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Revised (07-11-17)

aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding

Hydraulic Rotary Actuators

HUB, LTR, HTR, M, Tork-Mor Series

Catalog HY03-1800-2US

Parker

ENGINEERING YOUR SUCCESS.

Parker Hannifin is the leading global manufacturer of components and systems designed to control motion, flow and pressure in all types of machinery. Parker is a Fortune 300 corporation listed on the New York Stock Exchange as PH.

Parker offers more than 1,400 product lines that control motion in 1,000 industrial, mobile and aerospace markets. We are the only manufacturer to offer our customers choice of hydraulic, pneumatic, electromechanical and computer motion control solutions.

Furthermore, we have the largest global distribution network in our field, with more than 7,500 distributors serving more than 422,000 customers.

The Pneumatic Division is Parker's primary source for pneumatic valves, prep-air products, linear actuators, and **hydraulic rotary actuators**. Additionally, Pneumatic Division offers products that use electromechanical, pneumatic and hydraulic technologies and has developed a business model that is based totally on customer needs. Pneumatic Division customers can select the level of integration that best meets their needs.

Ordering valve or actuator products from Parker brings with it all of the benefits you have come to expect: quality, solution integrity, worldwide distribution and extensive field and customer support. Add supplier reduction, shorter lead times, simplified ordering and more efficient shipping and you'll agree that Parker's total solution capabilities are designed with your specific application in mind.

Contact Parker Pneumatic Division with your specific requirement, and our engineers will be pleased to work out the details of your design.

Application Engineering Help

Parker Pneumatic provides premier application engineering services to our customers. Our engineers have detailed understanding of our products to help your staff select the appropriate actuator for any application. Parker designs and manufacturers all major types of rotary actuators. Due to this broad base, we can offer the customer the optimum solution. Your engineers can also work independently with our user-friendly catalog and our computer-based analysis and selection tools. The actuators can be sized to meet the specific performance aspects of the application. Additionally, only the Pneumatic Division provides information that allows the engineer to assess life requirements for the actuator. The engineer can precisely select the actuator that will provide the correct level of torque output over the full anticipated duty cycle life of his equipment. This ensures that the customer gets trouble free operation throughout its service life, avoiding expensive, unanticipated downtime. The ability to predict the operational life of the unit allows the customer to institute regularly scheduled preventative maintenance programs, maximizing production uptime. This is an additional value that Parker Pneumatic Division brings to the application.

Alternative Energy

To meet economically viable cost targets ($/kWh) that compare to those of fossil-fuel power supply solutions, solar-power equipment suppliers look for innovative engineering solutions that provide maximum efficiency combined with low cost. Parker has designed and supplied specialized actuators optimized to stringent performance requirements. The highly efficient rack-and-pinion gearing at the heart of actuator systems provides high power at low rotational speeds. The actuator is capable of driving the maximum number of solar panels under high wind conditions at a slow speed, allowing precision tracking of the sun. The low maintenance, stand-alone system has an integrated fluid reservoir and offers variable drive speeds if multiple pumps are used

Steel Industry

This world of extremes presents many unique challenges for equipment used for automating critical processes.

Parker hydraulic rotary actuators are a vital part of the steel making industry. Unlike a cylinder, the hydraulic rotary actuator is completely enclosed in a rugged steel housing that protects critical working elements from the harsh and contaminated environment of the mill.

In addition to a broad, standard line of small actuators suitable for a variety of tasks, Parker's large precision units supply millions of in-lbs of controlling torque to tip and control the ladles of molten steel. Other applications include coil-box actuators and actuators used in walking beam arrangements to move large red-hot structural shapes through cooling beds. Parker also offers the M Series of actuators specifically designed for the mill environment. The M Series offers the high reliability, durability, and ease of maintenance so important to ensuring uninterrupted production.

Boomslewer and Large Actuators

The world's largest hydraulic rotary actuator was supplied to the shipbuilding industry for self-unloading freighters plying the Great Lakes and the oceans of the world. The Boomslewer actuator generates 64 million in-lbs of torque to precisely control and position the ship's 120-meter long cargo-conveyor boom. The actuator housing structure is an integral part of the ship's structure and is designed to absorb the megaton loads induced by the cargo conveyor, the loads caused by the wind, and the ship-listing loads acting on the boom. The actuator has a self-contained reservoir, hydraulic power supply, and control valving, and is manufactured to the exacting requirements of the American Bureau of Shipping and Lloyds.

We have supplied hundreds of these actuators to a variety of domestic and overseas customers around the world during our 40 plus year history. Parker's worldwide support network assures effective communication, provides for successful coordination of technical and business requirements, and guarantees smooth delivery through export and import processes.

Marine and Submerged Applications - Water Control Management

The Pneumatic Division of Parker Hannifin has furnished specialty actuators for submerged and marine operations for 45 years. It supplies the US Military with actuators to automate valves, deploy antennas, open and close torpedo doors and hatches, and to perform other tasks. Most of these actuators are custom-made to meet specific requirements.

Our largest Tork-Mor vane-type actuator operates the pool gates for the Shamu Seaworld attraction. Our HTR and M Series units are used in gantry and boom actuation functions on ships. Our actuators also are built into steering systems on surface ships and into vane control on submersibles.

Some actuators are approved by municipal engineers for use in major metropolitan areas for storm-water, potable-water, and flood-gate control. These actuators are rated for 3000 psi and 300,000 in-lbs of torque, to position 48-in. butterfly valves while submerged to 150 feet in fresh water. These units were equipped with position feedback and sensor packages rated for depth. The rugged reliability of these heavy-duty actuators allows them to absorb the load and shocks of a seismic event.

High Tech Applications

Some of the most demanding actuator requirements come from customers that lead our nation's space program. Parker Pneumatic Division has been a proud supplier of specialty actuators for rotating umbilicals, multi-ton maintenance platforms, and blast doors on launch towers at Kennedy Space Center and the Vandenberg Air Force Base.

Another recent example of the Parker engineering team's diverse capabilities is its work with the engineers specifying equipment for the next-generation neutron-science facility at the Oak Ridge National Laboratory. The Spallation Nuclear Source is where a 2 MW proton beam blasts atoms, and where product safety and reliability are as important as performance and function. Two specialized actuators rated for 3000 psi and generating 3 million in-lbs of torque assure reliable opening and closing of a 75,000-lb steel-protection door on the target hot cell.

Offshore Technology

Parker technology is in demand in the offshore industry in a variety of areas. Actuators of varying sizes and with multiple specialized features provide reliable, effective, and low-cost solutions to the unique world of offshore rigs. Our HTR300 and HTR600 units are used in cable-winch and handling systems on both surface ships and offshore installations. We supply special actuators for large processing valves, some requiring 4 million in-lbs of operating torque.

Electrohydraulic valve actuators in sizes from 1800 in-lbs to 75,000 in-lbs are used regularly in oil-tank vent and shutoff valves, and in precision control of process fluids. We also have the capability to provide certified API 16C actuators that meet the stringent requirements for choke and kill systems within the oil industry.

Mobile Applications - Trucks, Man Lifts

Parker actuators are used in a variety of mobile applications and can be integrated with power units from Parker Oildyne Division and valves from Parker's Hydraulic Valve Division to supply a single-source, drop-in, stand-alone system. Some fire trucks use this system to position ladders for easy access, while some buses and vans use it for deployment of handicap access ramps.

The enclosed, leak-proof piston seals make actuators ideal for applications where holding a load hydraulically is a critical requirement. The safety and reliability of Parker actuators assure precise manipulation of man-lift baskets in the construction industry. Other actuators perform miscellaneous functions on oil-industry process trucks, refuse trucks, mobile X-ray scanner trucks for homeland security, vacuum truck cable reels, and dump truck load covers.

In the mining industry, HTR and M Series units see use in diverse applications, from small mobile-roof bolters to giant tunnel-boring machines requiring 6 million in-lbs of torque. Fork-lift steering and mobile-industrial transporters are examples of actuator applications in the factories. The aircraft industry uses actuators on machines that test A380 front-gear steering and those that dump fire retardant from aircraft-mounted tanks, as well as on gyrating flight simulators.

Process Industry

The processing industry has many operational and environmental situations where actuators must function under adverse loading and severe thermal, shock, or environmental conditions. On rubber-mixer machines, heavy-duty actuators rated at 3000 psi and supplying torques from 75,000 to 300,000 in-lbs not only satisfy high static loads, but accept the punishment of shock loads. In these applications the actuator acts as a damping mechanism that absorbs high-production speeds for door actuation. Many major automotive tire manufacturers specify the 300M Series units as preferred equipment. The units provide the Mill rating, long life, durability, and ease of maintenance that are recognized as providing the best value in the hydraulic rotary-actuator market.

Internal Intensive Mixer courtesy of Kobelco Stewart Bolling, Inc. Hudson, Ohio

Parker Hannifin Corporation
Three Year Extended Warranty

Parker Hannifin Corporation will extend[1] its standard limited warranty on **ALL** Hydraulics Group components to thirty-six (36) months if they are protected by properly installed and maintained[2] Parker hydraulic filters. Components covered by this warranty include all cylinders, valves, and hydraulic components manufactured by Parker in any of our global facilities. This warranty covers Parker components; anywhere in the world you may ship your equipment.

Parker's obligation under this warranty is limited to the replacement or repair of any failed components. The buyer understands that Parker will not be liable for any other costs or damages.

The buyers of quality Parker components and filters benefit by having **ONE** source for all hydraulic needs: **Parker.**

Hydraulics Group

[1] This extended warranty may apply to failures resulting from contamination, but will not cover products that are not properly installed or maintained, or to failures resulting from misapplication, abuse and misuse.

[2] Proper maintenance intervals and procedures, as set out in product manuals, catalogs, or otherwise require verification. Verification methods will be determined and agreed to by Parker and the OEM in advance of the extended warranty taking effect.

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⚠ WARNING

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker Hannifin Corporation, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application including consequences of any failure, and review the information concerning the product or system in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

The products described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by Parker Hannifin Corporation and its subsidiaries at any time without notice.

Offer of Sale

The items described in this document are hereby offered for sale by Parker Hannifin Corporation, its subsidiaries or its authorized distributors. This offer and its acceptance are governed by the provisions stated on the separate page of this document entitled "Offer of Sale".

Custom Engineering

Parker offers the broadest range of automation products in the industry, most of them presented as catalog items with standard performance limits and rigidly established dimensions and interfaces. Parker Pneumatic Division can offer much more than this. Parker Pneumatic Division is continuously investing in product improvements and upgrades that bring value to the customer and address specific customer needs. Many of these new ideas and customer inputs are developed from working directly with new customers on custom designed actuators. Our engineering and sales team welcomes your input and looks forward to helping develop products meeting your specific needs. Parker Pneumatic Division is the industry leader in actuator technology. We have invested in the engineering and analytical tools to fully understand the capabilities of our product offerings. We have the team in place and the analysis and technical capabilities to evaluate your special requirements and to work with your engineers to establish an optimum solution.

Rack-and-pinion actuators offer the opportunity for the customer to define and integrate specific features or strengths into the actuator housings. If required, special actuator housings can be fabricated from a machined block or a weldment versus the standard cast housing. This special housing can be designed with special dimensional features and strength capabilities to integrate directly into the customer's structure. The actuator assembly thus becomes a drop-in device with precision-machined features defined by the customer, built-in bearing capability, and other critical features in addition to supplying rotary power and positioning. These values are incorporated into one low-cost package the customer can buy, without doubling up on the expense of building similar features into his apparatus.

A summary of other specialty features successfully designed into rack-and-pinion actuator products are as follows:

- Housing and shafting with special materials and features designed to carry high loads.
- Actuator features recognized industry wide for providing durability, long life, and reliability of 99% in 10 million cycles.
- Rotations to 1080°, variety of speeds, special shafting, mounting, and porting accommodations.
- Units with minimal backlash, plus combined linear and rotational motion.
- Units integrated with control-valve packages, and position feedback for total system solutions
- Special materials – titanium, monel, stainless steels, bronzes, composites.
- Compliance to customer specs and agency certifications – ABS, FDA, military, UL/CE, SAE, and API 16C certification.
- Special environments and applications – robotic, submerged, clean room, medical, PC chips, and corrosive atmosphere.

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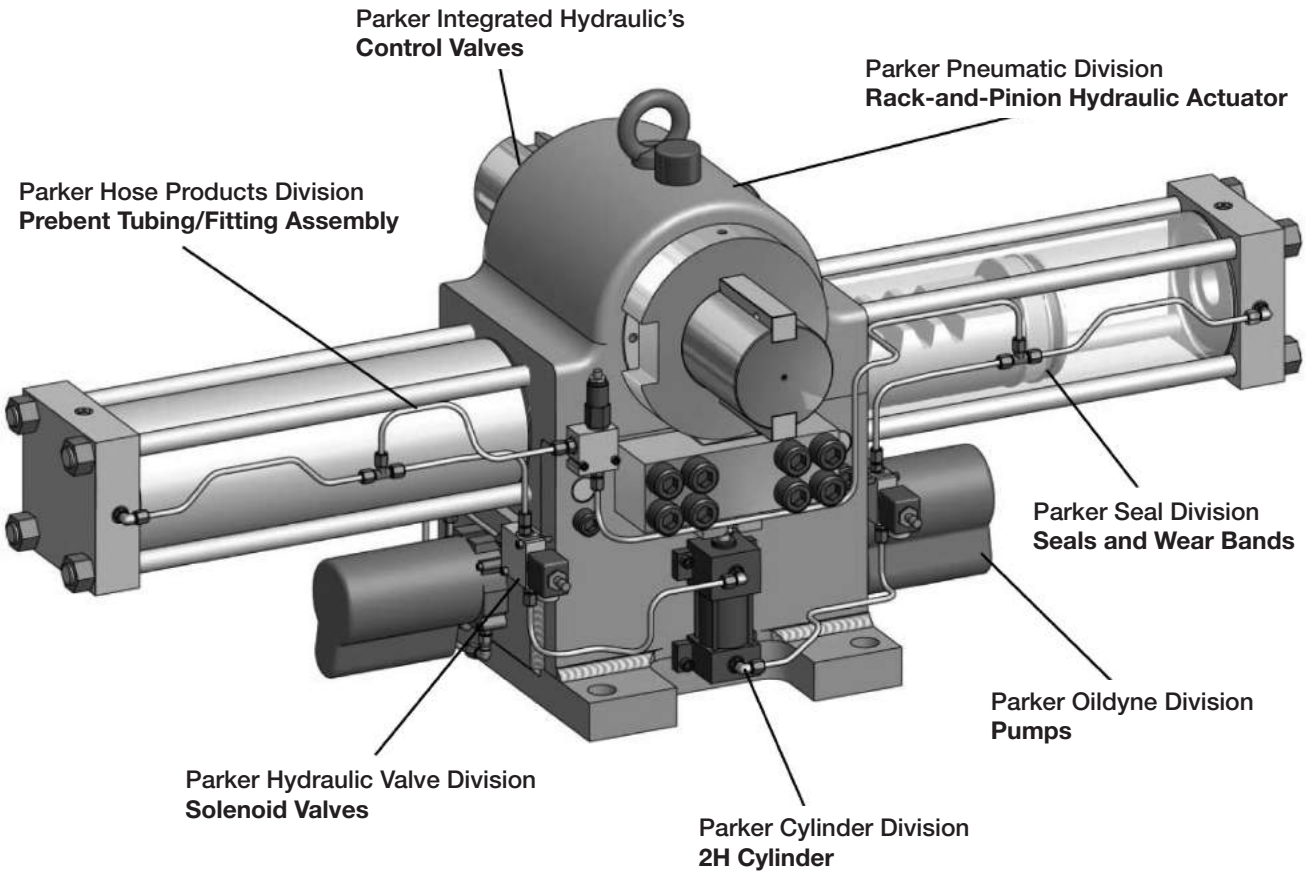
Integrated Hydraulics Packages from Parker Worldwide

Parker is a global corporation having 142 different Divisions and offering thousands of products. Because of the broad spectrum of product in all types of automation technology, we are able to formulate innovative solutions to new or complex problems. We pride ourselves on having the expertise to work as a team with customer's technical personnel, Parker's field systems specialists, and a comprehensive network of distributors. We use these resources to pull together technologies from different Parker Divisions and to offer a fully integrated package to meet the customer's needs.



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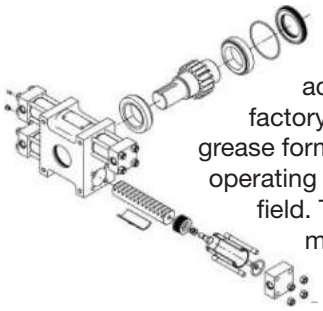
Gears Materials Options and Hardness

Pneumatic Division has extensive experience in rack-and-pinion gear rotary actuator technology that can be quickly applied to satisfy specific customer needs. All gears are designed to provide long life and durability. Standard gears and racks are fabricated from thru-hardened alloy steel selected and specified in accordance with the American Gear Manufacturers Quality Class 6-10. High-quality alloy steel is rigorously inspected to achieve compliance with the AGMA quality class. Each actuator size has gearing incorporated that achieves the rated torque without breakage. Data is presented for every size of actuator gearset to allow proper selection for long production-cycle life without adverse wear out. Gearing can also be custom designed to achieve specific loading and life characteristics. Options include improved materials, surface treatments for high hardness and extended wear under extreme loads and speeds, specialized lubricants, and others.

Reliability, Durability Features

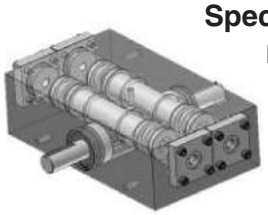
Pneumatic Division manufactures a wide variety of rotary and linear actuators. The HTR Series heavy-duty hydraulic rack-and-pinion rotary actuators are recognized for rugged durability and life. These are used extensively in a wide variety of applications where high reliability is considered of key importance to maintaining production-line output without downtime, or to achieving mission-critical functionality. These actuators utilize time-proven design concepts and materials to produce a product unique in the industry. Their large tapered-roller bearings support high external radial and thrust loads. The tie-rod cylinder construction complies with NFPA heavy-duty, Series 2H certification requirements. The gearing is manufactured to AGMA standards. Proprietary analysis programs are employed to demonstrate reliability rates of 99% in 10 million cycles in special cases, as requested by customers. The analyses results have been incorporated into this catalog (pages 4 and 5 of selection guide in introduction section), and offer the customer the ability to easily select actuators meeting both performance and durability requirements.



Lubrication

Each hydraulic rotary actuator is greased at the factory using specialized gear grease formulated for the typical operating conditions seen in the field. The type of grease is a multipurpose, extra pressure (EP) lithium-based grease containing molybdenumdisulfide as a solid lubricant. At the factory, the rolling-element bearings are packed at assembly and the gear case is filled to approximately 75% full. At normal speeds and operation within the life rating of the actuator, the unit will provide trouble-free service without the need for additional lubrication. If the unit is disassembled for standard seal maintenance, it will need to be repacked and relubricated.

The gear housing is equipped with a relief valve that is set to vent pressure from the gear case in the event of piston-seal bypass prior to seal maintenance. The vent relief provides a visual indication that seal maintenance is required since some grease will be forced through the vent fitting.



Specialty Housings

Rack and pinion actuators offer the opportunity for the customer to define and integrate specific features or strengths into the actuator housing. If required, special actuator housings can be fabricated from a machined block or a weldment versus our standard cast housing. Special housings can be designed with dimensional features and strength capabilities integrated directly into the customer's structure. Thus, in addition to supplying the rotary power and positioning function, the actuator assembly thus becomes a drop-in device with precision machining features defined by the customer, built in bearing capability, and other critical features. These values can be incorporated as one low cost package for the customer, without adding additional expense by building similar features into the apparatus.

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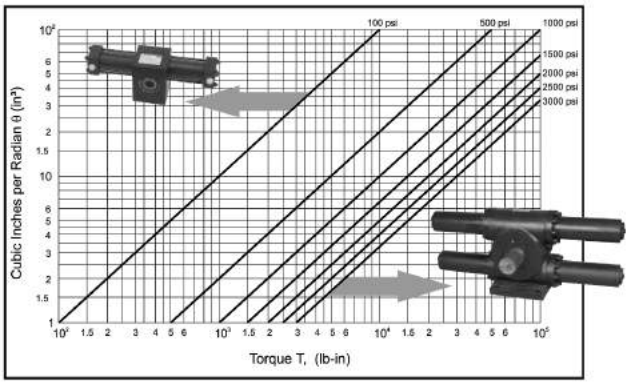
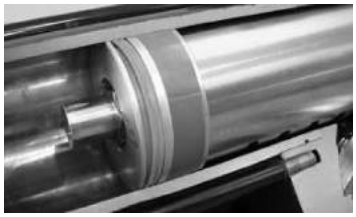
Efficiency

The most efficient actuator type is the rack-and-pinion. The efficiency of this spur-gear actuator is very high, typically in the low-to-mid 90th percentile. This offers advantages for the overall hydraulics system size since the actuator displacements are minimized and the size of the required Hydraulic Power Unit (HPU) pump, motor, and reservoir can be minimized. This means less cost for the customer. Additionally, system inefficiency is important in applications with high-speed production cycles since the inefficiency produces rapid heating of the fluid. To control this, a heat-exchange system is required, adding cost and complexity to the application. Vane-type actuators have efficiencies at approximately 70%, and helical style actuators are only about 55% efficient.





Seals

Pneumatic Division is continuously investing in product improvements and upgrades that bring increased value to the customer. Our most recent improvement is on the dynamic piston seal where we see the highest wear and interaction with the working fluid. The new single lip piston seal is a Parker proprietary 90 Shore A hardness polyurethane. This material provides extended temperature capability, excellent resistance to compression set and high rebound characteristics.

The new pinion shaft seals are capable of longer life at higher pressure. These seals traditionally have been o-rings that seal effectively at low delta pressures in the grease-packed gear case. However, in the event of piston-seal wear over time, hydraulic pressure leakage to the gear case, can cause case pressures of 650 psi. The single lip of the o-ring in this dynamic application has limited life. We have incorporated dual lobed seal technology at this interface as well. The new seal fits into the same grooves, but operates at a lower compression squeeze than the equivalent o-ring. The dual-lobed seal thus sees less wear from the pinion shaft during its dynamic life and operates more effectively at the higher pressure during piston-seal bypass.

Specialty Coatings

All units from the Parker Pneumatic Division come from the factory with a standard corrosion protection coating of black waterborne acrylic polymer paint. This coating complies with various ASTM standards for solvent, impact, and chemical resistance, as well as, salt spray.

Parker also offers specialty treatments suitable for different environments such as sea or fresh water, high humidity and temperatures, or corrosive fluids encountered in various processing industries. Alternatively, Parker fabricates actuators entirely from stainless steel when this highest level of protection is required. Specialty protective processes may be selected based on coordination with the Parker engineering department.

Wear Bands and Rack Bearings

Most actuator applications operate at fairly low velocities. For example, speeds up to one radian/sec (approximately 60 degrees/sec) are typical. However, some actuators require operation at higher speeds. This subjects the critical surfaces in the unit to high sliding velocities and contact loads that can lead to fast and catastrophic failure of the unit if not properly considered.

Parker understands the engineering specifics within the actuator and has developed proprietary analytical tools that allow us to examine the customer's special operating conditions and make recommendations regarding them. We can offer options for the wear-band materials and the rack-bearing materials, as well as, configurations to satisfy higher speeds and loads. Options that we have successfully applied include rack bearings made of premium bronze, composite, and pre-lubricated graphite. Similarly we can offer premium wear-band materials or composite wear bands, depending on the application requirements.

Factory Acceptance Testing

Every Parker rotary actuator undergoes several test sequences prior to shipment from the factory. Each lot of actuators has test documentation completed and kept on file. Specific additional testing, if required, by the customer can be quoted and done, with QC documentation packages supplied, if required. Each unit is marked with a nameplate having model number, pressure rating, serial number, and date code that must remain on the unit to maintain the warranty.

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Fax completed form to (330) 334-3335 or email pdnapps@parker.com

CONTACT INFORMATION:

Name: _____ **Phone Number:** _____

Company: _____ **Fax Number:** _____

Address: _____

APPI ICATION DETAIl S:

1. **Torque Requirement:** _____ **in-lb.**
2. **Operating Pressure:** _____ **psi**
3. **Requirement Rotation:** _____ ° (i.e. 90°, 180° etc.)
4. **Cycle Time:** _____ **sec.** (Time to complete rotation in one direction.)
5. **End of Stroke Options Required:** _____ (i.e. Cushions, Stroke Adjusters)
6. **Bearing Support Required** - Include weight of external load and direction in which it will be applied. (i.e. radial, thrust)

   _____
7. **Operating Temperature:** _____ **°F**
8. **Type of Fluid Used:** _____
9. **Brief Description of Application** (If needed, sketch can be submitted using the space provided at the bottom of this page.)

   _____

ACTUATOR DETAIl S:

1. **Type of Mounting Style Preferred:** _____
2. **Type of Shaft Connection Preferred:** _____
3. **Any Special Options Desired?** _____

   _____

Sk ETCH:

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Introduction

Rack & Pinion Actuators

Vane Style Actuators

Sensors & Feedback

Engineering Guidelines

Service Bulletins

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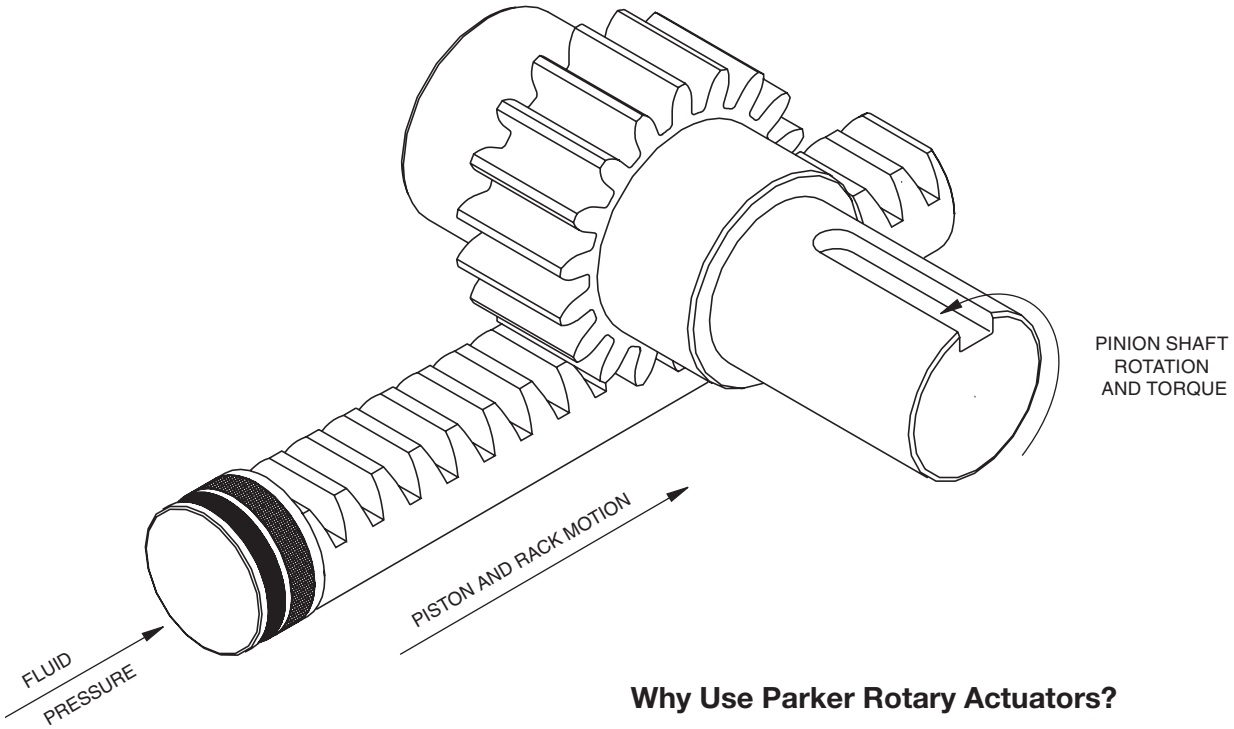
Parker . . .
l eading the Industry

Parker leads the industry in development of new and innovative features to make rack and pinion rotary actuators more reliable, efficient and safe. With a firm commitment to product quality and design research, Parker rotary actuators are continually being improved so that you can enjoy benefits such as long service life and increased productivity.

What Is a Rack & Pinion Rotary Actuator?

Parker rotary actuators convert fluid power into rotary motion for a wide variety of industrial applications. Pressurized fluid is applied to a circular piston inside a cylinder which pushes a rack across the pinion gear. This action turns the shaft, generating rotary motion. This motion is transferred through the shaft to the machinery for applications such as upending, turning, roll-over, tilting, indexing, transferring, mixing, valve operating, tensioning and clamping.



Where Can Parker Rack & Pinion Actuators Be Used?

- Material Handling
- Machine Tool
- Primary Metals
- Rubber and Plastics Machinery
- Mobile Equipment
- Robotics
- Packaging
- Valve Actuation
- Multi-Process Industry
- Cranes and Hoists
- Mining and Oil Field Equipment
- Military
- Commercial Marine

Why Use Parker Rotary Actuators?

- Provides uniform torque in both directions.
- Simple design.
- Wide range of sizes.
- High torque output in a small package size.
- More efficient operation and longer time between servicing.
- Performs under the most adverse ambient conditions.
- No external linkage needed for rotary motion.
- Good load holding capability with no drift.
- Optional cushions can stop inertial loads*.
- Rotation can be specified to fit exact application needs.
- Will support radial and thrust loads.

* Within actuator limits.

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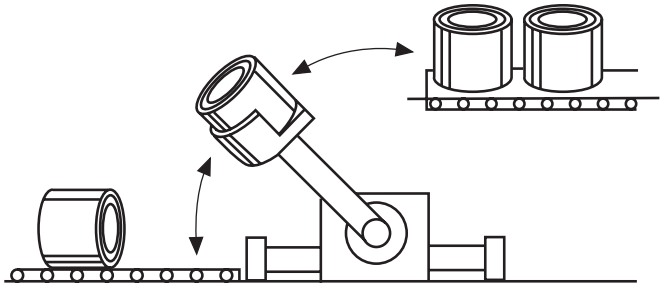
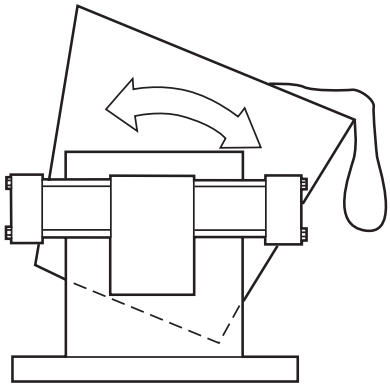
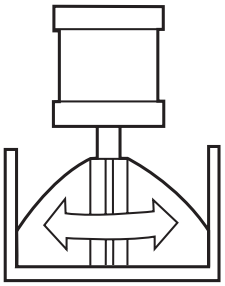


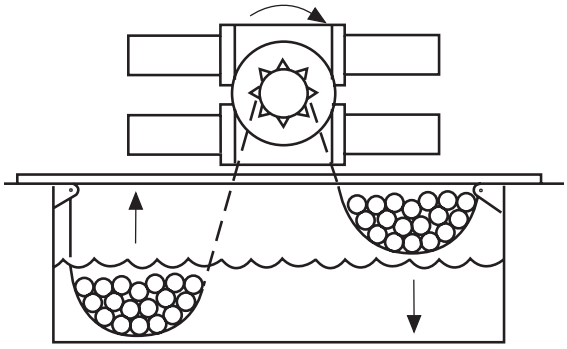
Transfer
(Upending/Downending)



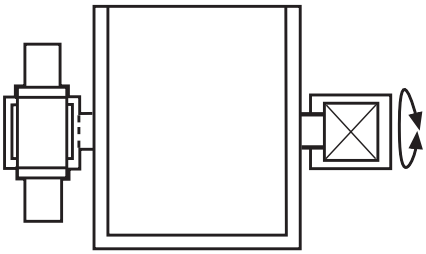
Unloading/Dumping

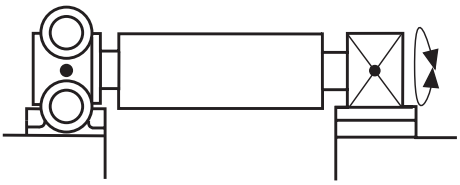


Mixing

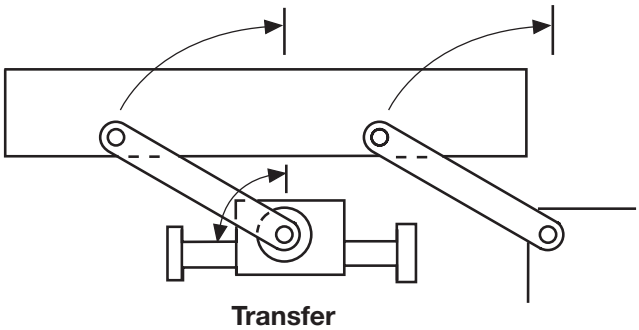


Tube Pickling Drive Conveyor

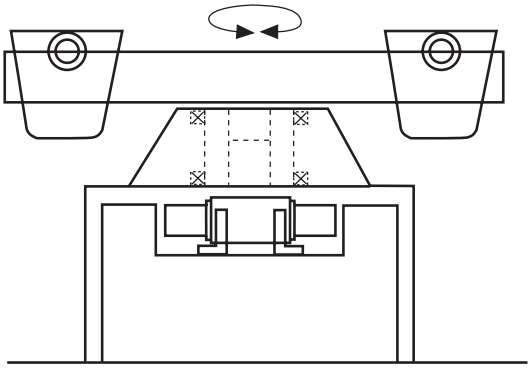




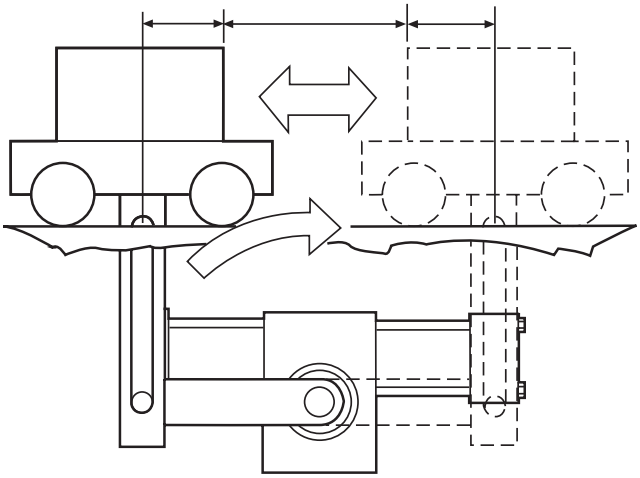
Welding Frame Rollover



Transfer
(I ifting/Feeding)



I adle Turret



Harmonic Drive

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A rack and pinion rotary actuator consists of a housing with bearings, a rack and pinion gear rotary group and hydraulic cylinder parts. The cylinder pistons drive the rack gear across the pinion gear to generate torque at some rotational velocity. Gear tooth life is well understood and with the help of the AGMA 2001-B88 calculation model, we can make gear train life estimates. The following tables suggest a relationship between a desired total torque value and a desired durability cycle life.

Durability Cycle Life

A gear tooth can break either when overloaded or by load induced metal fatigue. The tooth overload failure mode is obvious. Parker historically uses the "bending stress" criteria to establish torque ratings. Tooth bending capability remains a useful criteria. Parker proposes to broaden the selection criteria by publishing torque versus durability life guidelines and suggestions.

Parker Pneumatic Division has generated the following tables as an actuator selection aid. We suggest actuator selection begin with the consideration of both torque and desired durability life. Use these tables to discover possible candidate HUB, LTR, HTR and Mill type actuators for consideration.

How to Use

These suggestions are made not respective of the available operational pressure. Select the desired total torque requirements on the left hand column. Then select the desired durability cycle life column. In that square, find an actuator suggestion that should meet both the gear train durability and cycle life criteria. An actuator with greater capabilities than the one suggested should satisfy the same criteria. For example, if the block suggests an LTR151 for the given torque and durability life, then an LTR152 is also suitable as would be an HTR1.8 or any actuator larger than the LTR151.

Caution: These charts are intended as a guide only. Refer to actual product data in the catalog before specifying an actuator. Factors such as bearing loads and shock loads may influence actuator selection. It is not feasible for any catalog to note, describe and anticipate all product limitations. It is incumbent upon the OEM or user to qualify any particular product for each and every application.

NOTE: Consult factory for gear train life information if:
HUB system pressure exceeds 1750 psig
LTR system pressure exceeds 750 psig
HTR system pressure exceeds 1750 psig
M system pressure exceeds 2250 psig

Completely fill out the "Application Fax" and submit the form prior to contact with the factory.

Torque vs Durability Cycle l ife*
Torques from 200 to 1100 in-lb

Torque level in-lb	Nm	10 thousand cycles nominal life	100 thousand cycles nominal life	1 million cycles nominal life	10 million cycles nominal life
1100	124	LTR151	HTR1.8 or HUB018	HTR3.7	LTR152
1000	113	LTR151	HTR1.8 or HUB018	HTR1.8 or HUB018	LTR152
900	102	LTR151 or HTR.9	LTR151	HTR1.8 or HUB018	HTR3.7
800	90	HTR.9	LTR151	HTR1.8 or HUB018	HTR1.8 or HUB018
700	79	LTR102 or HTR.9	LTR151	LTR151	HTR1.8 or HUB018
600	68	LTR102 or HTR.9	LTR102 or HTR.9	LTR151	LTR151
500	57	LTR102 or HTR.9	LTR102 or HTR.9	LTR102 or HTR.9	LTR151
400	45	LTR101	LTR102 or HTR.9	LTR102 or HTR.9	LTR102 or HTR.9
300	34	LTR101	LTR101	LTR102 or HTR.9	LTR102 or HTR.9
200	23	LTR101	LTR101	LTR101	LTR101

*Durability life estimates based on AGMA 2001-B88 gear life model for pitting resistance.

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Torque vs Durability Cycle l ife*
Torques from 2000 to 10000 in-lb

Torque level in-lb	Nm	10 thousand cycles nominal life	100 thousand cycles nominal life	1 million cycles nominal life	10 million cycles nominal life
10000	1130	HTR10, LTR321 or HUB100	LTR322	HTR30/45	HTR30/45
9000	1017	HTR10 or HUB100	HTR15/22	HTR30/45	HTR30/45
8000	904	HTR10, LTR252 or HUB100	HTR15/22	LTR322	HTR30/45
7000	791	HTR7.5 or HUB075	HTR10 or HUB100	HTR15/22	HTR30/45
6000	678	LTR321/252	HTR10 or HUB100	HTR15/22	HTR30/45
5000	565	HTR5 or LTR202/252	LTR202/321	HTR10 or HUB100	HTR15/22
4000	452	LTR202/251	LTR202/321	LTR202/321	HTR10 or HUB100
3000	339	HTR3.7 or LTR251	HTR5	LTR202/321	LTR321
2000	226	HTR1.8 or LTR152	HTR1.8/3.7 or LTR152	LTR101/251/152 or HTR5	LTR201/251/152

Torque vs Durability Cycle l ife*
Torques from 15000 to 100000 in-lb

Torque level in-lb	Nm	10 thousand cycles nominal life	100 thousand cycles nominal life	1 million cycles nominal life	10 million cycles nominal life
100000	11300	150M or HTR150	150M	150M	150M or HTR300
90000	10170	150M or HTR150	150M	150M	150M or HTR300
80000	9040	150M or HTR150	150M	150M	150M or HTR300
70000	7910	75M or HTR75	75M	150M	150M or HTR300
60000	6780	75M or HTR75	75M or HTR150	75M or HTR150	150M or HTR300
50000	5650	75M or HTR75	75M or HTR150	75M or HTR150	75M or HTR150
40000	4520	75M or HTR75	75M or HTR150	75M or HTR150	75M or HTR150
30000	3390	HTR30	HTR75	75M or HTR150	75M or HTR150
20000	2260	HTR30/45 or LTR322	HTR30/45	HTR75	HTR75
15000	1695	HTR15/22 or LTR322	HTR30/45	HTR30/45	HTR30/45

Torque vs Durability Cycle l ife*
Torques from 100000 to 600000 in-lb

Torque level in-lb	Nm	10 thousand cycles nominal life	100 thousand cycles nominal life	1 million cycles nominal life	10 million cycles nominal life
600000	67764	600M or HTR600		Consult factory.	
500000	56470	600M or HTR600	600M		
400000	45176	600M or HTR600	600M	600M	
300000	33882	300M or HTR600	600M or HTR600	600M	600M
200000	22588	300M or HTR300	300M	600M or HTR600	600M or HTR600
100000	11300	150M or HTR150	150M or HTR300	150M or HTR300	150M or HTR300

*Durability life estimates based on AGMA 2001-B88 gear life model for pitting resistance.

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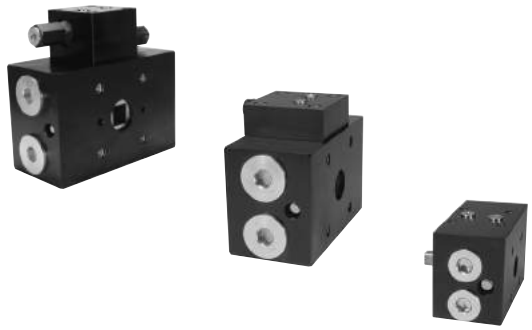
HUB Series

The Hydraulic Unibody Series (HUB) actuator is designed to perform in the harshest environmental conditions. Built with a hard coat anodized housing and through hardened, high strength alloy steel pinion and racks, this product is ideal for numerous applications where weather can be a factor. The HUB Series is designed with several add-on valve modules for lower overall integration costs, as well as, an increase in product performance. Multiple feedback and visual indication options are also available.

- Rack and pinion design provides excellent efficiency characteristics and minimizes HPU Size
- Direct mounting design to numerous process valves allows for minimal integration cost
- Integrated valve modules options are available for increased performance and reduced plumbing cost
  - Cross-over vent module - allows for flow between both cylinder ports.
  - Counter-balance valve module with Cross-over vent - designed for load holding in both directions and preventing a run-away load situation from occurring. Also allows for flow between both cylinder ports.
  - D03 Solenoid ready module - manifold block directly mounted to actuator for reduced plumbing and increase in performance
- Numerous linear and positional feedback and visual indication options available
- Environmentally rugged for reliable performance in harsh conditions



Operating information

Maximum operating pressure:	3000 PSI (207 bar)
Standard rotation:	90°
Rotational tolerance:	-0°, +2°
Output torques @:	3000 PSI (207 bar) 1800 in-lb to 10,000 in-lb
Maximum breakaway pressure:	70 PSIG (4.8 bar)
Mounting orientation:	unrestricted
Operating temperature range: Nitrile seals	 -40°F to 180°F (-40°C to 82°C)
Standard timing:	12:00 position at midstroke. See pages A12 through A15 for details.
Recommended filtration:	ISO class 17/14 or cleaner

I TR Series

The LTR Series provides superior performance in low pressure hydraulic applications found in packaging, material handling, machine tool and automated assembly industries.

Sealed ball bearings and floating pistons ensure low breakaway pressure and smooth operation. PolyPak piston seals and wearbands eliminate leakage and cylinder scoring. Alloy steel racks and pinions provide the strength and resilience for minimum downtime. A broad offering of options provides unmatched flexibility in design and application. These include cushions, stroke adjusters, flow controls, and position sensors, as well as application matched shaft, mounting, porting and seal variations. Three position and antibacklash units are also available.

Operating information

Output Torques	1000 psi (69 bar): 395 in-lb to 22,813 in-lb
Nominal pressure:	1000 PSIG (69 bar) (3L cylinder pressure ratings apply)
Operating temperature range: Nitrile seals Fluorocarbon seals	 -40°F to 180°F (-40°C to 82°C) -5°F to 250°F (-21°C to 121°C)
Standard rotations:	90°, 180°, 270°, 360°, 450°
Rotational tolerance	-0°, +2°
Breakaway pressure:	30 PSIG (2 bar) maximum
Mounting orientation:	unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Recommended filtration:	ISO class 17/14 or better

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HTR Series

When durability, performance, and reliability are required in the most demanding industrial applications, specify the HTR Series actuator. This series is designed for medium duty service found in machine tool, transfer line, material handling and other critical applications.

Through hardened alloy steel pinion and racks, supported by large capacity tapered roller bearings in a ductile iron housing, ensure long life, even with externally applied radial and thrust loads. The heavy duty Wear-Pak pistons are equipped with self-energizing deep PolyPak piston seals and a rugged wear band for long life operation. Standard NFPA cylinder construction allows for a wide variety of rotation options, complementing the broad offering of shaft and mounting styles.

Operating information

Output torques @	
3000 PSI (207 bar):	900 in-lb to 600,000 in-lb (Larger output torques available upon request)
Maximum operating pressure:	3000 PSI (207 bar) non-shock
except HTR22/45:	2000 PSI (138 bar) non-shock
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Fluorocarbon seals	-20°F to 250°F (-29°C to 121°C)
Standard rotations:	90°, 180°, 360°, 450°
Rotational tolerance:	-0°, +2°
Maximum breakaway pressure:	70 PSIG (4.8 bar)
Mounting orientation:	Unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Recommended filtration:	ISO class 17/14 or better

M Series

Designed to meet steel mill specifications, these non tie rod rotary actuators incorporate a range of exclusive features designed to provide durability and dependability in the most arduous operating environment.

Wear band pistons on both ends and bronze bearings under the center of the alloy steel rack provide critical support while helping to prevent scoring or galling of the cylinder tubes. Large diameter tapered roller bearings support the pinion, allowing the unit to absorb high external loads. PolyPak seals provide long life operation and, for ease of maintenance, can be changed without removing the actuator from the installation.

Operating information

Output torques @	
3000 PSI (207 bar):	75,000 in-lb to 50,000,000 in-lb
Maximum operating pressure:	3000 PSI (207 bar)
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Fluorocarbon seals	-20°F to 250°F (-29°C to 121°C)
Standard rotations:	90°, 180°, 360°, 450°
Rotational tolerance:	-0°, +2°
Maximum breakaway pressure:	75 psi (5 bar)
Mounting orientation:	Unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Housing:	
Heavy duty	Ductile iron (units up to 1000M)
Steel	Weldments (units larger than 1000M)

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Parker . . . l eading the Industry

Parker combines many years of vane actuator experience with innovative product design to lead the industry in the development of reliable and efficient rotary actuators. When you specify Parker rotary vane actuators, you can rely on reduced maintenance costs and increased productivity.

Why Use Parker Vane Style Rotary Actuators?

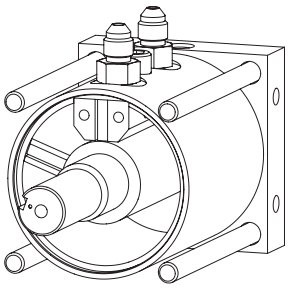
- High torque output in a small package size
- Very economical for OEM applications
- Zero backlash allows precise positioning
- Provides uniform torque in both directions
- Simplicity of design
- Washdown compatible
- Performs under the most adverse ambient conditions
- Cleanroom compatible
- Guaranteed zero external leakage
- Will support radial and thrust loads
- Wide range of sizes

Where Can Parker Vane Style Rotary Actuators Be Used?

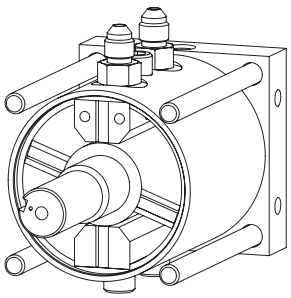
- Material Handling
- Machine Tool
- Rubber and Plastics Machinery
- Robotics
- Packaging
- Valve Actuation
- Food Processing
- Electronics Manufacturing
- Conveyors

How Do Vane Actuators Work?

Parker vane actuators provide the maximum amount of output torque from the smallest possible envelope size. They convert fluid pressure into rotary motion for a wide variety of industrial applications. Two basic styles are available. Single vane models have a maximum rotation of 280°, while the double vane units produce twice the torque output from identical envelope dimensions and have a maximum rotation of 100°.



Single Vane



Double Vane

A short cylindrical chamber encloses a vane attached to a central shaft. Pressure is applied through a stationary barrier (stator) within the body to one side of the vane. The opposite side of the vane is connected to exhaust through the stator. This pressure overcomes seal friction and produces rotation of the vane and central shaft. Due to vane actuator design, there will always be some internal bypass in these units and therefore they should not be used as a brake to support loads.

Tork-Mor Series

Tork-Mor Series actuators are produced in eighteen sizes generating up to 145,000 in-lb of torque at rated pressure. Capable of providing full torque instantly in either direction, they operate at pressures up to 1000 psi. The Tork-Mor Series can be mounted in any axis using a wide variety of standard or optional mountings.

Proven reliable through many years of field service, the Tork-Mor Series incorporates many quality features including precision ball bearings to provide shaft support, externally removable gland for ease of seal replacement and cylinders honed to a 10 micro inch finish to ensure long seal life.

Operating information

Output torques @ 500 PSI (35 bar):	800 in-lb to 145,000 in-lb
Maximum operating pressure:	1000 PSI (69 bar) hydraulic
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Fluorocarbon seals	-20°F to 250°F (-29°C to 121°C)
Rotations:	
S Models	280°
DS Models	100°
Rotational tolerance:	±1°
Maximum allowable drainline pressure:	50 PSIG (3.4 bar) hydraulic
Mounting orientation:	Unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Recommended filtration:	ISO class 17/14 or better

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HUB Series - Hydraulic Unibody
Hydraulic Rack & Pinion Rotary Actuators

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Market Segments/Applications	Market/Segment	Typical Application(s)	Product Series				
			HUB	LTR	HTR	M	Tork-Mor
	Aerospace	Water bomb, tank door actuation		●			
	Aggregate	Granite block rollover			●		
	Aluminum	Automation				●	
	Automation	Mounting, Processing, Flood gate actuation, End of arm tooling	●	●	●		●
	Automotive	Automation, Clamping, Tube bending			●		●
	Conveyor	Swing & rotate		●	●		●
	Entertaining	Pool gate actuation, Robotic joint motion					●
	Fluid Management & Flow Control	Power plants			●	●	
	Industrial	Automation, Clamping					●
	Machine Builders	End of arm tooling			●		
	Marine/Offshore	Boomslewer, Submersible			●	●	
	Mining	Mobile longhole drilling, Tunnel boring	●		●	●	
	Mobile	Fire truck ladder rotation, Aerial lift basket, X-ray boom rotation, Forklift handling & storage, Refuse tippers	●	●	●	●	
	Nuclear	Door actuation				●	
	Oil & Gas	Process valve actuation	●		●		
	Oil Industry Machinery	Clamping, Lockout	●				●
	Paper & Pulp	Walking beam				●	
	Plastics	Blow molding, Injection molding			●		●
	Rubber	Mixing			●	●	
	Solar	Panel rotation			●		
	Space	Rocket launch tower				●	
	Steel & Casting	Ladle Tilt, Coil Box, Steel Booming, Pipe fabrication			●	●	●
	Testing Equipment	Flight Simulators, Cycle loading, Tensile test Machines			●		●
	Transportation	Bus wheelchair ramp		●			
	Water Management	Valve Actuation	●		●		
	Welding	Weld gun indexing, Clamping					●

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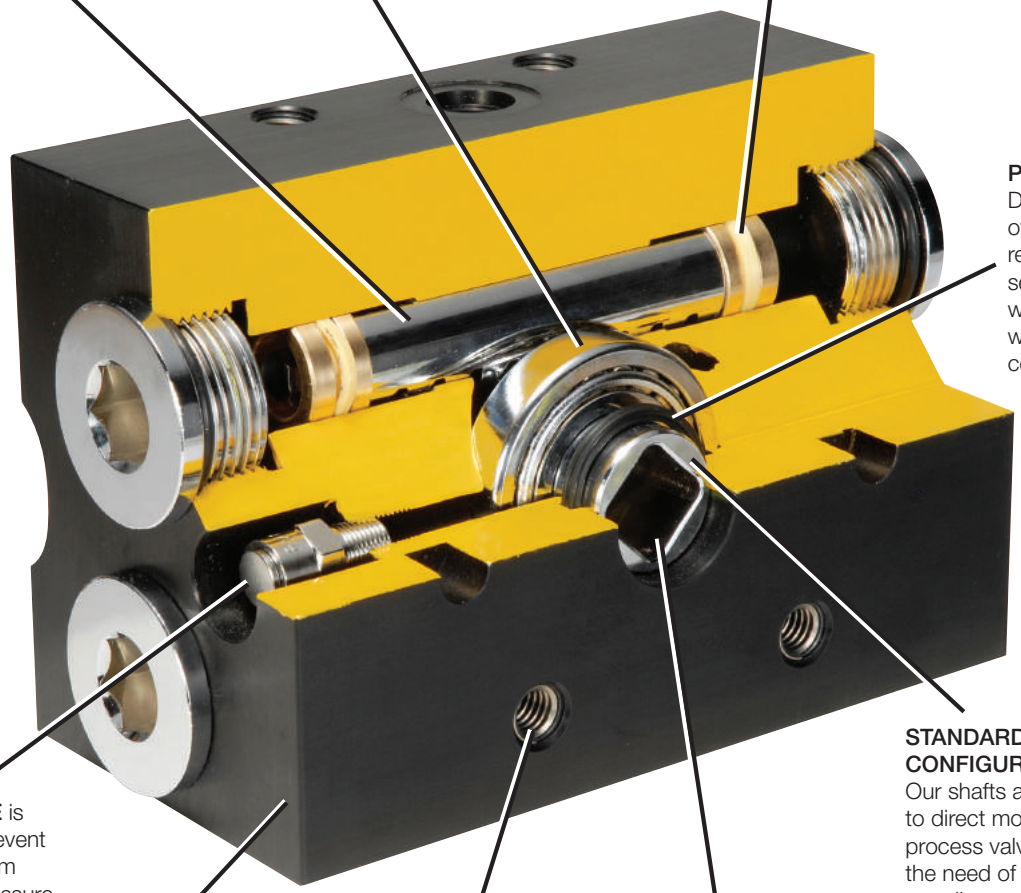
HUB Series

WEAR BANDS (HUB075 & HUB100)
Filled PTFE bands (std) precisely position pistons and prevent side loading from scoring cylinder bores.

PISTON SEALS
Piston lip seals made from abrasion resistant 4300 polyurethane for reliable service. These seals offer a wide temperature range so that this product may be used in a wide variety of applications. Piston seals can be inspected and replaced without disconnecting the load from the shaft. (Employ proper safety practices to prevent damage to people or equipment.)

TAPERED ROLLER BEARINGS are designed to support large external axial and radial loads applied to the shaft.

RACK & PINION made from through hardened, high strength alloy steels for long and durable service life.



PINION SEALS
Dual lobed seal of abrasion resistant materials seals effectively with minimum wear at dynamic conditions.

STANDARD SHAFT CONFIGURATIONS
Our shafts are designed to direct mount to various process valves without the need of additional coupling.

RELIEF VALVE is designed to prevent the housing from seeing high pressure due to piston seal bypass.

SHAFT ORIENTATION
Mid stroke at 12:00 position is standard.

HOUSING
Anodized aluminum housing is designed to minimize external fitting and plumbing connections and rugged enough for the harsh outside environment.

THREADED MOUNTING HOLES
Our standard mounting uses four tapped holes re-inforced with stainless steel inserts on the customer mounting face of the housing. Both inch and metric (ISO 5211) are available and provide direct mounting to a wide range of process valves.

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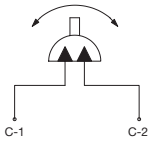
HUB Series



SAE #6 ports - pages A10 & A11 for additional information

Torque output (in-lb)	Imperial/ Metric	Mounting pattern	Shaft size (female square)	Feedback	Visual indication	Part number
1,800	Imperial	3.25"	.625"	None	None	**HUB018-090ZZ-A1B12BZZA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D12BZZA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F12BZZA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C12BZZA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E12BZZA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J12BZZA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L12BZZA**
1,800	Imperial	3.25"	.625"	None	Line on shaft	**HUB018-090ZZ-A1B12BZAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D12BZAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F12BZAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C12BZAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E12BZAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J12BZAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L12BZAA**
1,800	Imperial	3.25"	.625"	Rotary Linear Potentiometer (RLPO)*	Line on shaft	**HUB018-090ZZ-A1B12BAAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D12BAAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F12BAAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C12BAAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E12BAAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J12BAAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L12BAAA**
1,800	Imperial	3.25"	.625"	StoneL*	Green on/ Red off	**HUB018-090ZZ-A1B12BCCA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D12BCCA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F12BCCA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C12BCCA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E12BCCA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J12BCCA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L12BCCA**

* Additional feedback information on pages A21 thru A26.

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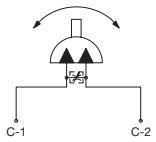
HUB Series



SAE #6 ports with cross-over vent module - pages A10, A11 & A18 for additional information

Torque output (in-lb)	Imperial/ Metric	Mounting pattern	Shaft size (female square)	Feedback	Visual indication	Part number
1,800	Imperial	3.25"	.625"	None	None	**HUB018-090ZZ-A1B1BBZZA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1BBZZA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1BBZZA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1BBZZA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1BBZZA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1BBZZA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1BBZZA**
1,800	Imperial	3.25"	.625"	None	Line on shaft	**HUB018-090ZZ-A1B1BBZAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1BBZAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1BBZAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1BBZAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1BBZAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1BBZAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1BBZAA**
1,800	Imperial	3.25"	.625"	Rotary Linear Potentiometer (RLPO)*	Line on shaft	**HUB018-090ZZ-A1B1BBAAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1BBAAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1BBAAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1BBAAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1BBAAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1BBAAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1BBAAA**
1,800	Imperial	3.25"	.625"	StoneL*	Green on/ Red off	**HUB018-090ZZ-A1B1BBCCA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1BBCCA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1BBCCA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1BBCCA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1BBCCA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1BBCCA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1BBCCA**

* Additional feedback information on pages A21 thru A26.

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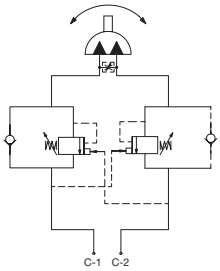
HUB Series



SAE #6 ports with counter-balance valve module - pages A10, A11 & A19 for additional information

Torque output (in-lb)	Imperial/ Metric	Mounting pattern	Shaft size (female square)	Feedback	Visual indication	Part number
1,800	Imperial	3.25"	.625"	None	None	**HUB018-090ZZ-A1B1DBZZA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1DBZZA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1DBZZA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1DBZZA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1DBZZA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1DBZZA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1DBZZA**
1,800	Imperial	3.25"	.625"	None	Line on shaft	**HUB018-090ZZ-A1B1DBZAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1DBZAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1DBZAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1DBZAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1DBZAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1DBZAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1DBZAA**
1,800	Imperial	3.25"	.625"	Rotary Linear Potentiometer (RLPO)*	Line on shaft	**HUB018-090ZZ-A1B1DBAAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1DBAAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1DBAAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1DBAAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1DBAAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1DBAAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1DBAAA**
1,800	Imperial	3.25"	.625"	StoneL*	Green on/ Red off	**HUB018-090ZZ-A1B1DBCCA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1D1DBCCA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1F1DBCCA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6C1DBCCA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6E1DBCCA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6J1DBCCA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6L1DBCCA**

* Additional feedback information on pages A21 thru A26.

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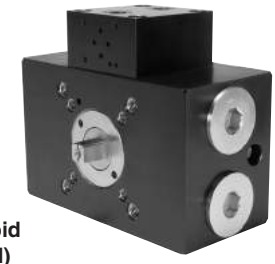
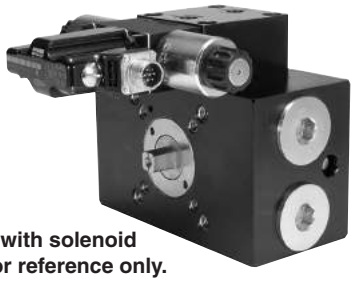
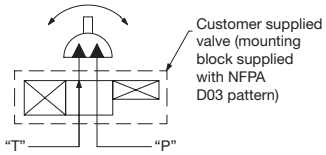


Without solenoid valve (standard)



Shown with solenoid valve for reference only.



SAE #6 ports with D03 directional control valve ready - pages A10, A11 & A20 for additional information

Torque output (in-lb)	Imperial/ Metric	Mounting pattern	Shaft size (female square)	Feedback	Visual indication	Part number
1,800	Imperial	3.25"	.625"	None	None	**HUB018-090ZZ-A1BA2BZZA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1DA2BZZA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1FA2BZZA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6CA2BZZA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6EA2BZZA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6JA2BZZA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6LA2BZZA**
1,800	Imperial	3.25"	.625"	None	Line on shaft	**HUB018-090ZZ-A1BA2BZAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1DA2BZAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1FA2BZAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6CA2BZAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6EA2BZAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6JA2BZAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6LA2BZAA**
1,800	Imperial	3.25"	.625"	Rotary Linear Potentiometer (RLPO)*	Line on shaft	**HUB018-090ZZ-A1BA2BAAA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1DA2BAAA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1FA2BAAA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6CA2BAAA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6EA2BAAA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6JA2BAAA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6LA2BAAA**
1,800	Imperial	3.25"	.625"	StoneL*	Green on/ Red off	**HUB018-090ZZ-A1BA2BCCA**
7,500	Imperial	5.00"	.875"			**HUB075-090ZZ-B1DA2BCCA**
10,000	Imperial	5.00"	1.125"			**HUB100-090ZZ-B1FA2BCCA**
1,800	Metric	70 mm	11 mm			**HUB018-090ZZ-K6CA2BCCA**
1,800	Metric	70 mm	14 mm			**HUB018-090ZZ-K6EA2BCCA**
7,500	Metric	102 mm	22 mm			**HUB075-090ZZ-L6JA2BCCA**
10,000	Metric	140 mm	27 mm			**HUB100-090ZZ-N6LA2BCCA**

* Additional feedback information on pages A21 thru A26.

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HUB	075	-	090	Z	Z	-	B	1D	12	B	A	A	A

Rotary Actuator Series	
HUB	Hydraulic Unibody

Torque Output at 3000 PSI	
018	1,800 in-lb - .875 in bore (double rack)
075	7,500 in-lb - 1.5 in bore (double rack)
100	10,000 in-lb - 1.5 in bore (double rack)

Degrees Rotation	
090	90 Degrees

Cushion	
Z	None (std)

Stroke Adjusters	
Z	None (std)

Process Valve Mounting Pattern	
A	3.25 in (018 only), Imperial
B	5.00 in (075 and 100 only), Imperial
K	70 mm (018 only), Metric
L	102 mm (075 only), Metric
N	140 mm (100 only), Metric

See **TABLE 1** for proper combinations, additional information on page A16.

Shaft Configuration & Size	
1B	.625 in female square (018 only), Imperial
1D	.875 in female square (075 only), Imperial
1F	1.125 in female square (100 only), Imperial
6C	11 mm female square (018 only), Metric
6E	14 mm female square (018 only), Metric
6J	22 mm female square (075 only), Metric
6L	27 mm female square (100 only), Metric

See **TABLE 1** for proper combinations, additional information on page A17.

Port Type or Direct Mount Valve Modules	
12	SAE #6 straight thread
1B	SAE #6 straight thread with cross-over vent valve
1D	SAE #6 straight thread with counter-balance valve (pilot ratio 7:1)
A2	SAE #6 straight thread with D03 directional control valve ready (valve not included)

See **TABLE 2** for valves included with each option, additional information on pages A18 thru A20.

Seals	
B	4300 Polyurethane

Feedback	
A	Rotary linear potentiometer (RLPO), 0-40 VDC, position right (standard)
B	Rotary linear potentiometer (RLPO), 0-40 VDC, position left
C	StoneL, SST dual module
D	StoneL, 4-20 mA position transmitter
E	StoneL, SST dual module & 4-20 mA position transmitter
Z	No feedback

See **TABLE 3** for proper combinations, additional information on pages A21 thru A26.

Visual Indication	
A	Line on shaft (standard)
C	Color indicator (green on / red off)
Z	No feedback

See **TABLE 3** for proper combinations, additional information on pages A21 thru A26.

Engineering Level	
A	Current engineering level

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How to build a Unibody - easy as 1, 2, 3 ..... HUB075-090ZZ-B1D12BAAA

1. **All white font digits** of the HUB part number above are fixed and **never change**
2. To make the proper selection for the remaining digits **refer to the Tables below** that match the digit color.
3. Each table will show **only** the possible combinations of digits that can be placed together.

HUB075-090ZZ-B1D12BAAA

TABLE 1

SHAFT CONFIGURATION & SIZE		PROCESS VALVE MOUNTING PATTERN		
		HUB018	HUB075	HUB100
		A	B	
		3.25 in	5.00 in	
1B	.625 in	●		
1D	.875 in		●	
1F	1.125 in			●
		K	L	N
		70 mm	102 mm	140 mm
6C	11 mm	●		
6E	14 mm	●		
6J	22 mm		●	
6L	27 mm			●

HUB075: B = 5.00 in

1D .875

TABLE 2

PORT TYPE		DIRECT MOUNT VALVE MODULES			
		Thread ports only	Cross-over vent valve included	Counter-balance valve included	Solenoid valve ready included
12	SAE #6 straight thread	●			
1B	SAE #6 straight thread with cross-over vent valve		●		
1D	SAE #6 straight thread with counter-balance valve (pilot ratio 7:1)		●	●	
A2	SAE #6 straight thread with D03 directional control valve ready (valve not incl)				●

12 SAE #6 straight thread,

TABLE 3

FEEDBACK		VISUAL INDICATION		
		A Line on shaft	C Color indicator (green on / red off)	Z No visual indication
A	Rotary Linear Potentiometer (RLPO), 0-40 VDC, position right (standard)	●		
B	Rotary Linear Potentiometer (RLPO), 0-40 VDC, position left	●		
C	StoneL, SST dual module		●	
D	StoneL, 4-20 mA position transmitter		●	
E	StoneL, SST dual module & 4-20 mA position transmitter		●	
Z	No feedback	●	●	●

A Rotary Linear Potentiometer (RLPO), 0-40 VDC, position right (standard)

A Line on shaft

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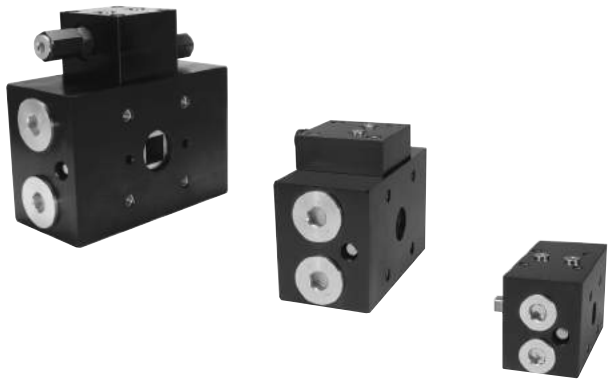
The Hydraulic Unibody Series (HUB) actuator is a single piece housing/cylinder design that is able to perform in the harshest environmental conditions. Built with a hard coat anodized housing and through hardened, high strength alloy steel pinion and racks, this product is ideal for numerous applications where weather can be a factor. The HUB Series is designed with several add-on valve modules for lower overall integration costs, as well as, an increase in product performance. Multiple feedback and visual indication options are also available.

- Rack and pinion design provides excellent efficiency characteristics and minimizes HPU Size
- Direct mounting design to numerous process valves allows for minimal integration cost
- Integrated valve module options are available for increased performance and reduced plumbing cost
  - Cross-over vent module - allows for flow between both cylinder ports, thus allowing free rotation.
  - Counter-balance valve module with Cross-over vent - designed for load holding in both directions and preventing a run-away load situation from occurring. Also allows for flow between both cylinder ports.
  - D03 Solenoid ready module - manifold block directly mounted to actuator for reduced plumbing and increase in performance
- Numerous linear and positional feedback and visual indication options available
- Environmentally rugged for reliable performance in harsh conditions



Operating information

Maximum operating pressure:	3000 PSI (207 bar)
Standard rotation:	90°
Rotational tolerance:	-0°, +2°
Output torques @:	3000 PSI (207 bar) 1800 in-lb to 10,000 in-lb
Maximum breakaway pressure:	70 PSIG (4.8 bar)
Mounting orientation:	unrestricted
Operating temperature range: Nitrile seals	 -40°F to 180°F (-40°C to 82°C)
Standard timing:	12:00 position at midstroke. See pages A12 through A15 for details.
Recommended filtration:	ISO class 17/14 or cleaner

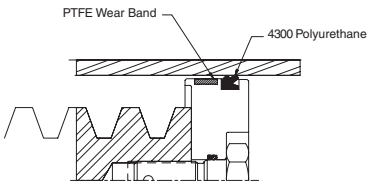
Output Torque Table

Double Rack Model	Maximum Pressure Rating PSI (bar)	Actual Output Torque in-lb (Nm) at Specified Pressure 1000 PSI (69 bar)	2000 PSI (138 bar)	3000 PSI (207 bar)	Gear Train Rating Durability (1) in-lb (2)	PSID (3)	Maximum Angular Backlash Minutes	Standard Rotation Degrees	Displacement in³ (cm³)	Standard Unit Weight lb (kg)
HUB018	3000 (207)	600 (68)	1200 (136)	1800 (203)	850	1420	45	90	1.13 (19)	10 (4.5)
HUB075	3000 (207)	2500 (283)	5000 (565)	7500 (848)	3330	1350	40	90	4.86 (79)	23 (10.4)
HUB100	3000 (207)	3300 (373)	6600 (746)	10000 (1130)	5725	1720	30	90	6.25 (102)	29 (13.2)

1. The durability is defined as the capacity of the gear set to support the stated load without fatigue related gear surface damage. Use the durability rating for high production duty of 1 million cycles and/or high speed applications (180° in less than three seconds or more than one cycle per minute).
2. Durability rated output torque.
3. Pressure differential between the inlet and outlet ports (non shock).

Seal Materials

Effective filtration is vital to the long life and satisfactory performance of a rotary actuator. If the piston seals of a rack and pinion rotary are worn or damaged, fluid which leaks past the piston will enter the gear housing. In the event of internal leakage into the gear housing, the pressure relief valve protects the shaft seal.



Seal class	Seal type	Wear ring type	Fluid medium	Temperature range	Pressure range	Filtration
Standard type 1	4300 Polyurethane U-cup	Filled PTFE	General purpose, Petroleum-based fluids	-40°F to 180°F (-40°C to 82°C)	3000 PSI 207 bar	Minimum ISO class 17/14 Cleanliness level

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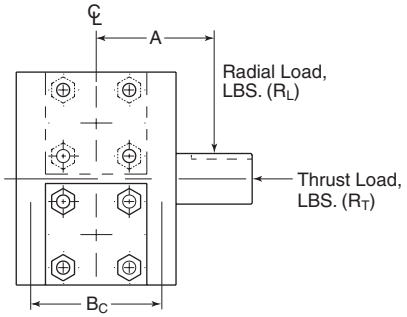
Bearing Load Capacities



Dynamic [1] Bearing Load Capacities vs. Operating Pressure

Model	Radial Load (lbs.) R_L (per bearing) @ 1000 PSID (69 bar)	2000 PSID (138 bar)	3000 PSID (207 bar)	Thrust Load (lbs.) R_T @ 1000 PSID (69 bar)	2000 PSID (138 bar)	3000 PSID (207 bar)	Bearing Centers (B_C)	Overhung Moment (in-lb) R_L x ($A+B_C/2$) @ 1000 PSID (69 bar)	2000 PSID (138 bar)	3000 PSID (207 bar)
HUB018	4030 (278)	4030 (278)	4030 (278)	2790 (192)	2790 (192)	2790 (192)	0.62	2499 (172)	2499 (172)	2499 (172)
HUB075	6750 (465)	6750 (465)	6750 (465)	3830 (264)	3830 (264)	3830 (264)	106	7155 (493)	7155 (493)	7155 (493)
HUB100	8560 (590)	8560 (590)	8560 (590)	4460 (308)	4460 (308)	4460 (308)	1.02	8731 (602)	8731 (602)	8731 (602)

NOTES: 1. Static bearing load capacities = dynamic valves x 1.5
2. Values listed are "Bearing" moment capacities. Standard male shaft sizes do not provide 4:1 design factor at these operating conditions. Larger shaft sizes are available. Consult factory for further details.

Lubrication

Low speed, high torque applications typically require class 5 or class 6 lubrication provisions. Parker rotary actuators are assembled with TEXACO MOLYTEX EP (2) extreme pressure grease. This grease should be replaced with each major overhaul.

Base Kit Ordering Information

PSK-HUB018 - **10** **1** **P**

Basic Kit Size	
PSK-HUB018	HUB018 basic kit number
PSK-HUB075	HUB075 basic kit number
PSK-HUB100	HUB100 basic kit number

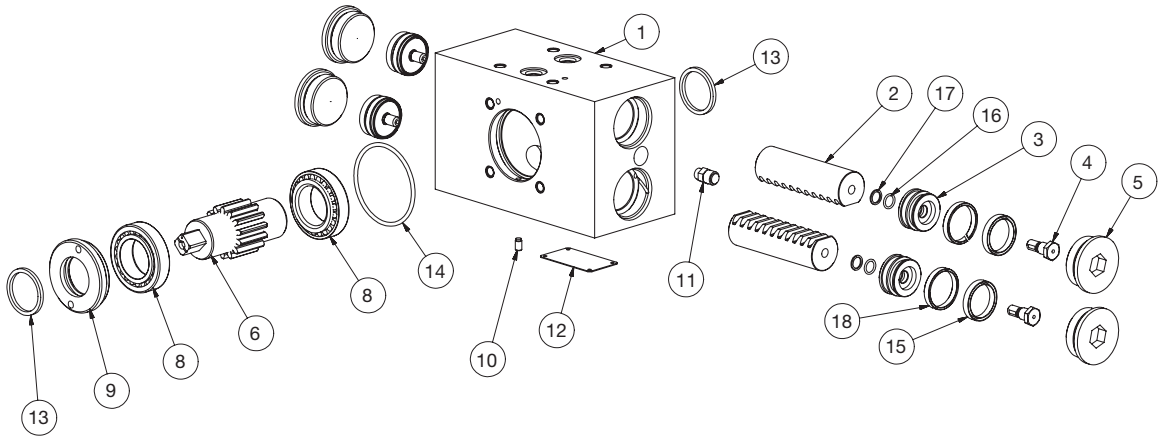
Kit Number	
10	Base actuator

Kit Type	
1	Seal kit

Label Suffix	
P	Parker North America

Item #	Description	Qty	Item #	Description	Qty
1	Housing	1	11	Relief Valve	1
2	Rack	2	12	Name Plate	1
3*	Piston (018 only)	4	13*	Quad Ring	2
4*	Rack Bolt	4	14*	O-ring	1
5	Plug, SAE	4	15*	Piston Seal	4
6	Pinion	1	16*	O-ring	4
8	Bearing	2	17*	Back-up Ring	4
9	Bearing Cap	1	18*	Wear Band (075 & 100 only)	4
10	SHSS	1			

* Items included in seal kit.



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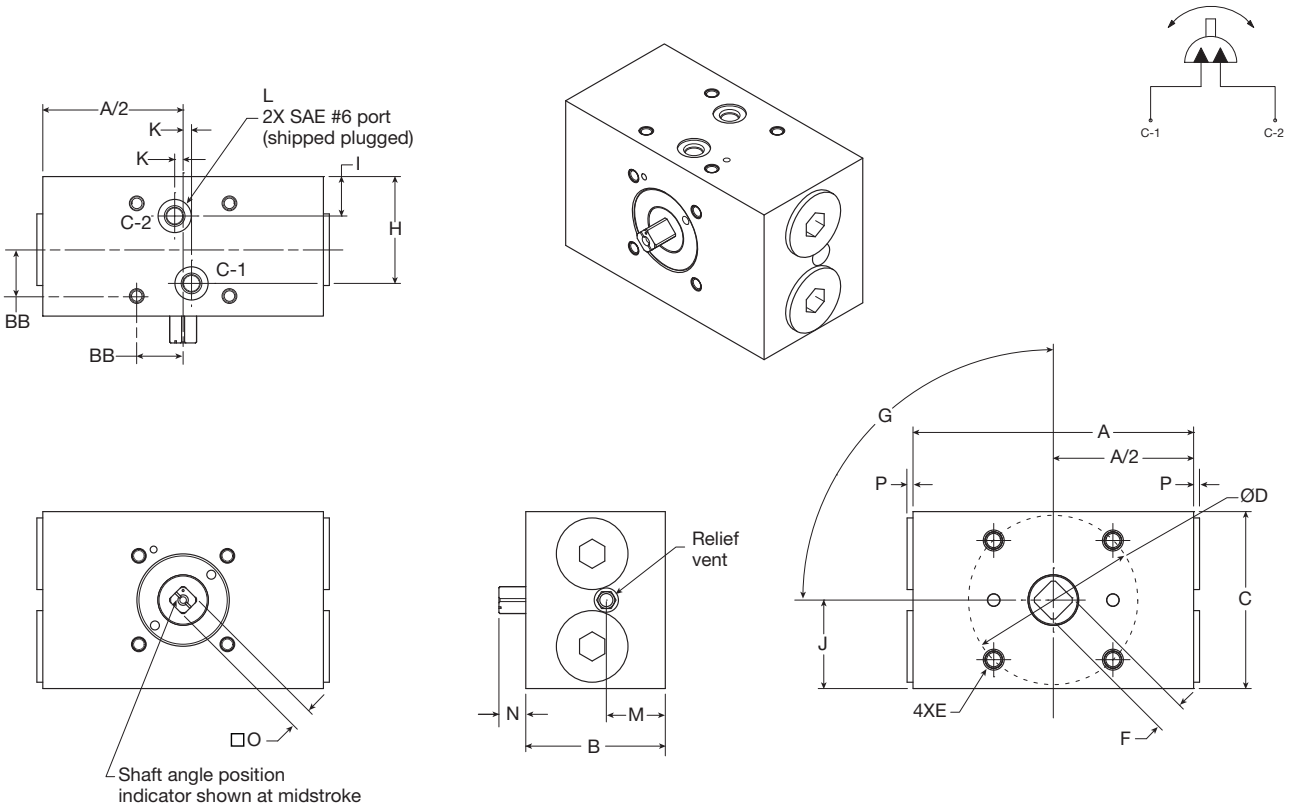
HUB Series

SAE #6 ports



HUB075 series shown above.

