



AUTOMOTIVE TEST SOLUTIONS

Next Generation Test Solutions

Rev. 1, April 2025

TRUSTED PARTNER FOR LEADING-EDGE TEST SOLUTIONS

There's never been a more challenging time for professionals in the automotive test arena. New designs, shorter vehicle time-to-market, increased regulatory pressure, added features and the drive for cost efficiencies mean today's test and application engineers must be innovative and resourceful in approaching every test.

Technology is opening opportunities to integrate physical and virtual testing and that means going beyond the same old test equipment you have been using for decades.

At Moog, we understand what it takes to be successful in this industry. Combining the global resources of a billion-dollar corporation specialized in motion control solutions, the flexibility of a forward thinking engineering group with roots in test and simulation and customer collaboration to understand your needs and how you work, we deliver leading-edge solutions for automotive manufacturers and test labs around the world.

INNOVATION THAT DRIVES PERFORMANCE

Moog pioneered the commercial servo valve in 1951, contributing to the test industry as we know it through the application of precision motion control. Today Moog is a pioneer in introducing high-performance hydraulic and innovative electric-based technologies to the test lab, - creating the advantages you need to test faster and more efficient, test higher performance and accelerate product development

Our hexapod design is another example of how Moog's research and development has moved over from the aerospace world to help customers work more efficiently in 6-Degrees of Freedom (DOF) applications. It provides a minimal footprint and optimized power supply for a range of key test applications.

In addition, thanks to our experience in simulation and robotics, we're helping push the limits of human-in-the loop testing; allowing customers to safely incorporate a dramatically higher degree of test control and more accurate data generation.



GLOBAL REACH, PERSONAL TOUCH ON THE LOCAL LEVEL



In more than 20 countries worldwide, Moog representatives are ready to respond to your auto test needs. Whether it's providing a key Moog component or facilitating the design of a one-of-a-kind test rig, our technical teams have earned a reputation for taking on the toughest challenges and making them our own. And because we're truly a global organization - working in the world's key automotive manufacturing centers like Japan, China, India, Korea, France, Germany and the US - you can expect prompt turnaround times and a close, face-to-face working relationship with a partner who understands your market.

MEETING YOUR TOUGHEST CHALLENGES

TO IMPROVE YOUR APPROACH TO EVERY TEST, DISCOVER HOW MOOG'S TEST SOLUTIONS CAN IMPROVE YOUR COMPETITIVENESS BY HELPING YOU FIND NEW AND BETTER WAYS OF PERFORMING AUTOMOTIVE TESTS

Here are just a few of the areas in which our expertise and technology play a key role:

- Achieving more accurate data generation and faster testing
- Integrating physical and virtual testing
- Introducing electric technologies that allow higher frequencies
- Offering better solutions to 6-DOF applications
- Featuring both electric and hydraulic technology
- Incorporating both hardware and human in the loop (H2IL)

PERFORMANCE TESTING

Performance testing is the assessment of ride and handling behaviors that will optimize the quality and performance of a module or a full vehicle. This type of test involves extremely fast and precise measurements and can include a human-in-the-loop.

Our expertise combined with close customer collaboration is the key to more rapid, reliable and versatile performance testing. From human-rated tests to electric actuation to hexapod configurations, we provide leading-edge technology to meet our customer's needs and enable their creativity.



STRUCTURAL AND DURABILITY TESTING

Structural and durability testing involves quantitative tests of endurance, fatigue, and structural capabilities of components or modules.

Our approach to achieving faster and better tests on new models, parts and prototypes using electric and hydraulic technologies, ensures we can meet even the highest requirements for frequency, payloads and stiffness.

Moog expertise, combined with the world-class performance of our products such as fatigue-rated actuators, servo valves and test controllers make us a leader in providing both simple and complex structural and durability test solutions.



OUR SOLUTIONS - MULTI-AXIS TEST SYSTEMS

MULTI-AXIS TEST SYSTEMS CAN REFER TO SIMPLE OR COMPLEX TEST CONFIGURATIONS DEPENDING ON THE TEST ARTICLES, THE TEST ENVIRONMENT AND THE NUMBER OF AXES CREATED

In most cases, multi-axis test systems are used for structural testing applications that require higher performance in both acceleration and frequency response.

Whether it is hydraulic or electric, Moog delivers solutions for single and multi-axis structural and performance testing of parts, components, systems and subsystems.

Our world-class systems and components combined with our expertise ensures you will work with the solution that helps you test with higher performance, efficient and safe.

