Technical Information

Orbital Motors
Type WS

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OPERATING RECOMMENDATIONS

OIL TYPE

Hydraulic oils with anti-wear, anti-foam and demulsifiers are recommended for systems incorporating these motors. Straight oils can be used but may require VI (viscosity index) improvers depending on the operating temperature range of the system. Other water based and environmentally friendly oils may be used, but service life of the motor and other components in the system may be significantly shortened. Before using any type of fluid, consult the fluid requirements for all components in the system for compatibility. Testing under actual operating conditions is the only way to determine if acceptable service life will be achieved.

FLUID VISCOSITY & FILTRATION

Fluids with a viscosity between 20 - 43 cSt [100 - 200 S.U.S.] at operating temperature is recommended. Fluid temperature should also be maintained below 85°C [180° F]. It is also suggested that the type of pump and its operating specifications be taken into account when choosing a fluid for the system. Fluids with high viscosity can cause cavitation at the inlet side of the pump. Systems that operate over a wide range of temperatures may require viscosity improvers to provide acceptable fluid performance.

We recommend maintaining an oil cleanliness level of ISO 17-14 or better.

INSTALLATION & START-UP

When installing a motor it is important that the mounting flange of the motor makes full contact with the mounting surface of the application. Mounting hardware of the appropriate grade and size must be used. Hubs, pulleys, sprockets and couplings must be properly aligned to avoid inducing excessive thrust or radial loads. Although the output device must fit the shaft snug, a hammer should never be used to install any type of output device onto the shaft. The port plugs should only be removed from the motor when the system connections are ready to be made. To avoid contamination, remove all matter from around the ports of the motor and the threads of the fittings. Once all system connections are made, it is recommended that the motor be run-in for 15-30 minutes at no load and half speed to remove air from the hydraulic system.

MOTOR PROTECTION

Over-pressurization of a motor is one of the primary causes of motor failure. To prevent these situations, it is necessary to provide adequate relief protection for a motor based on the pressure ratings for that particular model. For systems that may experience overrunning conditions, special precautions must be taken. In an overrunning condition, the motor functions as a pump and attempts to convert kinetic energy into hydraulic energy. Unless the system is properly configured for this condition, damage to the motor or system can occur. To protect against this condition a counterbalance valve or relief cartridge must be incorporated into the circuit to reduce the risk of overpressurization. If a relief cartridge is used, it must be installed upline of the motor, if not in the motor, to relieve the pressure created by the over-running motor. To provide proper motor protection for an over-running load application, the pressure setting of the pressure relief valve must not exceed the intermittent rating of the motor.

HYDRAULIC MOTOR SAFETY PRECAUTION

A hydraulic motor must not be used to hold a suspended load. Due to the necessary internal tolerances, all hydraulic motors will experience some degree of creep when a load induced torque is applied to a motor at rest. All applications that require a load to be held must use some form of mechanical brake designed for that purpose.

MOTOR/BRAKE PRECAUTION

Caution! - The motor/brakes are intended to operate as static or parking brakes. System circuitry must be designed to bring the load to a stop before applying the brake.

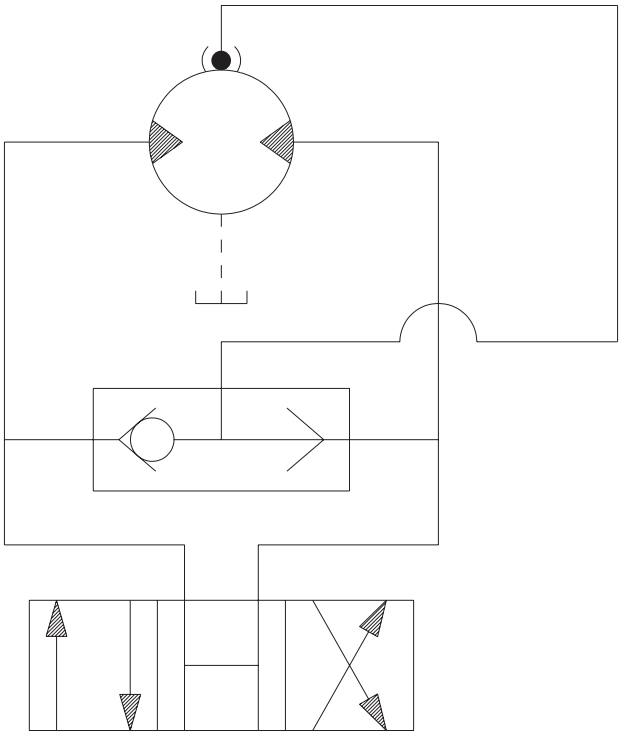
Caution! - Because it is possible for some large displacement motors to overpower the brake, it is critical that the maximum system pressure be limited for these applications. Failure to do so could cause serious injury or death. When choosing a motor/brake for an application, consult the performance chart for the series and displacement chosen for the application to verify that the maximum operating pressure of the system will not allow the motor to produce more torque than the maximum rating of the brake. Also, it is vital that the system relief be set low enough to insure that the motor is not able to overpower the brake.

To ensure proper operation of the brake, a separate case drain back to tank must be used. Use of the internal drain option is not recommended due to the possibility of return line pressure spikes. A simple schematic of a system utilizing a motor/brake is shown on page 4. Although maximum brake release pressure may be used for an application, a 34 bar [500 psi] pressure reducing valve is recommended to promote maximum life for the brake release piston seals. However, if a pressure reducing valve is used in a system which has case drain back pressure, the pressure reducing valve should be set to 34 bar [500 psi] over the expected case pressure to ensure full brake release. To achieve proper brake release operation, it is necessary to bleed out any trapped air and fill brake release cavity and hoses before all connections are tightened. To facilitate this operation, all motor/brakes feature two release ports. One or both of these ports may be used to release the brake in the

OPERATING RECOMMENDATIONS & MOTOR CONNECTIONS

MOTOR/BRAKE PRECAUTION (continued)

unit. Motor/brakes should be configured so that the release ports are near the top of the unit in the installed position.



TYPICAL MOTOR/BRAKE SCHEMATIC

Once all system connections are made, one release port must be opened to atmosphere and the brake release line carefully charged with fluid until all air is removed from the line and motor/brake release cavity. When this has been accomplished the port plug or secondary release line must be reinstalled. In the event of a pump or battery failure, an external pressure source may be connected to the brake release port to release the brake, allowing the machine to be moved.

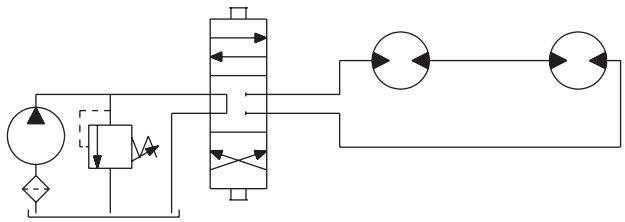
▶ NOTE: It is vital that all operating recommendations be followed. Failure to do so could result in injury or death.

MOTOR CIRCUITS

There are two common types of circuits used for connecting multiple numbers of motors – series connection and parallel connection.

SERIES CONNECTION

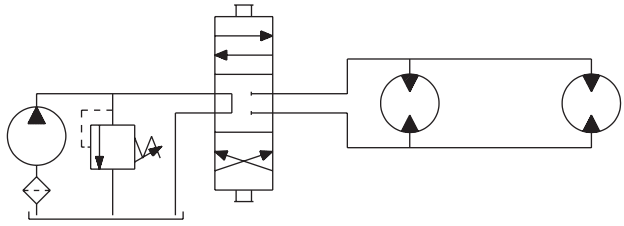
When motors are connected in series, the outlet of one motor is connected to the inlet of the next motor. This allows the full pump flow to go through each motor and provide maximum speed. Pressure and torque are distributed between the motors based on the load each motor is subjected to. The maximum system pressure must be no greater than the maximum inlet pressure of the first motor. The allowable back pressure rating for a motor must also be considered. In some series circuits the motors must have an external case drain connected. A series connection is desirable when it is important for all the motors to run the same speed such as on a long line conveyor.



SERIES CIRCUIT

PARALLEL CONNECTION

In a parallel connection all of the motor inlets are connected. This makes the maximum system pressure available to each motor allowing each motor to produce full torque at that pressure. The pump flow is split between the individual motors according to their loads and displacements. If one motor has no load, the oil will take the path of least resistance and all the flow will go to that one motor. The others will not turn. If this condition can occur, a flow divider is recommended to distribute the oil and act as a differential.

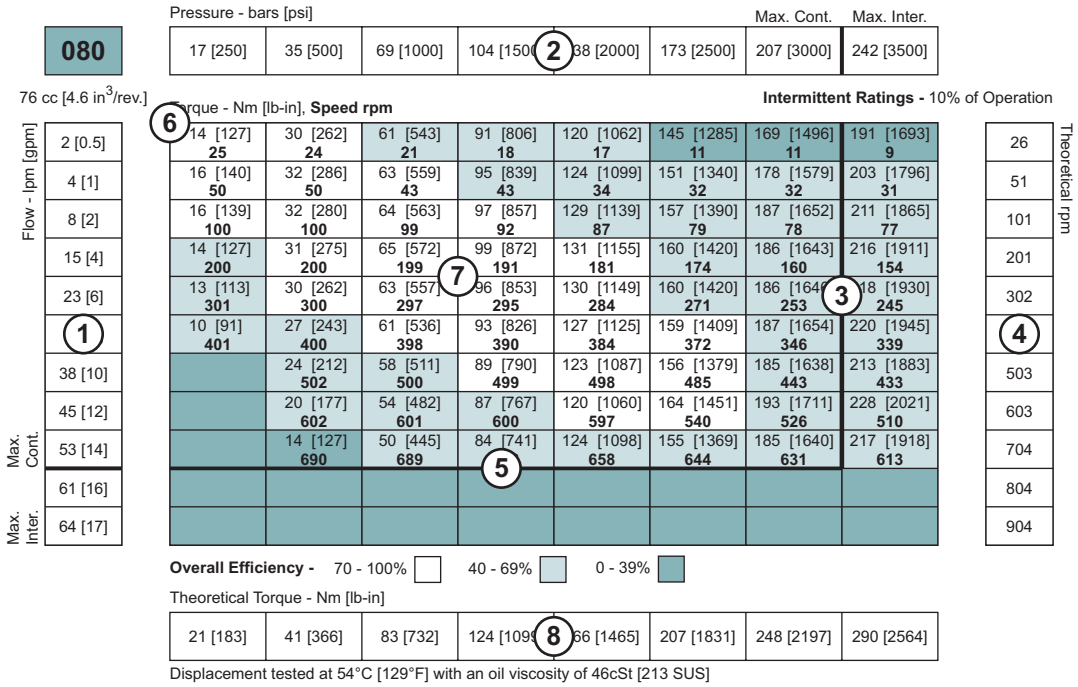


SERIES CIRCUIT

▶ NOTE: The motor circuits shown above are for illustration purposes only. Components and circuitry for actual applications may vary greatly and should be chosen based on the application.

PRODUCT TESTING

Performance testing is the critical measure of a motor's ability to convert flow and pressure into speed and torque. All product testing is conducted using a state of the art test facility. This facility utilizes fully automated test equipment and custom designed software to provide accurate, reliable test data. Test routines are standardized, including test stand calibration and stabilization of fluid temperature and viscosity, to provide consistent data. The example below provides an explanation of the values pertaining to each heading on the performance chart.