Dimensions, inch (mm)

Model	A	B	C	D	E†	F	D	E†	F	G	H	I	J
HUB018	6.18 (156.9)	3.20 (81.3)	4.13 (104.9)	3.250	3/8-16 X .56 Deep	.625 Nominal	70	M8 X 12 Deep	11 or 14mm	90°	2.39 (6.07)	1.01 (25.6)	1.81 (46.05)
HUB075	8.33 (211.6)	4.14 (105.2)	5.25 (133.4)	5.000	1/2-13 X .50 Deep	.875 Nominal	102	M10 X 15 Deep	22mm	90°	3.17 (80.5)	1.17 (29.7)	2.63 (66.80)
HUB100	9.50 (241.3)	4.14 (105.2)	6.00 (152.4)	5.000	1/2-13 X .50 Deep	1.13 Nominal	140	M16 X 24 Deep	27mm	90°	3.17 (80.5)	1.17 (29.7)	3.00 (76.20)

Model	K	L	M	N	O	P	BB
HUB018	0.13 (3.3)	SAE #6	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.125 (28.6)
HUB075	0.25 (6.4)	SAE #6	0.87 (22.1)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.375 (34.9)
HUB100	0.25 (6.4)	SAE #6	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.375 (34.9)

Imperial housings and shafts only.
Metric housing and shafts only.

† Thread depth is for Helicoil hole depth may be longer.

2D & 3D CAD for all variations available for download at www.parker.com/pneu/hub

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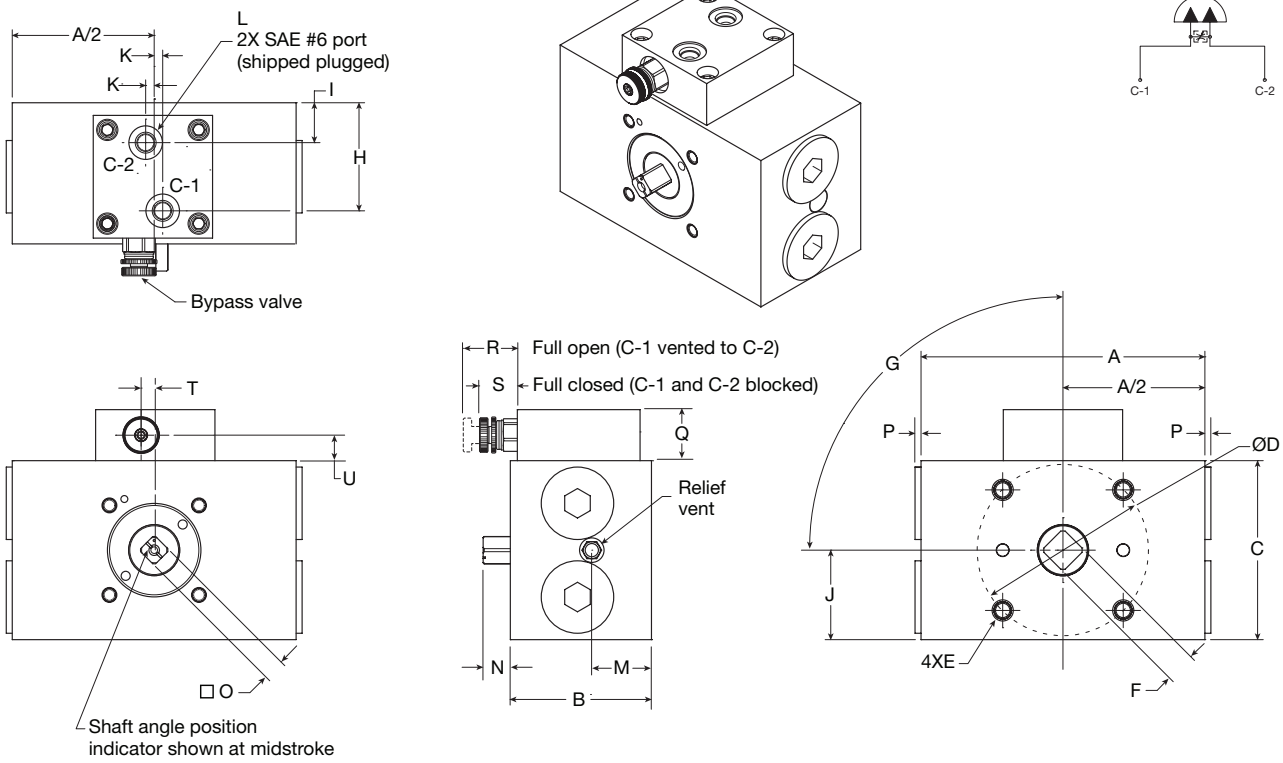
HUB Series

SAE #6 ports with cross-over vent module



HUB075 series shown above.

Dimensions, inch (mm)

Model	A	B	C	D	E†	F	D	E†	F	G	H	I	J
HUB018	6.18 (156.9)	3.20 (81.3)	4.13 (104.9)	3.250	3/8-16 X .56 Deep	.625 Nominal	70	M8 X 12 Deep	11 or 14mm	90°	2.30 (58.42)	1.01 (25.65)	1.83 (46.48)
HUB075	8.33 (211.6)	4.14 (105.2)	5.25 (133.4)	5.000	1/2-13 X .50 Deep	.875 Nominal	102	M10 X 15 Deep	22mm	90°	3.17 (80.5)	1.17 (29.7)	2.63 (66.80)
HUB100	9.50 (241.3)	4.14 (105.2)	6.00 (152.4)	5.000	1/2-13 X .50 Deep	1.13 Nominal	140	M16 X 24 Deep	27mm	90°	3.17 (80.5)	1.17 (29.7)	3.00 (76.20)

Model	K	L	M	N	O	P	Q	R	S	T	U
HUB018	0.25 (6.4)	SAE #6	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.50 (38.1)	1.45 (36.8)	1.25 (31.7)	0.38 (9.6)	0.75 (19.1)
HUB075	0.25 (6.4)	SAE #6	0.87 (22.1)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.50 (38.1)	1.45 (36.8)	1.25 (31.7)	0.42 (10.67)	0.75 (19.1)
HUB100	0.25 (6.4)	SAE #6	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.50 (38.1)	1.45 (36.8)	1.25 (31.7)	0.42 (10.67)	0.75 (19.1)

Imperial housings and shafts only.
Metric housing and shafts only.

† Thread depth is for Helicoil hole depth may be longer.

2D & 3D CAD for all variations available for download at www.parker.com/pneu/hub

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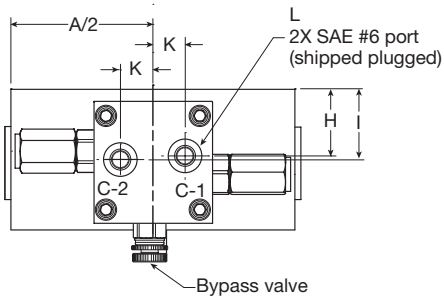
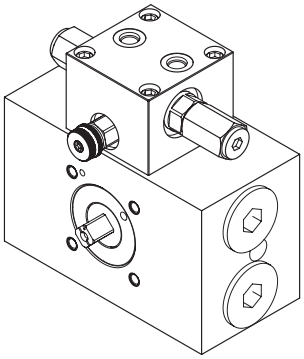
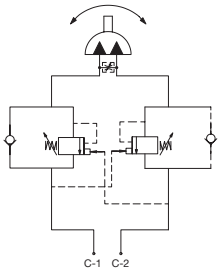
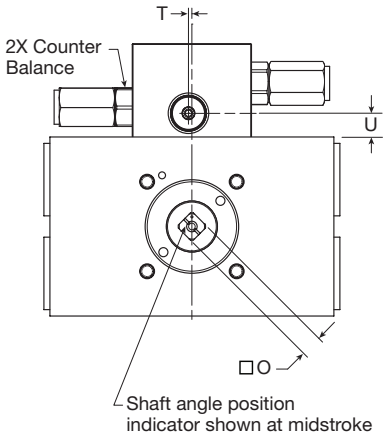
HUB Series

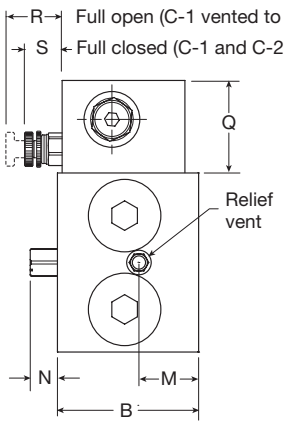
SAE #6 ports with counter-balance valve module

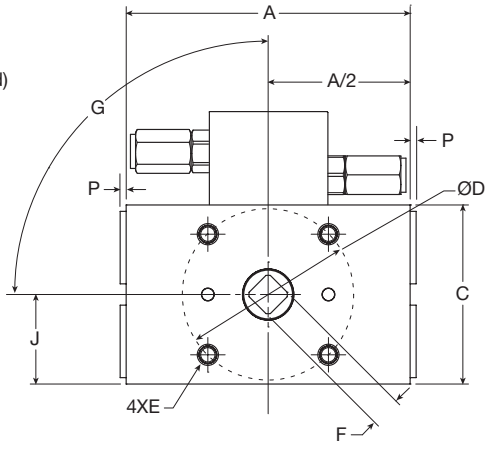












HUB075 series shown above.

Dimensions, units (mm)

Model	A	B	C	D	E†	F	D	E†	F	G	H	I	J	K	L
HUB018	6.18 (156.9)	3.20 (81.3)	4.13 (104.9)	3.250	3/8-16 X .56 Deep	.625 Nominal	70	M8 X 12 Deep	11 or 14mm	90°	1.53 (38.9)	1.66 (42.16)	1.81 (45.97)	0.68 (17.27)	SAE #6
HUB075	8.33 (211.6)	4.14 (105.2)	5.25 (133.4)	5.000	1/2-13 X .50 Deep	.875 Nominal	102	M10 X 15 Deep	22mm	90°	1.97 (50.0)	2.07 (52.6)	2.63 (66.80)	0.80 (20.3)	SAE #6
HUB100	9.50 (241.3)	4.14 (105.2)	6.00 (152.4)	5.000	1/2-13 X .50 Deep	1.13 Nominal	140	M16 X 24 Deep	27mm	90°	1.97 (50.0)	2.07 (52.6)	3.00 (76.20)	0.80 (20.3)	SAE #6

Model	M	N	O	P	Q	R	S	T	U
HUB018	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	2.73 (69.3)	1.45 (36.8)	1.25 (31.7)	0.1 (2.5)	0.80 (20.3)
HUB075	0.87 (22.1)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	2.73 (69.3)	1.45 (36.8)	1.25 (31.7)	0.1 (2.5)	0.69 (17.5)
HUB100	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	2.73 (69.3)	1.45 (36.8)	1.25 (31.7)	0.1 (2.5)	0.69 (17.5)

Imperial housings and shafts only.

Metric housing and shafts only.

† Thread depth is for Helicoil hole depth may be longer.

2D & 3D CAD for all variations available for download at www.parker.com/pneu/hub

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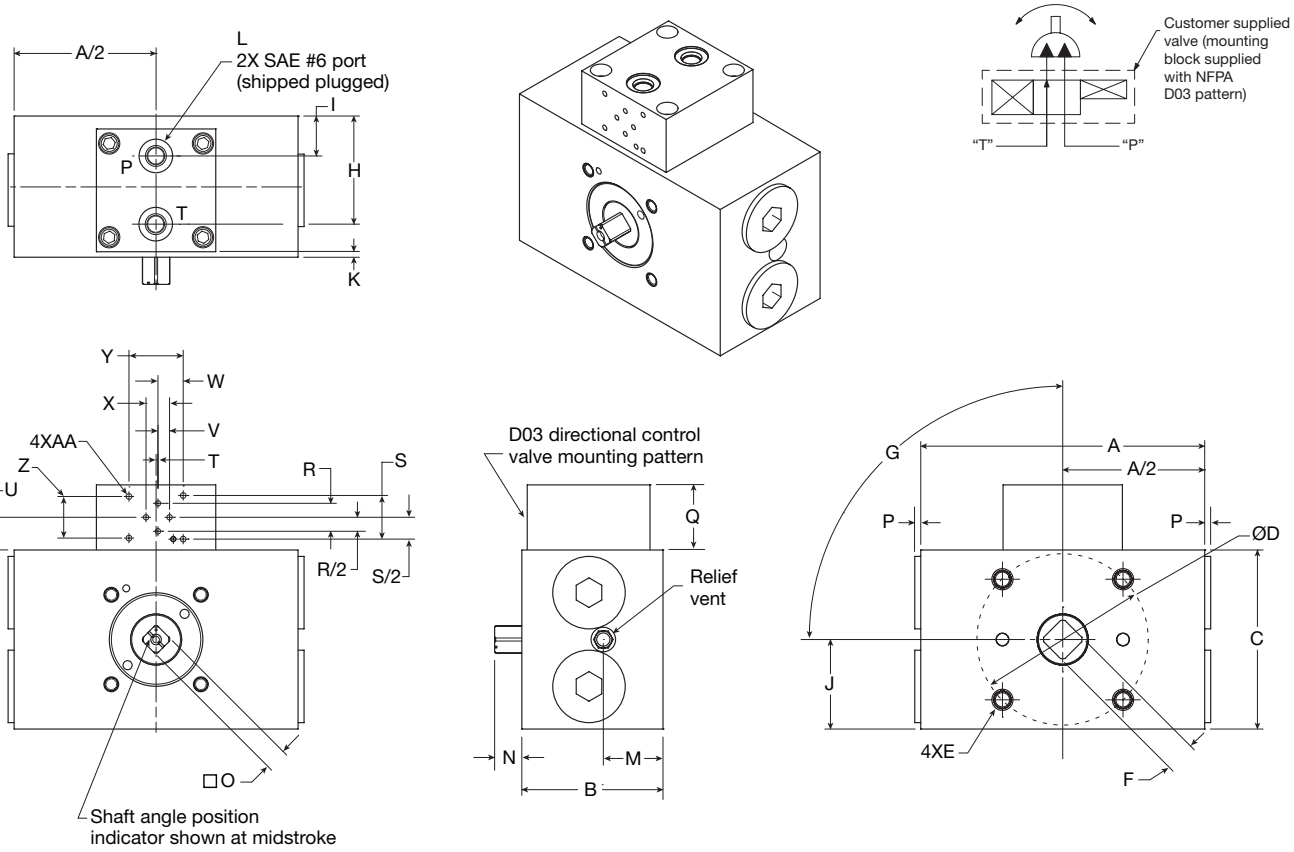
HUB Series

SAE #6 ports with D03 directional control valve ready



HUB075 series shown above.

Dimensions, inches (mm)

Model	A	B	C	D	E†	F	D	E†	F	G	H	I	J	K	L
HUB018	6.18 (156.9)	3.20 (81.3)	4.13 (104.9)	3.250	3/8-16 X .56 Deep	.625 Nominal	70	M8 X 12 Deep	11 or 14mm	90°	2.4 (60.96)	1.0 (25.40)	3.09 (78.5)	0.1 (2.54)	SAE #6
HUB075	8.33 (211.6)	4.14 (105.2)	5.25 (133.4)	5.000	1/2-13 X .50 Deep	.875 Nominal	102	M10 X 15 Deep	22mm	90°	3.2 (81.3)	1.2 (30.48)	4.16 (105.7)	0.1 (2.54)	SAE #6
HUB100	9.50 (241.3)	4.14 (105.2)	6.00 (152.4)	5.000	1/2-13 X .50 Deep	1.13 Nominal	140	M16 X 24 Deep	27mm	90°	3.2 (81.3)	1.2 (30.48)	4.75 (120.6)	0.1 (2.54)	SAE #6

Model	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
HUB018	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	2.10 (53.3)	0.82 (20.8)	1.28 (35.5)	0.055 (1.39)	0.95 (24.1)	0.34 (8.63)	0.74 (18.8)	0.69 (17.5)	1.59 (40.4)	1.22 (30.99)	M5 X 10mm Deep
HUB075	0.87 (22.1)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.90 (48.3)	0.82 (20.8)	1.28 (35.5)	0.055 (1.39)	0.95 (24.1)	0.34 (8.63)	0.74 (18.8)	0.69 (17.5)	1.59 (40.4)	1.22 (30.99)	M5 X 10mm Deep
HUB100	0.80 (20.3)	0.8 (20.3)	0.63 (16.0)	0.2 (5.1)	1.90 (48.3)	0.82 (20.8)	1.28 (35.5)	0.055 (1.39)	0.95 (24.1)	0.34 (8.63)	0.74 (18.8)	0.69 (17.5)	1.59 (40.4)	1.22 (30.99)	M5 X 10mm Deep

Imperial housings and shafts only.
Metric housing and shafts only.
Reference only - see D03 specifications for exact dimensions.

† Thread depth is for Helicoil hole depth may be longer.

2D & 3D CAD for all variations available for download at www.parker.com/pneu/hub

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Unibody Process Valve Mounting Table

	Unibody Size (4,5,6)	Process Valve & Shaft Config (14, 15, 16)	Process Valve							Pattern Size	Mounting Hole Dia	Shaft Configuration	Female (Square or DD) Size
			ABZ	WECO	SPM	Demco	VDI/VDE 3845 ISO 5211	Fisher	Econosto				
Imperial	018	A1B		X	X					3.250	3/8-16	Female Square	0.625
		A2B										Female DD	0.563 x 0.375
		A2C				X							0.625 x 0.375
		A2D	X										0.625 x 0.438
		A2F				X							0.838 x 0.500
	075	B1D		X	X					5.000	1/2-13	Female Square	0.875
		B2F				X						Female DD	0.838 x 0.500
		B2G	X										0.875 x 0.625
		B2H				X							0.963 x 0.625
	100	B1F		X	X					5.000	1/2-13	Female Square	1.13
		B2J				X						Female DD	1.338 x 0.75
Metric	018	J6C					X			50	M6	Female Square	11
		J6E					X						14
		K6C					X	X		70	M8		11
		K6E					X	X	X				14
		K7E					X					Female DD	18.1 x 14.0
	075	L6C						X		102	M10	Female Square	11
		L6E					X	X					14
		L6G					X						17
		L6H					X	X					19
		L6J					X	X	X				22
		L7J					X					Female DD	28.2 x 22.0
		M6E						X		125	M12	Female Square	14
		M6G					X						17
		M6H					X	X					19
		M6J					X	X					22
	100	N6H						X		140	M16	Female Square	19
		N6J					X	X					22
		N6L					X	X					27
		N7L					X					Female DD	36.2 x 27.0
		R6H						X		165	M20	Female Square	19
		R6J						X					22
		R6L					X	X					27

Others available upon request.
For additional process valves not shown, consult factory for proper mounting considerations.

Part numbers are standard.

These options are available upon request. Consult factory for additional information, pricing and leadtime.

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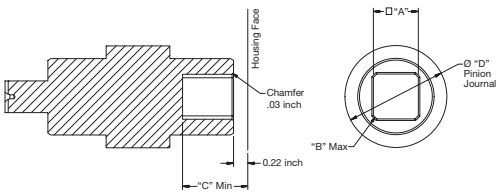
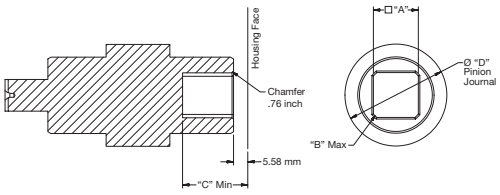
Shaft Options

Female Square (Imperial) – Option 1



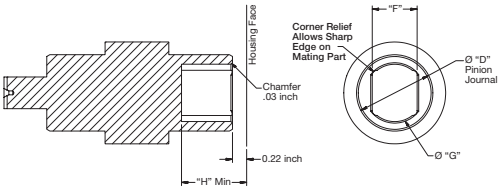
Unibody Size (4,5,6)	Shaft Config & Size (14, 15, 16)	A (inch)		B (inch)	C (inch)	D (inch)	
		Dim	Tol			Dim	Tol
018	A1B	0.625	+.005 / +.007	0.06	1.32	0.999	+0 / -.001
075	B1D	0.875	+.005 / +.007	0.04	1.42	1.499	+0 / -.001
100	B1F	1.125	+.005 / +.007	0.04	1.42	1.780	+0 / -.001

Female Square (Metric) – Option 6



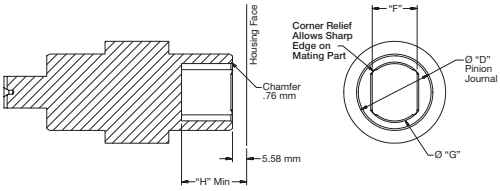
Unibody Size (4,5,6)	Shaft Config & Size (14, 15, 16)	A (mm)		B (mm)	C (mm)	D (inch)	
		Dim	Tol			Dim	Tol
018	K6C	11	+.13 / +.18	1.0	23.6	0.999	+0 / -.001
	K6D	12	+.13 / +.18	1.0	26.0	0.999	+0 / -.001
	K6E	14	+.13 / +.18	1.1	29.0	0.999	+0 / -.001
	K6F	16	+.13 / +.18	1.1	29.0	0.999	+0 / -.001
075	L6C	11	+.13 / +.18	1.0	23.6	1.499	+0 / -.001
	L6E	14	+.13 / +.18	1.1	29.0	1.499	+0 / -.001
	L6G	17	+.13 / +.18	1.1	29.0	1.499	+0 / -.001
	L6H	19	+.13 / +.18	1.2	29.0	1.499	+0 / -.001
	L6J	22	+.13 / +.18	1.4	31.0	1.499	+0 / -.001
100	N6H	19	+.13 / +.18	1.2	29.0	1.780	+0 / -.001
	N6J	22	+.13 / +.18	1.4	31.0	1.780	+0 / -.001
	N6L	27	+.13 / +.18	1.4	32.6	1.780	+0 / -.001
	R6H	19	+.13 / +.18	1.2	29.0	1.780	+0 / -.001
	R6J	22	+.13 / +.18	1.4	31.0	1.780	+0 / -.001
	R6L	27	+.13 / +.18	1.4	32.6	1.780	+0 / -.001

Female Double D (Imperial) – Option 2



Unibody Size (4,5,6)	Shaft Config & Size (14, 15, 16)	F (inch)		G (inch)		H (inch)	D (inch)	
		Dim	Tol	Dim	Tol		Dim	Tol
018	A2A	0.375	+.003 / +.005	0.500	+.005 / +.007	1.32	0.999	+0 / -.001
	A2B	0.375	+.003 / +.005	0.563	+.005 / +.007	1.32	0.999	+0 / -.001
	A2C	0.375	+.003 / +.005	0.625	+.005 / +.007	1.32	0.999	+0 / -.001
	A2D	0.438	+.003 / +.005	0.625	+.005 / +.007	1.32	0.999	+0 / -.001
	A2F	0.500	+.003 / +.005	0.838	+.005 / +.007	1.32	0.999	+0 / -.001
075	B2F	0.500	+.003 / +.005	0.838	+.005 / +.007	1.40	1.499	+0 / -.001
	B2G	0.625	+.003 / +.005	0.875	+.005 / +.007	1.40	1.499	+0 / -.001
	B2H	0.625	+.003 / +.005	0.963	+.005 / +.007	1.40	1.499	+0 / -.001
100	B2H	0.625	+.003 / +.005	0.963	+.005 / +.007	1.40	1.780	+0 / -.001
	B2J	0.750	+.003 / +.005	1.338	+.005 / +.007	1.40	1.780	+0 / -.001

Female Double D (Metric) – Option 7



Unibody Size (4,5,6)	Shaft Config & Size (14, 15, 16)	F (mm)		G (mm)		H (mm)	D (inch)	
		Dim	Tol	Dim	Tol		Dim	Tol
018	K7E	14	+.08 / +.13	18.1	+.13 / +.18	25.6	0.999	+0 / -.001
075	L7J	22	+.08 / +.13	28.2	+.13 / +.18	39.6	1.499	+0 / -.001
100	N7L	27	+.08 / +.13	36.2	+.13 / +.18	48.6	1.780	+0 / -.001

Others available upon request.
Customer is responsible for proper sizing and selection of mating shaft.

Part numbers are standard.

These options are available upon request. Consult factory for additional information, pricing and leadtime.

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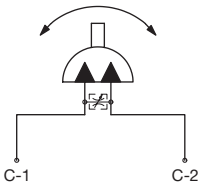
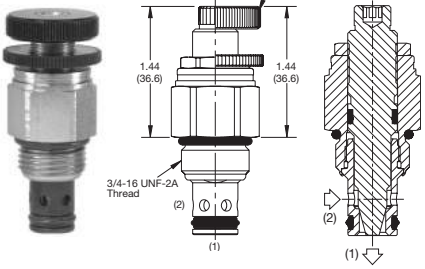
Technical Data

The HUB Cross-over module is designed to allow free flow between ports C-1 and C-2 when open. This module can be ordered at the same time as the base actuator (as one finished good part number) or later with an upgrade kit. Similar to the HUB actuator, this module is designed with a hard coat anodized housing that is reliable in harsh environmental conditions. This module also utilizes Parker's proven needle valve cartridge product from Hydraulic Cartridge Systems Division.



Cartridge Features

- Hardened, precision ground parts for durability
- Compact size for reduced space requirements
- Fine adjustment needle with locking nut
- Polyurethane "D"-Ring eliminates backup rings and prevents hydrolysis
- All external parts zinc plated



Operating information

Maximum operating pressure:	3000 PSI (207 bar)
Cartridge material:	All parts steel, operating parts hardened steel
Operating temperature range:	-40°F to 180°F (-45°C to 82°C)
Fluid compatibility / viscosity:	Mineral-based or synthetic with lubricating properties at viscosities of 45 to 2000 SSU (6 to 420 cSt)
Filtration:	ISO code 16/13 SAE Class 4 or better

Kit Ordering Information

PSK-HUB018 - **20** **2** **P**

	Basic Kit Size
PSK-HUB018	HUB018 basic kit number
PSK-HUB075	HUB075, HUB100 basic kit number

	Kit Number
20	Cross-over valve

	Kit Type
2*	Replacement kit
4	Upgrade kit

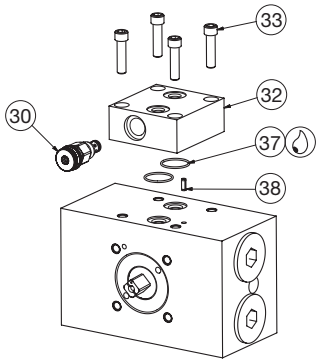
* Only available with basic kit size PSK-HUB018

	Label Suffix
P	Parker North America

SEE TABLE FOR ALL POSSIBLE KIT COMBINATIONS

Cross-over Vent Module Kit Table			ORIGINAL ACTUATOR PURCHASED			
			12	1B	1D	A2
			Base unit	with Cross-over module	with C-balance module	with Sol ready module
HUB Kit Number & Type	202	Cross-over Valve Replacement Kit		30	30	
	204	Cross-over Valve Upgrade Kit	30, 32, 33 (4), 37 (2), 38			

Item numbers and quantities included in each kit.



Item #	Description	Qty
30	Cross-over vent valve	1
32A	Cross-over vent block, size 018	1
32B	Cross-over vent block, size 075, 100	1
33	Cap screw	4
37	O-ring	2
38	3/16 x 3/4, SS spring pin	1

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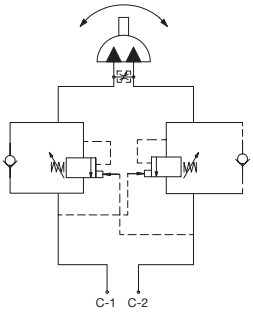
Technical Data

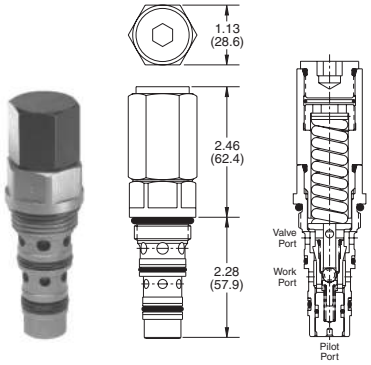
The HUB Counter-balance module with Cross-over vent is designed for load holding in both directions of actuation and prevents a run-away load situation from occurring. This module is available as part of a finish good actuator or can be integrated in the field with an upgrade kit. As with all other HUB options, this module is designed with a hard coat aluminum housing for durability in harsh conditions.

The Counter-balance module also includes the cross-over functionality that was described on pages A18-A19. Similarly, this module allows free flow between ports C-1 and C-2 of the actuator when the needle valve is backed out. This module also incorporates Parker's proven valve technology from Hydraulic Cartridge Systems Division for the counter-balance valve.



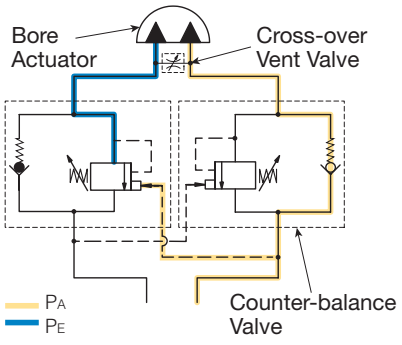
Cartridge Features

- Conical Poppet design provides longer metering stroke for stable operation
- Hardened seat provides reliable load holding
- Tamper resistant cap for added safety and security
- All external parts zinc plated
- Non-vented Counter-balance with adjustability

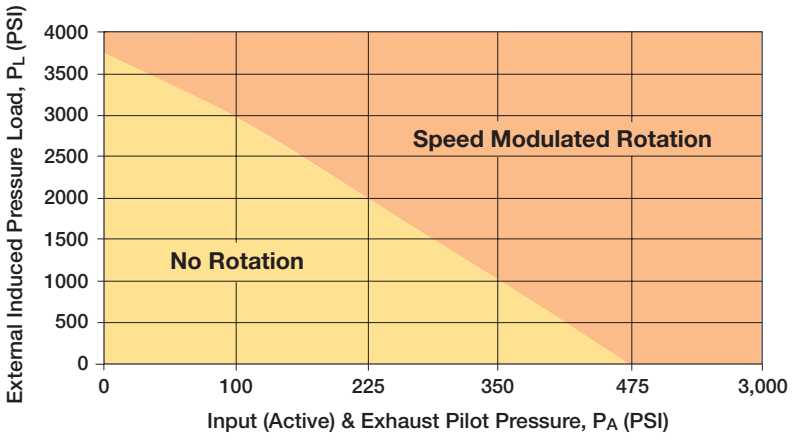


Operating information

Maximum operating pressure:	3000 PSI (207 bar)
Leakage at 150 SSU (32 cSt):	5 drops/min. (.33 cc/mm) @ 80% of thermal crack pressure
Cartridge material:	All parts steel, operating parts hardened steel
Operating temperature range: Nitrile	-40°F to 180°F (-45°C to 82°C)
Fluid compatibility / viscosity:	Mineral-based or synthetic with lubricating properties at viscosities of 45 to 2000 SSU (6 to 420 cSt)
Filtration:	ISO code 16/13 SAE Class 4 or better



Movement of actuator with counter-balance valves



P_A Input (active) & exhaust pilot pressure (psi)
P_E Sum of pressures in exhaust chamber (psi)
P_L External induced pressure load (psi)
P_R Reaction pressure in exhaust chamber from P_A (psi)

$P_R = P_A - P_{friction}$
$P_E = P_L + P_R$

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Wadsworth, Ohio
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Counter-balance Module Kit Ordering Information

PSK-HUB018 - 30 2 P

	Basic Kit Size
PSK-HUB018	HUB018 basic kit number
PSK-HUB075	HUB075, HUB100 basic kit number

	Kit Number
30	Counter-balance valve

	Kit Type
2*	Replacement kit
4	Upgrade kit

*Only available with basic kit size PSK-HUB018

	Label Suffix
P	Parker North America

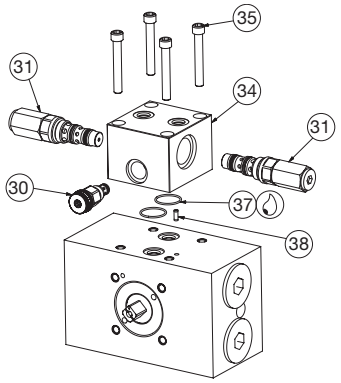
SEE TABLE FOR ALL POSSIBLE KIT COMBINATIONS

Item #	Description	Qty
30	Cross-over vent valve	1
31	Counter-balance valve	2
34A	Cross-over / Counter-balance valve block, size 018	1
34B	Cross-over / Counter-balance valve block, size 075, 100	1
35	Cap screw	4
37	O-ring	2
38	3/16 x 3/4, SS spring pin	1

Counter-balance Valve Module Kit Table

HUB Kit Number & Type			ORIGINAL ACTUATOR PURCHASED 12 Base unit	1B with Cross-over module	1D with C-balance module	A2 with Sol ready module
	302	Counter-balance valve replacement kit			31 (1)	
	304	Counter-balance valve upgrade kit	30, 31 (2), 34, 35 (4), 37 (2), 38			

Item numbers and quantities included in each kit.



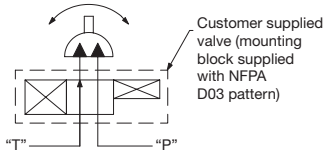
D03 Directional Control Valve Ready
Technical Data

The HUB solenoid ready module is a hard coated anodized aluminum block that allows for D03 valves to be mounted directly to the actuator. This option is ideal for applications with limited available space. The reduced plumbing required is also a cost savings during integration. Similar to the HUB's other options, this module can be ordered as part of the original actuator or added on later with an upgrade kit.

Operating information

Maximum operating pressure:	3000 PSI (207 bar)
Mounting orientation:	Unrestricted
Operating temperature range:	-40°F to 180°F (-45°C to 82°C)

Without solenoid valve (standard)



Shown with solenoid valve for reference only.

D03 Directional Control Valve Ready Kit Ordering Information

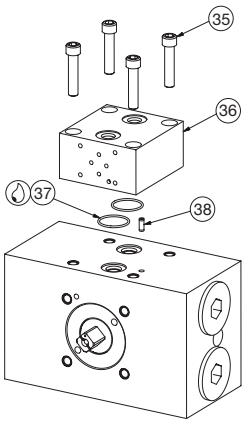
PSK-HUB018 - 40 4 P

	Basic Kit Size
PSK-HUB018	HUB018 basic kit number
PSK-HUB075	HUB075 & HUB100 basic kit number

	Kit Number
40	D03 directional control valve ready

	Kit Type
4	Upgrade kit

	Label Suffix
P	Parker North America



Item #	Description	Qty
35	Cap screw	4
36A	Solenoid block, size 018	1
36B	Solenoid block, size 075, 100	1
37	O-ring	2
38	3/16 x 3/4, SS spring pin	1

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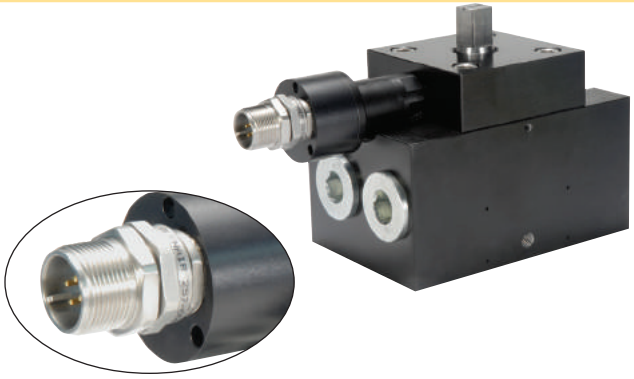
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

Rotary Linear Potentiometer Feedback

0-40 VDC linear position feedback (RLPO)

Parker's 0-40 VDC linear position feedback solution is accurate, reliable, and designed to handle the harshest environmental conditions. The robust hard coat anodized aluminum construction and electroless nickel plated (ENP) steel components make this feedback option ideal for use in corrosive outside environments. With a low profile design, this solution is perfect for applications where space is a premium.

- **Environmentally rugged –** Hard coat anodized aluminum module and electroless nickel plated (ENP) steel components that are designed to withstand the harshest environmental conditions.
- **Direct mounting to output shaft –** Cam coupled design provides precision rotation position for accurate feedback.
- **Low profile design -** Clearance above the actuator is critical in many systems. The Parker RLPO feedback module has a less than 2" height requirement.
- **Redundancy capabilities for additional safety requirements –** Additional plugged port located opposite the RLPO unit that can be used for a second RLPO unit.



Potentiometer Linear Motion

Compact linear motion potentiometer features long life with high resolution conductive plastic element. Shaft spring to ensure the shaft is fully extracted for repeatability and reliability.

Operating information

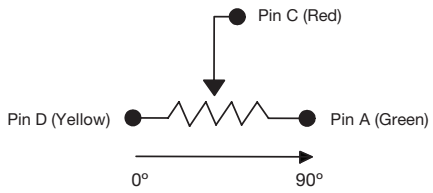
Operating temperature range:	-13°F to 221°F (-25°C to 105°C)
Storage temperature:	-40°F to 257°F (-40°C to 125°C)
IP protection grade	IP67
Connector material:	Stainless steel
Connector type:	4 pin w/ 7/8-20 UNEF (based on MIL-DTL-5015)

Specifications

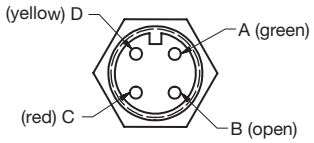
Electrical	
Resistance values	10 K ohms
Resistance tolerance (standard)	± 15%
Linearity tolerance (standard)	± 2%
Resolution	Essentially infinite (<0.01 mm)
Output smoothness	< 0.1% against input voltage
Power @ 40°	0.2W
Temperature coefficient of element	40 ppm/K
Contact resistance variation	< 2%
Insulation resistance	> 1,000 Mohm @ 500 VDC
Dielectric strength	1 minute @ 500 VAC
Maximum wiper current	1mA
Recommended wiper current	< 1µA

Mechanical	
Mechanical stroke (mm)	7.0
Life expectancy, shaft cycles	20 million
Vibration	15 g/10 Hz to 2,000 Hz
Shock	50 g/11ms

Wiring Diagram



Receptacle Pin Layout



Typical valve position	Resistance (KΩ) Pin D - common Pin A - positive Across D to C	Pin D - positive Pin A - common Across A to C
0°	7.2	2.9
90°	1	9.2

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StoneL® Valve Communication Solutions

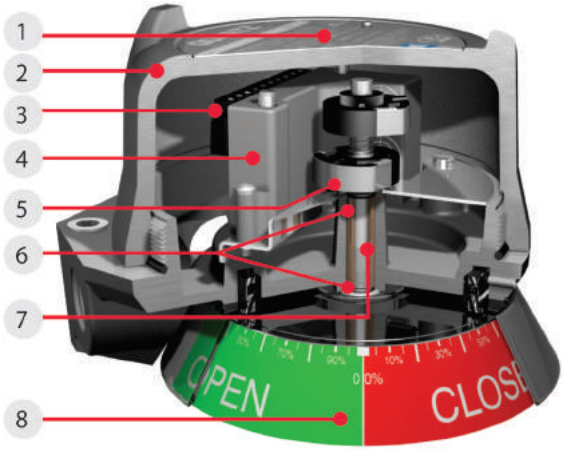
Quartz

Dual module solid state or 4-20 mA position feedback

The StoneL Quartz series is durable, corrosion-resistant, and versatile, making it ideal for most of your process valve monitoring requirements. The robust epoxy coated anodized aluminum construction makes this platform extremely durable and well suited for use in corrosive, heavy wash down environments. This versatile platform adapts to a wide variety of valve systems. The QX explosion proof version is offered as the standard that will be provided from the factory fully mounted and positioned. Nonincendive and intrinsically options are available upon request.

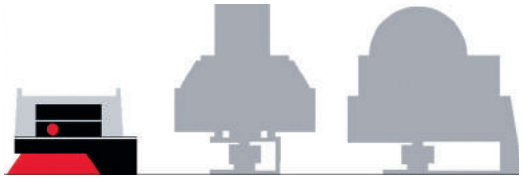
The explosion-proof, water tight and corrosion-resistant enclosure is approved for use in div. 1/zone 1 hazardous areas.

1. **Enclosure optimized for environment –** Explosion proof, water tight and corrosion resistant cover
2. **Rapid enclosure access –** Screw-on cover allows quick enclosure access, saving you valuable maintenance and set-up time. The cover provides a vapor tight seal and allows entry to internal components in less than five seconds.
3. **Faster wiring –** Pre-wired and labeled terminal strip enables quick, convenient attachment of field wires.
4. **Wide variety of switching & communication –** Dual module sensors and communication standard, as well as, continuous signal output available in a 4 to 20 mA position transmitter.
5. **Quick set cams are easy to adjust –** Touch and tune switch settings allow you to make adjustments in seconds without the use of tools.
6. **Dual shaft o-ring seals eliminate corrosion –** Top inner and bottom outer shaft o-rings seal the drive bushing from both external corrosives and internal contaminants that enter the enclosure.
7. **Special drive bushing assures long cycle life –** The oil impregnated bronze bushing maintains smooth operation and eliminates the potential for shaft seizure due to actuator shaft eccentricity.
8. **Space saving visual indication –** Visual indicator offers excellent view ability without sacrificing accessibility or adding to space requirements.



Space saving low profile design

Clearance above the actuator is critical in complex piping systems. The Quartz series clearly displays valve position and encloses all electrical components in an explosion proof compartment with less than 5” clearance requirement.



For more information regarding this product series please visit StoneL’s website – ***www.StoneL.com***

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StoneL Valve Communication

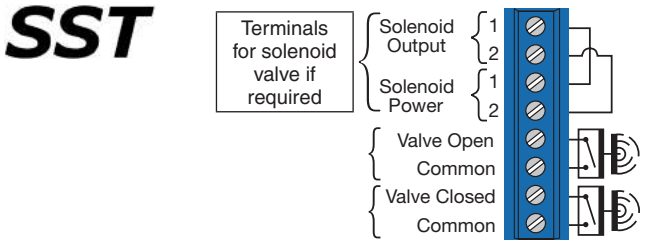
Dual module system

The Quartz series is available with the dual module as one of its various configurations. Two solid state sensors and/or communications and other electronics are sealed in for the ultimate in reliability and convenience.

Specifications - Switching and sensors

SST switching sensors (C)	
Configuration	(2) SST solid state sensors Wire termination for one solenoid
Operation	NO/NC (cam selectable)
Maximum current inrush	2.0 amps @ 125 VAC / VDC
Maximum current continuous	0.3 amps @ 125 VAC / VDC
Minimum on current	2.0 mA
Maximum leakage current	0.5 mA
Voltage range	8 to 125 VDC 24 to 125 VAC
Maximum voltage drop	6.5 volts @ 10 mA 7.0 volts @ 100 mA

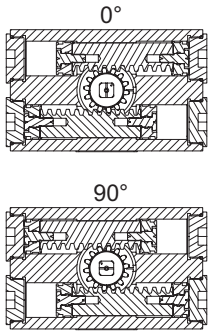
Wiring diagram (C)



Visual Indicators

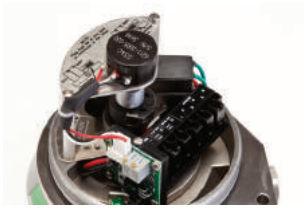
Available with the Quartz Series or as a stand-alone unit. Clearly view valve position status from up to 75 feet. The indicator's rugged polycarbonate construction makes it resistant to physical damage and tolerant to most corrosives.

0°	90°
RED CLOSED	GREEN OPEN

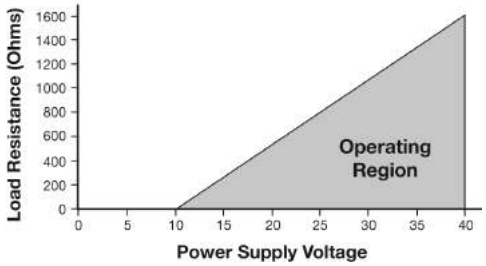


Position transmitter - 4 to 20 mA

Position transmitters provide a precise 4 to 20 mA signal on a two-wire DC loop. Control valves and dampers are accurately monitored through their range of travel offering assurance of exact valve position at all times.



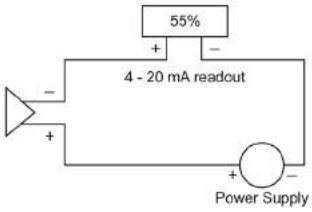
Load Curve



Specifications - Position transmitter

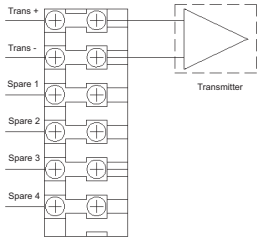
Position transmitter (D, E)	
Output	2-wire 4 to 20 mA
Supply source	10 to 40 VDC
Span range	35° to 270° (adjustable) Consult factory for special requirements
Maximum loading	700 ohmn @ 24 VDC
Linearity error	+/- 0.85" maximum
Cycle life	2 million rotations
Vibration tolerance	Acceptable

Electrical schematic

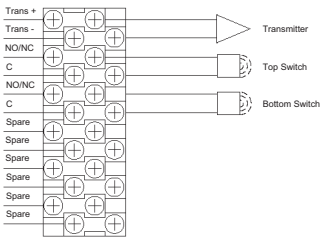


Wiring diagram (D, E)

Position Transmitter



Position Transmitter and Switches



For more information regarding this product series please visit StoneL's website – ***www.StoneL.com***

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Feedback Options Table		A, B	C	D	E
					
Description		RLPO Potentiometer	StoneL Quartz, SST dual module	StoneL Quartz, 4-20 mA position transmitter	StoneL Quartz, SST dual module with 4-20 mA position transmitter
Replacement kit part numbers (SENSOR ONLY)		PSK-HUB018-502P	PSK-HUB018-512P	PSK-HUB018-522P	PSK-HUB018-532P
Upgrade kit part numbers - conversion from an existing actuator with no feedback to one with feedback			PSK-HUB018-514P	PSK-HUB018-524P	PSK-HUB018-534P
			PSK-HUB075-514P	PSK-HUB075-524P	PSK-HUB075-534P
			PSK-HUB100-514P	PSK-HUB100-524P	PSK-HUB100-534P
Max electrical load		0.2W @ 70°C	0.3A @ 125 VAC/VDC	700 Ohms @ 24 VDC	Same option as C & D
Sensor technology		Potentiometer	Solid State Sensors	Potentiometer	Solid State Sensors with Potentiometer
Input		10-40 VDC	8-125 VDC, 24-125 VAC	10-40 VDC	Same option as C & D
Output		0-40V range (FRP)	EOS	4-20 mA signal on two wire DC loop (FRP)	Same option as C & D
Connection		4 pin, 7/8"-20 UNEF	Terminal block thru 3/4" & 1/2" NPT conduit holes		
Approvals / Compliance Standards	IP67	●	●	●	●
	Intrinsically safe			●	
	Explosion proof		●	●	●
	Other	NEMA 4, 4X & 6	NEMA 4, 4X & 6	NEMA 4, 4X & 6	NEMA 4, 4X & 6
Temp Range		-13°F to 221°F (-25°C to 105°C)	-40°F to 176°F (-40°C to 80°C)	-40°F to 176°F (-40°C to 80°C)	-40°F to 176°F (-40°C to 80°C)
Visual Indication Options Available with each Feedback Option	Line on shaft	●			
	green on/ red off	Consult factory	●	●	●

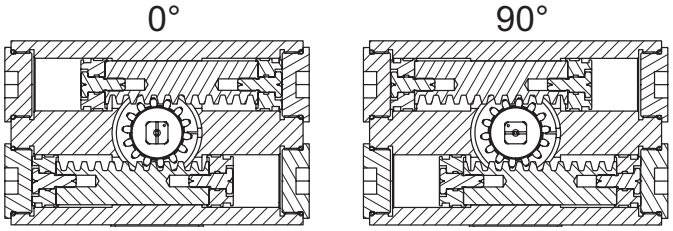
Note: Cables are not available for purchase.

FRP = Full Range Position

EOS = End of Stroke

Visual Indicator Options Table	C
	
Description	Color indicator
Replacement kit part number (VISUAL INDICATOR ONLY)	PSK-HUB018-702P*
Upgrade kit part numbers - conversion from an existing actuator with no visual indicator to one with visual indicator	PSK-HUB018-704P
	PSK-HUB075-704P
	PSK-HUB100-704P

*Visual indicator replacement kit does not include bracket or hardware.



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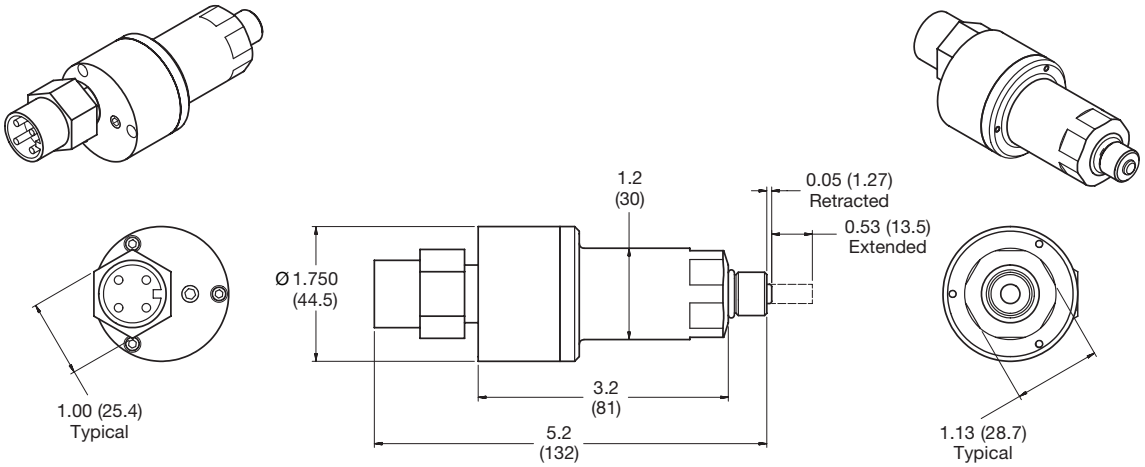
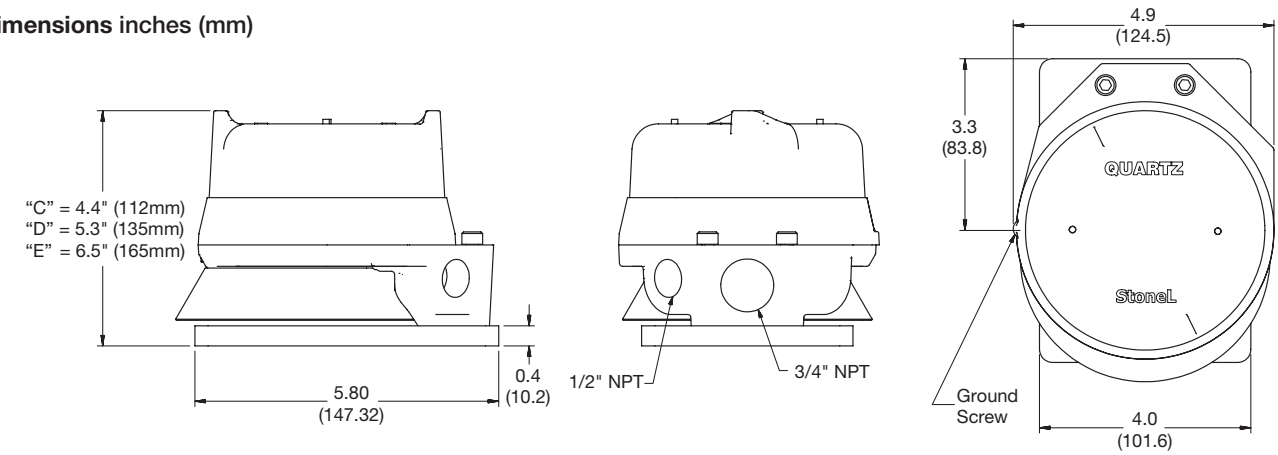
Rotary Linear Potentiometer
(Feedback option A & B)



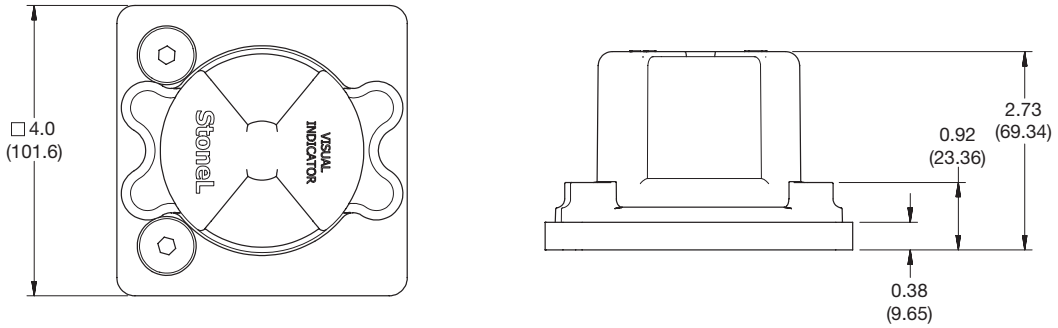
StoneL - Quartz
(Feedback option C, D & E)

Dimensions inches (mm)



NOTE: Cover height varies based on model number.

StoneL - stand alone visual indicator
(Visual Indication option C)



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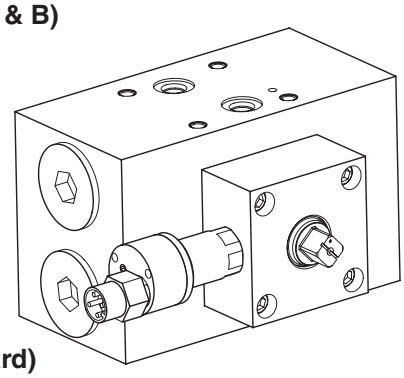
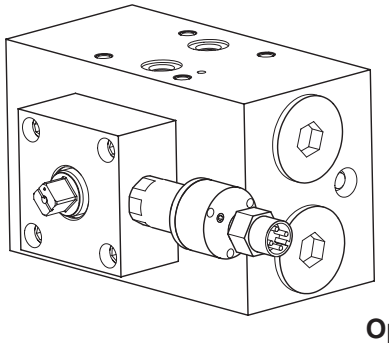
Rotary Linear Potentiometer
(Feedback option A & B)

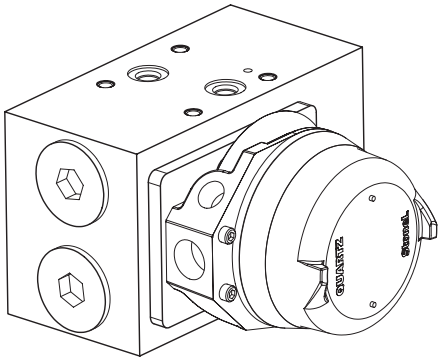


Option A (Standard)

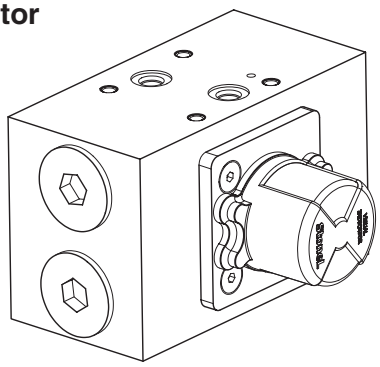


Option B

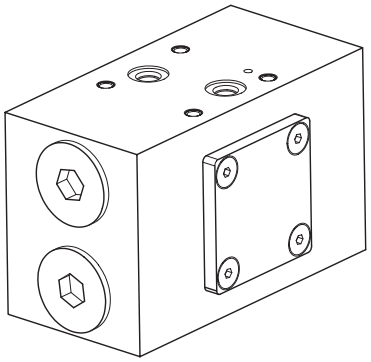
StoneL - Quartz
(Feedback option C, D & E)



StoneL Stand Alone Visual Indicator
(Feedback option Z and Visual indicator option C)



No Visual Indicator
(Feedback option Z and Visual indicator option Z)



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LTR Series
Light Duty Hydraulic Rack & Pinion Rotary Actuators

Parker Hannifin Corporation
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

			Product Series				
	Market/Segment	**Typical Application(s)**	**HUB**	**LTR**	**HTR**	**M**	**Tork-Mor**
Market Segments/Applications	Aerospace	Water bomb, tank door actuation		●			
	Aggregate	Granite block rollover			●		
	Aluminum	Automation				●	
	Automation	Mounting, Processing, Flood gate actuation, End of arm tooling	●	●	●		●
	Automotive	Automation, Clamping, Tube bending			●		●
	Conveyor	Swing & rotate		●	●		●
	Entertaining	Pool gate actuation, Robotic joint motion					●
	Fluid Management & Flow Control	Power plants			●	●	
	Industrial	Automation, Clamping					●
	Machine Builders	End of arm tooling			●		
	Marine/Offshore	Boomslewer, Submersible			●	●	
	Mining	Mobile longhole drilling, Tunnel boring	●		●	●	
	Mobile	Fire truck ladder rotation, Aerial lift basket, X-ray boom rotation, Forklift handling & storage, Refuse tippers	●	●	●	●	
	Nuclear	Door actuation				●	
	Oil & Gas	Process valve actuation	●		●		
	Oil Industry Machinery	Clamping, Lockout	●				●
	Paper & Pulp	Walking beam				●	
	Plastics	Blow molding, Injection molding			●		●
	Rubber	Mixing			●	●	
	Solar	Panel rotation			●		
	Space	Rocket launch tower				●	
	Steel & Casting	Ladle Tilt, Coil Box, Steel Booming, Pipe fabrication			●	●	●
	Testing Equipment	Flight Simulators, Cycle loading, Tensile test Machines			●		●
	Transportation	Bus wheelchair ramp		●			
	Water Management		●		●		
	Welding	Weld gun indexing, Clamping					●

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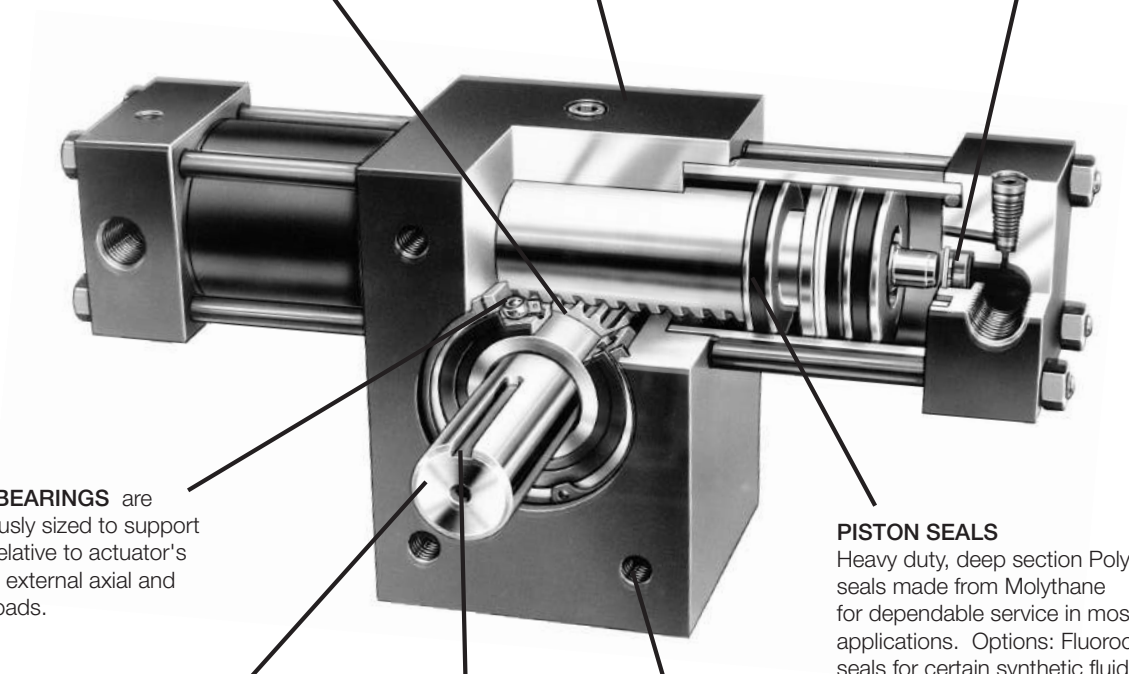
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

LTR Series

RACK & PINION made from through hardened, high strength alloy steels for long and durable service life in most applications.

HOUSING
High strength housing serves as a firm base to drive large torque requirements.

OPTIONAL CUSHIONS
If properly adjusted, cushions can serve as a braking device for most industrial applications. The proven Parker "floating cushion bushing" serves as a high performance check valve for "quick get away" and the needle valve can be adjusted to regulate the exhaust flow from the piston. Our design uses no springs or check valve seats that can break under normal usage.



BALL BEARINGS are generously sized to support large (relative to actuator's weight) external axial and radial loads.

PISTON SEALS
Heavy duty, deep section Polypak seals made from Molythane for dependable service in most applications. Options: Fluorocarbon seals for certain synthetic fluids; and carboxylated nitrile seals for water based fluids. Piston seals can be inspected and replaced without disconnecting the load from the shaft. (Employ proper safety practices to prevent damage to people or equipment.)

STANDARD MALE KEYED SHAFT is made integral with the pinion gear and is suitable for most applications. Options: double male key, hollow bore keyed and splined shafts are available.

KEYWAY mid stroke at 12:00 position is standard.

THREADED MOUNTING HOLES
Our standard mounting has four bolt holes drilled and tapped on the front and back of the housing. Options: pilot ring or base mount.

Parker Hannifin Corporation
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

Ordering information – Inch

LTR	25	1	–	090	3	F	P	–	A	B	2	1	M	V	–	C	

Model	
10	1" bore
15	1-1/2" bore
20	2" bore
25	2-1/2" bore
32	3-1/4" bore

Rotation [1]	
090	90°
180	180°
270	270°
360	360°
Or specify any other rotation.	

Configuration	
1	Single rack
2	Double rack
3	Three position actuator
7	Antibacklash

Cushions	
Omit	None
1	Cushioned CW rotation *
2	Cushioned CCW rotation *
3	Cushioned both rotations
4	Four cushions **
8	High performance cushion **
9	Special

Stroke adjusters	
Omit	None
D	0-30° CW rotation *^
E	0-30° CCW rotation *^
F	0-30° both rotations *^
X	Special

Port flow controls	
Omit	None
P	Flow control both rotations
R	Flow control CW rotation *
S	Flow control CCW rotation *

Mounting	
A	Face/base (standard)
F	Front flange
G	Foot flange
P	Pilot ring
R	Rear flange
X	Special

Shaft	
A	Female keyed
B	Single male keyed (standard)
C	Double male keyed
R	Preload keyway
X	Special

Port threads	
1	SAE straight thread (standard)
2	NPTF
9	Special

Port location	
1	Position 1 (standard)
2	Position 2
3	Position 3
4	Position 4
9	Special

Standard options	
Omit	None
H	Resolver feedback
J	Potentiometer
M	Magnetic piston ring
S	Shaft seal cover Δ

Seals	
Omit	Nitrile (standard)
V	Fluorocarbon
W	Carboxylated nitrile
X	Special

Design series	
C	Current

Special Options	
Omit	Standard
Two or three-digit code assigned by factory and applies when any "X" or "9" appears in the model number or when special options or features are required.	

Other options
Detail in clear text: Proximity switches – Specify high or low range, rotation direction.

Notes:

[1] For 3-position units, specify middle and total rotation separated by a "/", ie 045/180.

* Viewed from shaft end

** Double Rack Models Only. Use four cushions for existing applications only. For new applications, use option 8, High Performance Cushion.

^ Reduces to 10° with cushions

Δ For use with standard male shafts only

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Ordering information – Metric

LTR	25	1	–	090	3	F	P	–	B	D	4	1	M	V	–	C	

Model	
10	1" (25.4mm) bore
15	1-1/2" (38.1mm) bore
20	2" (50.8mm) bore
25	2-1/2" (63.5mm) bore
32	3-1/4" (82.6mm) bore

Configuration	
1	Single rack
2	Double rack
3	Three position actuator
7	Antibacklash

Rotation [1]	
090	90°
180	180°
270	270°
360	360°
Or specify any other rotation.	

Cushions	
Omit	None
1	Cushioned CW rotation *
2	Cushioned CCW rotation *
3	Cushioned both rotations
4	Four cushions **
8	High performance cushion **
9	Special

Stroke adjusters	
Omit	None
D	0-30° CW rotation *^
E	0-30° CCW rotation *^
F	0-30° both rotations *^
X	Special

Port flow controls	
Omit	None
P	Flow control both rotations
R	Flow control CW rotation *
S	Flow control CCW rotation *

Mounting	
B	Face/base (standard)
H	Front flange
K	Foot flange ◊
S	Pilot ring
T	Rear flange
X	Special

Shaft	
D	Single male keyed (standard)
E	Female keyed
F	Double male keyed
X	Special

Port threads	
4	BSPP (standard)
5	DIN 3852/1
6	ISO 6149/1
1	SAE straight thread
2	NPTF
9	Special

Port location	
1	Position 1 (standard)
2	Position 2
3	Position 3
4	Position 4
9	Special

Standard options	
Omit	None
H	Resolver feedback
J	Potentiometer
M	Magnetic piston ring
S	Shaft seal cover Δ

Seals	
Omit	Nitrile (standard)
V	Fluorocarbon
W	Carboxylated nitrile
X	Special

Design series	
C	Current

Special Options	
Omit	Standard
Two or three-digit code assigned by factory and applies when any "X" or "9" appears in the model number or when special options or features are required.	

Other options
Detail in clear text:
Proximity switches – Specify high or low range, rotation direction.

Notes:

[1] For 3-position units, specify middle and total rotation separated by a "/", ie 045/180.

* Viewed from shaft end

** Double Rack Models Only. Use four cushions for existing applications only. For new applications, use option 8, High Performance Cushion.

^ Reduces to 10° with cushions

Δ For use with standard male shafts only

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The LTR series rotary actuator is ideal for low pressure hydraulic applications. The LTR Series actuator combines an alloy steel gear set with a high strength aluminum housing and Parker 3L or 2A Series cylinder components into an actuator suitable for years of trouble free service. The actuator maximizes volumetric efficiency by using self-energizing PolyPak seals. Mechanical efficiency is maximized by using antifriction bearings and Wear-pak® piston technology.

- Hydraulic cushions to minimize noise, vibration shock and assist deceleration control
- Reed, Hall Effect or proximity switches for position sensing
- End-of-rotation stroke adjusters for load position control and accurate rotation adjustment
- Built-in meter outflow control valves with reverse flow check valves provide a neat package
- Three position option can be used with many special machine and material handling applications

Operating information

Output Torques	1000 psi (69 bar): 395 in-lb to 22,813 in-lb
Nominal pressure:	1000 PSIG (69 bar) (3L cylinder pressure ratings apply)
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Flurocarbon seals	-20°F to 250°F (-29°C to 121°C)
Standard rotations:	90°, 180°, 270°, 360°, 450°
Rotational tolerance	-0°, +2°
Breakaway pressure:	30 PSIG (2 bar) maximum
Mounting orientation:	unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Recommended filtration:	ISO class 17/14 or better

Specifications

		Theoretical output torque[1], in-lb versus input pressure, PSI (bar)						Gear train rating pitting life estimate 1 million cycles		Displacement per degree of rotation	Maximum angular backlash	Maximum rotational tolerance
Single rack	Double rack[2]	100 (7)	250 (17)	500 (34)	750 (52)	1000 (69)	1500 (103)	inch-lbf[3]	PSID[4]	in³/deg.	Minutes	Degrees
101		39	98	197	295	395	592	270	800	0.007	60	-0/+5
	102	79	197	395	592	–	–	580	800	0.014	60	-0/+5
151		118	294	590	885	1180	1770	665	650	0.021	45	-0/+4
	152	236	590	1180	1770	2360	3530	1400	650	0.042	45	-0/+4
201		282	705	1410	2115	2830	4240	1790	750	0.049	35	-0/+3
251		430	1074	2148	3222	4295	6443	2100	550	0.075	35	-0/+3
	202	565	1410	2820	4230	5650	8470	3790	750	0.099	35	-0/+3
	252	859	2148	4295	6442	8590	12885	4250	550	0.150	35	-0/+3
321		1141	2852	5703	8554	11407	–	3880	400	0.199	25	-0/+2
	322	2281	5703	11407	17110	22813	–	6160	300	0.398	25	-0/+2

1. As a precaution, consult factory whenever using the LTR with port flow controls, cushions, or stroke adjusters on double rack units. These options may require the units to be pressure derated.
2. Double rack actuators should specify type 4 or 8 cushions and four stroke adjusters and four flow controls (one per end cap) to balance the gear tooth forces on the pinion. Contact the factory for ordering code information. Type 1, 2, or 3 cushions, type A, B, or C stroke adjusters and type P, R, and S port flow controls may cause a destructive bending couple upon the pinion gear under some operating conditions.
3. Durability rated output torque.
4. Pressure differential between the inlet and outlet ports (non-shock).
5. Reduce LTR Series pressure rating by 50% when specifying a magnetic piston with aluminum cylinder tubes, option "M" except on LTR101 and 102 models, or when a unit has cushions.

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Bearing Load Capacities & Gear Train Available

	Bearing load capacities*				Distance		Available stopping work per endcap / cushion**			
	Radial		Thrust		between bearings		Strength criteria		Durability criteria	
Model	**lb**	**kN**	**lb**	**kN**	**inch**	**mm**	**in-lb**	**Nm**	**in-lb**	**Nm**
10	100	0.4	50	0.2	1.40	35	300	34	141	16
15	250	1.1	125	0.5	2.15	54	900	102	348	39
20	500	2.2	250	1.1	2.15	54	1500	169	936	106
25	750	3.3	375	1.6	2.50	63	2250	254	1098	124
32	1000	4.4	500	2.2	3.75	95	5000	565	2029	229

* Bearing capacities only.
** Check total stopping torque ratings to determine if actuator will stop load. Double rack actuators should use Type 4 or Type 8 cushion option for table data to remain correct.

Cushion Deceleration Control

The cushion causes the resisting torque that can be used to decelerate a rotational load. Please note the cushion has to provide enough resistance to control: drive torque caused by the hydraulic system pressure; plus the torque caused by gravity pulling on the rotational load; and the kinetic energy associated with the motion of the inertia load. Since the actuator's cushion has to be able to control the sum of all three torque factors, we suggest including cushion capacity as one of the actuator selection criteria.

It is strongly suggested that proportional valves be used instead of cushions to control (decelerate) high inertial loads. This provides the ability to reduce inlet pressure while generating deceleration pressure. It also allows for longer ramp times, thus increasing deceleration stroke.

SUPPLEMENTAL INFORMATION
KINETIC ENERGY BASIC FORMULA

$KE = 1/2\ J_m\omega^2$

$$\omega = 0.0175 \times \frac{2\Theta_A + \Theta_C + 2\Theta_D}{\text{Rotation Time (sec.)}}$$

where:
KE = Kinetic Energy (in-lb)
J_m = Rotational Mass Moment of Inertia (in-lb-sec^2)
See Page A35 for formulas.
ω = Peak Velocity (rad/sec)
(Assuming trapezoidal velocity profile)
Θ_A = Acceleration Angle (deg)
Θ_C = Constant Velocity Angle (deg)
Θ_D = Deceleration Angle (deg)

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Kinetic Energy Capacity

The energy values below assume drive pressure is maintained through cushion stroke.

Single Rack Units with Single Set of Cushions (30°)

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*											
	0 PSI		250 PSI		500 PSI		750 PSI		1000 PSI		1500 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability
LTR101	310	141	258	141	207	141	155	141	103	103	0	0
LTR151	927	348	772	348	618	348	463	348	309	309	0	0
LTR201	2220	936	1850	936	1480	936	1110	936	740	740	0	0
LTR251	3373	1098	2811	1098	2248	1098	1686	1098	1124	1098	0	0
LTR321	11945	2029	8959	2029	5973	2029	2986	2029	0	0	na	na

Double Rack Units with Single Set of Cushions (30°)

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*											
	0 PSI		250 PSI		500 PSI		750 PSI		1000 PSI		1500 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability
LTR102	310	141	103	103	0	0	0	0	0	0	0	0
LTR152	924	348	616	348	308	308	0	0	0	0	0	0
LTR202	2217	936	1478	936	739	739	0	0	0	0	0	0
LTR252	3373	1098	2249	1098	1124	1098	0	0	0	0	0	0
LTR322	5971	2029	2986	2029	0	0	0	0	0	0	0	0

Double Rack Units with Double Set of Cushions (30°)**

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*											
	0 PSI		250 PSI		500 PSI		750 PSI		1000 PSI		1500 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability
LTR102	310	303	206	206	103	103	0	0	0	0	0	0
LTR152	1848	732	1540	732	1232	732	924	732	616	616	0	0
LTR202	4434	1982	3695	1982	2956	1982	2217	1982	1478	1478	0	0
LTR252	6745	2223	5621	2223	4496	2223	3373	2223	2248	2223	0	0
LTR322	11943	3222	8957	3222	5971	3222	2986	2986	0	0	0	0

* Must deduct work (energy) done to overcome potential energy effects of load. WPE = TPE x Θ, where Θ is in radians.

** Extreme care must be exercised so that both cushions are adjusted equally for each direction or dangerous pressure intensification and gear train stresses could result. (Suggest high performance cushion option.)