SEAT BACK FATIGUE TEST SYSTEMS

Precise control of position or force perfectly suited for testing of seating systems and components. Avoids pressure fluctuation and seal friction issues across loading, stroke, and frequency ranges.



SEAT BELT ANCHORAGE TEST SYSTEMS

Moog Electric Multi-Axis Test Systems are well suited for seat belt anchorage or similar strength tests because the industry standard load cells and absolute encoders provide fine resolution, the servomotors ramp loads smoothly and quickly, and the real-time test controller synchronizes all actuators by providing commands, recording signals, and monitoring safety data at thousands of points per second.



DOOR CLOSURE TEST SYSTEMS

Moog door closure test systems play a vital role in measuring vehicle durability and quality. Electric Multi-Axis Test Systems provide precise and repeatable position, velocity and force and record it all to provide reliability and confidence in test results.

HYDRAULIC SIMULATION TABLES

STRUCTURAL AND DURABILITY TESTING OF PARTS, ACCESSORIES, SYSTEMS AND SUBSYSTEMS

The hexapod configuration used by Moog Hydraulic Simulation Tables is the optimum design to achieve simulation and structural test capability using acceleration, force and displacement inputs, and to reproduce data collected on proving grounds regardless of your test type, method or specimen.

By understanding today's test trends and challenges, and listening closely to the needs of customers around the world, we developed different types of Hydraulic Simulation tables for specific applications.

The Standard Hydraulic Simulation Table can accommodate loads up to 680 kg (1,500 lb) and reach frequencies over 100 Hz.

The High Frequency Hydraulic Simulation Table is specially designed to reach higher frequencies, up to 200 Hz.

The Light Payload Hydraulic Simulation Table is designed for smaller and lower weight payloads of up to 300 kg.



THULE GROUP CONTINUES TO EXPAND SAFETY AND PERFORMANCE TESTING

Thule Group invested in a Moog Hydraulic Simulation Table and expanded its testing capacity by ordering a next-generation Moog Hydraulic Simulation Table that can achieve test frequencies up to 100 Hz. Due to Thule Group's growing product portfolio and the continuous focus on product safety testing needs have increased and so a second system was required."

Thule Group's decision to select Moog is based on the reliability and performance of the current hydraulic simulation table, the level of service provided over the years and Moog's technical expertise.

Eric Gustavsson, VP Product Compliance at Thule, said the test system has proven to be very successful: "We simulate 'time history files' to accurately replicate any specific road conditions needed for the tests. The system itself is very compact and because of its lay-out provides excellent accessibility to our lab personnel. Our lab's productivity is optimized by Moog's software and the fast and simple iteration process. We use it very intensively, running it constantly, 24 hours per day. As the company's testing know-how has increased over the years, engineers have been able to take full advantage of the test system's potential.

Gustavsson explains: "Different customers demand different types of tests and different test profiles.

The Moog system allows us to simulate a wide range of car types and sizes in different road and terrain conditions. It really enables us to simulate the most extreme conditions with high accuracy, within a short test set-up time.

This is of vital importance to our product development and qualification process, for which Thule is so well known."



ELECTRIC SIMULATION TABLES

RESEARCH AND DEVELOPMENT TESTS AND PERFORMANCE TESTING OF VEHICLES, SYSTEMS AND SUBSYSTEMS

Moog Electric Simulation Tables are used to perform research and development performance tests and driver training. Our experience in the design of electric hexapods and control systems enables us to provide customers with electric simulation tables capable of reaching frequency levels up to 35 Hz for test purposes.

Position, velocity and acceleration are controlled by the system through integrated control hardware and software. Depending on the configuration of the system, the simulation table can support payloads up to 28 tons, while requiring only a minimum of space in your test lab.

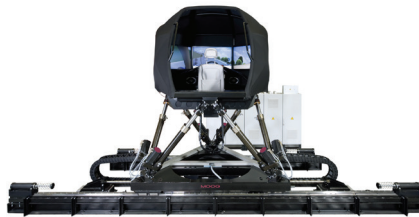
Typical tests performed with the Electric Simulation Table are driving simulation, ride and comfort testing, qualitative evaluation for human response, vehicle components (e.g. fuel tanks), kinematics and compliance, NVH (noise vibration and harshness), BSR (buzz, squeak and rattle testing), functional testing (e.g. turret testing and antenna testing) and medical research.



Ride and comfort testing



Fluid tank testing



Driving simulator testing



Antenna testing

MOOG DEVELOPS INNOVATIVE FUEL TANK TEST SYSTEM FOR FIAT

The test system is designed to perform dynamic functional tests on automotive fuel tanks, with the ability to simulate real-world road conditions. The behavior of the liquid fuel and components of the fuel tank system can be tested and evaluated. The test results allow the customer to optimize the desired configurations and verify the design of specific fuel tank systems.