1. Flow represents the amount of fluid passing through the motor during each minute of the test.

2. Pressure refers to the measured pressure differential between the inlet and return ports of the motor during the test.

3. The maximum continuous pressure rating and maximum intermittent pressure rating of the motor are separated by the dark lines on the chart.

4. Theoretical RPM represents the RPM that the motor would produce if it were 100% volumetrically efficient. Measured RPM divided by the theoretical RPM give the actual volumetric efficiency of the motor.

5. The maximum continuous flow rating and maximum intermittent flow rating of the motor are separated by the dark line on the chart.

6. Performance numbers represent the actual torque and speed generated by the motor based on the corresponding input pressure and flow. The numbers on the top row indicate torque as measured in Nm [lb-in], while the bottom number represents the speed of the output shaft.

7. Areas within the white shading represent maximum motor efficiencies.

8. Theoretical Torque represents the torque that the motor would produce if it were 100% mechanically efficient. Actual torque divided by the theoretical torque gives the actual mechanical efficiency of the motor.

ALLOWABLE BEARING & SHAFT LOADING

This catalog provides curves showing allowable radial loads at points along the longitudinal axis of the motor. They are dimensioned from the mounting flange. Two capacity curves for the shaft and bearings are shown. A vertical line through the centerline of the load drawn to intersect the x-axis intersects the curves at the load capacity of the shaft and of the bearing.

In the example below the maximum radial load bearing rating is between the internal roller bearings illustrated with a solid line. The allowable shaft rating is shown with a dotted line.

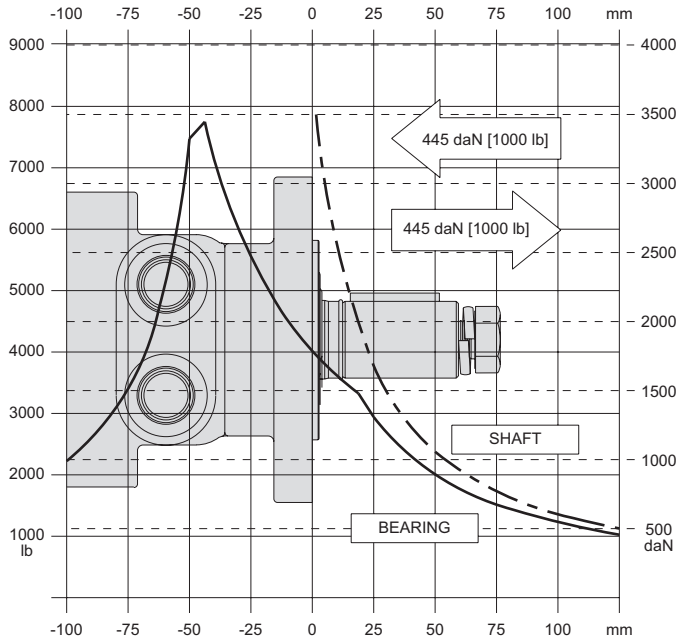
The bearing curves for each model are based on labratory analysis and testing results constructed at the organization. The shaft loading is based on a 3:1 safety factor and 330 Kpsi tensile strength. The allowable load is the lower of the curves at a given point. For instance, one inch in front of the mounting flange the bearing capacity is lower than the shaft capacity. In this case, the bearing is the limiting load. The motor user needs to determine which series of motor to use based on their application knowledge.

ISO 281 RATINGS VS. MANUFACTURERS RATINGS

Published bearing curves can come from more than one type of analysis. The ISO 281 bearing rating is an international standard for the dynamic load rating of roller bearings. The rating is for a set load at a speed of 33 1/3 RPM for 500 hours (1 million revolutions). The standard was established to allow consistent comparisons of similar bearings between manufacturers. The ISO 281 bearing ratings are based solely on the physical characteristics of the bearings, removing any manufacturers specific safety factors or empirical data that influences the ratings.

Manufacturers' ratings are adjusted by diverse and systematic laboratory investigations, checked constantly with feedback from practical experience. Factors taken into account that affect bearing life are material, lubrication, cleanliness of the lubrication, speed, temperature, magnitude of the load and the bearing type.

The operating life of a bearing is the actual life achieved by the bearing and can be significantly different from the calculated life. Comparison with similar applications is the most accurate method for bearing life estimations.



EXAMPLE LOAD RATING FOR MECHANICALLY RETAINED NEEDLE ROLLER BEARINGS

Bearing Life L_{10} = $(C/P)^p$ [10^6 revolutions]

L_{10} = nominal rating life

C = dynamic load rating

P = equivalent dynamic load

Life Exponent ^{p} = 10/3 for needle bearings

BEARING LOAD MULTIPLICATION FACTOR TABLE

RPM	FACTOR	RPM	FACTOR
50	1.23	**500**	0.62
100	1.00	**600**	0.58
200	0.81	**700**	0.56
300	0.72	**800**	0.50
400	0.66		

VEHICLE DRIVE CALCULATIONS

When selecting a wheel drive motor for a mobile vehicle, a number of factors concerning the vehicle must be taken into consideration to determine the required maximum motor RPM, the maximum torque required and the maximum load each motor must support. The following sections contain the necessary equations to determine this criteria. An example is provided to illustrate the process.

Sample application (vehicle design criteria)

vehicle description .....4 wheel vehicle
vehicle drive.....2 wheel drive
GVW .....1,500 lbs.
weight over each drive wheel .....425 lbs.
rolling radius of tires .....16 in.
desired acceleration .....0-5 mph in 10 sec.
top speed..... 5 mph
gradability 20%
worst working surface.....poor asphalt

To determine maximum motor speed

$$RPM = \frac{2.65 \times KPH \times G}{rm} \qquad RPM = \frac{168 \times MPH \times G}{ri}$$

Where:
MPH = max. vehicle speed (miles/hr)
KPH = max. vehicle speed (kilometers/hr)
ri = rolling radius of tire (inches)
G = gear reduction ratio (if none, G = 1)
rm = rolling radius of tire (meters)

Example $RPM = \frac{168 \times 5 \times 1}{16} = 52.5$

To determine maximum torque requirement of motor

To choose a motor(s) capable of producing enough torque to propel the vehicle, it is necessary to determine the Total Tractive Effort (TE) requirement for the vehicle. To determine the total tractive effort, the following equation must be used:

TE = RR + GR + FA + DP (lbs or N)

Where:
TE = Total tractive effort
RR = Force necessary to overcome rolling resistance
GR = Force required to climb a grade
FA = Force required to accelerate
DP = Drawbar pull required

The components for this equation may be determined using the following steps:

Step One: Determine Rolling Resistance

Rolling Resistance (RR) is the force necessary to propel a vehicle over a particular surface. It is recommended that the worst possible surface type to be encountered by the vehicle be factored into the equation.

$$RR = \frac{GVW}{1000} \times R \text{ (lb or N)}$$

Where:
GVW = gross (loaded) vehicle weight (lb or kg)
R = surface friction (value from Table 1)

Example $RR = \frac{1500}{1000} \times 22 \text{ lbs} = 33 \text{ lbs}$

Table 1

Rolling Resistance	
Concrete (excellent)	10
Concrete (good)	15
Concrete (poor)	20
Asphalt (good)	12
Asphalt (fair)	17
Asphalt (poor)	22
Macadam (good)	15
Macadam (fair)	22
Macadam (poor)	37
Cobbles (ordinary)	55
Cobbles (poor)	37
Snow (2 inch)	25
Snow (4 inch)	37
Dirt (smooth)	25
Dirt (sandy)	37
Mud	37 to 150
Sand (soft)	60 to 150
Sand (dune)	160 to 300

Step Two: Determine Grade Resistance

Grade Resistance (GR) is the amount of force necessary to move a vehicle up a hill or “grade.” This calculation must be made using the maximum grade the vehicle will be expected to climb in normal operation.

To convert incline degrees to % Grade:
% Grade = [tan of angle (degrees)] x 100

$$GR = \frac{\%\ Grade}{100} \times GVW \text{ (lb or N)}$$

Example $GR = \frac{20}{100} \times 1500 \text{ lbs} = 300 \text{ lbs}$

VEHICLE DRIVE CALCULATIONS

Step Three: Determine Acceleration Force

Acceleration Force (FA) is the force necessary to accelerate from a stop to maximum speed in a desired time.

$$FA = \frac{MPH \times GVW\ (lb)}{22 \times t} \qquad FA = \frac{KPH \times GVW\ (N)}{35.32 \times t}$$

Where:

t = time to maximum speed (seconds)

Example $FA = \frac{5 \times 1500\ lbs}{22 \times 10} = 34\ lbs$

Step Four: Determine Drawbar Pull

Drawbar Pull (DP) is the additional force, if any, the vehicle will be required to generate if it is to be used to tow other equipment. If additional towing capacity is required for the equipment, repeat steps one through three for the towable equipment and sum the totals to determine DP.

Step Five: Determine Total Tractive Effort

The Tractive Effort (TE) is the sum of the forces calculated in steps one through three above. On low speed vehicles, wind resistance can typically be neglected. However, friction in drive components may warrant the addition of 10% to the total tractive effort to insure acceptable vehicle performance.

TE = RR + GR + FA + DP (lb or N)

Example TE = 33 + 300 + 34 + 0 (lbs) = 367 lbs

Step Six: Determine Motor Torque

The Motor Torque (T) required per motor is the Total Tractive Effort divided by the number of motors used on the machine. Gear reduction is also factored into account in this equation.

$$T = \frac{TE \times ri}{M \times G}\ \text{lb-in per motor} \qquad T = \frac{TE \times rm}{M \times G}\ \text{Nm per motor}$$

Where:

M = number of driving motors

Example $T = \frac{367 \times 16}{2 \times 1}$ lb-in/motor = 2936 lb-in

Step Seven: Determine Wheel Slip

To verify that the vehicle will perform as designed in regards to tractive effort and acceleration, it is necessary to calculate wheel slip (TS) for the vehicle. In special cases, wheel slip may actually be desirable to prevent hydraulic system overheating and component breakage should the vehicle become stalled.

$$TS = \frac{W \times f \times ri}{G}\ \text{(lb-in per motor)} \qquad TS = \frac{W \times f \times rm}{G}\ \text{(N-m per motor)}$$

Where:

f = coefficient of friction (see table 2)

W = loaded vehicle weight over driven wheel (lb or N)

Example $TS = \frac{425 \times .06 \times 16}{1}$ lb-in/motor = 4080 lbs

Table 2

Coefficient of friction (f)	
Steel on steel	0.3
Rubber tire on dirt	0.5
Rubber tire on a hard surface	0.6 - 0.8
Rubber tire on cement	0.7

To determine radial load capacity requirement of motor

When a motor used to drive a vehicle has the wheel or hub attached directly to the motor shaft, it is critical that the radial load capabilities of the motor are sufficient to support the vehicle. After calculating the Total Radial Load (RL) acting on the motors, the result must be compared to the bearing/shaft load charts for the chosen motor to determine if the motor will provide acceptable load capacity and life.

