

# RACE WINNING MOTION CONTROL



MOTORSPORT SOLUTIONS

# MOTORSPORT AND MOOG - A WINNING COMBINATION



## MEETING YOUR CHALLENGES

Motorsport presents a number of unique challenges to motion control suppliers. Whereas Formula 1 looks for low weight, small size and performance, rallying looks for ruggedness and the ability to perform reliably in fairly brutal conditions such as extreme temperatures, adverse weather and demanding time constraints. Moog has been at the forefront of sub miniature actuation systems in motorsport since 1982, initially supplying active ride height equipment to Team Lotus for use on their Lotus 92 Formula 1 car. Over the intervening years, Moog has continuously developed a range of products and systems for actuation in many types of motorsport including Formula 1, World Rally Championship (WRC), Moto GP, Touring Cars, and WEC prototypes.

## PRODUCT HOMOLOGATION

All Moog electro-hydraulic and hydro-mechanical products used in Formula 1 are homologated by the FIA, this indicates they are approved for use with the standard Formula 1 Electronic Control Unit (ECU).



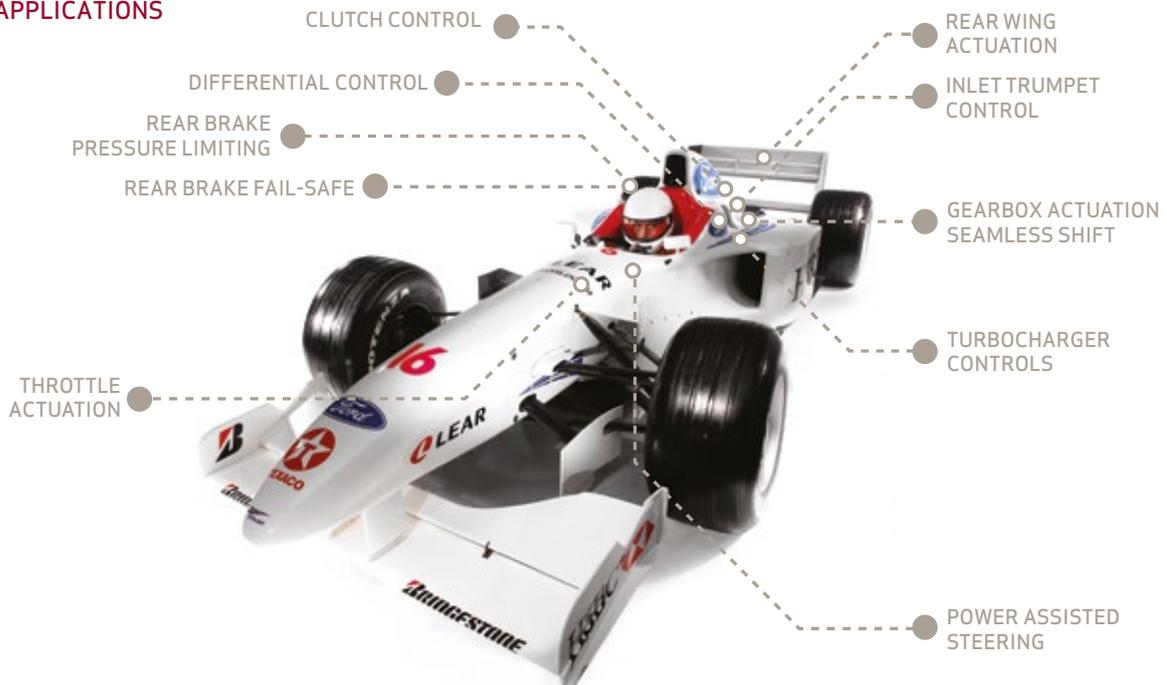
## CAPABILITY

Moog has a dedicated global motorsport design, development, manufacture and service center based at its Tewkesbury facility in the UK. This center has a specialist team of engineers, designers and product managers working on motorsport product development and custom systems. Moog's application engineers stay abreast of the latest motorsport regulations, and offer expert advice on the design of systems. Moog can also offer assistance with system simulation and modelling.

## MOOG OVERVIEW

Moog has developed a reputation throughout the world as a company with employees and motion control products that are at the forefront of the aerospace and industrial industries. Moog's high-performance actuation systems and components control human-rated spacecraft, launch vehicles, satellites, missiles and aircraft. We also provide controls on a variety of industrial machines manufactured and installed all over the world – installations where flow, precision, velocity, force and acceleration are critical.