Unit Weights

	Rotation							
	90°		180°		270°		360°	
Model	lb	kg	lb	kg	lb	kg	lb	kg
LTR101	2-1/4	1	2-1/2	1.1	2-3/4	1.2	3	1.3
LTR102	3-1/2	1.6	3-7/8	1.8	4-1/4	1.7	4-5/8	2.1
LTR151	8-7/8	4	9-5/8	4.3	10-3/8	4.7	11-1/8	5
LTR152	12-5/8	5.7	14-1/8	6.4	15-5/8	7.1	19-1/2	8.8
LTR201	14-5/8	6.6	16	7.2	17-3/8	7.9	18-7/8	8.6
LTR202	21-3/4	9.9	24-1/2	11.1	27-1/2	12.5	30-1/2	13.8
LTR251	22-5/8	10.3	24-3/4	11.2	27-1/4	12.4	29-3/8	13.3
LTR252	33-5/8	15.2	38-1/8	16.8	42-3/4	19.4	47-1/8	21.4
LTR321	46-5/8	21.1	50-1/8	22.7	53-1/2	24.3	56-7/8	25.8
LTR322	66-5/8	30.2	73-5/8	33.4	78-3/8	35.5	87-1/8	39.5

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Kinetic Energy Basic Formula

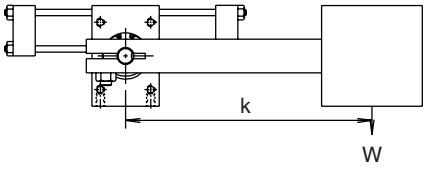
$$KE = 1/2\ J_m\omega^2$$

$$\omega = 0.0175 \times \frac{2\Theta_A + \Theta_C + 2\Theta_D}{\text{Rotation Time (Sec.)}}$$

where:
KE = Kinetic Energy (in-lb)
J_m = Rotational mass moment of inertia (in-lb-sec^2)
(Dependent on physical size of object and weight)
ω = Peak Velocity (rad/sec) (Assuming trapezoidal velocity profile)
Θ_A = Acceleration Angle (deg)
Θ_C = Constant Velocity Angle (deg)
Θ_D = Deceleration Angle (deg)
W = Weight of load (lb)
g = Gravitational constant = 386.4 in/sec^2
k = Radius of gyration (in)

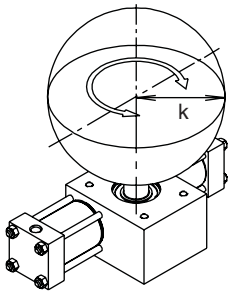
MASS MOMENTS OF INERTIA MODELS & FORMULAS

POINT LOAD



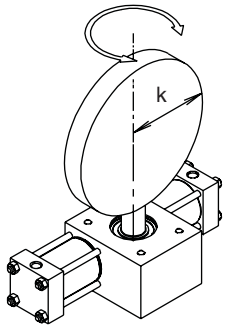
$$J_m = \frac{W}{g} \times k^2$$

SOLID SPHERE -
Mounted on center



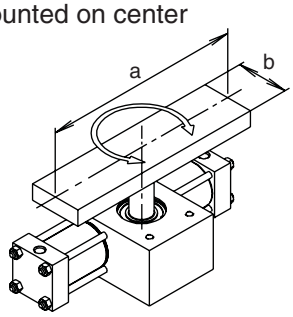
$$J_m = \frac{2}{5} \times \frac{W}{g} \times k^2$$

THIN DISK-
End mounted on center



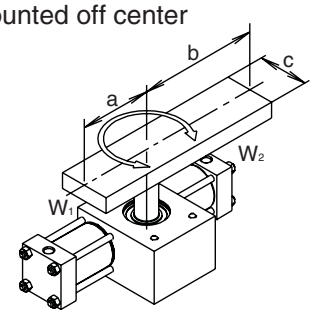
$$J_m = \frac{W}{g} \times \frac{k^2}{4}$$

THIN RECTANGULAR PLATE
Mounted on center



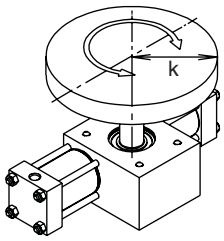
$$J_m = \frac{W}{g} \times \frac{a^2 + b^2}{12}$$

THIN RECTANGULAR PLATE
Mounted off center



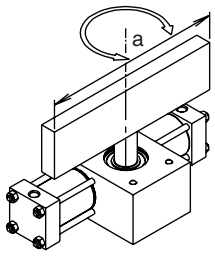
$$J_m = \frac{W_1}{g} \times \frac{4a^2 + c^2}{12} + \frac{W_2}{g} \times \frac{4b^2 + c^2}{12}$$

THIN DISK
Mounted on center



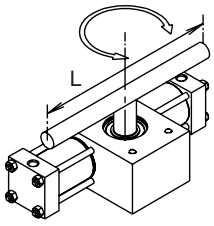
$$J_m = \frac{W}{g} \times \frac{k^2}{2}$$

THIN RECTANGULAR PLATE
End mounted on center



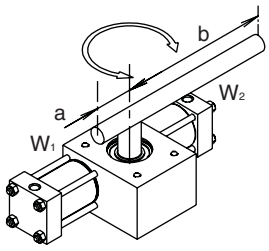
$$J_m = \frac{W}{g} \times \frac{a^2}{12}$$

SLENDER ROD
Mounted on center



$$J_m = \frac{W}{g} \times \frac{L^2}{12}$$

SLENDER ROD
Mounted off center



$$J_m = \frac{W_1}{g} \times \frac{a^2}{3} + \frac{W_2}{g} \times \frac{b^2}{3}$$

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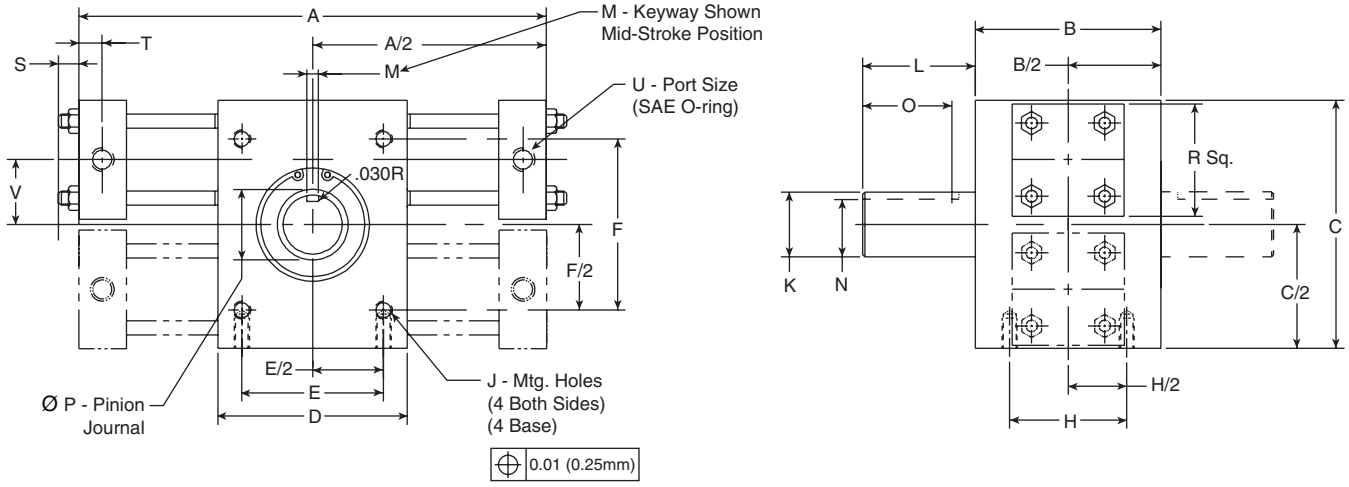
Standard Inch Unit with Face/Base Mount (A) and Male Keyed Shaft (B)
Standard Metric Unit with Face/Base Mount (B) and Male Keyed Shaft (D)

Double Male Keyed Shaft (C, F) shown in phantom



Dimensions for inch units (inches)

Model	Rotation	A	B	C	D	E	F	H	J	K	L	M	N	O	P	R	S	T	U	V
10	90° 180° 360°	6-11/16 8-1/4 1-17/16	2	3	2	1.50	2.00	1.50	1/4-20 x 3/8 DP	.500 .499	7/8	.125 .127	.430 .425	5/8	.59	1-1/2	.39	.31	7/16-20 SAE #4	3/4
15	90° 180° 360°	9-1/8 1-13/16 15-3/8	3	4-1/4	3	2.00	3.00	2.00	5/16-18 x 1/2 DP	.875 .874	1-7/8	.188 .190	.771 .761	1-1/2	.98	2	.44	.44	7/16-20 SAE #4	1-1/16
20	90° 180° 360°	11-3/16 14-1/16 19-11/16	3	5	4	2.50	3.50	2.00	3/8-16 x 1/2 DP	1.125 1.124	1-7/8	.250 .252	.986 .976	1-1/2	1.18	2-1/2	.50	.44	9/16-18 SAE #6	1-1/4
25	90° 180° 360°	12-9/16 15-1/2 20-5/8	3-1/2	6	4	2.50	4.50	2.00	1/2-13 x 3/4 DP	1.375 1.374	2-1/4	.313 .315	1.201 1.191	1-3/4	1.38	3	.50	.44	9/16-18 SAE #6	1-1/2
32	90° 180° 360°	16-5/8 21-1/8 29-3/8	5	8	5	3.00	5.00	2.50	3/4-10 x 1 DP	1.750 1.749	3-1/2	.375 .377	1.542 1.532	3	1.77	3-3/4	.58	.56	3/4-16 SAE #8	1-15/16

Dimensions for metric units (mm)

Model		A	B	C	D	E	F	H	J	K	L	M P9	N	O	P	R	S	T	U*	V
10	90° 180° 360°	169.9 209.6 290.5	50.8	76.2	50.8	40	50	40	M6 x 1 x 10 DP	12.00 11.98	22.2	4	10.9 10.8	15	15	38.1	9.9	7.9	1/8	19.1
15	90° 180° 360°	231.8 284.2 390.5	76.2	108.0	76.2	50	80	50	M8 x 1.25 x 13 DP	22.00 21.98	47.6	6	18.5 18.4	38	25	50.8	11.1	11.2	1/4	27.0
20	90° 180° 360°	284.2 357.2 500.1	76.2	127.0	101.6	63	90	50	M10 x 1.5 x 13 DP	28.00 27.98	47.6	8	24.0 23.8	38	30	63.5	12.7	11.2	1/4	31.8
25	90° 180° 360°	319.1 393.7 523.9	88.9	152.4	101.6	63	115	50	M12 x 1.75 x 19 DP	34.00 33.98	57.2	10	29.0 28.8	44	35	76.2	12.7	11.2	1/4	38.1
32	90° 180° 360°	422.3 536.6 746.1	127.0	203.2	127.0	80	125	63	M20 x 2.5 x 25 DP	42.00 41.98	88.9	12	37.0 36.8	76	45	95.3	14.8	14.2	1/2	49.2

* BSPP/G

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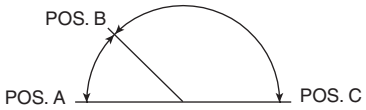
Three Position Actuator (3)

In addition to the standard two position actuators, three position units are also available. All standard options are also available.



Operation:

A standard double rack unit is fitted with stop tubes of varying lengths on the upper rack. Pressurizing port C-2 (with ports C-1, C-3 exhausted) causes counterclockwise pinion rotation to angular position A. Alternately applying pressure to C-1 (with C-2 and C-4 exhausted) will cause clockwise rotation to angular position C. Both positions A and C are at end of stroke, thus typical end cap options such as cushions, bumpers, and stroke adjusters will operate at these positions only.

Position B is obtained by pressurizing all ports. Pressure applied to the upper floating pistons centers the rack between the stop tubes, rotating the pinion to position B. The lower rack is free floating as the forces are equal on both ends.

Dimensional Data:

Three position actuator dimensions are identical to the standard double rack units. If stroke adjusters are specified they will be fitted to the upper rack, flow controls and cushions will be on the lower rack. Rotational tolerances are given in the chart to the right.

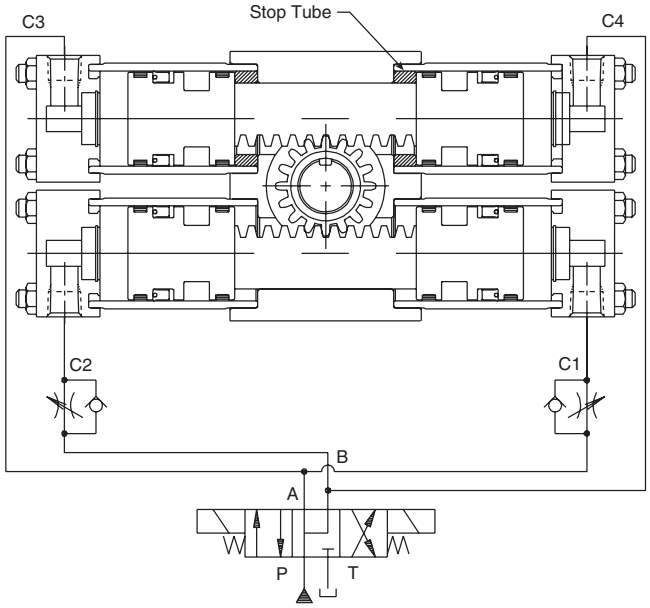
Output Torque:

Output torque of the multiple position actuator is equivalent to the torque output of the same size single rack unit. The chart to the bottom right gives selected torque values for specified pressures.

Ordering Information:

Three position actuators can be ordered by inserting a 3 into the "configuration" space in the model code. The desired middle and total rotation should be stated in the model code separated by a "/". The beginning position, 0°, need not be specified. For example: **LTR153-045/180-AB21-C** is a standard, three position actuator. Position A is 0°, position B is 45°, and position C is 180°.

CAUTION: Keep loop pressure drops low for proper operation.



Rotation Tolerances

Model	Total Rotation, Degrees	Between Positions, Degrees[1]	Backlash Minutes
103	-0, +5	±1	50
153	-0, +4	±1/2	40
203	-0, +3	±1/2	30
253	-0, +3	±1/2	30
323	-0, +2	±1/4	15

1. Measured from centers of backlash.

Theoretical Output Torque, (in-lb) at Specified Pressure

Model	100 psi (6.8 bar)	500 psi (34 bar)	1000 psi (68 bar)
103	39	197	395
153	118	590	1180
203	282	1410	2820
253	430	2148	4295
323	1141	5703	11407

NOTE: When magnetic piston ring option "M" is ordered, all pistons will be so equipped. The pressure rating is derated by 50% with the magnetic piston option, due to aluminum cylinder tube being used.

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Antibacklash Actuator (7)

An antibacklash actuator is used to obtain precision positioning at the end of rotation. The backlash normally associated with rack and pinion actuators is eliminated by this unique configuration.

Operation:

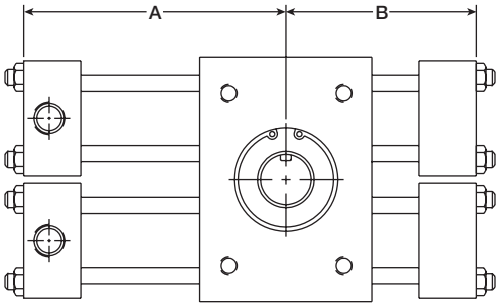
A double rack unit is modified for actuation on one end only. Alternately pressurizing C-1 or C-2 causes clockwise and counter-clockwise rotation, respectively. Backlash in the rack & pinion is eliminated as the pinion is tightly "trapped" between both racks at the end of stroke, preventing any further motion.

Dimensional Data:

Antibacklash actuators are similar in size and configuration to standard double rack units with one set of shorter cylinders. The table to the right shows dimensions for this shorter side. If cushions, stroke adjusters or port flow controls are ordered, they will be fitted to the powered rack side.

Output Torque:

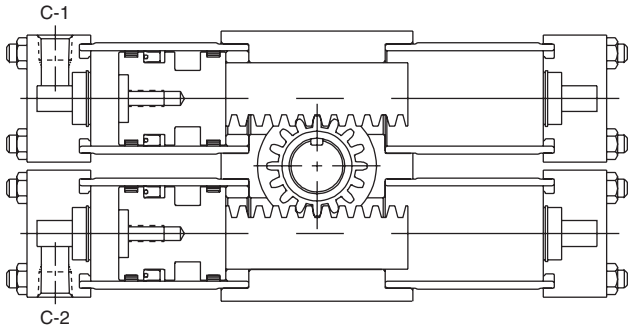
Output torque of the antibacklash actuator is equivalent to the torque output of the same size single rack unit. The chart to the bottom right gives selected torque values for specified pressures.



Ordering Information:

Antibacklash actuators can be ordered by inserting a "7" into the "configuration" space in the model code. For example: **LTR157-180F-AR21-C** is a hydraulic antibacklash actuator with a theoretical output torque of 1000 in-lb at 1000 psi.

The optional stroke adjusters make the rotation variable between 120° and 180°. The preload key option on the shaft is also specified to eliminate any backlash in the key and flange coupling interface.



		A		B	
Model	**Rotation**	**inch**	**mm**	**inch**	**mm**
	90	3-3/4	95	2-3/4	70
107	180	4-1/8	105	3-3/4	95
	360	5-3/4	146	5	127
	90	4-9/16	116	3-5/16	84
157	180	5-5/8	143	4-9/16	116
	360	7-11/16	195	6-5/8	168
	90	5-5/8	143	4-1/8	105
207	180	7-1/16	179	5-5/8	143
	360	9-7/8	251	8-1/2	216
	90	6-5/16	160	4-3/8	111
257	180	7-3/4	197	6-5/16	160
	360	10-5/16	262	8-13/16	224
	90	8-5/16	211	5-13/16	148
327	180	10-9/16	268	8-5/16	211
	360	14-11/16	373	12-7/16	316

Theoretical output torque, (in-lb) at specified pressure

Model	**100 psi (6.8 bar)**	**500 psi (34 bar)**	**1000 psi (68 bar)**
107	39	197	395
157	118	590	1180
207	282	1410	2820
257	430	2148	4295
327	1141	5703	11407

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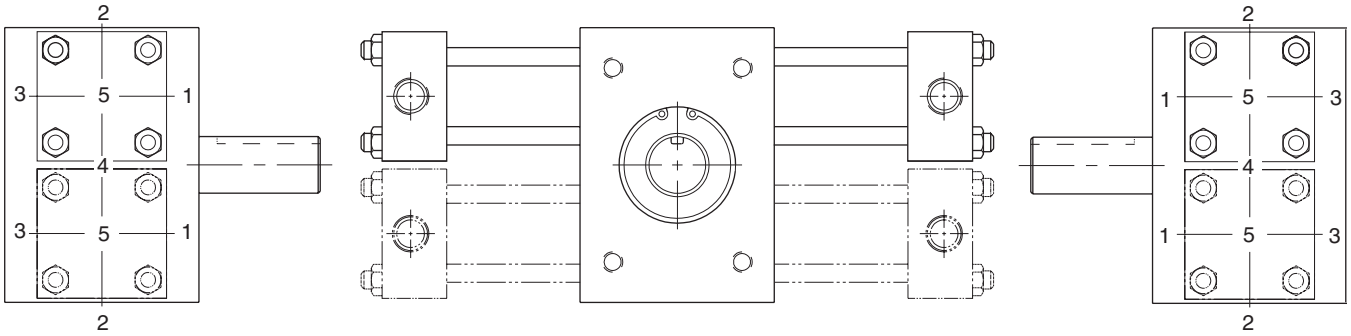
Port Location (1, 2, 3, 4, 5)

End caps can be assembled to the units with ports facing different directions as shown.



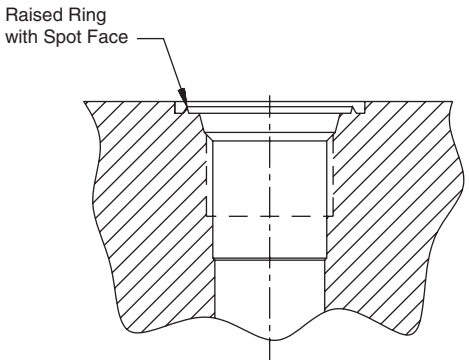
NOTE:

1. Port position 1 is standard.
2. Port positions 2, 3 and 4 are standard options available at no additional cost.
3. Port position 4 available with single rack actuators only.
4. For port position 5, consult factory.

Port Threads (1, 2, 4, 5, 6)

Model	Standard SAE Straight Thread (1)	NPT (2)	BSPP/G (4)	Metric DIN (5) & ISO (6)
10	7/16 - 20 (SAE 4)	1/8	1/8	M10 x 1
15	7/16 - 20 (SAE 4)	1/4	1/4	M14 x 1.5
20	9/16 - 18 (SAE 6)	1/4	1/4	M14 x 1.5
25	9/16 - 18 (SAE 6)	1/4	1/4	M14 x 1.5
32	3/4 - 16 (SAE 8)	3/8	1/2	M22 x 1.5

ISO 6149/1 Port Identification



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Cushions (1, 2, 3, 4) *

The standard cushions operate over the last 30° of rotation in either CW, CCW or both directions. A floating bushing ensures no binding of the cushion spear. For severe operating conditions, four cushions should be fitted on double rack units. All cushions are fully adjustable. On double rack units with type 1, 2 or 3, cushion adjustment will be located on the upper cylinder.

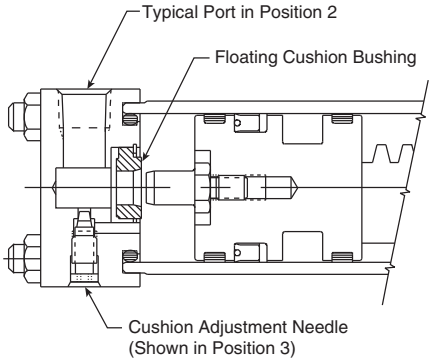
For double rack units where Option 4 (four cushions) is selected please take special care to make sure that adjacent cushions (ie both C-1 ports) are adjusted to the same cushion setting so as to ensure that both cushions are working together. An improper setting could result in one of the cushions not being utilized and thus result in premature gear train life or other damage to the unit.

* For gear train durability, see table below.

Standard Cushion Adjuster Needle Locations

Port Position	Cushion Adjuster Position
1	2
2	3
3	2
4**	3
5	Consult Factory

** On single rack only



High Performance Cushion (8)

(This option available with double rack units only)

By combining the output/exhaust flow from two cylinders, then routing it across a single cushion needle, cushion performance is improved. The increased volume passing over the needle provides better control. This unique circuit eliminates two pipe or tubing tees.

Operation:

The work ports of a standard directional valve are plumbed to ports C-1 and C-2. Port A-1 is plumbed directly to A-2, and port B-1 is plumbed to B-2. When pressure is applied to port C-1 (clockwise shaft rotation), fluid is also directed through line A to the other rack. Exhaust flow from B-2 through B-1 is directed through the cushion bushing and cushion adjustment at port C-2. When the cushion spear closes off the main passage, total flow from both end caps is directed across one cushion adjustment needle, equalizing back pressure and improving control. Alternatively, pressurizing C-2 and exhausting C-1 reverses the operation.

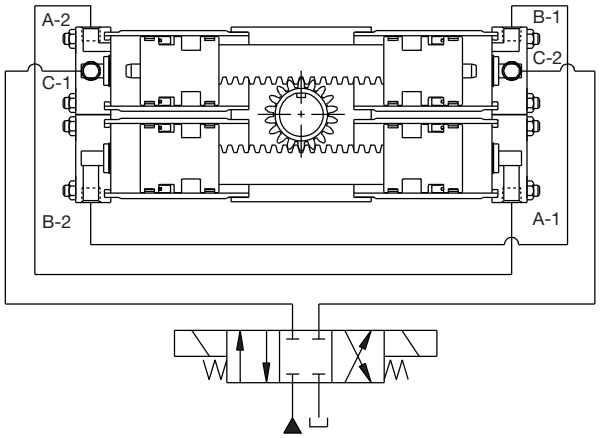
Dimensional Information:

Units are identical to standard double rack and pinion units, with the exception of porting location. This chart describes the location of the ports.

Suggestion: Use Type 4 or Type 8 cushion arrangements for double rack actuators. Use Type 1, 2 or 3 cushion arrangements exclusively for single rack actuators.

Gear Set Durability

The table to the right provides energy ratings based on gear train durability when using various cushion options for the LTR Series.



Work ports C-1, C-2 port position	Cushion adjustment position	Connection ports A-1, A-2 & B-1, B-2 port position
1	2	3
2	3	1
3	2	1

	Total energy capacity (in-lb)		Port to port ΔP (PSID)	
Model	Code 1,2,3	Code 8	Code 1,2,3	Code 8
LTR101	141	N/A	800	N/A
LTR102	141	303	400	800
LTR151	348	N/A	650	N/A
LTR152	348	732	325	650
LTR201	936	N/A	750	N/A
LTR202	936	1982	375	750
LTR251	1098	N/A	550	N/A
LTR252	1098	2223	275	550
LTR321	2029	N/A	400	N/A
LTR322	2029	3222	200	400

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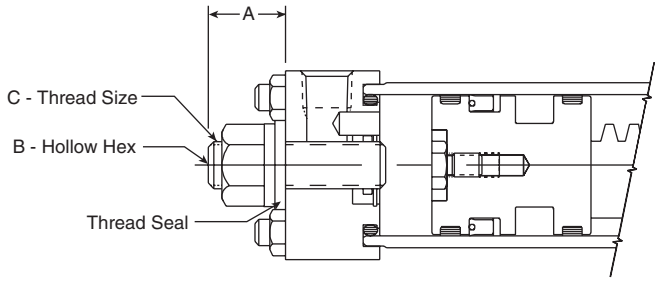
Stroke Adjusters (D, E, F) 30°

Fine control of the end of travel points of the rotary actuator can be obtained by specifying stroke adjusters. These operate by reducing the maximum travel of the actuator by up to 30° in each rotational direction. Adjustment within this range is made by the user. Several types of stroke adjuster are available. The design illustrated is suitable for applications requiring infrequent adjustment.

Stroke Adjusters and Cushions

The addition of stroke adjusters requires an increase in build length. On double rack units with cushions, the cushion is fitted to the upper rack and the stroke adjuster to the lower. (Consult factory.)

The increase in build length, for both single and double rack units, is shown as dimension A in the table. Cushion performance may be affected by the addition of a stroke adjuster. Please consult the factory in critical applications.



		A (max) – Increased build length					
		30°adjustment without cushioned end cap		10°adjustment* with cushioned end cap			C
Model	One (1) turn adj.	inch	mm	inch	mm	B	UNF
10	4.0°	.63	16	.38	10	1/8	1/4-28
15	4.2°	.88	23	1.13	29	1/4	1/2-20
20	3.1°	1.13	29	1.13	29	1/4	1/2-20
25	3.3°	1.13	29	1.13	29	1/4	1/2-20
32	2.6°	1.50	38	2.13	54	3/8	3/4-16

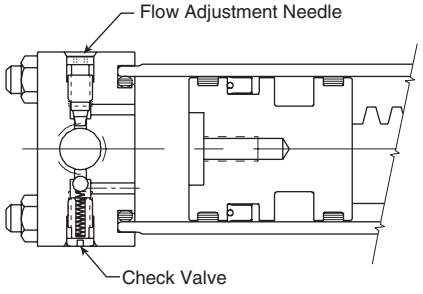
* Standard cushions operate over the last 30° of standard rotation. Stroke adjuster will decrease the effective cushion length by the amount of inward adjustment.

CAUTION: Due to end of stroke loading on some applications, four stroke adjusters may be needed with double rack actuators to avoid pinion gear damage.

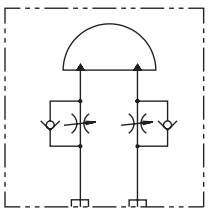
Port Flow Controls (P, R, S)

Built in meter-out flow controls provide adjustment of actuator speed and eliminate the cost and space needed for externally plumbed components. A separate ball check is used to provide free flow in the opposite direction. Flow controls may be ordered in conjunction with cushions or stroke adjusters.

Four port flow controls are suggested with double rack actuators to avoid pinion gear damage.



Schematic



NOTE: When both cushions and port flow controls are specified the end caps will be stamped “C” and “P” respectively near the adjustment needles.

Standard Adjustment Needle Locations

Port Position	Needle Position
1	2
2	3
3	2
4*	3

* On single rack only

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Mounting Options:

Inch Units (F, G, P, R)
Metric Units (H, K, S, T)

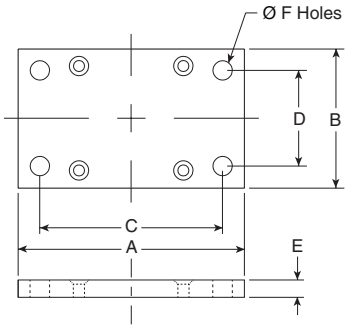
Flanged and Pilot Mountings

LTR Series rotary actuators are available with options such as face/base, pilot or flanged mounting styles to suit the requirements of different applications.

Note: Actuators are shipped with mounting flange installed unless otherwise noted.

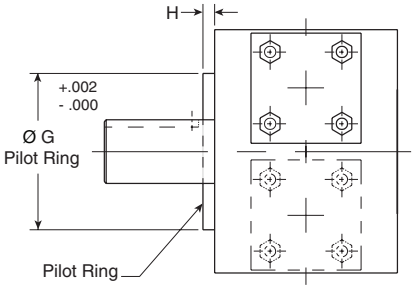
Foot Flange (G, K)

	Inch (G)						Metric (K)					
Model	**A**	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
10	3.25	2.00	2.625	1.375	.250	.281	82	51	67	35	7	6.5
15	4.50	3.00	3.875	2.125	.438	.406	114	76	98	54	11	11
20	4.50	4.00	3.875	3.375	.438	.406	114	102	98	86	11	11
25	5.50	4.00	4.500	3.000	.438	.531	140	102	114	76	11	13.5
32	8.00	5.00	6.500	3.500	.750	.781	N/A	N/A	N/A	N/A	N/A	N/A



Pilot Ring (P, S)

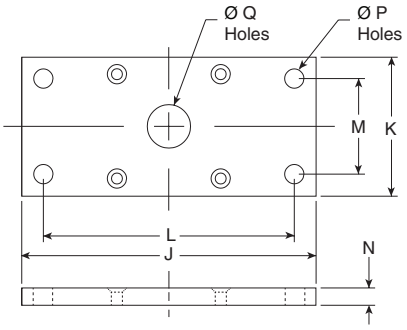
	Inch (P)		Metric (S)	
Model	**G**	**H**	**G**	**H**
10	1.125	.125	28.58	3.2
15	2.001	.25	50.83	6.4
20	2.166	.23	55.04	5.8
25	2.680	.25	68.05	6.1
32	3.347	.25	85.04	6.4



Front (F, H) or Rear Flange (R, T)

NOTE: Shaft seal cover option "S" is not available with flange mounting.

	Inch (F, R)							Metric (H, T)						
Model	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**
10	4.25	2.00	3.625	1.375	.250	.281	.625	108	51	92	35	7	6.5	15
15	5.75	3.00	5.125	2.125	.438	.406	1.000	146	76	130	54	11	11	25
20	6.50	4.00	5.875	3.375	.438	.406	1.250	165	102	149	86	11	11	31
25	8.25	4.00	7.250	3.000	.438	.531	1.625	210	102	184	76	11	13.5	40
32	12.00	5.00	10.000	3.000	.750	.781	2.000	305	127	254	76	19	22	48



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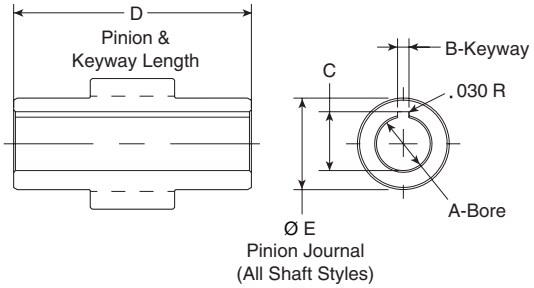
Shaft Options (A, E, R)

Units are equipped standard with single male keyed shaft (B, D). Double male keyed (C, F) also available as shown on page A36. Also available:

Female Keyed (A)
Metric Female Keyed (E)



NOTE: Female keyed pinions are designed primarily for pneumatic service. Review shaft stresses before using in a hydraulic application.

Dimensions, inches (A)

Model	A	B	C	D	E
10	.375 .377	.094 .096	.428 .438	1-13/16	.59
15	.500 .502	.125 .127	.560 .570	2-11/16	.98
20	.750 .752	.187 .189	.837 .847	2-23/32	1.18
25	1.000 1.002	.250 .252	1.083 1.093	3-1/8	1.38
32	1.250 1.252	.250 .252	1.367 1.377	4-9/16	1.77

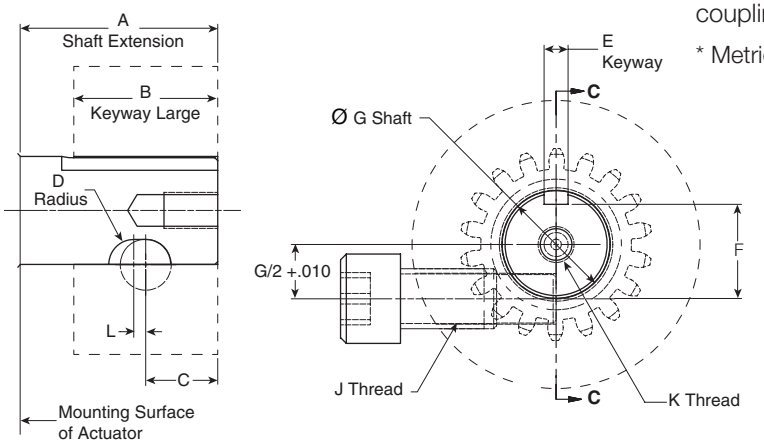
Dimensions, mm (E)

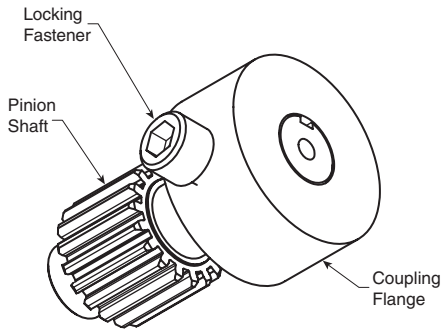
Model	A	B P9	C	D	E
10	9.05 9.00	3	10.65 10.40	46.0	15.0
15	12.05 12.00	4	14.05 13.80	68.1	24.9
20	20.05 20.00	6	23.05 22.80	68.8	30.0
25	25.05 25.00	8	28.55 28.30	78.7	35.0
32	32.05 32.00	10	35.55 35.30	115.8	45.0

Preload Key (R)*

The preload key option is recommended for use with available Parker transition coupler flanges or any time coupling backlash is not desired.

* Metric preload key option not available as a standard option.





Dimensions, inches (R)

Model	A	B	C	D	E	F	G	H	J	K	L
10	7/8	5/8	.375	.156	.125 .127	.430 .425	.500 .499	1-1/2	3/8-24	10-32 x 3/8 DP	.125
15	1-7/8	1-1/2	.812	.219	.188 .190	.771 .761	.875 .874	2	1/2-20	5/16-24 x 1/2 DP	.125
20	1-7/8	1-1/2	.812	.250	.250 .252	.986 .976	1.125 1.124	3	5/8-11	3/8-24 x 9/16 DP	.125
25	2-1/4	1-3/4	1.000	.250	.313 .315	1.201 1.191	1.375 1.374	3-1/2	3/4-10	3/8-24 x 9/16 DP	0
32	3-1/2	3	1.500	.437	.375 .377	1.542 1.532	1.750 1.749	4	1-8	1/2-20 x 3/4 DP	0

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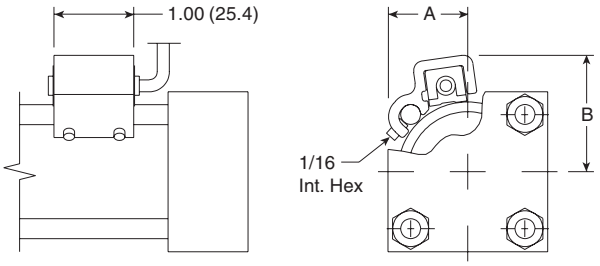
Magnetic Piston (M)

This option prepares the actuator for use with Reed and Hall Effect switches. The "M" option should be specified to provide a magnet on the cylinder piston and aluminum cylinder tubes. *The pressure of the actuator is derated by 50% with the magnetic piston option due to the aluminum cylinder tubes.*

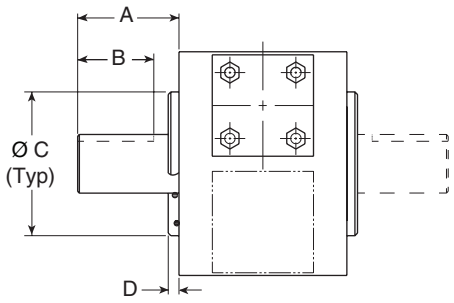
Order switches separately from the Sensors section.



Model	A inch (mm)	B inch (mm)
10	.84 (21)	1.22 (30)
15	.99 (25)	1.46 (37)
20	1.27 (32)	1.68 (43)
25	1.45 (37)	1.89 (48)
32	1.71 (43)	2.20 (56)

Shaft Seal Covers (S)

Shaft Seal covers are designed to prolong bearing life by isolating them from external contamination and pressure. They are designed for use with standard male shafts only (not hollow shafts). *Shaft seals are not available with flange mounting.*



Specifications

Max. Pressure Differential: 500 psi (34 bar)
Material: Anodized Aluminum
Shaft Seal: Double Lip Wiper
Body Seal: O-Ring

	A		B		C		D	
Model	Inch	mm	Inch	mm	Inch (+.000, -.002)	mm (+.00, -.05)	Inch	mm
10	7/8	22	1/2	12	1.875	48	.25	7
15	1-7/8	46	1-5/16	33	3.000	76	.38	10
20	1-7/8	46	1/5/16	33	3.250	83	.38	10
25	2-1/4	56	1-5/8	41	3.625	92	.38	10
32	3-1/2	88	2-7/8	73	4.480	114	.38	10

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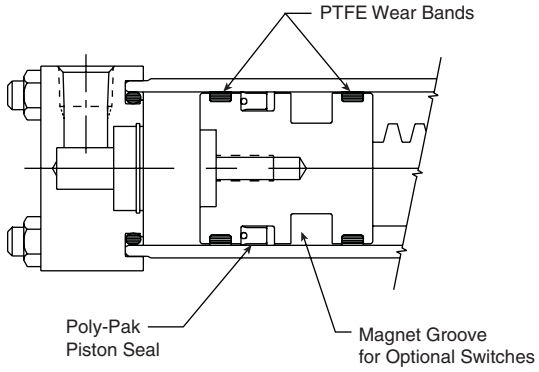
Piston Seals (V, W)

The floating Wear-Pak piston fitted as standard to all LTR Series rotary actuator employes a filled PTFE wear band to prevent metal-to-metal contact. The hydraulic LTR Series actuator uses a Molythane Polypak seal, which is self-energizing for improved sealing. The Molythane seal is wear, roll and extrusion resistant. For higher temperatures or use with synthetic fluids, Fluorocarbon seals should be specified; for water glycol or high water content fluids, carboxylated nitrile seals are available.



Filtration

Effective filtration is vital to the long life and satisfactory performance of a rotary actuator. If the piston seals of a rack and pinion rotary actuator are worn or damaged, fluid leaks past the piston and will enter the gear housing.

Any external leakage from the gear housing indicates worn or damaged piston seals. Seals and tubes should be examined and, if necessary, be replaced at the earliest opportunity.

Seal Options

Seal option code	Seal type	Wear ring type	Fluid medium	Temperature range	Hydraulic filtration
Omit (Standard)	Molythane	Filled PTFE	General purpose applications, petroleum-based fluids	-40°F to 180°F (-40°C to 82°C)	ISO Class 17/14 Cleanliness Level
Option V	Fluorocarbon	Filled PTFE	High temperature operation, special synthetic fluids	-20°F to 250°F (-29°C to 121°C)	
Option W	Carboxylated Nitrile	Filled PTFE	Water-based fluids	30°F to 180°F (0°C to 82°C)	

Feedback Packages

Feedback packages available for use with LTR Series rotary actuators include:

- Precision feedback potentiometer (J)
- Precision resolver feedback (H)

The feedback packages may be ordered as part of the model code. See Sensors section for specifications.

Seal Kit Ordering Information

- Standard units are equipped with nitrile seals.
- Optional seal compounds are available.
- See parts list for items contained in seal kits.

PSK	—	LTR322
Parker Seal Kit		Base Model

V	
Omit	Nitrile Seals (Std)
V	Fluorocarbon Seals
Q	Quad Ring Piston Seals
W	Carboxylated Nitrile (Piston Seals Only)

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Switch Characteristics

Proximity Switches
- End Cap Mounted
- Solid State Electronics
- LED Indicator
- 10-30 VDC or 50-230 VAC/DC
- PNP and NPN Available
- Senses Cushion Spear on Piston
- Highest Cost
- Long Life

Hall Effect Switches
- Fully Adjustable Travel
- Solid State Electronics
- LED Indicator
- 50-30 VDC
- PNP and NPN Available
- Senses magnet band on piston (Aluminum cylinders required)
- Medium Cost
- Long Life

Reed Switches
- Fully Adjustable Travel
- Mechanical Reed
- LED Indicator
- 50-30 VDC or 85-150 VAC
- Senses magnet band on piston (Aluminum cylinders required)
- Lowest Cost
- Medium Life

Proximity Switches

The inductive type proximity switch provides end of rotation indication. The non-contact probe senses the presence of the ferrous cushion spear and has no springs, plungers, cams or dynamic seals that can wear out or go out of adjustment. The switch is solid state and meets NEMA 4, 12 & 13 specifications. For ease of wiring, the connector housing is rotatable through 360°. To rotate, lift the cover latch, position, and release.

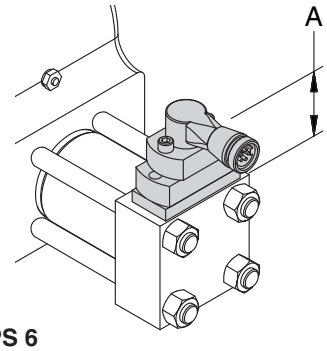
The switch make/break activation point may occur at 0.125" to ±0.125" from end of stroke. Depending on the actuator size, this distance may cause activation at 2° to 15° before end of stroke.

A standard proximity switch controls 50-230 VAC/DC loads from 5 to 500 mA. The low 1.7 mA off-state leakage current can allow use for direct PLC input. The standard short circuit protection (SCP) protects the switch from a short in the load or line upon sensing such a condition (5 amp or greater current) by assuming a non-conductive mode. The fault condition must be corrected and the power removed to reset the switch preventing automatic restarts.

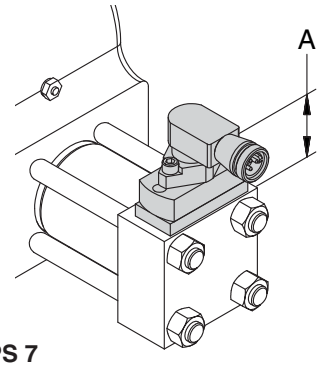
The low voltage DC switch is also available for use with 10-30 VDC. This switch is in a non-rotatable housing, but does incorporate the short circuit protection.

Both switches are equipped with two LEDs, “Ready” and “Target”. The “Ready” LED is lit when power is applied and the cushion spear is not present. The “Target” LED will light and the “Ready” LED will go out when the switch is closed, indicating the presence of the cushion spear. Both LEDs flashing indicates a short circuit condition.

NOTES:
1. Available with or without cushions.
2. Not available with stroke adjusters.
3. Prsesure rating: 3000 psi
4. Operating temperature: -4°F to 158°F
5. Specify switch type, orientation and voltage when ordering
6. Not available on size 10 units.
7. The low voltage DC switch is available in non-rotatable style only. Consult representative for further information.



EPS 6



EPS 7

Model	A, inch (mm) EPS 6 & 7
15	2.17 (55.1)
20	2.75 (69.9)
25	2.48 (63.0)
32	2.25 (57.2)

Hall Effect and Reed Switches

Reed and Hall Effect switches are available for use with LTR Series rotary actuators. The “M” option should be specified to provide a magnet on the cylinder piston and to use aluminum cylinders.

Order proximity, Hall Effect and reed switches separately. See Sensors section for specifications and ordering information.

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HTR Series
Hydraulic Rack & Pinion Rotary Actuators

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Market Segments/Applications	Market/Segment	Typical Application(s)	Product Series				
			HUB	LTR	HTR	M	Tork-Mor
	Aerospace	Water bomb, tank door actuation		●			
	Aggregate	Granite block rollover			●		
	Aluminum	Automation				●	
	Automation	Mounting, Processing, Flood gate actuation, End of arm tooling	●	●	●		●
	Automotive	Automation, Clamping, Tube bending			●		●
	Conveyor	Swing & rotate		●	●		●
	Entertaining	Pool gate actuation, Robotic joint motion					●
	Fluid Management & Flow Control	Power plants			●	●	
	Industrial	Automation, Clamping					●
	Machine Builders	End of arm tooling			●		
	Marine/Offshore	Boomslewer, Submersible			●	●	
	Mining	Mobile longhole drilling, Tunnel boring	●		●	●	
	Mobile	Fire truck ladder rotation, Aerial lift basket, X-ray boom rotation, Forklift handling & storage, Refuse tippers	●	●	●	●	
	Nuclear	Door actuation				●	
	Oil & Gas	Process valve actuation	●		●		
	Oil Industry Machinery	Clamping, Lockout	●				●
	Paper & Pulp	Walking beam				●	
	Plastics	Blow molding, Injection molding			●		●
	Rubber	Mixing			●	●	
	Solar	Panel rotation			●		
	Space	Rocket launch tower				●	
	Steel & Casting	Ladle Tilt, Coil Box, Steel Booming, Pipe fabrication			●	●	●
	Testing Equipment	Flight Simulators, Cycle loading, Tensile test Machines			●		●
	Transportation	Bus wheelchair ramp		●			
	Water Management		●		●		
	Welding	Weld gun indexing, Clamping					●

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HTR Series

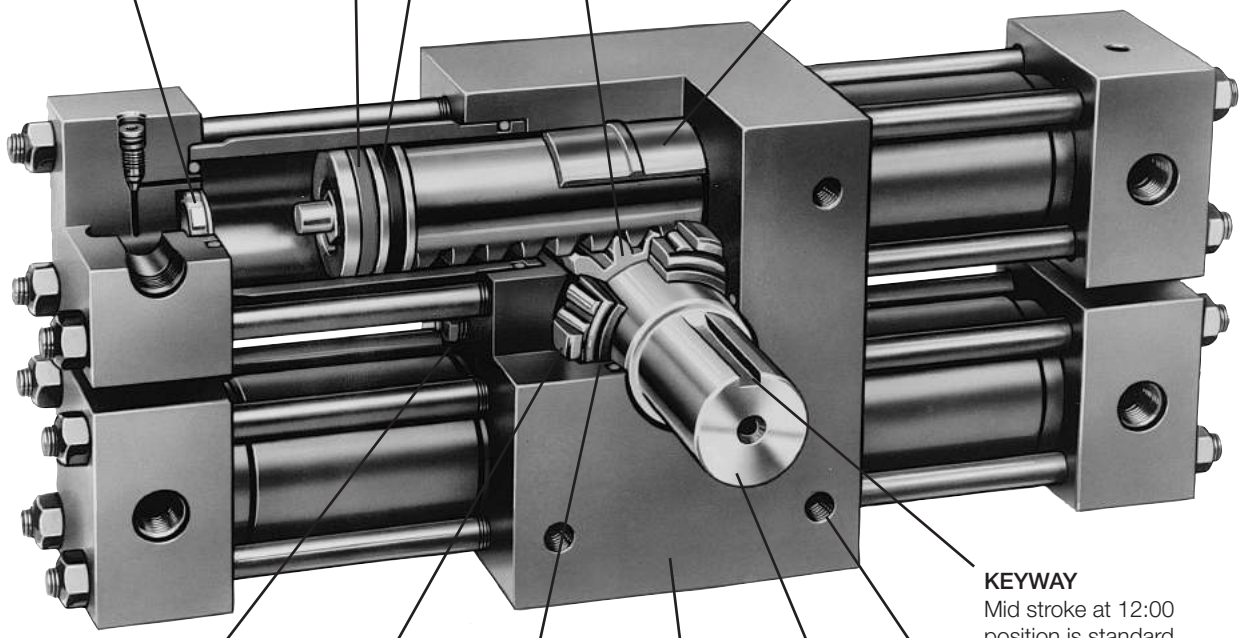
PISTON SEALS
Depending on actuator size, either dual lip seals made from abrasion resistant polyurethane or heavy duty, deep section Polypak seals made from Molythane for dependable service in most applications. Options: Fluorocarbon seals for certain synthetic fluids; and carboxilated nitrile seals for water based fluids. Piston seals can be inspected and replaced without disconnecting the load from the shaft. (Employ proper safety practices to prevent damage to people or equipment.)

OPTIONAL CUSHIONS
If properly adjusted, cushions can serve as a braking device for most industrial loads and applications. The proven Parker "floating cushion bushing" serves as a high performance check valve for quick cushion get away and the needle valve can be adjusted to regulate the exhaust flow from the piston. Our design uses no springs or check valve seats that can fatigue or break under normal usage.

WEAR BANDS
Filled PTFE bands (std) precisely position pistons and prevent side loading from scoring cylinder bores. High strength wear band options available.

RACK & PINION made from through hardened, high strength alloy steels for long and durable service life in most applications. Option: Case hardening.

BRONZE RACK BEARING
reduces friction, wear and tear between the housing and the rack gear. Replaceable bronze bearing comes standard with HTR15 through HTR600 actuators. High strength bearing material options available.



KEYWAY
Mid stroke at 12:00 position is standard

THREADED MOUNTING HOLES
Our standard mounting uses four bolt holes drilled and tapped on the front and back of the housing. Options: additional pilot ring or base mount.

RELIEF VALVE is designed to prevent the housing from seeing pressure due to piston seal bypass. Seal kits are available.

TAPERED ROLLER BEARINGS are generously sized to support large external axial and radial loads applied to the shaft.

PINION SEALS
Dual lobed seal of abrasion resistant materials seals effectively with minimum wear at dynamic conditions.

HOUSING
The heavy, high strength, shock resistant, ductile iron housing serves as a firm base to drive large output torque requirements.

STANDARD MALE KEYED SHAFT
is made integral with the pinion gear and is suitable for most applications. Options: double male key, hollow bore keyed and spline shafts are available.

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Ordering information – Inch

HTR **150** – **180** **3** **C** – **A** **B** **1** **1** **V** **J** – **C** ☐

Size Torque output at 3000 psi	
Single rack units	
.9	900 in-lb
3.7	3,700 in-lb
5	5,000 in-lb
15	15,000 in-lb †
22	15,000 in-lb †
75	75,000 in-lb †
300	300,000 in-lb †
Double rack units	
1.8	1,800 in-lb
7.5	7,500 in-lb
10	10,000 in-lb
30	30,000 in-lb †
45	30,000 in-lb †
150	150,000 in-lb †
600	600,000 in-lb †

Degrees rotation	
090	90°
180	180°
360	360°
450	450°
Specify other rotations.	

Cushion	
Omit	None (standard)
1	CW rotation
2	CCW rotation
3	Both rotations
4	Four cushions **
8	High performance cushion **
9	Special

Stroke adjusters	
Omit	None
A	0-5° CW rotation^
B	0-5° CCW rotation^
C	0-5° both rotation^
D	0-30° CW rotation^^
E	0-30° CCW rotation^^
F	0-30° both rotations^^
X	Special

Mounting style	
A	Face (standard)
B	Base mount
P	Pilot mount
X	Special

Shaft configuration	
A	Female keyed
B	Single male keyed (standard)
C	Double male keyed
D	Female 10B spline
E	Single male 10B spline
F	Double male 10B spline
J	Female involute spline (HTR300/600 only)
P	Single male involute spline (HTR300/600 only)
V	Double male involute spline (HTR300/600 only)
X	Special

Port type	
1	SAE straight thread (standard)
2	NPTF
3	Flange
9	Special

Port location (see port location table)	
1	Side: Position 1 (standard)
2	Side: Position 2
3	Side: Position 3
4	Side: Position 4 (single rack only)
5	End
9	Special

Seals	
Omit	Molythane/nitrile (standard)
V	Fluorocarbon
W	Carboxylated nitrile

Options (multiple choices allowed)	
H	Resolver feedback
J	Feedback potentiometer
R	Bronze rack bearing
X	Other, special ‡

Design series	
A	Sizes .9 & 1.8 only
C	Sizes 3.7 thru 600

Special options ‡	
Omit	Standard unit
Three-digit code assigned by factory when any "X" or "9" appears in the model number or when special options or features are required.	

Notes:

† Replaceable bronze rack bearing comes standard.

* Specify location.

** Double Rack Models Only. Use four cushions for existing applications only. For new applications, use option 8, High Performance Cushion.
See options section for additional information.

^ Not available with End Ports. Standard 5° Stroke Adjusters and Standard Cushions available together on all units.
Single rack units require additional "A" length.

^^ Not Available with End Ports or Cushions.

‡ Special options
Other options such as air bleeds* and sensors must be ordered separately with detailed text.

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Ordering information – Metric

HTR **150** – **180** **3** **C** – **D** **G** **4** **1** **V** **J** – **C** ☐

Size Torque output at 3000 psi	
Single rack units	
.9	900 in-lb
3.7	3,700 in-lb
5	5,000 in-lb
15	15,000 in-lb †
22	15,000 in-lb †
75	75,000 in-lb †
300	300,000 in-lb †
Double rack units	
1.8	1,800 in-lb
7.5	7,500 in-lb
10	10,000 in-lb
30	30,000 in-lb †
45	30,000 in-lb †
150	150,000 in-lb †
600	600,000 in-lb †

Degrees rotation	
090	90°
180	180°
360	360°
450	450°
Specify other rotations.	

Cushion	
Omit	None (standard)
1	CW rotation
2	CCW rotation
3	Both rotations
8	High performance cushion **
9	Special

Stroke adjusters	
Omit	None
A	0-5° CW rotation^
B	0-5° CCW rotation^
C	0-5° both rotation^
D	0-30° CW rotation^^
E	0-30° CCW rotation^^
F	0-30° both rotations^^
X	Special

Mounting style	
C	Face (standard)
D	Base mount
T	Pilot mount
X	Special

Shaft configuration	
G	Female keyed
H	Single male output, keyed (standard)
K	Double male output, keyed
L	Female ISO straight spline
M	Single male ISO straight spline (Not available with HTR300/600)
N	Double male ISO straight spline (Not available with HTR300/600)
X	Special

Port type	
4	BSPP (standard)
5	Metric to DIN 3852/1
6	Metric to ISO 6149/1
1	SAE straight thread
2	NPTF
3	Flange
9	Special

Port location (see port location table)	
1	Side: Position 1 (standard)
2	Side: Position 2
3	Side: Position 3
4	Side: Position 4 (single rack only)
5	End
9	Special

Seals	
Omit	Molythane/nitrile (standard)
V	Fluorocarbon
W	Carboxylated nitrile

Special options	
H	Resolver feedback
J	Feedback potentiometer
R	Bronze rack bearing
X	Other, special ‡

Design series	
A	Sizes .9 & 1.8 only
C	Sizes 3.7 thru 600

Special options ‡	
Omit	Standard unit
Three-digit code assigned by factory when any "X" or "9" appears in the model number or when special options or features are required.	

Notes:

† Replaceable bronze rack bearing comes standard.

* Specify location.

** Double Rack Models Only. Use four cushions for existing applications only. For new applications, use option 8, High Performance Cushion.

See options section for additional information.

^ Not available with End Ports. Standard 5° Stroke Adjusters and Standard Cushions available together on all units.

Single rack units required additional "A" length.

^^ Not Available with End Ports or Cushions

‡ Special options

Other options such as air bleeds* and sensors must be ordered separately with detailed text.

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The HTR Series rotary actuator incorporates many hydraulic and mechanical features that make this actuator both robust and ideal for the most demanding high production applications. These features include: high load capability tapered roller bearings; a chrome alloy steel rack and pinion gear set; a high strength ductile iron or steel housing; and proven Parker Hannifin cylinder components.

The HTR Series actuators have been successfully employed in automotive plant production machinery; machine tool equipment; plastics and rubber processing machinery; basic metals production machinery and in material handling machinery. The HTR Series can be employed as an integral machine component, where the actuator can simultaneously transmit torque and support the line shaft or the load. Such an arrangement allows for the elimination of one set of external support bearings.

Optional cushions can also be incorporated to decelerate external loads, thus eliminating the need for an external deceleration device such as shock absorbers or brakes. Additionally, machine installations can be simplified with the hollow shaft feature by eliminating additional coupling. This is achieved by means of a square shaft key or if needed the housing can be drilled and tapped to mount various brackets. For easy serviceability, the piston seals can be inspected and replaced while the actuator remains installed on the machinery.

- Hydraulic cushions to minimize noise, vibration shock and assist deceleration control
- Reed, Hall Effect or proximity switches for position sensing
- End-of-rotation stroke adjusters for load position control and accurate rotation adjustment
- Built-in meter out flow control valves with reverse flow check valves provide a neat package
- Three position option can be used with many special machine and material handling applications
- Rack and pinion design provides excellent efficiency characteristics (90-95%) and minimizes HPU Size
- Minimal Heat Build Up, Limits Need for Heat Exchanger Large Hollow Gears Offer More Shaft Options
- HTR series are designed for Low Wear on dynamic seals and longer life
- Excellent in High Speed Production Applications

Operating information

Output torques @ 3000 PSI (207 bar):	900 in-lb to 600,000 in-lb (Larger output torques available upon request)
Maximum operating pressure: except HTR22/45:	3000 PSI (207 bar) non-shock 2000 PSI (138 bar) non-shock
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Fluorocarbon seals	-5°F to 250°F (-21°C to 121°C)
Standard rotations:	90°, 180°, 360°, 450°
Rotational tolerance:	-0°, +2°
Maximum breakaway pressure:	70 PSIG (4.8 bar)
Mounting orientation:	Unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Recommended filtration:	ISO class 17/14 or better

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Model		Maximum Pressure Rating, PSI (bar)	Actual output torque, in-lb (Nm) at specified pressure			Gear train rating durability[1]		Maximum angular backlash, minutes[4]	Standard rotation degrees	Displacement in³ (cm³)	Standard unit weight, lb (kg)
Single rack	Double rack		1000 PSI (69 bar)	2000 PSI (138 bar)	3000 PSI (207 bar)	inch-lbf[2]	PSID[3]				
HTR.9		3000 (207)	300 (34)	600 (68)	900 (102)	400	1340	45	90	0.57 (9.3)	11 (5)
									180	1.13 (19)	14 (6)
									360	2.27 (37)	20 (9)
	HTR1.8	3000 (207)	600 (68)	1200 (136)	1800 (203)	850	1420	45	90	1.13 (19)	16 (7)
									180	2.27 (37)	19 (9)
									360	4.53 (74)	25 (11)
HTR3.7		3000 (207)	1250 (141)	2500 (283)	3700 (418)	1570	1300	40	90	2.43 (40)	28 (13)
									180	4.86 (80)	31 (14)
									360	9.71 (159)	37 (17)
	HTR7.5	3000 (207)	2500 (283)	5000 (565)	7500 (848)	3330	1350	40	90	4.86 (79)	35 (16)
									180	9.71 (159)	41 (19)
									360	19.4 (318)	53 (24)
HTR5		3000 (207)	1650 (186)	3300 (373)	5000 (565)	2700	1620	30	90	3.12 (51)	37 (17)
									180	6.25 (102)	39 (18)
									360	12.50 (205)	49 (22)
	HTR10	3000 (207)	3300 (373)	6600 (746)	10000 (1130)	5725	1720	30	90	6.25 (102)	45 (20)
									180	12.50 (205)	54 (25)
									360	25.0 (410)	66 (30)
HTR15		3000 (207)	5000 (565)	10000 (1130)	15000 (1695)	9300	1860	25	90	8.9 (145)	55 (25)
									180	17.8 (291)	60 (27)
									360	36.5 (582)	70 (32)
	HTR30	3000 (207)	10000 (1130)	20000 (2260)	30000 (3390)	19700	1970	25	90	17.8 (291)	89 (40)
									180	35.5 (582)	97 (44)
									360	71.0 (1164)	117 (53)
HTR22		2000 (138)	7500 (848)	15000 (1695)	—	9300	1240	25	90	13.9 (227)	60 (27)
									180	27.8 (455)	66 (30)
									360	55.5 (910)	79 (36)
	HTR45	2000 (138)	15000 (1695)	30000 (3390)	—	19700	1320	25	90	27.8 (455)	98 (45)
									180	55.5 (910)	108 (49)
									360	111 (1819)	134 (61)
HTR75		3000 (207)	25000 (2825)	50000 (5650)	75000 (8475)	25000	1000	25	90	46 (754)	197 (90)
									180	92 (1508)	219 (100)
									360	184 (3016)	263 (120)
	HTR150	3000 (207)	50000 (5650)	100000 (11300)	150000 (16950)	53000	1060	25	90	92 (1508)	321 (146)
									180	184 (3016)	367 (167)
									360	368 (6032)	454 (206)
HTR300		3000 (207)	100000 (11300)	200000 (22600)	300000 (33900)	125000	1250	20	90	178 (2913)	760 (345)
									180	355 (5827)	840 (382)
									360	711 (11653)	910 (414)
	HTR600	3000 (207)	200000 (22600)	400000 (45200)	600000 (67800)	265000	1325	20	90	355 (5827)	1110 (505)
									180	711 (11653)	1260 (573)
									360	1422 (23290)	1560 (709)

1. The durability is defined as the capacity of the gear set to support the stated load without fatigue related gear surface damage. Use the durability ratings for high production duty of 1 million cycles and/or high speed applications (180° in less than three seconds or more than one cycle per minute).
2. Durability rated output torque.
3. Pressure differential between the inlet and outlet ports (non shock).
4. To minimize backlash in the actuator, order a double rack a few degrees longer and add stroke adjusters.

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Kinetic Energy Capacity

The energy values below assume drive pressure is maintained through cushion stroke.

Single Rack Units with Single Set of Cushions (20°)

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*											
	0 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI		2500 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability
HTR.9	314	140	262	140	209	140	157	140	105	105	52	52
HTR3.7	1309	548	1091	548	872	548	654	548	436	436	218	218
HTR5	1745	942	1454	942	1163	942	873	873	582	582	291	291
HTR15	5235	3246	4362	3246	3490	3246	2618	2618	1745	1745	872	872
HTR22	5235	3246	3926	3246	2618	2618	1309	1309	0	0	0	0
HTR75	26175	8725	21812	8725	17448	8725	13088	8725	8724	8724	4362	4362
HTR300	104700	43625	87247	43625	69793	43625	52350	43625	34897	34897	17449	17449

Double Rack Units with Single Set of Cushions (20°)

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*											
	0 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI		2500 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability
HTR1.8	314	140	209	140	105	105	0	0	0	0	0	0
HTR7.5	1309	548	873	548	436	436	0	0	0	0	0	0
HTR10	1745	942	1163	942	582	582	0	0	0	0	0	0
HTR30	5235	3246	3490	3246	1745	1745	0	0	0	0	0	0
HTR45	5235	3246	2618	2618	0	0	0	0	0	0	0	0
HTR150	26175	8725	17450	8725	8727	8725	0	0	0	0	0	0
HTR600	104700	43625	69801	43625	34907	34907	0	0	0	0	0	0

Double Rack Units with Double Set of Cushions (20°)**

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*											
	0 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI		2500 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability
HTR1.8	628	297	523	297	419	297	314	297	209	209	105	105
HTR7.5	2618	1162	2181	1162	1745	1162	1309	1162	872	872	436	436
HTR10	3490	1998	2908	1998	2326	1998	1745	1745	1163	1163	582	582
HTR30	10470	6875	8725	6875	6979	6875	5235	5235	3490	3490	1745	1745
HTR45	10470	6875	7853	6875	5235	5235	2618	2618	0	0	0	0
HTR150	52350	18497	43623	18497	34897	18497	26175	18497	17448	17448	8725	8725
HTR600	209400	92485	174493	92485	139586	92485	104700	92485	69793	69793	34899	34899

* Must deduct work (energy) done to overcome potential energy effects of load. WPE = TPE x Θ, where Θ is in radians.

** Extreme care must be exercised so that both cushions are adjusted equally for each direction or dangerous pressure intensification and gear train stresses could result. (Suggest high performance cushion option.)

Cushion Deceleration Control

The cushion causes the resisting torque that can be used to decelerate a rotational load. Please note the cushion has to provide enough resistance to control: drive torque caused by the hydraulic system pressure; plus the torque caused by gravity pulling on the rotational load; and the kinetic energy associated with the motion of the inertia load. Since the actuator's cushion has to be able to control the sum of all three torque factors, we suggest including cushion capacity as one of the actuator selection criteria.

It is strongly suggested that proportional valves be used instead of cushions to control (decelerate) high inertial loads. This provides the ability to reduce inlet pressure while generating deceleration pressure. It also allows for longer ramp times, thus increasing deceleration stroke.

SUPPLEMENTAL INFORMATION
KINETIC ENERGY BASIC FORMULA

$$KE = 1/2\ J_m\omega^2$$

$$\omega = 0.0175 \times \frac{2\Theta_A + \Theta_C + 2\Theta_D}{\text{Rotation Time (sec.)}}$$

where:

KE = Kinetic Energy (in-lb)

J_m = Rotational Mass Moment of Inertia (in-lb-sec^2)
See page A35 of LTR section for formulas.

ω = Peak Velocity (rad/sec)
(Assuming trapezoidal velocity profile)

Θ_A = Acceleration Angle (deg)

Θ_C = Constant Velocity Angle (deg)

Θ_D = Deceleration Angle (deg)

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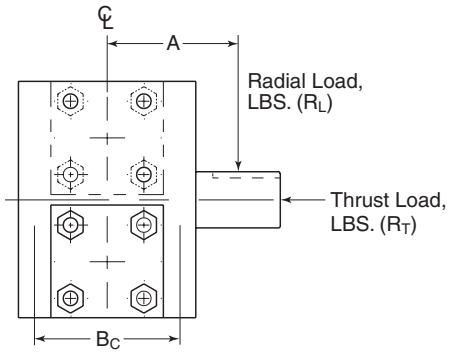
Bearing Load Capacities



Dynamic [1] Bearing Load Capacities vs. Operating Pressure

	Radial Load (lbs.) R_L (per bearing) @			Thrust Load (lbs.) R_T @			Bearing	Overhung Moment (in-lb) R_L x (A+B_C/2) @		
Model	1000 PSID (69 bar)	2000 PSID (138 bar)	3000 PSID (207 bar)	1000 PSID (69 bar)	2000 PSID (138 bar)	3000 PSID (207 bar)	Centers (B_C)	1000 PSID (69 bar)	2000 PSID (138 bar)	3000 PSID (207 bar)
HTR.9	3927	3824	3722	2690	2590	2490	0.62	2435	2371	2307
HTR1.8	4030	4030	4030	2790	2790	2790	0.62	2499	2499	2499
HTR3.7	6448	6146	5843	3610	3360	3120	1.06	6835	6514	6194
HTR7.5	6750	6750	6750	3830	3830	3830	1.06	7155	7155	7155
HTR5	8258	7956	7653	4240	4020	3810	1.02	8423	8115	7807
HTR10	8560	8560	8560	4460	4460	4460	1.02	8731	8731	8731
HTR15	14823	14286	13748	12300	11810	11330	1.83	27126	26143	25160
HTR30	15360	15360	15360	12780	12780	12780	1.83	28109	28109	28109
HTR22	14521	13681	na	12060	11330	na	1.83	26573	25037	na
HTR45	15360	15360	na	12780	12780	na	1.83	28109	28109	na
HTR75	20471	18322	16174	16540	14060	11570	3.99	81680	73106	64533
HTR150	22620	22620	22620	19020	19020	19020	3.99	90254	90254	90254
HTR300	38355	33520	28686	24090	19710	15340	5.95	228214	199447	170680
HTR600	43190	43190	43190	28460	28460	28460	5.95	256981	256981	256981

NOTES: 1. Static bearing load capacities = dynamic valves x 1.5
2. Values listed are "Bearing" moment capacities. Standard male shaft sizes do not provide 4:1 design factor at these operating conditions. Larger shaft sizes are available. Consult factory for further details.

Lubrication

In general, low speed, high torque applications require class 5 or class 6 lubrication provisions. Our assemblers use TEXACO MOLYTEX EP(2) extreme pressure grease to lubricate our gear sets as our standard lubricant. The grease should be replaced with each major overhaul.

Some high cycle applications with an operational system pressure below 1000 PSIG (69 Bar) and with adequate mechanical shock control may successfully use the hydraulic fluid as the gear train lubricant. We can modify the housing by adding a case drain line to carry away excessive lubricant. Ensure the case drain connection is looped to ensure the housing remains filled with lubricant.

High performance applications that feature high pressure and high cycle rates should consider using an external lubrication circuit system to charge the gear set with clean, cool lubricant suitable for class 3 or 4 service. An SAE80 or SAE90 lubricant circulating system should be suitable. We can modify the housing for a lubrication circuit inlet and outlet. Ensure the plumbing is run in such a way the housing remains filled with lubricant.

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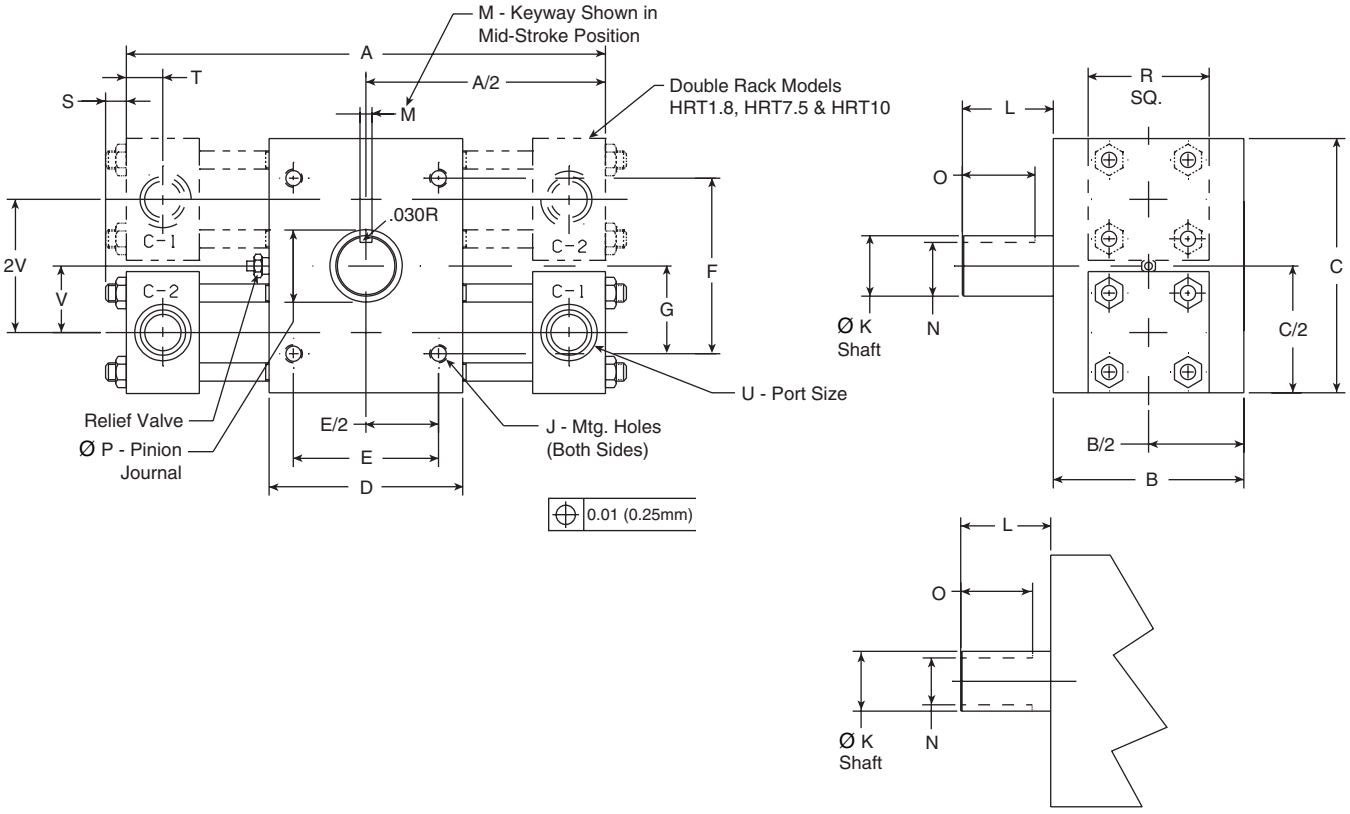
HTR.9 thru HTR10 Single and Double Rack

Inch Units with Face Mount (A) and Male Keyed Shaft (B)
Metric Units with Face Mount (C) and Male Keyed Shaft (H)



Metric Keyed Shaft

Dimensions, Inch

Model	Rotation Degrees	A	B	C	D	E	F	G	J	K†	L	M†	N†	O	P	R	S	T	U (SAE)	V
HTR.9 HTR1.8	90	7-1/4	3	3-5/8	3-1/2	2.625	2.375	1.188	5/16-18 x 1/2 DP	.875 .874	1-5/16	.250 .252	.732 .722	1	1	1-3/4	.38	.50	9/16-18 (#6)	0.94
	180	9-1/8																		
	360	12-7/8																		
HTR3.7 HTR7.5	90	10-1/8	3-15/16	5-1/4	4	3.000	3.625	1.813	3/8-16 x 9/16 DP	1.250 1.249	1-7/8	.311 .312	1.074 1.064	1-1/2	1-1/2	2-1/2	.52	.72	9/16-18 (#6)	1.38
	180	13-1/8																		
	360	18-1/4																		
HTR5 HTR10	90	11-3/8	3-15/16	6	4	3.000	5.000	2.500	3/8-16 x 9/16 DP	1.750 1.749	2-5/8	.438 .440	1.500 1.490	2	1-25/32	2-1/2	.52	.72	9/16-18 (#6)	1.63
	180	14-5/8																		
	360	22-1/8																		

Dimensions, Metric (mm)

Model	Rotation Degrees	A	B	C	D	E	F	G	J	K +0, -.02	L	M P9	N +0, -.02	O	P	R	S	T	U BSPP/G	V
HTR.9 HTR1.8	90	184.2	76.2	92.1	88.9	70	60	30	M8 x 1.25 x 13 DP	22	33	6	18.5	25.4	25.4	44.5	9.6	12.7	1/4	23.8
	180	231.8																		
	360	327.0																		
HTR3.7 HTR7.5	90	257.2	100.0	133.4	101.6	75	90	45	M10 x 1.5 x 16 DP	28	48	8	20	38.1	38.1	63.5	13.3	18.3	1/4	34.9
	180	333.4																		
	360	463.6																		
HTR5 HTR10	90	288.9	100.0	152.4	101.6	75	125	62.5	M10 x 1.5 x 16 DP	44	66	12	39	50.8	44.5	63.5	13.3	18.3	1/4	41.3
	180	371.5																		
	360	562.0																		

† Tolerance minimum and maximum

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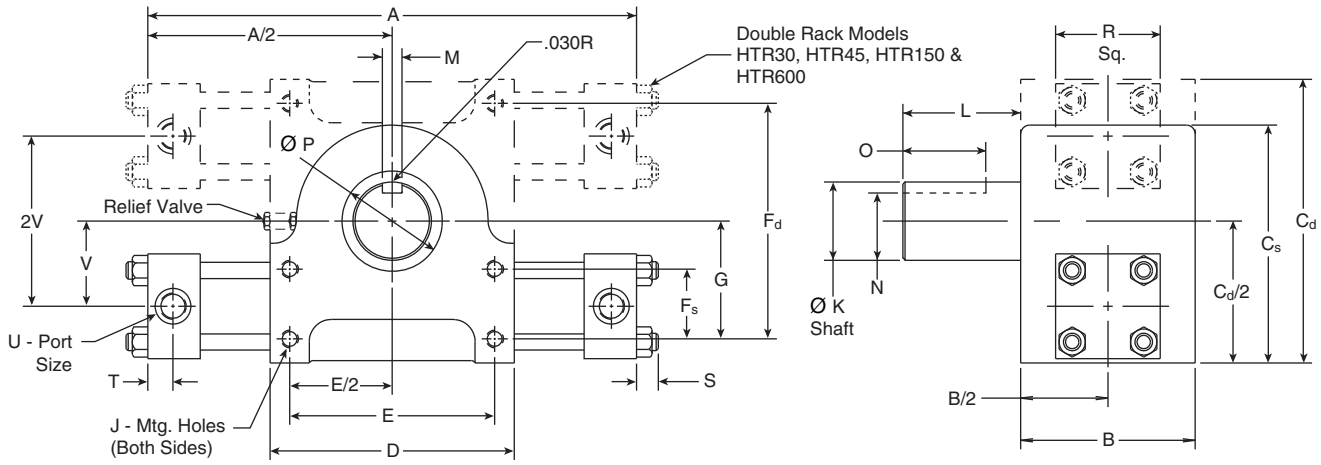
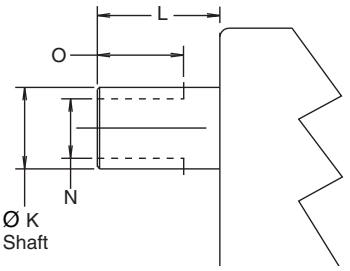
HTR15 thru HTR600 Single and Double Rack

Inch Units with Face Mount (A) and Male Keyed Shaft (B)
Metric Units with Face Mount (C) and Male Keyed Shaft (H)



Dimensions

Model	Rotation Degrees	A (inch)	A (mm)
	90	16	406.4
HTR15/30	180	21-3/8	543.0
	360	32-1/8	816.0
	90	16-3/8	416.0
HTR22/45	180	21-3/4	552.5
	360	32-3/8	822.3
	90	20-1/4	514.4
HTR75/150	180	27-5/8	701.7
	360	42-1/4	1073.2
	90	31-1/4	793.8
HTR300/600	180	43-3/4	1111.3
	360	68-7/8	1749.4



Metric Keyed Shaft

Dimensions, Inch

Model	B	Cd	Cs	D	E	Fd	Fs	G	J	K†	L	M†	N†	O	P	R	S	T	U (SAE)	V
HTR15	5	–	6-7/8	7	5.875	–	2.000	3.375	1/2-13 x	2.250	3-3/8	.563	1.933	2-3/8	2-7/8	3	.67	.72	3/4-16	2-7/16
HTR30		8-1/8	–			6.750	–		3/4 DP	2.249		.565	1.923						(#8)	
HTR22	5	–	6-15/16	7	5.875	–	2.000	3.375	1/2-13 x	2.250	3-3/8	.563	1.933	2-3/8	2-7/8	3-1/2	.67	.72	3/4-16	2-7/16
HTR45		8-3/8	–			6.750	–		3/4 DP	2.249		.565	1.923						(#8)	
HTR75	7-1/2	–	10	8-1/2	6.500	–	4.500	5.750	3/4-16 x	3.000	4-1/2	.750	2.577	3-3/8	3-3/4	5	.82	.84	1-1/16-12	3-1/2
HRT150		13	–			11.500	–		1-1/8 DP	2.999		.752	2.567						(#12)	
HTR300	12	–	15-1/4	15-7/8	13.000	–	5.000	7.625	1-1/4-7 x	5.000	7-1/2	1.250	4.296	6	6-1/2	7-1/2	1.22	1.25	1-5/16-12	5-1/8
HTR600		18-3/4	–			13.500	–	6.750	1-7/8 DP	4.999		1.252	4.286						(#16)	

Dimensions, Metric (Metric male and female shafts have 2 keyways)

Model	B	Cd	Cs	D	E	Fd	Fs	G	J	K +0, -.02	L	M P9	N +0, -.02	O	P	R	S	T	U BSPP/G	V
HTR15	127.0	–	174.6	177.8	150	–	50	85	M12x1.75	54	86	16	42	60	73.0	76.2	17.0	18.3	1/2	61.9
HTR30		206.4	–			170	–		x19 DP											
HTR22	127.0	–	176.2	177.8	150	–	50	85	M12x1.75	54	86	16	42	60	73.0	88.9	17.0	18.3	1/2	61.9
HTR45		212.7	–			170	–		x19 DP											
HTR75	190.5	–	254.0	215.9	165	–	115	145	M20x2.5	76	115	22	58	85	95.3	127.0	20.7	21.3	3/4	88.9
HTR150		327.0	–			290	–		x30 DP											
HTR300	304.8	–	387.4	403.2	330	–	125	175	M30x3.5	125	190	32	103	152	165.1	190.5	31.0	31.8	1	130.2
HTR600		476.3	–			350	–	195	x48 DP											

† Tolerance minimum and maximum

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Cushions (1, 2, 3, 4) *

The standard cushion operates over the last 20° of rotation in either or both directions. A floating bushing ensures no binding of cushion spear. All cushions are fully adjustable.

For severe operating conditions high performance cushions should be fitted on double rack units. On double rack units with only two cushions, cushions are located on upper cylinders.

