

HIGH PERFORMANCE MOTION CONTROL FOR MARINE APPLICATIONS

The Marine Industry

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The marine industry faces many challenges in operating environments that are both harsh and unpredictable, and in which shipping of all types must be able to operate around the clock. In such a diverse and demanding marine market, shipbuilders are under increasing pressure to provide technology capable of delivering excellent performance and lower operational costs, as well as energy savings, noise emission reduction and shorter machinery downtimes.

The industrial marine sector is also undergoing significant and broad technological changes, which include increasing digitalization as well as a need for lower emission levels and higher safety standards among many others. Marine systems and equipment engineers face all of these challenges, and are required to provide innovative solutions that add value to onboard technology.

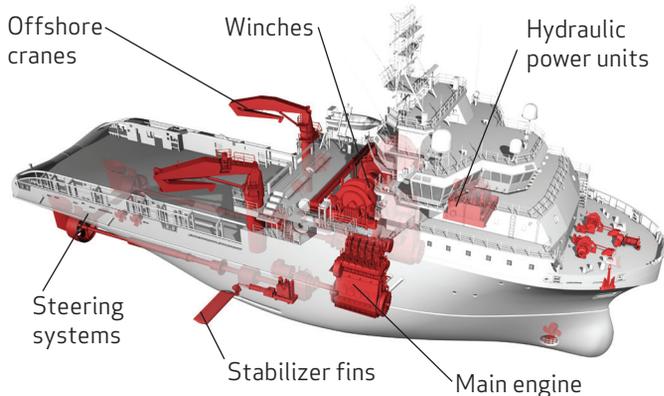
Moog's products and solutions can meet the demands of the marine sector's extreme operating environments, and deliver reliable, long-life performance for a range of shipping applications.

Our experience in tailoring high-performance motion control technology to specific machinery requirements, provides our customers in the industrial marine sector with a unique competitive advantage. Moog products can be used successfully across many types of industrial shipping vessel that perform a wide variety of tasks.

As a trusted motion control partner for the marine sector Moog offers flexible, comprehensive and timely global support that ensures onboard applications function reliably around the clock.

APPLICATIONS THAT BENEFIT FROM OUR RANGE OF ELECTRIC AND HYDRAULIC SOLUTIONS

Moog's products and solutions consistently perform in the world's harshest environments. Offering leading-edge custom solutions and services that set the pace in today's rapidly changing global marine industry



SHIPBUILDING - ROBUST MOTION CONTROL TECHNOLOGY FOR ALL WEATHER OPERATIONAL RELIABILITY



Moog develops and manufactures motion control technology for the marine industry delivering excellent, round the clock application performance in the most extreme weather conditions. Our products have a long service life and range from Electrohydrostatic Pump Units, High Torque Servo Motors, Servo Valves and Radial Piston Pumps, Slip Rings and Rotary Unions that meet the demanding requirements of onboard applications such as engines, steering systems and deck cranes. We provide experienced engineering support that helps ship builders and integrators reduce the onboard machinery footprint, limit noise and vibration levels while lowering fuel use and exhaust emissions.

With over 50 years of experience delivering motion control solutions to the shipbuilding industry, our extensive product range is proven and project ready for your applications.

FLOATING PRODUCTION SYSTEMS



The search for new oil and gas reserves has continually forced offshore exploration companies to drill in deeper water. Under these conditions, water depth and harsh weather heavily influence which type of installation to use.

We design, manufacture and deliver unique Floating Production System swivels to meet the demanding requirements of offshore operators worldwide. Typically comprised of Electrical Slip Rings, Toroidal Fluid Swivel and Fiber Optic Rotary Joints, swivels are used in a variety of Floating Production Systems (FPS) including buoys, turret moorings and offshore loading towers.

REMOTE OPERATED VEHICLES (ROV)



ROVs have revolutionized our ability to work efficiently and effectively below the surface of the world's oceans. Whether the task is related to deep-sea scientific exploration, Naval defense operations or supporting offshore oil and gas developments, today's ROVs have evolved into very powerful, well-instrumented work systems able to accommodate a wide variety of complex payloads.

Setting the standard for performance and reliability in the marine environment, our products - electrical Slip Rings, fiber optic rotary joints and fiber optic multiplexer systems - are designed to exceed the demanding specifications required for subsea operations.

