomography was capable of simulating driving-related loads such as braking, acceleration and cornering with such unprecedented precision that it was now possible to examine the behavior of specific internal components of car and commercial vehicle tires under the high loads acting upon them. This pioneering, non-destructive process yielded a whole range of illuminating insights because these individual internal components are constantly changing shape and position depending on the loads to which they are subjected. Tomographic methods enabled engineers to design new tires even better capable of efficiently transferring the forces generated during driving onto the road surface. In the same year, at the Contidrom, Continental opened the first facility of its kind anywhere in the world: the Automated Indoor Braking Analyzer (AIBA).

Fully Automated Brake Testing with AIBA

In 2012, Continental opened the Automated Indoor Braking Analyzer (AIBA) at the Contidrom proving ground. The building is around 300 meters long and up to 30 meters wide.

This one-of-a-kind facility allows the brake performance of tires fitted to fully automated driverless vehicles to be tested on different road surfaces – year round and regardless of the weather. The tracks can be used for wet or dry testing. The results are much more easily reproducible than with conventional methods because the effect of unpredictable external influences is taken out of the equation.

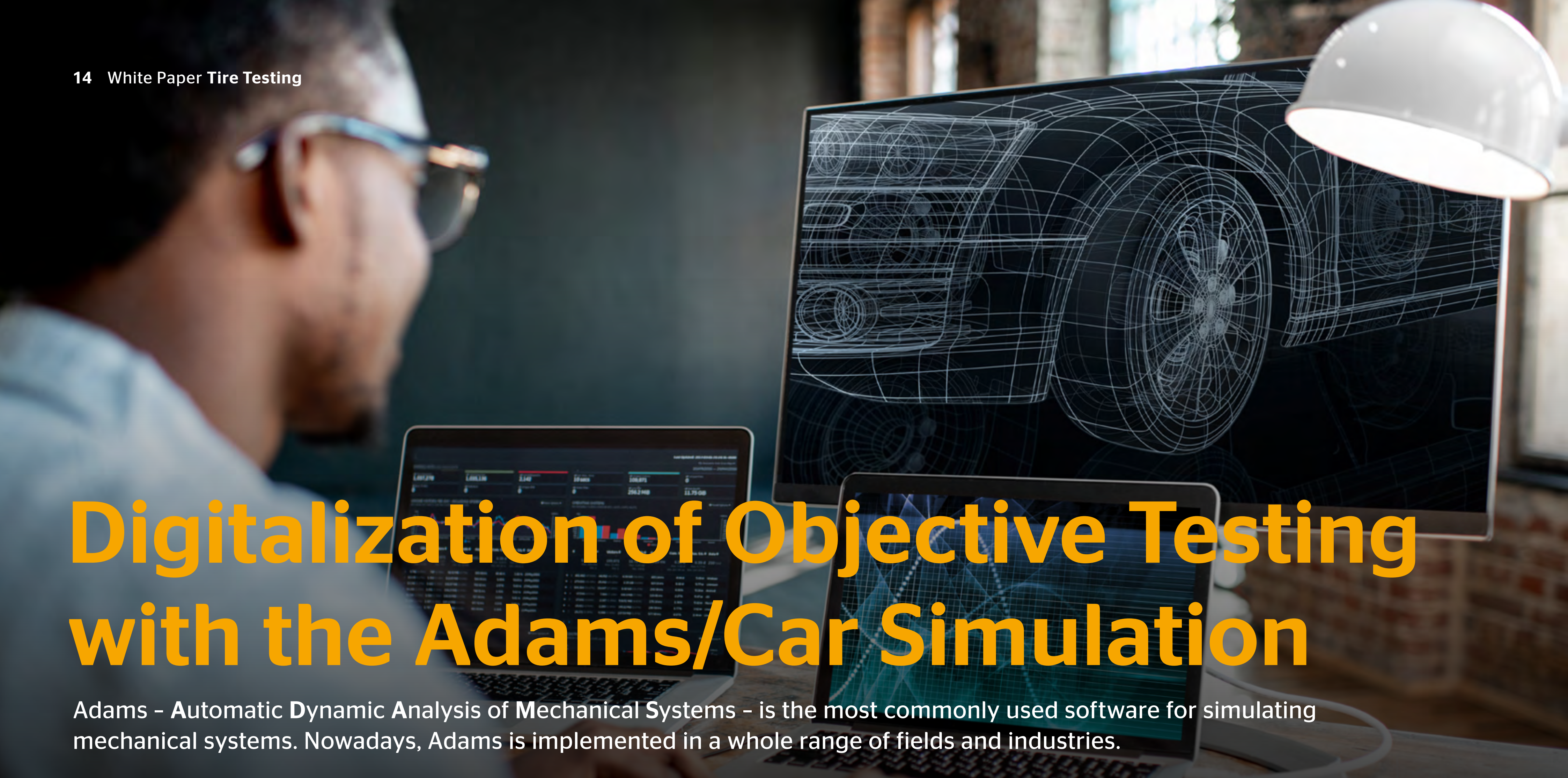
From the outside, it looks pretty unremarkable, but it represents a milestone in the development of test technology for summer and winter tires alike. Whatever the weather outside, in there up to 100,000 brake tests can be performed annually using fully automated driverless vehicles. In its climate-controlled zone, this high-tech facility has up to five “roadways”, which can be quickly and easily moved using special hydraulic equipment. The test vehicles are accelerated to speeds of up to 120 km/h by means of a linear drive – like on modern roller coasters – over a distance of just 100 meters. Standard dry brake tests are conducted from a speed of 100 km/h, while standard wet brake tests take place starting at 80 km/h. Precision braking is initiated with an ABS controller on a dry or wet roadway. In addition, the ambient temperature of the “summer roadway” can be set to between 10°C and 25°C. The brake test is recorded by a host of sensors on the wheel and in the vehicle. One test run – the drive to the starting point, acceleration, braking to a standstill and the drive back to the starting point – takes four minutes. That means that in theory, 15 tests can be performed every hour, 24 hours a day.