## FORMULA 1 RACING CAR TYPICAL 2019 SEASON APPLICATIONS





## TEST AND SIMULATION

Applying state of the art test techniques has become essential in creating successful new high performance automotive products and sub-systems.

Moog's technological expertise and reputation for innovation, along with close customer collaboration, are key reasons we have rapidly become a leader in high performance test and simulation systems.

Creative designs and incorporation of world-class servomotors and actuators ensure that Moog's systems can reach higher levels of fidelity, efficiency and longevity.

Proven experience in flight simulation and an ability to enable human beings to participate in the testing are key advantages we offer to motorsport design and development facilities. This "human-in-the loop" technology sets us apart from other system providers and is crucial in developing tests requiring feelings of comfort and realism.

With thousands of motion bases developed for leading customers around the world, Moog is a global leader in the design, development and manufacture of electric and hydraulic motion platforms that span a variety of key applications with payloads ranging from 1,000 Kg (2,200 lbs) to 16,000 Kg (36,000 lbs).

From ride and comfort testing to driving simulation, our complex test rigs can provide full evaluations for components as well as full vehicle testing to ensure quicker and better product development.

## MOOG DRIVING SIMULATOR HEIGHTENS REALITY OF VIRTUAL TEST LAPS FOR FERRARI DRIVERS

Ferrari and Moog teamed up on a multi-million euro development project, which led to the creation of the Ferrari Driving Simulator. This new collaborative development simulates real race track scenarios and tests different aspects of an F1 racing car. The Driving Simulator has an integrated motion control and testing system, complete software package, cockpit and a dedicated operator workstation.

### The Challenge

Ferrari required mechanical frequencies high enough to help drivers get the most accurate feel of the car. Velocity and acceleration levels had to reach a level never met before by such a system.

### The Solution

Moog's project management and engineering teams worked very closely with Ferrari engineers at Moog's facility during the development of this driving simulator. Moog met Ferrari's every specification and expectation for a system that can develop car designs as well as deliver driver training.

This helped Ferrari to realize the maximum benefit from high performance motion control systems and the design of new actuators to deliver the desired strength and stiffness at a lower weight.

### The Result

- The new simulator offers test drivers a heightened sense of driving reality as well as a being highly responsive and receiving immediate feedback from their actions.
- High bandwidth and low latency makes braking and steering more responsive creating the high fidelity test drivers need to correctly feel and assess the car's behaviour.
- Test drivers can feel the difference of a modification to a part or component of the car without the risk of a high acceleration rate of real test driving.
- Current and future car designs, the training of new drivers on multiple F1 circuits, cuts track time, enabling better planned training which is not determined by the weather conditions.



# HIGH PERFORMANCE MOTION SOLUTIONS

Whilst we are generally known for our Servo Valves, we also produce a range of other sub miniature proportional valves and actuators for use in motorsport and other applications requiring high performance solutions and minimized size and weight.

## E024 SERVO VALVE

The E024 Series Miniature Servo Valve is available in two basic versions: a standard version with a linear flow gain characteristic and a high resolution dual gain version. The E024 Series was developed from the proven E030 Series aerospace Servo Valve that is widely used for control surface actuation in civil and military aircraft.

It is ideal for motorsport applications where very high levels of power density are required, that can not be achieved with electrical actuation. These include: selector drum positioning, clutch control, throttle control and torque control in limited slip differentials.



## E024 SERVO VALVE WITH LVDT

This special version of the E024 Series motorsport servo valve incorporates an integral Linear Variable Differential Transformer (LVDT) position sensor. The 5 wire LVDT with high temperature capability, permits continuous monitoring of correct valve operation.

This valve is designed to be used in safety critical control systems where it is essential that the correct operation of the valve is continuously monitored. Typical applications include motorsport braking systems and other applications requiring control loop integrity.



## E050 SERIES SERVO VALVES

This range of valves is a development of the well established 30 Series Aerospace Servo Valve. The motorsport version has a higher temperature capability, performing to specification at temperatures at 165 °C (329 °F). It also has improved environmental sealing using precision o-ring seals to protect the pilot stage. These valves have been widely adopted by the rally car industry, which requires higher flow rates up to 10 l/m (2.64 USg/min), and long service life in difficult environments.