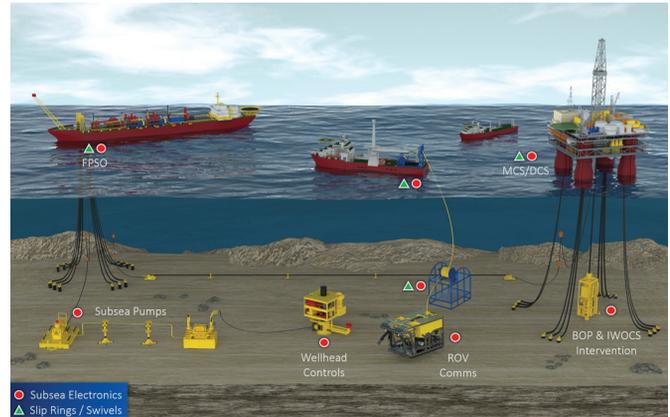
APPLICATIONS THAT BENEFIT FROM OUR RANGE OF ELECTRIC AND HYDRAULIC SOLUTIONS

RENEWABLES



Moog has provided rotary solutions, electronics components and condition monitoring solutions for harsh marine applications for over 30 years. Leveraging this expertise, Moog created a wide range of standard products specifically for tidal energy, offshore wind energy and wave energy applications. Specific uses may include: mooring systems, pitch rotary swivels, yaw rotary swivels, electronics for control systems and monitoring of umbilical cables.

SUBSEA OILFIELD COMMUNICATION



Robust and highly reliable subsea communication systems are required to safely and efficiently control a wide range of subsea applications from Blow Out Preventer (BOP) controls to subsea processing and well-head instrumentation. Long subsea tie-backs and networked links to adjacent fields, coupled with the introduction of more sophisticated and data-intensive sensors, are driving the need for higher speed communication solutions with advanced data traffic management and diagnostics.

Leveraging our expertise with field proven communication and networking technologies from the ROV market, we design, test, and manufacture a wide range of subsea control products including fiber optic modems, Ethernet switches. Reliability and availability are optimized with robust designs, redundancy options, extensive diagnostics, fault tolerant protocols, and extensive qualification. We provide both standard and customized systems for critical subsea applications with options for card-level and packaged solutions.

EXPERTISE AND INNOVATION FOR A RANGE OF MARINE INDUSTRY CHALLENGES

Through close collaboration with its marine customers, Moog can help move the ideas of shipbuilding design engineers forward. Our portfolio of electromechanical, electrohydraulic and hybrid technology ranges from Servo Valves, Brushless Motors, the Electrohydrostatic Pump Unit, High Torque Motors, Slip Rings and Ball and Roller Screws. Moog's experts can help customers adapt these to meet their specific application requirements, irrespective of the technology.

We can therefore, help our customers in the shipbuilding industry resolve a number of the challenges facing them in today's demanding and highly competitive marine market.

IMPROVING ENERGY EFFICIENCY

Rising energy costs and the increasing requirement to reduce emissions means that ship owners and operators are seeking cleaner, more cost effective marine solutions on both new build and currently operational vessels. Moog's range of technology neutral products, ranging from High Torque Motors to Electrohydrostatic Pump Units, lower energy costs by providing power where and when it is needed, and lessen any risk of oil spillages while also lowering the overall machinery footprint. They also help limit both noise and vibration.

REDUCING OPERATIONAL DOWNTIME

Marine customers need to ensure that onboard applications operate efficiently and reliably around the clock and in all weathers. Moog's product technology allows end users to

monitor its performance, reduce any potential downtime, while also simplifying maintenance processes and spare parts storage. Our experts work closely with customer application engineers to ensure that Moog motion control solutions, from servo-proportional valves to radial piston pumps and motors, meet specified machine performance requirements and deliver dependable operational performance.

DELIVERING INDUSTRY 4.0 SOLUTIONS

Reducing expensive operational downtime means getting the most out of onboard applications such as engines, steering systems and stabilization fins. Moog's solutions feature sophisticated diagnostics and condition monitoring technology that is designed to prevent costly disruption or machine failure. Our technology is supported by a team of engineering experts, who will assist customers in getting the most out of their shipping machinery investment.