Thanks to this unique facility, Continental combines the benefits of lab-based and outdoor vehicle testing and employs the most accurate and high-precision brake test procedures anywhere in the world. Before it opened, tire testers had to perform the tests under ever-changing environmental variables like temperature and wind out on the very exposed Contidrom test track. The vehicles were guided along a rail, and the tire testers had to initiate braking themselves – even in situations where the ABS would otherwise deploy. In addition to the results already being distorted by a human’s reaction time and the force applied, the air and surface temperatures also led to a degree of scatter. But thanks to the AIBA, this systemic scatter can now be completely eliminated, leading to a 70% improvement in the reproducibility of the test results. Continental was now the first tire manufacturer in the world capable of performing tests under one roof all year round, whatever the weather.

2018: The Renaissance of the Driverless Test Vehicle

Exactly 50 years after the first driverless tire test vehicles started doing the rounds at the Contidrom, their state-of-the-art successors started doing the same in Uvalde, Texas.

The new driverless tire test vehicle for the proving ground in the U.S.A. was a version of the "Cruising Chauffeur" – a test vehicle developed by Continental for highway cruising – that had been specially modified to perform tire testing. While the focus of development with the Cruising Chauffeur was on automated driving to assist drivers along highways, the development team behind the Uvalde test vehicle are taking automation to a whole new level by modifying the tire test vehicles so that they can drive autonomously around the test track without a test driver even needing to be present in the vehicle. The medium-term aim is to send multiple autonomous test vehicles out onto the track simultaneously, all monitored from a control center. The primary goal is to perform optimized endurance tests on the different test tracks in Uvalde. Until autonomous vehicles were deployed, test drivers had to drive the vehicles hundreds of miles – often in extreme heat and extremely challenging environmental conditions – in order to identify any problems or anomalies with new tire designs or rubber compounds. Thanks to automation and the ability to control vehicles with exceptional precision, not only are the results more easily comparable but track usage is also optimized, helping to reduce wear and tear as a result.