## E242 CARTRIDGE DIRECT DRIVE VALVE (DDV) PROPORTIONAL VALVE

The E242 Cartridge DDV Proportional Valve was developed especially to meet the demands of the rally car industry. Of cartridge construction, it uses a robust linear electric motor to actuate the flow control spool. The maximum flow capability of 18 L/min (4.8 USg/min) is able to meet the requirements of the majority of motorsport applications. The cartridge design permits compact packaging on applications where multiple valves are required to be mounted in a single manifold. The Direct Drive design is extremely resistant to hydraulic contamination allowing the valve to be used in challenging environments.



## E243-500/501 FAILSAFE SWITCHING VALVES FOR BRAKE SYSTEMS

Derived from the proven Moog PAS Valve, the E243 - 500/501 is designed for use in conjunction with a 3-way solenoid valve, and can be used for on-off actuation in applications such as Brake By Wire (BBW) and Rear Wing (DRS). An energy efficient - close fitting spool with negligible leakage, it can handle control flows of up to 15 l/m (3.96 USg/min), and incorporates a seal on the spool for fluid separation, and the Perlast seal options are compatible for both brake and HPU hydraulic fluids.



## E243 LINEAR POWER ASSISTED STEERING (PAS) VALVES

An alternative to the Moog Rotary PAS Valve, the linear unit is an easy to use, closed-center Power Steering Valve which can be applied to any vehicle having a high pressure hydraulic supply. The design allows easy tuning both for the level and the linearity of assistance. These valves have been successfully applied in Formula 1, Rally Cars and Le Mans cars.



## E085 MINIATURE ACTUATOR WITH EDDY CURRENT SENSOR

Moog offers a range of sub-miniature actuators optimized specifically for motorsport applications. Many of these designs incorporate a robust integral eddy-current position sensor along with external conditioning electronics. This type of sensor, already widely applied in motorsport applications was chosen because of its ability to withstand high temperature and vibration levels. Actuators can also be supplied without a transducer or with an external LVDT position sensor if required. Typical applications include throttle actuation, gear box indexing, clutch control and turbo charger wastegate actuation.



## MINIATURE HYDRAULIC POWER UNITS

Moog can provide a range of miniature hydraulic power units for 12 and 24 Volt operation. These units use a high efficiency axial piston pump powered by a custom designed brushless motor. The associated electronic controller provides closed-loop control of pressure in a hydraulic accumulator supplying a hydraulic system.



## SERVO CONTROLLERS

Moog has a wide range of 12-24 volt electronics for automotive/mobile applications. These include analogue/digital servo controllers as well as a wide range of signal conditioning modules.



## E081 INTEGRATED MOTORSPORT SYSTEMS

If required, we have the capability to design, manufacture and deliver complete motorsport motion control systems, utilizing either hydraulic or electrical actuation technology. Working together with the customer, to evolve a detailed specification we can assist with the detailed design and supply a complete package. Typically, these systems are fully tested at Moog in conjunction with the customer's ancillary hardware, before delivery, enabling fast development times.



## E050 FUEL REGULATING VALVES

The E050 Fuel Regulating Valve is a precision two-stage pressure regulator designed to be used in conjunction with a fixed displacement fuel pump. The two stage design yields a constant fuel pressure independent of pump delivery. Weighing in at just 28 gm (1 oz), it is much smaller and more accurate than a conventional diaphragm valve.



## PRECISION BALL SCREWS

Moog can provide a wide range of customized precision ball and roller screws for high performance applications. These are used in applications which require accurate positioning, with the ability to generate high loads and acceleration. This technology has been successfully applied to inertial damper ( J-damper ) applications in the Motorsport industry.



## BRUSHED AND BRUSHLESS MOTORS

In addition to miniature hydraulics components for Motorsport, Moog also offers a revolutionary range of miniature electric actuation technology. These include power dense high performance brushless motors- some with integrated drive electronics, as well as direct acting linear electric motors.

These products were originally developed for the space and defense industry, and are therefore particularly suited to the harsh requirements of motorsport applications.



## TOTAL SUPPORT



Delivering world-class motion control products and solutions means taking customer support far beyond the initial sale. It requires a dedicated approach to addressing your challenges and helping you achieve maximum productivity on a daily basis.

The Motorsport Center incorporates its own production and service facility, complying to Class 100,000 aerospace clean room standards. In addition to the UK facility, there is a dedicated team of motorsport specialists strategically placed at worldwide locations.

