# HYDRAULIC MOTORS

## Selecting and Integrating Low-Speed, High-Torque Hydraulic Motors for Mobile and Industrial Machinery

Parker


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# TORQMOTORS

## Selecting and Integrating Low-Speed, High-Torque Hydraulic Motors for Mobile and Industrial Machinery

Low-speed, high-torque (LSHT) hydraulic motors provide compact, robust and controllable rotary power for mobile machinery (e.g., zero-turn mowers, specialty harvester, utility work truck functions or walk-behind skid steer) and industrial equipment (e.g., mixers, conveyors and shredders).

### Motor Technologies Overview

Each motor type has its own set of applications where they are a better choice than others. The final decision always will depend on what is required in terms of application performance and motor life versus where you want to be with cost.

Motors are rated by displacement, with displacement defined as the volume of fluid that it takes to rotate the shaft of the motor once. The common rating units are cubic inches per revolution (CIR), or cubic centimeters per revolution (CCR).

Motors are also rated by torque, the amount of twisting force the motor can deliver. The common measurements of torque are inch-pounds (in.-lb) and Newton-meters (Nm). The torque of a motor is a function of motor displacement and system pressure.

Starting torque in hydraulic systems is discussed in two ways. First, it is the motor's torque capability at zero speed to initiate motion, often lower than its continuous torque due to internal leakage and friction. Secondly, it is the torque required to begin moving the driven load (breakaway torque), which is typically higher than the torque needed to keep the load moving. The magnitude depends on the load, motor displacement, fluid properties, and mechanical losses. In electric motors, "starting torque" commonly refers to the immediate torque available from rest, whereas hydraulic terminology distinguishes between the motor's starting capability and the load's breakaway requirement.

Stall torque is the maximum torque a hydraulic motor develops as speed falls to zero; it is not the same as running (continuous) torque. Running torque is the steady torque required to sustain operation at a given speed and load. As the load increases, system pressure rises and the required torque increases; accordingly. Once the differential pressure reaches the relief setting, the motor will stop rotating (stall). Motor rotational speed is measured in rpm and, for hydraulic motors, is primarily a function of input flow and motor displacement.

# Common LSHT Motor Classes and Types

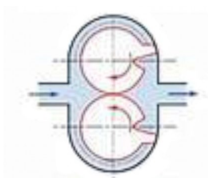
LSHT motors convert fluid power to mechanical torque at relatively low output speed, avoiding external gear reduction in many cases.

**Key attributes:**

- High starting torque and low speeds
- Compact with high power density
- Broad controllability via fluid flow and pressure
- Tolerates shock loads and hostile environments

**Typical operating ranges:**

- Displacement: 2.2 c.i.r. – 58.5 c.i.r.
- Flow Rate: 9 gpm – 30 gpm
- Starting Torque: 389 in. lb. – 8772 in. lb.
- Output Torque: 630 in. lb. – 13409 in. lb.
- Operating Speed: 118 rpm – 1141 rpm
- Pressure Differential: 1233 psid – 4000 psid

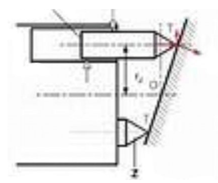


## Gear Motors

Gear motors come in two varieties, the gerotor and external spur gear designs. Orbital (geroller) styles are classified as LSHT motors; however, some do exist with the HSLT classification. They consist of a matched rotor set enclosed in a housing. When hydraulic fluid is moved into the motor, it causes the gears to rotate. One of the gears is connected to the motor output shaft, which produces the motor's rotary motion.

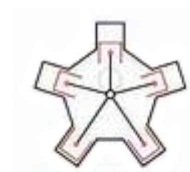
## Vane Motors

Vane motors are typically classified as HSLT units. However, larger displacements will fall into the LSHT range. Hydraulic fluid enters the motor and is applied to a rectangular vane, which slides into and out of the center rotor. This center rotor is connected to the main output shaft. The fluid being applied to the vane causes the output shaft to rotate.