Digitalization of Objective Testing with the Adams/Car Simulation

Adams – **A**utomatic **D**ynamic **A**nalysis of **M**echanical **S**ystems – is the most commonly used software for simulating mechanical systems. Nowadays, Adams is implemented in a whole range of fields and industries.

Adams analyzes the movement of three-dimensional mechanical systems in a highly realistic manner, taking into account all the physical interactions. It uses flexible elements to integrate elastic components and takes into account friction and complex contact states. The simulation results include the forces, positions, speeds and acceleration of all the system components.

In the automotive industry, Adams and the Adams/Car module have become the de facto standard. Engineers use the software to define joints, drives and flexible connection elements such as rubber bearings, screws, dampers and trace curves. But the engineers not only develop sub-systems like the body, chassis and drive train but also test complete vehicle systems. The simulation enables them to perform reproducible tests and analyses and examine a range of “What If?” scenarios before production of the first prototypes without the risks to test drivers and vehicles involved in physical testing.

By combining the Adams/Car and Adams/Tire modules, developers can add tires to a mechanical model and simulate driving maneuvers such as braking, steering, accelerating, idling or skidding. This software made it possible for the first time ever to perform highly complex and sophisticated objective tire tests in a virtual space. The program simulates the forces and torques acting on tires on normal roads or even bumpy terrain. It calculates the forces and torques exerted on the vehicle by the tires due to the interaction between the tire and road surface. With different tire models, developers can analyze the different dynamic responses of vehicles to steering, braking and acceleration. The simulation can deliver valuable insight even about the shock-absorbing properties of a tire and, in turn, ride comfort. The system analyzes vehicle vibrations in conjunction with different test tires on uneven roads with obstacles such as railroad crossings, ruts, or cobblestones, which generate short wavelengths.

Digitalization of Subjective Testing with the Driving Simulator

The Contidrom is home to a brand-new dynamic driving simulator capable of calculating exact driving dynamics parameters for the tires and the test vehicle. It is designed to provide Continental's professional test drivers with the same subjective driving impressions as tire tests on the test track. Continental is among the pioneers in the use of innovative hybrid test technology.

Since 2022, a "driver-in-the-loop" (DIL) simulator combines state-of-the-art technology with the extensive experience of our professional test drivers. To achieve this, the simulator will be fed with all the relevant data on the vehicle for which a new tire is being developed and supplemented by data from Continental on the rubber compound, tire architecture and tread design. This enables a test driver in the simulator to test a specific tire model for a specific model variant, allowing new tire models to be tested in all conceivable applications and driving situations and on a wide variety of surfaces, ultimately yielding useful and reliable results at an early stage of the development process – and for any vehicle and drive variant. The simulator can also be used for comprehensively testing and optimizing new material variants before the first test tire has even been made – after all, Continental is conducting extensive research into the potential of sustainable materials for tire construction.

With increased space of four by five meters and higher resolution, the Delta S3 simulator from Ansible Motion represents the absolute state of the art in simulation technology. Its ability to accurately evaluate tires in a virtual space ensures a more realistic experience including lane changes, tight and long-distance cornering and driving on different surfaces. The Delta S3 will also allow Continental's engineers to simulate acceleration procedures over a long period of time.

Every test cycle that is completed in the driving simulator instead of on real roads means fewer test tires that need to be produced. With the new driving simulator, Continental can shorten development times and optimize the use of resources in production and logistics. The project is also an integral part of Continental's extensive endeavors to improve sustainability. The company's goal is to become the most progressive tire manufacturer in being environmentally and socially responsible. To this end, Continental is investing significantly in innovative technologies and sustainable products and services along its entire value chain.

In case of any further questions, please get in touch with one of our Tires media contacts. You can find a list of contact persons **here.**

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