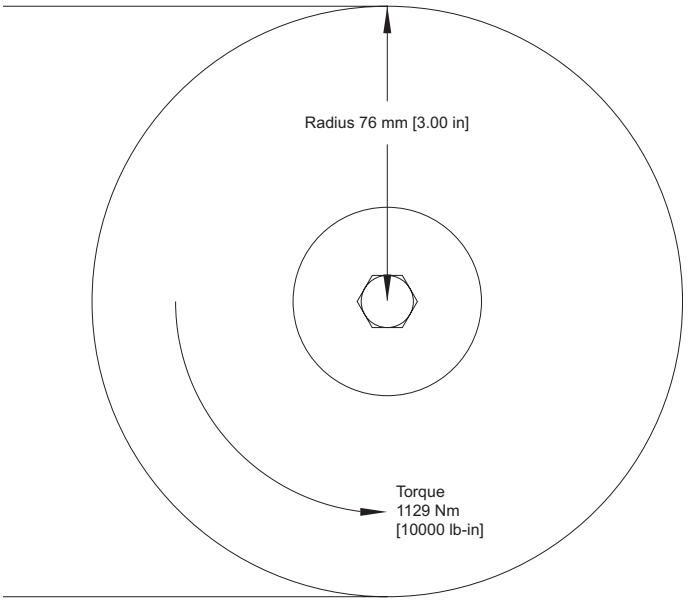
$$RL = \sqrt{W^2 + \left(\frac{T}{ri}\right)^2}\ lb \qquad RL = \sqrt{W^2 + \left(\frac{T}{rm}\right)^2}\ kg$$

Example $RL = \sqrt{425^2 + \left(\frac{2936}{16}\right)^2} = 463\ lbs$

Once the maximum motor RPM, maximum torque requirement, and the maximum load each motor must support have been determined, these figures may then be compared to the motor performance charts and to the bearing load curves to choose a series and displacement to fulfill the motor requirements for the application.

INDUCED SIDE LOAD

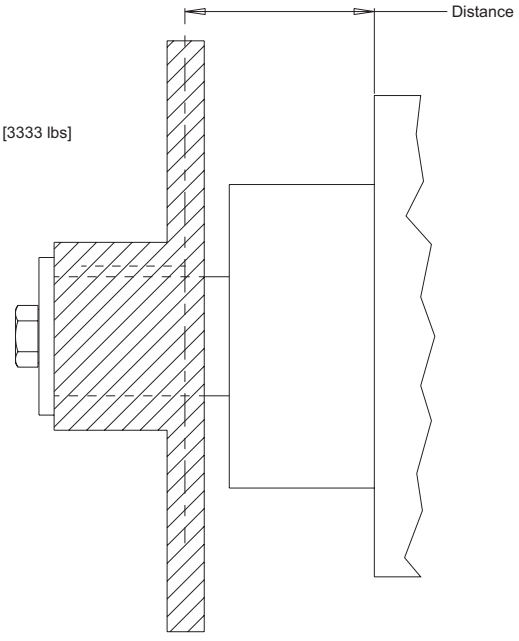
In many cases, pulleys or sprockets may be used to transmit the torque produced by the motor. Use of these components will create a torque induced side load on the motor shaft and bearings. It is important that this load be taken into consideration when choosing a motor with sufficient bearing and shaft capacity for the application.



To determine the side load, the motor torque and pulley or sprocket radius must be known. Side load may be calculated using the formula below. The distance from the pulley/sprocket centerline to the mounting flange of the motor must also be determined. These two figures may then be compared to the bearing and shaft load curve of the desired motor to determine if the side load falls within acceptable load ranges.

$$\text{Side Load} = \frac{\text{Torque}}{\text{Radius}}$$

Side Load = 14855 Nm [3333 lbs]



HYDRAULIC EQUATIONS

Multiplication Factor	Abbrev.	Prefix
10^{12}	T	tera
10^{9}	G	giga
10^{6}	M	mega
10^{3}	K	kilo
10^{2}	h	hecto
10^{1}	da	deka
10^{-1}	d	deci
10^{-2}	c	centi
10^{-3}	m	milli
10^{-6}	u	micro
10^{-9}	n	nano
10^{-12}	p	pico
10^{-15}	f	femto
10^{-18}	a	atto

Theo. Speed (RPM) =

$$\frac{1000 \times \text{LPM}}{\text{Displacement (cm}^3\text{/rev)}} \quad \text{or} \quad \frac{231 \times \text{GPM}}{\text{Displacement (in}^3\text{/rev)}}$$

Theo. Torque (lb-in) =

$$\frac{\text{Bar x Disp. (cm}^3\text{/rev)}}{20\ \text{pi}} \quad \text{or} \quad \frac{\text{PSI x Displacement (in}^3\text{/rev)}}{6.28}$$

Power In (HP) =

$$\frac{\text{Bar x LPM}}{600} \quad \text{or} \quad \frac{\text{PSI x GPM}}{1714}$$

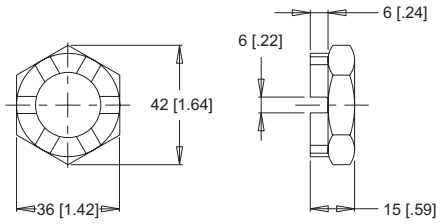
Power Out (HP) =

$$\frac{\text{Torque (Nm) x RPM}}{9543} \quad \text{or} \quad \frac{\text{Torque (lb-in) x RPM}}{63024}$$

SHAFT NUT INFORMATION

35MM TAPERED SHAFTS
M24 x 1.5 Thread

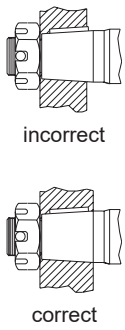
A Slotted Nut



Torque Specifications: 32.5 daNm [240 ft.lb.]

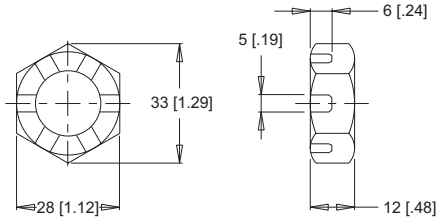
PRECAUTION

The tightening torques listed with each nut should only be used as a guideline. Hubs may require higher or lower tightening torque depending on the material. Consult the hub manufacturer to obtain recommended tightening torque. To maximize torque transfer from the shaft to the hub, and to minimize the potential for shaft breakage, a hub with sufficient thickness must fully engage the taper length of the shaft.



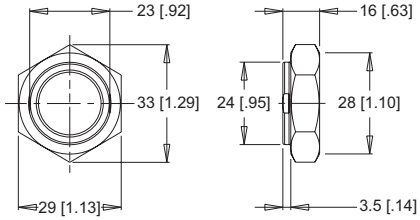
1" TAPERED SHAFTS
3/4-28 Thread

A Slotted Nut



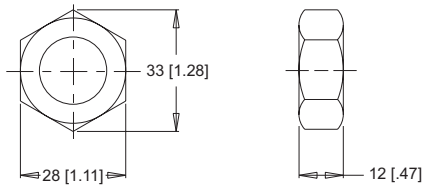
Torque Specifications: 20 - 23 daNm [150 - 170 ft.lb.]

B Lock Nut



Torque Specifications: 24 - 27 daNm [180 - 200 ft.lb.]

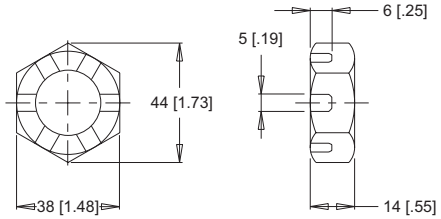
C Solid Nut



Torque Specifications: 20 - 23 daNm [150 - 170 ft.lb.]

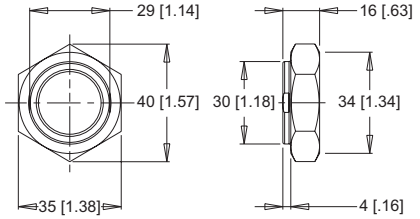
1-1/4" TAPERED SHAFTS
1-20 Thread

A Slotted Nut



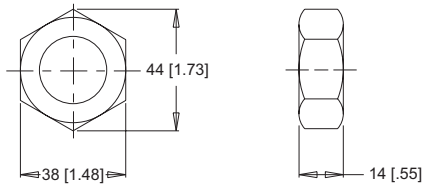
Torque Specifications: 38 daNm [280 ft.lb.] Max.

B Lock Nut



Torque Specifications: 33 - 42 daNm [240 - 310 ft.lb.]

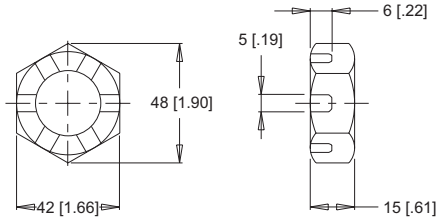
C Solid Nut



Torque Specifications: 38 daNm [280 ft.lb.] Max.

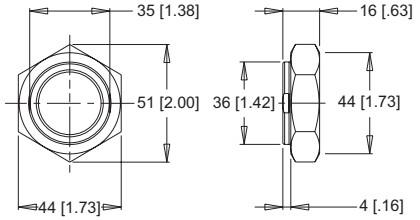
1-3/8" & 1-1/2" TAPERED SHAFTS
1 1/8-18 Thread

A Slotted Nut



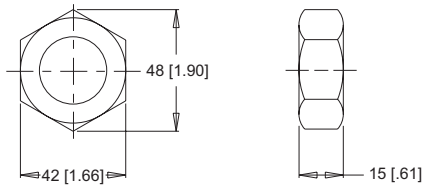
Torque Specifications: 41 - 54 daNm [300 - 400 ft.lb.]

B Lock Nut



Torque Specifications: 34 - 48 daNm [250 - 350 ft.lb.]

C Solid Nut



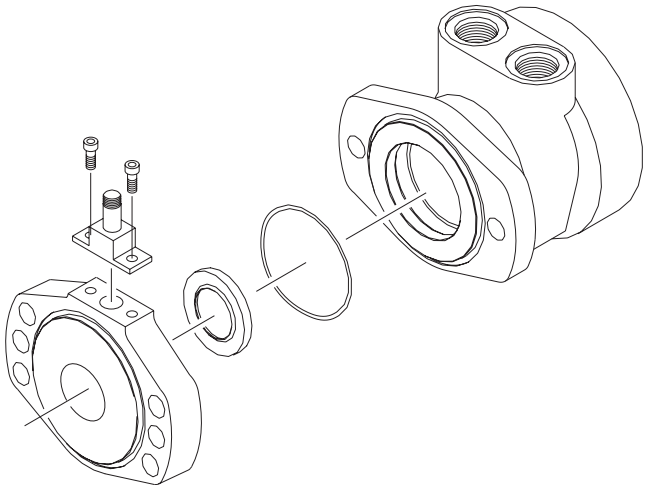
Torque Specifications: 41 - 54 daNm [300 - 400 ft.lb.]

SPEED SENSORS

We offer both single and dual element speed sensor options providing a number of benefits to users by incorporating the latest advancements in sensing technology and materials. The 700 & 800 series motors single element sensors provide 60 pulses per revolution with the dual element providing 120 pulses per revolution, with all other series providing 50 & 100 pulses respectively. Higher resolution is especially beneficial for slow speed applications, where more information is needed for smooth and accurate control. The dual sensor option also provides a direction signal allowing end-users to monitor the direction of shaft rotation .