PROVIDING LONG LIFE PERFORMANCE

Whether providing products for new shipping applications or retrofitting older machinery, Moog is able to deliver enhanced performance, cost effective operation and longer service life. Our components reduce the need for cabling and wiring as well as overall space requirements, making maintenance easier and helping extend application life times. Moog has the capability to work with customers across the world in providing technology neutral expertise across a range of shipping applications, and our engineers are able to handle many marine retrofit challenges.

DELIVERING ENERGY SAVINGS, REDUCING EMISSIONS

The Request

The leading designer of two stroke diesel engines, with sizes ranging from 1,560 kW to 82,440 kW, is using a motion control solution for engines fitted with an electronically controlled camshaft. Moog had the opportunity to provide servo valves capable of performing the fuel injection profiles demanded by the engine control system, with the aim of reducing both engine energy use and exhaust emissions.

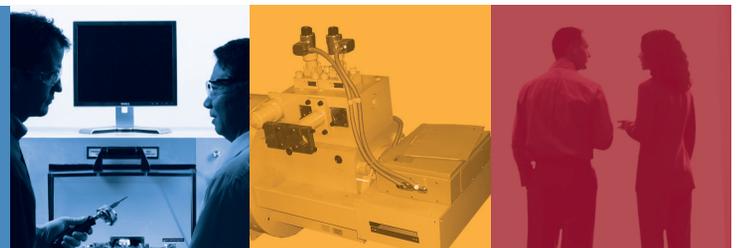
The Solution

Moog decided to provide the company with its fully digitally controlled D636 Direct Operated Series Servo Valves for analog signals, which are directly driven by a linear force motor and do not require a pilot flow. The valves are reliable and highly robust, thus making them suitable for demanding

applications such as marine engines. Moog's ability to offer the valve as an off the shelf customized solution with freely programmable code segments, meant that the company's design engineers could customize its functionality according to their specific requirements.

The Result

Moog's D636 Valves met the engine manufacturer's requirements, helping to reduce both fuel consumption and emissions significantly. Our ability to deliver this easily customizable solution quickly with global service support met a vital requirement of all marine application manufacturers. The company now use the D636 widely on many of its diesel engines, and they have been able to lower both machine downtime and maintenance costs.



WORLD-CLASS PRODUCT PERFORMANCE

Moog provide a wide array of high quality hydraulic, electric and hybrid products designed to meet the marine industry's most challenging machine applications. These building blocks lie at the heart of all our motion control solutions, and Moog's solutions focused approach demonstrates that we have both the technology and expertise to design and install customized components that specifically meet marine customer requirements. In other words, we can work directly with you to create unique solutions that are precisely tailored to your machinery needs.

OVERVIEW OF SOME KEY PRODUCTS FOR MARINE DESIGN ENGINEERS AND MACHINERY BUILDERS

Servo and Proportional Valves

Moog Servo and Proportional Valves provide excellent, high-performance motion control for a range of industrial shipping applications. Equipped with both digital and analog electronics, their rugged design allows for their operational use even in the most demanding and hazardous environments. Moog valves maximize machine performance and are available with several fieldbuses including EtherCat and PROFIBUS-DP, offering high-speed advanced control and remote diagnostics for troubleshooting.

Applications:

- Main engines
- Water jet
- Steering systems
- Stabilizer fins
- Offshore cranes



Radial Piston Pump – RKP

Moog's Radial Piston Pump (RKP Series) offers a long life cycle, lower noise emissions and high performance across a range of demanding and hazardous environments. Its design offers marine customers an optimized pump housing design that incorporates nine pistons, that help improve fluid delivery and reduce hydraulic flow pulsation. Consequently, the RKP is among the quietest pumps available on the market and offers a long service life. The RKP can also be equipped with digital onboard electronics for more precise control of pressure and flow.

Applications:

- Main engines
- Water jet
- Steering systems
- Stabilizer fins
- Offshore cranes

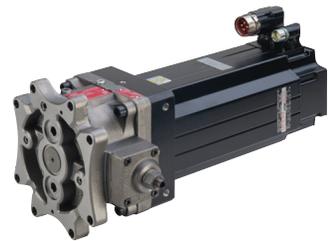


Electrohydrostatic Pump Unit - EPU

Moog's Electrohydrostatic Pump Unit (EPU) forms the core of the Electrohydrostatic Actuation System and enables the use of decentralized drive systems. It can be used across a range of onboard applications and, crucially for this market, removes any need for a hydraulic power unit and complex piping, thus facilitating space saving. The EPU provides power when and where it is needed, can be used with environmentally friendly fuels and reduces both energy costs and emissions. It generates less noise and vibration, while maintenance is straightforward and comparatively fast.