The patented 8-DOF (degrees of freedom) Moog test system is comprised of a 6-DOF Electric Simulation Table with an innovative extra 2-DOF tilt table on top for increased pitch and roll motion. The Electric Simulation Table is used to reproduce the higher frequency road profiles, where the tilt table can simulate the cornering and acceleration behavior of the vehicle. This allows for the inclusion of different conditions during driving that

lead to extreme fuel-sloshing effects, such as mountain driving, instant braking or very sharp cornering maneuvers. In addition, the Moog Replication and Moog Sinesweep Test Module software enables the user to replicate and play out time history drive files that were recorded at the test track or perform resonant-frequency research.

“We look forward to testing the functionality of our fuel tanks in a realistically simulated environment. We expect that the Moog test system will increase the speed of testing and save cost, because we can limit the use of outdoor test tracks. The laboratory setting will allow us to setup tests faster and to run the test programs whenever we need to and under repeatable conditions,” said a customer’s engine systems testing representative.

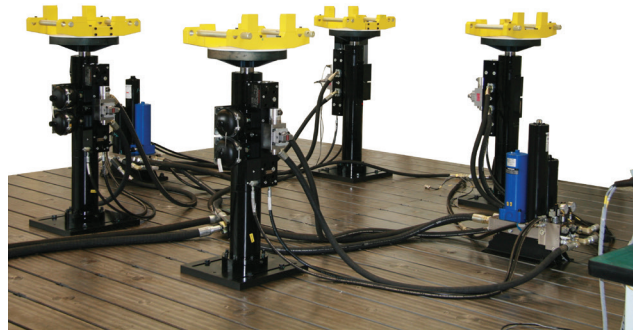
SIMULATION SYSTEMS

STRUCTURAL, PERFORMANCE AND DURABILITY TESTING FOR RIDE QUALITY EVALUATIONS, NOISE AND VIBRATION ASSESSMENTS AND SQUEAK AND RATTLE

The Moog Tire Coupled Simulation System provides vertical inertial loads through the vehicle's tire patch. Simulating vertical acceleration or displacement inputs of the wheel from data collected on the proving ground road, the system is used throughout the vehicle development process.

From ride quality evaluations to noise and vibration assessments of design candidates and prototypes, the Tire Coupled Simulation System has become an invaluable asset for the product development engineer in their research labs.

The system is also deployed in durability test labs to prove out selected structural, chassis, and suspension designs. Production and assembly facilities use it to assess squeak and rattle concerns at end of line tests.



HIGH FIDELITY MOTION SYSTEMS FOR IMMERSIVE TRAINING

Experience the immersive VR training platform showcasing our capabilities using motion systems, HMD motion compensation software, control loading and motion platforms.

Moog's Motion Compensation Software prevents the uncomfortable mismatching between the sense of motion and the visual input to the user. In this groundbreaking demo, users step into a virtual world with unprecedented comfort and fluidity. Moog Motion employs advanced algorithms and motion sensors to sync virtual movement with real-world sensations, ensuring a seamless and truly immersive experience.

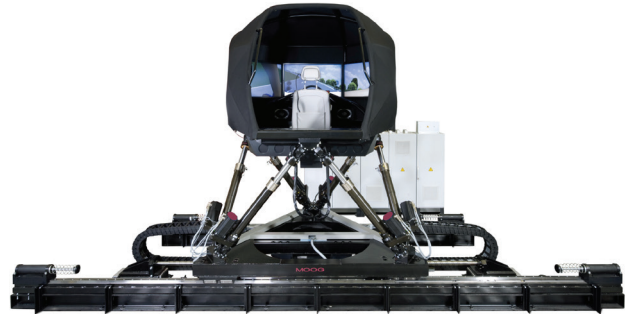


DRIVING SIMULATORS

FROM DRIVER TRAINING TO VEHICLE DEVELOPMENT HYDRAULIC SOLUTIONS

Until recently driving simulators were used mainly for driver training (truck, bus, car, motor) and HMI (Human Machine Interface) investigation. Due to a dramatic improvement in simulation software, vehicle models and computer performance, driving simulators have become a viable tool to reduce development time and costs while improving the design of vehicles and components.

Moog can supply complete customized systems for these applications with integrated simulation software as a turn key solution. With deliveries to world leading automotive suppliers and manufacturers, such as Daimler, Ferrari, Dallara and others, Moog plays a leading role in designing and delivering high performance driving simulators adapted to your specific requirements.