Unlike competitive designs that breach the high pressure area of the motor to add the sensor, the speed sensor option utilizes an add-on flange to locate all sensor components outside the high pressure operating environment. This eliminates the potential leak point common to competitive designs. Many improvements were made to the sensor flange including changing the material from cast iron to acetal resin, incorporating a Buna-N shaft seal internal to the flange, and providing a grease zerk, which allows the user to fill the sensor cavity with grease. These improvements enable the flange to withstand the rigors of harsh environments.

Another important feature of the new sensor flange is that it is self-centering, which allows it to remain concentric to the magnet rotor. This produces a consistent mounting location for the new sensor module, eliminating the need to adjust



the air gap between the sensor and magnet rotor. The o-ring sealed sensor module attaches to the sensor flange with two small screws, allowing the sensor to be serviced or upgraded in the field in under one minute. This feature is especially valuable for mobile applications where machine downtime is costly. The sensor may also be serviced without exposing the hydraulic circuit to the atmosphere. Another advantage of the self-centering flange is that it allows users to rotate the sensor to a location best suited to their application. This feature is not available on competitive designs, which fix the sensor in one location in relationship to the motor mounting flange.

FEATURES / BENEFITS

- Grease fitting allows sensor cavity to be filled with grease for additional protection.
- Internal extruder seal protects against environmental elements.
- M12 or weatherpack connectors provide installation flexibility.
- Dual element sensor provides up to 120 pulses per revolution and directional sensing.
- Modular sensor allows quick and easy servicing.
- Acetal resin flange is resistant to moisture, chemicals, oils, solvents and greases.
- Self-centering design eliminates need to set magnet-to-sensor air gap.
- Protection circuitry

SENSOR OPTIONS

Z - 4-pin M12 male connector
This option has 50 pulses per revolution on all series except the DT which has 60 pulses per revolution. This option will not detect direction.

Y - 3-pin male weatherpack connector*
This option has 50 pulses per revolution on all series except the DT which has 60 pulses per revolution. This option will not detect direction.

X - 4-pin M12 male connector
This option has 100 pulses per revolution on all series except the DT which has 120 pulses per revolution. This option will detect direction.

W - 4-pin male weatherpack connector*
This option has 100 pulses per revolution on all series except the DT which has 120 pulses per revolution. This option will detect direction.

*These options include a 610mm [2 ft] cable.

SPEED SENSORS

SINGLE ELEMENT SENSOR - Y & Z

Supply voltages ..... 7.5-24 Vdc
Maximum output off voltage ..... 24 V
Maximum continuous output current ..... < 25 ma
Signal levels (low, high) ..... 0.8 to supply voltage
Operating Temp .....-30°C to 83°C [-22°F to 181°F]

DUAL ELEMENT SENSOR - X & W

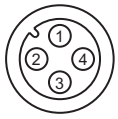
Supply voltages ..... 7.5-18 Vdc
Maximum output off voltage ..... 18 V
Maximum continuous output current ..... < 20 ma
Signal levels (low, high) ..... 0.8 to supply voltage
Operating Temp .....-30°C to 83°C [-22°F to 181°F]

SENSOR CONNECTORS

Z Option PIN

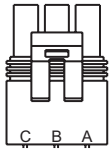
1	positive	brown or red
2	n/a	white
3	negative	blue
4	pulse out	black

X Option PIN



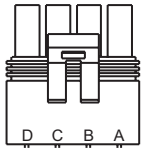
1	positive	brown or red
2	direction out	white
3	negative	blue
4	pulse out	black

Y Option PIN



A	positive	brown or red
B	negative	blue
C	pulse out	black
D	n/a	white

W Option PIN



A	positive	brown or red
B	negative	blue
C	pulse out	black
D	direction out	white

PROTECTION CIRCUITRY

The single element sensor has been improved and incorporates protection circuitry to avoid electrical damage caused by:

- reverse battery protection
- overvoltage due to power supply spikes and surges (60 Vdc max.)
- power applied to the output lead

The protection circuit feature will help “save” the sensor from damage mentioned above caused by:

- faulty installation wiring or system repair
- wiring harness shorts/opens due to equipment failure or harness damage resulting from accidental conditions (i.e. severed or grounded wire, ice, etc.)
- power supply spikes and surges caused by other electrical/electronic components that may be intermittent or damaged and “loading down” the system.

While no protection circuit can guarantee against any and all fault conditions. The single element sensor from us with protection circuitry is designed to handle potential hazards commonly seen in real world applications.

Unprotected versions are also available for operation at lower voltages down to 4.5V.

FREE TURNING ROTOR

The ‘AC’ option or “Free turning” option refers to a specially prepared rotor assembly. This rotor assembly has increased clearance between the rotor tips and rollers allowing it to turn more freely than a standard rotor assembly. For spool valve motors, additional clearance is also provided between the shaft and housing bore. The ‘AC’ option is available for all motor series and displacements.

There are several applications and duty cycle conditions where ‘AC’ option performance characteristics can be beneficial. In continuous duty applications that require high flow/high rpm operation, the benefits are twofold. The additional clearance helps to minimize internal pressure drop at high flows. This clearance also provides a thicker oil film at metal to metal contact areas and can help extend the life of the motor in high rpm or even over speed conditions. The ‘AC’ option should be considered for applications that require continuous operation above 57 LPM [15 GPM] and/or 300 rpm. Applications that are subject to pressure spikes due to frequent reversals or shock loads can also benefit by specifying the ‘AC’ option. The additional clearance serves to act as a buffer against spikes, allowing them to be bypassed through the motor rather than being absorbed and transmitted through the drive link to the output shaft. The trade-off for achieving these benefits is a slight loss of volumetric efficiency at high pressures.

INTERNAL DRAIN

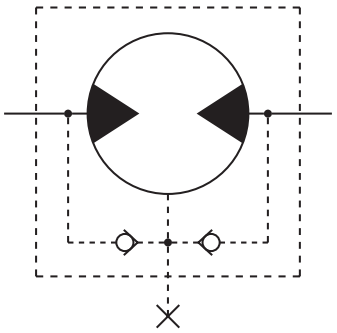
The internal drain is an option available on all HB, DR, and DT Series motors, and is standard on all WP, WR, WS, and D9 series motors. Typically, a separate drain line must be installed to direct case leakage of the motor back to the reservoir when using a HB, DR, or DT Series motor. However, the internal drain option eliminates the need for a separate drain line through the installation of two check valves in the motor endcover. This simplifies plumbing requirements for the motor.

The two check valves connect the case area of the motor to each port of the endcover. During normal motor operation, pressure in the input and return lines of the motor close the check valves. However, when the pressure in the case of the motor is greater than that of the return line, the check valve between the case and low pressure line opens, allowing the case leakage to flow into the return line. Since the operation of the check valves is dependent upon a pressure differential, the internal drain option operates in either direction of motor rotation.

Although this option can simplify many motor installations, precautions must be taken to insure that return line pressure remains below allowable levels (see table below) to insure proper motor operation and life. If return line pressure is higher than allowable, or experiences pressure spikes, this pressure may feed back into the motor, possibly causing catastrophic seal failure. Installing motors with internal drains in series is not recommended unless overall pressure drop over all motors is below the maximum allowable backpressure as listed in the chart below. If in doubt, contact your authorized representative.

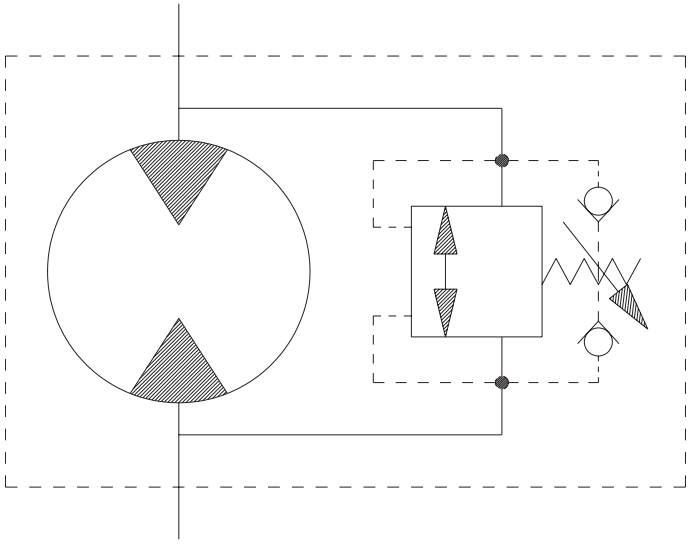
MAXIMUM ALLOWABLE BACK PRESSURE

Series	Cont. bar [psi]	Inter. bar [psi]
HB	69 [1000]	103 [1500]
DR	69 [1000]	103 [1500]
DT	21 [300]	34 [500]
D9	21 [300]	21 [300]
Brakes	34 [500]	34 [500]



VALVE CAVITY

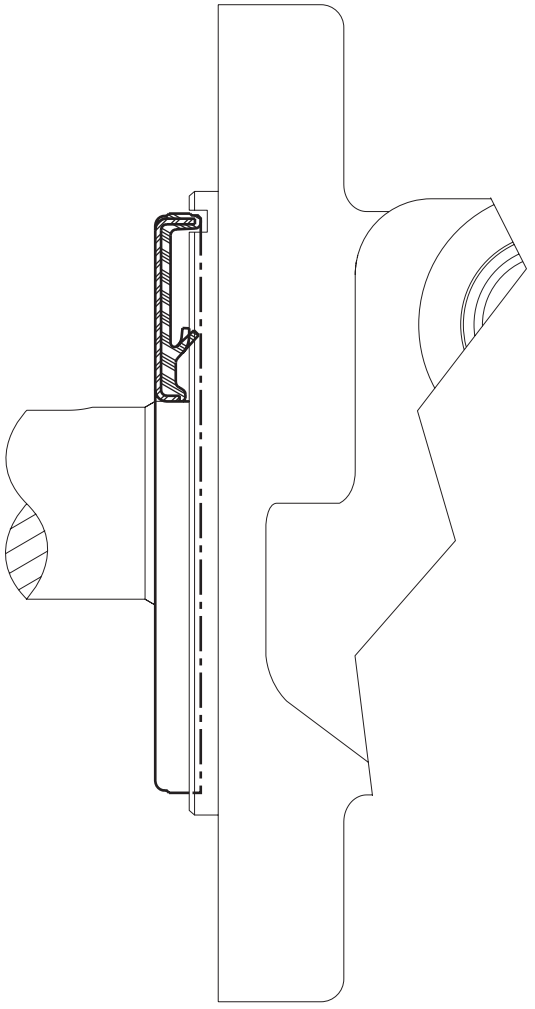
The valve cavity option provides a cost effective way to incorporate a variety of cartridge valves integral to the motor. The valve cavity is a standard 10 series (12 series on the 800 series motor) 2-way cavity that accepts numerous cartridge valves, including overrunning check valves, relief cartridges, flow control valves, pilot operated check fuses, and high pressure shuttle valves. Installation of a relief cartridge into the cavity provides an extra margin of safety for applications encountering frequent pressure spikes. Relief cartridges from 69 to 207 bar [1000 to 3000 psi] may also be factory installed.



For basic systems with fixed displacement pumps, either manual or motorized flow control valves may be installed into the valve cavity to provide a simple method for controlling motor speed. It is also possible to incorporate the speed sensor option and a programmable logic controller with a motorized flow control valve to create a closed loop, fully automated speed control system. For motors with internal brakes, a shuttle valve cartridge may be installed into the cavity to provide a simple, fully integrated method for supplying release pressure to the pilot line to actuate an integral brake. To discuss other alternatives for the valve cavity option, contact an authorized distributor.