Applications:

- Water jet
- Steering systems
- Stabilizer fins
- Offshore cranes



Servo Motors

Moog Servo Motors are manufactured to provide the precise torque, speed and power marine applications require. Our technology delivers the highest dynamics and reliability, smooth low speed performance and characteristics matched to optimize machinery performance. The High Torque Motor, for example, requires no oil and its condition monitoring sensors allow end users to anticipate downtime, thereby significantly improving machine availability. Brakes, sensors and bearings can be replaced after 40,000 hours and it requires comparatively limited onboard space.

Applications:

- Water jet
- Steering gear
- Stabilizer fins



WORLD-CLASS PRODUCT PERFORMANCE

Moog is also specialized in rotary solutions for the transmission of power, signals, network data and media from stationary to rotary components and offers a variety of complimentary high performance electronics and sensors in order to complete our portfolio.

Our different brands have been well known and regarded within the Marine sector for many years. As our customers mostly need a combination Slip Ring unit that serves multiple functions we are able to combine our available technologies mentioned below to provide the best possible product for our customers. As the world market leader for Slip Rings we are able to provide any rotary solution your application might need. We call this "The Power of Moog: Complete Rotary Solutions" and we make the impossible possible in motion control.

Slip Rings

As pioneer and the world market leader for Slip Rings Moog provides a wide range of Slip Rings to an almost full range of applications in the Marine sector. Our product range reaches from small encapsulated Slip Rings for low current and data transmission to huge FPSO and electric pod Slip Rings for high voltage and high current transmission. Moog's portfolio includes especially aggrandized designs and water proof subsea solutions when necessary. We offer a wide range of standard Slip Rings and are particularly strong in customizing our Slip Rings exactly to customer's needs.

Applications:

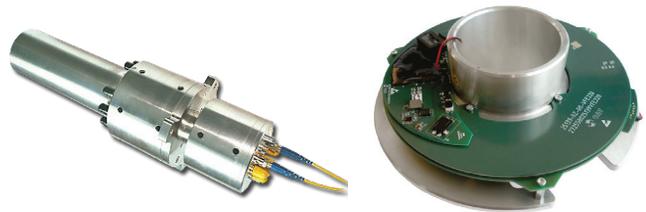
- FPSO
- Pod propulsion
- Offshore wind turbines
- Deck and harbor cranes
- Winches and cable reels
- Seismic sector
- Pod propulsion (signals and main motor),
- Winches, Offshore wind,
- ROV
- Cranes
- Seismic
- IWOCs
- And many more



Fiber Optical Rotary Joint (FORJ) / Capacitive

High and ultimately reliable data transmission over long distances and electromagnetic compatibility impaired (EMC) environment can be a challenge that our customers solve with our contact-less transmission technologies.

FORJ (Fiber Optical Rotary Joint) are the optical equivalent to an electrical Slip Ring and have practically unlimited bandwidth. While the number of physical channels has a limit multiplexing (see Electronics) significantly expands the number of effective channels. Our maintenance free and modular capacitive solutions serve transmit PROFINET Class C (IRT), SERCOS III, POWERLINK, EtherCAT, MECHATROLINK-III and other protocols whenever high flexibility and plant availability is needed.



Fluid Rotary Unions (FRU)

Moog is a manufacturer of highly advanced Rotary Unions. Moog's fluid rotary unions are currently used around the world to ensure reliable transmission of life support, process, power and control fluids.

Special seals are selected based on chemical compatibility, design pressure, design temperature, required service life and acceptable leakage rate. Leak collection can be supplied when required for environmental or personnel safety. Fluid rotary unions can be combined with our electrical Slip Rings and fiber optic rotary joints. Further to an extensive range of standard products, we also provide individual solutions as your competent partner.