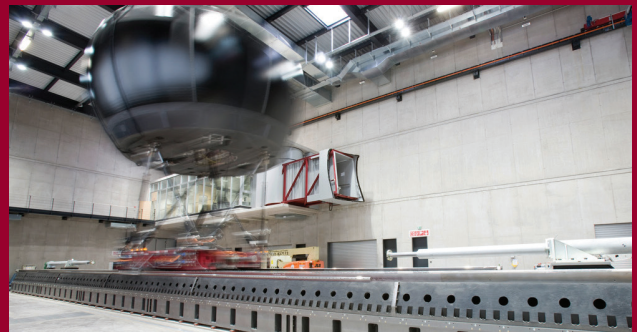


DAIMLER LEADING-EDGE DYNAMIC DRIVING SIMULATOR

Moog provided the high dynamic motion control system and software portion of the Daimler AG driving simulator, located at the Mercedes Benz Technology Center in Sindelfingen, Germany. Moog's motion control expertise is part of the successful development of this dynamic driving simulator.

The Moog electrical motion base is a hexapod consisting of six moveable legs supporting a dome. Inside the dome there is a full-size Mercedes-Benz car model where test drivers sit and view a 360° projection screen showing real-life traffic scenes with moving pedestrians, oncoming traffic and buildings. The entire motion system is mounted on a lateral rail, which allows for the simulation of sideways movements, such as lane changes. The complete motion system is controlled by Moog real-time software. From the driver's inputs to pedals and steering wheel the Daimler

vehicle models calculate position, velocity and acceleration data. Moog software ensures that this information is translated to movements in the hexapod and lateral rail so the driver's expectations are matched. Consequently, driving the simulator feels the same as driving a car.



DALLARA ACCELERATES RACE CAR DEVELOPMENT AND ENHANCES DRIVER TRAINING

Dallara, a leading car manufacturer, had been looking for a way to effectively shorten product development time and reduce the cost of testing and driver training compared to track testing. Dallara asked Moog, the market leader in electric 6 DOF (Six Degrees Of Freedom) motion bases, to provide the motion system with dome, steering wheel control loading, electric cabinet with real time controller and real time PC with Moog cueing software to enhance the performance of its driving simulator. The solution is based on high-fidelity motion simulation technology that has been used successfully in innovative test and training systems for the aerospace, defense and automotive industries.



TEST CONTROLLERS TO EFFECTIVELY SETUP, RUN AND MONITOR YOUR TESTS

Moog delivers the flexibility, innovation and trusted solutions you need for an effective approach to automotive testing. Moog Test Controllers incorporate a unique control-loop technology for high-performance control of force, displacement and acceleration. Thousands of Moog control channels have been installed and used daily in test labs around the world for decades.

TEST CONTROLLER

The Moog Test Controller is a real-time modular control system that can control or collect data from any hydraulic or electric test system. The robust and compact modules have a wide range of transducer inputs and control outputs that can be easily configured for optimum use. The Moog test software allows the end user to control and record all of



these signals in an easy to use format providing maximum value for many years of reliable usage.

Applications

- X-poster test rigs
- Hydraulic simulation tables
- Electric simulation tables
- Buzz, squeak and rattle (BSR) testing
- Structural static and fatigue test systems

Advantages

- Reliable results
- Unsurpassed precision
- Easily configurable

COMPONENTS TO ENSURE BEST PRECISION

SERVO VALVES

Moog Hydraulic Test Actuators and Simulation Tables incorporate our well known servo valves. Moog Servo Valves are known for their exact tolerances, high performance and durability. They are the preferred choice of leading test engineers and set the world standard for hydraulic servo valve performance.



stiffness and increased side load capabilities. They have a robust design which offers low maintenance due to improved seal life, and improved cushion design (improved energy dissipation).

HYDRAULICS

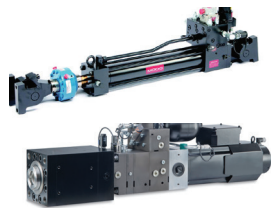
The Moog Modular Hydraulic Service Manifold (M-HSM) provides an effective hydraulic engagement and isolation control to a test system or individual hydraulic actuator.

Typically, the M-HSM inlet ports are connected to a central Hydraulic Power Unit (HPU). The outlet ports are connected to servo hydraulic systems or actuators. Moog M-HSM is designed to be working under 280 bar system pressure, and the maximum rated flow capacity is ranged from 400 to 1000 l/min. The M-HSM can be connected with up to 4 control stations (more on request) and supply each station with the maximum flow of the size.