## Piston Motors

Piston motors come in a variety of designs with both LSHT and HSLT classifications. In-line piston motors are classified as HSLT. Hydraulic fluid enters the motor and is applied to a series of pistons inside a cylinder barrel. The pistons are pressed against a swash plate, which is at an angle. The pistons push against this angle, which causes the rotation of the swash plate that is mechanically connected to the output shaft of the motor. The swash plate can be a fixed or variable angle. Variable angle motors can have their displacements adjusted between a maximum and minimum setting. The command signals to change the displacement can be electrical, hydraulic or a combination of both. They can be both fixed and variable displacement.



## Radial Piston Motors

Radial piston motors are LSHT classified. These motors are designed with pistons arranged perpendicular to the output shaft. Typically, the pistons will ride against a cam, which is mechanically connected to the output shaft. The pistons will force the cam to rotate as hydraulic fluid enters the motor. These motors can produce high torques at low speeds, down to half a revolution per minute.

In general, these motors are fixed displacement. However, some versions will allow for variable displacement. They accomplish this by limiting the number of pistons that can receive hydraulic fluid. Other versions change the internal geometry of the cam the pistons are acting against.

## Motor Selection Considerations

All the following questions are important to answer when selecting a hydraulic motor. Engage your supplier/vendor to compare motor types, confirm operating pressure and flow, duty cycle, side-load capability, controls, loop architecture, and life-versus-cost tradeoffs:

- What are the performance needs of the application?
- What is the load and amount of break away and running torque needed?
- What is the shaft speed and horsepower?
- What is the operating pressure and flow?
- Is displacement fixed or variable?
- What is the operating temperature?
- Is there any leakage potential?
- What noise level can the application handle?
- How reliable is the motor design?
- What type of controls will be used: mechanical or electronic?
- Is ease of installation critical?
- Is ease of maintenance necessary?
- What is the bearing type and expected life?
- What is the expected motor life?
- Is it open or closed loop?
- What kind of contamination potential is there?
- What certifications and approvals are needed?

# Core Sizing Equations and Workflow

**1.** Define mechanical requirements:
   - Required torque (T) at shaft, Nm
   - Required speed (n), rpm
   - Duty cycle, reversals, and expected shock loads

**2.** Estimate displacement (D) and operating pressure (ΔP):
   - Theoretical torque: $T\_th = (\Delta P \times D) / (2\pi)$
   - Actual torque: $T = T\_th \times \eta m$
   - Solve for D: $D = (T \times 2\pi) / (\Delta P \times \eta m)$
   - Units: ΔP in Pa, D in $m^3$/rev (convert to cc/rev by ×10^6)

**3.** Estimate flow (Q) and power:
   - Theoretical flow: $Q\_th = n \times D$
   - Actual flow: $Q = Q\_th / \eta v$
   - Hydraulic power: $P\_hyd = \Delta P \times Q$
   - Shaft power: $P\_out = T \times (2\pi n/60) = P\_hyd \times (\eta m \times \eta v)$

**4.** Check motor limits:
   - Rated/peak pressure vs duty cycle
   - Maximum speed for chosen displacement
   - Case drain requirement and allowable return-line backpressure
   - Thermal and viscosity window
   - Bearing load ratings (radial and axial), and shaft bending/shear limits

**5.** Validate system interactions:
   - Inlet conditions: avoid cavitation (adequate charge or supply pressure)
   - Overrunning loads: cross-port relief or counterbalance valves
   - Deceleration and stopping: brakes, reliefs, or dynamic controls
   - Filtration and contamination class

**Engineering Data >** https://www.parker.com/content/dam/Parker-com/Literature/Pump-Motor-Division/Engineering/PDFs/HY13-1590-010-Engineering-Data.pdf

# Integration Essentials

## Case Drain and Backpressure

- Many orbital motors require a case drain to keep internal leakage pressure low, improve lubrication, and avoid seal blowout.
- Typical guideline: keep case pressure low (often below ~1–2 bar), and ensure continuous, unrestricted drain to tank.
- If return-line pressure is high or variable, case drain is mandatory.