SLINGER SEAL

Slinger seals are available on select series offered by us. Slinger seals offer extendes shaft/shaft seal protection by prevented a buildup of material around the circumference of the shaft which can lead to premature shaft seal failures. The slinger seals are designed to be larger in diameter than competitive products, providing greater surface speed and ‘slinging action’.



Slinger seals are also available on 4-hole flange mounts on select series. Contact a Customer Service Representative for additional information.

WS (350/351 Series)

Heavy Duty Hydraulic Motor

OVERVIEW

The WS targets agricultural equipment, skid steer attachments, and other applications that require greater torque under demanding conditions. A distinguishing feature of the WS in relation to competitive products is its heavy duty drive link with a larger pitch diameter. This enables the WS to better withstand pressure and torque spikes and is reflected in its intermittent and peak performance ratings. Additional product features include a three zone commutator valve, heavy-duty tapered roller bearings, and case drain with integral internal drain.

FEATURES / BENEFITS

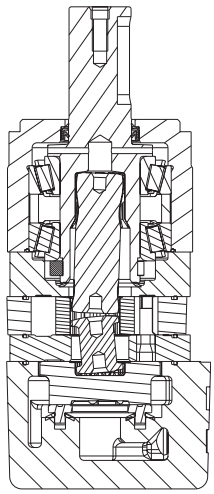
- Ten shaft and six mounting options to meet the most common SAE and European requirements.
- Heavy- duty tapered roller bearings for extra side load capacity.
- Heavy-duty drive link with larger pitch diameter than competitors for greater resistance to pressure and torque spikes.
- Three zone commutator valve for high flow capacity.
- Standard case drain with integral internal drain for extended shaft seal life.

TYPICAL APPLICATIONS

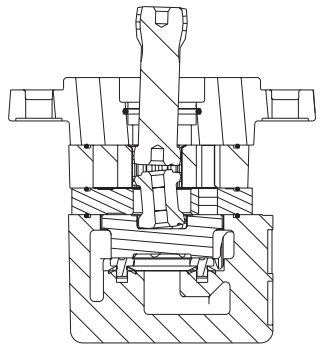
Medium-duty wheel drives, sweepers, grain augers, spreaders, feed rollers, brush drives, mowers, harvesting equipment gear box mounts and more

SERIES DESCRIPTIONS

350/351 - Hydraulic Motor
Compact



350-351 - Hydraulic Motor
Short Motor



SPECIFICATIONS

CODE	Displacement cm^3 [in^3/rev]	Max. Speed rpm		Max. Flow lpm [gpm]		Max. Torque Nm [lb-in]		Max. Pressure bar [psi]		
		cont.	inter.	cont.	inter.	cont.	inter.	cont.	inter.	peak
080	79 [4.8]	843	929	68 [18]	76 [20]	230 [2036]	305 [2699]	207 [3000]	276 [4000]	310 [4500]
100	100 [6.1]	756	945	76 [20]	95 [25]	270 [2390]	362 [3204]	207 [3000]	276 [4000]	310 [4500]
110	112 [6.8]	669	837	76 [20]	95 [25]	312 [2761]	418 [3699]	207 [3000]	276 [4000]	310 [4500]
130	129 [7.9]	588	734	76 [20]	95 [25]	370 [3328]	499 [4416]	207 [3000]	276 [4000]	310 [4500]
160	161 [9.8]	471	707	76 [20]	114 [30]	472 [4177]	627 [5549]	207 [3000]	276 [4000]	310 [4500]
200	201 [12.3]	377	566	76 [20]	114 [30]	579 [5124]	765 [6770]	207 [3000]	276 [4000]	310 [4500]
230	229 [14.0]	330	495	76 [20]	114 [30]	655 [5779]	872 [7717]	207 [3000]	276 [4000]	310 [4500]
250	248 [15.1]	305	459	76 [20]	114 [30]	657 [5814]	769 [6806]	190 [2750]	224 [3250]	259 [3750]
320	322 [19.6]	235	352	76 [20]	114 [30]	861 [7620]	1003 [8877]	190 [2750]	224 [3250]	259 [3750]
400	396 [24.2]	191	285	76 [20]	114 [30]	858 [7593]	1048 [9275]	155 [2250]	190 [2750]	224 [3250]
500	495 [30.2]	153	229	76 [20]	114 [30]	851 [7531]	1064 [9416]	121 [1750]	155 [2250]	172 [2500]

► Performance data is typical. Performance of production units varies slightly from one motor to another. Running at intermittent ratings should not exceed 10% of every minute of operation.

DISPLACEMENT PERFORMANCE

► Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended. For additional information on product testing please refer to page 6.

080

79 cm³ [4.8 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm] / Theoretical rpm

Flow - lpm [gpm]	17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000]	242 [3500]	276 [4000]	Theoretical rpm
2 [0.5]	18 [159] **23**	38 [336] **22**	74 [655] **19**							25
4 [1]	18 [159] **50**	40 [354] **47**	77 [682] **42**	115 [1018] **38**	150 [1328] **30**	182 [1611] **23**				51
8 [2]	18 [159] **100**	39 [345] **96**	77 [682] **91**	117 [1036] **82**	154 [1363] **74**	192 [1699] **63**	224 [1983] **53**			101
15 [4]	18 [159] **187**	39 [345] **182**	78 [690] **179**	118 [1044] **169**	156 [1381] **154**	194 [1717] **138**	230 [2036] **126**	260 [2301] **107**		190
23 [6]	17 [150] **290**	37 [327] **282**	77 [682] **272**	116 [1027] **264**	155 [1372] **248**	192 [1699] **229**	223 [1974] **217**	264 [2337] **193**	302 [2673] **168**	291
30 [8]	16 [142] **379**	36 [319] **369**	76 [673] **348**	117 [1036] **349**	155 [1372] **335**	194 [1717] **315**	224 [1983] **300**	266 [2354] **277**	304 [2691] **242**	380
38 [10]	14 [124] **480**	34 [301] **468**	73 [646] **457**	114 [1009] **451**	153 [1354] **435**	191 [1690] **414**	230 [2036] **390**	265 [2345] **383**	305 [2699] **340**	481
45 [12]	13 [115] **565**	33 [292] **556**	72 [637] **544**	113 [1000] **537**	152 [1345] **518**	190 [1682] **496**	223 [1974] **477**	265 [2345] **447**	304 [2691] **424**	570
53 [14]		30 [266] **655**	69 [611] **642**	115 [1018] **630**	148 [1310] **616**	189 [1673] **585**	223 [1974] **572**	264 [2337] **545**	305 [2699] **519**	671
61 [16]		26 [230] **752**	66 [584] **747**	103 [912] **736**	146 [1292] **705**	182 [1611] **678**	225 [1991] **650**	262 [2319] **644**	303 [2682] **600**	772
68 [18] Max. Inter. Cont.		26 [230] **843**	65 [575] **830**	106 [938] **825**	147 [1301] **798**	186 [1646] **769**	218 [1929] **768**	260 [2301] **753**	303 [2682] **682**	861
76 [20]			61 [540] **929**	101 [894] **924**	140 [1239] **898**	174 [1540] **873**	214 [1894] **848**	258 [2283] **803**	302 [2673] **772**	962

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

Rotor Width									
15.7 [.617] mm [in]	22 [192]	45 [394]	88 [778]	132 [1172]	176 [1556]	219 [1939]	264 [2334]	308 [2728]	351 [3111]

Theoretical Torque - Nm [lb-in]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

100

100 cm³ [6.1 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm] / Theoretical rpm

Flow - lpm [gpm]	17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000]	242 [3500]	276 [4000]	Theoretical rpm
2 [0.5]	14 [124] **19**	38 [336] **19**	77 [681] **17**							20
4 [1]	17 [150] **39**	42 [372] **39**	86 [761] **37**	130 [1151] **35**	169 [1496] **31**	205 [1814] **24**				40
8 [2]	15 [133] **79**	43 [381] **78**	89 [788] **76**	135 [1195] **73**	179 [1584] **68**	220 [1947] **61**	259 [2292] **52**	290 [2567] **35**		80
15 [4]	14 [124] **148**	43 [381] **148**	91 [805] **145**	136 [1204] **140**	181 [1602] **134**	224 [1982] **125**	267 [2363] **113**	308 [2726] **98**	341 [3018] **67**	150
23 [6]	14 [124] **228**	43 [381] **228**	90 [797] **224**	137 [1212] **218**	182 [1611] **209**	226 [2000] **197**	270 [2390] **185**	314 [2779] **164**	354 [3133] **135**	230
30 [8]	12 [106] **299**	41 [363] **298**	88 [779] **294**	136 [1204] **286**	181 [1602] **275**	225 [1991] **262**	270 [2390] **246**	314 [2779] **226**	356 [3151] **194**	300
38 [10]	10 [89] **372**	38 [336] **372**	85 [752] **369**	132 [1168] **365**	178 [1575] **351**	223 [1974] **337**	269 [2381] **319**	315 [2788] **296**	360 [3186] **263**	380
45 [12]		37 [327] **444**	84 [743] **435**	132 [1168] **434**	178 [1575] **419**	223 [1974] **403**	270 [2390] **384**	317 [2805] **361**	362 [3204] **325**	450
53 [14]		35 [310] **525**	82 [726] **520**	129 [1142] **514**	176 [1558] **498**	221 [1956] **481**	269 [2381] **457**	317 [2805] **432**	363 [3213] **397**	530
61 [16]		33 [292] **604**	79 [699] **600**	126 [1115] **592**	172 [1522] **576**	218 [1929] **558**	266 [2354] **533**	314 [2779] **503**	361 [3195] **474**	610
68 [18]		31 [274] **675**	75 [664] **674**	123 [1089] **662**	169 [1496] **643**	216 [1912] **622**	263 [2328] **597**	313 [2770] **566**	360 [3186] **532**	680
76 [20] Max. Cont.		29 [257] **756**	71 [628] **754**	120 [1062] **742**	167 [1478] **723**	214 [1894] **700**	262 [2319] **673**	310 [2744] **640**	359 [3177] **600**	760
83 [22]			69 [611] **825**	117 [1035] **813**	164 [1451] **794**	211 [1967] **769**	259 [2292] **743**	308 [2726] **708**	356 [3151] **669**	830
91 [24]			65 [575] **905**	114 [1009] **893**	161 [1425] **875**	208 [1841] **853**	256 [2266] **823**	305 [2699] **781**	352 [3115] **749**	910
95 [25] Max. Inter.			62 [549] **945**	111 [982] **931**	159 [1407] **908**	206 [1823] **882**	254 [2248] **854**	304 [2690] **805**	351 [3106] **750**	950

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

Rotor Width									
19.7 [.776] mm [in]	27 [239]	56 [493]	110 [972]	166 [1465]	220 [1944]	274 [2423]	329 [2916]	385 [3409]	439 [3888]

Theoretical Torque - Nm [lb-in]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

WS (350/351 Series)
Heavy Duty Hydraulic Motor

DISPLACEMENT PERFORMANCE

▶ Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended. For additional information on product testing please refer to page 6.