Applications:

- Seismic
- Pod propulsion
- Winches and cable reels
- IWOCs
- Deck and harbor crane
- Marine controls



WORLD-CLASS PRODUCT PERFORMANCE

Electronics

Moog's industry standard electronics products are centered around converting multiple copper signals to a reduced number of fiber optic links, also known as multiplexing. A major benefit to multiplexing is reducing the number of fiber optic cables or FORJ passes. Condition monitoring is built in to most electronics assemblies to assist in preventative maintenance or quickly diagnose problems, which can reduce down time.



Applications:

- FPSO
- Oil rig & BOP
- Winches & cable reels
- Subsea pumps
- Wellhead controls
- ROV
- IWOCs

COMBINATION UNITS EXAMPLES

FPSO Slip Ring

FPSO stands for Floating Production Storage and Offload ships. These enormous ships are used in the oil production industry and are stacked with our huge combination units consisting of high voltage and data Slip Rings, FRU, FORJ, electronics and surrounding equipment.



Pod Propulsion Slip Ring

Pods are used on modern ship's propulsion systems. They are freely turnable systems that hold the propeller, main propulsion shaft, main motor and auxiliaries.

The demanding environmental conditions are mastered by our systems consisting of power and data Slip Ring, FRU, FORJ, Capacitive solution and electronics.



Air Gun Slip Ring

Air Guns are under water devices used for the examination of seafloor layer with the purpose of finding oil and gas deposits.

Our combination units consisting of low voltage Slip Rings and high pressure FRU perfectly cope with the harsh environmental requirements of this application.



MOOG MARINE BRAND SOLUTIONS AND PRODUCTS

FOCAL™

MOOG FOCAL

Highly Reliable Marine Rotary and Data Transfer Solutions

Focal Technologies specializes in providing custom electrical slip ring, fiber optic, fluid swivel and optical multiplexer solutions. Innovation and performance are incorporated in all that we do. From our ability and willingness to customize products to our ISO 9001 certification, to our unmatched global capacity, we are defining and delivering custom integrated and proven products for the harshest marine environments in the world.

Product features include hybrid packages that combine fiber, electrical and fluid swivels, packaging for harsh environments, certification for hazardous locations and adaptation to your project's size and mounting constraints.

- Marine Slip Rings
- Fiber Optic Rotary Joints
- Multiplexer
- Media Converters
- Floating Production Systems
- Fluid Rotary Unions
- Condition Monitoring
- Renewable Swivels

Focal Technologies Corporation
77 Frazee Ave., Dartmouth
Nova Scotia, Canada B3B 1Z4
Tel.: +1-902-468-2263
Email: focal@moog.com

REKOFA

MOOG REKOFA

Moog Rekofa designs and manufactures a portfolio of electromechanical systems for the transfer of current, signals and data in rotating devices or structures. The technology can be combined to include electrical, pneumatic, hydraulic and multi-channel fibre optic transfers and is typically used in wind turbines, automotive, industrial and construction equipment. Rekofa was acquired by Moog Inc. in April 2017 and is certified in accordance to ISO9001 and ISO14001.

Rekofa has been designing and manufacturing current transfer systems for more than 100 years. These systems are distributed globally from its headquarters in Antweiler. Refoka's products are used wherever there needs to be continuously rotating transfer of currents, data and media to a stationary component.

- Standard Slip Rings
- Fluid Rotary Joints
- Customized Slip Rings
- Hybrid Rotary Solutions
- Signal and Data Transmission
- Cable Reel Drums
- Contactless Solutions (Fiber Optics)
- Industrial Carbon Brushes
- Slip Ring Collectors

Moog Rekofa GmbH
Bergstrasse 41
D - 53533 Antweiler a. d. Ahr, Germany
Tel.: +49 2693 / 9333-0
info@moog.rekofa.com

MOOG MARINE BRAND SOLUTIONS AND PRODUCTS



GAT

In operation since 1978, GAT specializes in electrotechnical transmission, fluid and sealing technologies. We design and manufacture rotary unions, slip rings, air bearings and torsion motors for a wide range of industrial applications.

Both standard and custom GAT products are driven by innovation, research, industry experience and high-technology precision for exceptional accuracy, quality and durability. We apply stringent quality control testing to all our products, using various performance trials that simulate the customer's application environment, for flawless operation and exceptional product value. In addition, our products are ISO 9001:2015 certified.

GAT became a subsidiary of Moog, Inc. in December 2019.