TEST ACTUATORS

High-performance hydraulic and electric test actuators are incorporated in our single- and multi-axis test systems, simulation tables and tire coupled simulation systems. Various types are available, such as short and longer stroke electric test actuators to service specific test applications. Hydraulic test actuators are available with hydrostatic or polymer bearings depending on the needed performance. Our hydraulic test actuators are engineered to deliver consistent performance over hundreds of millions of cycles. They provide increased reliability,



The M-HSM can provide Off/Low/High controlled hydraulic pressurization to the test system to establish smooth hydraulic engagement which helps avert pressure surges to the test system or damage to the specimen.

SERVICE AND SUPPORT

FIVE POINT INSPECTION PROCESS

Our number one goal is to eliminate downtime and make repairs that will deliver reliability and cost savings for years to come. When you send in your repair, it must work like new when you get it back. This is the Moog Global Support® promise.

- Incoming inspection will provide the customer details on the performance of the assembly. For actuators it could be leakage or response. For electronic modules it could be a non-functional connection. The inspection will also provide details to our technicians in regards to critical performance specs that need to be addressed.
- Technicians will then review engineering notes for any design improvements that may have been initiated since inception.
- Servo valves are removed and sent through the same rigorous evaluation, disassembly and test.
- Finally, the individual component or assembly will be tested to original specs to ensure the overhauled unit meets all design and performance criteria as if it were new.

MOOG ENGINEERING ON CALL FOR YOU

In today's competitive manufacturing environment, machine performance plays a significant role in determining your bottom line. Moog Global Support is key to achieving cost-effective machine operation, day in and day out.

We are committed to providing world-class motion control products and solutions, taking customer support far beyond the initial sale. Our dedicated approach solves your problems, addresses your machine challenges, and allows you to achieve maximum productivity on a daily basis.

REPAIR CAPABILITIES

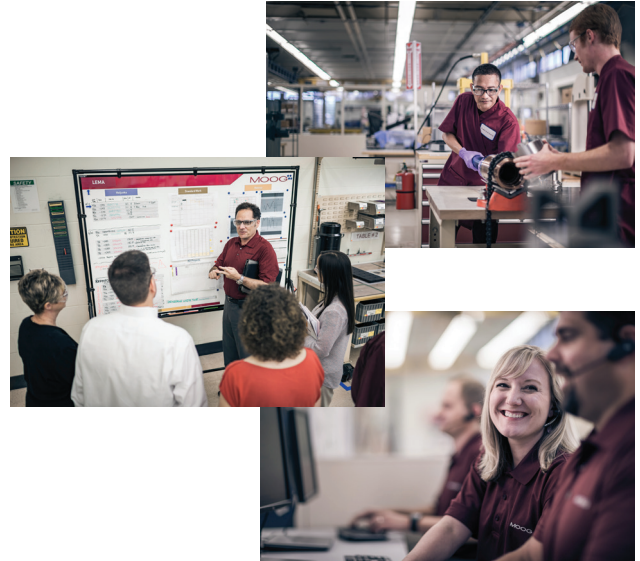
Moog Global Support® is designed to keep your critical machines up and running at peak performance with only 100% genuine Moog replacement parts. Only Moog replacement parts can deliver the reliability, versatility and long life that you would expect from a world leader in motion control solutions. Each Moog part delivers essential components with precise dimensions, close tolerances and specifications. Because we understand the key role our parts play in the overall operation of your



machine, we carefully inspect and test each repair to identify only those components that need replacement.

THE MOOG DIFFERENCE

It's time you worked with a partner who can offer both the world-class products you desire and collaborative expertise you need to reach the next level of performance. Contact us today to see the difference Moog can make.



THINKING ABOUT AN UPGRADE?

Our servo valve products include cleaning, repair and trade-in programs to keep you running or using the latest technology.

Our software maintenance agreements keep you up-to-date with the latest features, stabilizing updates, and ease-of-use improvements.

Our control hardware includes updates to processors, storage space, and multi-range conditioners as changes occur to add years of useful life to your initial purchase.

Do you have an analog test controller?

Moog can provide a digital controller to provide commands to the existing controller as a transition to full digital or a drop-in replacement in one step. Why not take advantage of the many features digital controls can bring to your tests like advanced control loops and sequenced tests, built-in data acquisition, and settings that can be saved for future use. Contact Moog for more details!

MORE PRODUCTS. MORE SUPPORT.

Moog designs a range of motion control products to complement those featured in this document. Moog also provides service and support for all of our products. For more information, contact the Moog facility closest to you.

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