110

112 cm³ [6.8 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm]	17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000]	242 [3500]	276 [4000]	Theoretical rpm
2 [0.5]	22 [195] **17**	49 [434] **17**	98 [867] **15**							18
4 [1]	23 [204] **35**	51 [451] **35**	102 [903] **34**	149 [1319] **32**	197 [1743] **29**					36
8 [2]	23 [204] **70**	51 [451] **70**	105 [929] **68**	156 [1381] **66**	204 [1805] **63**	242 [2142] **56**	281 [2487] **40**	302 [2673] **24**		71
15 [4]	22 [195] **133**	50 [443] **131**	103 [912] **128**	156 [1381] **123**	207 [1832] **117**	256 [2266] **107**	304 [2690] **92**	345 [3053] **73**	371 [3283] **41**	134
23 [6]	22 [195] **203**	48 [425] **202**	101 [894] **198**	156 [1381] **192**	209 [1850] **184**	261 [2310] **173**	312 [2761] **159**	361 [3195] **136**	405 [3584] **106**	205
30 [8]	20 [177] **267**	45 [398] **265**	100 [885] **260**	155 [1372] **252**	208 [1841] **242**	260 [2301] **231**	312 [2761] **215**	363 [3213] **192**	412 [3646] **159**	268
38 [10]	19 [168] **337**	42 [372] **336**	95 [841] **330**	153 [1354] **320**	205 [1814] **308**	258 [2283] **292**	312 [2761] **278**	363 [3213] **254**	415 [3673] **224**	339
45 [12]	17 [150] **400**	42 [372] **399**	94 [832] **392**	151 [1336] **383**	204 [1805] **370**	257 [2274] **355**	312 [2761] **336**	366 [3239] **313**	418 [3699] **277**	402
53 [14]		38 [336] **470**	93 [823] **463**	148 [1310] **452**	201 [1779] **437**	254 [2248] **418**	309 [2735] **399**	364 [3221] **372**	418 [3699] **338**	473
61 [16]		36 [319] **542**	90 [797] **534**	142 [1257] **524**	198 [1752] **509**	252 [2230] **489**	308 [2726] **465**	362 [3204] **438**	417 [3690] **407**	545
68 [18]		32 [283] **606**	87 [770] **598**	143 [1266] **586**	195 [1726] **571**	249 [2204] **549**	305 [2699] **525**	360 [3186] **497**	415 [3673] **461**	607
76 [20] Max. Cont.		28 [248] **669**	82 [726] **668**	138 [1221] **656**	191 [1690] **641**	245 [2168] **618**	300 [2655] **593**	357 [3159] **560**	412 [3646] **521**	679
83 [22]			78 [690] **731**	134 [1186] **719**	185 [1637] **702**	239 [2115] **679**	296 [2620] **652**	352 [3115] **621**	408 [3611] **576**	741
91 [24]			72 [637] **803**	127 [1124] **790**	181 [1602] **771**	235 [2080] **747**	291 [2575] **721**	349 [3089] **683**	406 [3593] **635**	813
95 [25] Max. Inter.			70 [620] **837**	125 [1106] **821**	179 [1584] **801**	233 [2062] **780**	289 [2558] **751**	346 [3062] **714**	403 [3567] **668**	848

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% ☐ 40 - 69% ☐ 0 - 39% ☐

Rotor Width	Theoretical Torque - Nm [lb-in]								
22.1 [.871] mm [in]	30 [268]	62 [552]	123 [1089]	185 [1641]	246 [2177]	307 [2713]	369 [3266]	431 [3181]	492 [4354]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

130

129 cm³ [7.9 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm]	17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000]	242 [3500]	276 [4000]	Theoretical rpm
2 [0.5]	23 [204] **15**	53 [469] **15**								16
4 [1]	24 [212] **30**	55 [487] **30**	113 [1000] **30**	167 [1478] **29**	225 [1991] **27**					31
8 [2]	25 [221] **61**	57 [504] **61**	119 [1053] **60**	179 [1584] **58**	234 [2071] **54**	290 [2567] **46**	331 [2929] **29**			62
15 [4]	26 [230] **115**	58 [513] **115**	122 [1080] **113**	186 [1646] **109**	247 [2186] **103**	306 [2708] **93**	363 [3213] **77**	416 [3682] **55**		116
23 [6]	25 [221] **177**	57 [504] **177**	122 [1080] **174**	187 [1655] **169**	250 [2213] **161**	312 [2761] **147**	373 [3301] **130**	431 [3814] **105**	483 [4275] **70**	178
30 [8]	23 [204] **232**	57 [504] **232**	120 [1062] **228**	186 [1646] **222**	250 [2213] **212**	313 [2770] **197**	376 [3328] **179**	437 [3867] **156**	494 [4372] **125**	233
38 [10]	22 [195] **294**	54 [478] **294**	118 [1044] **290**	184 [1628] **283**	248 [2195] **273**	312 [2761] **257**	376 [3328] **237**	439 [3885] **212**	499 [4416] **182**	295
45 [12]	20 [177] **348**	53 [469] **348**	116 [1027] **343**	183 [1620] **334**	246 [2177] **321**	310 [2744] **304**	375 [3319] **282**	439 [3885] **255**	499 [4416] **221**	349
53 [14]		49 [434] **410**	113 [1000] **405**	179 [1584] **395**	243 [2151] **380**	307 [2717] **361**	373 [3301] **336**	437 [3867] **311**	499 [4416] **275**	411
61 [16]		46 [407] **472**	110 [974] **467**	176 [1558] **456**	240 [2124] **439**	304 [2690] **417**	370 [3275] **392**	435 [3850] **364**	497 [4398] **328**	473
68 [18]		42 [372] **526**	106 [938] **521**	172 [1522] **510**	236 [2089] **493**	300 [2655] **470**	366 [3239] **442**	432 [3823] **411**	495 [4381] **376**	527
76 [20] Max. Cont.		38 [336] **588**	102 [903] **583**	167 [1478] **572**	232 [2053] **553**	297 [2628] **527**	363 [3213] **499**	428 [3788] **467**	491 [4345] **423**	589
83 [22]		33 [292] **642**	98 [867] **638**	164 [1451] **627**	228 [2018] **607**	293 [2593] **581**	359 [3177] **549**	423 [3744] **517**	485 [4292] **473**	643
91 [24]		30 [266] **704**	93 [823] **702**	158 [1398] **692**	222 [1965] **677**	288 [2549] **648**	354 [3133] **625**	421 [3726] **576**	483 [4275] **531**	705
95 [25] Max. Inter.		27 [239] **734**	91 [805] **733**	158 [1398] **720**	220 [1947] **703**	286 [2531] **672**	351 [3106] **639**	419 [3708] **602**	483 [4275] **559**	736

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% ☐ 40 - 69% ☐ 0 - 39% ☐

Rotor Width	Theoretical Torque - Nm [lb-in]								
25.4 [1.000] mm [in]	35 [309]	72 [636]	142 [1254]	214 [1890]	283 [2508]	353 [3125]	425 [3761]	497 [4397]	567 [5015]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

DISPLACEMENT PERFORMANCE

► Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended. For additional information on product testing please refer to page 6.

160

161 cm³ [9.8 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm] / Theoretical rpm

2 [0.5]	21 [186] **11**	65 [575] **10**							12
4 [1]	29 [257] **24**	67 [593] **24**	140 [1239] **23**	209 [1850] **21**					25
8 [2]	31 [274] **49**	71 [628] **48**	143 [1266] **47**	214 [1894] **46**	285 [2522] **43**	352 [3115] **36**			50
15 [4]	34 [301] **92**	75 [664] **92**	154 [1363] **91**	231 [2044] **88**	306 [2708] **84**	380 [3363] **77**	454 [4018] **64**	519 [4593] **43**	93
23 [6]	32 [283] **142**	75 [664] **141**	155 [1372] **140**	235 [2080] **139**	314 [2779] **133**	390 [3452] **123**	466 [4124] **108**	537 [4752] **85**	604 [5345] **52**	143
30 [8]	31 [274] **185**	73 [646] **185**	154 [1363] **184**	234 [2071] **183**	315 [2788] **178**	394 [3487] **166**	472 [4177] **151**	547 [4841] **130**	615 [5443] **99**	186
38 [10]	28 [248] **233**	72 [637] **231**	153 [1354] **229**	231 [2044] **229**	311 [2752] **223**	391 [3460] **210**	471 [4168] **194**	548 [4850] **175**	620 [5487] **144**	236
45 [12]	25 [221] **280**	67 [593] **280**	151 [1336] **272**	229 [2027] **269**	310 [2744] **260**	391 [3460] **243**	466 [4124] **227**	544 [4814] **202**	624 [5522] **159**	280
53 [14]	23 [204] **328**	63 [558] **327**	145 [1283] **320**	227 [2009] **312**	307 [2717] **303**	388 [3434] **288**	467 [4133] **271**	548 [4850] **247**	622 [5505] **216**	329
61 [16]		58 [513] **378**	139 [1230] **372**	221 [1956] **366**	302 [2673] **361**	386 [3416] **350**	468 [4142] **328**	549 [4859] **305**	626 [5540] **273**	379
68 [18]		53 [469] **418**	135 [1195] **412**	217 [1920] **410**	298 [2637] **406**	380 [3363] **389**	468 [4142] **370**	549 [4859] **348**	627 [5549] **312**	422
Max. Cont. 76 [20]		53 [469] **471**	133 [1177] **467**	216 [1912] **455**	296 [2620] **440**	377 [3336] **423**	461 [4080] **397**	544 [4814] **368**	609 [5390] **348**	472
83 [22]		44 [389] **515**	126 [1115] **514**	205 [1814] **513**	282 [2496] **504**	359 [3177] **491**	440 [3894] **467**	523 [4629] **434**	602 [5328] **384**	516
91 [24]		38 [336] **560**	119 [1053] **556**	207 [1832] **547**	284 [2513] **546**	368 [3257] **532**	440 [3894] **515**	521 [4611] **493**	606 [5363] **461**	565
95 [25]		34 [301] **585**	112 [991] **580**	194 [1717] **579**	276 [2443] **574**	365 [3230] **555**	445 [3938] **540**			590
Max. Inter. 114 [30]			94 [832] **707**	177 [1566] **706**	269 [2381] **687**	341 [3018] **676**	418 [3699] **654**			708

Rotor Width

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% ☐ 40 - 69% ☐ 0 - 39% ☐

mm [in]	Theoretical Torque - Nm [lb-in]									Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]
31.8 [1.251]	44 [386]	90 [794]	177 [1565]	266 [2358]	354 [3130]	441 [3901]	530 [4694]	620 [5488]	707 [6259]	

200

201 cm³ [12.3 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	190 [2750]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm] / Theoretical rpm