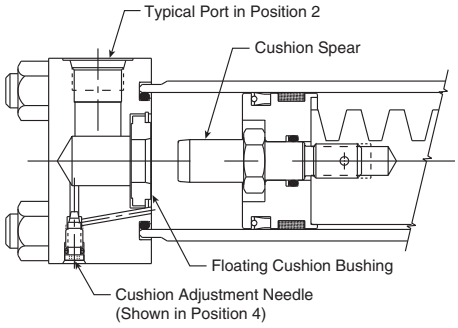
For double rack units where Option 4 (four cushions) is selected please take special care to make sure that adjacent cushions (ie both C-1 ports) are adjusted to the same cushion setting so as to ensure that both cushions are working together. An improper setting could result in one of the cushions not being utilized and thus result in premature gear train life or other damage to the unit.

* For gear train durability, see table below.

Standard Cushion Adjuster Needle Locations

Port position	Cushion adjuster position
1	2
2	3
3	2
4**	3
5	2

**Single rack only

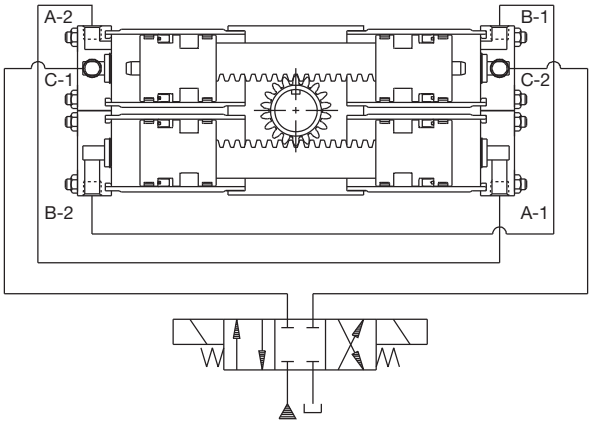


Suggestions: Use either Type 4 or Type 8 cushion option with HTR1.8, 7.5, 30, 45, 150 and 600 size actuators. Avoid Type 1, 2 or 3 cushions with double rack units. The use of proportional valves instead of cushions is recommended with high inertial loads.

High Performance Cushion (8)

(This option available with double rack units only)

By combining the output/exhaust flow from two cylinders, then routing it through a single cushion bushing and cushion adjuster, cushion performance is enhanced. The increased cushion flow results in better control, doubles the cushioning torque, and eliminates dangerous pressure intensification. This unique circuit also eliminates two pipe or tubing tees.



Operation:

The work ports of a standard directional valve are plumbed to ports C-1 and C-2. Port A-1 is plumbed directly to A-2, and port B-1 is plumbed to B-2. When pressure is applied to port C-1 (clockwise shaft rotation), fluid is also directed through line A to the other rack. Exhaust flow from B-1 through B-2 is directed through the cushion bushing and cushion adjustment. When the cushion spear closes off the main passage, total flow from both end caps is directed across one cushion adjustment needle, equalizing back pressure and improving performance. Alternatively, pressurizing C-2 and exhausting C-1 reverses the operation.

Work ports C-1, C-2 port position	Cushion adjustment position	Connection ports A-1, A-2 & B-1, B-2 port position
1	2	3
2	3	1
3	2	1
5	2	3

Dimensional Information:

Units are identical to standard double rack and pinion units, with the exception of porting location. The chart describes the location of the ports.

Gear Set Durability

The table to the right provides energy ratings based on gear train durability when using various cushion options for the HTR Series.

	Total energy capacity (in-lb)		Port to port ΔP (PSID)	
Model	Code 1,2,3	Code 8	Code 1,2,3	Code 8
HTR.9	140	—	1340	—
HTR1.8	140	297	670	1340
HTR3.7	548	—	1300	—
HTR7.5	548	1162	650	1300
HTR5	942	—	1620	—
HTR10	942	1998	810	1620
HTR15/22	3246	—	1860/1240	—
HTR30/45	3246	6875	930/620	1860/1240
HTR75	8725	—	1000	—
HTR150	8725	18497	500	1000
HTR300	43625	—	1250	—
HTR600	43625	92485	625	1250

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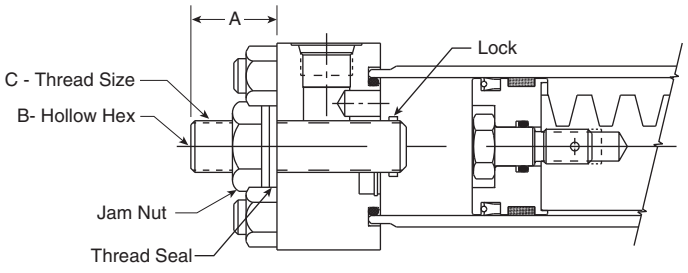
Stroke Adjusters

Fine control of the end of travel points of the rotary actuator can be obtained by specifying stroke adjusters. These operate by reducing the maximum travel of the actuator within preset limits of either 5° or 30° in each direction. Adjustment within this range is variable and may be carried out by the user. Several types of stroke adjusters are available as shown – the designs illustrated are suitable for applications requiring infrequent adjustment.

Limit the setup of stroke adjust to 1-2 adjustments. If frequent adjustments are required, consult factory.

Stroke Adjusters and Cushions

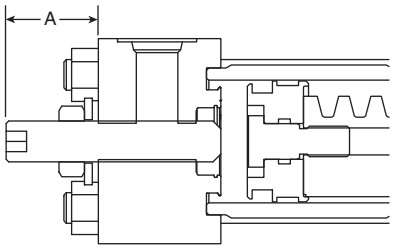
5° stroke adjusters may be combined with the cushioning devices shown. 30° stroke adjusters cannot be combined with cushions. The addition of stroke adjusters requires an increase in build length. On double rack units with cushions, the cushion is fitted to the upper rack and the stroke adjuster to the lower. The increase in build length, for both single and double rack units, is shown as dimension A in the table. Cushion performance may be reduced by the addition of a stroke adjuster. Please consult the factory in critical applications.



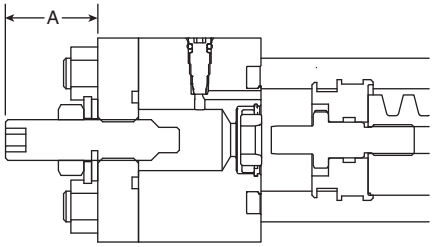
Lock limits unthreading from outside.

Caution: damage to end cap may result if disassembled in this direction.

Type I Stroke Adjusters, 5° and 30°



Type II Stroke Adjusters, 5°



		A (max) – Increased build length							
		TYPE I 5° adjustment without cushioned end cap		TYPE II 5° adjustment with cushioned end cap		TYPE I 30° adjustment without cushioned end cap			
Model	One (1) turn adj.	inch	mm	inch	mm	inch	mm	B	C
HTR.9 HTR1.8	4.2°	.50	12.7	.88	22.4	.75	19.1	5/32	5/16 - 24 UNF
HTR3.7 HTR7.5	3.3°	.63	16	1.13	28.7	1.13	28.7	1/4	1/2 - 20 UNF
HTR5 HTR10	2.5°	.63	16	1.13	28.7	1.13	28.7	1/4	1/2 - 20 UNF
HTR15/30 HTR22/45	2.0°	.88	22.4	1.81	46	1.63	41.4	3/8	3/4 - 16 UNF
HTR75 HTR150	2.0°	2.56	65	3.75	95.3	3.56	90.4	15/16 Ext. Sq.	1-1/2 - 12 UNF
HTR300 HTR600	Consult Factory								

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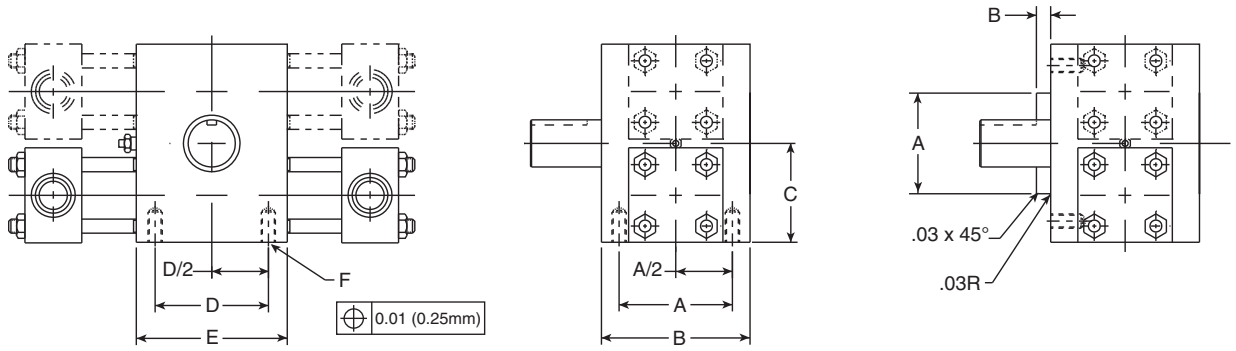
Base and Pilot Mounting

HTR Series rotary actuators are available with the options of face, base, or pilot mounting styles to suit the requirements of different applications. Mounting dimensions for the face mounting styles are shown with other major dimensions on the previous pages. The equivalent dimensions for base and pilot mounting styles are shown in the tables below.

Model	Mounting Hole Bolt Size	Suggested Bolt Torque	Mounting Face Torque Limit*
HTR.9 HTR1.8	5/16-18 UN x 12 dp	126 in-lb	900 in-lb 1800 in-lb
HTR3.7 HTR7.5	3/8-16 UN x 9/16 dp	300 in-lb	3750 in-lb 7500 in-lb
HTR5 HTR10	3/8-16 UN x 9/16 dp	300 in-lb	7500 in-lb 10,000 in-lb
HTR15 HTR30	1/2-13 UN x 3/4 dp	60 ft-lb	15,000 in-lb 15,000 in-lb
HTR22 HTR45	1/2-13 UN x 3/4 dp	60 ft-lb	30,000 in-lb 30,000 in-lb
HTR75 HTR150	3/4-16 UN x 1-1/8 dp	160 ft-lb	63,500 in-lb 99,740 in-lb
HTR300 HTR600	1-1/4-7 UN x 1-7/8 dp	720 ft-lb	300,000 in-lb 600,000 in-lb

*Without additional reinforcement.

Mounting Options (B, D, P, T)



Base Mounting, Inch (B)

Model	A	B	C	D	E	F
HTR.9 HTR1.8	2.250	3	1.813	2.625	3-1/2	5/16-18 NC x 1/2 DP
HTR3.7 HTR7.5	3.000	3-15/16	2.625	3.000	4	3/8-16 NC x 9/16 DP
HTR5 HTR10	3.000	3-15/16	3.000	3.000	4	3/8-16 NC x 9/16 DP
HTR15/30 HTR22/45	3.875	5	4.063 4.188	5.875	7	1/2-13 NC x 3/4 DP
HTR75 HTR150	5.750	7-1/2	6.438	6.500	8-1/2	3/4-16 NF x 11/8 DP
HTR300 HTR600	9.500	12	9.375	13.000	15-7/8	11/4-7 NC x 17/8 DP

Base Mounting, Metric* (D)

Model	A	B	C	D	E	F
HTR.9 HTR1.8	60	76.2	46.1	70	88.9	M8 x 1.25 x 13
HTR3.7 HTR7.5	75	100.0	66.7	75	101.6	M10 x 1.5 x 16
HTR5 HTR10	75	100.0	76.2	75	101.6	M10 x 1.5 x 16
HTR15/30 HTR22/45	100	127.0	103.2 106.4	150	177.8	M12 x 1.75 x 19
HTR75 HTR150	146	190.5	163.5	165	215.9	M20 x 2.5 x 30
HTR300 HTR600	240	304.8	238.2	330	403.2	M30 x 3.5 x 48

Pilot Mounting, Inch (P), Metric (T)

	Inch		Metric*	
Model	A	B	A	B
HTR.9 HTR1.8	1.875 1.873	1/4	47.63	6.5
HTR3.7 HTR7.5	2.625 2.623	1/4	66.68	6.5
HTR5 HTR10	2.875 2.873	1/4	73.03	6.5
HTR15/30 HTR22/45	4.250 4.248	3/8	107.95	10
HTR75 HTR150	5.500 5.498	3/8	139.67	10
HTR300 HTR600	8.750 8.748	1/2	225.25	12

*Dimensions given in mm.

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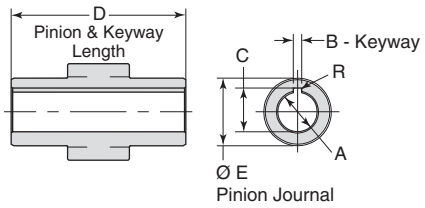
Shaft Options

Single Male Keyed (B)

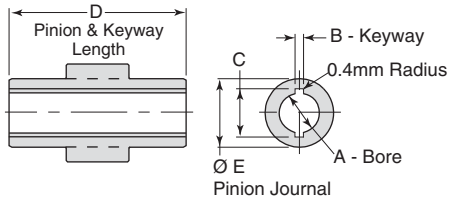
Metric version (H) also available

Model	Torque, in-lb	Key Size	Suggested Key Material
HTR.9 / HTR1.8	1,800	1/4 x 1/4 x 1	C1018CR
HTR3.7 / HRT7.5	7,500	5/16 x 5/16 x 1-1/2	C1018CR
HTR5 / HTR10	10,000	7/16 x 7/16 x 2	C1018CR
HTR15 / HTR30	30,000	9/16 x 9/16 x 2-3/8	C1018CR
HTR22 / HTR45	30,000	9/16 x 9/16 x 2-3/8	C1018CR
HTR75 / HTR150	102,000	3/4 x 3/4 x 3-3/8	C1045CR
HTR300 / HTR600	475,000	1-1/4 x 1-1/4 x 6	C1018CR

Female Keyed Shaft (A)

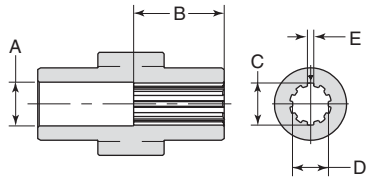


Metric Female Keyed Shaft (G)



Model	Option A*						Option G (DIN 6886)**				
	A†	B†	C†	D	E	R	A H7	B P9	C +.4	D	E
HTR.9 HTR1.8	.625 .626	.187 .189	.709 .719	2.94	1.00	.030	16	5	20.6	74.6	25.4
HTR3.7 HRT7.5	.875 .876	.187 .189	.964 .974	3.88	1.50	.015	22	6	27.6	98.4	38.1
HTR5 HTR10	1.250 1.252	.250 .252	1.367 1.377	3.88	1.78	.030	32	10	38.6	98.4	44.5
HTR15 HTR30	2.000 2.003	.500 .502	2.223 2.233	4.94	2.88	.030	48	14	55.6	125.4	73.0
HTR22 HTR45	2.000 2.003	.500 .502	2.223 2.233	4.94	2.88	.030	48	14	55.6	125.4	73.0
HTR75 HTR150	2.750 2.755	.750 .753	3.032 3.042	7.44	3.75	.030	72	20	81.8	188.9	95.2
HTR300 HTR600	5.000 5.005	1.250 1.252	5.366 5.376	11.94	6.50	.030	125	32	139.8	303.2	165.1

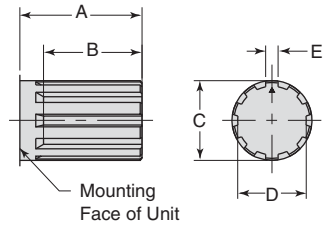
Female Splined Shaft (D, L)



30° involute splined female shafts available for HTR300/600 (J). Consult factory.

Model	Option D (10B Spline)*					Option L (DIN/ISO 14)**					No. of Splines
	A	B	C†	D†	E†	A	B	C	D	E	
HTR.9 HTR1.8	.66	.63	.625 .624	.538 .537	.098 .096	17	16	16	13	3.5	6
HTR3.7 HRT7.5	.91	.88	.876 .875	.753 .752	.137 .135	23	22	22	18	5	6
HTR5 HTR10	1.16	1.3	1.125 1.124	.968 .967	.176 .174	29	29	28	23	6	6
HTR15 HTR30	2.03	2.00	2.000 1.998	1.720 1.718	.312 .309	49	50	48	42	8	8
HTR22 HTR45	2.03	2.00	2.000 1.998	1.720 1.718	.312 .309	49	50	48	42	8	8
HTR75 HTR150	3.03	3.00	3.000 2.998	2.580 2.578	.468 .465	73	76	72	62	12	8

Male Splined Shaft (E, M)



30° involute splined female shafts available for HTR300/600 (P,V). Consult factory.

Model	Option E (10B Spline)*					Option M (DIN/ISO 14)**					No. of Splines
	A	B	C†	D†	E†	A	B	C	D	E	
HTR.9 HTR1.8	1.34	.88	.873 .872	.747 .742	.134 .133	33	22	22	18	5	6
HTR3.7 HRT7.5	1.91	1.25	1.248 1.246	1.069 1.064	.192 .191	48	28	28	23	6	6
HTR5 HTR10	2.65	1.75	1.748 1.746	1.499 1.494	.270 .269	66	44	42	36	7	8
HTR15 HTR30	3.41	2.25	2.247 2.245	1.928 1.923	.347 .346	86	58	54	46	9	8
HTR22 HTR45	3.41	2.25	2.247 2.245	1.928 1.923	.347 .346	86	58	54	46	9	8
HTR75 HTR150	4.53	3.00	2.997 2.995	2.573 2.568	.464 .463	115	76	72	62	12	8

* Dimensions in inches ** Dimensions in mm †Tolerance minimum and maximum

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Port Sizes and Positions

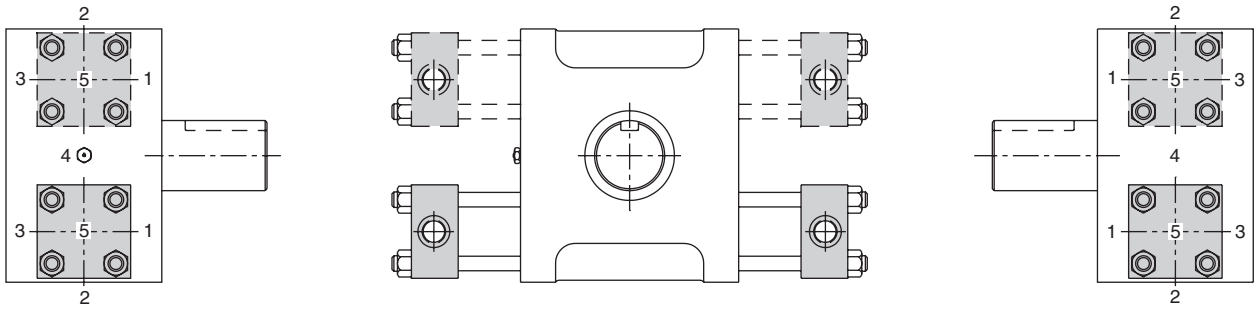
The standard port styles for HTR Series rotary actuators are SAE and BSP (parallel) port, but NPTF, flanged and metric port styles to DIN 3852/1 and ISO 6149/1 are also available. The relevant sizes of port for each model of rotary actuator are shown.

Ports will be supplied in position 1, as shown in the diagram, unless a different position is specified on the order. Ports are available in positions 2, 3, and 4 at no extra cost; position 5 is available as an extra cost option.

Air Bleeds

These may be fitted in end cap positions unoccupied by ports or cushions specify location in clear text.

Port Locations



NOTE:

1. Port position 1 is standard.
2. Port position 2, 3 and 4 are standard options available at no additional cost.
3. Port position 5 is available at additional cost; not available with stroke adjusters.

Port types and sizes

Model	Standard SAE Straight Thread (1)	Code 61 SAE Flange (3)	NPT (2) BSPP (4)	Metric DIN (5)* or ISO (6)
HTR.9 HTR1.8	9/16 - 18 (SAE 6)	N/A	1/4	M14 x 1.5
HTR3.7 HTR7.5	9/16 - 18 (SAE 6)	N/A	1/4	M14 x 1.5
HTR5 HTR10	9/16 - 18 (SAE 6)	N/A	1/4	M14 x 1.5
HTR15 HTR30	3/4 - 16 (SAE 8)	N/A	1/2	M22 x 1.5
HTR22 HTR45	3/4 - 16 (SAE 8)	N/A	1/2	M22 x 1.5
HTR75 HTR150	11/16 - 12 (SAE 12)	3/4	3/4	M27 x 2
HTR300 HTR600	15/16 - 12 (SAE 16)	1	1	M33 x 2

* DIN 3852/1
** ISO 6149/1 (Not available with HTR.9 or HTR1.8)

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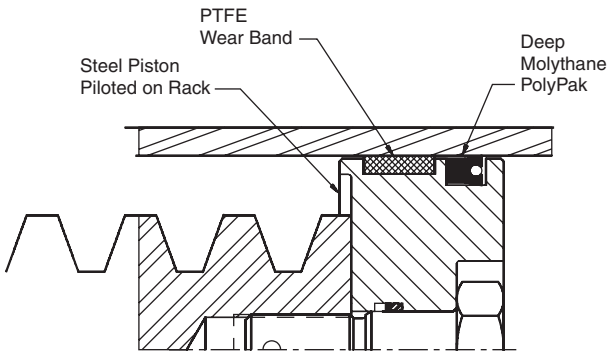
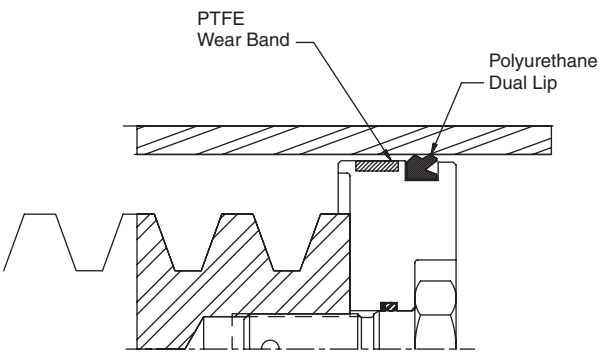
Seal Materials (V, W)

Effective filtration is vital to the long life and satisfactory performance of a rotary actuator. If the piston seals of a rack and pinion rotary are worn or damaged, fluid which leaks past the piston will enter the gear housing. In the event of internal leakage into the gear housing, the pressure relief valve protects the shaft seal.

TYPE I



TYPE II



Seal class	Seal type	Wear ring type	Fluid medium	Temperature range	Pressure range	Filtration
Standard Type 1 *	Molythane PolyPak	Filled PTFE	General purpose, Petroleum-based fluids	-40°F to 180°F -40°C to 82°C	3000 PSI 207 bar	Minimum ISO Class 17/14 Cleanliness Level
Standard Type II **	Polyurethane Dual Lip	Filled PTFE	General purpose, petroleum-based fluids	-40°F to 180°F -40°C to 82°C	3000 PSI 207 bar	
Fluorocarbon (V)	Fluorocarbon	Filled PTFE	High temperature and/or synthetic fluids	-20°F to 250°F -29°C to 121°C	3000 PSI 207 bar	
Nitrile (W)	Carboxylated Nitrile	Filled PTFE	Water Glycol, high water content fluids	30°F to 180°F 0°C to 82°C	2000 PSI 138 bar	

* Standard on HTR.9/1.8, 3.7/7.5 and 5/10
** Standard on HTR15/30, 22/45, 75/150 and 3000

Seal Kit Ordering Information

- Standard units are equipped with nitrile seals.
- Optional seal compounds are available.
- See parts list for items contained in seal kits.

PSK	—	HTR.9
Parker Seal Kit		Base Model

V		
Omit	=	Nitrile Seals (Std)
V	=	Fluorocarbon Seals
W	=	Carboxylated Nitrile Piston Seals

NOTE: The seal kit is equipped with parts necessary to re-seal Design Series "A", "B" or "C" HTR Series rotary actuators. If the actuator model number ends in C###, call factory for seal kit part number.

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Proximity Switches

(Namco Cylindicators or Balluff Cylinder Indicator Sensor)

The inductive type proximity switch provides end of rotation indication. The non-contact probe senses the presence of the ferrous cushion spear and has no springs, plungers, cams or dynamic seals that can wear out or go out of adjustment. The switch is solid state and meets NEMA 1, 12 & 13 specifications. For ease of wiring the connector housing is rotatable through 304°. To rotate, lift the cover latch, position and release.

The switch make/break activation point may occur at 0.125" to ±0.125" from the end of stroke. Depending on the actuator size, this distance may cause activation at 2° to 15° from end of stroke.

The standard proximity switch controls 50-230 VAC/DC loads from 5 to 500 mA. The low 1.7 mA off-state leakage current can allow use for direct PLC input. The standard short circuit protection (SCP) protects the switch from a short in the load or line upon sensing such a condition (5 amp or greater current) by assuming a non-conductive mode. The fault condition must be corrected and the power removed to reset the switch preventing automatic restarts.

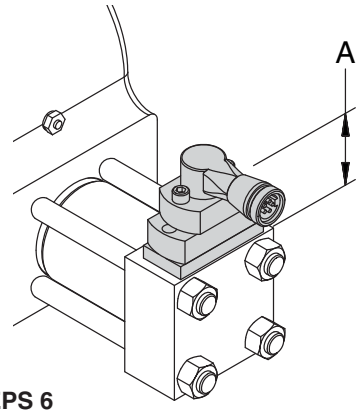
The low voltage DC switch is also available for use with 10-30 VDC. The switch is in a non-rotatable housing, but does incorporates the short circuit protection.

Both switches are equipped with two LEDs, “Ready” and “Target”. The “Ready” LED is lit when power is applied and the cushion spear is not present. The “Target” LED will light and the “Ready” LED will go out when the switch is closed, indicating the presence of the cushion spear. Both LEDs flashing indicates a short circuit condition.

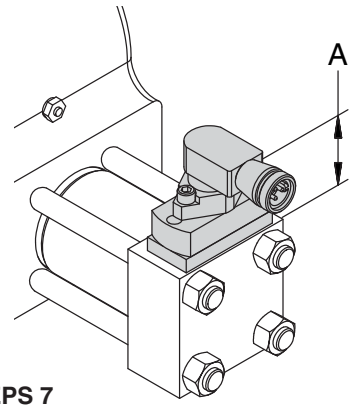
Order proximity sensors separately. See Sensors section for specifications and ordering information.

NOTES:

1. Available with or without cushions.
2. Not available with stroke adjusters.
3. Pressure rating: 3000 psi
4. Operating temperature: -4°F to 158°F
5. Specify switch type, orientation and voltage when ordering.
6. The low voltage DC switch is available in non-rotatable style only, consult representative for further information.



EPS 6



EPS 7

Model	A, inch (mm) EPS 6 & 7
HTR.9 HTR1.8	2.21 (56.1)
HTR3.7 HTR7.5	2.70 (68.6)
HTR5 HTR10	2.70 (68.6)
HTR15 HTR30	2.64 (67.0)
HTR22 HTR45	2.37 (60.2)
HTR75 HTR150	1.87 (47.5)
HTR300 HTR600	3.45 (87.6)

Feedback Packages

Feedback packages available for use with HTR Series rotary actuators include:

- Precision feedback potentiometer (J)
- Precision resolver feedback (H)
- Linear potentiometer feedback (Oildyne Teknar)
- LDT feedback (MTS Temposonics)

The feedback potentiometer (J) and resolver feedback (H) may be ordered as part of the model code. The other options must be ordered separately as specials. See Sensors section for specifications.

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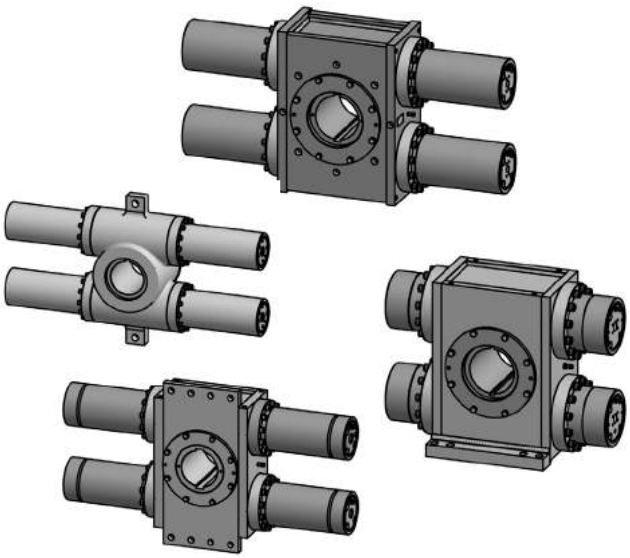

M Series
Heavy Duty Mill Series Rotary Actuators

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			Product Series				
	Market/Segment	**Typical Application(s)**	**HUB**	**LTR**	**HTR**	**M**	**Tork-Mor**
Market Segments/Applications	Aerospace	Water bomb, tank door actuation		●			
	Aggregate	Granite block rollover			●		
	Aluminum	Automation				●	
	Automation	Mounting, Processing, Flood gate actuation, End of arm tooling	●	●	●		●
	Automotive	Automation, Clamping, Tube bending			●		●
	Conveyor	Swing & rotate		●	●		●
	Entertaining	Pool gate actuation, Robotic joint motion					●
	Fluid Management & Flow Control	Power plants			●	●	
	Industrial	Automation, Clamping					●
	Machine Builders	End of arm tooling			●		
	Marine/Offshore	Boomslewer, Submersible			●	●	
	Mining	Mobile longhole drilling, Tunnel boring	●		●	●	
	Mobile	Fire truck ladder rotation, Aerial lift basket, X-ray boom rotation, Forklift handling & storage, Refuse tippers	●	●	●	●	
	Nuclear	Door actuation				●	
	Oil & Gas	Process valve actuation	●		●		
	Oil Industry Machinery	Clamping, Lockout	●				●
	Paper & Pulp	Walking beam				●	
	Plastics	Blow molding, Injection molding			●		●
	Rubber	Mixing			●	●	
	Solar	Panel rotation			●		
	Space	Rocket launch tower				●	
	Steel & Casting	Ladle Tilt, Coil Box, Steel Booming, Pipe fabrication			●	●	●
	Testing Equipment	Flight Simulators, Cycle loading, Tensile test Machines			●		●
	Transportation	Bus wheelchair ramp		●			
	Water Management		●		●		
	Welding	Weld gun indexing, Clamping					●

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M Series

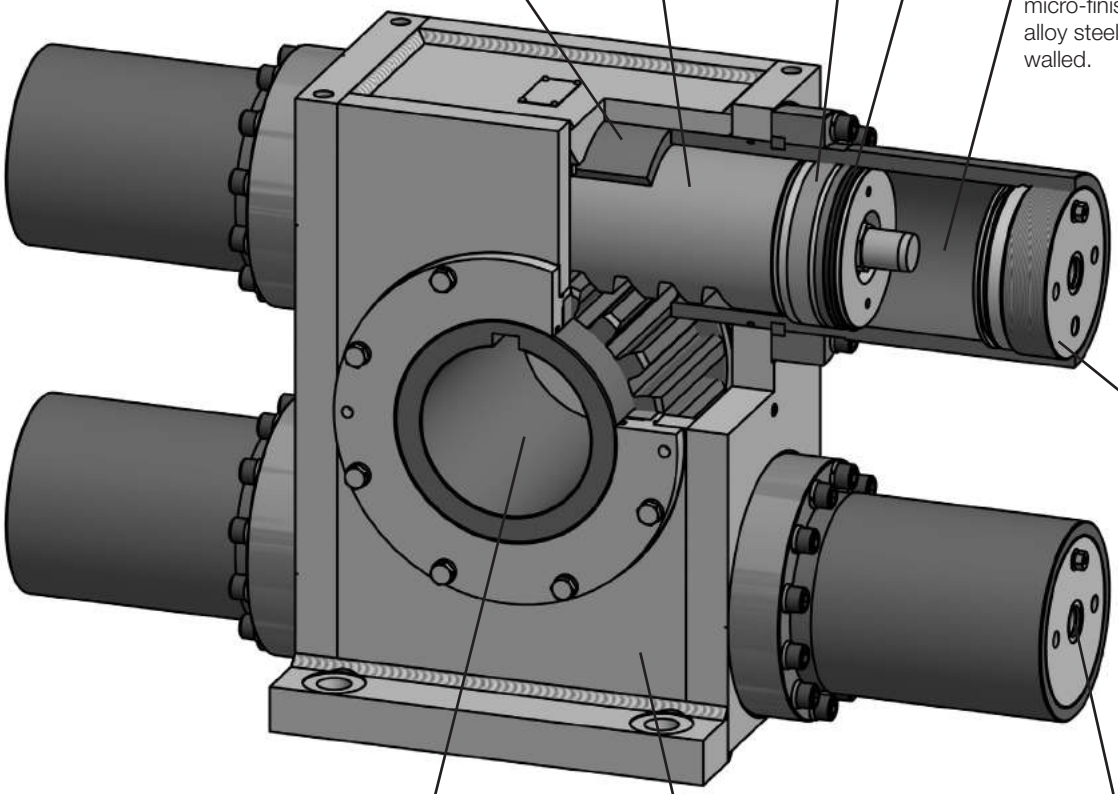
WEAR BANDS – Bronze impregnated PTFE is standard, provides smooth sliding motion while protecting the cylinder walls against metal to metal contact. Optional wear band material can be specified for high speed and high load conditions.

RACKS AND PINION – Heat treated and hardened chrome alloy steel for shock resistance and long wear life; heavy-duty gear design with large pitch diameter reduces angular backlash.

RACK BEARINGS – Large self-aligning bronze rack bearings for low bearing pressure and long life.

PISTON SEALS – Heavy duty Molythane PolyPak seals are self-compensating for wear and long life between maintenance.

CYLINDERS – Precision micro-finish honed seamless alloy steel tubing, thick-walled.



END CAPS – Alloy steel, rugged mill type construction.

PORTS – Standard SAE 4-bolt flange, tapered pipe threads or straight threads.

LARGE BORE PINION – Fits directly on customer's shaft; eliminates need for coupling.

HOUSING is high strength ductile iron, rugged one-piece construction or steel weldment.

NOTE:
All pressure-containing seals can be inspected or replaced without removing the actuator from customer's shaft.

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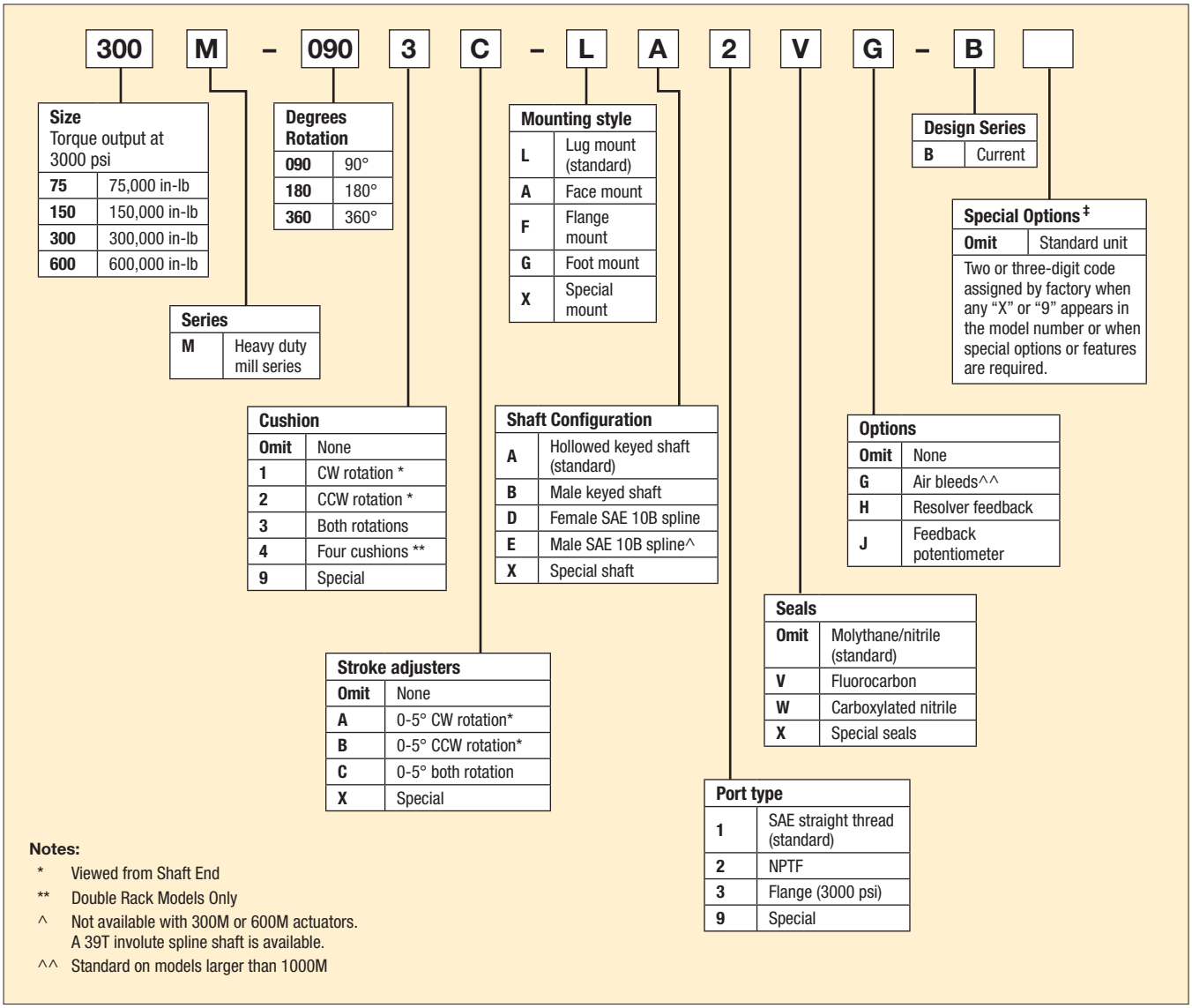
Ordering information



Notes:

* Viewed from Shaft End

** Double Rack Models Only

^ Not available with 300M or 600M actuators. A 39T involute spline shaft is available.

^^ Standard on models larger than 1000M

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Designed to meet steel mill specifications, these non-tie rod units incorporate a range of features that provide heavy duty dependable service. The heat treated pinions provide low tooth contact pressures and permit hollow shaft configurations with bore sizes capable of transmitting full operating torques, including shock loadings. The M Series units are fitted with wear ring bushings that provide full support and eliminate the possibility of contact between cylinder and piston. The large diameter tapered roller bearings on the pinion allow the actuator to absorb considerable thrust, radial and overhung loads. For ease of maintenance, all pressure seals on M Series can be inspected or replaced without removing the actuator from the customer's shaft.

- Rack and pinion design provides excellent efficiency characteristics and minimizes HPU Size
- Minimal heat build up, limits need for heat exchanger
- Large hollow gears offer more shaft options
- M series are designed for low wear on dynamic seals and longer life
- Excellent in high speed production applications

Operating information

Output torques @ 3000 PSI (207 bar):	75,000 in-lb to 50,000,000 in-lb
Maximum operating pressure:	3000 PSI (207 bar)
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Fluorocarbon seals	-20°F to 250°F (-29°C to 121°C)
Standard rotations:	90°, 180°, 360°, 450°
Rotational tolerance:	-0°, +2°
Maximum breakaway pressure:	75 psi (5 bar)
Mounting orientation:	Unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Housing:	
Heavy duty	Ductile iron (units up to 1000M)
Steel	Weldments (units larger than 1000M)

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Model		Maximum Pressure	Actual output torque, in-lb (Nm) at specified pressure			Maximum angular backlash, minutes	Standard rotation degrees	Displacement (cubic Inches)	Standard unit weight, (lb)
Single rack	Double rack	Rating, PSI	1000 PSI (69 bar)	2000 PSI (138 bar)	3000 PSI (207 bar)				
							90	43.4	202
75M		3,000	25,000	50,000	75,000	15	180	86.9	217
							360	174	259
							90	86.9	301
	150M	3,000	50,000	100,000	150,000	15	180	174	331
							360	347	415
							90	176	648
300M		3,000	100,000	200,000	300,000	10	180	351	727
							360	703	881
							90	351	1033
	600M	3,000	200,000	400,000	600,000	10	180	703	1191
							360	1,405	1499
							90	556	1526
	1,000M	3,000	333,000	667,000	1,000,000	10	180	1,112	1774
							360	2,224	2294
							90	833	2100
	1,500M	3,000	500,000	1,000,000	1,500,000	10	180	1,666	2500
							360	3,332	3300
							90	1,248	3800
	2,000M	3,000	667,000	1,333,000	2,000,000	10	180	2,496	4480
							360	4,992	5850
							90	1,727	4900
	3,000M	3,000	1,000,000	2,000,000	3,000,000	10	180	3,454	5700
							360	6,908	7300
							90	2,389	Consult Factory
	4,000M	3,000	1,333,000	2,667,000	4,000,000	10	180	4,778	
							360	9,556	
							90	2,937	Consult Factory
	5,000M	3,000	1,667,000	3,333,000	5,000,000	10	180	5,874	
							360	11,748	
							90	3,552	Consult Factory
	6,000M	3,000	2,000,000	4,000,000	6,000,000	10	180	7,104	
							360	14,208	
							90	3,910	Consult Factory
	7,000M	3,000	2,333,000	4,667,000	7,000,000	10	180	7,820	
							360	15,640	
							90	4,640	Consult Factory
	8,000M	3,000	2,667,000	5,333,000	8,000,000	10	180	9,280	
							360	18,560	
							90	5,020	Consult Factory
	9,000M	3,000	3,000,000	6,000,000	9,000,000	10	180	10,040	
							360	20,080	
							90	5,840	Consult Factory
	10,000M	3,000	3,333,000	6,667,000	10,000,000	10	180	11,680	
							360	23,360	
							90	8,7100	Consult Factory
	15,000M	3,000	5,000,000	10,000,000	15,000,000	10	180	17,420	
							360	34,840	
							90	11,476	Consult Factory
	20,000M	3,000	6,667,000	13,333,000	20,000,000	10	180	22,952	
							360	45,904	
							90	14,262	Consult Factory
	25,000M	3,000	8,333,000	16,667,000	25,000,000	10	180	28,524	
							360	57,048	
							90	17,815	Consult Factory
	30,000M	3,000	10,000,000	20,000,000	30,000,000	10	180	35.630	
							360	71,260	
							90	23,687	Consult Factory
	40,000M	3,000	13,333,000	26,667,000	40,000,000	10	180	47,374	
							360	94,748	
							90	27,369	Consult Factory
	50,000M	3,000	16,667,000	33,333,000	50,000,000	10	180	54,738	
							360	109,476	

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Kinetic Energy Capacity

The energy values below assume drive pressure is maintained through cushion stroke.

Single Rack Units with Single Set of Cushions (20°)

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*													
	0 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI		2500 PSI		3000 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max	Durability	Max.	Durability
75M	26175	14245	21812	14245	17448	14245	13088	13088	8724	8724	4362	4362	0	0
300M	194700	54400	87247	54400	69793	54400	52350	52350	34897	34897	17449	17449	0	0

Double Rack Units with Single Set of Cushions (20°)

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*													
	0 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI		2500 PSI		3000 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max	Durability	Max.	Durability
150M	26175	14245	17450	14245	8727	8727	0	0	0	0	0	0	0	0
600M	104700	54400	69801	54400	34907	34907	0	0	0	0	0	0	0	0
1000M	174500	97107	116335	97107	58178	581178	0	0	0	0	0	0	0	0

Double Rack Units with Double Set of Cushions (20°)**

	Kinetic Energy Rating (in-lb) of Cushion at Specified Drive Pressure*													
	0 PSI		500 PSI		1000 PSI		1500 PSI		2000 PSI		2500 PSI		3000 PSI	
Model	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max.	Durability	Max	Durability	Max.	Durability
150M	52350	30168	43623	30168	34879	30168	26175	26175	17448	17448	8725	8725	0	0
600M	209400	115216	174493	115215	13986	115216	104700	69793	69793	69793	34899	34899	0	0
1000M	349000	194215	2090622	194215	232643	194215	174500	174500	116322	116322	58164	58164	0	0

* Must deduct work (energy) done to overcome potential energy effects of load. WPE = TPE x Θ, where Θ is in radians.

** Extreme care must be exercised so that both cushions are adjusted equally for each direction or dangerous pressure intensification and gear train stresses could result. (Suggest high performance cushion option.)

Cushion Deceleration Control

The cushion causes the resisting torque that can be used to decelerate a rotational load. Please note the cushion has to provide enough resistance to control: drive torque caused by the hydraulic system pressure; plus the torque caused by gravity pulling on the rotational load; and the kinetic energy associated with the motion of the inertia load. Since the actuator's cushion has to be able to control the sum of all three torque factors, we suggest including cushion capacity as one of the actuator selection criteria.

It is strongly suggested that proportional valves be used instead of cushions to control (decelerate) high inertial loads. This provides the ability to reduce inlet pressure while generating deceleration pressure. It also allows for longer ramp times, thus increasing deceleration stroke.

SUPPLEMENTAL INFORMATION
KINETIC ENERGY BASIC FORMULA

$KE = 1/2\ J_m\omega^2$

$$\omega = 0.0175 \times \frac{2\Theta_A + \Theta_C + 2\Theta_D}{\text{Rotation Time (sec.)}}$$

where:

KE = Kinetic Energy (in-lb)

J_m = Rotational Mass Moment of Inertia (in-lb-sec^2)
See page A35 of LTR section for formulas.

ω = Peak Velocity (rad/sec)
(Assuming trapezoidal velocity profile)

Θ_A = Acceleration Angle (deg)

Θ_C = Constant Velocity Angle (deg)

Θ_D = Deceleration Angle (deg)

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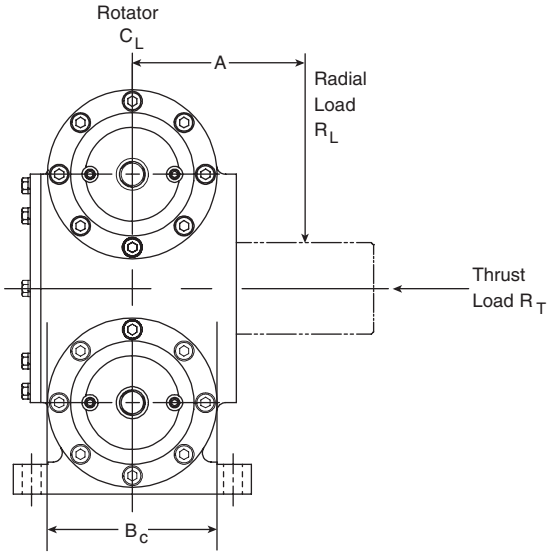
Bearing Load Capacities

Each M Series Actuator is fitted with heavy duty tapered roller bearings as standard and can support high external loads. The table provides load capacities for each unit.

Any distance "A" is possible as long as bearing limits are observed. See overhung moment equation.



Bearing Load Capacities "M" Series Rotator

	Radial load-lbs. per bearing (R_L)		Thrust load-lbs. (R_T)		Bearing centers (B_c) distances	Overhung moment inch-lbs. R_L x ($A+B_c/2$)	
Model	Dynamic	Static	Dynamic	Static	Inch	Dynamic	Static
75M	34,000	51,000	15,000	22,500	3.40	115,600	173,400
150M	42,000	63,000	15,000	22,500	3.40	142,800	214,200
300M	42,000	63,000	20,000	30,000	5.65	237,300	355,950
600M	57,000	85,500	20,000	30,000	5.65	322,050	493,075
1000M	50,000	75,000	20,000	30,000	7.40	370,000	555,000

Unit Weights

	Rotation 90°		**180°**		**360°**	
Model	**lb**	**kg**	**lb**	**kg**	**lb**	**kg**
75M	202	92	217	99	259	118
150M	301	137	331	150	415	188
300M	648	294	727	330	881	400
600M	1033	469	1191	541	1499	681
1000M	1526	693	1774	805	2294	1041
1500M	2100	953	2500	1135	3300	1498
2000M	3800	1725	4500	2043	5900	2679
3000M	4900	2225	5700	2588	7300	3314

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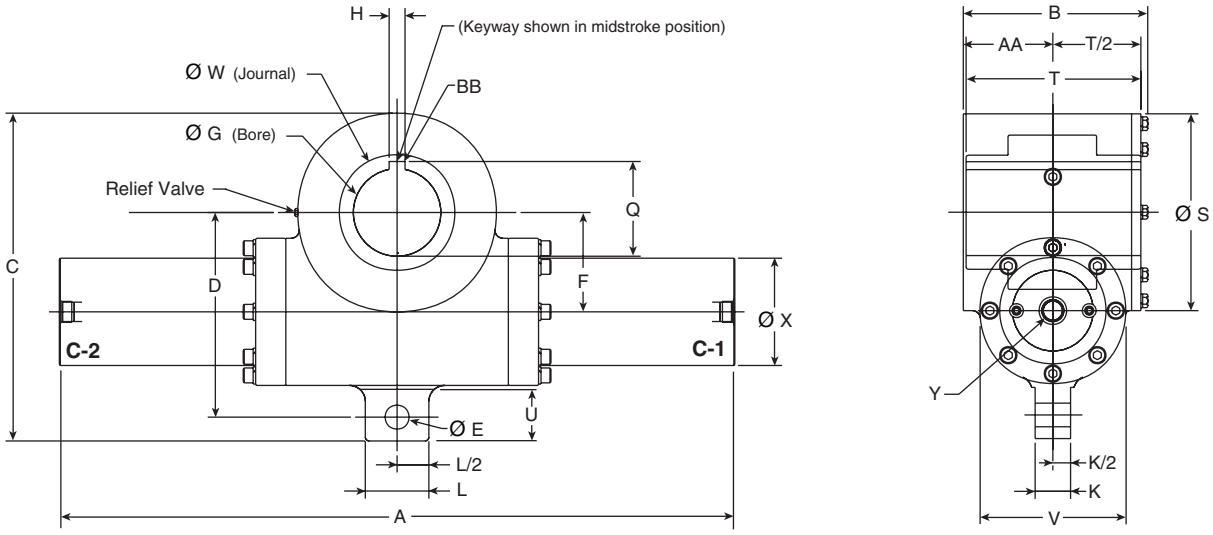
Single Rack

with Standard Lug Mount (L) and Hollow Keyed Shaft (A)



Dimension, Inch – Sizes 75M and 300M

Model	Rotation Degrees	A	B	C (+.13 -.00)	D	E	F	G	H*	K	L (+.13 -.00)	Q
75M	90	24.00	8.00	14.25	8.63	1.000	4.13	3.500 3.505	.750 .753	1.50	3.00	3.840
	180	34.50										
	360	55.50										
300M	90	34.25	11.88	20.63	12.88	1.500	6.25	5.500 5.505	1.000 1.003	2.25	4.00	5.960
	180	48.50										
	360	76.75										

Model	Rotation Degrees	S (+.13 -.00)	T	U	V (+.25 -.00)	W	X	Y	AA	BB
75M	90, 180, 360	9.25	7.50	2.13	6.00	5.00	4.00	1-1/16-12 SAE #12	3.81	0.030
300M	90, 180, 360	12.50	11.25	3.25	9.25	7.25	6.75	1-5/16-12 SAE #16	5.69	0.032

Note: All dimensions in inches unless otherwise specified.
* Tolerance minimum and maximum

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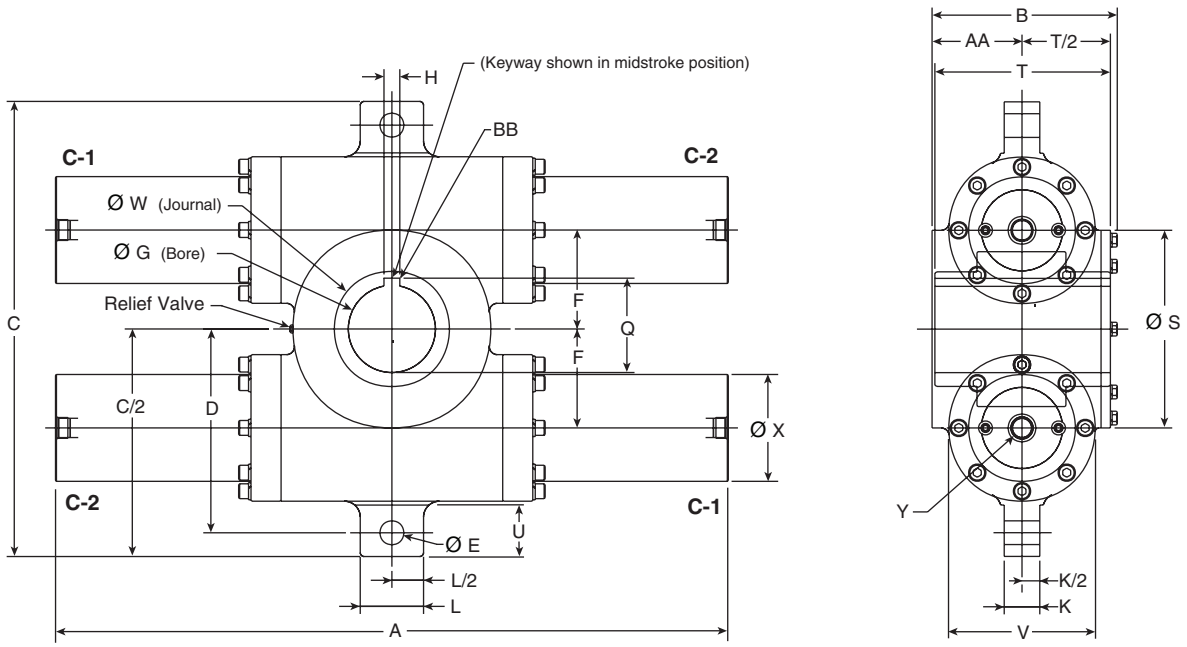
Double Rack

with Standard Lug Mount (L) and Hollow Keyed Shaft (A)



Dimension, Inch – Sizes 150M, 600M and 1000M

Model	Rotation Degrees	A	B	C (+.13 -.00)	D	E	F	G	H	K	L (+.13 -.00)	Q
150M	90	24.50	8.00	19.25	8.63	1.000	4.13	3.500 3.505	0.750 0.753	1.50	3.00	3.840
	180	34.50										
	360	55.50										
600M	90	34.25	11.88	28.75	12.88	1.500	6.25	5.500 5.505	1.000 1.003	2.25	4.00	5.960
	180	48.50										
	360	76.75										
1000M	90	40.25	13.88	32.50	14.75	1.500	7.25	7.250 7.255	1.000 1.002	2.25	4.00	7.725
	180	57.00										
	360	90.50										

Model	Rotation Degrees	S (+.13 -.00)	T	U	V (+.25 -.00)	W	X	Y	AA	BB
150M	90, 180, 360	9.25	7.50	2.13	6.00	5.00	4.00	1-1/16-12 SAE #12	3.81	0.030
600M	90, 180, 360	12.50	11.25	3.25	9.25	7.25	6.75	1-5/16-12 SAE #16	5.96	0.032
1000M	90, 180, 360	14.50	12.00	3.25	10.25	9.13	7.75	1-5/16-12 SAE #16	6.75	0.060

Note: All dimensions in inches unless otherwise specified.

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Double Rack

with Standard Lug Mount (L) and Hollow Keyed Shaft (A)

Dimension, Inch – Sizes 1,500M to 50,000M

Model	Rotation Degrees	A	B	C	D	E	F	G	H	K
	90	44								
1,500M	180	62	16-1/2	35	16	1-1/2	8-1/4	8	1-1/4 x 13-1/2	2-1/4
	360	101-1/2								
	90	48								
2,000M	180	70	19	41-1/2	18-7/8	1-3/4	9-3/8	9-1/2	1-1/2 x 14-1/2	2-1/4
	360	114								
	90	48-1/2								
3,000M	180	70-1/2	21	45-3/4	20-7/8	2	10-1/8	9-3/4	1 (2) x 16	3
	360	114-1/2								
	90	54								
4,000M	180	79	23-1/2	51-1/4	23-3/8	2-1/4	11-3/8	11-1/4	1-1/2 x 18-1/2	3-1/2
	360	129								
	90	55								
5,000M	180	80-1/2	25	54-3/4	25-1/8	2-1/4	12-5/8	12-1/2	1-1/2 x 18-1/2	3-1/2
	360	130-1/2								
	90	63-1/2								
6,000M	180	95	25-1/2	57-1/2	26-1/4	2-1/2	13	13-1/2	1-3/4 x 21-1/2	3-3/4
	360	158								
	90	74-1/2								
7,000M	180	109-1/2	26-1/2	61-1/2	28	2-3/4	14	15	2 x 22	4
	360	179								
	90	76								
8,000M	180	114	26-1/2	63-3/4	29-1/4	2-3/4	15	16	2-1/4 x 22	4
	360	190								
	90	80								
9,000M	180	121	26-1/2	67	30-1/2	3	16	18	2-1/2 x 18-1/2	4-1/2
	360	203								
	90	85								
10,000M	180	129	28	69	31-1/2	3	17	20	2-1/2 x 22	4-1/2
	360	217								
	90	102								
15,000M	180	159	28	82	37-1/2	3-1/2	21-1/2	22	2-1/2 x 22	5
	360	272								
	90	110								
20,000M	180	173	29	87	39-1/2	4	23-1/2	31	2-1/2 (2) x 22	5
	360	298-1/2								
	90	110								
25,000M	180	173	30-1/2	95	42-1/2	5	24-1/2	31	2-1/2 (2) x 26	5
	360	298-1/2								
	90	112								
30,000M	180	175	32-1/2	98	44	5	25	31	2-1/2 (2) x 28	5
	360	300-1/2								
	90	132								
40,000M	180	207-1/2	36	108	49	5	28-1/2	38	3 (2) x 30	6
	360	358								
	90	133								
50,000M	180	209	37	111	50-1/2	5	29-1/4	38	3 (2) x 32	6
	360	359-1/2								

* *Units 1500M and above have dimensions that are subject to change. Consult factory on these dimension before any design implementation is initiated.*

Note: All dimensions in inches unless otherwise specified.

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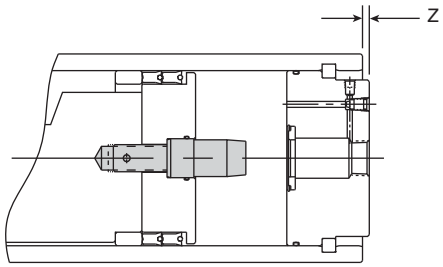
Cushions (1, 2, 3, 4)

The standard cushions operate over the last 20° of rotation in either or both directions. A floating bushing ensures no binding of cushion spear. For severe operating conditions, 4 cushions should be fitted on double rack units.

All cushions are fully adjustable. Double rack units should be fitted with Type 4 cushions.

For double rack units where Option 4 (four cushions) is selected please take special care to make sure that adjacent cushions (ie both C-1 ports) are adjusted to the same cushion setting so as to ensure that both cushions are working together. An improper setting could result in one of the cushions not being utilized and thus result in premature gear train life or other damage to the unit.

NOTE: Proportional valves are recommended instead of cushions for high inertial loads.



Model	Z (in)
75M	.50
150M	.50
300M	.25
600M	.25
1000M	.00

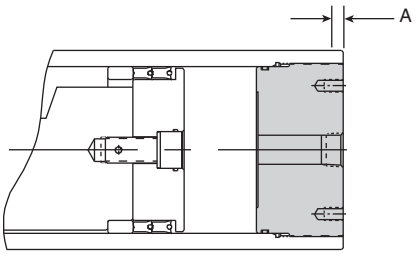
Cushion Kinetic Energy Capacity

Model	Cushion code	Dissipation (Inch lbf)	Cushion code	Cushion work (in-lb)
75M	3	27,630	1,2	27,165
150M	4	55,300	1,2,3	27,165*
300M	3	84,190	1,2	104,700
600M	4	168,370	1,2,3	104,700*
1000M	4	192,000	1,2,3	192,000*

* Must deduct work done by any existing drive pressure and work done to control potential energy.

5° Stroke Adjusters (A, B, C)

Model	(1) Turn adj.
75M 150M	1°
300M 600M	8°
1000M	7°



Model	A (in)
75M	.956
150M	.956
300M	.426
600M	.426
1000M	.527

NOTE:

1. Maximum unit rotation is equal to rotation specified in model code. Adjusters allow rotational positioning equal to or less than the maximum rotation.
2. Stroke adjusters are available with or without cushions. Double rack units will have cushions and stroke adjusters on lower rack.

Note: All dimensions in inches unless otherwise specified.

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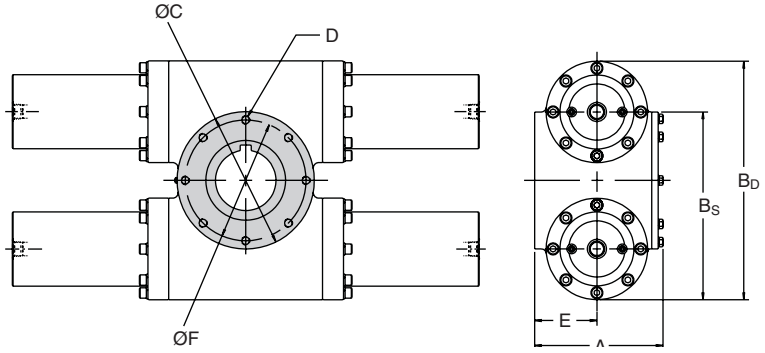
Face Mounting (A)

In addition to the flange shown, made to order sizes can be manufactured.



Model	Torque in-lb @ 3,000 psi	A	BS	BD	C	D	E	F
75M	75,000	8	11.75	N/A	9.25	5/8-18 x 15/16 DP	3.81	8.000
150M	150,000	8	N/A	14.25	9.25	5/8-18 x 15/16 DP	3.81	8.000
300M	300,000	11.875	17.13	N/A	12.50	3/4-16 x 1-1/8 DP	5.69	11.000
600M	600,000	11.875	N/A	21.75	12.50	3/4-16 x 1-1/8 DP	5.69	11.000
1000M	1,000,000	13.625	N/A	24.75	14.50	1-1/4-12 x 1-7/8 DP	6.75	12.000

Face Mounting Bi-directional Torque Capacity (without dowel devices)

Model	Bolt Size	Suggested bolt torque (ft-lb)	Bi-directional torque capacity* (in-lb)
75M	5/8-18 x 15/16 dp	100	105,495
150M	5/8-18 x 15/16 dp	100	105,495
300M	3/4-16 x 1-1/8 dp	160	167,200
600M	3/4-16 x 1-1/8 dp	160	167,200
1000M	1-1/4-12 x 1-7/8 dp	720	496,800

* With additional reinforcement.

Bi-directional bolt torque capacity is equal to:

μ x clamp load x lever arm length from center of rotation

(μ = .3 assumed).

Suggested Reinforcement

Model	Dowel Ø	Qty.	Bolt circle diameter
150M	.75	2	8
300M	.75	4	11
600M	1.00	4	11
1000M	1.00	8	12

Note: All dimensions in inches unless otherwise specified.

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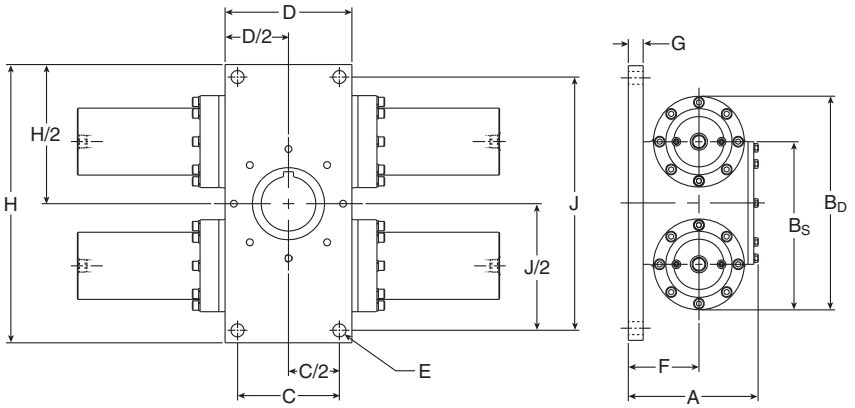
Flange Mounting (F)

In addition to the flange shown, made to order sizes can be manufactured.

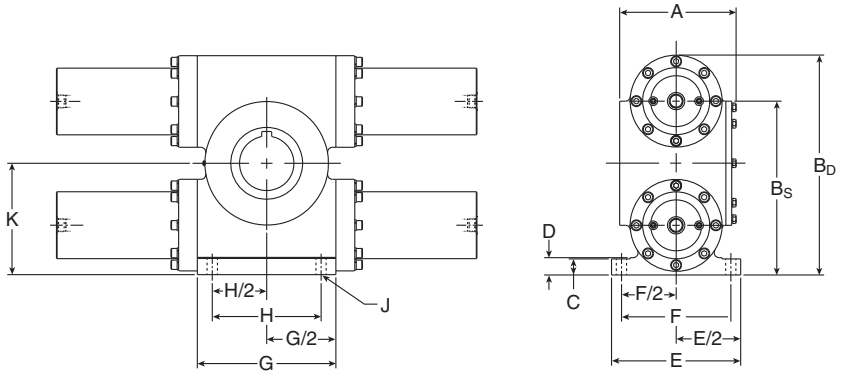


Model	Torque in-lb @ 3000 psi	A	B_S	B_D	C	D	E	F	G	H	J
75M	75,000	9.25	11.75	N/A	7.500	9.500	1.063	5.06	1.25	19.25	17.250
150M	*	9.25	N/A	14.25	7.500	9.500	1.063	5.06	1.25	19.25	17.250
300M	*	13.375	17.13	N/A	10.250	12.750	1.313	7.19	1.50	28.00	25.500
600M	*	13.375	N/A	21.75	10.250	12.750	1.313	7.19	1.50	28.00	25.500
1000M	*	15.375	N/A	24.75	11.500	16.750	1.563	8.50	1.75	32.25	29.250

* Consult factory with applications data.

Foot Mounting (G)

The foot is an integral part of the housing, machined on all sides to accommodate shear block mounting. (1000M & smaller).



Model	Torque in-lb @ 3000 psi	A	B_S	B_D	C	D	E	F	G	H	J	K	
75M	75,000	8	12.00	N/A	1.38	1.50	11.00	9.5000	10.00	7.500	0.781	7.375	+0.005 −0.000
150M	150,000	8	N/A	14.50	1.38	1.50	11.00	9.5000	10.00	7.500	0.781		
300M	300,000	11.875	17.50	N/A	1.63	1.75	13.00	11.000	14.00	11.000	1.031	11.250	+0.005 −0.000
600M	600,000	11.875	N/A	22.13	1.63	1.75	13.00	11.000	14.00	11.000	1.031		
1000M	1,000,000	13.875	N/A	25.13	1.88	2.00	16.00	13.500	16.75	13.500	1.281	12.755	+0.000 −0.005

Note: All dimensions in inches unless otherwise specified.

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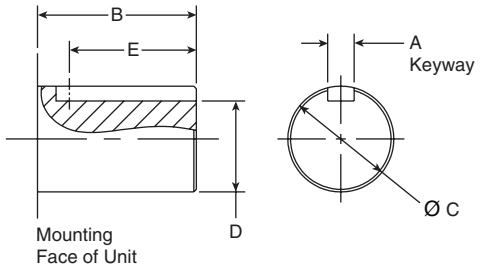
Shaft Options (B, D, E)

All shaft options shown in mid-stroke position.

Male Keyed Shaft (B)

Model	A	B	C	D	E	Torque Rating
75M 150M	.749 .750	4.50	3.000 2.999	2.577 2.572	3.38	102,000 in-lb
300M 600M	1.249 1.250	7.50	5.000 4.999	4.297 4.292	6.00	475,000 in-lb
1000M	2.000 2.002	12.00	8.000 7.999	6.873 6.868	10.00	1,000,000 in-lb



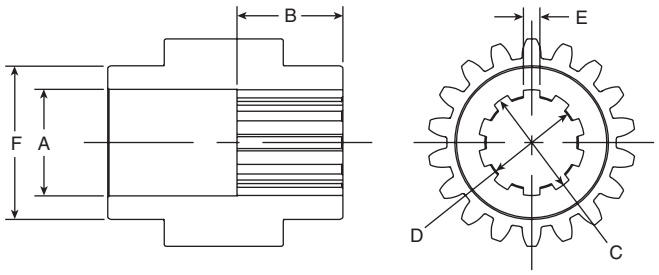
Suggested Key Materials

Model	A	E	Material
75M	0.750/0.749	3.38	C1018 CR
150M	0.750/0.749	3.38	C1045 CR
300M	1.250/1.249	6	C1018 CR
600M	1.250/1.249	6	C1018 CR

Female SAE 10B Spline (D)

Model	A	B	C	D	E	F
75M 150M	3.03	3.00	3.000 2.998	2.580 2.578	0.468 0.465	4.999 4.997

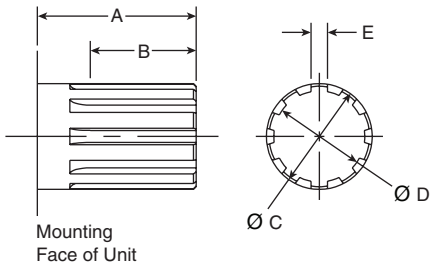
30° involute splined female shaft may be available on all sizes, consult factory.



Male SAE 10B Spline (E)

Model	A	B	C	D	E
75M 150M	4.50	2.88	2.997 2.995	2.573 2.568	0.464 0.463

30° involute splined male shaft may be available on all sizes, consult factory.



Note: All dimensions in inches unless otherwise specified.

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Ports (1, 2, 3)

SAE straight thread ports or 4 bolt flanges are recommended for all applications. NPT ports are available but not recommended.

Model	Standard SAE straight thread (1)	NPT (2)	4 bolt flange (3) SAE J518 (3000 psi)
75M 150M	1-1/16 -12 (SAE 12)	3/4	3/4
300M 600M	1-5/16 -12 (SAE 16)	1	1
1000M	1-5/16 -12 (SAE 16)	1	1

Seals (V, W)

Seal class	Seal type	Wear ring type	Fluid medium	Temperature range	Filtration
Standard	Molythane PolyPak	Filled PTFE	General purpose, petroleum-based fluids	-40°F to 180°F -40°C to 82°C	Class 17/14 Cleanliness Level
Fluorocarbon (V)	Fluorocarbon	Filled PTFE	High temperature and/or synthetic fluids	-20°F to 250°F -29°C to 121°C	
Nitrile (W)	Carboxylated Nitrile *	Filled PTFE	Water Glycol, high water content fluids	30°F to 180°F 0°C to 82°C	

* Not available in every size. Factory will automatically make appropriate substitutions as necessary.

For Seal Kits and Spare Parts, contact the Pneumatic Division at 269-629-5000.

Feedback Packages

Feedback packages available for use with M Series rotary actuators include:

- Precision feedback potentiometer (J)
- Precision resolver feedback (H)
- LDT feedback (MTS Temposonics)

The feedback potentiometer (J) and resolver feedback (H) may be ordered as part of the model code. The other options must be ordered separately.

See Sensors section for specifications.

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Tork-Mor Series
Vane Style Hydraulic Rotary Actuators

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Market Segments/Applications	Market/Segment	Typical Application(s)	Product Series: HUB	LTR	HTR	M	Tork-Mor
	Aerospace	Water bomb, tank door actuation		●			
	Aggregate	Granite block rollover			●		
	Aluminum	Automation				●	
	Automation	Mounting, Processing, Flood gate actuation, End of arm tooling	●	●	●		●
	Automotive	Automation, Clamping, Tube bending			●		●
	Conveyor	Swing & rotate		●	●		●
	Entertaining	Pool gate actuation, Robotic joint motion					●
	Fluid Management & Flow Control	Power plants			●	●	
	Industrial	Automation, Clamping					●
	Machine Builders	End of arm tooling			●		
	Marine/Offshore	Boomslewer, Submersible			●	●	
	Mining	Mobile longhole drilling, Tunnel boring	●		●	●	
	Mobile	Fire truck ladder rotation, Aerial lift basket, X-ray boom rotation, Forklift handling & storage, Refuse tippers	●	●	●	●	
	Nuclear	Door actuation				●	
	Oil & Gas	Process valve actuation	●		●		
	Oil Industry Machinery	Clamping, Lockout	●				●
	Paper & Pulp	Walking beam				●	
	Plastics	Blow molding, Injection molding			●		●
	Rubber	Mixing			●	●	
	Solar	Panel rotation			●		
	Space	Rocket launch tower				●	
	Steel & Casting	Ladle Tilt, Coil Box, Steel Booming, Pipe fabrication			●	●	●
	Testing Equipment	Flight Simulators, Cycle loading, Tensile test Machines			●		●
	Transportation	Bus wheelchair ramp		●			
	Water Management		●		●		
	Welding	Weld gun indexing, Clamping					●

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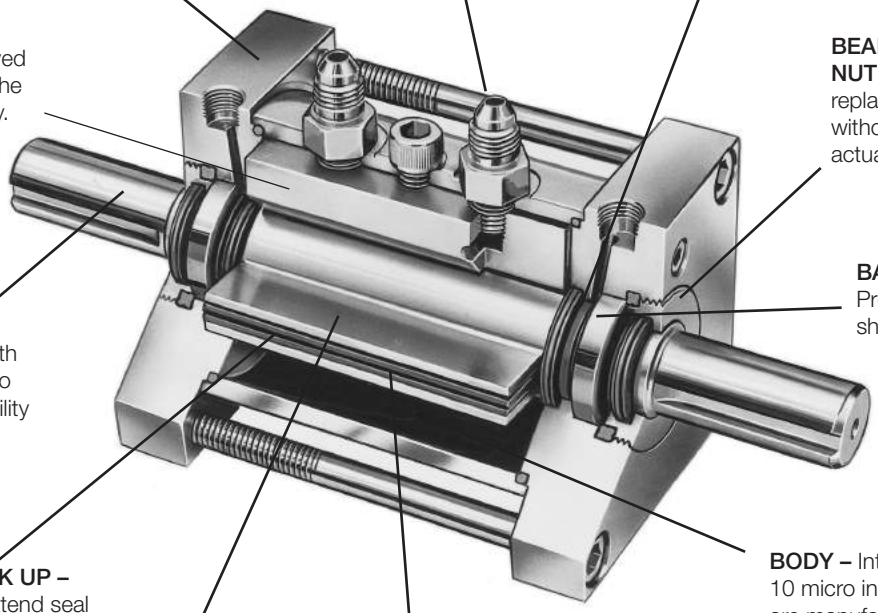
Tork-Mor Series



HEAD – Cold drawn steel with ground inner surface for maximum seal life.

PORTS – 37° JIC straight thread or female NPT ports can be provided.

THRUST BEARING – Bronze bearing maintains correct axial position of shaft assembly.

STATOR – Keyed and bolted to the body for rigidity.

BEARING RETAINING NUT – Allows for replacement of shaft seal without disassembling the actuator.

BALL BEARINGS – Provide substantial shaft support.

SHAFT – High strength steel, stress relieved to provide greater durability & strength.

VANE SEAL BACK UP – PTFE back ups extend seal life by prevention of seal extrusion.

BODY – Internally honed to a 10 micro inch finish. Bodies are manufactured from high tensile seamless steel or DOM tubing.

VANE – Keyed to the shaft for maximum strength.

VANE SEAL – One piece molded seal available in compounds to suit most industrial fluids.

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Ordering information

S **42** – **B** **B** **5** ☐ ☐ – ☐

Rotation	
S	Single vane 280°
DS	Double vane 100°

Size			
Size	**Rotation**	**Torque at max. pressure (in-lb)**	**Max. pressure (PSI)**
33	S	800	500
33	DS	1,625	500
42	S	3,370	1000
42	DS	6,740	1000
44	S	4,100	750
44	DS	5,500	500
46	S	4,050	500
46	DS	3,750	250
74	S	20,000	1000
74	DS	29,600	750
77	S	25,300	750
77	DS	33,800	500
105	S	61,300	1000
105	DS	124,000	1000
108	S	71,000	750
108	DS	145,000	750
1012	S	70,300	500
1012	DS	142,000	500

Mounting style	
B	Base mount, position 1 (BM1) (standard)
C	Base mount, position 2 (BM2)
D	Base mount, position 3 (BM3)
E	Base mount, position 4 (BM4)
A	Face mount (FM)
F	Front mount (FF)
G	Side foot (SF)
H	End foot (EF)
X	Special mounting

Shaft style	
B	Single male keyed shaft (standard 7 & 10 Sizes)
C	Double male keyed shaft (standard 3 & 4 Sizes)
E	Single male SAE 10B splined shaft
F	Double male SAE 10B splined shaft
L	Single square shaft (SB)
M	Double square shaft (SB)
X	Special

Ports	
5	SAE straight thread (standard)
2	NPTF (FPP)
9	Special

Seals	
Omit	Nitrile (standard)
V	Fluorocarbon
X	Special

Options	
Omit	None
L	Limit switch actuator (LS)
H	Resolver feedback
J	Feedback potentiometer - 10K
S	Tapered lock stop (TLS)
T	Thrust bearings* Δ

* Choose Type (T1, T2, T3) from page B9.
Δ Not available with end foot mount & size 105 or larger.

Special options ‡	
Omit	Standard unit
Two-digit code assigned by factory when any "9" or "X" appears in the model number or when special options or features are required.	

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Tork-Mor Series actuators are produced in eighteen sizes generating up to 145,000 in-lb of torque at rated pressure. Capable of providing full torque instantly in either direction, they are available with 100° or 280° rotation at pressures up to 1000 psi. The Tork-Mor Series can be mounted in any axis using a wide variety of standard or optional mountings. Proven reliable through many years of field service, the Tork-Mor Series incorporates many quality features including precision ball bearings to provide shaft support, externally removable gland for ease of seal replacement, and cylinders honed to a 10 micro inch finish to ensure long seal life.