GAT offers reliable, high quality products, trusted by customers worldwide for over four decades. Get exceptional, tailor-made solutions from development and production to sales – all from a single source.

- Rotary Unions
- Air Bearings
- Slip Rings
- Torsion Motors
- Combined Rotary Unions
- & Slip Rings

Moog GAT GmbH
Industriestraße 11
D - 65366 Geisenheim, Germany
Tel.: +49 6722 93788-0
Email: moog-gat.info@moog.com

ABOUT MOOG

HYDRAULIC SOLUTIONS

Since Bill Moog invented the first commercially viable servo valve in 1951, Moog has set the standard for world-class hydraulic technology. Today, Moog products are used in a variety of applications - providing high power, enhanced productivity and ever better performance for some of the worlds most demanding applications.

ELECTRIC SOLUTIONS

Clean operation, low noise generation, less maintenance and reduced power consumption make Moog electric solutions ideal for applications worldwide. Moog is the ideal partner for applications where transitioning technologies requires special expertise. Moog is world market leader for Slip Rings.

HYBRID SOLUTIONS

By incorporating the advantages of existing hydraulic and electric technologies - including modular flexibility, increased efficiency and cleanliness - into innovative hybrid solutions, Moog offers new performance potential in specialized applications.

MOOG GLOBAL SUPPORT

Moog Global Support is our promise to offer world-class Repair and Maintenance Services delivered expertly by our trained technicians. With the reliability only available from a leading manufacturer with facilities around the world, Moog offers you service and expertise you can count on to keep your equipment operating as it should.

This promise offers many benefits to our customers including:

- Reduce your downtime by keeping critical machines running in peak performance
- Protect your investment by ensuring reliability, versatility and long-life of products
- Better plan your maintenance activities and make systematic upgrades
- Leverage our flexible programs to meet the unique service requirements of your facility
- Look to Moog for global support including:
- Repair services using OEM parts are performed by trained technicians to the latest specifications
- Stock management of spare parts and products to prevent unplanned downtime
- Flexible programs, tailored to your needs such as upgrades, preventative maintenance and annual/multiyear contracts
- On-site services bring the expertise to you, providing quicker commissioning, set-up and diagnostics
- Access to reliable services that are guaranteed to offer consistent quality anywhere in the world

For more information on Moog Global Support visit www.moog.com



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.

Australia
+61 3 9561 6044
Service + 61 3 8545 2140
info.australia@moog.com
service.australia@moog.com

Brazil
+55 11 3572 0400
info.brazil@moog.com
service.brazil@moog.com

Canada
+1 716 652 2000
info.canada@moog.com

China
+86 21 2893 1600
Service +86 21 2893 1626
info.china@moog.com
service.china@moog.com

France
+33 1 4560 7000
Service +33 1 4560 7015
info.france@moog.com
service.france@moog.com

Germany
+49 7031 622 0
Service +49 7031 622 197
info.germany@moog.com
service.germany@moog.com

Hong Kong
+852 2 635 3200
info.hongkong@moog.com

India
+91 80 4057 6666
Service +91 80 4057 6604
info.india@moog.com
service.india@moog.com

Ireland
+353 21 451 9000
info.ireland@moog.com

Italy
+39 0332 421 111
Service 800 815 692
info.italy@moog.com
service.italy@moog.com

Japan
+81 46 355 3767
info.japan@moog.com
service.japan@moog.com

Korea
+82 31 764 6711
info.korea@moog.com
service.korea@moog.com

Luxembourg
+352 40 46 401
info.luxembourg@moog.com

The Netherlands
+31 252 462 000
info.thenetherlands@moog.com
service.netherlands@moog.com

Singapore
+65 677 36238
Service +65 651 37889
info.singapore@moog.com
service.singapore@moog.com

South Africa
+27 12 653 6768
info.southafrica@moog.com

Spain
+34 902 133 240
info.spain@moog.com

Sweden
+46 31 680 060
info.sweden@moog.com

Turkey
+90 216 663 6020
info.turkey@moog.com

United Kingdom
+44 (0) 1684 858000
Service +44 (0) 1684 278369
info.uk@moog.com
service.uk@moog.com

USA
+1 716 652 2000
info.usa@moog.com
service.usa@moog.com

For more information, visit www.moog.com/industrial

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High Performance Motion Control for Marine Applications
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