4 [1]	40 [354] **19**	87 [770] **18**	189 [1673] **17**	282 [2496] **15**							20
8 [2]	44 [389] **39**	97 [858] **39**	192 [1699] **38**	286 [2531] **37**	370 [3275] **36**	456 [4036] **33**					40
15 [4]	45 [398] **74**	99 [876] **74**	198 [1752] **73**	298 [2637] **71**	391 [3460] **67**	481 [4257] **63**	526 [4655] **60**	566 [5009] **57**	645 [5708] **50**		75
23 [6]	42 [372] **113**	97 [858] **113**	196 [1735] **112**	296 [2620] **108**	389 [3443] **104**	478 [4230] **98**	523 [4629] **93**	568 [5027] **93**	653 [5779] **80**	724 [6407] **66**	114
30 [8]	40 [354] **148**	94 [832] **147**	194 [1717] **146**	293 [2593] **142**	388 [3434] **136**	478 [4230] **129**	525 [4646] **125**	568 [5027] **121**	658 [5823] **109**	724 [6407] **96**	149
38 [10]	36 [319] **188**	91 [805] **187**	191 [1690] **186**	292 [2584] **181**	388 [3434] **175**	483 [4275] **167**	533 [4717] **162**	579 [5124] **158**	672 [5947] **146**	759 [6717] **126**	189
45 [12]	32 [283] **223**	87 [770] **222**	186 [1646] **221**	288 [2549] **217**	386 [3416] **208**	482 [4266] **198**	532 [4708] **194**	579 [5124] **188**	675 [5974] **175**	765 [6770] **162**	224
53 [14]	30 [266] **263**	81 [717] **262**	181 [1602] **261**	283 [2505] **257**	382 [3381] **248**	479 [4239] **236**	528 [4673] **235**	576 [5098] **224**	673 [5956] **212**	765 [6770] **194**	264
61 [16]	27 [239] **302**	72 [637] **301**	172 [1522] **299**	276 [2443] **297**	375 [3319] **288**	473 [4186] **276**	524 [4637] **269**	571 [5053] **263**	667 [5903] **248**	761 [6735] **231**	303
68 [18]		66 [584] **337**	167 [1478] **336**	269 [2381] **332**	368 [3257] **324**	466 [4124] **312**	518 [4584] **303**	566 [5009] **297**	664 [5876] **279**	757 [6699] **262**	338
Max. Cont. 76 [20]		58 [513] **377**	157 [1389] **375**	260 [2301] **372**	359 [3177] **364**	457 [4044] **353**	510 [4514] **343**	559 [4947] **336**	656 [5806] **320**	751 [6646] **302**	378
83 [22]		50 [443] **412**	153 [1354] **410**	251 [2221] **408**	352 [3115] **398**	449 [3974] **387**	503 [4452] **377**	550 [4868] **372**			413
91 [24]		41 [363] **452**	145 [1283] **450**	244 [2159] **448**	346 [3062] **436**	445 [3938] **421**	496 [4390] **415**	538 [4761] **410**			453
95 [25]			139 [1230] **472**	239 [2115] **466**	339 [3000] **456**	438 [3876] **441**	491 [4345] **430**	539 [4770] **423**			473
Max. Inter. 114 [30]			116 [1027] **566**	213 [1885] **561**	313 [2770] **549**	416 [3682] **531**	468 [4142] **521**	512 [4531] **519**			567

Rotor Width

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% ☐ 40 - 69% ☐ 0 - 39% ☐

mm [in]	Theoretical Torque - Nm [lb-in]									Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]
39.4 [1.552]	54 [481]	112 [991]	221 [1954]	333 [2944]	441 [3907]	550 [4870]	608 [5379]	662 [5861]	774 [6852]	883 [7814]

WS (350/351 Series)

Heavy Duty Hydraulic Motor

DISPLACEMENT PERFORMANCE

▶ Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended. For additional information on product testing please refer to page 6.

230

229 cm³ [14.0 in³] / rev

Flow - lpm [gpm]	Pressure - bar [psi] 17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	172 [2500]	190 [2750]	207 [3000] Max. Cont.	242 [3500]	276 [4000] Max. Inter.	Theoretical rpm
4 [1]	50 [443] **16**	98 [867] **15**	198 [1752] **14**	310 [2744] **13**							17
8 [2]	42 [372] **34**	99 [876] **34**	204 [1805] **34**	316 [2797] **33**	416 [3682] **32**	510 [4514] **28**	552 [4885] **25**	594 [5257] **22**			35
15 [4]	47 [416] **65**	104 [920] **64**	214 [1894] **63**	325 [2876] **62**	426 [3770] **58**	526 [4655] **55**	580 [5133] **51**	626 [5540] **47**	721 [6381] **37**		66
23 [6]	45 [398] **99**	105 [929] **99**	218 [1929] **98**	331 [2929] **96**	438 [3876] **93**	544 [4814] **87**	598 [5292] **83**	649 [5744] **79**	752 [6655] **67**	843 [7461] **50**	100
30 [8]	43 [381] **130**	103 [912] **129**	217 [1920] **127**	332 [2938] **125**	441 [3903] **121**	549 [4859] **116**	602 [5328] **111**	654 [5788] **106**	758 [6708] **39**	859 [7602] **76**	131
38 [10]	40 [354] **165**	100 [885] **164**	214 [1894] **162**	330 [2921] **159**	440 [3894] **154**	548 [4850] **148**	604 [5345] **144**	655 [5797] **138**	761 [6735] **123**	866 [7664] **105**	166
45 [12]	35 [310] **196**	95 [841] **194**	211 [1867] **192**	328 [2903] **189**	438 [3876] **184**	546 [4832] **177**	604 [5345] **172**	656 [5806] **167**	764 [6761] **152**	869 [7691] **130**	197
53 [14]	30 [266] **230**	90 [797] **230**	206 [1823] **227**	323 [2859] **223**	435 [3850] **217**	544 [4814] **210**	601 [5319] **204**	654 [5788] **197**	763 [6753] **183**	871 [7708] **113**	231
61 [16]	28 [248] **265**	84 [743] **265**	200 [1770] **262**	317 [2805] **257**	430 [3806] **251**	540 [4779] **243**	598 [5292] **237**	652 [5770] **231**	763 [6753] **216**	872 [7717] **192**	266
68 [18]		77 [681] **295**	191 [1690] **292**	311 [2752] **288**	425 [3761] **281**	536 [4744] **272**	593 [5248] **266**	648 [5735] **260**	759 [6717] **244**	869 [7691] **222**	297
Max. Cont. 76 [20]		68 [602] **330**	184 [1628] **327**	302 [2673] **323**	416 [3682] **316**	529 [4682] **306**	586 [5186] **300**	642 [5682] **294**			332
83 [22]		58 [513] **361**	176 [1558] **358**	295 [2611] **353**	410 [3629] **346**	523 [4629] **336**	580 [5133] **329**	636 [5629] **323**			362
91 [24]		51 [451] **396**	167 [1478] **393**	285 [2522] **388**	400 [3540] **380**	513 [4531] **370**	571 [5053] **363**	627 [5549] **357**			397
95 [25]			164 [1451] **411**	250 [2478] **406**	395 [3496] **399**	507 [4487] **389**	564 [4991] **382**	622 [5505] **375**			415
Max. Inter. 114 [30]			130 [1151] **495**	253 [2239] **489**	368 [3257] **480**	483 [4275] **467**	541 [4788] **460**	594 [5257] **452**			498

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Rotor Width	Theoretical Torque - Nm [lb-in]
45.5 [1.791] mm [in]	62 [548] | 128 [1129] | 251 [2226] | 379 [3355] | 503 [4451] | 627 [5548] | 693 [6129] | 754 [6677] | 882 [7806] | 1006 [8903]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

250

248 cm³ [15.1 in³] / rev

Flow - lpm [gpm]	Pressure - bar [psi] 17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	155 [2250]	172 [2500]	190 [2750] Max. Cont.	207 [3000]	224 [3250] Max. Inter.	Theoretical rpm
4 [1]	51 [481] **15**	112 [991] **15**	230 [2036] **14**								16
8 [2]	53 [469] **31**	118 [1044] **31**	236 [2089] **30**	355 [3142] **28**	464 [4106] **23**	522 [4620] **19**	575 [5089] **15**				32
15 [4]	50 [443] **59**	119 [1053] **59**	239 [2115] **58**	361 [3195] **54**	476 [4213] **46**	531 [4699] **42**	586 [5186] **37**	644 [5699] **31**	696 [6160] **26**	740 [6549] **22**	60
23 [6]	50 [443] **92**	115 [1018] **92**	237 [2097] **90**	360 [3186] **83**	476 [4213] **74**	525 [4646] **70**	585 [5177] **64**	640 [5664] **58**	697 [6168] **52**	751 [6646] **47**	93
30 [8]	47 [416] **120**	111 [982] **120**	234 [2071] **117**	357 [3159] **110**	475 [4204] **101**	531 [4699] **93**	598 [5292] **87**	657 [5814] **78**	712 [6301] **72**	759 [6717] **71**	121
38 [10]	42 [372] **152**	108 [956] **151**	231 [2044] **150**	355 [3142] **144**	475 [4204] **131**	533 [4717] **126**	591 [5230] **119**	654 [5788] **108**	707 [6257] **105**	769 [6806] **90**	153
45 [12]	35 [310] **180**	102 [903] **180**	225 [1991] **179**	351 [3106] **172**	469 [4151] **162**	528 [4673] **155**	585 [5177] **147**	647 [5726] **138**	704 [6230] **130**	755 [6682] **119**	181
53 [14]	32 [283] **213**	92 [814] **213**	216 [1912] **212**	342 [3027] **205**	462 [4089] **193**	521 [4611] **187**	580 [5133] **181**	641 [5673] **170**	698 [6177] **163**	754 [6673] **152**	214
61 [16]	29 [257] **245**	83 [735] **244**	210 [1859] **244**	333 [2947] **238**	454 [4018] **226**	512 [4531] **221**	571 [5053] **213**	633 [5602] **203**	691 [6115] **196**	746 [6602] **184**	246
68 [18]	27 [239] **273**	73 [646] **272**	200 [1770] **271**	323 [2859] **267**	445 [3938] **256**	504 [4460] **249**	563 [4983] **240**	623 [5514] **231**			274
Max. Cont. 76 [20]		63 [558] **305**	188 [1664] **303**	310 [2744] **301**	433 [3832] **289**	494 [4372] **283**	552 [4885] **273**	613 [5425] **267**			306
83 [22]		57 [504] **334**	179 [1584] **334**	302 [2673] **328**	425 [3761] **314**	484 [4283] **307**	545 [4823] **297**	608 [5381] **286**			335
91 [24]		41 [363] **366**	171 [1513] **364**	291 [2575] **358**	413 [3655] **343**	476 [4213] **334**	534 [4726] **327**	596 [5275] **316**			367
95 [25]		32 [283] **382**	160 [1416] **381**	280 [2478] **381**	401 [3549] **368**	463 [4098] **359**	524 [4637] **348**	584 [5168] **341**			383
Max. Inter. 114 [30]			128 [1133] **459**	246 [2177] **456**	372 [3292] **442**	431 [3814] **434**	494 [4372] **422**	554 [4903] **412**			460

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Rotor Width	Theoretical Torque - Nm [lb-in]
39.4 [1.552] mm [in]	67 [594] | 138 [1223] | 272 [2410] | 411 [3633] | 545 [4821] | 612 [5415] | 679 [6008] | 750 [6637] | 817 [7231] | 884 [7825]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

DISPLACEMENT PERFORMANCE

► Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended. For additional information on product testing please refer to page 6.