- Thrust Loads: Units have no thrust load capacity. See page B9 for optional thrust load bearings and their capacities.
- Radial Loads: External radial loads are not recommended and can reduce the life of the unit. Consult factory before applying.
- Vane design provides fair efficiency characteristics.
- Limited rotation torque range
- Small package size is suitable for application with space constraints
- Precision positioning is achieved due to no backlash design
- Suited for medium speed production applications

Operating information

Output torques @ 500 PSI (35 bar):	800 in-lb to 145,000 in-lb
Maximum operating pressure:	1000 PSI (69 bar) hydraulic
Operating temperature range:	
Nitrile seals	-40°F to 180°F (-40°C to 82°C)
Fluorocarbon seals	-20°F to 250°F (-29°C to 121°C)
Rotations:	
S Models	280°
DS Models	100°
Rotational tolerance:	±1°
Maximum allowable drainline pressure:	50 PSIG (3.4 bar) hydraulic
Mounting orientation:	Unrestricted
Standard timing:	Keyway in 12:00 position at midstroke
Recommended filtration:	ISO class 17/14 or better

Model Quick Reference

Model		Rated pressure (psi)		Output torque							Maximum bypass leakage		Max. breakaway pressure (psi)	Unit weights (lbs)
280° Rotation	100° Rotation	Normal Operating	Non-Shock	50 psi	100 psi	250 psi	500 psi	750 psi	1000 psi	Capacity (cu. in.)	100 psi Air (cfm)	500 psi Oil* (cu. in./min)		
S33	—	350	500	38	115	360	800	—	—	8.7	.20	2.5	25	8
—	DS33	350	500	77	235	728	1,625	—	—	6.2	.25	3.0	25	8.5
S42	—	750	1000	85	240	750	1,640	2,350	3,370	17.9	.25	3.0	25	16
—	DS42	750	1000	170	480	1,500	3,280	4,700	6,740	12.8	.30	3.5	25	19
S44	—	500	750	160	415	1,280	2,700	4,100	—	31.8	.25	3.0	25	22
—	DS44	350	500	325	840	2,570	5,500	—	—	22.6	.30	3.5	25	23
S46	—	350	500	240	600	1,850	4,050	—	—	47.7	.25	3.0	25	25
—	DS46	150	250	490	1,220	3,750	—	—	—	34.1	.30	3.5	25	27
S74	—	750	1,000	540	1,390	4,230	9,500	14,500	20,000	106	.30	3.5	25	92
—	DS74	500	750	1,080	2,800	8,560	19,300	29,600	—	75.7	.35	4.0	25	118
S77	—	500	750	950	2,430	7,400	16,700	25,300	—	186	.30	3.5	25	105
—	DS77	350	500	1,900	4,900	15,000	33,800	—	—	133	.35	4.0	25	120
S105	—	750	1,000	1,660	4,260	13,000	29,300	44,500	61,300	326	.30	5.0	25	290
—	DS105	750	1,000	3,330	8,650	26,300	59,300	90,900	124,000	233	.35	5.5	25	345
S108	—	500	750	2,660	6,820	20,800	46,900	71,000	—	521	.30	5.0	25	340
—	DS108	500	750	5,330	13,900	42,100	94,800	145,000	—	372	.35	5.5	25	362
S1012	—	350	500	3,990	10,200	31,200	70,300	—	—	781	.30	5.0	25	365
—	DS1012	350	500	7,990	20,800	63,100	142,000	—	—	558	.35	5.5	25	400

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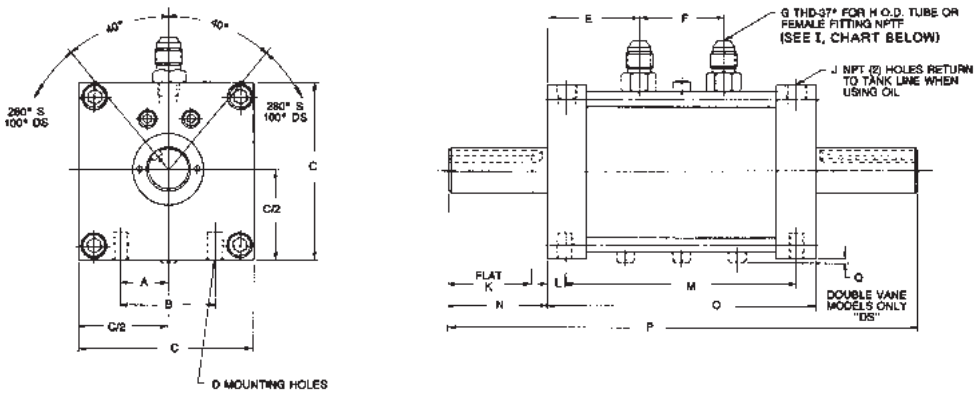
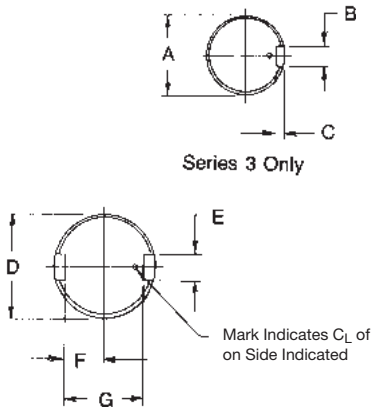
Series 3 & 4 with Std. Base Mount (B) and Double Male Keyed Shaft (C)



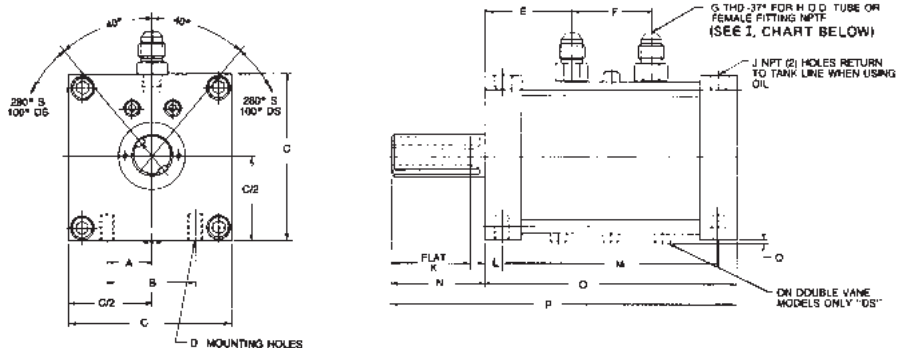
Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S & DS33	0.813	1.625	3.00	5/16-18 NC x .47 DP	1-5/8	1-1/2	7/16-20	1/4	1/8	1/8-27	1.50	.38	4	1.75	4-3/4	8-1/4	1/4
S & DS42	1.188	2.375	4.50	3/8-16 NC x .56 DP	1-5/8	1	9/16-18	3/8	1/4	1/8-27	2.50	.50	3-1/4	3.00	4-1/4	10-1/4	9/32
S & DS44	1.188	2.375	4.50	3/8-16 NC x .56 DP	1-3/4	2-1/2	9/16-18	3/8	1/4	1/8-27	2.50	.50	5	3.00	6	12	9/32
S & DS46	1.188	2.375	4.50	3/8-16 NC x .56 DP	2-3/4	2-1/2	9/16-18	3/8	1/4	1/8-27	2.50	.50	7	3.00	8	14	9/32

Shaft Details for Standard Male Keyed Shafts (B & C)



Model	A		B		C		D		E		F		G	
S & DS33	.749	+.000 -.001	.188	+.001 -.000	.093	+.000 -.003	N/A		N/A		N/A		N/A	
S & DS4	N/A		N/A		N/A		.999	+.000 -.001	.250	+.000 -.001	.390	+.000 -.001	.780	+.000 -.002
S & DS7	N/A		N/A		N/A		1.749	+.000 -.001	.375	+.002 -.000	.730	+.000 -.002	1.460	+.000 -.010
S & DS10	N/A		N/A		N/A		2.999	+.000 -.001	.750	+.002 -.000	1.200	+.000 -.003	2.400	+.000 -.010

Series 7 & 10 with Std. Base Mount (B) and Single Male Keyed Shaft (B)



Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S & DS74	1.875	3.750	8.00	3/4-10 NC x 1.13 DP	2-11/16	1-5/8	1-1/16 -12	3/4	3/4	1/8-27	5.00	.69	5-5/8	5.50	7	12.50	5/8
S & DS77	1.875	3.750	8.00	3/4-10 NC x 1.13 DP	3-3/8	3-1/4	1-1/16 -12	3/4	3/4	1/8-27	5.00	.69	8-5/8	5.50	10	15.50	5/8
S & DS105	3.000	6.000	12.25	1-14 NC x 1.50 DP	3-3/4	2-1/2	1-5/16 -12	1	1	1/4-18	8.00	1.25	7-1/2	9.00	10	19.00	5/8
S & DS108	3.000	6.000	12.25	1-14 NC x 1.50 DP	4-1/4	4-1/2	1-5/16 -12	1	1	1/4-18	8.00	1.25	10-1/2	9.00	13	22.00	5/8
S & DS1012	3.000	6.000	12.25	1-14 NC x 1.50 DP	6-1/4	4-1/2	1-5/16 -12	1	1	1/4-18	8.00	1.25	14-1/2	9.00	17	26.00	5/8

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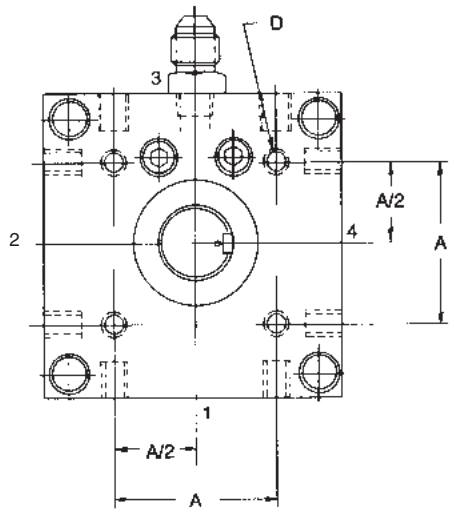
Face Mount (A)
Base Mount (B, C, D, E)

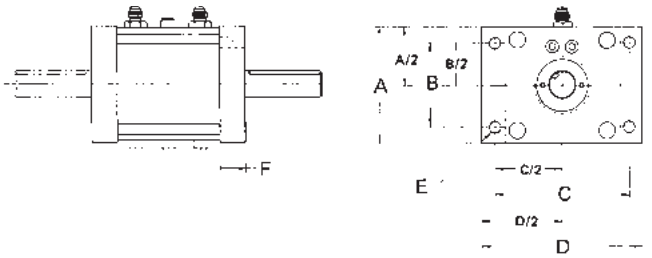
In addition to the standard base mounting holes in position 1, similar holes can be provided at position 2, 3 or 4. Alternate mounting holes can also be provided for face mounting as shown.



Standard

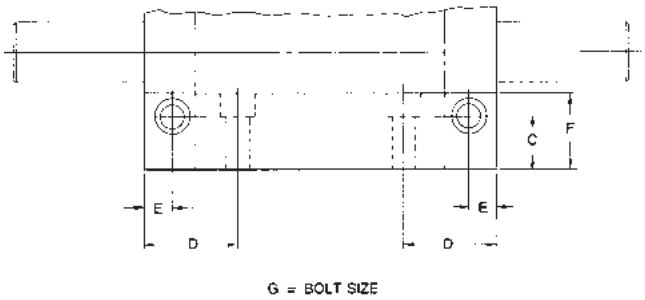
Model	A	D
S & DS33	1-5/8	5/16 -18 x .47 DP
S & DS4	2-3/8	3/8 -16 x .56 DP
S & DS7	3-3/4	3/4 -10 x 1.13 DP
S & DS10	6	1-14 x 1.50 DP

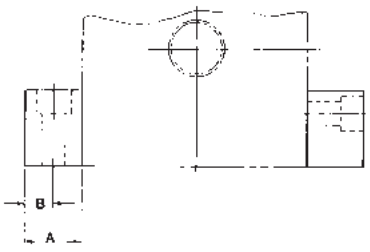
Front Flange Mount (F)



Model	A	B	C	D	E	F
S33	3.00	2.000	3.750	4.625	0.344	0.75
S4	4.50	3.250	5.250	6.250	0.406	1.00
S7	8.00	6.000	9.500	11.00	0.781	1.50
S10	12.25	10.000	14.500	16.50	1.031	2.50

Side Foot Mount (G)





Model	A	B	C	D	E	F	G
SF-3	3/4	3/8	11/16	1-1/4	3/8	1	5/16
SF-4	1	1/2	1	1-1/4	1/2	1/2	3/8
SF-7	1-1/2	3/4	2	2	11/16	3	3/4
SF-10	2	1	3	3-1/4	1-1/4	4	1

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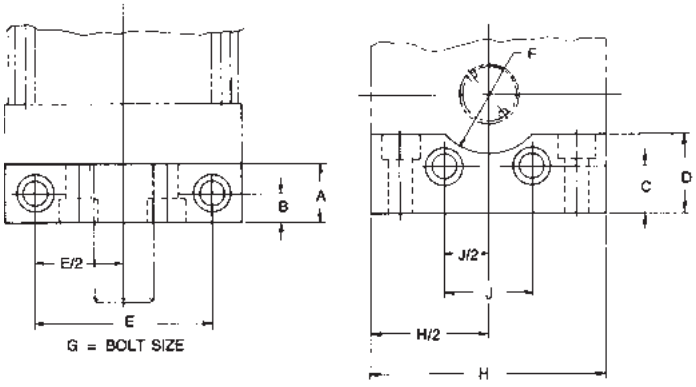
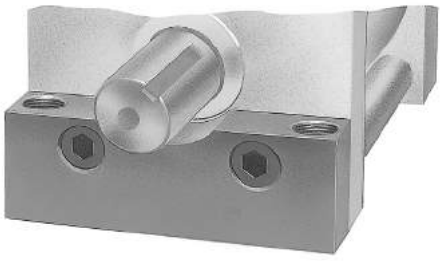
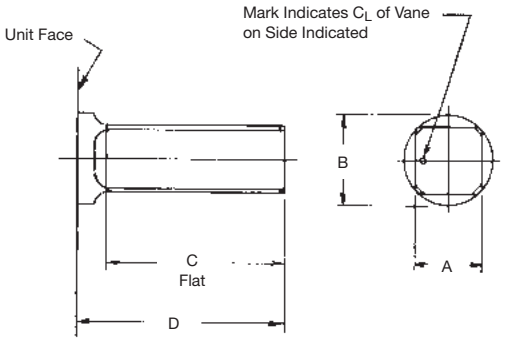
End Foot Mount (H)





Model	A	B	C	D	E	F	G	H	J
EF-3	3/4	3⁄8	11⁄16	1	2-3/4	3/4	5⁄16	3-1/2	1-5⁄8
EF-4	1	1/2	1-1⁄16	1-1/2	3-3/4	1	3⁄8	4-1/2	2-3⁄8
EF-7	1-1/2	3/4	2-1⁄8	3	6-3⁄8	1-1/2	3/4	8	3-3/4
EF-10	2	1	3-1⁄8	4-1/2	10	1-3/4	1	12-1/4	6

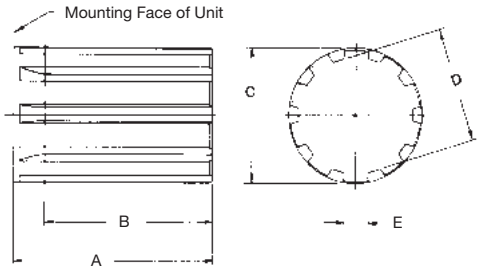
Shaft Options



Optional shafts are available as shown. Output shafts can also be provided to your special requirements.

Square Shafts (L, M)

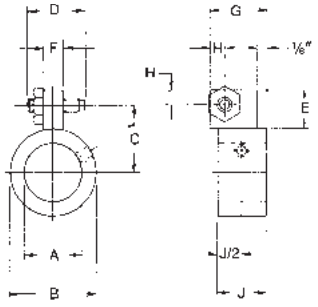
Model	A		B		C	D
S33	.564	+.000 -.001	.749	+.000 -.001	1-1/2	1-3/4
S4	.815	+.000 -.001	.999	+.000 -.001	2-1/2	3
S7	1.378	+.000 -.001	1.749	+.000 -.001	5	5-1/2
S10	2.504	+.000 -.001	2.999	+.000 -.001	8	9



Splined Shafts (E, F)

Model	A	B	C	D	E
S33	1.75	1.00	.748 .747	.639 .634	.114 .113
S4	2.98	2.50	.998 .997	.854 .849	.153 .152
S7	3.63	2.63	1.748 1.746	1.499 1.494	.270 .269
S10	5.75	4.50	2.997 2.995	2.573 2.568	.464 .463

Limit Switch Actuator (L)



Model	A	B	C	D	E	F	G	H	J
LS-3	3/4	1	7⁄8	3/4	1/2	1/4	5⁄8	3/16	5⁄8
LS-4	1	1-1/2	1-3⁄8	1	7⁄8	3⁄8	1-1⁄8	1/4	1
LS-7	1-3/4	2-1/4	1-3/4	1	7⁄8	3⁄8	1-1⁄8	1/4	1
LS-10	3	3-3/4	2-5⁄8	1	1	½	1-1/4	1/4	1

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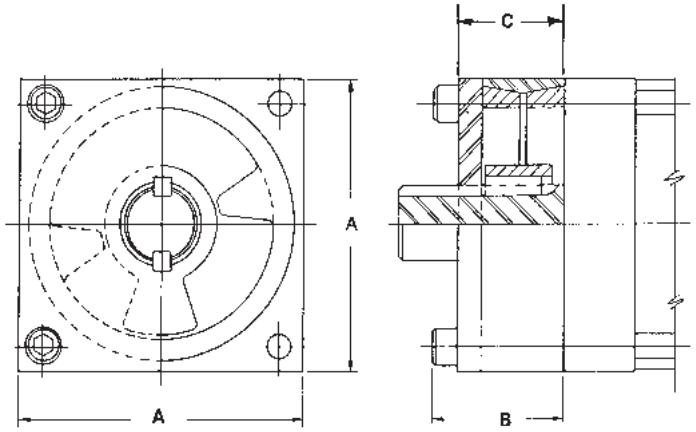
Taper Lock Stop (S)



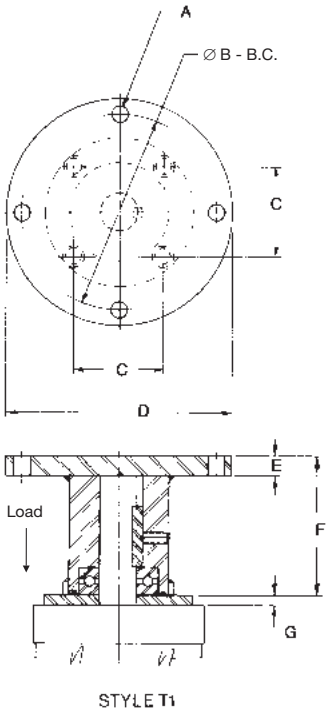
This option provides easy adjustment of rotation for light to medium duty applications.

Model	A	B	C
TLS-3	3	1-3/8	1-1/8
TLS-4	4-1/2	1-5/8	1-5/16
TLS-7	8	2-1/2	2-1/8

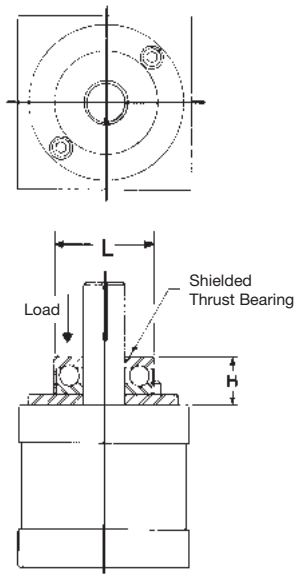
Thrust Bearings (T1, T2, T3)

External thrust bearings are advised for axially loaded applications. This includes applications where actuators are mounted in a vertical position causing the weight of the shaft assembly to exert axial thrust.

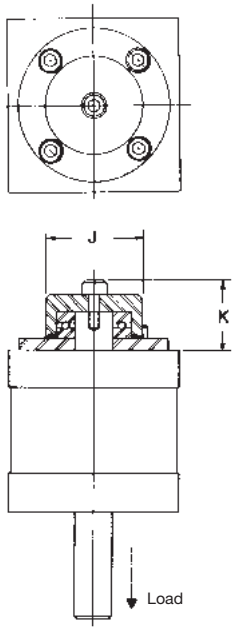
Model	Thrust Capacity (lbs)	A	B	C	D	E	F	G	H	J	K	L
S3	1600	11/32	3-3/4	1-5/8	4-5/8	3/8	2-1/8	3/16	1-3/16	2	1-3/8	1-1/2
S4	2500	13/32	5-1/4	2-3/8	6	1/2	3-1/2	1/4	1	2-5/8	1-3/4	2
S7	4000	21/32	7-1/2	3-3/4	9	5/8	4-1/2	3/8	1-1/4	3-5/8	2-1/8	3-1/8



STYLE T1



STYLE T2



STYLE T3

Additional Options

- Fluorocarbon Seals (V)
- Feedback Potentiometer (J) – Consult factory for limitations

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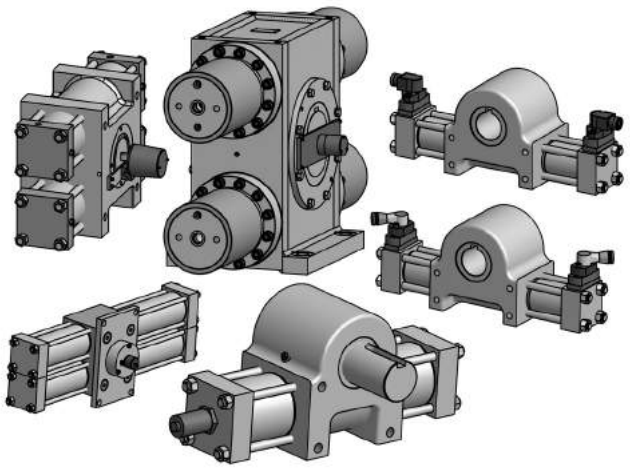


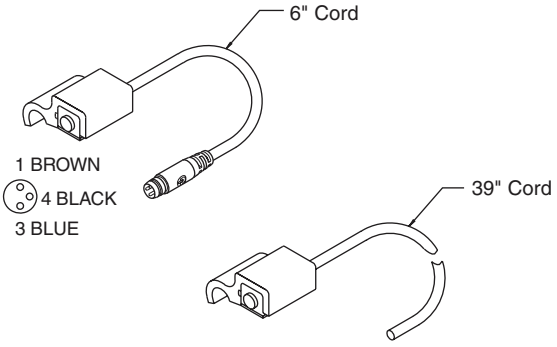
Electronic Sensors
Solid State, Reed and Proximity Sensors, Feedback Packages

Parker Hannifin Corporation
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

Solid State (Hall Effect) Sensors

	PNP		NPN	
Model	**With 6" Male Quick Connect**	**With 39" Potted-in Leads**	**With 6" Male Quick Connect**	**With 39" Potted-in Leads**
10	SWH-1PC	SWH-1P	SWH-1NC	SWH-1N
15	SWH-1PC	SWH-1P	SWH-1NC	SWH-1N
20	SWH-2PC	SWH-2P	SWH-2NC	SWH-2N
25	SWH-2PC	SWH-2P	SWH-2NC	SWH-2N
32	SWH-2PC	SWH-2P	SWH-2NC	SWH-2N

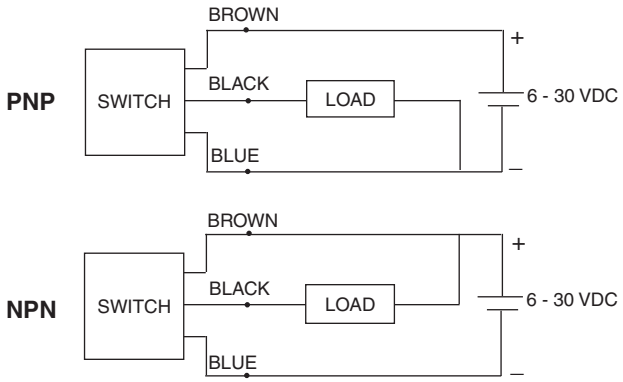
Note: Switches with male quick connect option require female cordsets to be ordered separately. See Sensors Accessories.



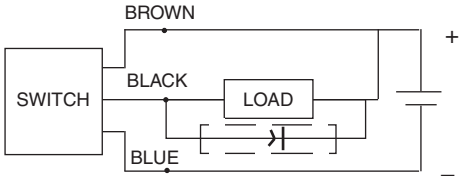
Specifications

Type	Solid State (PNP or NPN)
Switching Logic	Normally Open
Supply Voltage Range	6 - 30 VDC
Current Output Range	Up to 100 mA at 5VDC, Up to 200 mA at 12VDC and 24VDC
Current Consumption	7 mA at 5VDC, 15 mA at 12VDC, and 30 mA at 24VDC
Switching Response	1000 Hz Maximum
Residual Voltage	1.5V Maximum
Leakage Current	10uA Maximum
Breakdown Voltage	1.8k VACrms for 1 sec., lead to case
Min. Current for LED	1mA
Operating Temperature	14°F to 140°F (-10°C to 60°C)
Enclosure Protection	Meets IEC IP67, fully encapsulated
Lead Wire	3 conductor, 24 gauge
Lead Wire Length	39 in (1 m)
Vibration Resistance	10-55 Hz, 1.5mm double amplitude

Wiring connection



Protection circuit*



* When connecting an inductive load (relay, solenoid valve, etc.), a protection circuit is recommended. Use a 100V, 1A diode. (NPN connection shown.)

C
Sensors and Feedback

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Pneumatic Division
Wadsworth, Ohio
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Reed Switches

Model	With 6" Male Quick Connect	With 39" Potted-in Leads
10	SWR-1C	SWR-1
15	SWR-1C	SWR-1
20	SWR-2C	SWR-2
25	SWR-2C	SWR-2
32	SWR-2C	SWR-2

Note: Switches with male quick connect option require female cordsets to be ordered separately. See Sensors Accessories.

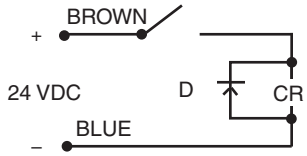
Specifications

Switching Logic	Normally Open
Voltage Rating	85-125 VAC or 6-30 VDC*
Power Rating	10 Watts AC or DC/Resistive Load 5 Watts AC or DC/Inductive Load
Switching Current Range	10-200 mA/Resistive Load (PC, Sequencer) 10-100 mA/Inductive Load (Relay)
Switching Response	300 Hz Maximum
Breakdown Voltage	1.8k VACrms for 1 sec., lead to case
Min. Current for LED	18mA
Operating Temperature	14°F to 140°F (-10°C to 60°C)
Enclosure Protection	Meets IEC IP67, fully encapsulated
Lead Wire	2 conductor, 22 Gauge
Lead Wire Length	39 in (1 m)
Vibration Resistance	10-55 Hz, 1.5mm double amplitude

* Polarity is restricted for DC operation
(+) to White
(-) to Black
If these connections are reversed the contacts will close, but the LED will not light.

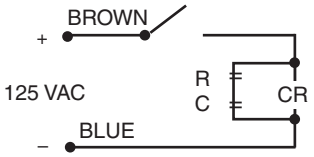
Protection circuit (Inductive loads)

(Required for proper operation 24 VDC)
Select a diode with a breakdown voltage and current rating according to the load. Place a diode in parallel to the load with the polarity as indicated:



CR: Relay coil (under 0.5W coil rating)

(Recommended for longer switch life 125 VAC)
Select a resistor and capacitor according to the load. Place a resistor and capacitor in parallel to the load:



CR: Relay coil (under 2W coil rating)
R: Resistor under 1 K ohm
C: Capacitor 0.1 µF

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8mm Cordset with Female Quick Connect

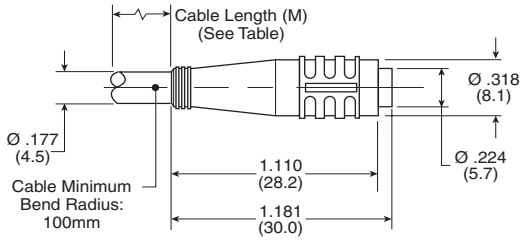
A female connector is available for all sensors with the male 8mm quick connect option. The male plug will accept a snap-on or threaded connector. Cordset part numbers are listed below:

Cable length	Threaded connector	Snap-on connector
5 meters	086620T005	086620S005
2 meters	086620T002	086620S002

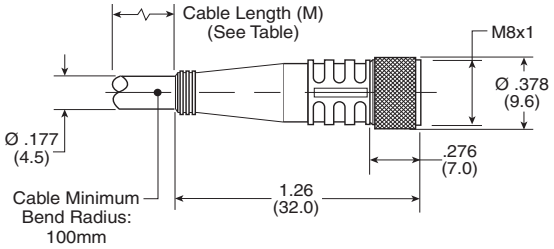
8mm Cordset Specifications:

Connector:	Oil resistant polyurethane body material, PA 6 (Nylon) contact carrier, spacings to VDE 0110 Group C, (150 AC/DC)
Contacts:	Gold plated beryllium copper, machined from solid stock
Coupling Method:	Snap-Lock or chrome plated brass nut
Cord Construction:	Oil resistant black PUR jacket, non-wicking, non-hygroscopic, 300V. Cable end is stripped and tinned.
Conductors:	Extra high flex stranding, PVC insulation
Temperature:	-40°F to 194°F (-40°C to 90°C)
Protection:	NEMA 1, 3, 4, 6P and IEC IP67
Cable Length:	6.56 ft (2m) or 16.4 ft (5m)

Snap-On Straight Connector



Threaded Straight Connector



12mm Cordset with Female Quick Connect

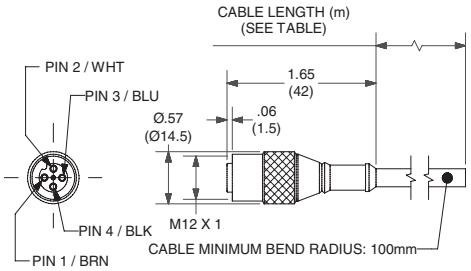
A female connector is available for all sensors with the male 12mm quick connect option. The cordsets are available with a right angle or straight connector. Cordset part numbers are listed below.

Cable length	Straight connector	Right angle connector
5 meters	9126487205	9126487305
2 meters	9126487202	9126487302

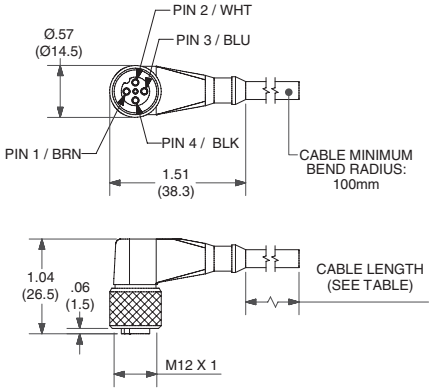
12mm Cordset Specifications:

Connector:	Polyvinyl chloride (PVC) body material, PVC contact carrier, spacing to VDE 0110 Group C, (250 VAC / 300 VDC)
Contacts:	Gold Plated Copper Tin (CuSn), stamped from stock.
Coupling Method:	Threaded nut: Chrome plated brass.
Cord Construction:	PVC non-wicking, non-hygroscopic, 250 VAC / 300 VDC. Cable end is stripped.
Conductors:	Extra high flex stranding with PVC insulation
Temperature:	-13°F to 158°F (-25°C to 70°C)
Protection:	NEMA 1, 3, 4, 6P and IEC IP67
Cable Length:	6.56 ft (2m) or 16.4 ft (5m)

Straight Connector



Right Angle Connector



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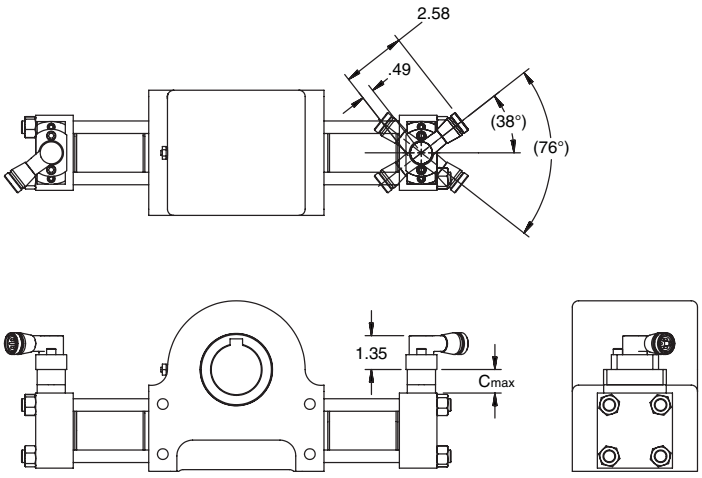
EPS-7 & EPS-6 Sensors

Connector housing is rotatable in the two 76° segments shown. To rotate, loosen screws, position the connector housing and secure screws.

Model Series	Cylinder Series	Cmax
LTR	2L	1.05"
HTR	2H	1.75"



Series and Parallel Wiring

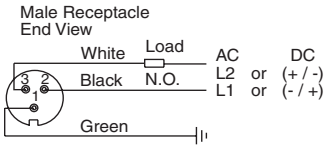
When Parker EPS-6 or 7 proximity switches are used as inputs to programmable controllers the preferred practice is to connect each switch to a separate input channel of the PC. Series or parallel operations may then be accomplished by the internal PC programming.

Parker EPS-6 or 7 switches may be hard wired for series operation, but the voltage drop through the switches (see specifications) must not reduce the available voltage below what is needed to actuate the load.

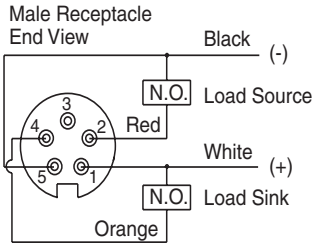
Parker EPS-6 or 7 switches may also be hard wired for parallel operation. However, the leakage current of each switch will pass through the load. The total of all leakage currents must not exceed the current required to actuate the load. In most cases, the use of two or more EPS-6 or 7 switches in parallel will require the use of a bypass (shunt) resistor.

Connector Pin Numbering

3-Pin Mini



5-Pin Mini



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Specifications

Style:	**EPS-7**	**EPS-6**
Description:	Economical, General Purpose, 2 wire device, primarily for AC applications, not suitable for 24 VDC applications.	Economical, General Purpose, 3-wire, DC sensor, dual output: sinking and sourcing.
Supply Voltage:	20 to 250 VAC/DC	10 to 30 VDC
Load Current, min:	8 mA	NA
Load Current, max:	300 mA	200 mA
Leakage Current:	1.7 mA, max.	10 micro amps max.
Voltage Drop:	7 V, max.	2 VDC max.
Operating Temperature:	-14° to +158° F	-14° to +158° F
Sensor Type:	Inductive proximity	Inductive proximity
Connection:	3 pin mini	5 pin mini
Enclosure Rating:	IEC IP67	IEC IP67
LED indication:	Yes	Yes
Short Circuit Protection:	Yes	Yes
Weld Field Immunity:	Yes	Yes
Output:	2 wire, Normally Open with leakage current	Dual output: DC Sinking and DC Sourcing, user selectable via wiring
Approvals/Marks:	CE, UL, CSA	CE, UL, CSA
Make/Break Location:		
Wiring Instructions:	Pin 1: AC Ground (Green) Pin 2: Output (Black) Pin 3: AC Line (White)	Pin 1: +10 to 30 VDC (White) Pin 2: Sourcing Output (Red) Pin 3: Grounded (not connected or required) Pin 4: Sinking Output (Orange) Pin 5: DC Common (Black)
Connector: Cable: 6' Cable: 12' Cable: 6', Right Angle	 085355-0006 085355-0012 087547-0006	 085917-0006 085917-0012 —

Part Numbers

Proximity Sensor	**EPS-7**	**EPS-6**
1.25" Probe	1488970125	1488960125
2.06" Probe	1488970206	1488960206
2.875" Probe	1488970288	1488960288
4.562" Probe	1488970456	1488960456

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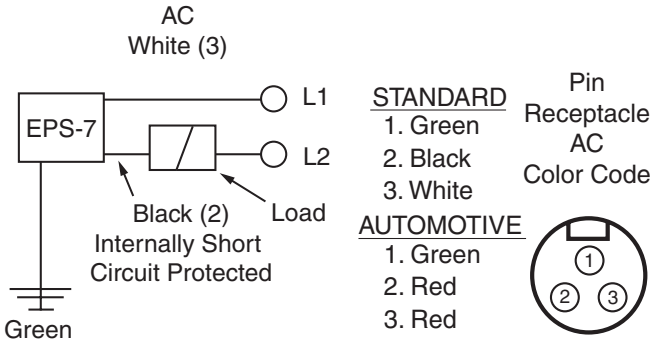
EPS-7

Connectors

The male quick disconnect on the Parker EPS-7 is a Brad Harrison 40909 connector.

Female connects must be purchased with one of the following cable lengths.

Cable length	Automotive	Standard
3'	085356003	0853550003
6'	085356006	0853550006
9'	085356009	—
12'	0853560012	0853550012

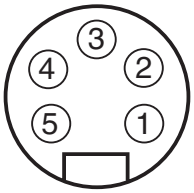


EPS-6

Connectors

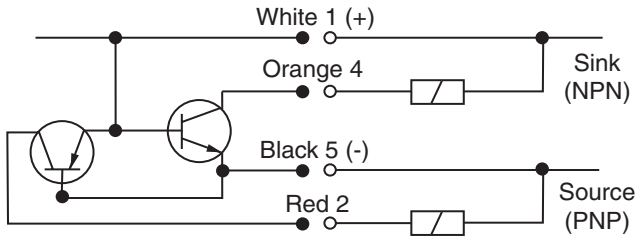
The male quick disconnect on the Parker EPS-6 is a Brad Harrison 41310 connector.

Plug Pin and Cable Identification



1) +10 to 30 VDC (White)
2) Source (Red)
3) Grounded not connected nor required
4) Sink (Orange)
5) Common (Black)

Cable length	Part number
3	085917 0003
6	085917 0006
12	085917 0012



LED function	"Ready"	"Target"
Power Applied (No Target)	ON	OFF
Target Present	OFF	ON
Short Circuit Condition	FLASH	FLASH

C
Sensors and Feedback

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Feedback packages are available for HUB, LTR, HTR, M Series and Tork-Mor actuators. The feedback potentiometer may be ordered as part of the model code (Code J). Other options must be ordered separately. See the following pages for specifications.

Model							
Single Rack	**Double Rack**	**Temposonics LDT Feedback**	**Teknar Linear Potentiometer**	**Precision Feedback Potentiometer**	**Resolver**	**RLPO**	**SST Dual Module**
	HUB018					Code A, B	StoneL Code C-E
	HUB075					Code A, B	StoneL Code C-E
	HUB100					Code A, B	StoneL Code C-E
LTR101	LTR102	—	—	Code J	Code H		
LTR151	LTR152	—	—	Code J	Code H		
LTR201	LTR202	—	—	Code J	Code H		
LTR251	LTR252	—	—	Code J	Code H		
LTR321	LTR322	—	—	Code J	Code H		
HTR.9	HTR1.8	—	—	Code J	Code H		
HTR3.7		—	—	Code J	Code H		
	HTR7.5	Prep only	Prep only	Code J	Code H		
HTR5		—	—	Code J	Code H		
	HTR10	Prep only	Prep only	Code J	Code H		
HTR15		Prep only	Prep only	Code J	Code H		
	HTR30	Prep only	Prep only	Code J	Code H		
HTR22		Prep only	Prep only	Code J	Code H		
	HTR45	Prep only	Prep only	Code J	Code H		
HTR75		Prep only	Prep only	Code J	Code H		
	HTR150	Prep only	Prep only	Code J	Code H		
HTR300		Prep only	Prep only	Code J	Code H		
	HTR600	Prep only	Prep only	Code J	Code H		
75M		Prep only	Prep only	Code J	Code H		
	150M	Prep only	Prep only	Code J	Code H		
300M		Prep only	Prep only	Code J	Code H		
	600M	Prep only	Prep only	Code J	Code H		
	1,000M	Prep only	Prep only	Code J	Code H		
	1,500M	Prep only	Prep only	Code J	Code H		
	2,000M	Prep only	Prep only	Code J	Code H		
	3,000M	Prep only	Prep only	Code J	Code H		
	4,000M	Prep only	Prep only	Code J	Code H		
	5,000M	Prep only	Prep only	Code J	Code H		
	6,000M	Prep only	Prep only	Code J	Code H		
	7,000M	Prep only	Prep only	Code J	Code H		
	8,000M	Prep only	Prep only	Code J	Code H		
	9,000M	Prep only	Prep only	Code J	Code H		
	10,000M	Prep only	Prep only	Code J	Code H		
	15,000M	Prep only	Prep only	Code J	Code H		
	20,000M	Prep only	Prep only	Code J	Code H		
	25,000M	Prep only	Prep only	Code J	Code H		
	30,000M	Prep only	Prep only	Code J	Code H		
	40,000M	Prep only	Prep only	Code J	Code H		
	50,000M	Prep only	Prep only	Code J	Code H		
33S	33DS	—	—	Code J	Code H		
42S	42DS	—	—	Code J	Code H		
44S	44DS	—	—	Code J	Code H		
46S	46DS	—	—	Code J	Code H		
74S	74DS	—	—	Code J	Code H		
77S	77DS	—	—	Code J	Code H		
105S	105DS	—	—	Code J	Code H		
108S	108DS	—	—	Code J	Code H		
1012S	1012DS	—	—	Code J	Code H		

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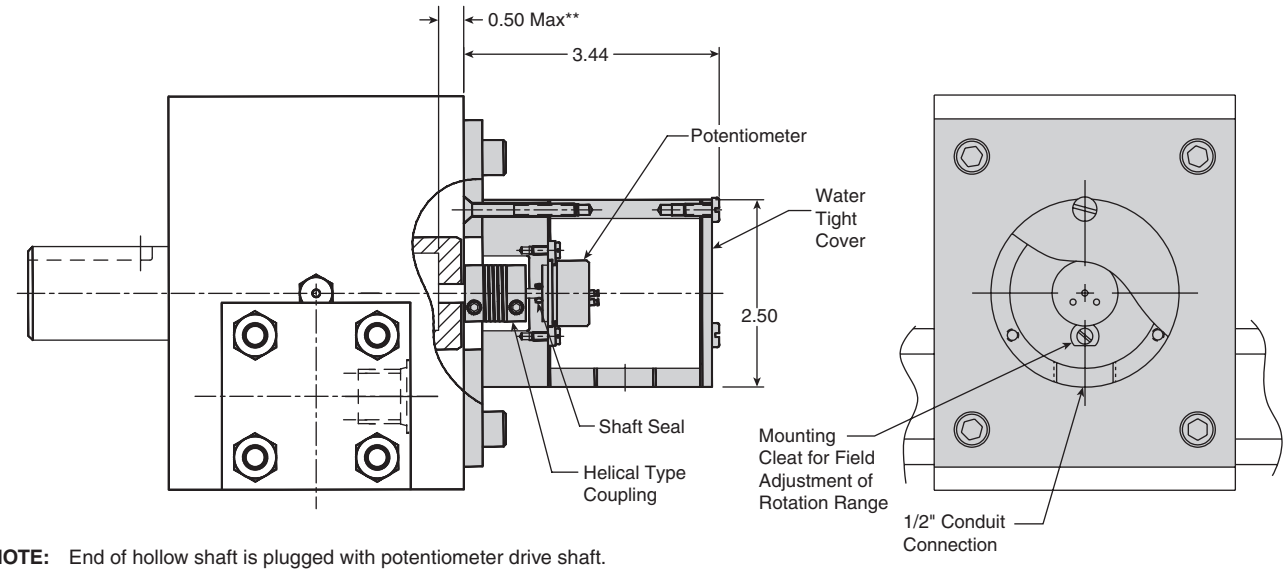
Precision Feedback Potentiometer Package (J)



****NOTE:** End of hollow shaft is plugged with potentiometer drive shaft. Mating shaft engaged length must clear plug thickness.

Application:

The potentiometer option is an analog feedback device designed for use on a wide variety of applications that utilize closed-loop feedback to achieve accurate position, velocity, or motion control. The potentiometer option can also be used on open-loop systems as a continuous, infinite position monitoring device.

Operation:

A potentiometer is a variable resistor. There are three electrical terminals on the potentiometer - two on opposite ends of a fixed conductive plastic element (terminals 1 and 3, see electrical schematic on the right) and one attached to the "wiper" that moves along the conductive element as the shaft rotates (terminal 2). As the potentiometer shaft rotates, resistance between terminal 2 and terminals 1 and 3 changes.

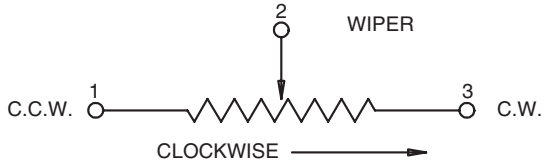
Because the resistance of the potentiometer is linear (± .1%), when a fixed voltage level is supplied across terminals 1 and 3, shaft position can be determined by reading the output voltage at terminal 2. By measuring the rate of change in voltage at terminal 2, rotational velocity can be determined. To determine actuator position or velocity, the potentiometer shaft is connected to the actuator shaft via a flexible coupling. The potentiometer is enclosed in a water tight enclosure for resistance to dirty environments.

Ordering information:

Specify in model code.

Potentiometer Specifications:

Potentiometer:	7/8" diameter single turn precision servo-mount with conductive plastic element
Resistance:	10K ohms
Resistance tolerance:	± 10%
Linearity:	± 1%
Resolution:	Essentially infinite
Effective electrical angle:	340° ± 3%
Power rating:	70°C - 1 watt 125°C - 0 watt
Temperature rating:	-40°C to + 125°C
Backlash:	0.1° max.
Rotational life:	20,000,000 rev.
Terminal:	Rear, turret style
Available on: Rack & pinion* -	 LTR Series HTR Series M Series
Vane -	Tork-Mor Series
Maximum rotation	360° mechanical
Electrical schematic:	



NOTE:

*1. Rack and pinion actuators have a small amount of backlash – consider before applying.

2. Electrohydraulic options and operation may affect other actuator components such as seals, bearings, etc. Consult your local representative for additional information.

C
Sensors and Feedback

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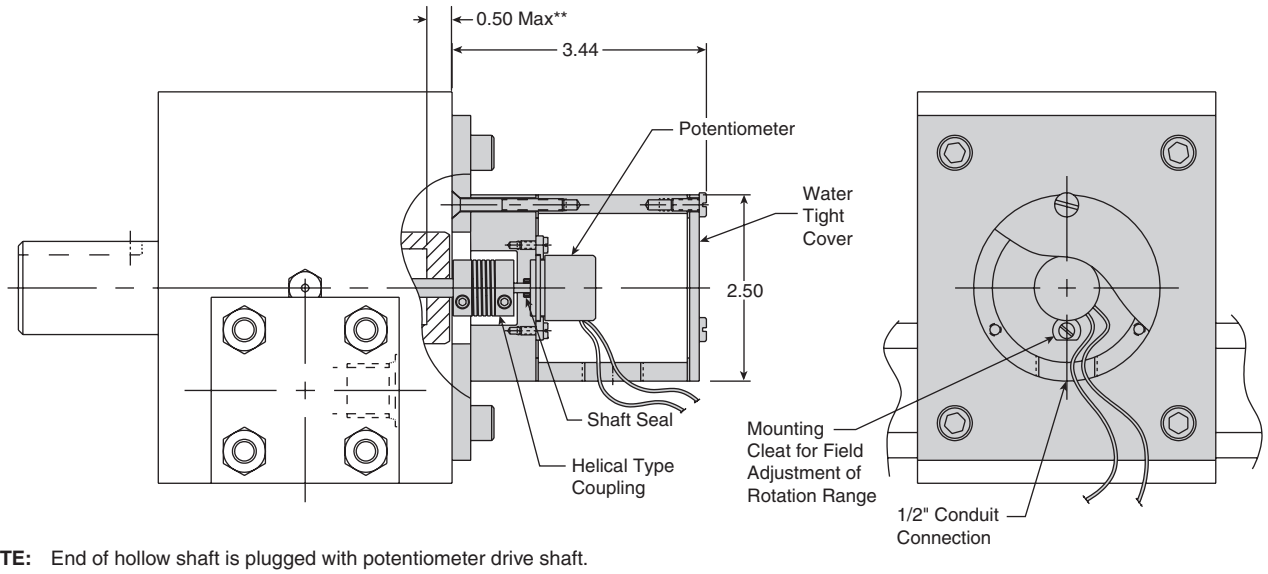
Precision Resolver Feedback Package (H)



****NOTE:** End of hollow shaft is plugged with potentiometer drive shaft. Mating shaft engaged length must clear plug thickness.

Application:

The resolver option is a precision analog feedback device designed for use on a wide variety of applications that utilize closed-loop feedback to achieve accurate position, velocity, or motion control. The resolver option can also be used on open-loop systems as a continuous, infinite position monitoring device.

Operation:

A resolver is a brushless rotary synchronous transformer which eliminates wiping contact and provides higher response and accuracy. A voltage and frequency is applied across the primary coil; changes in shaft position cause a proportional change in the secondary winding. Measuring the rate of change also provides velocity. To determine actuator position or velocity, the resolver shaft is connected to the actuator shaft via a flexible coupling. The resolver is enclosed in a water tight enclosure for resistance to dirty environments.

Ordering information:

Actuators can be supplied as complete packages as specified in the model code, or just the enclosure for the mounting of a customer supplied resolver can be provided. Consult the factory or your local representative for specific application and ordering information.

Resolver Specifications:

Resolver:	11D servo-mount, brushless synchro
Input voltage:	7.5 volts
Input frequency:	4000 Hz
Input current:	13.5 mA (max)
Input power:	60 mW
Output voltage:	4 volts
Phase shift:	-2°
Sensitivity:	70 mV/°
DC Rotor resistance:	15 ohms
DC Stator resistance:	19 ohms
Total null voltage:	20 mV
Accuracy (Maximum error):	7 minutes*
Leads:	#28 AWG, 12 inches long
Available on:	
Rack & pinion* -	LTR Series HTR Series M Series
Vane -	Tork-Mor Series

NOTE:

*1. Rack and pinion actuators have a small amount of backlash – consider before applying.

2. Electrohydraulic options and operation may affect other actuator components such as seals, bearings, etc. Consult your local representative for additional information.

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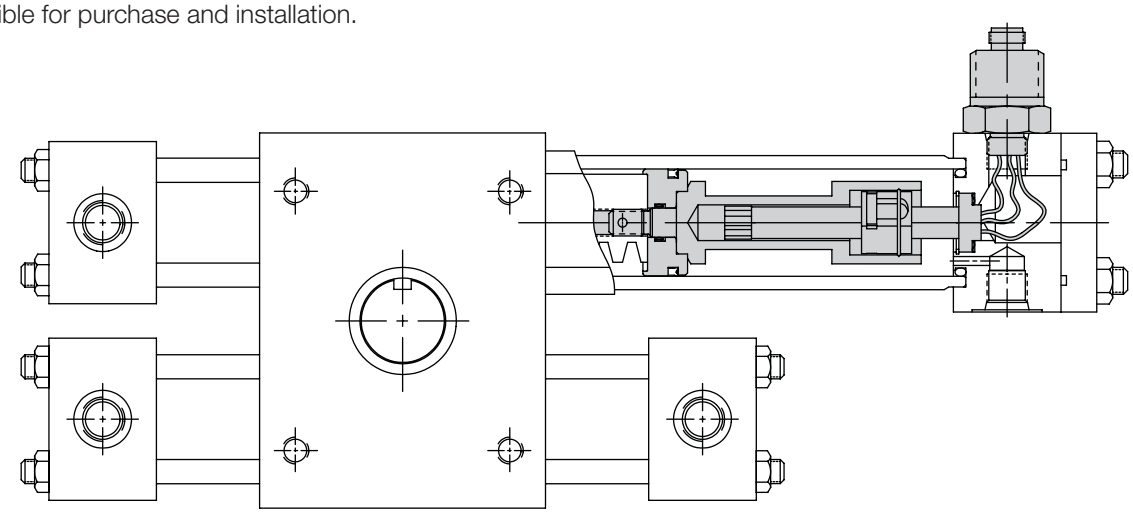
Linear Potentiometer Feedback Package (Prep only)

Actuator is provided prepped for feedback only. Customer is responsible for purchase and installation.



Application:

The linear potentiometer option is an analog feedback device typically used for rotary actuator rotations exceeding 340°, or where a standard rotary potentiometer cannot be connected to the actuator shaft. Applications for this device include closed loop feedback to achieve accurate position, velocity, or motion control. This option can also be used on open-loop systems as continuous, infinite position monitoring device.

Operation:

A potentiometer is a variable resistor. There are three electrical terminals on the potentiometer - two on opposite ends of a fixed conductive plastic element (terminals 1 and 3, see electrical schematic on the right) and one attached to the "wiper" that moves along the conductive element with the piston and rack. As the wiper moves along the element, resistance between terminal 2 and terminals 1 and 3 charges.

Because the resistance of the potentiometer is linear (± .1%), when a fixed voltage level is supplied across terminals 1 and 3, shaft position can be determined by reading the output voltage at terminal 2. By measuring the rate of change in voltage at terminal 2, rotational velocity can be determined. Since the linear potentiometer is enclosed in the actuator itself, it is safe for operation in dirty or wet environments.

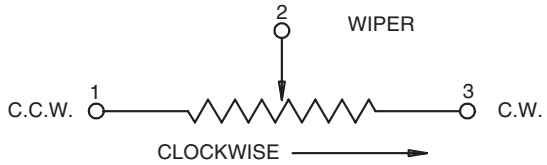
Ordering information:

Consult the factory or your local representative for specific application and ordering information.

Linear Potentiometer Specifications:

Potentiometer:	Calibrated conductive film with low resistance wiper carriage.
Resistance:	Approx. 1 K ohm per inch of stroke
Resistance tolerance:	± 20%
Linearity:	0.1% of full stroke
Voltage:	5 - 50 VDC
Resolution:	Essentially infinite*
Repeatability:	0.001*
Power rating:	70°C - 1 watt/cm^2 125°C - 0 watt/cm^2
Temperature rating:	-55°C to 125°C
Pressure rating:	3,000 psi
Terminal:	3 pin micro connector
Available on: Rack & pinion* -	 HTR Series M Series

Electrical schematic:



NOTE:

*1. Rack and pinion actuators have a small amount of backlash – consider before applying.

2. Electrohydraulic options and operation may affect other actuator components such as seals, bearings, etc. Consult your local representative for additional information.

C
Sensors and Feedback

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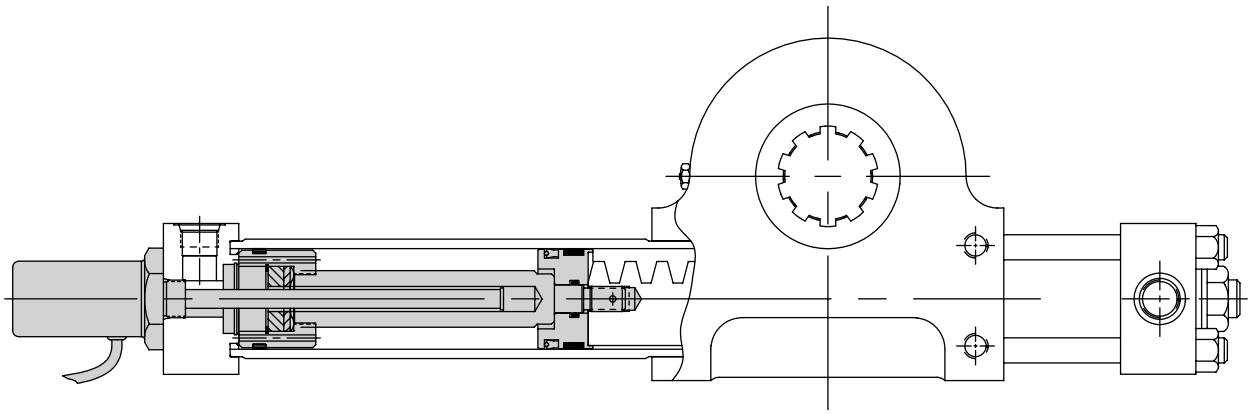
LDT Feedback Package (MTS Temposonics)



Application:

The linear displacement transducer (LDT) option provides digital feedback of the rack position via interaction between two magnetic fields. The LDT option is recommended for applications where rotation exceeds 340°, or where a standard rotary potentiometer or resolver cannot be connected to the actuator output shaft. Applications for this device include closed loop feedback to achieve accurate position, velocity, or motion control. This option can also be used on open-loop systems as a continuous, infinite position monitoring device.

Operation:

The LDT utilizes two magnets, a permanent one located on the piston, the other is a magnetic pulse generated by a current pulse along a wire inside a waveguide tube. The interaction between the fields produces a strain pulse which travels down the waveguide tube and is sensed by a coil at the end of the device. Position and velocity of the permanent magnet is pinpointed by measuring the lapsed time between the launching of the current pulse and the arrival of the strain pulse. An interface box converts this information to a usable output form, either digital or analog.

Ordering information:

Actuators can be provided as complete packages or with drilling and mounting for customers purchased LDTs. Consult the factory or your local representative for specific application and ordering information.

LDT Specifications:

Linearity:	±.05% of full stroke (min. ±.002 in.)*
Repeatability:	±.0001 in.*
Temperature coefficient (probe):	<10 ppm/°F
Temperature coefficient (electronics box):	
Digital:	<10 ppm/°F
Analog:	55 ppm/°F
Resolution*:	
Digital:	.004, .002, .001 or .0005 available*
Analog:	Stepless continuous output*
Output:	
Digital:	Absolute, TTL compatible, parallel or serial
Analog:	-10 to +10 VDC and 20mA range
Operating temperature:	
Digital:	0°F to 150°F
Analog:	35°F to 150°F
Hysteresis:	.0008 in.*
Available on:	
Rack & pinion* -	HTR Series M Series

NOTE:

*1. Rack and pinion actuators have a small amount of backlash – consider before applying.

2. Electrohydraulic options and operation may affect other actuator components such as seals, bearings, etc. Consult your local representative for additional information.

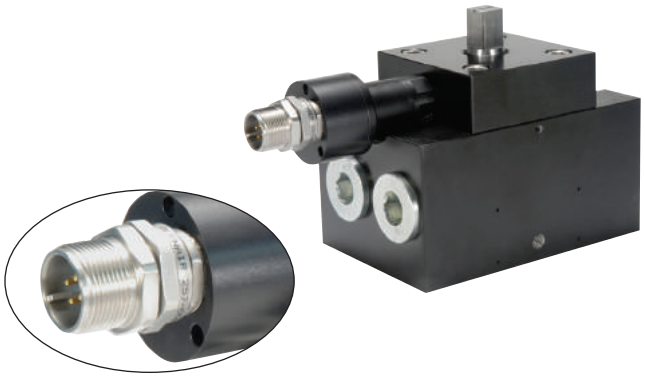
Parker Hannifin Corporation
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

Rotary Linear Potentiometer Feedback

0-40 VDC linear position feedback (RLPO)

Parker's 0-40 VDC linear position feedback solution is accurate, reliable, and designed to handle the harshest environmental conditions. The robust hard coat anodized aluminum construction and electroless nickel plated (ENP) steel components make this feedback option ideal for use in corrosive outside environments. With a low profile design, this solution is perfect for applications where space is a premium.

- **Environmentally rugged –** Hard coat anodized aluminum module and electroless nickel plated (ENP) steel components that are designed to withstand the harshest environmental conditions.
- **Direct mounting to output shaft –** Cam coupled design provides precision rotation position for accurate feedback.
- **Low profile design -** Clearance above the actuator is critical in many systems. The Parker RLPO feedback module has a less than 2" height requirement.
- **Redundancy capabilities for additional safety requirements –** Additional plugged port located opposite the RLPO unit that can be used for a second RLPO unit.



Potentiometer Linear Motion

Compact linear motion potentiometer features long life with high resolution conductive plastic element. Shaft spring to ensure the shaft is fully extracted for repeatability and reliability.

Operating information

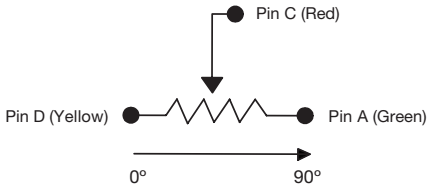
Operating temperature range:	-13°F to 221°F (-25°C to 105°C)
Storage temperature:	-40°F to 257°F (-40°C to 125°C)
IP protection grade	IP67
Connector material:	Stainless steel
Connector type:	4 pin w/ 7/8-20 UNEF (based on MIL-DTL-5015)

Specifications

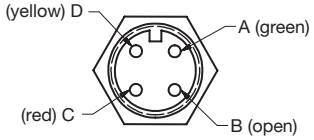
Electrical	
Resistance values	10 K ohms
Resistance tolerance (standard)	± 15%
Linearity tolerance (standard)	± 2%
Resolution	Essentially infinite (<0.01 mm)
Output smoothness	< 0.1% against input voltage
Power @ 40°	0.2W
Temperature coefficient of element	40 ppm/K
Contact resistance variation	< 2%
Insulation resistance	> 1,000 Mohm @ 500 VDC
Dielectric strength	1 minute @ 500 VAC
Maximum wiper current	1mA
Recommended wiper current	< 1µA

Mechanical	
Mechanical stroke (mm)	7.0
Life expectancy, shaft cycles	20 million
Vibration	15 g/10 Hz to 2,000 Hz
Shock	50 g/11ms

Wiring Diagram



Receptacle Pin Layout



	Resistance (KΩ)	
Typical valve position	Pin D - common Pin A - positive Across D to C	Pin D - positive Pin A - common Across A to C
0°	7.2	2.9
90°	1	9.2

C
Sensors and Feedback

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Pneumatic Division
Wadsworth, Ohio
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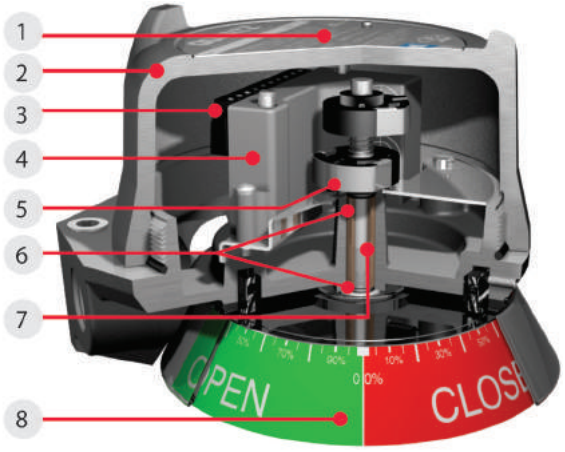
StoneL® Valve Communication Solutions

Quartz

Dual module solid state or 4-20 mA position feedback

The StoneL Quartz series is durable, corrosion-resistant, and versatile, making it ideal for most of your process valve monitoring requirements. The robust epoxy coated anodized aluminum construction makes this platform extremely durable and well suited for use in corrosive, heavy wash down environments. This versatile platform adapts to a wide variety of valve systems. The QX explosion proof version is offered as the standard that will be provided from the factory fully mounted and positioned. Nonincendive and intrinsically options are available upon request.

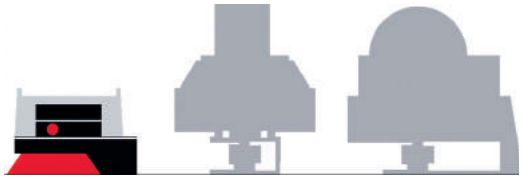
The explosion-proof, water tight and corrosion-resistant enclosure is approved for use in div. 1/zone 1 hazardous areas.



1. **Enclosure optimized for environment –** Explosion proof, water tight and corrosion resistant cover
2. **Rapid enclosure access –** Screw-on cover allows quick enclosure access, saving you valuable maintenance and set-up time. The cover provides a vapor tight seal and allows entry to internal components in less than five seconds.
3. **Faster wiring –** Pre-wired and labeled terminal strip enables quick, convenient attachment of field wires.
4. **Wide variety of switching & communication –** Dual module sensors and communication standard, as well as, continuous signal output available in a 4 to 20 mA position transmitter.
5. **Quick set cams are easy to adjust –** Touch and tune switch settings allow you to make adjustments in seconds without the use of tools.
6. **Dual shaft o-ring seals eliminate corrosion –** Top inner and bottom outer shaft o-rings seal the drive bushing from both external corrosives and internal contaminants that enter the enclosure.
7. **Special drive bushing assures long cycle life –** The oil impregnated bronze bushing maintains smooth operation and eliminates the potential for shaft seizure due to actuator shaft eccentricity.
8. **Space saving visual indication –** Visual indicator offers excellent view ability without sacrificing accessibility or adding to space requirements.

Space saving low profile design

Clearance above the actuator is critical in complex piping systems. The Quartz series clearly displays valve position and encloses all electrical components in an explosion proof compartment with less than 5” clearance requirement.



For more information regarding this product series please visit StoneL’s website – ***www.StoneL.com***

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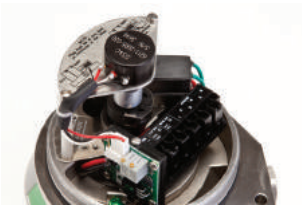
StoneL Valve Communication

Dual module system

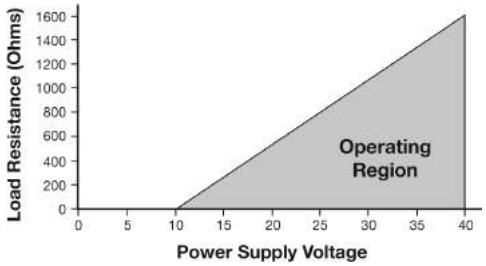
The Quartz series is available with the dual module as one of its various configurations. Two solid state sensors and/or communications and other electronics are sealed in for the ultimate in reliability and convenience.

Position transmitter - 4 to 20 mA

Position transmitters provide a precise 4 to 20 mA signal on a two-wire DC loop. Control valves and dampers are accurately monitored through their range of travel offering assurance of exact valve position at all times.



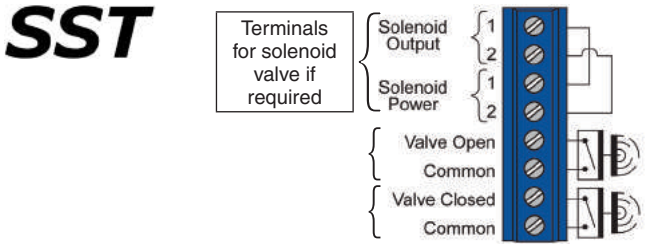
Load Curve



Specifications - Switching and sensors

SST switching sensors (C)	
Configuration	(2) SST solid state sensors Wire termination for one solenoid
Operation	NO/NC (cam selectable)
Maximum current inrush	2.0 amps @ 125 VAC / VDC
Maximum current continuous	0.3 amps @ 125 VAC / VDC
Minimum on current	2.0 mA
Maximum leakage current	0.5 mA
Voltage range	8 to 125 VDC 24 to 125 VAC
Maximum voltage drop	6.5 volts @ 10 mA 7.0 volts @ 100 mA

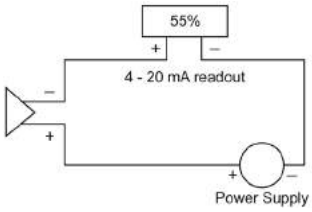
Wiring diagram (C)



Specifications - Position transmitter

Position transmitter (D, E)	
Output	2-wire 4 to 20 mA
Supply source	10 to 40 VDC
Span range	35° to 270° (adjustable) Consult factory for special requirements
Maximum loading	700 ohmn @ 24 VDC
Linearity error	+/- 0.85" maximum
Cycle life	2 million rotations
Vibration tolerance	Acceptable

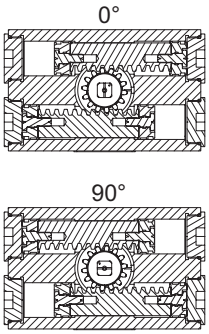
Electrical schematic



Visual Indicators

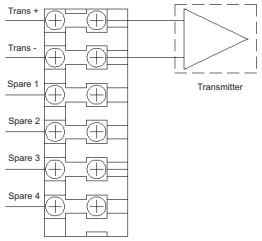
Available with the Quartz Series or as a stand-alone unit. Clearly view valve position status from up to 75 feet. The indicator's rugged polycarbonate construction makes it resistant to physical damage and tolerant to most corrosives.

0°	90°
RED CLOSED	GREEN OPEN

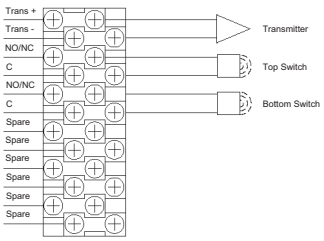


Wiring diagram (D, E)

Position Transmitter



Position Transmitter and Switches



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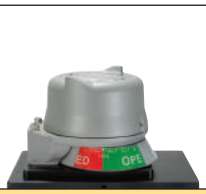
Feedback Options Table		A, B	C	D	E
					
Description		RLPO Potentiometer	StoneL Quartz, SST dual module	StoneL Quartz, 4-20 mA position transmitter	StoneL Quartz, SST dual module with 4-20 mA position transmitter
Replacement kit part numbers (SENSOR ONLY)		PSK-HUB018-502P	PSK-HUB018-512P	PSK-HUB018-522P	PSK-HUB018-532P
Upgrade kit part numbers - conversion from an existing actuator with no feedback to one with feedback			PSK-HUB018-514P	PSK-HUB018-524P	PSK-HUB018-534P
			PSK-HUB075-514P	PSK-HUB075-524P	PSK-HUB075-534P
			PSK-HUB100-514P	PSK-HUB100-524P	PSK-HUB100-534P
Max electrical load		0.2W @ 70°C	0.3A @ 125 VAC/VDC	700 Ohms @ 24 VDC	Same option as C & D
Sensor technology		Potentiometer	Solid State Sensors	Potentiometer	Solid State Sensors with Potentiometer
Input		10-40 VDC	8-125 VDC, 24-125 VAC	10-40 VDC	Same option as C & D
Output		0-40V range (FRP)	EOS	4-20 mA signal on two wire DC loop (FRP)	Same option as C & D
Connection		4 pin, 7/8"-20 UNEF	Terminal block thru 3/4" & 1/2" NPT conduit holes		
Approvals / Compliance Standards	IP67	●	●	●	●
	Intrinsically safe			●	
	Explosion proof		●	●	●
	Other	NEMA 4, 4X & 6	NEMA 4, 4X & 6	NEMA 4, 4X & 6	NEMA 4, 4X & 6
Temp Range		-13°F to 221°F (-25°C to 105°C)	-40°F to 176°F (-40°C to 80°C)	-40°F to 176°F (-40°C to 80°C)	-40°F to 176°F (-40°C to 80°C)
Visual Indication Options Available with each Feedback Option	Line on shaft	●			
	green on/ red off	Consult factory	●	●	●

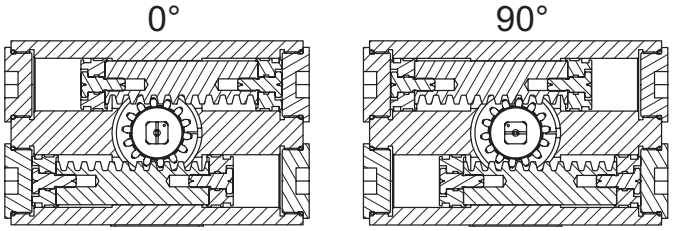
Note: Cables are not available for purchase.

FRP = Full Range Position

EOS = End of Stroke

Visual Indicator Options Table		C
		
Description		Color indicator
Replacement kit part number (VISUAL INDICATOR ONLY)		PSK-HUB018-702P*
Upgrade kit part numbers - conversion from an existing actuator with no visual indicator to one with visual indicator		PSK-HUB018-704P
		PSK-HUB075-704P
		PSK-HUB100-704P

*Visual indicator replacement kit does not include bracket or hardware.



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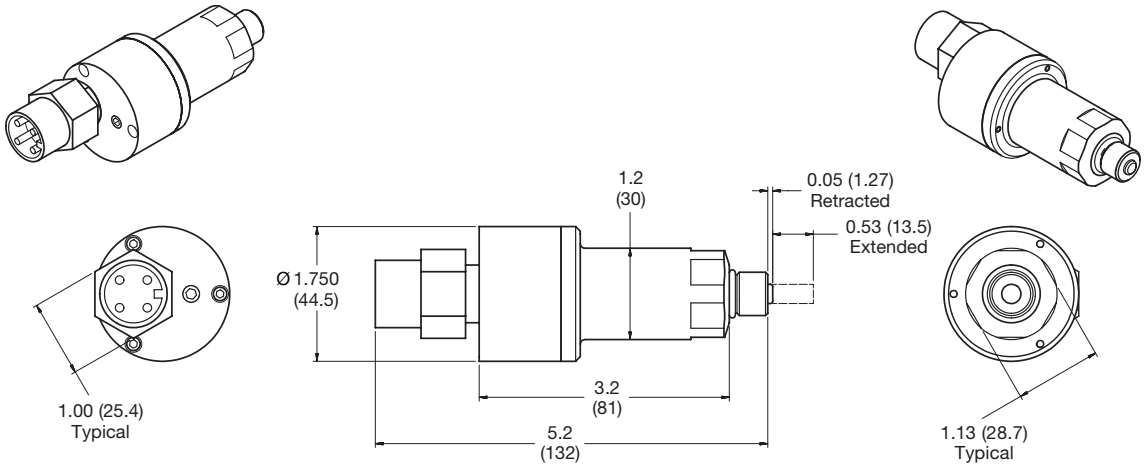
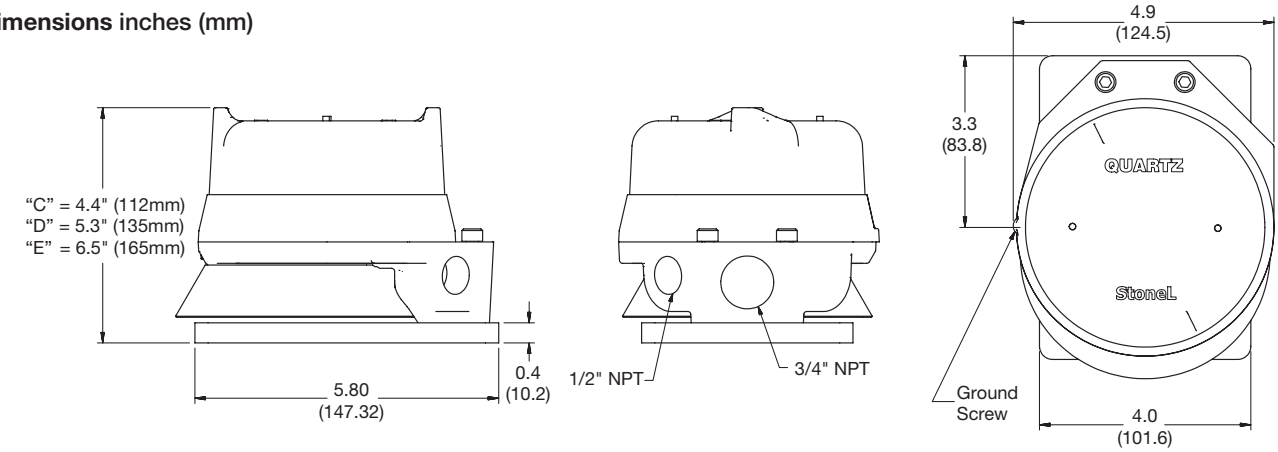
Rotary Linear Potentiometer
(Feedback option A & B)



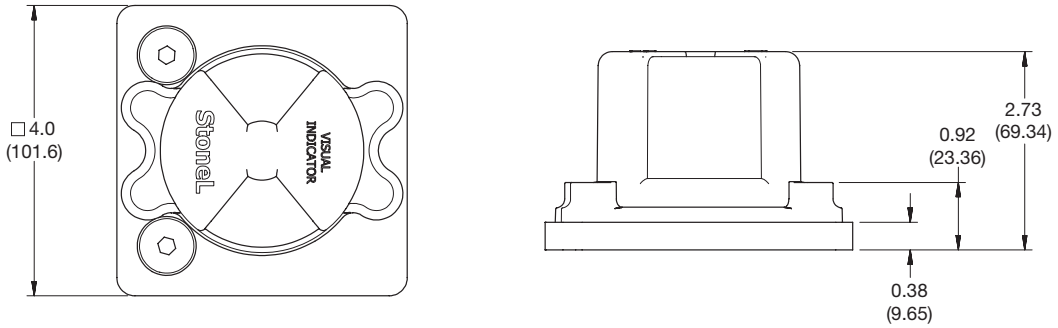
StoneL - Quartz
(Feedback option C, D & E)

Dimensions inches (mm)



NOTE: Cover height varies based on model number.