With rapid turn-round often required, motorsport customers benefit from a dedicated repair service, where a team of specialists provide anything from a functional test, to a complete strip down, repair and assembly, with specialist diagnostic reporting.



## SPECIALIST PRODUCTION TECHNIQUES FOR MOTORSPORT APPLICATIONS



Our capability includes the ability to produce extremely precise close-fitting cylindrical components using technology developed from Moog Servo Valve manufacture. Typically we can achieve diametric fit tolerances of 1.25 micron and axial tolerances of 2.00 micron using our temperature control machining and measurement facilities.

Furthermore, we have extensive expertise in the precision spark erosion of a wide range of features in a variety of materials and the manufacture of complex hydraulic manifolds.

Typical Applications include miniature manifolds, state of the art brake components, steering systems, fluid control and hydraulic and electric actuation.

## MOTORSPORT TECHNOLOGY IN OTHER HIGH PERFORMANCE APPLICATIONS

A by-product of competitive international motorsport is the active fostering of engineering innovation. Many technologies first seen in Formula 1 or rallying have transferred from the race track to result in performance benefits across our industrial and aerospace product ranges. Engineering teams work across both disciplines and a cross-pollination of ideas is something Moog encourages.

### SPECIAL EFFECTS



Our motion control systems are used in the film and theater industries.

The most common applications are robotics, electric/hydraulic actuation, and motion bases used for special effects, often in conjunction with Computer-Generated Imagery [CGI].

Some examples of films which have utilized Moog systems are:

Harry Potter, Sweeney Todd, Blackhawk Down, Saving Private Ryan, Judge Dredd, Casino Royale.

### AUTONOMOUS ROBOTS



Autonomous robotics require sub miniature components capable of delivering high forces. Our products can now be found in some of the world's most advanced mechanical robots where mobility, agility, dexterity and speed are required.

### MEDICAL



Medical engineering often uses precise motion control systems with some similar miniaturization to those of motorsport. Moog has provided both components and systems for a diverse range of medical applications such as sophisticated athletic training and rehabilitation machines.

### OIL AND GAS



The demanding environment of sub-sea engineering is a significant market for Moog. Our products and systems are used on Remotely Operated Vehicles (ROV), used for subsea, construction, maintenance and cable laying, where space is at a premium.

Typical applications are:

- Propulsion thruster speed control on autonomous vehicles
- The remote operation of robotic manipulator arms
- Transmission control for tracked vehicles on the seabed
- Steering controls and power generation for Measurement While Drilling (MWD), Logging While Drilling (LWD), and Tractor downhole tools

# PROFESSIONAL SERVICES TAILORED TO YOUR UNIQUE NEEDS



## REPAIR

Moog's factory repair services deliver less unplanned downtime

Benefit from "like-new" or customer specific performance in your machine without unnecessary tuning

Minimise risk of poor repair by non-authorized repair facilities with no access to authentic Moog parts, product specifications, valve test parameters or upgrades

Gain confidence, with 12 month warranty protection, extendable to 24 months. Only available from Moog as the OEM



## TRAINING

Get hands-on training from Moog trainers using Moog equipment in our facilities, on-site or with our approved training partners

Learn how to effectively manage installation and troubleshooting on your own

Speed up repair and maintenance in order to maximize uptime



## FIELD SERVICE

Reduce risk and keep machines up and running faster with expert support

Supplement your staff with expert professionals who know your applications

Benefit from less downtime and access to original drawings and documentation

Available in person, online, over the phone and via remote diagnostic tools



## RETROFITS/UPGRADES

Take advantage of exact replacements for multiple Moog motion control products to achieve "as-new" or customer specific performance

Improve the quality and performance of machines underperforming with retrofit components that incorporate the latest technology upgrades

Work with Moog technical experts who can recommend a course of action to add extra reliability to your operations



## OEM PARTS

Moog is the only provider of OEM replacement parts

Ensure industry-leading performance in your machine

Take advantage of global availability of spare parts

Gain greater output and longevity of products due to Moog's continuous design improvements



## FLEXIBLE SERVICE AGREEMENTS

Shift from unplanned "break and fix" approach to planned maintenance that will minimize risk of failure

Tailor a flexible and bundled program that focuses on your operating challenges

Reduce your total cost of ownership while taking a proactive approach to O&M services

# TAKE A CLOSER LOOK.

Moog designs a range of products that complement the performance of those featured in this catalogue. Visit our website for more information and the Moog facility nearest you.

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