## Overrunning Loads and Shock Protection

- Use cross-port relief valves to protect the motor from sudden pressure spikes (e.g., when a mass drives the motor).
- For lowering heavy loads, counterbalance valves provide controlled descent and prevent freewheeling.
- Anti-cavitation checks can reduce risk when the motor is driven externally.

## Bearings, Side Loads, and Mounting

- Wheel-type LSHT motors include heavy-duty bearings; verify radial load, axial load, and moment limits vs your wheel size and duty.
- Keep belt/chain tensions within shaft and bearing ratings; consider outboard bearings for high overhung loads.
- Align couplings carefully to limit misalignment and avoid premature seal/bearing wear.

## Filtration, Fluid, and Temperature

- Follow Parker's recommended cleanliness class (ISO 4406); LSHT motors are sensitive to contamination.
- Choose viscosity appropriate for ambient extremes; orbital motors need adequate viscosity for sealing and low-speed smoothness, but not so high as to cause pressure drops or startup stress.
- Warm-up sequences or bypasses can help in cold starts.

## Porting and Plumbing

- Select appropriate port style (SAE ORB, BSPP, flange) and ensure adequate line sizing to minimize pressure drop at expected flow.
- Avoid restrictions on return lines; manage backpressure and provide dedicated drain returns when specified.
- Observe correct orientation for bi-directional operation; some integrated valving options affect port assignment.

## Control, Smoothness, and Efficiency

- Low-speed smoothness: Disc-valve designs and roller-star sets typically offer better starting torque and reduced cogging at very low rpm.
- Efficiency improves with optimal viscosity, correct clearances, and staying within rated pressure/speed. Expect reduced volumetric efficiency at high temperatures or wear.
- Speed control: Open-center vs closed-center system dynamics matter. Consider flow controls, pressure-compensated valves, or electrohydraulic controls for precise speed regulation.

## Common Options and Accessories

- Integral parking brakes (spring-applied, hydraulically released) for holding loads.
- Integrated relief/anti-cavitation manifolds on some models.
- Multiple shaft configurations: tapered (wheel), splined (torque transmission), keyed (general).
- Mounting faces per SAE standards, plus foot mounts or custom flanges.
- Speed sensing (magnetic pickups) available on selected variants for feedback control.

# Understanding Parker's Torqmotor™ Range: Low Speed, High Torque Hydraulic Motors

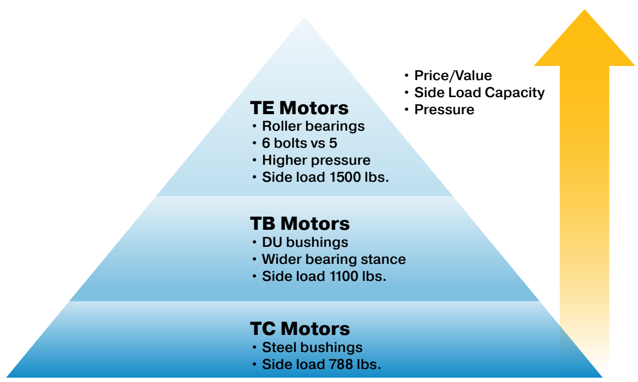
Having established a motor-first, application-driven selection process, the next step is to map those requirements to proven LSHT solutions. For designers prioritizing smooth low-speed control, high torque density, durability, and straightforward integration, Parker's Torqmotor™ gerollor motors align directly with these objectives.

Parker's Torqmotor™ product line encompasses several orbital motors designed around gerollor (rotor sets) with internal commutation (proprietary valving design).