StoneL - stand alone visual indicator
(Visual Indication option C)



C
Sensors and Feedback

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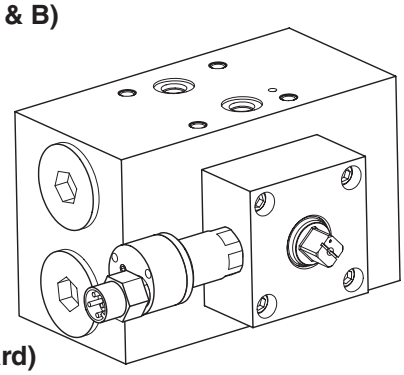
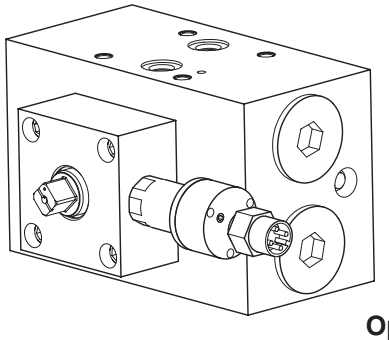
Rotary Linear Potentiometer
(Feedback option A & B)

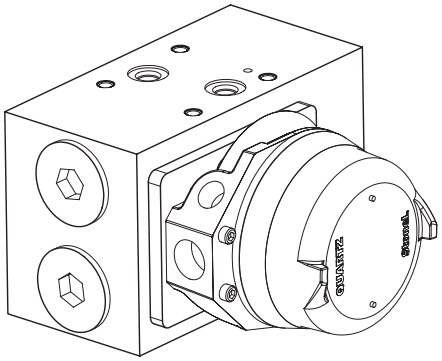


Option A (Standard)

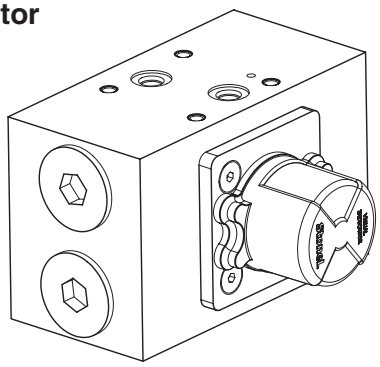


Option B

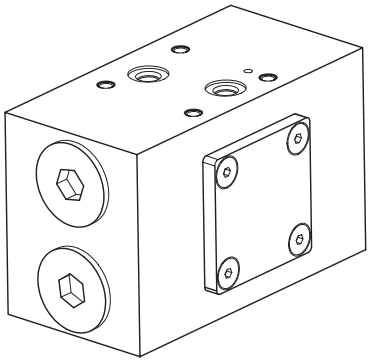
StoneL - Quartz
(Feedback option C, D & E)



StoneL Stand Alone Visual Indicator
(Feedback option Z and Visual indicator option C)



No Visual Indicator
(Feedback option Z and Visual indicator option Z)



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Engineering Guidelines

Reprinted from Bul. 0292-B1 Design Engineer's Handbook, Vol. 1 - Hydraulics.

Printed in The United States of America

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www.parker.com/pneu/rotary

A	Area
d	Diameter
F	Force
g_c	Gravitational constant (386 in/sec^2)
I	Mass mount of inertia
m	Mass
P	Pressure
P_C	Average cushion pressure
P_r	Relief valve pressure
Q	Volumetric flow rate
r	Radius
r_b	Bearing radius
t	Time
T	Torque
T_α	Angular acceleration torque
T_{α^*}	Angular deceleration torque
T_C	Cushion torque
T_D	Demand torque
T_f	Friction torque
V	Volume displacement
V_s	Specific Volume in terms of in^3 per radian
W	Weight
x	Distance or position
α	Angular acceleration
μ	Coefficient of friction
θ	Angular displacement or rotation
ω	Angular velocity
ω_o	Angular velocity at time = o
ω_t	Angular velocity at time = t

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Rotary Actuators

Introduction

A rotary actuator is the most compact device available for producing torque from hydraulic or pneumatic pressure. A self-contained unit, it is usually limited to one revolution or less and can provide oscillating motion as well as high and constant torque. Figure 1 shows the standard symbol for pneumatic and hydraulic rotary actuators.

There are many types of rotary actuators, each with design advantages as well as compromises. The three most commonly used are rack and pinion, vane, and helical. These type actuators are compared in Table 3 on page D7.

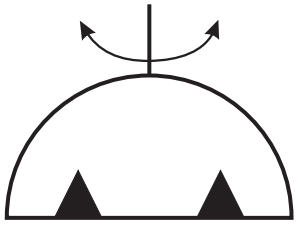

Figure 1 Hydraulic rotary actuator symbol

Types of Rotary Actuators

Rack and Pinion

Rack and pinion actuators consist of a housing to support a pinion which is driven by a rack with cylinder pistons on the ends (see Fig. 2). Theoretical torque output T, is the product of the cylinder piston area A, operating pressure P, and the pitch radius of the pinion r_p.

Equation 1) $T = PAr_p$

Single, double, or multiple rack designs are possible and overall efficiencies for rack and pinion units average 85 to 90%. Because standard cylinder components can be used to drive the rack, many standard cylinder features can be incorporated into rack and pinion actuators, such as cushions, stroke adjusters, proximity switches, and special porting. Additionally, virtually leakproof seals will allow the actuator to be held in any position under load.

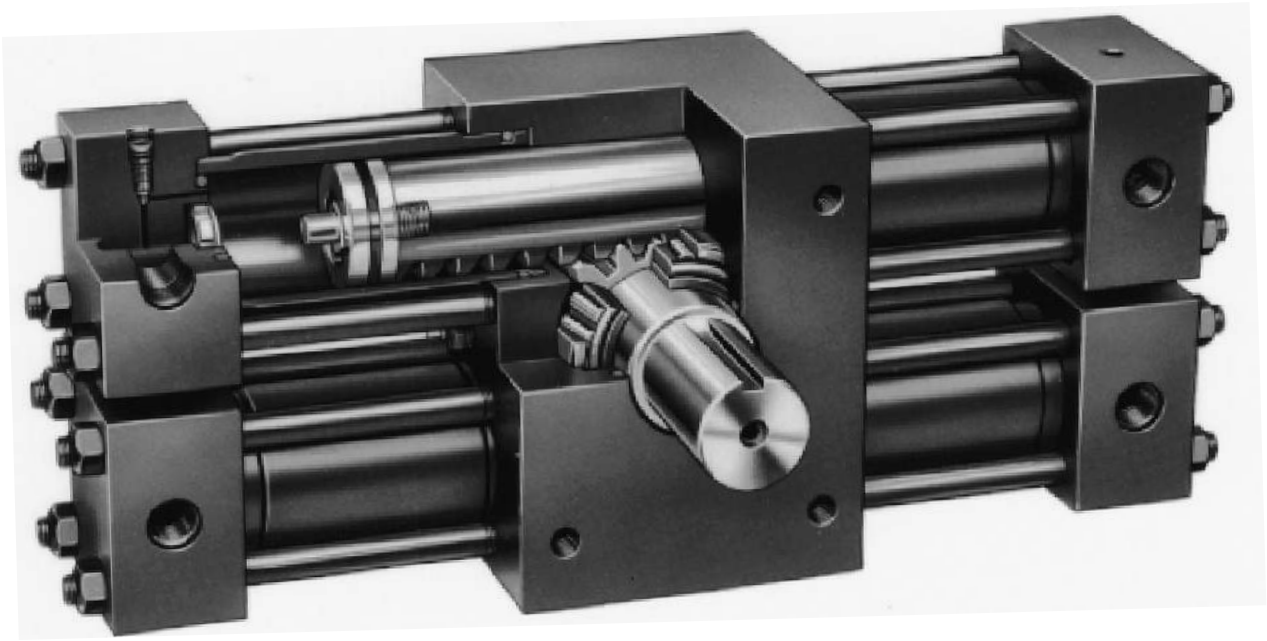

Figure 2 Rack and pinion type rotary actuator, double rack design

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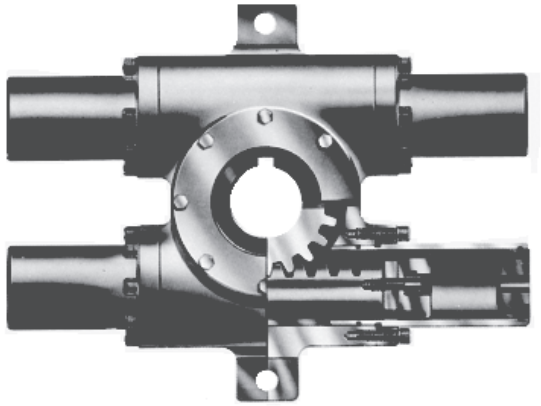

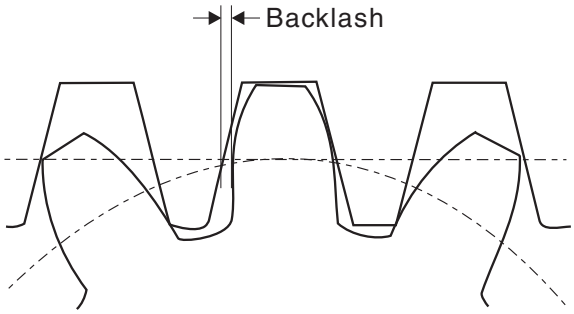

Figure 4 Gear backlash affects position accuracy

NOTE: Some systems require a mechanical locking device for safety reasons, or for holding loads over extended periods of time.

Both tie-rod and mill cylinder type (Fig. 3) constructions are available, and most types allow for service of all pressure containing seals without removing the unit from its mounting.

Rack and pinion actuators cover the widest range of torque, from 0.9 N•m *(8 in-lb)* pneumatic to over 5,630,630 N•m *(50,000,000 in-lb)* in hydraulic units. Because of their construction, they are not limited to 0.2π rad *(360 degrees)* of rotation, but rather can be built to as much as 10π rad *(1800 degrees)* (five revolutions). The majority of rack and pinion style actuators are sold for hydraulic service, generally 34 to 207 bar *(500 to 3000 psi)*.

Position repeatability in rack and pinion actuators is affected by the inherent backlash found in any gear arrangement. Backlash is the amount by which the width of a tooth space exceeds the thickness of the mating tooth and can be as much as π/360 *(0.5 degrees)* on smaller size units (Fig. 4). It should be noted, however, that this backlash can be reduced to almost nothing by preloading the rack into the pinion, but efficiencies will suffer to overcome the added friction.

Since the load ratings of the bearings used to support the pinion are large in comparison to the internal loading of the unit, extra bearing capacity is usually available. This can eliminate the need for machine support bearings, or handle overhung and thrust loads which would be detrimental to other types of rotary actuators. In other applications, a hollow pinion is used, which eliminates the need for a coupling and support brackets because the actuator can be mounted directly onto the input shaft.

Table 1: Rotary Actuator Applications

General Industry
Camming, indexing, clamping, positioning, tensioning, braking, tilting, etc.

Material Handling
Switching conveyors, turning and positioning container clamps on lift trucks, tensioning and guiding, operating valves, braking, lifting

Robotics
Rotation and positioning

Marine
Opening and closing hatches, swinging cargo handling gear, opening and closing fire and collision bulkhead doors, operating large valves of all types, positioning hydrofoils, steering control

Steel
Upending coils, turnstiles, rollover devices, tilting electric furnaces, indexing transfer tables, charging furnaces

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In general, rack and pinion actuators have a thin profile, but are not as physically compact as other styles of rotary actuators, and are usually slightly more expensive than vane actuators of equivalent torque output.

Vane

Vane style actuators consist of one or two vanes attached to a shaft (called the rotor), which is assembled into a body, and then held in place by two heads (Fig. 5). Rotation of single vane units is generally limited to 4.9 rad (280 degrees) by a fluid barrier (called a stator). Double vane units are limited to 1.7 rad (100 degrees) because two stators are required at opposite ends. The operating medium (air or oil) is ported across the shaft in double vane style actuators to eliminate the need for four ports. Fluid pressure acting on the exposed vane surface produces an output torque, shown in Equation 2:

Equation 2) $T = LWP$

Where the torque T is equal to the product of the vane length L, times the vane width W, times the system pressure P, times the radial distance r from the center of the rotor to the vane pressure center. Of course, a double vane style actuator will have twice the area of a single vane style actuator, and therefore twice the torque.

Available industry sizes range from a minimum of 1.4 N•m *(12 in-lb)* with small pneumatic actuators to a maximum of 84460 N•m *(750,000 in-lb)* with high pressure hydraulic actuators.

Vane style actuators have no backlash, but because of the seal configuration, cannot hold position without pressure being applied. The vane seal typically has sharp corners to seal in the body/head interface. Since this corner cannot be sealed completely, there is always a slight bypass flow. There is additional bypass flow in the shoulder area of the vane, so even rounding the vane at the top does not completely eliminate leakage. Vane actuators require external stops to prevent damage to the vane and stator, especially for high inertia and high speed applications.

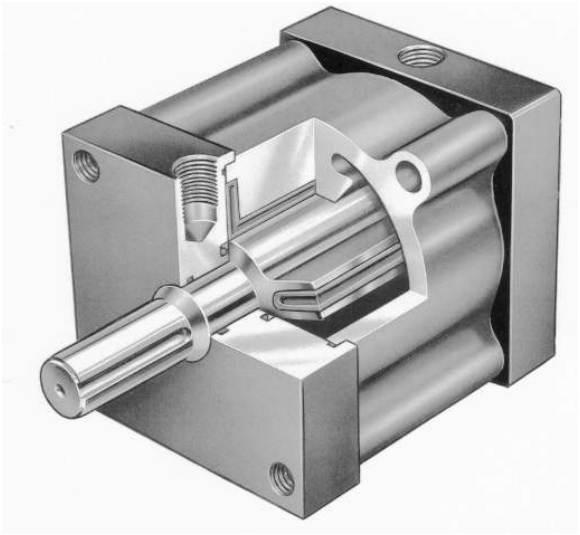

Figure 5 Vane type rotary actuaor

Vane actuators are very compact devices and are typically less expensive than rack and pinion units of equivalent torque and pressure. Units are available with and without external shaft load capacity.

Vane actuators can be segmented into three general product lines:

1) Small pneumatic actuators for small parts handling, fixturing, etc.
2) 69 bar *(1000 psi)* hydraulic actuators for machine tool, automotive equipment, and transfer lines.
3) 207 bar *(3000 psi)* actuators for the mobile equipment industry.

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Helical

Helical actuators consist of a piston sleeve, which functions similarly to a cylinder piston, and a rotating output shaft encased in a cylinder type housing (See Fig. 7). The linear motion of the piston sleeve produces rotary motion of the output shaft through the male helix cut on the shaft and a fixed helical nut. The torque output is proportional to the helix angle, system pressure, piston area, and the mean pitch radius of the helical shaft.

Helix designs provide maximum torque output for the smallest possible cross section. Double helix designs are also available to reduce the length of the unit or double the torque output.

Helical units are generally the most expensive rotary actuators but also the most compact. They do have backlash and can be made self-locking with special helix designs. Helical units can be hydraulically or pneumatically operated and are available from 2.3 to 450,451 N•m *(20 in-lb to 4,000,000 in-lb)* of torque.

Helical Type Actuators

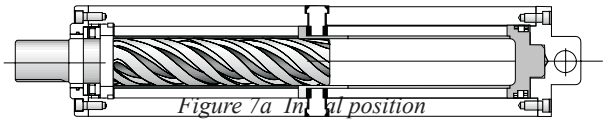

Figure 7a Initial position

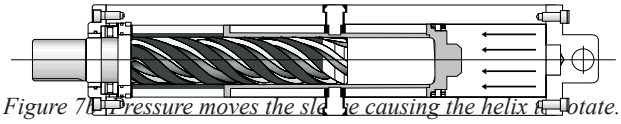

Figure 7b Pressure moves the sleeve causing the helix to rotate.

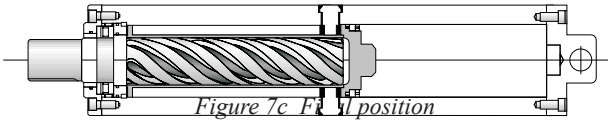

Figure 7c Final position

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Table 2: Rotary Actuator Comparison Chart

Feature	Rack & Pinion	Vane	Helical
Load holding ability	Leakproof cylinder seals allow holding of load in any position.	Square vane seals and shoulder seals always have slight bypass flow.	Leakproof cylinder seals will allow holding of load in any position.
Positioning	Inherent backlash of rack and pinion cause position tolerance up to 1/2°.	Zero backlash allows for exact positioning anywhere in the rotation.	Some backlash, but can be made locking with special helix designs.
Efficiency (hydraulic)	90% is average	75-80% is average	60% is average
Stops	External stops usually not required.	Internal stops available for some light duty applications; majority of applications require positive external stops.	External stops usually not required.
Cushions	Standard cylinder cushions be used.	Typically no cushions available. Parker HRN Series offers these.	Consult manufacturer
Size	Thin profile but larger overall space and weight requirements	Very compact, especially cross section	The most compact cross section for a given torque
Maintenance	Maintenance of pressure seals possible without complete disassembly of unit.	Maintenance of vane requires disassembly of unit.	Maintenance of seals requires disassembly of unit.
Mounting	Mounting styles include lug, foot, face, base, flange or shaft mounting with hollow pinion.	Mounting styles include base, foot, face or flange mounting.	Mounting styles include foot, flange or body mounting.
Operating Medium	Air or hydraulic operation	Air or hydraulic operation	Air or hydraulic operation
Available Rotation	90°, 180° and 360° standard, specials to 1800°	280° maximum single vane unit, 100° maximum double vane unit	Consult manufacturer; specials made to order
Price	Generally more expensive than equivalent torque vane units	Generally less expensive than equivalent torque rack and pinion units	Generally much more expensive than equivalent rack and pinion units

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Design torque

Design torque represents the maximum torque that an actuator must supply in an application. This maximum is the greater of the Demand Torque or the Cushion Torque. If the demand torque exceeds what the actuator can supply, the actuator will either move too slowly or stall. If the cushion torque is too high, the actuator may be damaged by excessive pressure. Demand torque and cushion torque are defined below in terms of load, friction, and acceleration torque.

Equations for calculating demand torque and cushion torque for some general applications are provided on the following pages.

T - Torque

The amount of turning effort exerted by a rotary actuator.

T_D - Demand Torque

This is the torque required from the actuator to do the job and is the sum of the load torque, friction torque, and acceleration torque, multiplied by an appropriate design factor. Design factors vary with the applications and the designers' knowledge.

Equation 3) $T_D = T_\alpha + T_f + T_L$

T_L - Load torque

This is the torque required to equal the weight or force of the load. For example, in Fig. 8a, the load torque is 563 N•M *(5000 in-lb)*; in Fig. 8b the load torque is zero; in Fig. 8c the load torque is 563 N•m *(5000 in-lb)*. The load torque term is intended to encompass all torque components that aren't included in the friction or acceleration terms.

T_f - Friction torque

This is the torque required to overcome friction between any moving parts, especially bearing surfaces. In Fig. 8a, the friction torque is zero for the hanging load; in Fig. 8b the friction torque is 775 N•m *(6880 in-lb)* for the sliding load; in Fig. 8c the friction torque is zero for the clamp.

Equation 4) $T_f = \mu W r$

T_α - Acceleration Torque

This is the torque required to overcome the inertia of the load in order to provide a required acceleration or deceleration. In Fig. 8a the load is suspended motionless so there is no acceleration. In Fig. 8b, the load is accelerated from 0 to some specified angular velocity. If the mass moment of inertia about the axis of rotation is I and the angular acceleration is α, the acceleration torque is equal to $I\alpha$. In Fig. 8c there is no acceleration.

Some values for mass moment of inertia are given in Table 3. Some useful equations for determining α are listed in Table 5. Equation 5 below shows the general equation for acceleration torque.

Equation 5) $T_\alpha = I\alpha$

T_C - Cushion Torque

This is the torque that the actuator must apply to provide a required deceleration. This torque is generated by restricting the flow out of the actuator (meter-out) so as to create a back pressure which decelerates the load. This back pressure (deceleration) often must overcome both the inertia of the load and the driving pressure (system pressure) from the pump. See applications.

Equation 6) $$T_C = T_{\alpha *} + \frac{P_r V}{\theta} - T_f \pm T_L$$

The friction torque T_f reduces the torque the actuator must apply to stop the load. The load torque T_L may add to, or subtract from the torque required from the actuator, depending upon the orientation of the load torque. For example, a weight being swung upward would result in a load torque that is subtracted.

Warning: Rapid deceleration can cause high pressure intensification at the outlet of the actuator. Always insure that cushion pressure does not exceed the manufacturer's pressure rating for the actuator.

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Demand Torque Examples

A) Due to load torque
The load is held motionless as shown.

$T_D = T_\alpha + T_f + T_L$

$T_\alpha = 0$

$T_f = 0$

$T_L = (500\ lb)(10\ in) = 5{,}000\ in\text{-}lb$

$T_D = 5{,}000\ in\text{-}lb$

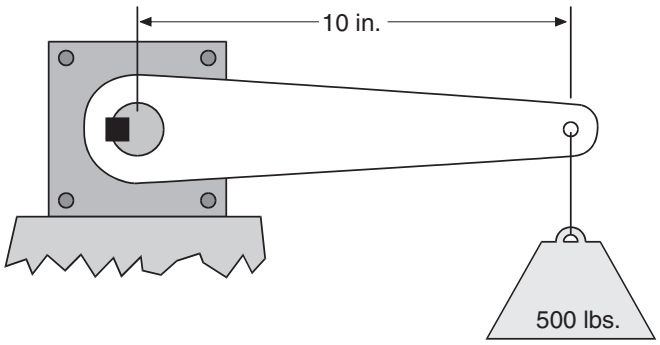

Figure 8a

B) Due to friction and acceleration
The 500 lb rotating index table is supported by bearings with a coefficient of friction of .25. The table's acceleration α is 2 rad/sec^2. The table's mass moment of inertia I is 2,330 in-lb-sec^2.

$T_D = T_\alpha + T_f + T_L$

$T_\alpha = I\alpha = (2{,}330\ in\text{-}lb\text{-}sec^2)(2/sec^2) = 4{,}660\ in\text{-}lb$

$T_f = \mu W r_b = 0.25\ (500\ lb)(55\ in) = 6{,}880\ in\text{-}lb$

$T_L = 0$

$T_D = 4{,}660\ in\text{-}lb + 6{,}880\ in\text{-}lb = 11{,}540\ in\text{-}lb$

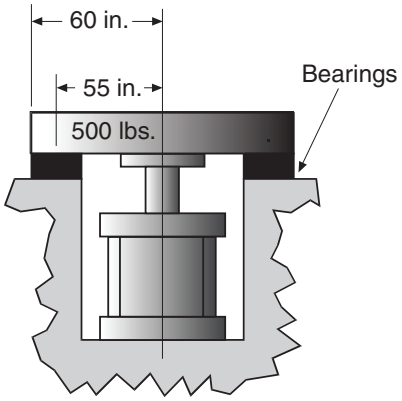

Figure 8b

C) Due to load torque

$T_D = T_\alpha + T_f + T_L$

$T_\alpha = 0$

$T_f = 0$

$T_L = (10\ in)\ (500\ lb) = 5{,}000\ in\text{-}lb$

$T_D = 5{,}000\ in\text{-}lb$

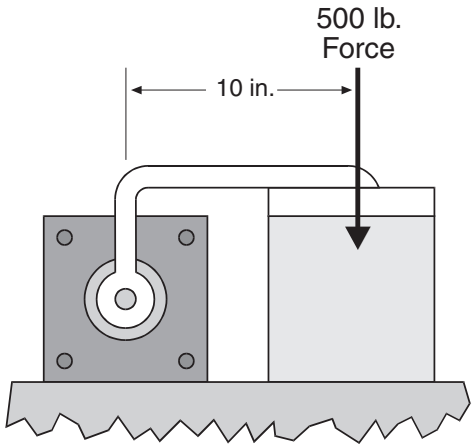

Figure 8c

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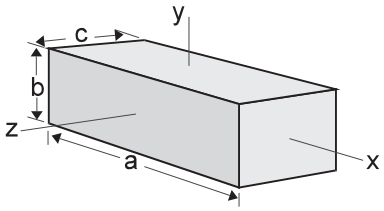
Table 3: Mass Moments of Inertia

Rectangular prism

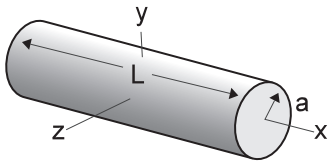
$$I_x = \frac{1}{12} m\left(b^2 + c^2\right)$$

$$I_y = \frac{1}{12} m\left(c^2 + a^2\right)$$

$$I_z = \frac{1}{12} m\left(a^2 + b^2\right)$$



Circular cylinder



$$I_x = \frac{1}{2} ma^2$$

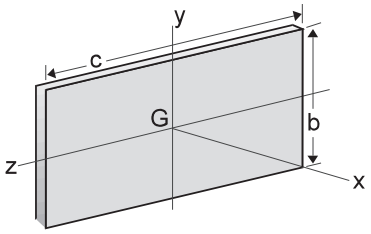
$$I_y = I_z = \frac{1}{12} m\left(3a^2 + L^2\right)$$

Thin rectangular plate

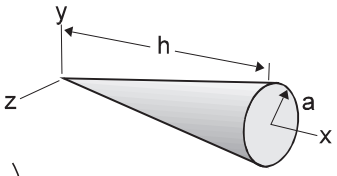
$$I_x = \frac{1}{12} m\left(b^2 + c^2\right)$$

$$I_y = \frac{1}{12} mc^2$$

$$I_z = \frac{1}{12} mb^2$$



Circular cone

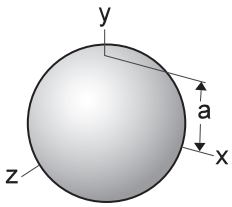


$$I_x = \frac{3}{10} ma^2$$

$$I_y = I_z = \frac{3}{5} m\left(\frac{1}{4} a^2 + h^2\right)$$

Sphere

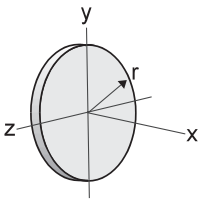
$$I_x = I_y = I_z = \frac{2}{5} ma^2$$



Thin disk

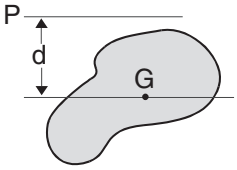
$$I_x = \frac{1}{2} mr^2$$

$$I_y = I_z = \frac{1}{4} mr^2$$



Parallel Axis Theorem:

$$I_p = \bar{I} + md^2$$



I_p = Mass moment of inertia about an axis parallel to a centroidal axis

$\bar{I}$ = Mass moment of inertia about a centroidal axis

m = Mass

d = Distance between axes

When acceleration is constant:

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\theta = \omega_0 t + \frac{1}{2} \omega_t t$$

$$\omega = \omega_0 + \alpha t$$

$$\omega = \left(\omega_0^2 + 2\alpha\theta\right)^{1/2}$$

$$\alpha = \frac{2\theta}{t^2}$$

$$\alpha = \frac{(\omega_t - \omega_0)^2}{2\theta}$$

$$\alpha = \frac{(\omega_t - \omega_0)}{t}$$

When velocity is constant:

$$\theta = \omega t$$

t = *time*

θ = *angular position*

ω_t = *angular velocity at time = t*

ω_0 = *angular velocity at time = 0*

α = *angular acceleration*

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Applied Torque Examples

NOTES:

1. The following equations are intended only as a guide. The design engineer should verify the accuracy of the equations and insure that all performance, safety and warning requirements of the application are met.
2. Unless specified otherwise, the following examples do not take into account actuator efficiency, system efficiency, friction or needed safety factors.
3. Deceleration torques are based upon the assumption that restrictor type flow controls force the pump to exert maximum pressure during deceleration. This is denoted as P_r.
4. Symbol followed by * indicates a deceleration.

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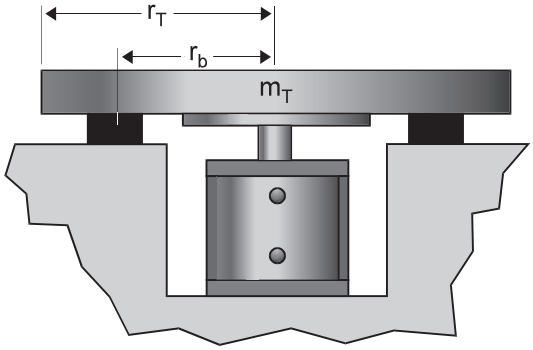
Round Index Table



A round index table that must overcome bearing friction and inertia. Assumptions, see notes 1, 2, and 3.

$$T_D = T_\alpha + T_f + T_L$$

T_L = 0, no load

$T_f = \mu W_1 r_b$, where $W_1 = m_1 g_C$

$T_\alpha = I_1 \alpha$

$$I_1 = \frac{1}{2} m_1 r_1^2$$

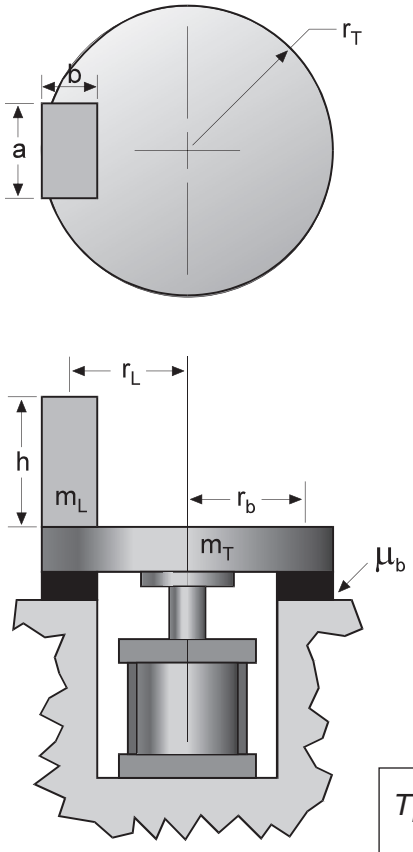
$$T_C = \frac{P_r V}{\theta} + T_{\alpha^*} - T_f \pm T_L$$

$$P_C = T_C \left[\frac{\theta}{V}\right]$$

$$T_D = \frac{1}{2} m_1 r_1^2 \alpha + \mu W_1 r_b$$

$$T_C = \frac{1}{2} m_1 r_1^2 \alpha + I_1 \alpha$$

Rotary Index Table with Rectangular Load



An index table rotating in a horizontal plane with a rectangular box. It must overcome bearing friction and inertia. Assumptions, see notes 1, 2, and 3.

$$T_D = T_\alpha + T_f + T_L$$

T_L = 0, no load

$T_f = (W_T + W_L) r_b \mu_{b,}$

where $W_T = m_T g_C$, $W_L = m_L g_C$

$T_\alpha = (I_T + I_L)\alpha$

$$I_T = \frac{1}{2} m_T r_T^2$$

$$I_L = \frac{1}{12} m_L (a^2 + b^2) + m_L r_L^2$$

$$T_C = \frac{P_r V}{\theta} + T_{\alpha^*} - T_f \pm T_L$$

$T_{\alpha^*} = (I_T + I_L)\alpha^*$

$$P_C = T_C \left[\frac{\theta}{V}\right]$$

$$T_D = (W_T + W_L) r_b \mu_b + \alpha \left[\frac{1}{2} m_T r_T^2 + \frac{1}{12} m_L (a^2 + b^2) + m_L r_L^2\right]$$

$$T_C = (\alpha + \alpha^*) \left[\frac{1}{2} m_T r_T^2 + \frac{1}{12} m_L (a^2 + b^2) + m_L r_L^2\right]$$

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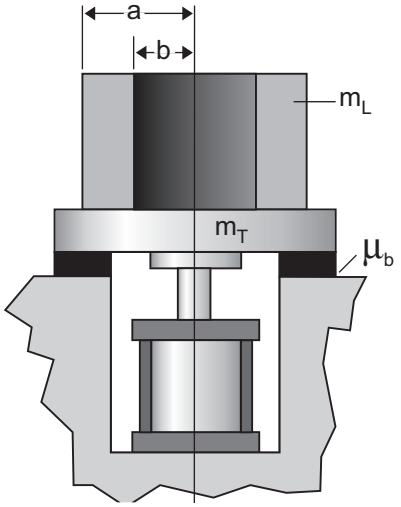
Rotary Index Table with Cylindrical Load



An index table rotating in a horizontal plane with a cylindrical load. It must overcome bearing friction and inertia. Assumptions, see notes 1, 2, and 3 on page D4-D12.

$$T_D = T_\alpha + T_f + T_L$$

T_L = 0, no load

$$T_f = (W_T + W_L) r_b \mu_b,$$

$$T_\alpha = (I_T + I_L)\alpha$$

$$I_T = \frac{1}{2} m_T r_T^2$$

$$I_L = \frac{1}{2} m_L (a^2 - b^2)$$

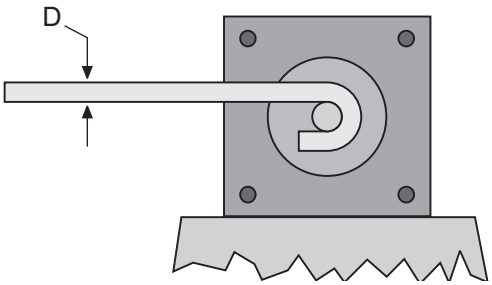
$$T_C = \frac{P_r V}{\theta} + T_{\alpha^*} - T_f \pm T_L \qquad P_C = T_C \left[\frac{\theta}{V}\right]$$

$$T_\alpha{}^* = (I_T + I_L)\alpha^*$$

$$T_D = (W_T + W_L) r_b \mu_b + \frac{\alpha}{2} [m_T r_T{}^2 + m_L (a^2 - b^2)]$$

$$T_C = \frac{1}{2} (\alpha + \alpha^*) [m_T r_T^2 + m_L (a^2 - b^2)]$$

Wire or Round Tube Bending



Bending tube or wire, no acceleration or friction concerns.

No acceleration, $T_\alpha = 0$
No friction, $T_f = 0$

$$T_D = T_L$$

$$T_L = \sigma_y \frac{I}{c}$$

σ_y = yield stress of the material (available from mechanical engineering texts)

$\frac{I}{c}$ = section modulus of the tube or wire (can be calculated or found in materials handbooks)

D = Outer diameter of wire or tube

d = Inside diameter of tube

Round tubing: $$T_D = \frac{\pi}{32} \left(\frac{D^4 - d^4}{D}\right) \sigma_y$$

Round wire: $$T_D = \frac{\pi \sigma_y D^3}{32}$$

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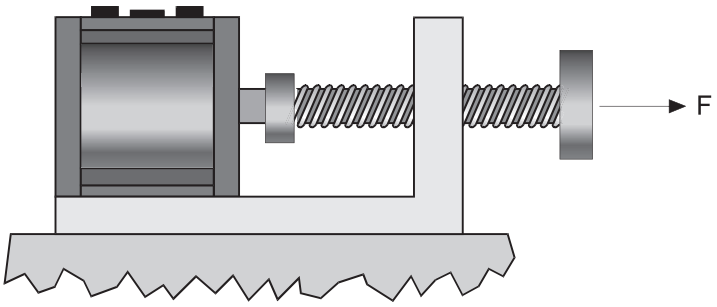
Screw Clamping

Screw clamp with no acceleration, neglecting friction.



$$T_D = T_\alpha + T_f + T_L$$

$$T_\alpha = 0$$

$$T_f = 0$$ *see note below

$$T_L = \frac{Fp}{2\pi}$$

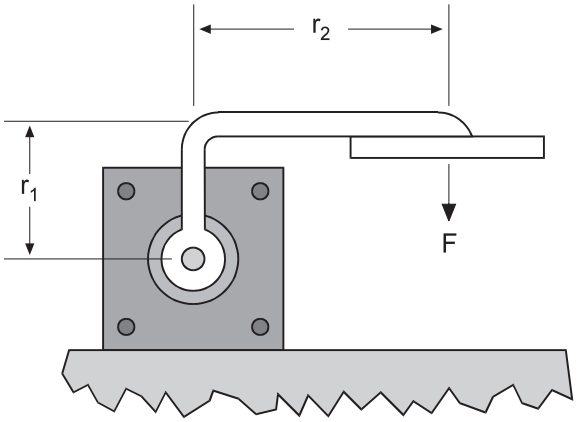
p = threads per inch

F = clamping force

*Friction torque could vary significantly based upon screw type, lubrication type, and bearings. To better approximate screw friction torque consult a machine design handbook.

Simple Clamp

A simple clamping mechanism with no friction or acceleration.



$$T_D = T_\alpha + T_f + T_L$$

$$T_\alpha = 0$$

$$T_f = 0$$

$$T_L = Fr_2$$

This clamping mechanism may be suitable for holding down parts for assembly, but does not have the mechanical advantage or the linear motion provided in the next two examples.

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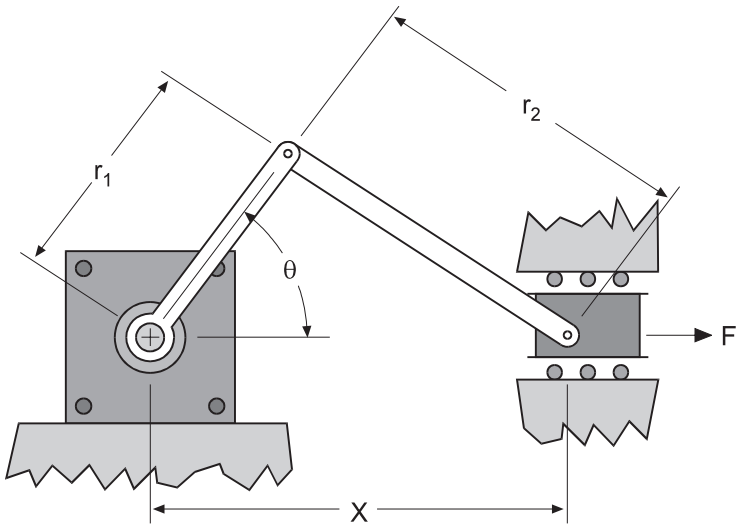
Linear Motion, Clamping

This type of clamp is characterized by a long stroke and a high clamping force as θ approaches zero.*



$$T_D = T_\alpha + T_f + T_L$$

$$T_\alpha = 0$$

$$T_f = 0$$

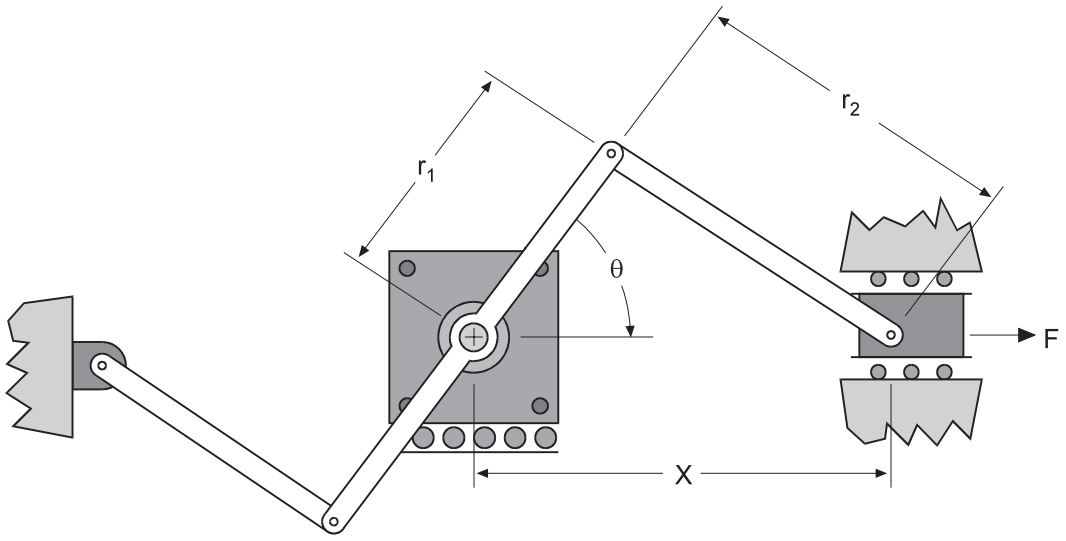
$$T_L = \frac{Fr_1}{2}\left[\frac{\sin 2\theta}{x - r_1 \sin\theta} + 2\sin\theta\right]$$

$$x = r_1 \cos\theta + \sqrt{r_2^2 - r_1^2 \sin^2\theta}$$

*To maintain control, θ should never be allowed to equal zero. Also, the force F should not be allowed to exceed the actuator's bearing capacity.

Improved Linear Motion, Clamping

Same as above, except that force is not limited by the actuator's bearing capacity.



*To maintain control, θ should never be allowed to equal zero.

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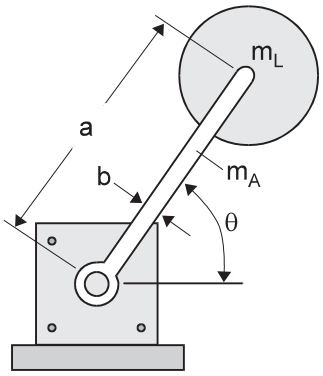
Overcenter Load



The load is rotated in a vertical plane. Load torque T_L is positive or negative depending upon position and direction of rotation. If the load resists the actuator's rotation, then T_L is positive. The mass m_L is free to rotate about its center.

$$T_D = T_\alpha + T_f + T_L$$

$$T_\alpha = I\alpha = \left[\frac{1}{12} m_A(a^2 + b^2) + m_L a^2\right]\alpha$$

$$T_f = r_b \mu_b (W_L + W_A)$$

r_b = shaft bearing radius, not shown

μ_b = bearing coefficient of friction

In most cases T_f will be very small compared to T_L.

$$T_L = \pm a \cos\theta \left[\frac{1}{2} W_A + W_L\right]$$

$$T_{D,MAX} = a\left[\frac{1}{2} W_A + W_L\right] + T_f + T_\alpha$$

$$T_C = \frac{P_r V}{\theta} + T_{\alpha^*} - T_f \pm T_L$$

$$T_{C,MAX} = \frac{P_r V}{\theta} + T_{\alpha^*} - T_f + a\cos\theta \left(\frac{1}{2} W_A + W_L\right)$$

$$T_{\alpha^*} = I\alpha^* = \left[\frac{1}{12} m_A(a^2 + b^2) + m_L a^2\right]\alpha^*$$

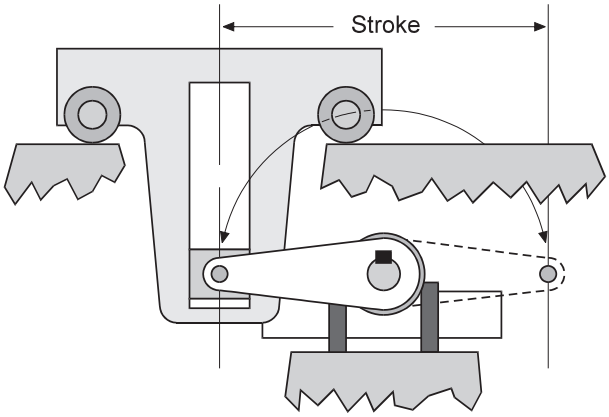
$$P_C = T_C \left[\frac{\theta}{V}\right]$$

If the mass m_L is not free to rotate about its center, then its mass moment of inertia about its own center I_L must be included in the equations for T_a and T_{a*} as follows:

$$T_\alpha = \left[\frac{1}{12} m_A(a^2 + b^2) + I_L + m_L a^2 \alpha\right]$$

$$T_{\alpha^*} = \left[\frac{1}{12} m_A(a^2 + b^2) + I_L + m_L a^2 \alpha^*\right]$$

Harmonic Drive



A harmonic linkage, as shown, is a compact and low cost method of providing linear motion with a very smooth acceleration.

Flow controls can be adjusted to provide the smooth acceleration and deceleration necessary to handle fragile parts such as bottles or light bulbs.

The smooth acceleration and deceleration also enables optimum cycle times for handling automotive components on transfer lines.

A schematic model of the harmonic drive is shown on the following page. The equations for demand torque, T_D will be defined in terms of the schematic model.

continued . . .

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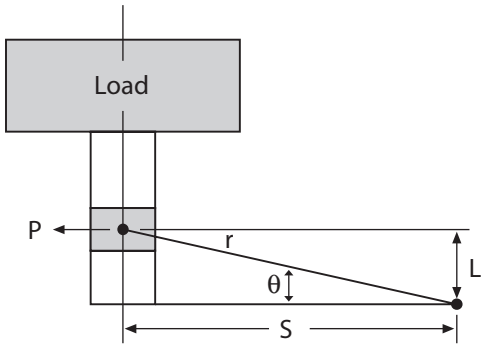
Harmonic Drive, continued



T_D = Actuator demand torque

r = Torque arm length

L = rsinθ

S = Stroke = rcosθ

W = Weight of the load

P = Bearing force against the slide

g = Gravitational acceleration

μ_L = Friction coefficient of the load

μ_S = Friction coefficient of the slide

θ = Actuator rotation in radians

ω = Angular velocity in rad/sec

t = time in seconds

A general equation can be derived relating the torque needed T_D to the object weight W, radius r, friction coefficients μ_S and μ_L, and the angular position θ. Because the position is expected to change with time t, the product of time and angular velocity ωt is substituted for θ in the equations below.

A.) $$\frac{T_D}{W} = \frac{r^2\omega^2}{g} \cos \omega t \sin \omega t + \frac{r^2\omega^2\mu_S}{g} \cos^2 \omega t + r\mu_L \sin \omega t + r\mu_L\mu_S \cos \omega t$$

Equation A gives the ratio of torque per weight for any time throughout the motion of the harmonic drive. To select an actuator it is the worst case torque that must be used for calculating T_D. The worst case, or maximum demand torque, can be calculated by taking the derivative of equation A with respect to time and solving for when the derivative is equal to zero. For reference the derivative of equation A with respect to time is given as equation B below.

B.) $$\frac{d(T_D/W)}{dt} = \frac{r\omega^2}{g}(2\cos^2 \omega t - 1) - \frac{2r\omega^2\mu_S}{g} \cos \omega t \sin \omega t + \mu_L \cos \omega t - \mu_L\mu_S \sin \omega t$$

Equations A and B have been solved to create the graphs on the next page for coefficients of friction of 0.05 and 0.25 respectively. (For the graphs, the coefficients μ_S and μ_L are set equal to each other.)

The preceding equations assume a constant angular velocity ω; as the inertia from the moving load tends to drive the actuator during the deceleration phase, it is recommended that pressure compensated restrictor type flow controls be used.

C.) $$T_C = \frac{P_r V}{\theta} + T_D - W\left[\frac{T_D}{W} \text{ (evaluated at 10 second throw time on graph)}\right]$$

Where P_r is the relief valve pressure, V is the actuator displacement, and θ is the actuators rated rotation in radians.

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Harmonic Drive, continued

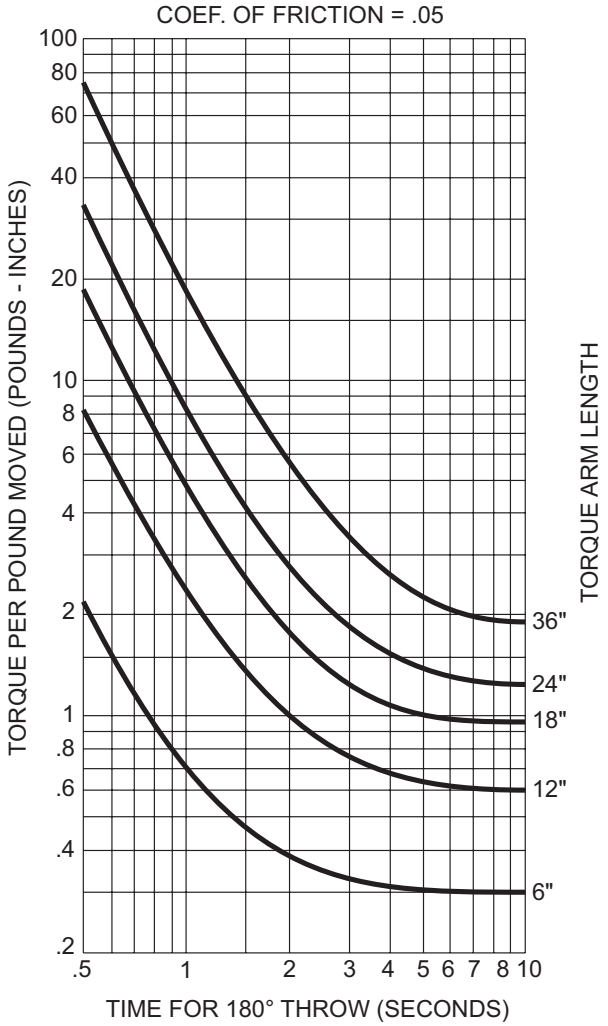

Figure 9

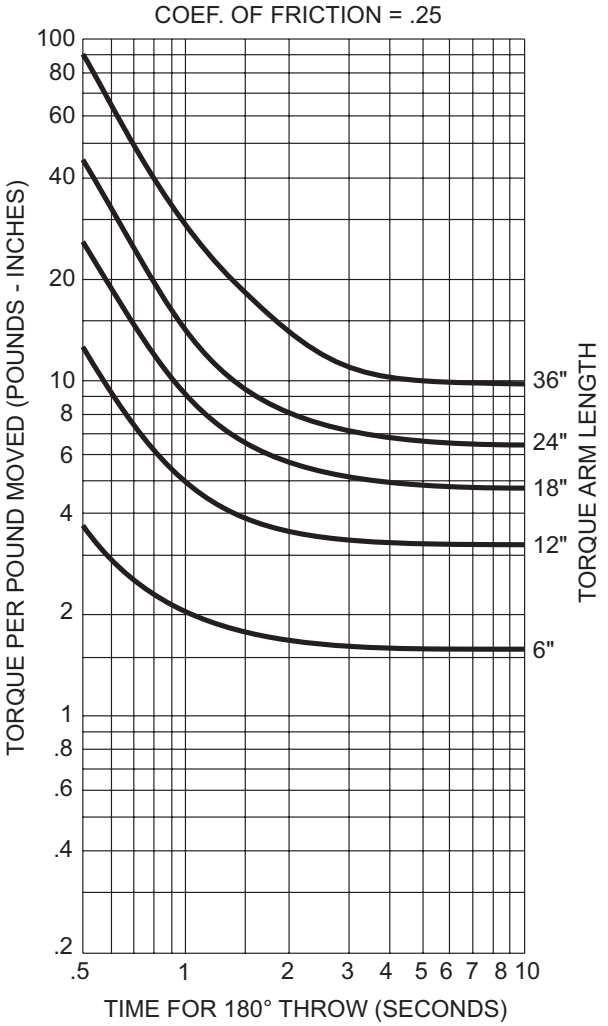

Figure 10

Example 1E: A 400 lb block must be moved 48 inches in 4 seconds with a harmonic drive. The block and the slide are supported with roller bearings (coeff. of friction = 0.05) a.) Calculate the demand torque T_D required. b.) Calculate the cushion torque if a 180° rotary actuator with a displacement V of 7.6 in³ is chosen, and the relief valve pressure P_r is set at 500 psi.

Solution:

a.) Use the curves for coef. of friction = 0.05 and draw a line from the 4 seconds on the time axis to intersect with the 24 inch torque arm curve.

$$\frac{\text{48 in travel}}{2} = \text{24 in torque arm length}$$

The intersecting line shows a requirement for $T_D/W = 1.5$: $T_D = 1.5\ (400\ lb) = 600\ in\text{-}lb$ **answer**

b.) Use equation C from the previous page to calculate the cushion torque T_C:

$$T_C = \frac{500\ psi\ (7.6\ in^3)}{\pi} + 600\ in\text{-}lb - \left(\frac{1.2\ in\text{-}lb}{lb}\right)\ (400\ lb) = 1{,}329\ in\text{-}lb$$ **answer**

D
Engineering Guidelines

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Sizing Rotary Actuators

The smallest rotary actuator displacement, that can be used in an application, is that displacement which can both deliver sufficient torque to move the load and also withstand the pressure required to stop the load. (Recall that cushion torque is generated by back pressure that is often greater than system pressure.) A method of determining the smallest rotary actuator displacement is summarized in Fig. 11 and outlined step-by-step below. (Also see the example problem on page D23.)

Note: This method is for constant torque rotary actuators such as vane, rack and pinion, or helical styles.

A. Determine the maximum allowable safe system pressure P_r that the pump and components can tolerate. This is typically the highest pressure the pump can supply to the system; however, this is not the actual system working pressure. The actual working pressure is determined after an actuator is selected.

B. Calculate the demand torque required. The demand torque T_D is given by equation 3 repeated here:

$$T_D = T_\alpha + T_f + T_L$$

Definitions for the above torque components and examples for calculation of T_D were discussed previously under the heading "Calculating Torque Requirements."

C. Calculate V/θ based upon T_D and the maximum system pressure chosen in Step A. V/θ is the volume displacement per one radian of rotation for a rotary actuator. V/θ can be calculated from the Equation 7, or by using Fig. 14. (Fig. 12 for S.I. units).

Equation 7) $$\frac{V}{\theta} = \frac{T_D}{P_r}$$

D. Calculate the cushion torque T_C required. In any application where the actuator has cushions, a deceleration valve, or any form of meter-out flow control, the flow out of the actuator is restricted creating a back pressure on the outlet side of the actuator. This back pressure is what creates the cushion torque which acts to decelerate, or cushion the actuator as it approaches the end of its rotation. The cushion torque can be calculated by the methods presented under the heading "Calculating Torque Requirements."

E. Calculate the cushion pressure P_C, for the rotary actuator with V/θ as calculated in step C, and T_C as calculated in step D. Use Equation 8:

Equation 8) $$P_C = T_C \left[\frac{\theta}{V}\right]$$

Note: Equation 8 calculates the *average* back pressure P_C, *not* the *maximum* back pressure. In most cases back pressure will not be constant and will exceed the average value calculated here.

F. If the value for P_C is considered impractical for your application, some ways to lower it are:

1. Reduce system pressure, then recalculate Steps C through E.
2. Increase the time for deceleration, then recalculate Steps D and E.
3. Use an external shock absorber.

G. Calculate the needed displacement V for the rotation you need. Use Equation 9 or Fig. 15. (Fig. 13 for S.I. units.)

Equation 9) $$V = \theta \left[\frac{V}{\theta}\right]$$

H. Select a rotary actuator with a torque rating greater than T_D, a displacement greater than V, and a pressure rating greater than P_C. Calculate system operating pressure P based upon the selected actuator's rated torque T, and the selected actuator's V/θ value using Equation 10 or Fig. 12.

Equation 10) $$P = T \left[\frac{V}{\theta}\right]$$

The relief valve setting P_r must be less than the maximum pressure from Step A, must be greater than P calculated in Equation 10, must not exceed the actuator's rated working pressure, and must be high enough to compensate for pressure drop through valves and lines.

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Actuator Flow Chart

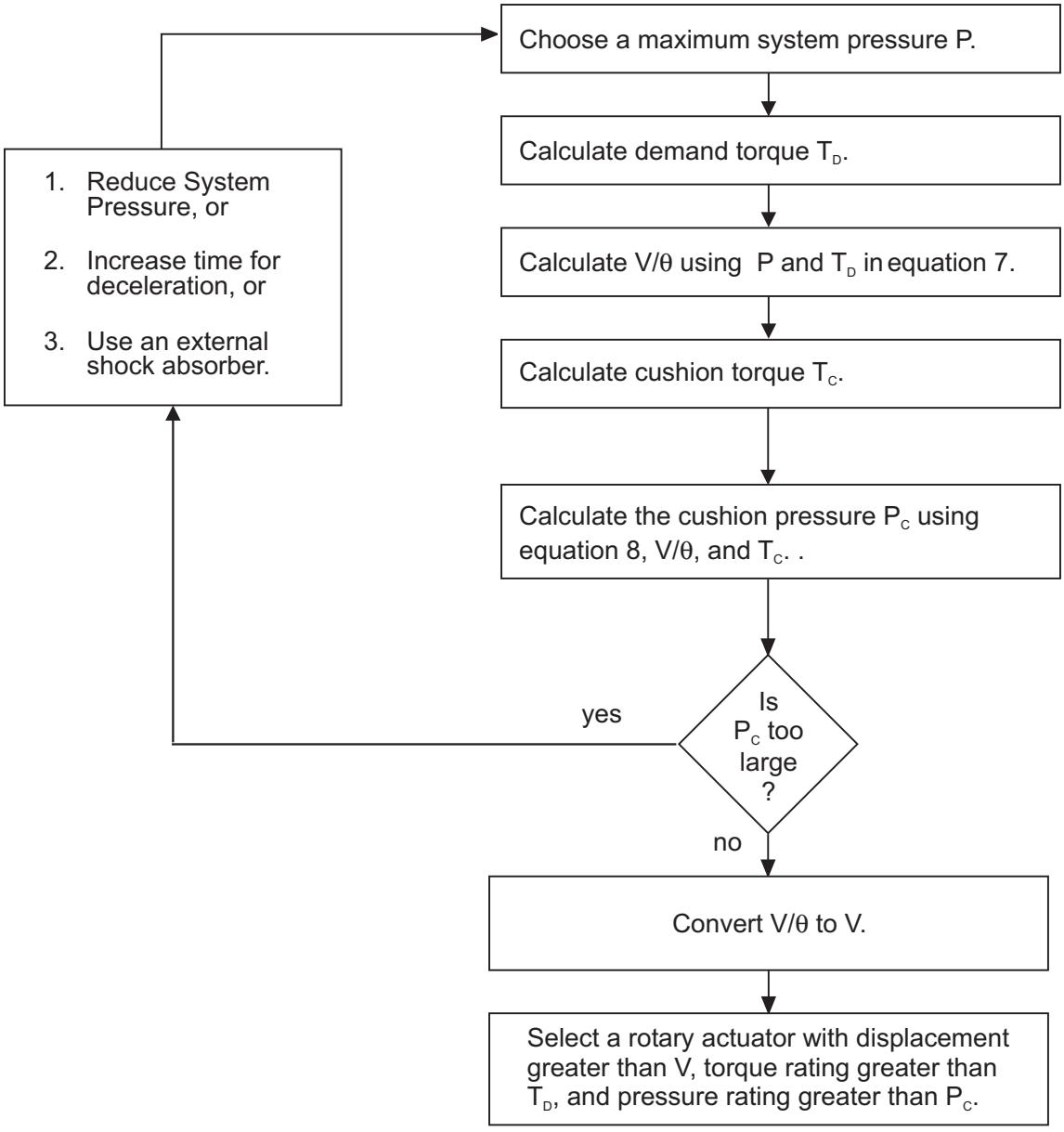

Figure 11: Flow chart for selecting a minimum volume actuator. *See example problem page D23.*

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Minimum Possible Rotary Actuator Volume (S.I. Units)

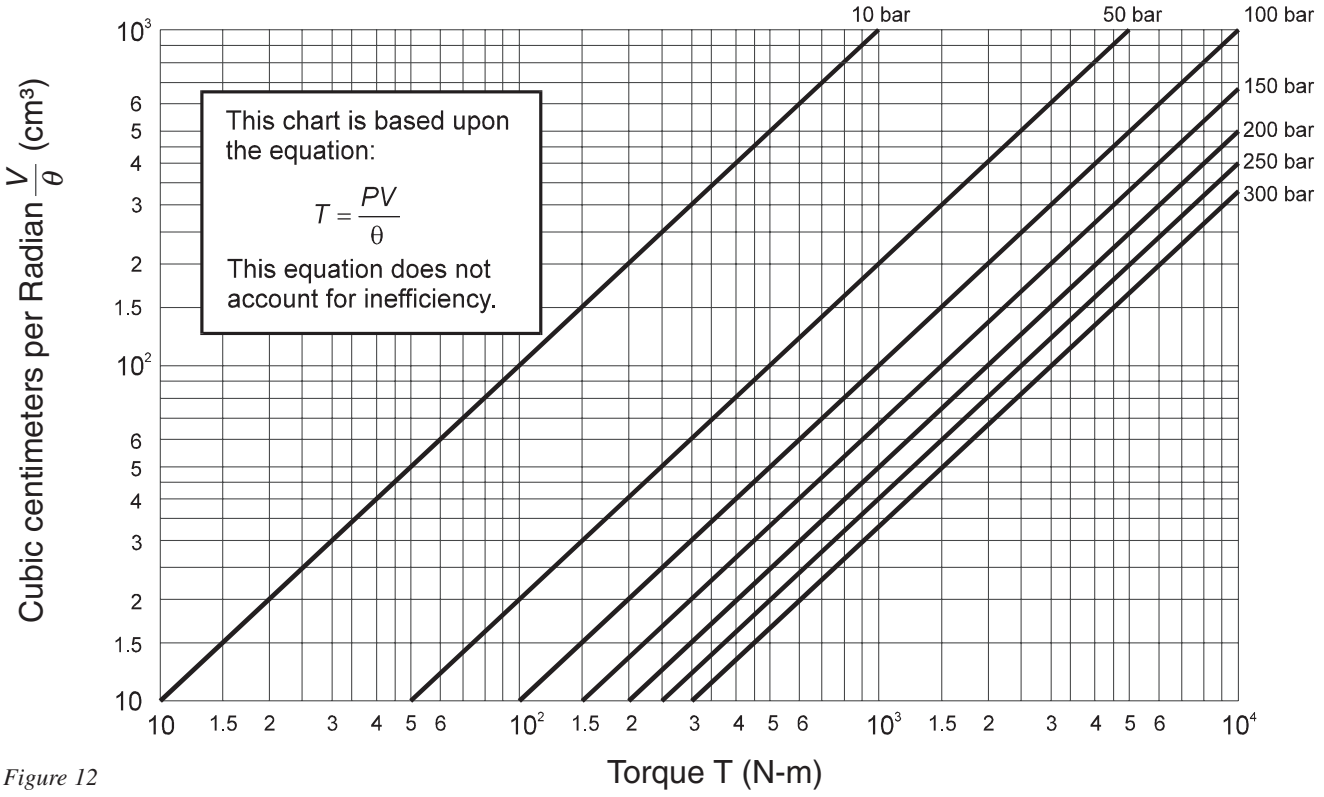

Figure 12

Coverting Volume per Radian to Volume Displacement (S.I. Units)

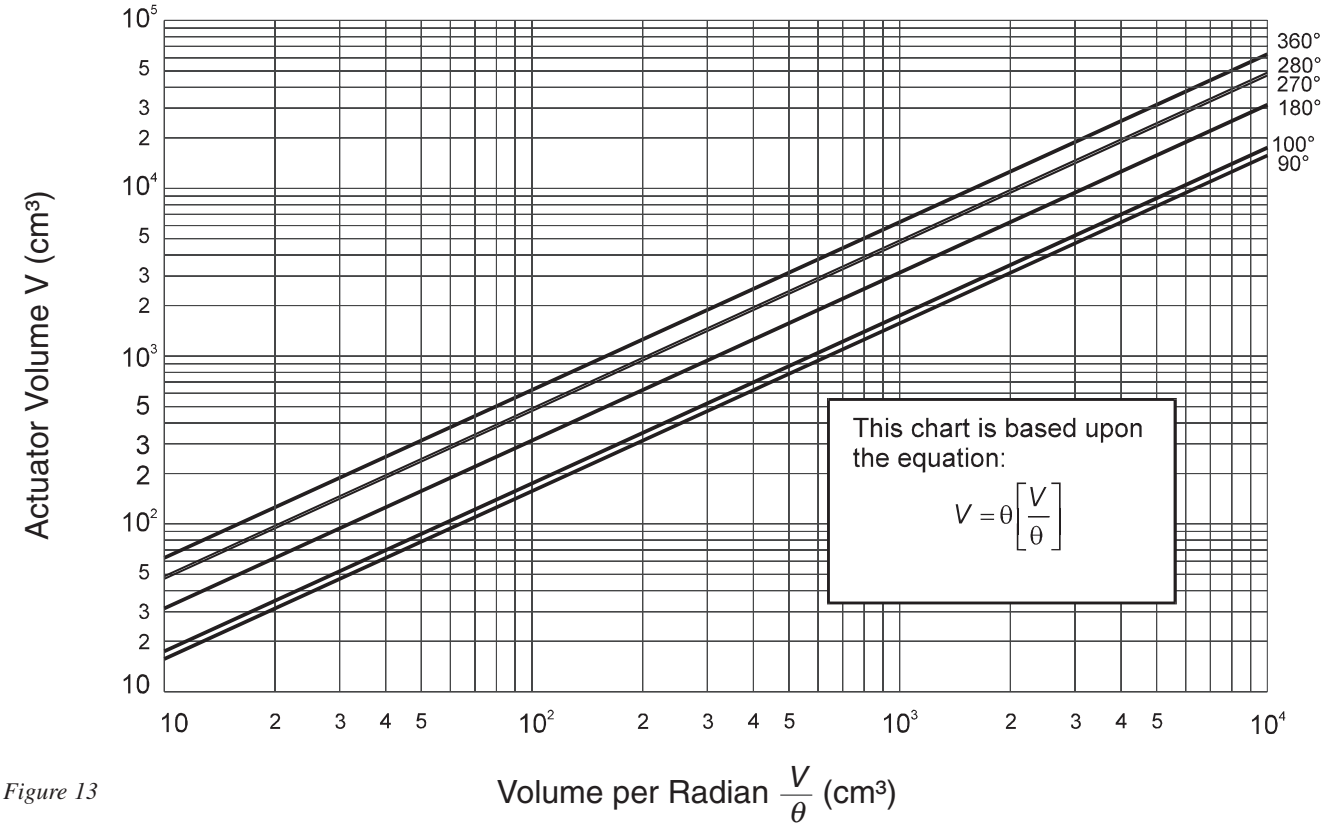

Figure 13

D
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Minimum Possible Rotary Actuator Volume (English Units)

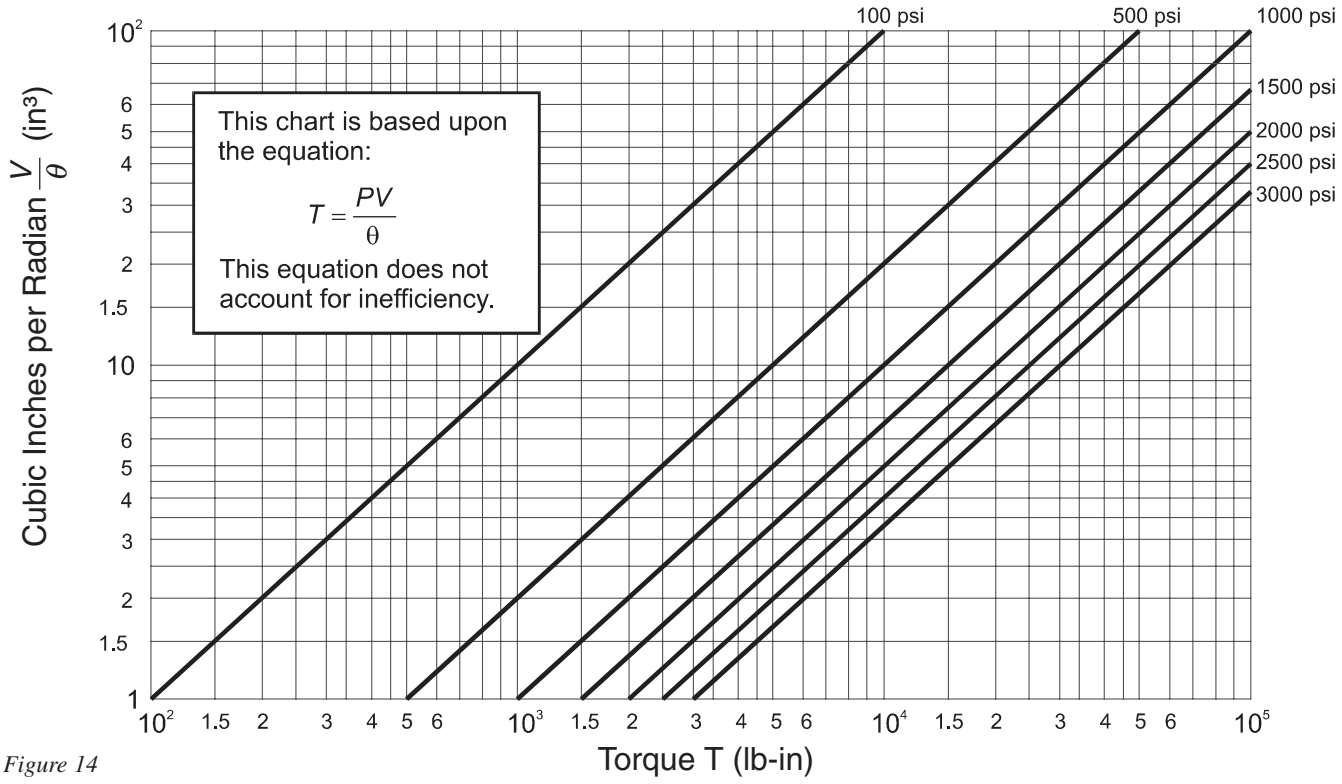

Figure 14

Coverting Volume per Radian to Volume Displacement (English Units)

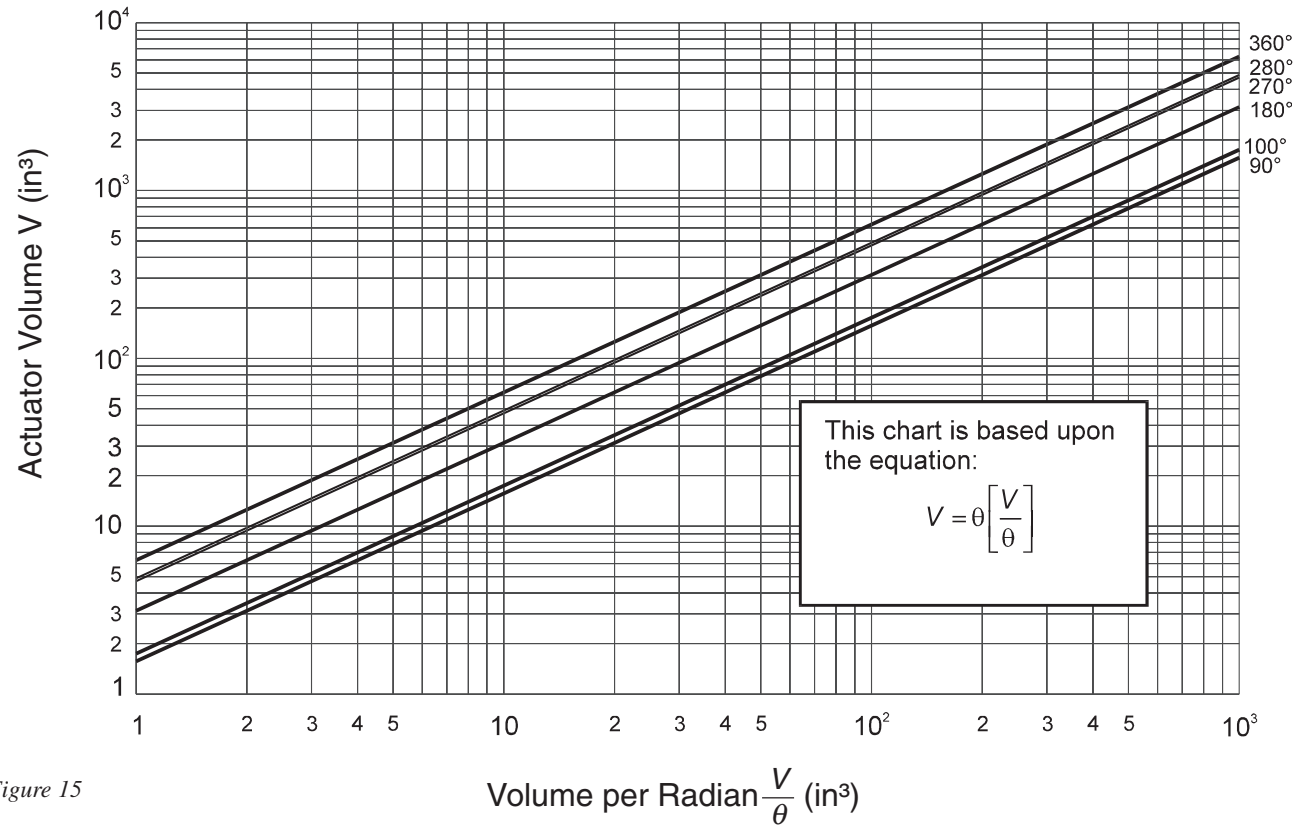

Figure 15

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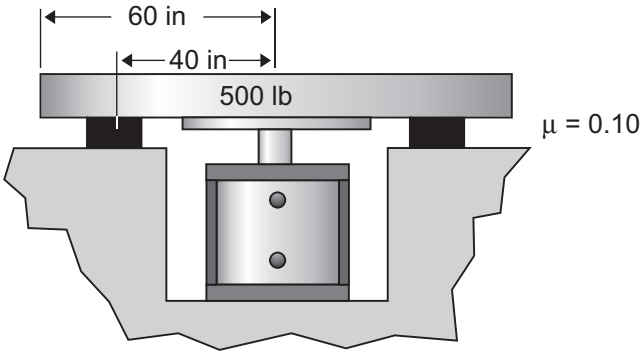
Example 2E: For the rotary index table shown , calculate the minimum requirements for an actuator to turn the index table 180°. Use $\alpha = \alpha^* = 2.5$ rad/sec², $P_r = 1000$ psi.



Solution: Use the flow chart Fig. 11, on page D20.

A.) The supply pressure P_r is given as 1000 psi.

B.) Calculate the demand torque T_D:

$$T_D = T_\alpha + T_f + T_L$$

$$T_\alpha = I\alpha$$

$$I = \frac{1}{2} mr^2 = \frac{1}{2}\left(\frac{500\ lb}{386\ in/sec^2}\right)(60\ in)^2 = 2332\ in\text{-}lb\text{-}sec^2$$

$$\alpha = 2.5\ rad/sec^2$$

$$T_\alpha = (2332\ in\text{-}lb\text{-}sec^2)(2.5\ rad/sec^2) = 5{,}830\ in\text{-}lb$$

$$T_f = \mu W r_b = (0.10)(500\ lb)(40\ in) = 2{,}000\ in\text{-}lb$$

$$T_L = 0$$

$$T_D = 5{,}830\ in\text{-}lb + 2{,}000\ in\text{-}lb + 0 = 7{,}830\ in\text{-}lb$$

C.) Calculate $\frac{V}{\theta}$ use Equation 7 or Fig. 14:

$$\frac{V}{\theta} = \frac{T_D}{P_r} = \frac{7{,}830\ in\text{-}lb}{1000\ psi} = 7.83\ in^3$$

D.) Calculate cushion torque T_C (see equations for Rotary Index Table)

$$T_C = \frac{P_r V}{\theta} + T_{\alpha^*} - T_f + T_L = 1000\ psi\,(7.83\ in^3) + 5{,}830\ in\text{-}lb - 2000\ in\text{-}lb + 0 = 11{,}660\ in\text{-}lb$$

Notice that since the rate of deceleration α^* is the same as the rate of acceleration α, the deceleration torque T_{α^*} is the same as the acceleration torque T_α.

E.) Calculate the cushion pressure P_C:

$$P_C = T_C\left[\frac{\theta}{V}\right] = \frac{11{,}660\ in\text{-}lb}{7.83\ in^3} = 1{,}489\ psi$$

F.) Is the cushion pressure too high? The cushion pressure (1,489 psi) is within the capability of most hydraulic rotary actuators. In cases where P_C becomes the dominant selection criteria, the designer should consider repeating the sizing calculations with a lower value for P_r, decreasing the deceleration rate α^*, or using an external shock absorber.

G.) Calculate the displacement V for the 180° rotation. Use Equation 9 or Fig. 15.

$$V = \theta\left[\frac{V}{\theta}\right] = \pi(7.83\ in^3) = 24.6\ in^3$$

H.) Select a rotary actuator with a torque rating greater than 7,830 in-lb with a supply pressure of 1000 psi, it will have a displacement greater than 24.6 in³, and must have a maximum pressure rating over 1,489 psi.

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TABLE 4: CONVERT Vs to V

Based upon equation Vsθ = V for converting specific volume into volume.

ACTUATOR ROTATION VOLUME

	ACTUATOR ROTATION (DEGREES)					
Vs	**90**	**100**	**180**	**270**	**280**	**360**
10	15.71	17.45	31.42	47.13	48.86	62.84
11	17.28	19.20	34.56	51.84	53.75	69.12
12	18.85	20.94	37.70	56.56	58.63	75.41
13	20.42	22.69	40.84	61.27	63.52	81.69
14	21.99	24.43	43.98	65.98	68.40	87.98
15	23.57	26.18	47.13	70.70	73.29	94.26
16	25.14	27.92	50.27	75.41	78.18	100.5
17	26.71	29.67	53.41	80.12	83.06	106.8
18	28.28	31.41	56.55	84.83	87.95	113.1
19	29.85	33.16	59.70	89.55	92.83	119.4
20	31.42	34.90	62.84	94.26	97.72	125.7
22	34.56	38.39	69.12	103.7	107.5	138.2
24	37.70	41.88	75.41	113.1	117.3	150.8
26	40.84	45.37	81.69	122.5	127.0	163.4
28	43.99	48.86	87.98	132.0	136.8	176.0
30	47.13	52.35	94.26	141.4	146.6	188.5
32	50.27	55.84	100.5	150.8	156.4	201.1
34	53.41	59.33	106.8	160.2	166.1	213.7
36	56.56	62.82	113.1	169.7	175.9	226.2
38	59.70	66.31	119.4	179.1	185.7	238.8
40	62.84	69.80	125.7	188.5	195.4	251.4
42	65.98	73.29	132.0	197.9	205.2	263.9
44	69.12	76.78	138.2	207.4	215.0	276.5
46	72.27	80.27	144.5	216.8	224.8	289.1
48	75.41	83.76	150.8	226.2	234.5	301.6
50	78.55	87.25	157.1	235.7	244.3	314.2
55	86.41	95.98	172.8	259.2	268.7	345.6
60	94.26	104.7	188.5	282.8	293.2	377.0
65	102.12	113.4	204.2	306.3	317.6	408.5
70	109.97	122.2	219.9	329.9	342.0	439.9
75	117.83	130.9	235.7	353.5	366.5	471.3
80	125.68	139.6	251.4	377.0	390.9	502.7
85	133.54	148.3	267.1	400.6	415.3	534.1
90	141.39	157.1	282.8	424.2	439.7	565.6
95	149.25	165.8	298.5	447.7	464.2	597.0
100	157.10	174.5	314.2	471.3	488.6	628.4

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Calculating Required Pump Flow

The flow rate required for a rotary actuator can be determined by the desired time for rotation and the rotary actuator's displacement. This is shown in Equation 5.

The equation is also plotted as Figure 16.

$$Q = \frac{V}{t}$$

where Q = Flow rate
V = Rotary actuator displacement
t = Time to fill displacement

EXAMPLE: A 280° vane rotary actuator is chosen to provide a 194° rotation in 2 seconds. If the rotary actuator's displacement is 77.8 in^3, find what flow rate is required from the pump. Assume constant angular velocity.

SOLUTION: The actuator is only rotating 194°, so the volume of oil required for this rotation is:

$V = 77.8\ in^3\ (194/280)$

$V = 53.9\ in^3\ for\ 194°\ rotation$

$$Q = \frac{V}{t}$$

$$Q = \frac{59.3\ in^3\ (60\ sec/min)}{2\ sec\ (231\ in^3/gal)} = 7\ \text{GPM}\quad \textbf{ANSWER}$$

EXAMPLE: A 180° rack and pinion rotary actuator is to accelerate from 0 to some angular velocity w during its first 10° of rotation, then remain at that angular velocity for the next 150° of rotation, then decelerate back to 0 radians/sec during the last 20°. The actuator is to rotate the total 180° in less than 2 seconds. If the actuator's displacement is 36 in^3, find:

A. The angular velocity w after the first 10° of rotation
B. The pump flow rate required for the rotary actuator
C. The pump flow required if the actuator traveled the entire 180° in 2 seconds at a constant angular velocity

SOLUTION:

A. Assume constant acceleration during the first 10° and constant deceleration during the last 20°.

$2\ sec = t_1 + t_2 + t_3$

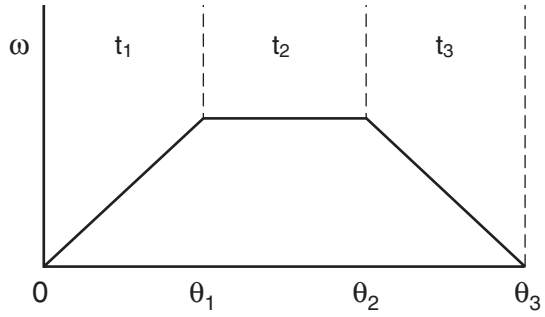
$$t_1 = 2\,\frac{\theta_1 - 0}{\omega} = \frac{2}{\omega}(10°)\frac{\pi}{180°} = \frac{1}{\omega}(.35)$$

$$t_2 = \frac{\theta_2 - \theta_1}{\omega} = \frac{1}{\omega}(150°)\frac{\pi}{180°} = \frac{1}{\omega}(2.62)$$

$$t_3 = 2\,\frac{\theta_3 - \theta_2}{\omega} = \frac{2}{\omega}(20°)\frac{\pi}{180°} = \frac{1}{\omega}(.70)$$

$$2\ sec = \frac{1}{\omega}[.35 + 2.62 + .70]$$

$\omega = 1.83$ rad/sec **ANSWER**



CONTINUED ON NEXT PAGE

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EXAMPLE CONTINUED

B. 180° rotary actuator has a volume displacement of 36 in3.
The cubin inches per radian can be expressed as:

$$V_s = \frac{V}{\theta} = \frac{36\ in^3}{\pi}\ radians$$

$$V_s = 11.5\ in^3/radian$$

NOTE: 180° = p radians

The actuator must be able to rotate at 1.83 rad/sec so the pump flow must be:

$$Q = V_s\omega$$

$$Q = (11.5\ in^3/radian)\ (1.83\ rad/sec)\ \frac{1\ gal}{231\ in^3}\ \frac{60\ sec}{min}$$

$$Q = 5.5\ \text{GPM}$$ **ANSWER**

C. If the entire 180° were traversed at constant speed in 2 seconds, the pump flow would be:

$$Q = \frac{V}{t}$$

$$Q = \frac{38\ in^3}{2\ sec}\ \frac{1\ gal}{231\ in^3}\ \frac{60\ sec}{min}$$

$$Q = 4.7\ \text{GPM}$$ **ANSWER**

Notice that in the above example, it is necessary to take into account the time required for acceleration and deceleration of the actuator in order to determine the maximum velocity required. It is the maximum velocity of the actuator that will determine the maximum flow required. Equations for velocity and acceleration are provided on page D10 in Table 3.

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Time/Revolution vs. Volume

Based on 100% efficiency and the equation:

$t = .26\ V/Q$

where t = time/rev. in seconds

V = displacement in in^3

Q = oil flow in GPM

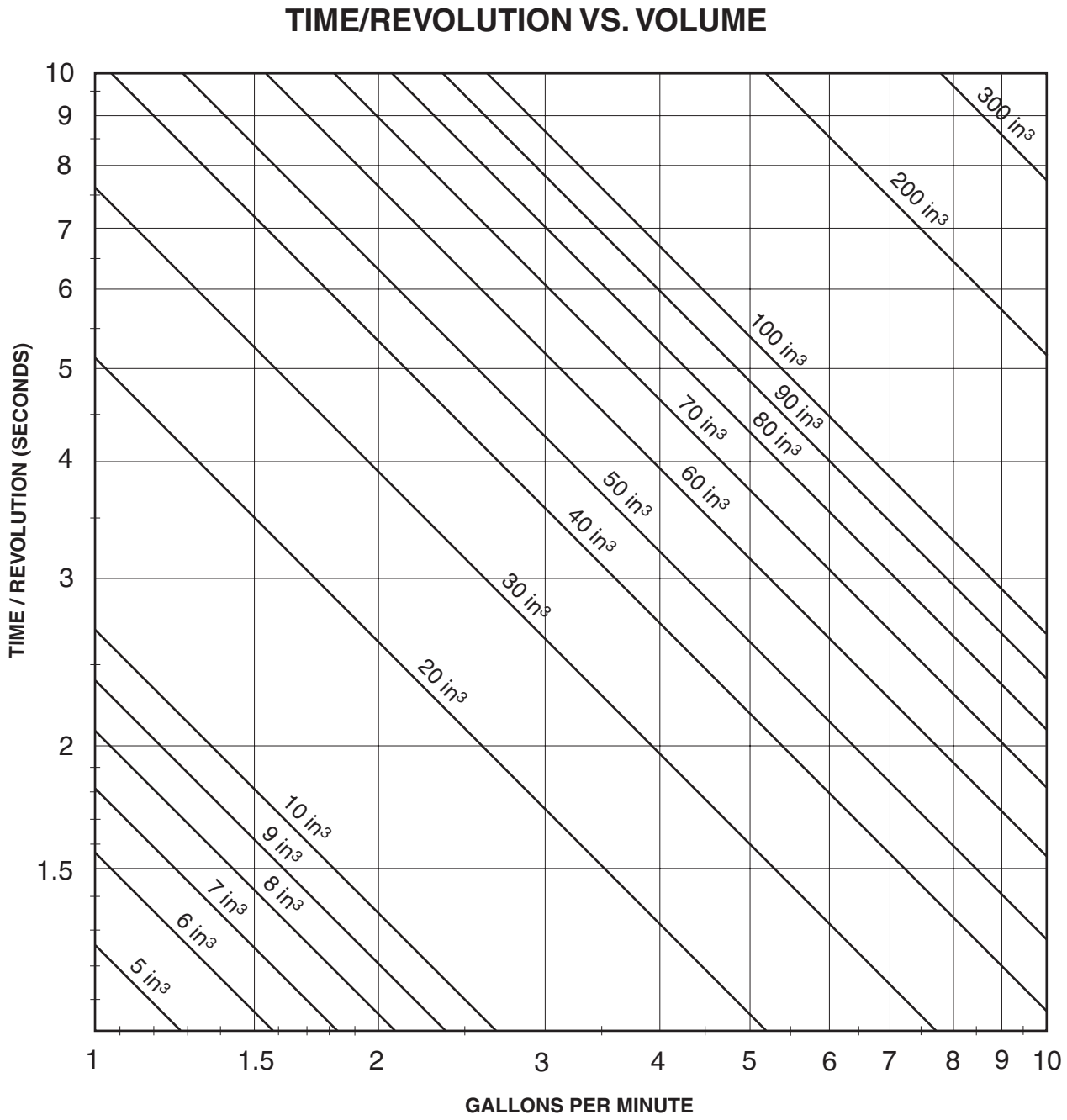

Figure 16

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Composite Hydraulic Circuit

When designing hydraulic operating circuits for rotary actuators, consideration should be given to the following criteria:

1. actuator rotational velocity
2. kinetic energy developed
3. actuator holding requirement
4. system filtration

Figure 17 is a composite drawing showing general recommendations for sample circuitry. It is intended as a guide only. Flow control valves (1) in the meter-out position provide controlled actuator velocity. Care should be taken if the load moves overcenter, as the combination of load and pump generated pressure may exceed the actuator rating.

To protect the actuator and other system components from shock pressures caused when the actuator is suddenly stopped in mid-stroke, crossover relief valves (2) should be installed as close to the actuator as possible. These relief valves also protect the actuator and system if the load increases and "back drives" the hydraulic system.

In applications involving high speeds or heavy loads, the built up kinetic energy may be too much for cushions to absorb during their 20° of operation. By using cam or lever operated deceleration valves (3) the deceleration arc can be increased beyond 20° so that kinetic energy can be absorbed more gradually and without overpressuring the actuator. Where there is a need to hold the load in intermediate positions for extended periods of time, pilot operated check valves (4) should be used. These must be used with leakproof actuator seals to hold the load in position; any bypass flow allows eventual drifting of the load.

Warning: For safety reasons, some applications require a mechanical locking device for holding loads over an extended period of time.

As with most standard hydraulic circuits, rotary actuator applications should have filtration to provide a continuous cleanliness rating of no more than 390 particles greater than 10 micron per milliliter of fluid. This is an ISO 17/14 fluid cleanliness classification. Filters (5) should be fitted and maintained to ensure this minimum level.

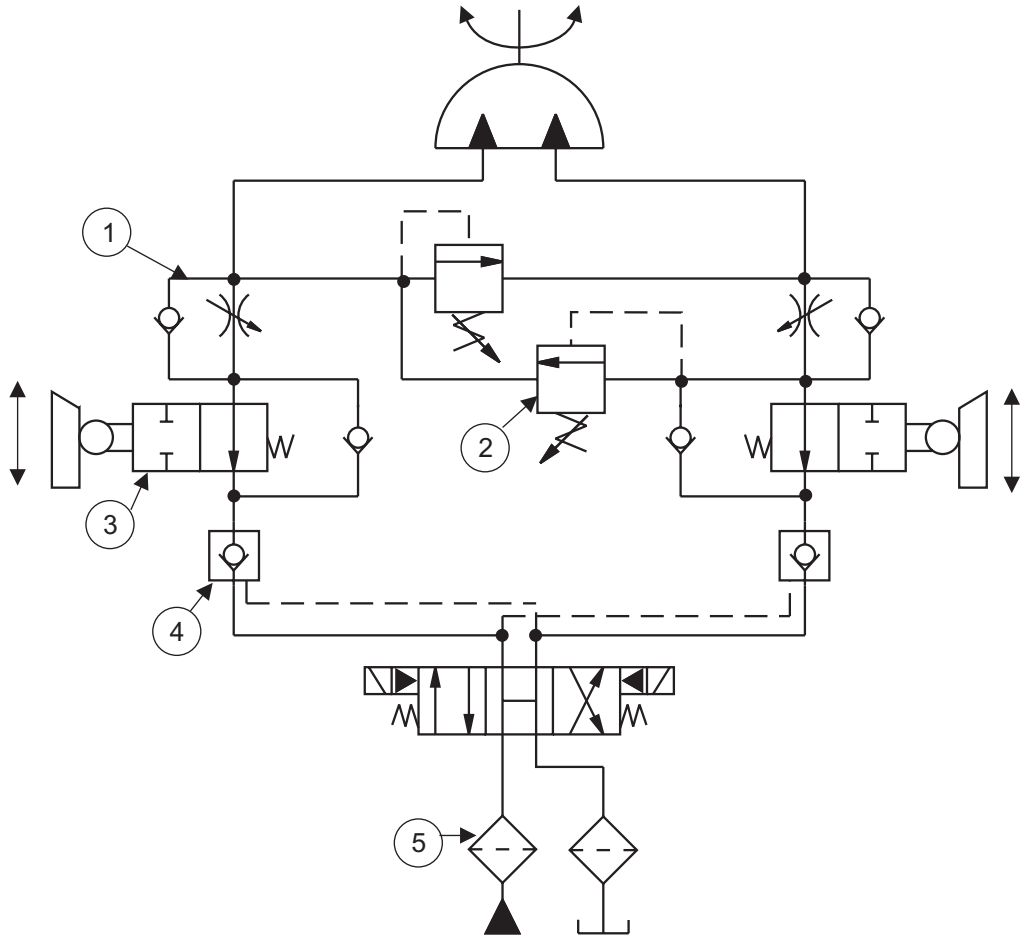

Figure 17 Hydraulic rotary actuator circuit

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Electrohydraulic Circuitry

The use of electrohydraulic components for rotary actuator applications can provide greater system flexibility. Figure 18 is a representative circuit showing some possible applications of electrohydraulic valves. Proportional or servo control valves (1) can provide continuous position, velocity or acceleration control of loads, and "closing the loop" around a position feedback device and can provide even greater control and velocity profiles for overcenter or varying loads. Even more precise position control is possible with the use of vane actuators or anti-backlash devices on rack and pinion units.

Torque control can also be achieved with servovalve (1) by taking advantage of the valve's pressure gain region.

All of the considerations from the composite hydraulic circuit (Fig. 17) are still relevant. Crossover relief valves (3) should be installed if there are uncontrolled sudden stops in mid-stroke, and caution should be exercised when running overcenter, running with high speeds, or moving high inertia loads. Filtration (4) is still a consideration, but the actuator requirements (ISO 17/14 class) are usually less demanding than the filtration requirements of today's electrohydraulic control valves.

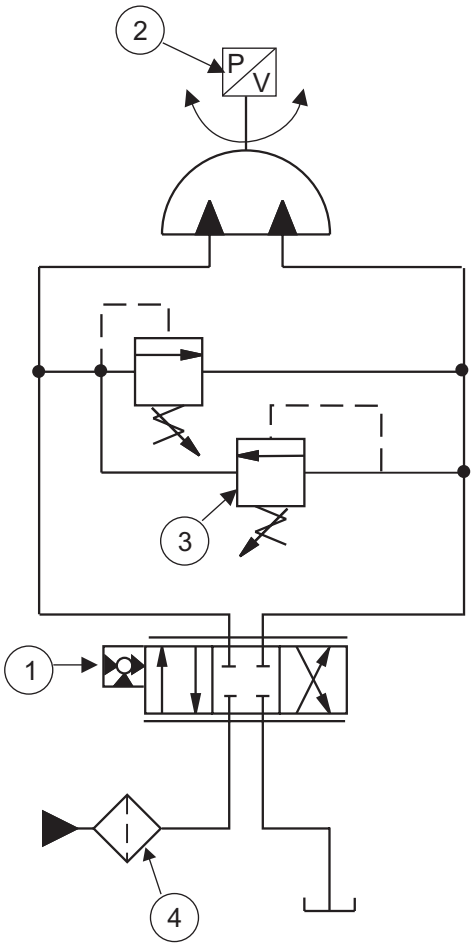

Figure 18 Electrohydraulic rotary actuator circuit

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Installation Instructions and Options

A. Stops

Vane units should not use the vane and stator as a positive stop. For light to medium loads, an internal taper lock stop, or external stops mounted to the machine framework, may be used. For high inertia or high speed loads, externally mounted valving or deceleration devices should be used to minimize system shocks.

Rack and pinion units can be stopped at the end of stroke provided the loads and speeds are not too high. Cushions can be used to decelerate the load to a gentle stop, providing the maximum actuator pressure rating is not exceeded by the cushions. Again, for high inertia or high speed loads, externally mounted valving or deceleration devices should be used to minimize system shocks.

B. Surge Pressures

Surge or shock pressure in excess of the actuator rated pressure are detrimental to unit life and must be avoided. Crossover relief valves mounted adjacent to the actuator can help reduce these abnormal pressure peaks.

Pressure developed by cushion or deceleration valves should also be kept below rated pressure.

C. Angular Velocity

Angular velocity can be controlled by metering the flow into or out of the actuator ports. This can be accomplished by the use of flow control valves; or if more sophisticated control is required, through the use of proportional or servo valves.

Care should be taken when using a meter-out circuit if the load moves over center, as the combination of load and pump generated pressures may exceed the actuator rating.

D. Drains

Some actuators are fitted with drain ports to minimize external leakage possibilities. These drain ports should be connected directly back to the oil reservoir with a minimum of back pressure (3.5 bar / *50 psi* maximum).

E. Gear Chamber

Some rack and pinion actuators are supplied with the gear chambers filled with a molybdenum disulfide grease to better absorb gear stress and extend gear life. This chamber should be checked and filled periodically to ensure adequate gear lubrication. The housing can be fitted with a small relief valve that vents excess pressure in the gear chamber to the atmosphere. This is an indication of pressure seal wear, because high pressure oil is bypassing the piston seal and pressuring the gear chamber. The piston seals should then be replaced.

F. Fluid Medium and Seals

For hydraulic usage, a clean, filtered, high-quality mineral-based hydraulic fluid with 150 to 500 S.U.S. viscosity at 100°F is recommended for use with standard Buna N seals. Cleanliness should be maintained to an ISO code 17/14 level.

Standard seal compound is Buna N for mineral-based hydraulic fluid. Other seal materials can be provided for most operating fluids. If there is a question about the correct seal compound, provide the name and type of operating fluid to the actuator manufacturer and ask for their recommendation.

G. Shaft Couplings

Couplings should engage the full length of the shaft keyway and pressure should only be applied after support has been provided on the opposite end of the shaft. Shafts should be within 0.005 TIR to ensure proper alignment.

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Maintenance Instructions and Service Bulletins

⚠ WARNING

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from The Company, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application, including consequences of any failure and review the information concerning the product or systems in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

The products described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by The Company and its subsidiaries at any time without notice.

EXTRA COPIES OF THESE INSTRUCTIONS ARE AVAILABLE FOR INCLUSION IN EQUIPMENT / MAINTENANCE MANUALS THAT UTILIZE THESE PRODUCTS. CONTACT YOUR LOCAL REPRESENTATIVE.

⚠ WARNING

To avoid unpredictable system behavior that can cause death, personal injury, and property damage:

- **Disconnect electrical supply before installation, servicing, or conversion.**
- **Operate within the manufacturer's specified conditions.**
- **Service in accordance with procedures listed in these instructions.**
- **Installation, service, and conversion of these products must be performed by knowledgeable personnel who understand how .electromechanical products are to be applied**
- **After installation, servicing, or conversion, electrical supplies should be connected and the product tested for proper function. If the product does not function properly, do not put into use.**
- **Warnings and specifications on the product should not be covered by paint, etc. If masking is not possible, contact your local representative for replacement labels.**

Safety Guide

For more complete information on recommended application guidelines, see the Safety Guide section of Pneumatic Division catalogs or you can download the **Pneumatic Division Safety Guide** at: www.parker.com/safety

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HUB Series Actuators

Maintenance Instructions & Parts List

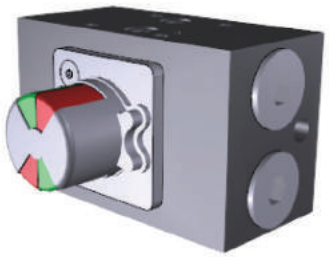
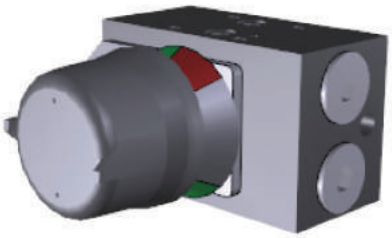
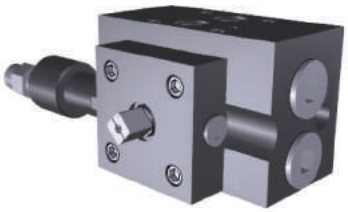
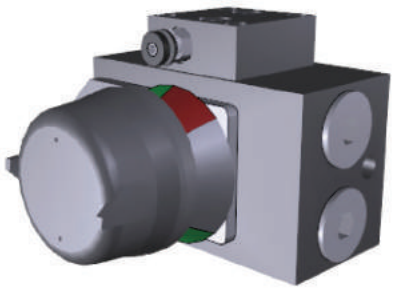
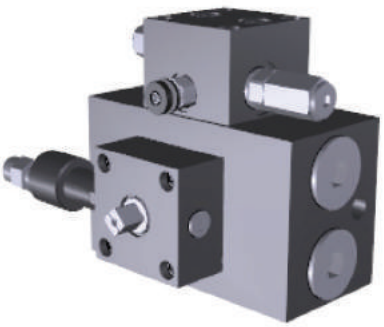
Provide Model Number and Serial Number When Ordering Spare Parts.

Introduction

This document describes the repair procedures to be used for the Parker hydraulic rotary actuator product series termed the HUB (Hydraulic Unibody). The HUB series is comprised of 3 basic size actuators with different torque ratings and physical sizes. They are designated as the HUB018, HUB075 and HUB100. These base actuator sizes can be configured in multiple variations by the addition of control valve modules and/or position feedback modules. This manual is arranged to describe the repair processes to be employed by the end user in order to accomplish the tear down and repair of the three base actuators with any combination of the valve and feedback modules. The figures below show several examples of the potential combinations as described above. These are provided for descriptive purposes only and do not reflect all the potential combination of options that can be configured and sold.

The three types of kits available are the following: base actuator seal repair, valve and feedback replacement, and upgrade. The base actuator seal repair kit will involve the actuator tear down and replacement of all wear components. The valve and feedback replacement kit consists of the components needed to replace the cartridge valve or feedback devices. The upgrade kit provides the ability to add to the base actuator, a control valve or feedback module that was not originally ordered with the unit. This allows the ability to field upgrade without the time and expense of returning the product to the factory. The following information describes the various kits of each category that are available for the HUB product series.

Please refer to the part number structure on the following page for proper selection of the desired service kit number and appropriate section for installation instructions. Section 4 is the torque table.

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How to select the proper kit for your HUB actuator

Step 1 Select the desired kit from the Unibody Kit Table below

Step 2 Select the Basic Kit Number (PSK-HUB###) based on the size of your HUB actuator. In some cases the desired kit can be used for multiple actuator sizes, therefore only one PSK kit number may be listed.

Step 3 Select the proper 3 digit code that corresponds to the desired Kit Type. To assist with this process, there is an additional reference table located to the right of the list of kit types. This table indicates which kit types are compatible with the original actuator that was purchased (based on the port type and direct mount option).

Example: PSK-HUB018-101P - HUB018 Actuator seal/rebuild kit
PSK-HUB075-304P - Counter-balance valve Upgrade kit for HUB100

Manual Section	Step 1	Step 2			Step 3	ORIGINAL ACTUATOR PURCHASED REFERENCE TABLE			
	Unibody Kit Table	BASIC KIT NUMBER			HUB Kit Number & Type	12	1B	1D	A2
		ACTUATOR SIZE				Base unit	with Cross-over module	with C-balance module	with Sol ready module
		018	075	100					
I, pg 3	Base Actuator Seal/ Rebuild Kit	PSK-HUB018	PSK-HUB075	PSK-HUB100	-101P	●	●	●	●
II, pg 4-6	Crossover Vent Valve Replacement Kit	PSK-HUB018			-202P		●	●	
	Crossover Vent Valve Upgrade Kit	PSK-HUB018	PSK-HUB075		-204P	●			
	Counterbalance Valve Replacement Kit	PSK-HUB018			-302P			●	
	Counterbalance Valve Upgrade Kit	PSK-HUB018	PSK-HUB075		-304P	●			
	Solenoid Ready Upgrade Kit	PSK-HUB018	PSK-HUB075		-404P	●			
III, pg 7-9	RLPO, 0-40 VDC Replacement Kit	PSK-HUB018			-502P	●	●	●	●
	StoneL - SST dual module Replacement Kit	PSK-HUB018			-512P	●	●	●	●
	StoneL - SST dual module Upgrade Kit	PSK-HUB018	PSK-HUB075	PSK-HUB100	-514P	●	●	●	●
	StoneL - 4-20 mA Position Transmitter Replacement Kit	PSK-HUB018			-522P	●	●	●	●
	StoneL - 4-20 mA Position Transmitter Upgrade Kit	PSK-HUB018	PSK-HUB075	PSK-HUB100	-524P	●	●	●	●
	StoneL - SST dual module & 4-20 mA Position Transmitter Replacement Kit	PSK-HUB018			-532P	●	●	●	●
	StoneL - SST dual module & 4-20 mA Position Transmitter Upgrade Kit	PSK-HUB018	PSK-HUB075	PSK-HUB100	-534P	●	●	●	●
	Visual Indicator (green on/red off) - Stand alone Replacement Kit	PSK-HUB018			-702P	●	●	●	●
	Visual Indicator (green on/red off) - Stand alone Upgrade Kit	PSK-HUB018	PSK-HUB075	PSK-HUB100	-704P	●	●	●	●

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1. Base actuator seal/Rebuild

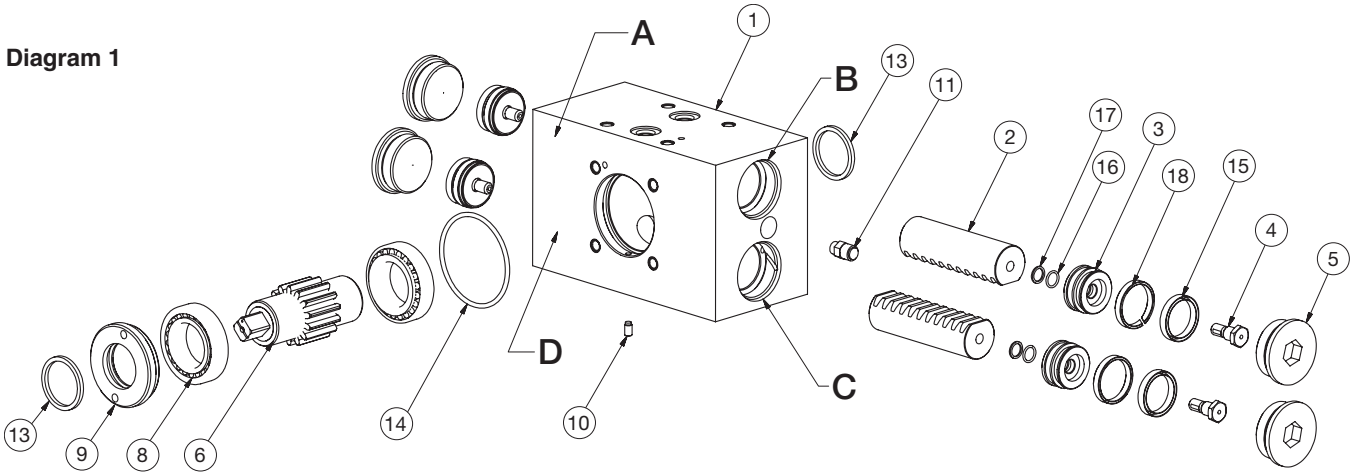
1.1. Tools Required

1.1.1. Proper replacement seal kit
1.1.2. Seal pick
1.1.3. Small hex wrench, (3/32" or 1/8" hex)
1.1.4. Hex bit for endcaps, 5/8" (HUB018), 3/4" (HUB075 & HUB100)
1.1.5. Spanner wrench, 13/64" diameter holes (HUB018), 17/64" diameter holes (HUB075 & HUB100)
1.1.6. Anti-seize paste
1.1.7. Moly Grease with EP additive (lithium based grease used at factory)

1.2. Procedure (Diagram 1)

1.2.1. Remove endcaps (5) in positions A & C.
1.2.2. Remove rack bolts (4) from the rack (2).
1.2.3. Rotate the pinion slowly until the pistons in positions A & C can be removed.
1.2.4. On the HUB018, remove the u-cup seal (15) and bronze piston (3) and replace with new components. On the HUB075 and HUB100, remove the u-cup seal (15) and wearband (18) and replace with new components.
1.2.5. Remove inner o-ring (16) and backup ring (17) on piston. Replace with new parts. Be sure to install in the proper order and with the concave side of backup ring facing the o-ring. Apply a small amount of o-ring lube to the parts to assist in the installation and re-assembly.
1.2.6. Apply a light coat of the seal lube to the u-cup seal and the cylinder bore.
1.2.7. Then insert the piston with the seals and wearband (if required) into the cylinder bore. On the HUB075 and HUB100, take care to hold the wearband onto the piston during assembly into the cylinder. NOTE: Pre-form the wearband to the piston diameter prior to inserting into the cylinder.
1.2.8. Assemble the rack bolt thru the piston and thread into the rack. Torque per table.
1.2.9. Apply a small amount of anti-seize to the housing threads and install the endcaps back into the housing and torque per table.
1.2.10. Follow steps 1.2.1 to 1.2.9 for components in positions B & D.
1.2.11. Remove bearing cap setscrew (10) from the housing (1).
1.2.12. Use spanner tool to remove the bearing cap (9). Note: Spanner wrench is recommended to avoid damaging pin holes.
1.2.13. Remove the bearing cap o-ring (14) from the housing (1).
1.2.14. Remove the outer taper roller bearing (8) and pinion (6). When removing the pinion, be sure the actuator is face down and that the two racks will not move while the pinion is out of the unit. Also, be sure to note the position of the timing mark on the pinion prior to disassembly. If the racks move while the pinion is removed, you will need to re-align the pinion to the racks. If the racks are not properly aligned to the pinion, the unit may not rotate properly.

Diagram 1



Parts List (Diagram 1)

Item	Description	Qty
1	Housing	1
2	Rack	2
3*	Piston (018 only)	4
4*	Rack Bolt	4
5	Endcap	4

Item	Description	Qty
6	Pinion	1
8	Bearing	2
9	Bearing Cap	1
10	Set Screw	1
11	Relief Valve	1

Item	Description	Qty
13*	Quad Ring	2
14*	O-ring	1
15*	U-cup	4
16*	O-ring	4
17*	Back-up Ring	4

Item	Description	Qty
18*	Wear Band (075 & 100 only)	4
80	Seal Lube Packet	1

* Items included in seal kit.

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1.2.15. Remove the quad ring (13) from the front of the housing and from the bearing cap. Locate the correct replacement seals, apply a small amount of the installation lube and re-install into grooves.

1.2.16. Insert the pinion back into the actuator. Be sure the rack teeth engage properly and the timing mark is consistent with the disassembly position.

1.2.17. Apply a generous amount of the Moly grease with EP additive to the pinion and rack gear teeth. The gear chamber should be filled to 75% of capacity.

1.2.18. Locate the proper bearing cap o-ring, apply seal lube and install into the housing.

1.2.19. Apply a small amount of anti-seize paste to the housing threads and then install the bearing cap and torque per table. Insert the setscrew and torque per table.

2. Valve Section

2.1. Cross-over Vent Valve Adjustment

2.1.1. To open the valve and allow fluid to pass between the cylinder chambers: rotate the thumbscrew jam nut counterclockwise to release the valve thumbscrew. Then rotate valve thumbscrew counterclockwise to allow the fluid to bypass. One full turn should allow the actuator shaft to be rotated with minimal resistance.

2.1.2. To close the valve and lock: hold the thumbscrew jam nut to prevent rotation and then rotate the valve thumbscrew clockwise until the hard stop is engaged. Tighten with fingers as much
as possible and then tighten the thumbscrew jam nut.

2.2. Cross-over Vent Valve Replacement (Diagram 2)

2.2.1. Remove the old cross-over vent valve (30) by disassembling with the provided hex nut on the valve.

2.2.2. Remove the new valve from the bag and assemble into the cavity. Valve has pre-applied light coat of oil to assist installation and provide good initial seal. Torque per the table.

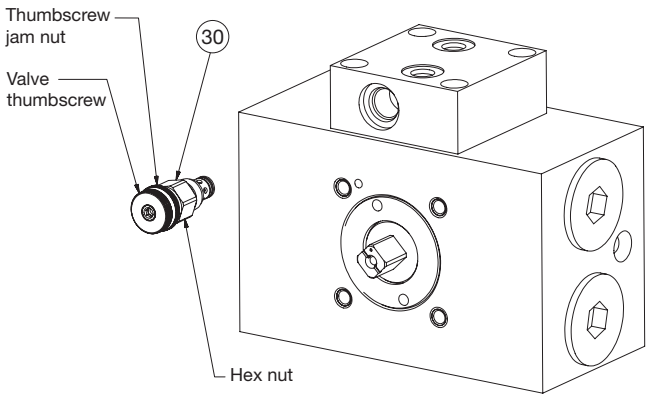
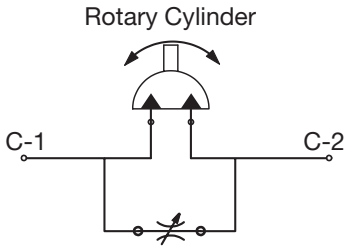


Diagram 2

Below is the hydraulic schematic of the cross-over vent valve describing the function.



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2.3. Cross-over Vent Valve Upgrade (Diagram 3)

2.3.1. Install spring pin (38) into manifold block (32) until 1/4" remains protruding.

2.3.2. Insert cross-over vent valve (30) into manifold block(32) and torque per table.

2.3.3. Apply seal lube to o-rings (37) and install onto manifold block. Attach manifold block to housing with bolts (33) and tighten per table.

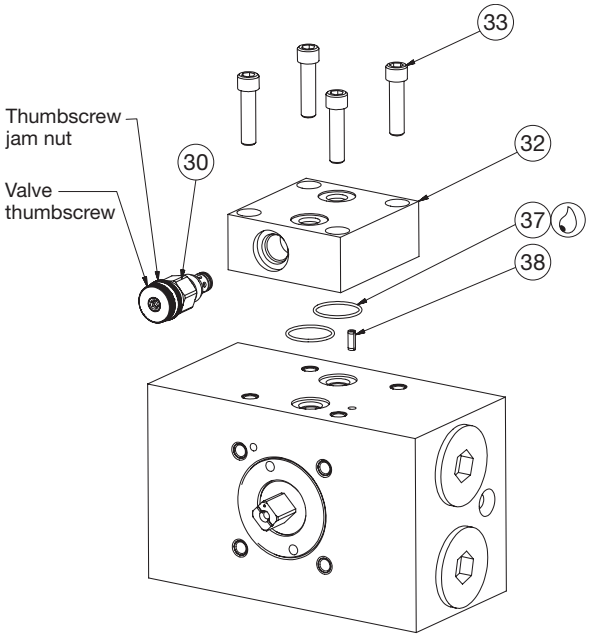

Diagram 3

Item #	Description	Qty
30	Cross-over vent valve	1
32	Manifold block	1
33	Cap screw	4
37	O-ring	2
38	Spring pin	1
80	Seal lube packet	1

2.4. Counterbalance Valve replacement (Diagram 4)

Note: The replacement kit includes a single counter-balance valve. 2 kits must be ordered if replacing both valves.

2.4.1. Remove the old counterbalance vent valve (31) by disassembling with the provided hex nut on the valve.

2.4.2. Remove the new valve from the bag and assemble into the cavity. Valve has pre-applied light coat of oil to assist installation and provide good initial seal. Torque per the table.

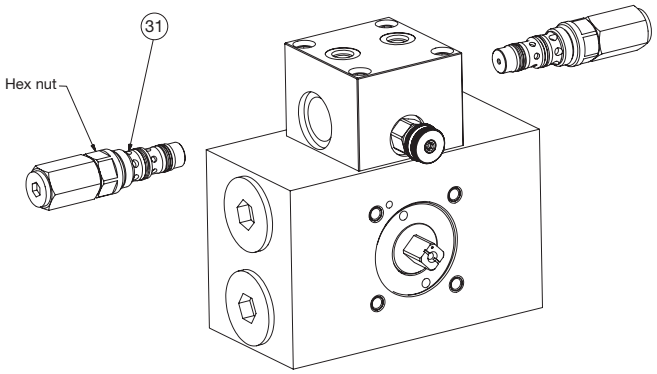

Diagram 4

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2.5. Counterbalance Valve Upgrade (Diagram 5)

2.5.1. Install spring pin (38) into manifold block (34) until 1/4" remains protruding.

2.5.2. Install counterbalance valves (31) into manifold block and torque per table.

2.5.3. Install cross-over vent valve (30) into manifold block and torque per table.

2.5.4. Apply seal lube to o-rings (37) and install into manifold block. Assemble manifold block to housing with bolts (33) and torque per table.

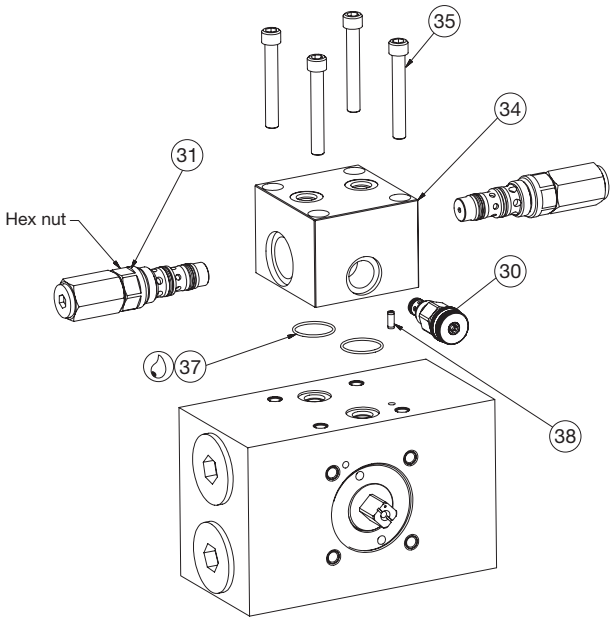

Diagram 5

Item #	Description	Qty
30	Cross-over vent valve	1
31	Counter-balance valve	2
34	Manifold block	1
35	Cap screw	4
37	O-ring	2
38	Spring pin	1
80	Seal lube packet	1

2.6. Solenoid Ready Upgrade (Diagram 6)

2.6.1. Install spring pin (38) into valve block (36) until 1/4" remains protruding.

2.6.2. Apply seal lube to o-rings (37) and install onto valve block. Assemble valve block to housing with bolts and torque per table.

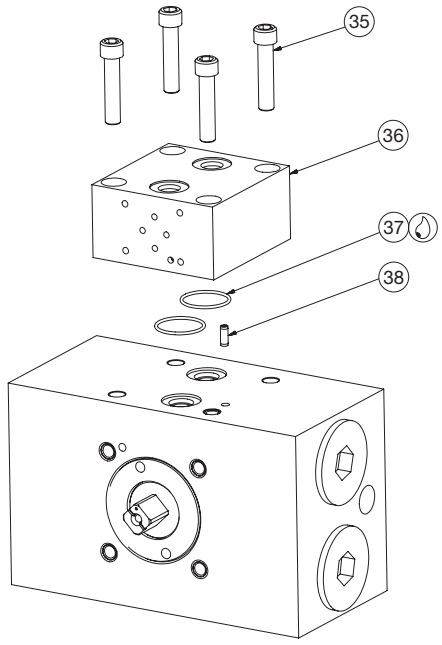

Diagram 6

Item #	Description	Qty
35	Cap screw	4
36	Manifold block	1
37	O-ring	2
38	Spring pin	1
80	Seal lube packet	1

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3. Feedback Section

3.1. RLPO, 0-40 VDC Replacement (Diagram 7)

3.1.1. Remove the RLPO module (50).

3.1.2. Install new RLPO module onto the manifold block (39) in the desired orientation. Torque per table. If feedback redundancy is required, a second RLPO module can be installed in place of the SAE plug.

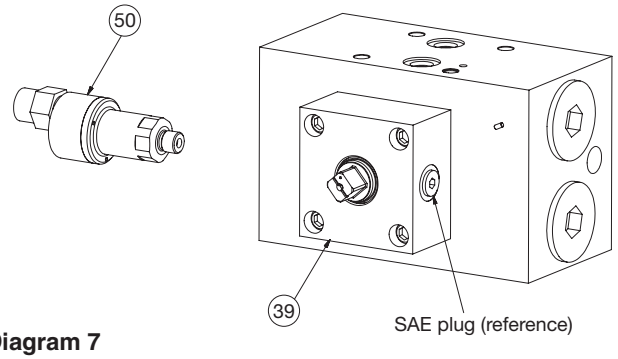
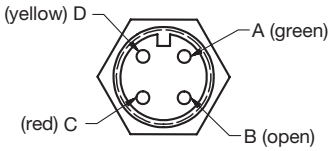


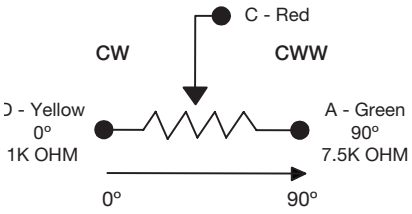
Diagram 7

See below for pin layout and electrical schematic of operation:



NOTE:
1. Use pins C & A for clockwise rotation.
2. Use pins C & D for counterclockwise rotation.

Receptacle Pin Layout



Schematic Layout

3.2. StoneL Replacement (Diagram 8)

3.2.1. Remove the two SHCS's (56) and pull the StoneL feedback off. The engaging clip will need to pop free.

3.2.2. Locate the new StoneL feedback and the drive clip. Remove the small pan head screw from the bottom of feedback device.

3.2.3. Push the new clip onto the locating pins and re-attach the pan head screw. Note: In some cases, the female feedback shaft will slide into the housing so that the pan head screw cannot be easily re-attached. If this occurs, remove the set screws on the large switch cover and then remove the cover. Hold the feedback shaft so that the pan-head screw can be re-installed. Then, re-install the switch cover.

3.2.4. Assemble the feedback onto the actuator using the SHCSs (56) and torque per table. Be sure the drive clip slides onto the actuator shaft.

3.2.5. Be sure that the visual window or red/green indicator is oriented as desired prior to assembly. Also, the visual angle at which the red/green indicator is visible can be adjusted with the indicated set screw.

3.2.6. Refer to section 3.6 to properly set the Solid State (SST Dual Module) sensor positions. Refer to section 3.7 to properly calibrate and set the 4-20mA potentiometer (position transmitter).

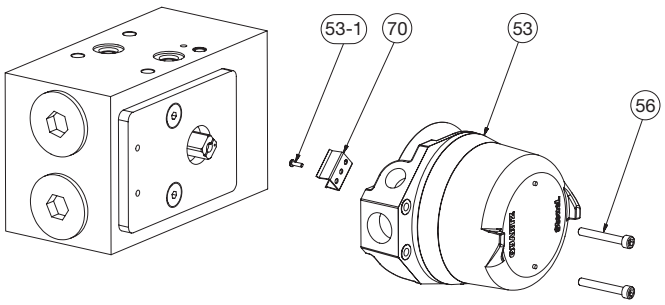


Diagram 8

Item #	Description	Qty
53	StoneL feedback	1
53-1	Slot head screw	1
56	Socket Head Cap Screws	2
70	Clip mount	1

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3.3. StoneL Upgrade (Diagram 9)

3.3.1. Install mounting plate (51) with two flathead screws (52). Be sure plate is oriented in the correct direction. Torque per table.

3.3.2. Attach clip (70) to bottom of module with slot head screw (53-1).

3.3.3. Install feedback module (53) with two bolts (56). Be sure clip on bottom of feedback module properly engages the shaft. Tighten bolts per torque table.

3.3.4. Refer to section 3.6 to properly set the Solid State (SST Dual Module) sensor positions. Refer to section 3.7 to properly calibrate and set the 4-20mA potentiometer (position transmitter).

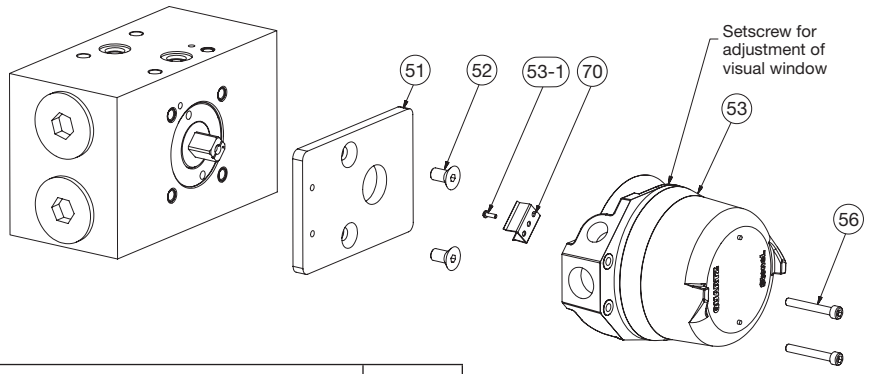

Diagram 9

Item #	Description	Qty
51	Mounting plate	1
52	Flathead Screws	2
53	StoneL feedback	1
53-1	Slot head screw	1
56	Socket Head Cap Screws	2
70	Clip mount	1

3.4. Visual Indicator – Stand alone (green on/red off) Replacement (Diagram 10)

Note orientation before removing.

3.4.1. Remove the four mounting screws (68). Remove the cover (67) and then remove flathead screw (67-5), visual indicator flag (67-4) and indicator hub (67-3).

3.4.2. Assemble the new VIR (67-3 and 67-4) with the flathead screw (67-5) and torque per table. Then assemble the VI cover (67) with mounting screws (68) and torque per table.

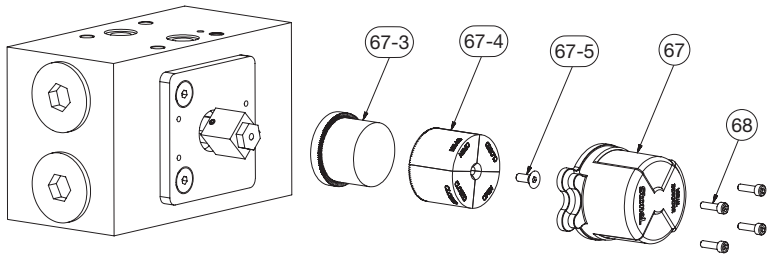

Diagram 10

Item #	Description	Qty
67	StoneL visual indicator cover	1
67-3	Hub	1
67-4	Visual indicator flag	1
67-5	M6x16 flat head cap screw	1
68	Mounting screw	4

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3.5. Visual Indicator - Stand alone (green on/red off) Upgrade (Diagram 11)

3.5.1. Install mounting plate (60) with two flatheads (52) and torque per table. Be sure plate oriented in the correct direction.

3.5.2. Install shaft coupling drive (66) with 2 set screws (67-2). Torque per table.

3.5.3. Install Indicator wheel (67-3 & 67-4) with flathead screw (67-5) to drive coupling (66). Torque per table. Be sure indicator wheel is oriented in proper direction.

3.5.4. Install visual indicator cap (67) with four mounting screws (68). Torque per table.

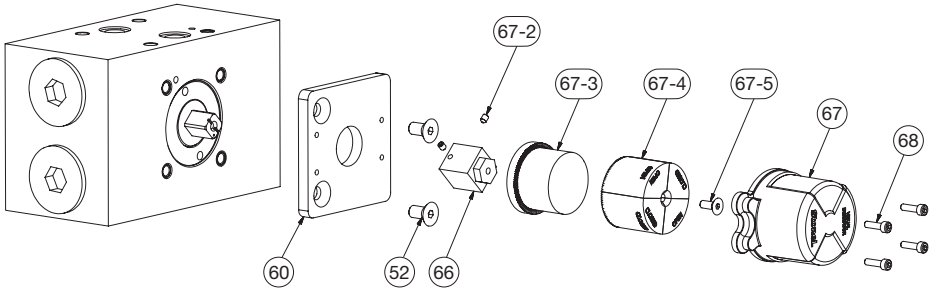

Diagram 11

Item #	Description	Qty
52	Flathead screw	2
60	Mounting plate	1
66	Shaft coupling drive	1
67	StoneL visual indicator cover	1
67-2	Set screw	2
67-3	Hub	1
67-4	Visual indicator flag	1
67-5	M6x16 flat head cap screw	1
68	Mounting screw	4

3.6. StoneL Solid State sensor position adjustment

3.6.1. Contact pdnapps@parker.com or view online at parker.com/pneu/hub

3.7. StoneL 4-20mA Position Transmitter Calibration

3.7.1. Contact pdnapps@parker.com or view online at parker.com/pneu/hub

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4. Torque Table

Item	Description	Qty	HUB018 ft-lbs	HUB075 & HUB100 ft-lbs
4	Rack Bolt	4	3	15
5	End Cap Plug	4	100	250
9	Bearing Cap	1	15	30
10	Bearing Cap Setscrew	1	2	4
30	Needle Valve	1	40-43	40-43
31	Counter-balance Valve	2	68-75	68-75
33	Bolts, Manifold Block	4	20	20
35	Bolts, Manifold Block	4	20	20
49	Bolts, Manifold Block	4	20	20
41	RLPO Setscrew	1	0.5	0.5
50	RLPO Module	1	34	34
52	Flathead Screws, Mounting Plate	2	30	30
53-1	Slot Head Screw for Clip	1	0.5	0.5
56	Bolts, Quartz Mounting	2	12	12
67-2	Setscrews, Drive Block	2	2	2
67-5	Flathead Screw, Visual Flag	1	7	7
68	Bolts, Visual Indicator	4	7	7

NOTE: Torque values apply to well lubricated threads

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LTR Series Actuators

Maintenance Instructions & Parts List

Provide Model Number and Serial Number When Ordering Spare Parts.

Introduction

Follow these instructions when installing, operating, or servicing the product.

The PTR/LTR Series Actuators will provide superior performance in heavy duty pneumatic and medium duty hydraulic applications. The new PTR Series "Wear-Tek" and LTR Series "Wear-Pak" piston sealing configurations and anti-friction ball bearings are used to guarantee low breakaway pressure and eliminate erratic motion at low speeds.

In the event that maintenance is required, the following steps should be used as a guide. It is recommended that a suitable oil or O-ring lubrication compatible with the operating media, such as Parker Lube-A-Cyl, be used on all seals and mating parts to facilitate assembly.

Inspection & Replacement (See Figure 1)

A. Inspection & Replacement of Piston Seal, #10, Wear Rings, #15, and O-Ring End Cap, #12.
   1. Remove Tie Rod Nuts, #17 from Tie Rods, #8.
   2. Pull End Cap, #16 free from Cylinder Tube, #14.
   3. Pull Cylinder Tube, #14 free from Housing, #13.
   4. Push Piston, #11 free from Cylinder Tube, #14.
   5. Inspect and/or replace Piston Seal, #10, Wear Rings, #15, and O-Ring End Cap, #12.
   6. Inspect and/or replace O-Ring Cylinder, #7 (for LTR Models only).
   7. Re-assemble as shown in figure and torque Tie Rod Nuts, #17 per Torque Table.

B. Inspection & Replacement of Bearing, #2.
   1. Remove Retaining Ring, #1.
   2. Press Pinion, #3, and Bearing #2 from housing, #13.
   3. Press Bearing, #2 free from Pinion, #3.
   4. Inspect or replace Bearing, #2.
   5. Press new Bearing, #2 into Housing, #13.
   6. Replace Pinion, #3 into Housing, #13.
   7. Press remaining new Bearing, #2 onto Pinion, #3.
   8. Replace Retaining Ring, #1.

Note: Prior to assembly of an LTR Series actuator, the rack and pinion are coated with a molycoat GN paste and a moly grease containing a minimum MSO2 content of 3%, such as Texaco Molytex EP2.

The PTR Series actuator's rack, pinion and seals are coated with Parker Lube-A-Cyl prior to assembly. 1.05 oz tube - part # 0761630000

Add lubrication as required.

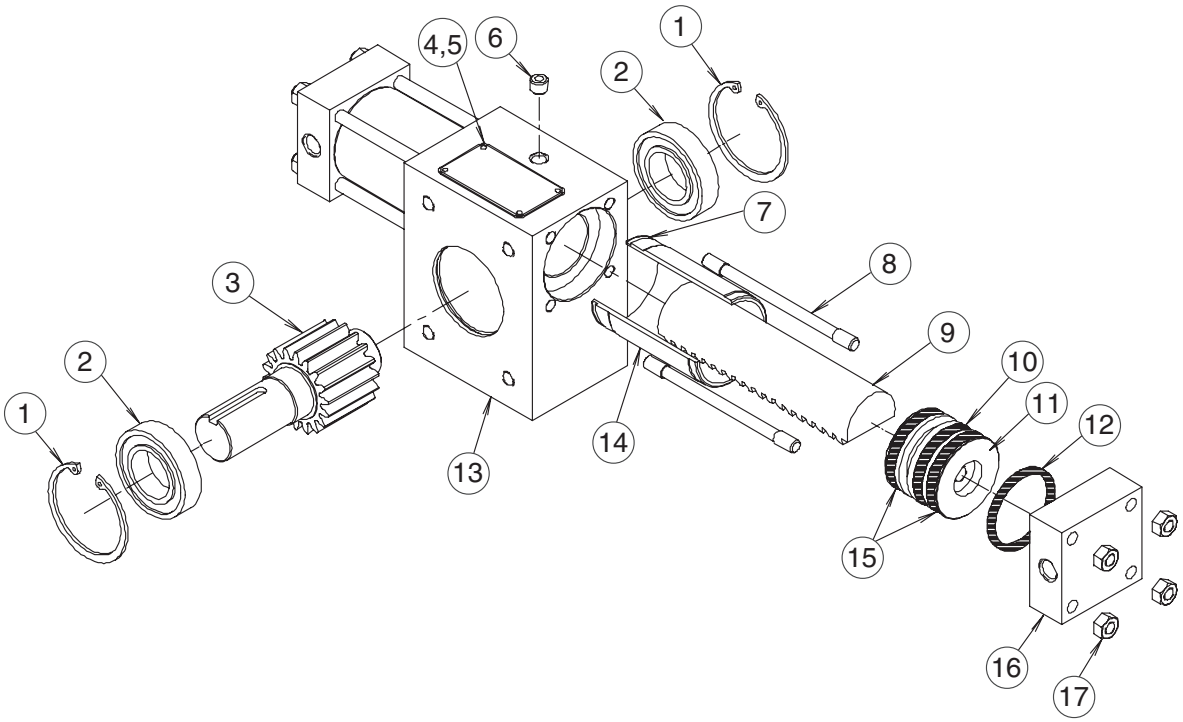

Figure 1

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Parts List (Figure 1 & 2)

Item No.	Description	Quantity	
		Single Rack	Double Rack
1	Retaining Ring	2	2
2	Bearing	2	2
3	Pinion	1	1
4	Name Plate	1	1
5	Drive Screws	4	4
6	Plug	1	1
7*	O-Ring, Cylinder Tube [1]	2	4
8	Tie Rod	8	16
9	Rack	1	2
10*	Piston Seal	2	4
11	Piston	2	4
12*	O-Ring, End Cap	2	4
13	Housing	1	1
14	Cylinder Tube	2	4
15*	Wear Ring	4	8
16	End Cap	2	4
17	Tie Rod Nut	8	16
18	Bumper	1X	1X
19	Bumper Bolt	1X	1X

All items marked with an asterisk (*) are included in a complete seal kit.

[1] = Only used on units with steel cylinder tubes. (LTR units)

x = Quantity as required per end cap option specified.

† = PTR units with the "Q" seal option will be equipped with these items.

Bumper Option (See Figure 2)

Built in polyurethane bumper pads absorb shock and noise, thus permitting faster cycle times and increased production rates. Recommended torque value for Bumper Bolt, item #19, is shown in Torque Table.

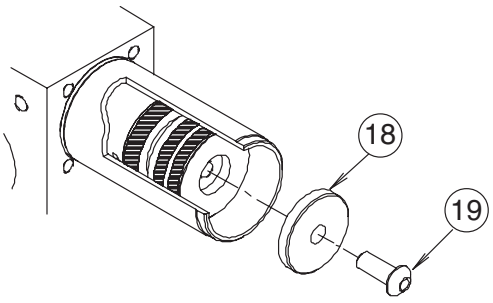

Figure 2

Seal Kit Ordering Information

- Standard units are equipped with nitrile seals.
- Optional seal compounds are available.
- See parts list for items contained in seal kits.
- Seal kit part numbers as follows:

PSK	—	LTR322
Parker Seal Kit		Base Model

V	
Omit	Nitrile Seals (Std)
V	Fluorocarbon Seals
Q	Quad Ring Piston Seals
W	Carboxylated Nitrile (Piston Seals Only)

Torque Table (ft-lb)

PTR/LTR Model	Tie Rod Nut #17 Cylinder Tube Material		Bumper Bolt #19	Piston Bolt #36 Cushion Plug #25	Shaft Seal Screw #50	Flange Bolt #46
	Aluminum	Steel				
101/102	1.5	-	3	3	3	5
151/152	3	5	6	6	3	10
201/202	6	11	20	20	3	17
251/252	6	11	20	20	3	40
321/322	15	20	50	50	3	130

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Cushion Option (Figure 3)

⚠ **Caution:** Before making any adjustment, turn off the system pressure. Never adjust cushion adjustment screw out past flush with end cap or counterbore.

DO NOT OVERTIGHTEN.

The standard cushions operate over the last 30° of rotation in either or both directions.

To Adjust:
Using an Allen wrench, turn Adjustment Screw, #21, clockwise or more cushioning, counterclockwise for less cushioning.

For double rack units where Option 4 (four cushions) is selected please take special care to make sure that adjacent cushions (ie both C-1 ports) are adjusted to the same cushion setting so as to ensure that both cushions are working together. An improper setting could result in one of the cushions not being utilized and thus result in premature gear train life or other damage to the unit.

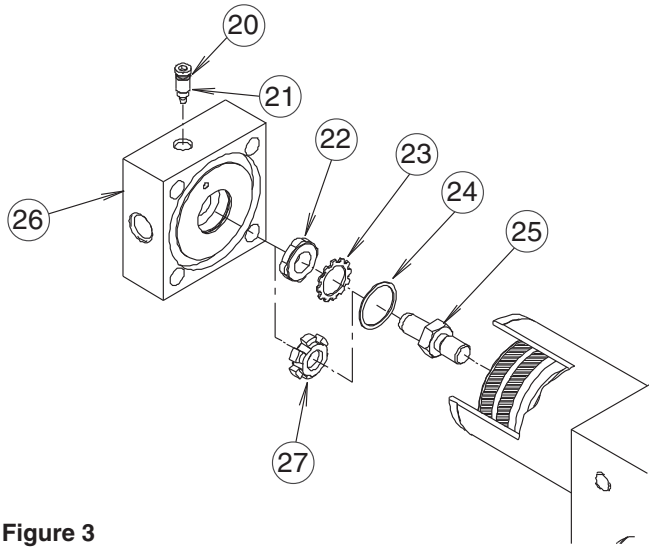

Figure 3

Port Flow Control Option (Figure 4)

Built in meter-out flow controls provide for precise regulation of actuator speed and eliminate the cost and space of externally mounted components. A separate spring loaded ball check is used to provide free flow in the opposite direction.

When both cushions and port flow controls are specified they will be stamped “C” and “P” respectively.

To Adjust:
Using an Allen wrench, turn Adjustment Screw, #29, clockwise for slower speed; counterclockwise for more speed.

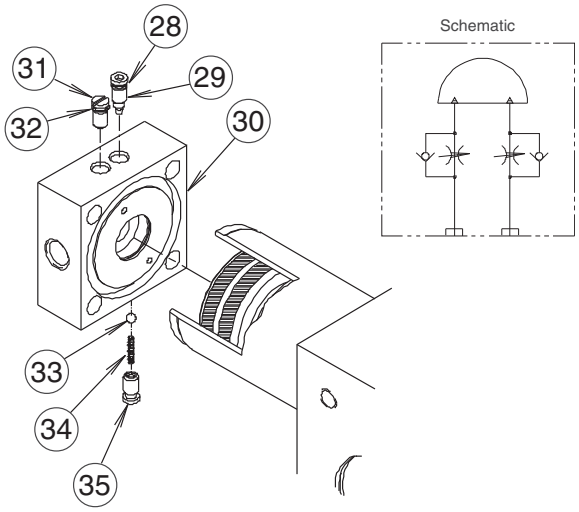

Figure 4

Parts List (Figure 3 & 4)

Item No.	Description	Quantity
20	O-Ring, Adjustment Screw	1
21	Cushion Adjustment Screw	1
22	Cushion Seal [1]	1
23	Cushion Seal Washer [1]	1
24	Retaining Ring	1
25	Cushion Plug	1
26	End Cap	1
27	Cushion Bushing [2]	1
28	O-Ring, Adjustment Screw	1
29	Flow Control Adj. Screw	1
30	End Cap	1
31	Plug	1
32	O-Ring, Plug	1
33	Check Ball	1
34	Check Spring	1
35	Check Plug	1

Notes:
Quantities shown are as required per end cap option specified.

[1] = Cushion seal configuration for use with pneumatic service.

[2] = Cushion bushing for use with hydraulic service

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Stroke Adjust Options (See Figures 5, 6 & 7)

Stroke adjusters will reduce the angle of rotation by 10° or 30° in either or both directions. Typical applications are for initial set up purposes where exact rotation requirements may change between various operations.

⚠ **CAUTION:** Before making any adjustments, turn off system pressure and ensure that no residual pressure exists in the actuator.

PTR/LTR Model	One Complete Turn of Adjuster Causes Specified Change in Rotation
101/102	4.0°
151/152	4.6°
201/202	3.2°
251/252	3.2°
312/322	2.4°

Standard cushions operate over the last 30° of rotation. Stroke adjusters will decrease the cushion length by the same amount. For example, reducing the rotation by 5° yields 25° cushion length.

To Adjust:

1. Loosen Jam Nut, #40.
2. Turn Stroke Adjuster, #41 clockwise to reduce stroke, counterclockwise to increase stroke.
3. Tighten Jam Nut, #40.
4. Resume system pressure

30° Stroke Adjust Option 30°

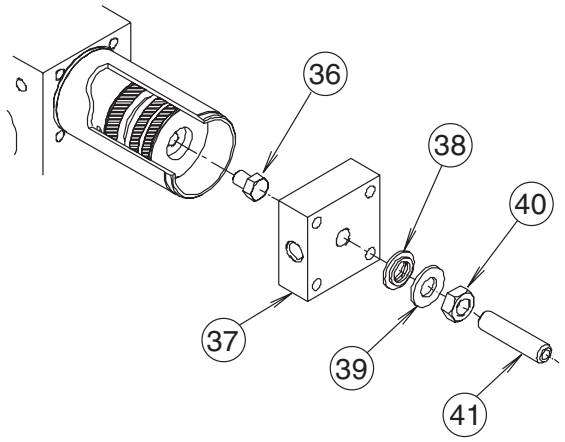

Figure 5

Stroke Adjust Option With Bumper

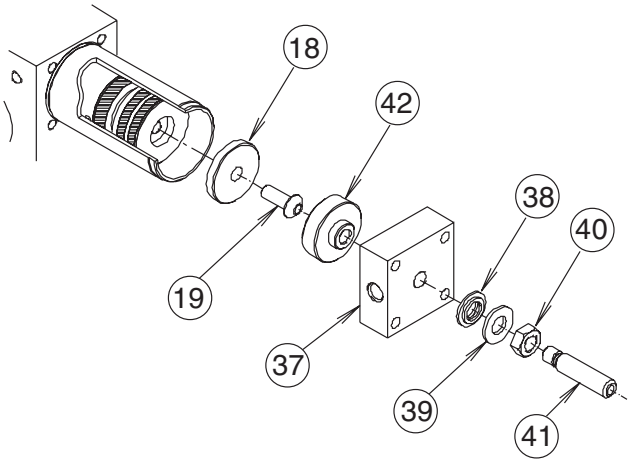

Figure 7

10° Stroke Adjustment With Cushion Option (Single Rack Units Only)

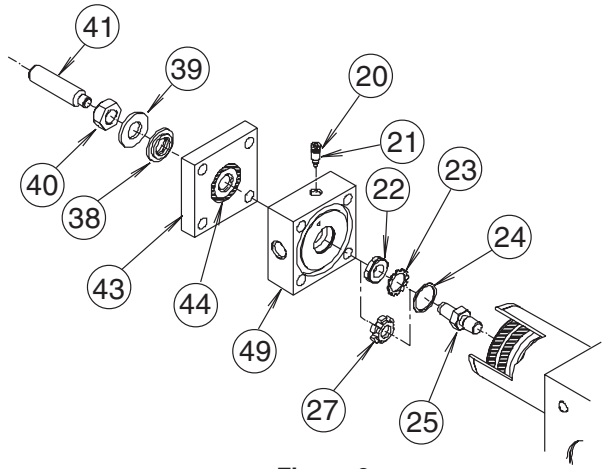

Figure 6

Parts List (Figure 5, 6 & 7)

Item No.	Description	Quantity
36	Piston Bolt	1
37	End Cap	1
38	Thread Seal	1
39	Lock Washer	1
40	Jam Nut	1
41	Stroke Adjuster	1
42	Stroke Adjust Head	1
43	Stroke Adjust Block	1
44	O-Ring, Stroke Adjust Block	1
45	End Cap	1

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Mounting Options (See Figure 8)

Mounting options utilize existing face and base mounting holes.

Shaft seal covers are designed to prolong bearing life by isolating them from external contamination and pressure.

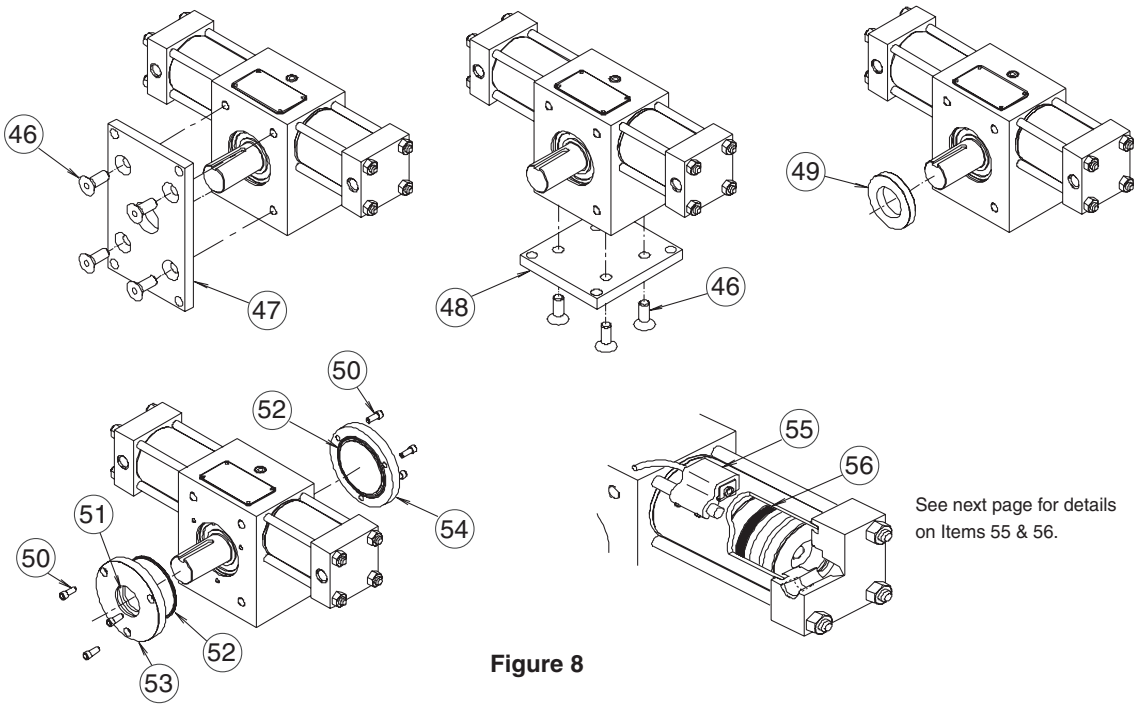
Notes:

1 = Quantity is 2 if double-end shaft extension is specified.

2 = Quantity is 0 if double-end shaft extension is specified.

Parts List (Figure 8)

Item No.	Description	Quantity
46	Flange Bolt	4
47	Front Flange	1
48	Foot Flange	1
49	Pilot Ring	1
50	Shaft Seal Cover Screw	6
51	Shaft Seal	1[1]
52	O-Ring	2
53	Shaft Seal Cover With Hole	1[1]
54	Shaft Seal Cover, Solid	1[2]



See next page for details on Items 55 & 56.

Figure 8

Reed Switch Option

Specifications

Switching Logic:	Normally Open
Voltage Rating:	85-125 VAC or 5-30 VDC*
Power Rating:	10 Watts AC or DC/Resistive Load 5 Watts AC or DC/Inductive Load
Switching Current Range:	10-200 mA/Resistive Load (PC, Sequencer) 10-100 mA/Inductive Load (Relay)
Switching Response:	300 Hz Maximum
Breakdown Voltage:	1.8kVACrms for 1 sec., lead to case
Min. Current for LED:	18mA
Operating Temperature:	14°F to 140°F(-10°C to 60°C)
Lead Wire Length:	39 inches (1 meter)

* Polarity is restricted for DC operation

(+) to BROWN

(-) to BLUE

If these connections are reversed the contacts will close, but the LED will not light.

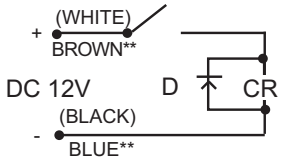
Prior to October, 1993:

(+) WHITE

(-) BLACK

Integral Circuit for Switching Contact Protection

(Required for proper operation 24 VDC)
Put Diode parallel to loads following polarity as shown below.

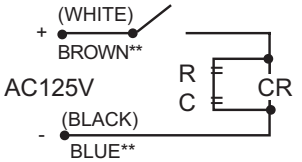


D: Diode: select a Diode with the breakdown voltage and current rating according to the load.

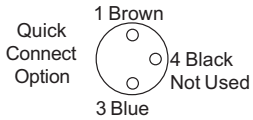
CR: Relay coil (under 0.5W coil rating)

** Applies to Switches Manufactured After 10/15/93.

(Recommended for longer switch life 125 VAC)
Put resistor and capacitor parallel to loads.



CR: Relay coil (under 2W coil ratings)
R: Resistor under 1 K ohm
C: Capacitor 0.1 µF



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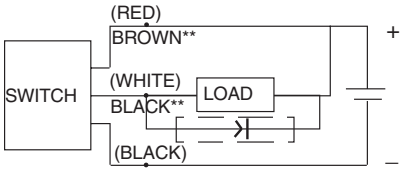
Hall Effect Switch Option

Specifications

Type:	Solid State Type (PNP or NPN)
Switching Logic:	Normally Open
Supply Voltage Range:	5 - 30 VDC
Current Output Range:	Up to 100 mA at 5 VDC, Up to 200 mA at 12 VDC and 24 VDC
Current Consumption:	7 mA at 5 VDC, 15 mA at 12 VDC, and 30 mA at 24 VDC
Switching Response:	1000 Hz Maximum
Residual Voltage:	1.5V Maximum
Leakage Current:	10uA Maximum
Breakdown Voltage:	1.8kVACrms for 1 sec., lead to case Min. Current for LED: 1 mA
Operating Temperature:	14°F to 140°F (-10°C to 60°C)
Lead Wire Length:	39 inches (1 meter)



* When connecting Inductive Load (relay, electromagnetic valve etc.) it is recommended to insert protection circuit. Diode 100V 1A. (NPN connection shown)

Proximity Switches (See Figure 9)

The inductive type proximity switch provides end of rotation indication. The non-contact probe senses the presence of the ferrous cushion spear and has no springs, plungers, cams or dynamic seals that can wear out or go out of adjustment. The switch is solid state and meets NEMA 1, 12 & 13 specifications. For ease of wiring the connector housing is rotatable through 360°. To rotate, lift the cover latch, position, and release.*

The standard proximity switch controls 20-230 VAC/DC loads from 5 to 500 mA. The low 1.7 mA off-state leakage current can allow use for direct PLC input. The standard short circuit protection (SCP) protects the switch from a short in the load or line upon sensing such a condition (5 amp or greater current) by assuming a non-conductive mode. The fault condition must be corrected and the power removed to reset the switch preventing automatic restarts.

The low voltage DC switch is also available for use with 10-30 VDC. This switch is in a non-rotatable housing, but does incorporate the short circuit protection.

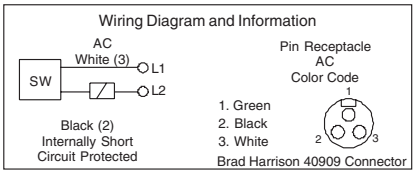
Both switches are equipped with two LEDs, “Ready” and “Target”. The “Ready” LED is lit when power is applied and the cushion spear is not present. The “Target” LED will light and the “Ready” LED will go out when the switch is closed, indicating the presence of the cushion spear.

Both LEDs flashing indicates a short circuit condition.

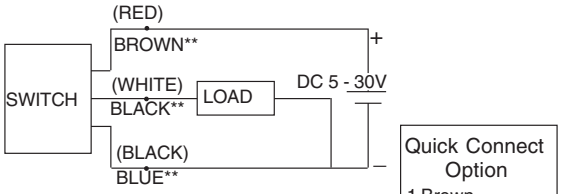
Notes:

1. Available with or without cushions.
2. Not available with stroke adjusters.
3. Pressure rating: 1500 psi
4. Operating temperature: -4°F to 158°F
5. Specify switch type, orientation and voltage when ordering.
6. Not available on PTR/LTR 10 size units.
7. The low voltage DC switch is available in non-rotatable style only; consult representative for further information.

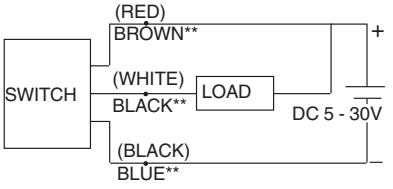
High Voltage Switch (20-230 VAC/DC)



PNP Wiring Connection



NPN Wiring Connection



** Applies to switches manufactured after 10/15/93.

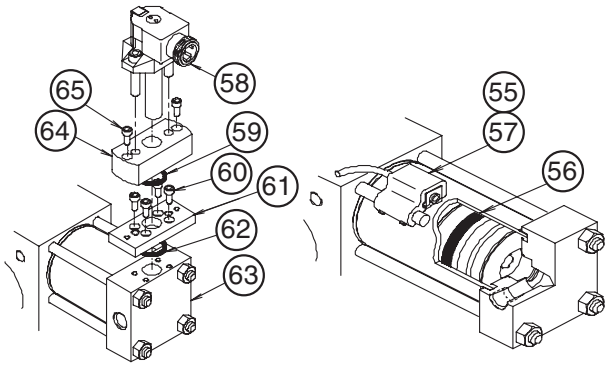


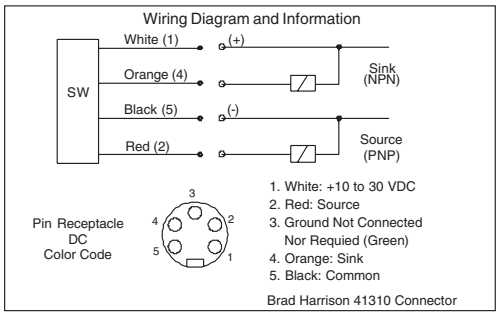
Figure 9

Parts List (Figure 9)

Item No.	Description	Qty.
55	Reed Switch Kit (Lead Type or Quick Connect)	1
56	Magnet	2
57	Hall Effect Switch Kit (Lead Type or Quick Connect)	1
58	Proximity Switch	1
59	O-Ring, Adaptor Block	1
60	Screw, Spacer Block	4
61	Spacer Block	1
62	O-Ring, Spacer Block	1
63	End Cap	1
64	Adaptor Block	1
65	Screw, Adaptor Block	2

Note: Quantities shown are as required per end cap option specified.

Low Voltage DC Switch (10-30 VDC)



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Air / Oil Option (6) (See Figure 10)

Speed Control Adjustment Procedure

⚠ **CAUTION:** Before making any adjustment, release the pneumatic pressure. Never adjust port flow control adjustment screw or cushion adjustment screw out past flush with end cap or counterbore. Do not overtighten.