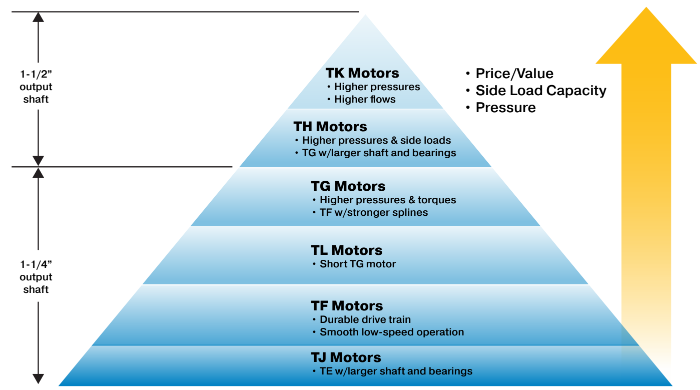
Key characteristics include:

- Fixed displacement for consistent performance.
- Ability to rotate clockwise or counterclockwise.
- No need for a case drain line, simplifying installation and reducing costs.
- Unique two pressure zone design that eliminates case strain common in other three pressure zone motors.
- High pressure shaft seals for leak-free operation.
- Configurable with optional relief and shuttle valves for application-specific needs.

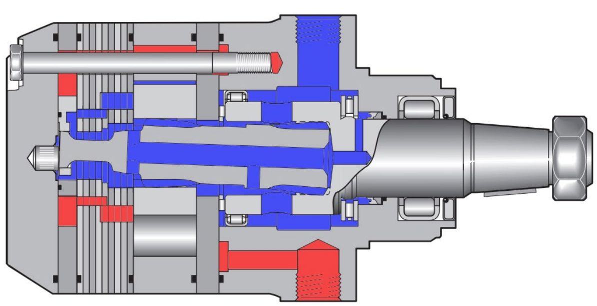
**Small Motors** (1 Inch Output Shaft)




**Large Motors** (>1 Inch Output Shaft)




*Different sizes of Parker Torqmotors™ means you can always find the right motor for your specific application needs.*



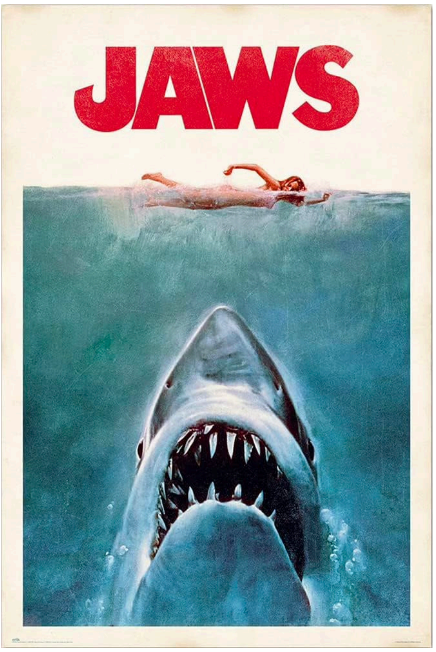
*The entire powertrain is continually washed in cool, high flow fluid to assure long life. Roller vanes and sealed commutator maintain high efficiency and provide smooth low speed performance.*

At the heart of the Torqmotor™ is the roller vane gerollor mechanism, an internal orbital style motor where a smaller internal rotor rotates inside a larger external stator. The inclusion of roller vanes reduce internal friction and automatically compensate for wear, ensuring that the motor maintains 100% performance throughout its service life.

Hydraulic fluid continuously flows across all internal splines and rotating parts, providing:

- Lubrication to reduce wear.
- Cooling to maintain optimal operating temperatures.
- Extended motor life due to reduced internal stress.

This design delivers up to 20% greater efficiency compared to conventional gerotor motors, making Parker's Torqmotor™ a top choice for applications demanding reliable low speed, high torque output.




# Fun Fact of Real-World Proven Performance

Parker's Torqmotor™ was even used to power the rotating mouth mechanism in the iconic movie Jaws, showcasing its reliability under extreme conditions. This legacy of performance continues in modern equipment where high starting torque, smooth operation, and long service life are critical.

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December 2025



Parker