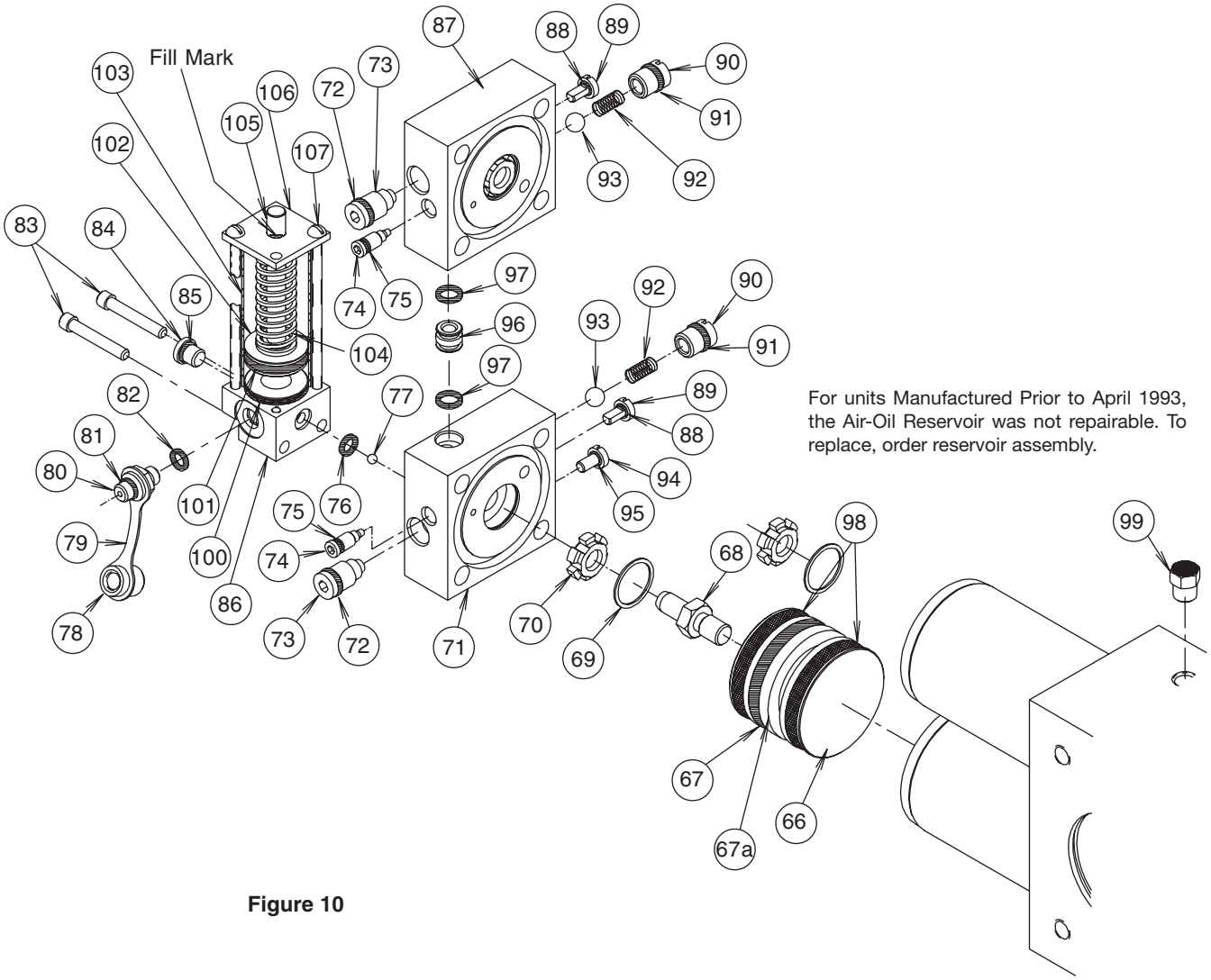
To control speed in either or both directions: Flow Control Adjustment Screw, #73, may be turned clockwise for slower rotational speed or counter-clockwise for faster rotational speed. When cushions are used with port flow control option, adjustment screws will be marked “C” and “P” respectively. Cushion Adjustment Screw, #74, can be turned clockwise for more cushion, counter-clockwise for less cushion. Always set flow control adjustment screw at desired actuator speed prior to adjusting cushion, which acts through the last 30° of actuator stroke.

Accumulator Charge Procedure

1. Remove Cap #78.
2. Attach fill gun, part #B161003. (filled with Mobil DTE-11M or equal), to fill port, #80.
3. Add oil to Spring Loaded Reservoir, #86.

⚠ **CAUTION:** Do not over-charge reservoir by extending fill mark on Piston Rod, #105, past accumulator face. (See drawing)

4. Bleed Reservoir, #86, as required by rotating the Air Bleeder Screw, #85, counter-clockwise until a smooth, air-free stream of oil is obtained.
5. Remove fill gun and replace cap.



For units Manufactured Prior to April 1993, the Air-Oil Reservoir was not repairable. To replace, order reservoir assembly.

Figure 10

Parts List (Figure 10)

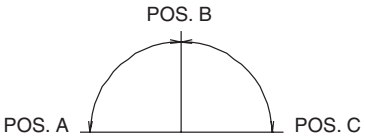
Item No.	Description	Quantity
66	Piston	2
67	Piston Seal	2
67A	PTFE Back-Up Ring	1
68	Cushion Plug	1
69	Retaining Ring	1
70	Cushion Bushing	1
71	End Cap	1
72	O-Ring Adjustment Screw	2
73	Flow Control Adj. Screw	2
74	Cushion Adjustment Screw	1
75	O-Ring Adjustment Screw	1
76**	O-Ring, Reservoir	1
77**	Check Ball	1
78**	Cap	1
79**	Strap	1
80**	Fill Port	1
81**	O-Ring	1
82**	O-Ring	1
83**	Bolt, Reservoir	2
84**	O-Ring, Bleeder Screw	1
85**	Air Bleeder Screw	1

Item No.	Description	Quantity
86**	Reservoir Housing	1
87	End Cap	1
88	Air Bleeder Screw	2
89	O-Ring, Bleeder Screw	2
90	Check Plug	2
91	O-Ring, Check Plug	2
92	Check Spring	2
93	Check Ball	2
94	Plug	1
95	O-Ring	1
97	O-Ring, Transfer Tube	2
98	Wear Ring	4
99	Breather	1
100**	O-Ring	1
101**	Piston Seal, Reservoir	1
102**	Reservoir Piston	1
103**	Reservoir Cylinder Tube	1
104**	Spring	1
105**	Piston Rod, Reservoir	1
106**	Reservoir End Cap	1
107**	Tie Rod	1

** Parts contained in Reservoir Assembly Item No. 108

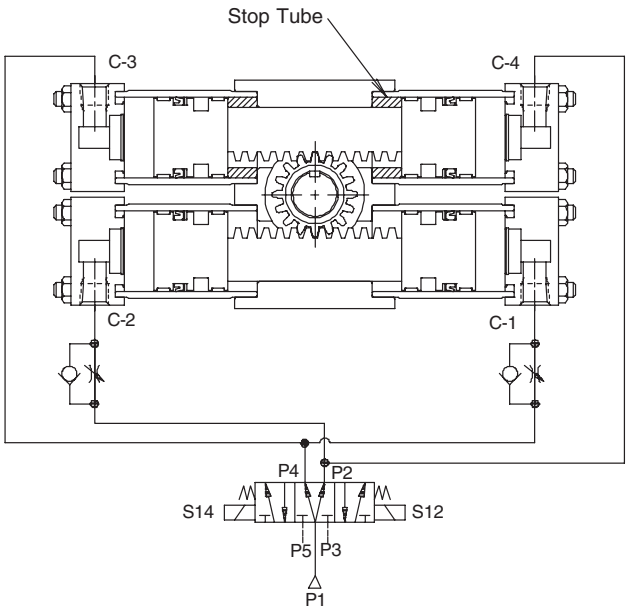
Three Position Actuator (3)

Recommended Operating Circuit



Operation:

A standard double rack unit is fitted with stop tubes on the upper rack, Energizing solenoid S14 connects valve port P4 to pressure, pressurizing actuator ports C1 and C3 (with ports C2 and C4 connected to exhaust), causing clockwise pinion rotation to angular position C. Alternately energizing solenoid S12 pressurizes actuator ports C2 and C4 (with C1 and C3 exhausted) causing counterclockwise rotation to angular position A. Position B is obtained by centering the control valve, which pressurizes all actuator ports. Pressure applied to the upper floating pistons centers the rack between the stop tubes. The lower rack is free floating as the forces are equal on both ends.



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HTR Series Actuators

Maintenance Instructions & Parts List

Provide Model Number and Serial Number When Ordering Spare Parts.

Introduction

Follow these instructions when installing, operating, or servicing the product.

General

HTR Series Hydraulic Rack & Pinion Actuators are designed for a maximum operating pressure of 3,000 psi non-shock (HTR22 and HTR45 2000 psi).

The actuator consists of a Pinion and one or two Racks located within a Housing. Pressurization of alternate cylinder port(s) results in shaft rotation.

The gear chamber has been filled with a Moly grease containing a minimum Molybdenum Disulfide (MSO2) content of 3%.

In the event that maintenance is required, the following steps should be used as a guide:

Assembly and Disassembly Procedures (See Figure 1)

A. Inspection & Replacement of End Cap Seals, #9.
   1. Place actuator in the mid-stroke position as shown. Remove Tie Rod Nuts, #10, from Tie Rods, #13.
   2. Pull End Cap, #11, free from Cylinder Tube, #12.
   3. Inspect and/or replace End Cap O-Ring, #9. Lubricate Seal and End Cap before reinstalling.
   4. Replace End Cap, #11, on Cylinder Tube, #12, and assemble Tie Rod Nuts, #10 to Tie Rods, #13.
   5. Torque Tie Rod Nuts per table on page 2.

B. Inspection & Replacement of Wear Rings, #4, Piston Seals, #5, and Cylinder O-Ring, #8.
   1. Repeat Steps A1 and A2.

For Models HTR75 through HTR600:

   2. Remove Rack Bolt, #7.
   3. Screw two (2) threaded rods into the tapped holes in Piston, #16, and pull free from Cylinder Tube, #12.

For Models HTR.9 through HTR45:

   4. Pull Cylinder Tube, #12, free from Housing, #2.
   5. Remove Rack Bolt, #7.

For All Models

   6. Inspect Piston, #16, and replace Piston Seal, #5.
   7. Inspect and/or replace Wear Rings, #4.
   8. Inspect and/or replace Cylinder O-Ring, #8.
   9. Replace Cylinder Tube, #12 to Housing, #2.
   10. Slide Piston, #16, with Piston Seal and Wear Rings assembled onto it, into Cylinder Tube, #12, until it contacts Rack, #17.
   11. Replace Rack Bolt, #7 and torque per table.

⚠ **Caution:** Nylon Slug, #6 is no longer used to prevent Rack Bolt from vibrating loose during operation. Current procedure is to apply Anerobic thread locker to thread area. New Rack Bolts will be supplied with patch applied. If no patch is present then follow instructions below:

   A. Use small brush to apply approximately 1/8 inch wide patch.
   B. No patch coverage permitted on first 3 threads.
   C. Patch to fill thread depth 1/3 to 1/2 full depth.

   12. Replace End Cap, #11, and Tie Rod Nuts, #10; torque per table on next page.

C. Inspection and Replacement of Pinion and Bearing Retainer O-Rings, #1 and #24.
   1. Loosen Lock Screw, #19.

      ⚠ **Caution:** Failure to do so will damage threads.

   2. Using spanner wrench, remove Bearing Retainer, #25, by turning counter-clockwise.
   3. Remove Bearings, #22, Pinion, #23, and Bearing Retainer O-Ring, #24,

      ⚠ **Caution:** Make match marks to re-establish the correct timing.

   4. Inspect and/or replace Pinion O-Ring, #1, located at the "front" or blind side of Housing #2.
   5. Reinstall Bearings, #22, and Pinion #23.
   6. Inspect and/or replace Bearing Retainer O-Ring, #24, located on outside diameter of Bearing Retainer, #25.
   7. Inspect and/or replace Pinion O-Ring, #1, located on inside diameter of Bearing Retainer, #25.
   8. Apply Moly Grease to Bearing Retainer Threads and reinstall into Housing, #2.
   9. Torque Bearing Retainer, #25 per table.
   10. Install and tighten Locking Screw, #19, per torque table.

D. Complete Disassembly of Actuator.
   1. Repeat Steps A1 and A2.
   2. Repeat Steps B2 through B5.
   3. Repeat Steps C1 and C3.

      ⚠ **Caution:** Make match marks to re-establish the correct timing.

   4. Push Rack from either end to remove from housing.

E. Reassembly of Actuator.
   1. Follow previous procedures for reassembly of all actuator parts. Refill the gear chamber with Moly Grease with a minimum MSO2 content of 3%; such as Texaco Molytex EP2.

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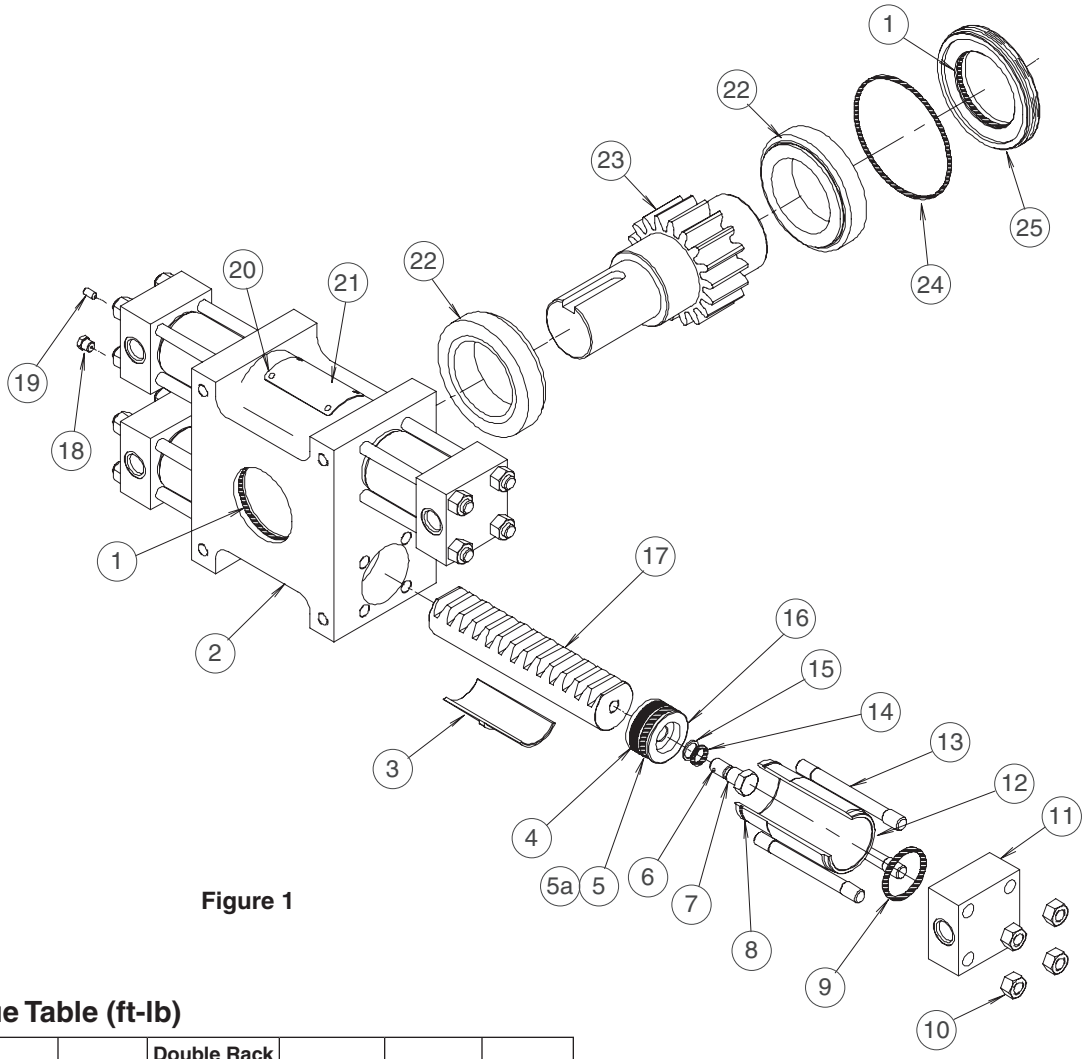

Figure 1

Torque Table (ft-lb)

Model	Tie Rod Nut #10	Double Rack Unit w/ Stroke Adj Tie Rod Nut #10	Rack Bolt #7 Cushion Plug #31	Bearing Retainer #25	Locking Screw #19
HTR.9/1.8	6	6	3	15	2
HTR3.7/7.5	15	20	15	30	4
HTR5/10	15	20	15	50	4
HTR15/30	30	45	40	100	4
HTR22/45	45	75	40	100	4
HTR75/150	130	225	130	250	15
HTR300/600	525	800	360	300	16

Maximum unit rotation is equal to rotation specified in the model code. Adjusters allow rotational positioning equal to or less than maximum rotation.

Model	One Complete Turn of Adjuster Causes Specified Changing in Rotation
HTR.9/1.8	4.0°
HTR3.7/7.5	3.3°
HTR5/10	2.5°
HTR15/30/22/45	2.0°
HTR75/150	2.0°
HTR300/600	1.2°

Seal Kit Ordering Information

- Standard units are equipped with nitrile seals.
- Optional seal compounds are available.
- See parts list for items contained in seal kits.
- Seal kit part numbers as follows:

PSK	—	HTR.9
Parker Seal Kit		Base Model

V	
Omit	Nitrile Seals (Std)
V	Fluorocarbon Seals
W	Carboxylated Nitrile Piston Seals

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Parts List (Figure 1)

Item No.	Description	Quantity	
		Single Rack	Double Rack
1*	O-Ring, Pinion	2	2
2	Housing	1	1
3	Rack Bearing	1	2
4*	Wear Ring	2	4
5*	Piston Seal	2	4
5a*	Back-Up Ring (See note 2)	2	4
6	Nylok Slug (Not used currently)	2	4
7	Rack Bolt - Vibra-tite	2	4
8*	O-Ring Cylinder	2	4
9*	O-Ring, End Cap	2	4
10	Tie Rod Nut	8	16
11	End Cap	2	4
12	Cylinder Tube	2	4
13	Tie Rod	8	16
14*	O-Ring, Rack Bolt	2	4
15*	Back-Up Ring, Rack Bolt	2	4
16	Piston	2	4
17	Rack	1	2
18	Relief Valve	1	1
19	Locking Screw	1	1
20	Drive Screw	4	4
21	Name Plate	1	1
22	Bearing	2	2
23	Pinion	1	1
24*	O-Ring, Bearing Retainer	1	1
25	Bearing Retainer	1	1

Notes:
* = Items marked with an asterisk (*) included in a seal repair kit.
[2] = 5a (Back-Up Ring) used only with fluorocarbon seals.

Cushion Option (See Figure 2)

⚠ **Caution:** Before making any adjustment, turn off the hydraulic pressure. Never adjust Cushion Screw out past flush with End Cap or counterbore.

DO NOT OVERTIGHTEN.

Adjustable cushions are designed to cushion the last 20° of actuator stroke.

To Adjust:

Using an Allen wrench, turn Adjustment Screw, #26, counter-clockwise for less cushioning.

For double rack units where Option 4 (four cushions) is selected please take special care to make sure that adjacent cushions (ie both C-1 ports) are adjusted to the same cushion setting so as to ensure that both cushions are working together. An improper setting could result in one of the cushions not being utilized and thus result in premature gear train life or other damage to the unit.

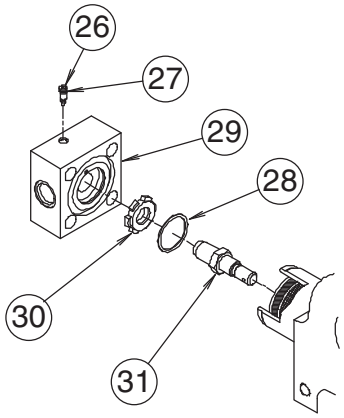

Figure 2

Stroke Adjust Option (See Figure 3)

⚠ **Caution:** Before making any adjustment, turn off the hydraulic pressure.

To Adjust:

1. Loosen Jam Nut, #36.
2. Turn Stroke Adjusters, #34, CW to reduce stroke, CCW to increase stroke.
3. Tighten Jam Nut, #36.
4. Resume system pressure.

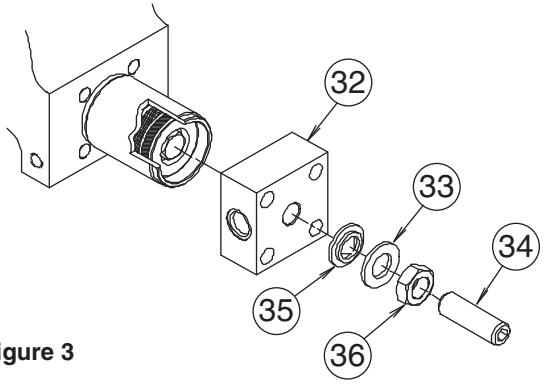

Figure 3

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Cushion and Stroke Adjust Option (See Figure 4)

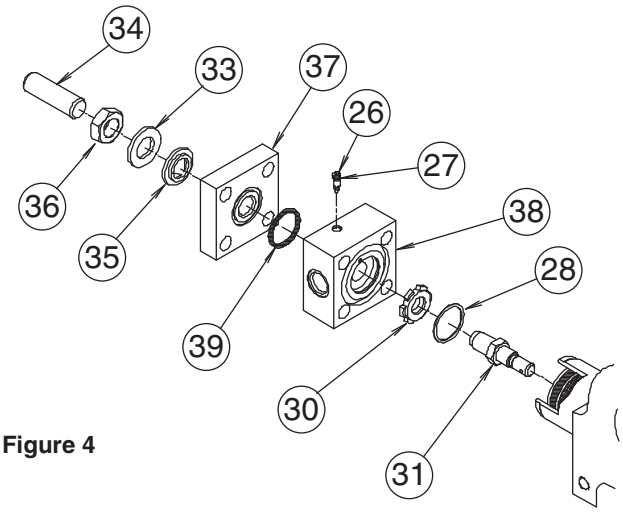

Figure 4

Parts List (Figures 2, 3 & 4)

Item No.	Description	Quantity
26	Cushion Adjustment Screw	1
27*	O-Ring, Adjustment Screw	1
28	Retaining Ring	1
29	End Cap	1
30	Cushion Bushing	1
31	Cushion Plug	1
32	End Cap	1
33	Washer	1
34	Stroke Adjuster	1
35*	Thread Seal	1
36	Jam Nut	1
37	Stroke Adjust Block	1
38	End Cap - W/SA	1
39*	O-Ring, Stroke Adjust Block	1

Note: Quantities required are per end cap option specified.
* = Items marked with an asterisk (*) included in a seal repair kit.

Proximity Switches (See Figure 5)

The inductive type proximity switch provides end of rotation indication. The non-contact probe senses the presence of the ferrous cushion spear and has no springs, plungers, cams or dynamic seals that can wear out or go out of adjustment. The switch is solid state and meets NEMA 1, 12 & 13 specifications. For ease of wiring the connector housing is rotatable through 360°. To rotate, lift the cover latch, position, and release.

The standard proximity switch controls 20-230 VAC/DC loads from 5 to 500 mA. The low 1.7 mA off-state leakage current can allow use for direct PLC input. The standard short circuit protection (SCP) protects the switch from a short in the load or line upon sensing such a condition (5 amp or greater current) by assuming a nonconductive mode. The fault condition must be corrected and the power removed to reset the switch preventing automatic restarts.

The low voltage DC switch is also available for use with 10-30 VDC. This switch is in a non-rotatable housing, but does incorporate the short circuit protection.

Both switches are equipped with two LEDs, “Ready” and “Target”. The “Ready” LED is lit when power is applied and the cushion spear is not present. The “Target” LED will light and the “Ready” LED will go out when the switch is closed, indicating the presence of the cushion spear. Both LEDs flashing indicates a short circuit condition.

Notes:
1. Available with or without cushions.
2. Not available with stroke adjusters.
3. Pressure rating: 3000 psi
4. Operating temperature: -4°F to 158°F
5. Specify switch type, orientation and voltage when ordering.
6. The low voltage DC switch is available in non-rotatable style only; consult representative for further information.

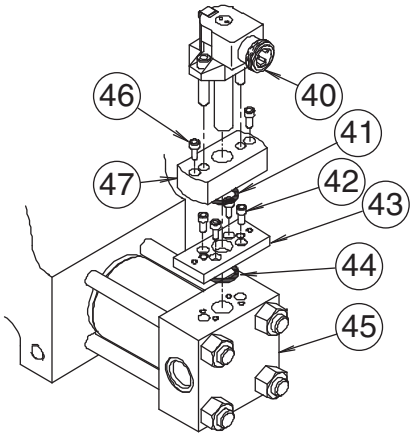

Figure 5

Parts List (Figure 5)

Item No.	Description	Quantity
40	Proximity Switch	1
41	O-Ring, Spacer Block	1
42	Bolt, Adaptor Block	4
43	Adaptor Block	1
44	O-Ring, Adaptor Block	1
45	End Cap	1
46	Bolt, Spacer Block	2
47	Spacer Block	1

Note: Quantities required are per end cap option specified.

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M Series Actuators

Maintenance Instructions & Parts List

Provide Model Number and Serial Number When Ordering Spare Parts.

Introduction

Follow these instructions when installing, operating, or servicing the product.

General

Limit the maximum operational pressure of the Parker M series rotary actuator to 3000 PSIG. Refer to the engineering catalog for operational specifications.

The actuator consists of the: rotary group which includes the rack gear and cylinder tubes; the pinion gear; the end cap group; the housing group; and the seal group.

The actuator rotates CCW when (facing the output shaft or mounting face) the lower left (and upper right) cylinder ports receive flow from a suitable power unit. Likewise, the actuator rotates CW when the lower right (and upper left) cylinder ports receive flow from a suitable power unit.

AAD lubricates the gear train with an EP grease that has a minimum MOS2 content of 3%. The factory installs TEXACO MOLYTEX EP(2) extreme pressure grease at assembly and test. If necessary, replenish the gear box lubricant with either MOLYTEX EP(2) lubricant or an equivalent.

Lubricant leakage from the housing relief valve is a symptom of a damaged piston seal and/or the cylinder tube bore. The urgency of repair depends upon the actuator's duty cycle and the rate at which the lubricant leaks from the housing. The typical repair involves replacing the piston seals; smoothing out any minor damage in the cylinder bore or replacing severely damaged cylinder tubes; and replacing or replenishing

the gear lubricant. Any good quality EP grease similar to TEXACO MOLYTEX EP(2) grease would be suitable.

In the event that a maintenance repair is needed, then we suggest using the following (outline) steps:

A. Inspection and Replacement of the End Cap O-Ring (14) and Back Up Ring (15)

1. Rotate shaft to mid-stroke position. Remove the end cap bolts (2) and the flat washers (3).
2. Screw threaded rod into tapped holes of end cap (16) and push end cap (16) into cylinder tube (29) and stop when you see the keeper ring (17).
3. Remove the keeper ring (17) by moving the short sides of the keeper rings radially into the cylinder; then move the larger top and bottom sides the same way.
4. Pull the end cap (16) out of the cylinder tube.
5. Cushion equipped end caps: remove adjusting screw (40.)

Assembly

(Omit steps 6 & 7 if end cap is not equipped with the cushion feature.)

6. Inspect adjusting screw o-ring (39); replace if necessary.
7. Install cushion adjusting screw into cushion equipped end cap.
8. Inspect end cap o-ring (14) and back up ring (15); replace if necessary. Note that the back up ring must be installed opposite the high pressure side of the o-ring.
9. Install end cap (16) into the cylinder tube (29) and push into position described in section A2.
10. Install the keeper ring (17) by positioning the large top and bottom segments and then the short segments. If necessary, suggest using a grease or vasoline as an installation aid to hold the segments in place.
11. Pull end cap (16) back into position against keeper ring.
12. Install the end cap bolts (2) and flat washers (3).
13. Apply proper torque to secure end cap assembly.

B. Inspection & Replacement of Piston Seal (12)

1. Follow steps 1, 2, 3 & 4 from section A.
2. Remove rack bolt (18) or remove cushion spear (35).
3. Install the piston (13) into the cylinder (29) and push until the piston is flush against the face of the rack gear (28).
4. Screw threaded rod into tapped holes in piston (13).
5. Pull piston, piston seal (12), and wear ring (11) free from cylinder (29).
6. Inspect and if necessary, replace the piston seal. (Polypak o-ring must face toward the high pressure side.) Replace the wear ring (11) if necessary.
7. Inspect and replace rack bolt or cushion spear o-ring seal (19) and back up ring (20). Replace if necessary. Install the back up ring opposite the pressure side.
8. Install the rack bolt (18) or the cushion spear (35) and tighten with the appropriate torque value presented in the table.

   ⚠ **CAUTION:** The nylok slug (21) is used to help the rack bolt or cushion spear resist loosening caused by vibration. Ensure the nylok slug is properly installed into the rack bolt or cushion spear prior to assembly. Replace if necessary.
9. Follow steps 6 through 13 from section A to install the end cap.

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C. Inspection and Replacement of Bearing Cap O-Ring (31) and Pinion O-Ring (33).

1. Remove bearing cap bolts (5) and lock washers (6).
2. Pull bearing cap (4) from the housing (1).
   ⚠ **CAUTION:** Use two bearing cap bolts (5) as "jacking screws" by screwing into the tapped holes in the bearing cap (4). Use wrench to "lift" the bearing cap out of the housing.
3. Mark witness marks on the pinion. Remove bearings (32) and pinion (34). Mark witness marks on the pinion (34) and rack gear (28) to ensure correct timing at assembly.
4. Inspect and replace pinion o-rings (33) in bearing cap (4) and in housing (1) if necessary.
5. Install bearings (32) and pinion (34) in housing. Pay attention to the witness marks so correct timing is achieved.
6. Inspect and replace bearing cap o-ring (31) if necessary.
7. Install bearing cap (4) and bearing cap bolts (5) with lock washers (6). Fasten bolts to torque values indicated in the table.

Bearing Preload Procedure "M" Series Rotary Actuators

1. After reassembly of actuator, torque bearing cap bolts, item #5, to the value given in the torque table on page E21.
2. Loosen bearing cap bolts and retighten to approximately 1/2 of the recommended torque value.
3. Using a feeler gauge, measure the gap between the bearing cap and housing created by the loosening of the bolts in step #2.
4. Add shims as required per the measurement taken. If shimming can not be obtained to the exact measured amount, get as close as possible without going over the measured thickness required.

   Note: shim thickness available: .005", .015"

D. Disassembly of Actuator. Procedure for Removal, Inspection and Replacement of Rack Bearing (27).

1. Follow suggested instructions 1, 2, and 3 from section C to remove bearing cap (4), bearings (32), and pinion (34).
   ⚠ **CAUTION**: Mark witness marks on the pinion (34) and rack gear (28) to ensure correct timing at assembly.
2. Follow suggested instruction 1, 2, 3, 4, and 5 from section B.
3. Remove keeper flange bolts (22) and keeper flange lock washers (23).
4. Remove keeper ring (25) by sliding keeper flange (24) along cylinder (29) until keeper ring (25) is exposed. Remove both sections of the keeper ring.
5. Pull cylinder (29) from housing (1).
6. Slide keeper flange (24) from cylinder (29).
7. Inspect and replace cylinder o-ring (26) if necessary.
8. Slide rack (28) out of the housing.
   ⚠ **CAUTION**: Use care not to damage the rack bearing. Ensure the rack gear teeth remain opposite from the rack bearing (27).
9. Inspect and replace rack bearing (27) if necessary.
   ⚠ **CAUTION**: Ensure the rack bearing remains centered in the housing.
10. Install rack gears (28). Ensure the rack gear is slid into place. Suggest using grease or vasoline to hold the rack bearing in place during rack installation. Center the rack gear inside the housing. Use generous amounts of EP2 grease or equivalent to coat and ensure the gear train is properly lubricated during operation.
11. Assemble keeper flange (24) and the keeper ring (25) on to the cylinder (29). Install keeper ring (25) in slot of cylinder (29) and the slide keeper flange (24) over keeper ring (25). Slide assembly into the housing.
12. Install keeper flange bolts (22) and lock washers (23). Fasten keeper flange bolts (22) to torque values specified in the table.
13. Repeat steps 4, 5, 6 and 7 from section C.
14. Repeat steps 7, 8 and 9 from section B.
15. Ensure housing has a generous amount of lubricant. Install the housing relief valve (10).

⚠ **CAUTION:**

Do not pump housing completely full of grease. Only a generous amount of lubricant is required. This will eliminate the potential of filling the "non-pressure" side of the cylinder tubes with grease.

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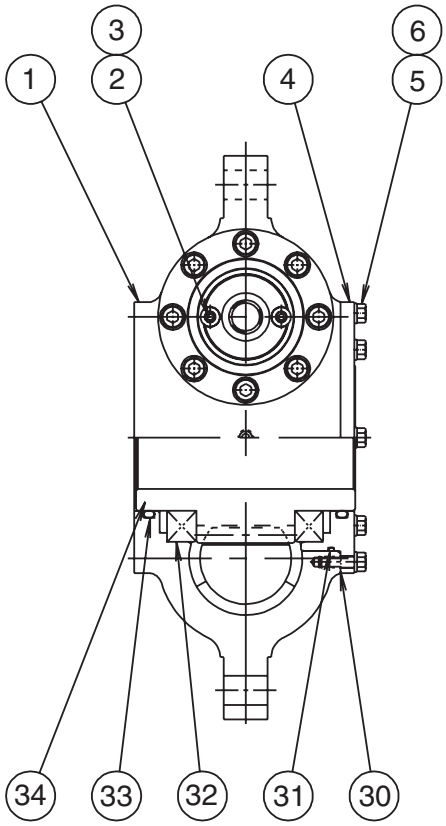
Item	Description	Quantity	
		Single	Double
1	Housing	1	1
2	Bolt, End Cap	4	8
3	Flat Washer, End Cap	4	8
4	Bearing Cap	1	1
5	Bolt, Bearing Cap	8	8
6	Lockwasher, Bearing Cap	8	8
7	Plug, Housing	1	1
8	Name Plate, Housing	1	1
9	Drive Screw, Name Plate	4	4
10	Relief Value, Housing	1	1
11*	Wear Ring, Piston	2	4
12*	Piston Seal	2	4
13	Piston	2	4
14*	O-Ring, End Cap	2	4
15*	Back-up ring, End Cap	2	4
16	End Cap	2	4
17	Keeper Ring, End Cap	2	4
18	Rack Bolt	2	4
19*	O-Ring, Rack Bolt	2	4
20*	Back-up Ring, Rack Bolt	2	4
21	Nylon Slug, Rack Bolt	2	4
22	Bolt, Keeper Flange	16	32
23	Lockwasher, Keeper Flange	16	32
24	Keeper Flange	2	4
25	Keeper Rings	2	4
26**	O-Ring, Cylinder	2	4
27	Rack Bearing, Housing	1	2
28	Rack	1	2
29	Cylinder	2	4
30‡	Shim	2	2
31**	O-Ring, Bearing Cap	1	1
32	Bearing	2	2
33*	O-Ring, Pinion	2	2
34	Pinion	1	1
35+	Cushion Plug	1	1
36+	Retainer Ring	1	1
37+	Cushion Bushing	1	1
38+	Plug, End Cap	1	1
39+*	O-Ring, Adjust Screw	1	1
40+	Cushion Adjusting Screw	1	1
41	Set Screw	2	4
42**	Air Bleeder	2	4

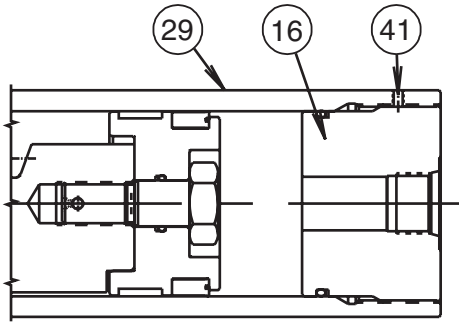
* Item Included in Seal Kit

** If Unit is Equipped With “G” Option (Air Bleeds)

\+ For Cushion in One Direction, Qty. 1
For Cushion in Both Directions, Qty. 2
On Double Rack for Cushion in Both Directions, Qty. 4

‡ Total Shims = 2 (1 of each, or as required)
1 Shim = 0.005" Thick
1 Shim = 0.015" Thick





5° Stroke Adjust Option
Caution: Do not adjust out past flush position

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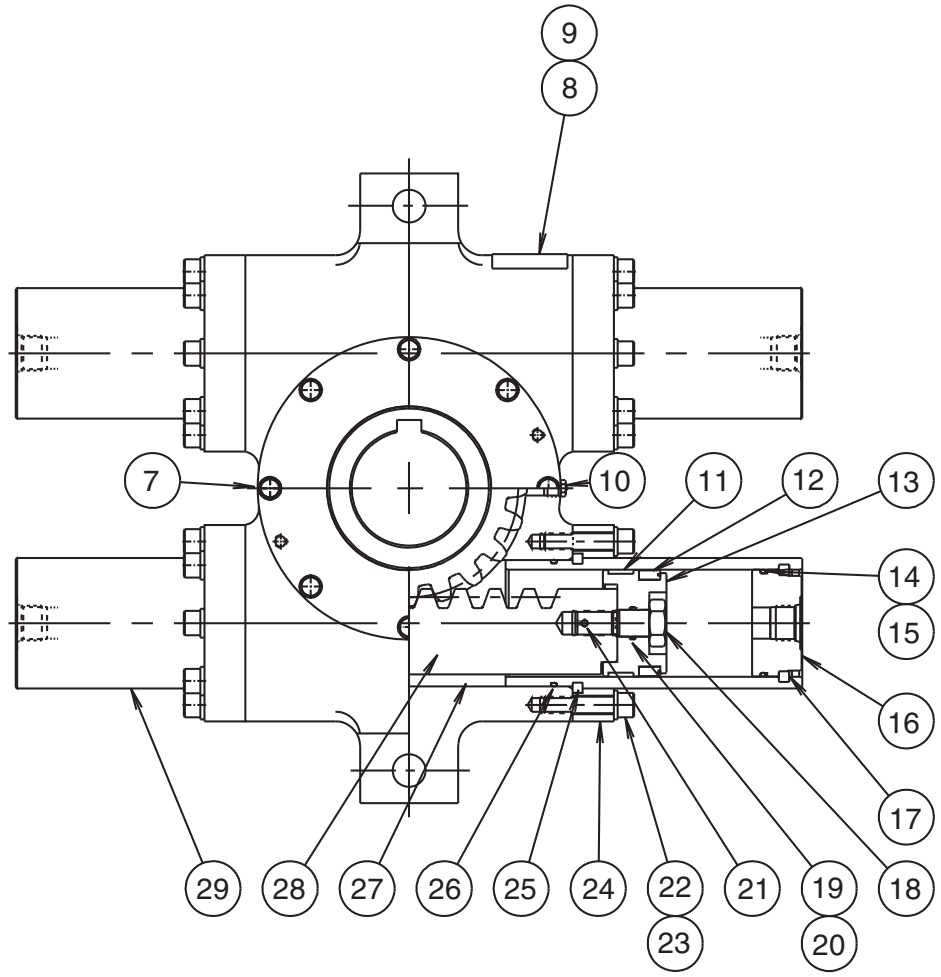
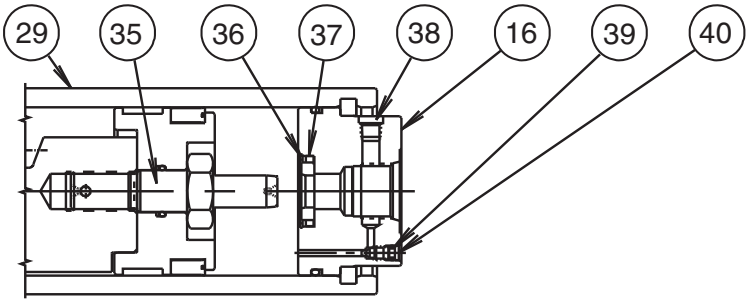
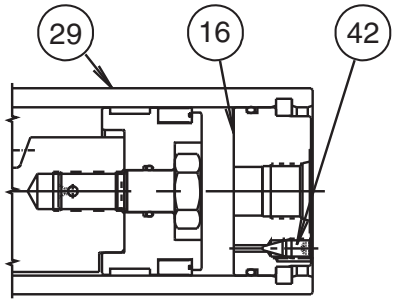




Cushion Detail



Air Bleed Detail

For double rack units where Option 4 (four cushions) is selected please take special care to make sure that adjacent cushions (ie both C-1 ports) are adjusted to the same cushion setting so as to ensure that both cushions are working together. An improper setting could result in one of the cushions not being utilized and thus result in premature gear train life or other damage to the unit.

Torque Table (ft-lb)

Model	Rack Bolt #24 Cush. Plug #35	Bearing Cap Bolt #3	Keeper Flange Bolt #33
15/30M	35	5	10
75/150M	35	18	45
300/600M	110	45	80
1000M	200	90	90

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Tork-Mor Series Actuators

Maintenance Instructions & Parts List

Provide Model Number and Serial Number When Ordering Spare Parts.

*The vane and stator should **NEVER** be used for a positive stop. See below Section #1 STOPS.*

Introduction

Follow these instructions when installing, operating, or servicing the product.

Tork-Mor Series actuators have been carefully designed to provide long, trouble-free life given that the unit has been correctly installed and operated within specifications.

The following lists factors relevant to service life and should be read before actuator installation.

1. Stops

The vane and stator should never be used as a positive stop. For light to medium loads a taper lock stop (TLS) option is available. Alternately, external stops mounted securely to machine framework are recommended. For high inertia or high speed loads, externally mounted valving should be used to minimize system shocks.

2. Surge Pressures

Surge or shock pressure in excess of the actuator rated pressure are detrimental to unit life and must be avoided. Crossover relief valves mounted adjacent to the actuator can help reduce these abnormal pressure peaks.

3. Angular Velocity

Angular velocity can be controlled by metering the flow into or out of the actuator ports. This is best accomplished by the use of flow control valves. The actuators are fitted with standard port sizes to provide optimum operating speeds with reasonable pressure drops.

4. Drains

The actuators are fitted with drain ports to minimize external leakage possibilities. These drain ports should be connected directly back to the oil reservoir with a minimum of back pressure.

5. Thrust Loads

External thrust bearings are required for actuators subjected to axial or thrust loads. These bearings are also recommended where large actuators are mounted in the vertical plane since for all practical purposes the shaft assembly is floating on the seals and can lead to accelerated seal wear.

6. Radial Loads

Tork-Mor Series actuators are fitted with ball or roller bearings to support the shaft assembly, but they should not be subjected to external loads. External bearings should be used to support overhung or radial loads.

Supplementary Data

Fluid Medium

For hydraulic usage a clean, filtered, mineral based oil with 150 to 400 SUS viscosity at 100°F is recommended for use with standard Buna seals. The correct filters can be provided by your Parker Distributor.

Air service units, including filter, regulator and lubricator will ensure correctly conditioned compressed air is available for pneumatically operated systems.

Vane Position

The vane is always positioned on the centerline of the keys with an “0” marking on the shaft end in line with a single vane.

Actuator Size

Selection of the correct actuator is achieved by determining the available system pressure then selecting a unit with 20% to 50% reserve capacity of the application load requirements.

Seals

Standard seal compound is nitrile for mineral based hydraulic fluid. Other seal materials can be provided for most operating fluids. To ensure correct seal compound please provide name and type of operating fluid.

Shaft Couplings

Couplings should engage the full length of shaft keyway and should only be pressed on after support has been provided on the opposite end of the shaft.

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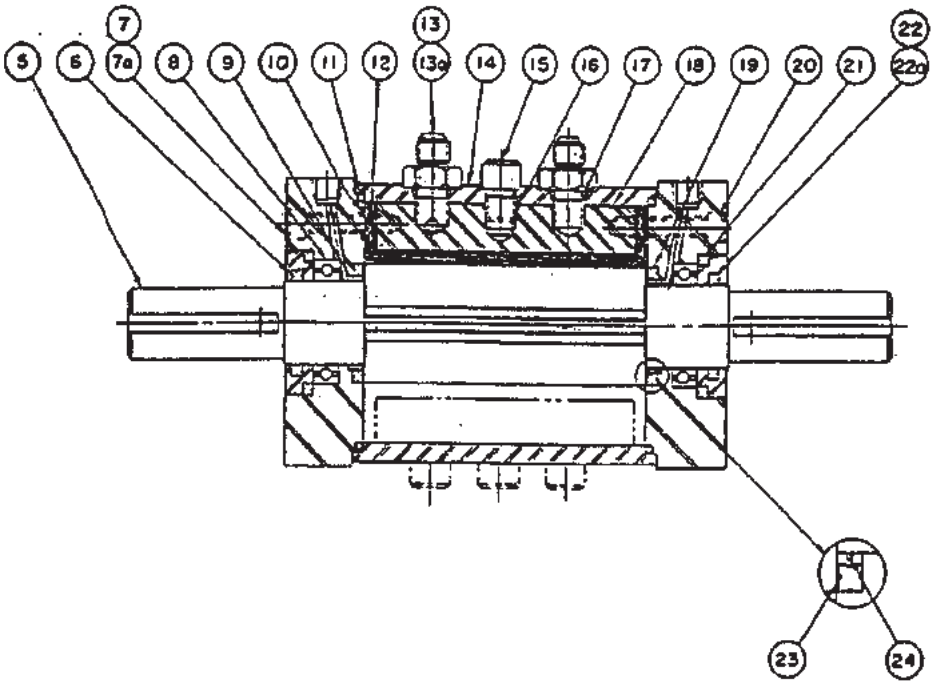

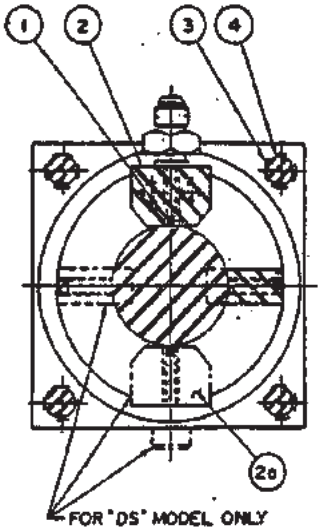

Item No.	Description	S33	DS33	S42	DS42	S44	DS44	S46	DS46	S74	DS74	S77	DS77	S105	DS105	S108	DS108	S112	DS112
• 1	PTFE Backup	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
2	Stator, Standard	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2a	Stator, Dummy	—	1	—	1	—	1	—	1	—	1	—	1	—	1	—	1	—	1
3	Allen Nut	—	—	—	—	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4	Tie Rod	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	Shaft Assembly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
• 6	Seal, Retainer Nut Inner	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
7	Head, Threaded	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7a	Head, C'bored	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	Bearing	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	Thrust Bearing	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
• 10	Seal, Stator	4	4	4	4	4	4	4	4	4	4	4	4	4	10	5	12	7	14
• 11	Seal, Head	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
• 12	"U" Seal	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	4	4
13	Male Connector	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13a	Female Connector	See Note 2																	
14	Body	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Bolt, Stator	1	2	—	2	1	4	3	6	—	2	1	4	—	2	1	4	3	6
• 16	Seal, Stator Bolt	1	2	—	2	1	4	3	6	—	2	1	4	—	2	1	4	3	6
17	Seal, Connector	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
• 18	Gasket	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
• 19	Seal, Shaft	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	Socket Head Cap Screw	4	4	4	4	4	4	4	4	4	4	4	4	4	8	4	8	4	8
• 21	Seal, Retainer Nut Outer	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	Retainer Nut, Standard [1]	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
22a	Retainer Nut, Solid [1]	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	1	1	1
23	Shaft, PTFE Glass Filled	—	—	—	—	—	—	—	—	2	2	2	2	2	2	2	2	2	2
• 24	Seal Thrust Bearing	—	—	—	—	—	—	—	—	2	2	2	2	2	2	2	2	2	2

• Recommended spare parts (seals)
1 On single end shaft units, (1) of Item #22 and (1) of Item #22a.
2 On units with female connector, quantity for Item #13a is (2).

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General

Tork-Mor Actuators, if properly installed, will give many thousand cycles of uninterrupted service. In due time the seals should be replaced and, if correctly installed, new actuator performance will be obtained. We recommend that Tork-Mor Actuators be returned to the factory for repairs. The cost is low and one-day service is our policy. Our trained personnel will see to it that "new actuator" performance is obtained.

In the event that field maintenance is required, the following steps outlined should be followed.

A. Disassembly and Inspection of Actuator

1. Remove Bearing Retainer Nuts (#22) from Heads (#7).
2. Remove Tie Rods (#4) from Heads (#7).
3. Remove Socket Head Screws (#20) from Heads (#7).
4. Remove Heads (#7) from Body (#14).
5. Remove Shaft (#5) from Body (#14).
6. Remove Ball Bearings (#8) from Heads (#7).
7. Remove Stator Bolts (#15) from Body (#14) and Connector Fittings (#13). On OS models also remove Stator Bolts (#15) from bottom of unit.
8. Remove all seals and clean all parts.

B. Replacement of Seals and Re-Assembly of Actuator

It is recommended that a suitable oil or *O-ring lube be used on all seals and mating parts to facilitate assembly.*

1. Install U-Seal (#12) and PTFE Back-Ups (#1) in Stator(s) (#2).
2. Replace Stator(s) (#2) with Gasket (#18) and Stator Bolt Seal(s) (#16) into Body (#14).
3. Replace Stator Bolt (#15) and Connectors (#13) with Seals (#17) but DO NOT tighten.
   (Stator bolts are not used on S-4-2 models.)
4. Install Head Seals (#11) Shaft Seals (#19) and Stator Seals (#10) in Heads (#7). On S-7, S-10, DS-7 and DS-10 series models, install Shaft PTFE (#23) on top of Shaft Seals (#19). On S-7 and S-10 series models, also install Thrust Bearing Seals (#24).
5. Place Body (#14) onto one Head (#17). Press lightly until body snaps into place. On DS models, install heads after shaft assembly is in place.
6. Replace Socket Head Screws (#20) in Head (#7) but DO NOT tighten.
7. Install U-Seal (#12) and PTFE Back-Ups (#1) into Shaft (#5).
8. Replace Shaft (#5) in Body (#14) and Head (#7). Vane should be located opposite Stator (#2).
9. Replace other Head (#7) into Body (#14). Press lightly until head snaps into place.
10. Replace Socket Head Screws (#20) in Head (#7) but DO NOT tighten.
11. Replace Tie Rods (#4) and tighten evenly.
12. Tighten Stator Bolt(s) (#15) and Socket Head Screws (#20).
13. Replace Bearings (#8) into Heads (#7). At this point the actuator may be pressurized to check Head Seals (#11) and Shaft Seals (#19) for leakage.
14. Install Outer Seals (#6) into Retaining Nuts (#22).
15. Install Inner Seals (#6) into Retaining Nuts (#22).
16. Screw Retainer Nuts (#22), into Heads (#7).

Tightening Torques

Model Size	Tie Rod Bolt (#4)
33	13 ft. lbs.
42	25 ft. lbs.
44	25 ft. lbs.
46	25 ft. lbs.
74	130 ft. lbs.
77	130 ft. lbs.
105	500 ft. lbs.
108	500 ft. lbs.
1012	500 ft. lbs.

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Safety Guide for Selecting and Using Hydraulic, Pneumatic Cylinders and Their Accessories

WARNING: ⚠ FAILURE OF THE CYLINDER, ITS PARTS, ITS MOUNTING, ITS CONNECTIONS TO OTHER OBJECTS, OR ITS CONTROLS CAN RESULT IN:

- **Unanticipated or uncontrolled movement of the cylinder or objects connected to it.**
- **Falling of the cylinder or objects held up by it.**
- **Fluid escaping from the cylinder, potentially at high velocity.**

THESE EVENTS COULD CAUSE DEATH OR PERSONAL INJURY BY, FOR EXAMPLE, PERSONS FALLING FROM HIGH LOCATIONS, BEING CRUSHED OR STRUCK BY HEAVY OR FAST MOVING OBJECTS, BEING PUSHED INTO DANGEROUS EQUIPMENT OR SITUATIONS, OR SLIPPING ON ESCAPED FLUID.

Before selecting or using Parker (The Company) cylinders or related accessories, it is important that you read, understand and follow the following safety information. Training is advised before selecting and using The Company's products.

1.0 General Instructions

1.1 Scope – This safety guide provides instructions for selecting and using (including assembling, installing, and maintaining) cylinder products. This safety guide is a supplement to and is to be used with the specific Company publications for the specific cylinder products that are being considered for use.

1.2 Fail Safe – Cylinder products can and do fail without warning for many reasons. All systems and equipment should be designed in a fail-safe mode so that if the failure of a cylinder product occurs people and property won't be endangered.

1.3 Distribution – Provide a free copy of this safety guide to each person responsible for selecting or using cylinder products. Do not select or use The Company's cylinders without thoroughly reading and understanding this safety guide as well as the specific Company publications for the products considered or selected.

1.4 User Responsibility – Due to very wide variety of cylinder applications and cylinder operating conditions, The Company does not warrant that any particular cylinder is suitable for any specific application. This safety guide does not analyze all technical parameters that must be considered in selecting a product. The hydraulic and pneumatic cylinders outlined in this catalog are designed to The Company's design guidelines and do not necessarily meet the design guideline of other agencies such as American Bureau of Shipping, ASME Pressure Vessel Code etc. The user, through its own analysis and testing, is solely responsible for:

- Making the final selection of the cylinders and related accessories.
- Determining if the cylinders are required to meet specific design requirements as required by the Agency(s) or industry standards covering the design of the user's equipment.
- Assuring that the user's requirements are met, OSHA requirements are met, and safety guidelines from the applicable agencies such as but not limited to ANSI are followed and that the use presents no health or safety hazards.
- Providing all appropriate health and safety warnings on the equipment on which the cylinders are used.

1.5 Additional Questions – Call the appropriate Company technical service department if you have any questions or require any additional information. See the Company publication for the product being considered or used, or call 1-800-CPARKER, or go to www.parker.com, for telephone numbers of the appropriate technical service department.

2.0 Cylinder and Accessories Selection

2.1 Seals – Part of the process of selecting a cylinder is the selection of seal compounds. Before making this selection, consult the "seal information page(s)" of the publication for the series of cylinders of interest.

The application of cylinders may allow fluids such as cutting fluids, wash down fluids etc. to come in contact with the external area of the cylinder. These fluids may attack the piston rod wiper and or the primary seal and must be taken into account when selecting and specifying seal compounds.

Dynamic seals will wear. The rate of wear will depend on many operating factors. Wear can be rapid if a cylinder is mis-aligned or if the cylinder has been improperly serviced. The user must take seal wear into consideration in the application of cylinders.

2.2 Piston Rods – Possible consequences of piston rod failure or separation of the piston rod from the piston include, but are not limited to are:

- Piston rod and or attached load thrown off at high speed.
- High velocity fluid discharge.
- Piston rod extending when pressure is applied in the piston retract mode.

Piston rods or machine members attached to the piston rod may move suddenly and without warning as a consequence of other conditions occurring to the machine such as, but not limited to:

- Unexpected detachment of the machine member from the piston rod.
- Failure of the pressurized fluid delivery system (hoses, fittings, valves, pumps, compressors) which maintain cylinder position.
- Catastrophic cylinder seal failure leading to sudden loss of pressurized fluid.
- Failure of the machine control system.

Follow the recommendations of the "Piston Rod Selection Chart and Data" in the publication for the series of cylinders of interest. The suggested piston rod diameter in these charts must be followed in order to avoid piston rod buckling.

Piston rods are not normally designed to absorb bending moments or loads which are perpendicular to the axis of piston rod motion. These additional loads can cause the piston rod to fail. If these types of additional loads are expected to be imposed on the piston rod, their magnitude should be made known to our engineering department.

The cylinder user should always make sure that the piston rod is securely attached to the machine member.

On occasion cylinders are ordered with double rods (a piston rod extended from both ends of the cylinder). In some cases a stop is threaded on to one of the piston rods and used as an external stroke adjuster. On occasions spacers are attached to the machine member connected to the piston rod and also used as a stroke adjuster. In both cases the stops will create a pinch point and the user should consider appropriate use of guards. If these external stops are not perpendicular to the mating contact surface, or if debris is trapped between the contact surfaces, a bending moment will be placed on the piston rod,

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which can lead to piston rod failure. An external stop will also negate the effect of cushioning and will subject the piston rod to impact loading. Those two (2) conditions can cause piston rod failure. Internal stroke adjusters are available with and without cushions. The use of external stroke adjusters should be reviewed with our engineering department.

The piston rod to piston and the stud to piston rod threaded connections are secured with an anaerobic adhesive. The strength of the adhesive decreases with increasing temperature. Cylinders which can be exposed to temperatures above +250°F (+121°C) are to be ordered with a non studded piston rod and a pinned piston to rod joint.

2.3 Cushions – Cushions should be considered for cylinder applications when the piston velocity is expected to be over 4 inches/second.

Cylinder cushions are normally designed to absorb the energy of a linear applied load. A rotating mass has considerably more energy than the same mass moving in a linear mode. Cushioning for a rotating mass application should be review by our engineering department.

2.4 Cylinder Mountings – Some cylinder mounting configurations may have certain limitations such as but not limited to minimum stroke for side or foot mounting cylinders or pressure de-ratings for certain mounts. Carefully review the catalog for these types of restrictions.

Always mount cylinders using the largest possible high tensile alloy steel socket head cap screws that can fit in the cylinder mounting holes and torque them to the manufacturer's recommendations for their size.

2.5 Port Fittings – Hydraulic cylinders applied with meter out or deceleration circuits are subject to intensified pressure at piston rod end.

The rod end pressure is approximately equal to:

$$\frac{\text{operating pressure x effective cap end area}}{\text{effective rod end piston area}}$$

Contact your connector supplier for the pressure rating of individual connectors.

3.0 Cylinder and Accessories Installation and Mounting

3.1 Installation

3.1.1 – Cleanliness is an important consideration, and cylinders are shipped with the ports plugged to protect them from contaminants entering the ports. These plugs should not be removed until the piping is to be installed. Before making the connection to the cylinder ports, piping should be thoroughly cleaned to remove all chips or burrs which might have resulted from threading or flaring operations.

3.1.2 – Cylinders operating in an environment where air drying materials are present such as fast-drying chemicals, paint, or weld splatter, or other hazardous conditions such as excessive heat, should have shields installed to prevent damage to the piston rod and piston rod seals.

3.1.3 – Proper alignment of the cylinder piston rod and its mating component on the machine should be checked in both the extended and retracted positions. Improper alignment will result in excessive rod gland and/or cylinder bore wear. On fixed mounting cylinders attaching the piston rod while the rod is retracted will help in achieving proper alignment.

3.1.4 – Sometimes it may be necessary to rotate the piston rod in order to thread the piston rod into the machine member. This operation must always be done with zero pressure being applied to either side of the piston. Failure to follow this procedure may result in loosening the piston to rod-threaded connection. In some rare cases the turning of the piston rod may rotate a threaded piston rod gland and loosen it from the cylinder head. Confirm that this condition is not occurring. If it does, re-tighten the piston rod gland firmly against the cylinder head.

For double rod cylinders it is also important that when attaching or detaching the piston rod from the machine member that the torque be applied to the piston rod end of the cylinder that is directly attaching to the machine member with the opposite end unrestrained. If the design of the machine is such that only the rod end of the cylinder opposite to where the rod attaches to the machine member can be rotated, consult the factory for further instructions.

3.2 Mounting Recommendations

3.2.1 – Always mount cylinders using the largest possible high tensile alloy steel socket head screws that can fit in the cylinder mounting holes and torque them to the manufacturer's recommendations for their size.

3.2.2 – Side-Mounted Cylinders – In addition to the mounting bolts, cylinders of this type should be equipped with thrust keys or dowel pins located so as to resist the major load.

3.2.3 – Tie Rod Mounting – Cylinders with tie rod mountings are recommended for applications where mounting space is limited. The standard tie rod extension is shown as BB in dimension tables. Longer or shorter extensions can be supplied. Nuts used for this mounting style should be torqued to the same value as the tie rods for that bore size.

3.2.4 – Flange Mount Cylinders – The controlled diameter of the rod gland extension on head end flange mount cylinders can be used
as a pilot to locate the cylinders in relation to the machine. After alignment has been obtained, the flanges may be drilled for pins or dowels to prevent shifting.

3.2.5 – Trunnion Mountings – Cylinders require lubricated bearing blocks with minimum bearing clearances. Bearing blocks should be carefully aligned and rigidly mounted so the trunnions will not be subjected to bending moments. The rod end should also be pivoted with the pivot pin in line and parallel to axis of the trunnion pins.

3.2.6 – Clevis Mountings – Cylinders should be pivoted at both ends with centerline of pins parallel to each other. After cylinder is mounted, be sure to check to assure that the cylinder is free to swing through its working arc without interference from other machine parts.

4.0 Cylinder and Accessories Maintenance, Troubleshooting and Replacement

4.1 Storage – At times cylinders are delivered before a customer is ready to install them and must be stored for a period of time. When storage is required the following procedures are recommended.

4.1.1 – Store the cylinders in an indoor area which has a dry, clean and noncorrosive atmosphere. Take care to protect the cylinder from both internal corrosion and external damage.

4.1.2 – Whenever possible cylinders should be stored in a vertical position (piston rod up). This will minimize corrosion due to possible condensation which could occur inside the cylinder. This will also minimize seal damage.

4.1.3 – Port protector plugs should be left in the cylinder until the time of installation.

4.1.4 – If a cylinder is stored full of hydraulic fluid, expansion of the fluid due to temperature changes must be considered. Installing a check valve with free flow out of the cylinder is one method.

4.1.5 – When cylinders are mounted on equipment that is stored outside for extended periods, exposed unpainted surfaces, e.g. piston rod, must be coated with a rust-inhibiting compound to prevent corrosion.

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4.2 Cylinder Trouble Shooting

4.2.1 – External Leakage

4.2.1.1 – Rod seal leakage can generally be traced to worn or damaged seals. Examine the piston rod for dents, gouges or score marks, and replace piston rod if surface is rough.

Rod seal leakage could also be traced to gland wear. If clearance is excessive, replace rod bushing and seal. Rod seal leakage can also be traced to seal deterioration. If seals are soft or gummy or brittle, check compatibility of seal material with lubricant used if air cylinder, or operating fluid if hydraulic cylinder. Replace with seal material, which is compatible with these fluids. If the seals are hard or have lost elasticity, it is usually due to exposure to temperatures in excess of 165°F (74°C). Shield the cylinder from the heat source to limit temperature to 350°F (177°C) and replace with fluorocarbon seals.

4.2.1.2 – Cylinder body seal leak can generally be traced to loose tie rods. Torque the tie rods to manufacturer's recommendation for that bore size.

Excessive pressure can also result in cylinder body seal leak. Determine maximum pressure to rated limits. Replace seals and retorque tie rods as in paragraph above. Excessive pressure can also result in cylinder body seal leak. Determine if the pressure rating of the cylinder has been exceeded. If so, bring the operating pressure down to the rating of the cylinder and have the tie rods replaced.

Pinched or extruded cylinder body seal will also result in a leak. Replace cylinder body seal and retorque as in paragraph above.

Cylinder body seal leakage due to loss of radial squeeze which shows up in the form of flat spots or due to wear on the O.D. or I.D. – Either of these are symptoms of normal wear due to high cycle rate or length of service. Replace seals as per paragraph above.

4.2.2 – Internal Leakage

4.2.2.1 – Piston seal leak (by-pass) 1 to 3 cubic inches per minute leakage is considered normal for piston ring construction. Virtually no static leak with lipseal type seals on piston should be expected. Piston seal wear is a usual cause of piston seal leakage. Replace seals as required.

4.2.2.2 – With lipseal type piston seals excessive back pressure due to over-adjustment of speed control valves could be a direct cause of rapid seal wear. Contamination in a hydraulic system can result in a scored cylinder bore, resulting in rapid seal wear. In either case, replace piston seals as required.

4.2.2.3 – What appears to be piston seal leak, evidenced by the fact that the cylinder drifts, is not always traceable to the piston. To make sure, it is suggested that one side of the cylinder piston be pressurized and the fluid line at the opposite port be disconnected. Observe leakage. If none is evident, seek the cause of cylinder drift in other component parts in the circuit.

4.2.3 – Cylinder Fails to Move the Load

4.2.3.1 – Pneumatic or hydraulic pressure is too low. Check the pressure at the cylinder to make sure it is to circuit requirements.

4.2.3.2 – Piston Seal Leak – Operate the valve to cycle the cylinder and observe fluid flow at valve exhaust ports at end of cylinder stroke. Replace piston seals if flow is excessive.

4.2.3.3 – Cylinder is undersized for the load – Replace cylinder with one of a larger bore size.

4.3 Erratic or Chatter Operation

4.3.1 – Excessive friction at rod gland or piston bearing due to load misalignment – Correct cylinder-to-load alignment.

4.3.2 – Cylinder sized too close to load requirements – Reduce load or install larger cylinder.

4.3.3 – Erratic operation could be traced to the difference between static and kinetic friction. Install speed control valves to provide a back pressure to control the stroke.

4.4 Cylinder Modifications, Repairs, or Failed Component – Cylinders as shipped from the factory are not to be disassembled and or modified. If cylinders require modifications, these modifications must be done at company locations or by The Company's certified facilities. The Cylinder Division Engineering Department must be notified in the event of a mechanical fracture or permanent deformation of any cylinder component (excluding seals). This includes a broken piston rod, tie rod, mounting accessory or any other cylinder component. The notification should include all operation and application details. This information will be used to provide an engineered repair that will prevent recurrence of the failure.

It is allowed to disassemble cylinders for the purpose of replacing seals or seal assemblies. However, this work must be done by strictly following all the instructions provided with the seal kits.

Parker Hannifin Corporation
Pneumatic Division
Wadsworth, Ohio
www.parker.com/pneu/rotary

PARKER-HANNIFIN CORPORATION
OFFER OF SALE

1. Definitions. As used herein, the following terms have the meanings indicated.

Buyer:	means any customer receiving a Quote for Products from Seller.
Goods:	means any tangible part, system or component to be supplied by the Seller.
Products:	means the Goods, Services and/or Software as described in a Quote provided by the Seller.
Quote:	means the offer or proposal made by Seller to Buyer for the supply of Products.
Seller:	means Parker-Hannifin Corporation, including all divisions and businesses thereof.
Services:	means any services to be supplied by the Seller.
Software:	means any software related to the Products, whether embedded or separately downloaded.
Terms:	means the terms and conditions of this Offer of Sale or any newer version of the same as published by Seller electronically at www.parker.com/saleterms.

2. Terms. All sales of Products by Seller are contingent upon, and will be governed by, these Terms and, these Terms are incorporated into any Quote provided by Seller to any Buyer. Buyer's order for any Products whether communicated to Seller verbally, in writing, by electronic date interface or other electronic commerce, shall constitute acceptance of these Terms. Seller objects to any contrary or additional terms or conditions of Buyer. Reference in Seller's order acknowledgement to Buyer's purchase order or purchase order number shall in no way constitute an acceptance of any of Buyer's terms of purchase. No modification to these Terms will be binding on Seller unless agreed to in writing and signed by an authorized representative of Seller.

3. Price; Payment. The Products set forth in Seller's Quote are offered for sale at the prices indicated in Seller's Quote. Unless otherwise specifically stated in Seller's Quote, prices are valid for thirty (30) days and do not include any sales, use, or other taxes or duties. Seller reserves the right to modify prices at any time to adjust for any raw material price fluctuations. Unless otherwise specified by Seller, all prices are F.C.A. Seller's facility (INCOTERMS 2010). All sales are contingent upon credit approval and payment for all purchases is due thirty (30) days from the date of invoice (or such date as may be specified in the Quote). Unpaid invoices beyond the specified payment date incur interest at the rate of 1.5% per month or the maximum allowable rate under applicable law.

4. Shipment; Delivery; Title and Risk of Loss. All delivery dates are approximate. Seller is not responsible for damages resulting from any delay. Regardless of the manner of shipment, delivery occurs and title and risk of loss or damage pass to Buyer, upon placement of the Products with the shipment carrier at Seller's facility. Unless otherwise agreed, Seller may exercise its judgment in choosing the carrier and means of delivery. No deferment of shipment at Buyers' request beyond the respective indicated shipping date will be made except on terms that will indemnify, defend and hold Seller harmless against all loss and additional expense. Buyer shall be responsible for any additional shipping charges incurred by Seller due to Buyer's acts or omissions.

5. Warranty. The warranty related to the Products is as follows: (i) Goods are warranted against defects in material or workmanship for a period of twelve (12) months from the date of delivery or 2,000 hours of use, whichever occurs first; (ii) Services shall be performed in accordance with generally accepted practices and using the degree of care and skill that is ordinarily exercised and customary in the field to which the Services pertain and are warranted for a period of six (6) months from the completion of the Services by Seller; and (iii) Software is only warranted to perform in accordance with applicable specifications provided by Seller to Buyer for ninety (90) days from the date of delivery or, when downloaded by a Buyer or end-user, from the date of the initial download. All prices are based upon the exclusive limited warranty stated above, and upon the following disclaimer:

DISCLAIMER OF WARRANTY: THE WARRANTY IS THE SOLE AND ENTIRE WARRANTY PERTAINING TO PRODUCTS. SELLER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS AND IMPLIED, INCLUDING DESIGN, NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE SOFTWARE IS ERROR-FREE OR FAULT-TOLERANT, OR THAT BUYER'S USE THEREOF WILL BE SECURE OR UNINTERRUPTED. BUYER AGREES AND ACKNOWLEDGES THAT UNLESS OTHERWISE AUTHORIZED IN WRITING BY SELLER THE SOFTWARE SHALL NOT BE USED IN CONNECTION WITH HAZARDOUS OR HIGH RISK ACTIVITIES OR ENVIRONMENTS. EXCEPT AS EXPRESSLY STATED HEREIN, ALL PRODUCTS ARE PROVIDED "AS IS".

6. Claims; Commencement of Actions. Buyer shall promptly inspect all Products upon receipt. No claims for shortages will be allowed unless reported to the Seller within ten (10) days of delivery. Buyer shall notify Seller of any alleged breach of warranty within thirty (30) days after the date the non-conformance is or should have been discovered by Buyer. Any claim or action against Seller based upon breach of contract or any other theory, including tort, negligence, or otherwise must be commenced within twelve (12) months from the date of the alleged breach or other alleged event, without regard to the date of discovery.

7. LIMITATION OF LIABILITY. IN THE EVENT OF A BREACH OF WARRANTY, SELLER WILL, AT ITS OPTION, REPAIR OR REPLACE THE NON-CONFORMING PRODUCT, RE-PERFORM THE SERVICES, OR REFUND THE PURCHASE PRICE PAID WITHIN A REASONABLE PERIOD OF TIME. **IN NO EVENT IS SELLER LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF, OR AS THE RESULT OF, THE SALE, DELIVERY, NON-DELIVERY, SERVICING, NON-COMPLETION OF SERVICES, USE, LOSS OF USE OF, OR INABILITY TO USE THE PRODUCTS OR ANY PART THEREOF, LOSS OF DATA, IDENTITY, PRIVACY, OR CONFIDENTIALITY, OR FOR ANY CHARGES OR EXPENSES OF ANY NATURE INCURRED WITHOUT SELLER'S WRITTEN CONSENT, WHETHER BASED IN CONTRACT, TORT OR OTHER LEGAL THEORY. IN NO EVENT SHALL SELLER'S LIABILITY UNDER ANY CLAIM MADE BY BUYER EXCEED THE PURCHASE PRICE PAID FOR THE PRODUCTS.**

8. Loss to Buyer's Property. Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which are or become Buyer's property, will be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer ordering the Products manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

9. Special Tooling. Special Tooling includes but is not limited to tooling, jigs, fixtures and associated manufacturing equipment acquired or necessary to manufacture Products. A tooling charge may be imposed for any Special Tooling. Such Special Tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in Special Tooling belonging to Seller that is utilized in the manufacture of the Products, even if such Special Tooling has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller has the right to alter, discard or otherwise dispose of any Special Tooling or other property in its sole discretion at any time.

10. Security Interest. To secure payment of all sums due, Seller retains a security interest in all Products delivered to Buyer and, Buyer's acceptance of these Terms is deemed to be a Security Agreement under the Uniform Commercial Code. Buyer authorizes Seller as its attorney to execute and file on Buyer's behalf all documents Seller deems necessary to perfect its security interest.

11. User Responsibility. The Buyer through its own analysis and testing, is solely responsible for making the final selection of the Products and assuring that all performance, endurance, maintenance, safety and warning requirements of the application of the Products are met. The Buyer must analyze all aspects of the application and follow applicable industry standards, specifications, and other technical information provided with the Product. If Seller provides Product options based upon data or specifications provided by the Buyer, the Buyer is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the Products. In the event the Buyer is not the end-user, Buyer will ensure such end-user complies with this paragraph.

12. Use of Products, Indemnity by Buyer. Buyer shall comply with all instructions, guides and specifications provided by Seller with the Products. **Unauthorized Uses**. If Buyer uses or resells the Products for any uses prohibited in Seller's instructions, guides or specifications, or Buyer otherwise fails to comply with Seller's instructions, guides and specifications, Buyer acknowledges that any such use, resale, or non-compliance is at Buyer's sole risk. Buyer shall indemnify, defend, and hold Seller harmless from any losses, claims, liabilities, damages, lawsuits, judgments and costs (including attorney fees and defense costs), whether for personal injury, property damage, intellectual property infringement or any other claim, brought by or incurred by Buyer, Buyer's employees, or any other person, arising out of: (a) improper selection, application, design, specification or other misuse of Products provided by Seller; (b) any act or omission, negligent or otherwise, of Buyer; (c) Seller's use of patterns, tooling, equipment, plans, drawings, designs or specifications or other information or things furnished by Buyer; (d) damage to the Products from an external cause, repair or attempted repair by anyone other than Seller, failure to follow instructions, guides and specifications provided by Seller, use with goods not provided by Seller, or opening, modifying, deconstructing or tampering with the Products for any reason; or (e) Buyer's failure to comply with these Terms. Seller shall not indemnify Buyer under any circumstance except as otherwise provided in these Terms.

13. Cancellations and Changes. Buyer may not cancel or modify any order for any reason, except with Seller's written consent and upon terms that will indemnify, defend and hold Seller harmless against all direct, incidental and consequential loss or damage. Seller, at any time, may change Product features, specifications, designs and availability.

14. Limitation on Assignment. Buyer may not assign its rights or obligations without the prior written consent of Seller.

15. Force Majeure. Seller does not assume the risk and is not liable for delay or failure to perform any of Seller's obligations by reason of events or circumstances beyond its reasonable control ("Events of Force Majeure"). Events of Force Majeure shall include without limitation: accidents, strikes or labor disputes, acts of any government or government agency, acts of nature, delays or failures in delivery from carriers or suppliers, shortages of materials, or any other cause beyond Seller's reasonable control.

16. Waiver and Severability. Failure to enforce any provision of these Terms will not invalidate that provision; nor will any such failure prejudice Seller's right to enforce that provision in the future. Invalidation of any provision of these Terms by legislation or other rule of law shall not invalidate any other provision herein and, the remaining provisions will remain in full force and effect.

17. Termination. Seller may terminate any agreement governed by or arising from these Terms for any reason and at any time by giving Buyer thirty (30) days prior written notice. Seller may immediately terminate, in writing, if Buyer: (a) breaches any provision of these Terms (b) appoints a trustee, receiver or custodian for all or any part of Buyer's property (c) files a petition for relief in bankruptcy on its own behalf, or one if filed by a third party (d) makes an assignment for the benefit of creditors; or (e) dissolves its business or liquidates all or a majority of its assets.

18. Ownership of Software. Seller retains ownership of all Software supplied to Buyer hereunder. In no event shall Buyer obtain any greater right in and to the Software than a right in the nature of a license limited to the use thereof and subject to compliance with any other terms provided with the Software.

19. Indemnity for Infringement of Intellectual Property Rights. Seller is not liable for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights ("Intellectual Property Rights") except as provided in this Section. Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on a third party claim that one or more of the Products sold hereunder infringes the Intellectual Property Rights of a third party in the country of delivery of the Products by the Seller to the Buyer. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of any such claim, and Seller having sole control over the defense of the claim including all negotiations for settlement or compromise. If one or more Products sold hereunder is subject to such a claim, Seller may, at its sole expense and option, procure for Buyer the right to continue using the Products, replace or modify the Products so as to render them non-infringing, or offer to accept return of the Products and refund the purchase price less a reasonable allowance for depreciation. Seller has no obligation or liability for any claim of infringement: (i) arising from information provided by Buyer; or (ii) directed to any Products provided hereunder for which the designs are specified in whole or part by Buyer; or (iii) resulting from the modification, combination or use in a system of any Products provided hereunder. The foregoing provisions of this Section constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for such claims of infringement of Intellectual Property Rights.

20. Governing Law. These Terms and the sale and delivery of all Products are deemed to have taken place in, and shall be governed and construed in accordance with, the laws of the State of Ohio, as applicable to contracts executed and wholly performed therein and without regard to conflicts of laws principles. Buyer irrevocably agrees and consents to the exclusive jurisdiction and venue of the courts of Cuyahoga County, Ohio with respect to any dispute, controversy or claim arising out of or relating to the sale and delivery of the Products.

21. Entire Agreement. These Terms, along with the terms set forth in the main body of any Quote, forms the entire agreement between the Buyer and Seller and constitutes the final, complete and exclusive expression of the terms of sale. In the event of a conflict between any term set forth in the main body of a Quote and these Terms, the terms set forth in the main body of the Quote shall prevail. All prior or contemporaneous written or oral agreements or negotiations with respect to the subject matter shall have no effect. These Terms may not be modified unless in writing and signed by an authorized representative of Seller.

22. Compliance with Laws. Buyer agrees to comply with all applicable laws, regulations, and industry and professional standards, including those of the United States of America, and the country or countries in which Buyer may operate, including without limitation the U.S. Foreign Corrupt Practices Act ("FCPA"), the U.S. Anti-Kickback Act ("Anti-Kickback Act"), U.S. and E.U. export control and sanctions laws ("Export Laws"), the U.S. Food Drug and Cosmetic Act ("FDCA"), and the rules and regulations promulgated by the U.S. Food and Drug Administration ("FDA"), each as currently amended. Buyer agrees to indemnify, defend, and hold harmless Seller from the consequences of any violation of such laws, regulations and standards by Buyer, its employees or agents. Buyer acknowledges that it is familiar with all applicable provisions of the FCPA, the Anti-Kickback Act, Export Laws, the FDCA and the FDA and certifies that Buyer will adhere to the requirements thereof and not take any action that would make Seller violate such requirements. Buyer represents and agrees that Buyer will not make any payment or give anything of value, directly or indirectly, to any governmental official, foreign political party or official thereof, candidate for foreign political office, or commercial entity or person, for any improper purpose, including the purpose of influencing such person to purchase Products or otherwise benefit the business of Seller. Buyer further represents and agrees that it will not receive, use, service, transfer or ship any Product from Seller in a manner or for a purpose that violates Export Laws or would cause Seller to be in violation of Export Laws.

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