320

322 cm³ [19.6 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	104 [1500]	138 [2000]	155 [2250]	172 [2500]	190 [2750] Max. Cont.	207 [3000]	224 [3250] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm] / Theoretical rpm

4 [1]	68 [602] **11**	145 [1283] **9**									12
8 [2]	77 [681] **24**	156 [1381] **24**	311 [2752] **23**	455 [4027] **21**	590 [5222] **20**	640 [5664] **19**					25
15 [4]	77 [681] **46**	160 [1416] **45**	311 [2752] **43**	458 [4053] **40**	594 [5257] **36**	655 [5797] **32**	705 [6239] **28**	770 [6815] **24**	835 [7390] **18**		47
23 [6]	73 [646] **70**	157 [1389] **69**	316 [2797] **68**	478 [4230] **64**	628 [5558] **57**	698 [6177] **53**	768 [6797] **48**	841 [7443] **43**	910 [8054] **38**	975 [8629] **30**	71
30 [8]	69 [611] **92**	154 [1363] **90**	316 [2797] **87**	479 [4239] **83**	631 [5584] **77**	705 [6239] **73**	780 [6903] **68**	860 [7611] **63**	929 [8222] **57**	998 [8832] **49**	93
38 [10]	64 [566] **116**	150 [1328] **114**	311 [2752] **111**	480 [4248] **106**	631 [5584] **100**	709 [6275] **96**	784 [6938] **90**	861 [7620] **83**	930 [8231] **79**	1000 [8850] **72**	118
45 [12]	59 [522] **138**	143 [1266] **136**	305 [2699] **133**	471 [4168] **127**	632 [5593] **119**	705 [6239] **115**	783 [6930] **110**	860 [7611] **105**	934 [8266] **98**	1000 [8850] **86**	140
53 [14]	49 [434] **162**	137 [1212] **160**	297 [2628] **157**	463 [4098] **151**	627 [5549] **142**	697 [6168] **138**	778 [6885] **132**	858 [7593] **126**	937 [8292] **120**	1003 [8877] **113**	165
61 [16]	41 [363] **187**	128 [1133] **185**	288 [2549] **182**	457 [4044] **175**	616 [5452] **167**	689 [6098] **161**	769 [6806] **156**	847 [7496] **150**			189
68 [18]	35 [310] **210**	120 [1062] **208**	282 [2496] **201**	452 [4000] **192**	609 [5390] **182**	683 [6045] **176**	762 [6744] **170**	841 [7443] **163**			211
Max. Cont. 76 [20]	26 [230] **235**	113 [1000] **230**	273 [2416] **225**	443 [3921] **216**	603 [5337] **203**	664 [5876] **199**	744 [6584] **192**	830 [7346] **184**			236
83 [22]		99 [876] **256**	262 [2319] **247**	430 [3806] **240**	590 [5222] **225**	660 [5841] **219**	741 [6558] **212**	820 [7257] **202**			258
91 [24]		85 [752] **282**	246 [2177] **273**	415 [3673] **267**	576 [5098] **249**	654 [5788] **242**	731 [6469] **233**	810 [7169] **225**			283
95 [25]		76 [673] **294**	241 [2133] **286**	404 [3575] **281**	571 [5053] **261**	648 [5735] **254**	719 [6363] **246**	804 [7115] **236**			295
Max. Inter. 114 [30]		44 [389] **352**	204 [1805] **345**	371 [3283] **337**	538 [4761] **321**	602 [5328] **314**	685 [6062] **304**	766 [6779] **293**			354

Rotor Width

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

63.5 [2.501]	87 [771]	179 [1587]	354 [3130]	533 [4717]	707 [6259]	794 [7030]	881 [7801]	974 [8618]	1061 [9389]	1148 [10160]

mm [in] — Theoretical Torque - Nm [lb-in]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

400

396 cm³ [24.2 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	69 [1000]	86 [1250]	104 [1500]	121 [1750]	138 [2000]	155 [2250] Max. Cont.	172 [2500]	190 [2750] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm] / Theoretical rpm

4 [1]	78 [690] **9**	180 [1593] **8**									10
8 [2]	84 [743] **19**	185 [1637] **19**	380 [3363] **18**	460 [4071] **18**	555 [4912] **17**	640 [5664] **15**					20
15 [4]	84 [743] **37**	185 [1637] **36**	374 [3310] **36**	468 [4142] **35**	559 [4947] **34**	648 [5735] **30**	736 [6514] **26**				38
23 [6]	77 [681] **57**	182 [1611] **56**	374 [3310] **55**	469 [4151] **53**	567 [5018] **50**	650 [5753] **46**	747 [6611] **41**	839 [7425] **37**	920 [8142] **30**	1002 [8868] **24**	58
30 [8]	76 [673] **75**	181 [1602] **74**	376 [3328] **71**	473 [4186] **69**	575 [5089] **65**	670 [5930] **61**	763 [6753] **56**	854 [7558] **50**	944 [8354] **43**	1043 [9231] **36**	76
38 [10]	67 [593] **95**	175 [1549] **94**	375 [3319] **91**	473 [4186] **89**	575 [5089] **84**	671 [5938] **79**	764 [6761] **74**	858 [7593] **68**	951 [8416] **62**	1048 [9275] **55**	96
45 [12]	57 [504] **113**	165 [1460] **112**	367 [3248] **109**	467 [4133] **106**	572 [5062] **102**	668 [5912] **97**	762 [6744] **90**	852 [7540] **82**	943 [8346] **77**	1044 [9239] **69**	114
53 [14]	44 [389] **133**	154 [1363] **132**	355 [3142] **130**	454 [4018] **127**	560 [4956] **123**	659 [5832] **118**	756 [6691] **112**	851 [7531] **104**	943 [8346] **96**	1032 [9133] **84**	134
61 [16]	32 [283] **153**	142 [1257] **153**	343 [3036] **149**	444 [3929] **146**	549 [4859] **141**	647 [5726] **135**	743 [6576] **129**	837 [7407] **123**	932 [8248] **114**		154
68 [18]		123 [1089] **170**	332 [2938] **166**	432 [3823] **162**	538 [4761] **156**	635 [5620] **150**	726 [6425] **145**	827 [7319] **137**			172
Max. Cont. 76 [20]		106 [938] **191**	316 [2797] **185**	418 [3699] **181**	523 [4629] **176**	619 [5478] **169**	717 [6345] **162**	812 [7186] **156**			192
83 [22]		100 [885] **208**	299 [2646] **205**	402 [3558] **201**	506 [4478] **195**	601 [5319] **191**	700 [6195] **183**	797 [7053] **176**			210
91 [24]		69 [611] **229**	277 [2451] **226**	378 [3345] **223**	479 [4239] **219**	579 [5124] **213**	676 [5983] **206**	773 [6841] **199**			230
99 [26]		46 [407] **249**	257 [2274] **247**	353 [3124] **245**	454 [4018] **241**	555 [4912] **236**	658 [5823] **228**	752 [6655] **222**			250
Max. Inter. 114 [30]			210 [1859] **285**	307 [2717] **283**	416 [3682] **279**	517 [4575] **273**	614 [5434] **266**	710 [6284] **259**			288

Rotor Width

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

63.5 [2.501]	107 [948]	221 [1952]	435 [3849]	542 [4797]	655 [5801]	763 [6749]	870 [7698]	977 [8646]	1084 [9594]	1198 [10598]

mm [in] — Theoretical Torque - Nm [lb-in]

Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

WS (350/351 Series)

Heavy Duty Hydraulic Motor

DISPLACEMENT PERFORMANCE

▶ Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended. For additional information on product testing please refer to page 6.

500

495 cm³ [30.2 in³] / rev

Pressure - bar [psi]

17 [250]	35 [500]	52 [750]	69 [1000]	86 [1250]	104 [1500]	121 [1750] Max. Cont.	138 [2000]	155 [2250] Max. Inter.

Intermittent Ratings are below and to the right of the BOLD line. **Intermittent Ratings -** 10% of Operation

Flow - lpm [gpm]

8 [2]	110 [974] **15**	236 [2089] **15**	352 [3115] **15**	467 [4133] **14**	581 [5142] **14**	699 [6186] **13**				16
15 [4]	108 [956] **29**	241 [2133] **29**	365 [3230] **29**	488 [4319] **28**	605 [5354] **28**	739 [6540] **27**	836 [7399] **25**			30
23 [6]	106 [938] **45**	240 [2124] **45**	366 [3239] **45**	488 [4319] **44**	610 [5399] **44**	738 [6531] **42**	851 [7531] **37**	961 [8505] **31**		46
30 [8]	98 [867] **60**	234 [2071] **60**	359 [3177] **60**	483 [4275] **59**	604 [5345] **58**	734 [6496] **56**	849 [7514] **52**	964 [8531] **45**	1063 [9408] **37**	61
38 [10]	87 [770] **76**	224 [1982] **76**	348 [3080] **76**	473 [4186] **75**	595 [5266] **74**	723 [6399] **71**	840 [7434] **67**	955 [8452] **61**	1063 [9408] **53**	77
45 [12]	76 [673] **90**	210 [1859] **90**	336 [2974] **90**	463 [4098] **89**	586 [5186] **88**	714 [6319] **85**	835 [7390] **80**	952 [8425] **73**	1064 [9416] **65**	91
53 [14]	60 [531] **106**	194 [1717] **106**	319 [2823] **106**	445 [3938] **105**	570 [5045] **104**	699 [6186] **101**	819 [7248] **96**	935 [8275] **88**	1050 [9293] **79**	107
61 [16]	40 [354] **122**	177 [1566] **122**	303 [2682] **121**	426 [3770] **121**	550 [4868] **120**	681 [6027] **117**	805 [7124] **106**	918 [8124] **106**		123
68 [18]		154 [1363] **136**	284 [2513] **136**	408 [3611] **135**	535 [4735] **134**	665 [5885] **131**	785 [6947] **126**			137
Max. Cont. 76 [20]		128 [1133] **153**	261 [2310] **153**	386 [3416] **152**	510 [4514] **150**	638 [5646] **147**	761 [6735] **142**			154
83 [22]		108 [956] **167**	237 [2097] **167**	361 [3195] **166**	487 [4310] **165**	606 [5363] **163**	738 [6531] **157**			168
91 [24]			206 [1823] **183**	343 [3036] **182**	465 [4115] **180**	595 [5266] **175**	719 [6363] **170**			184
99 [26]			181 [1602] **199**	317 [2805] **198**	435 [3850] **196**	574 [5080] **191**	697 [6168] **184**			200
Max. Inter. 114 [30]			117 [1035] **229**	251 [2221] **229**	381 [3372] **226**	516 [4567] **221**	641 [5673] **214**			230

Theoretical rpm

Rotor Width

78.9 [3.105] mm [in]

Torque - Nm [lb-in], **Speed rpm**

Overall Efficiency - 70 - 100% 40 - 69% 0 - 39%

134 [1185]	276 [2440]	410 [3626]	544 [4811]	678 [5996]	819 [7251]	953 [8437]	1087 [9622]	1221 [10807]

Theoretical Torque - Nm [lb-in]

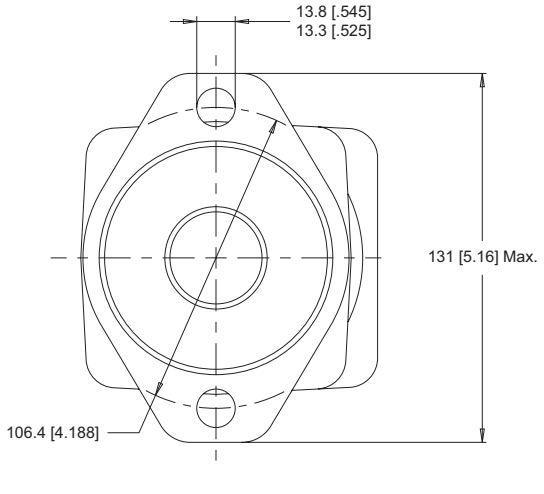
Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

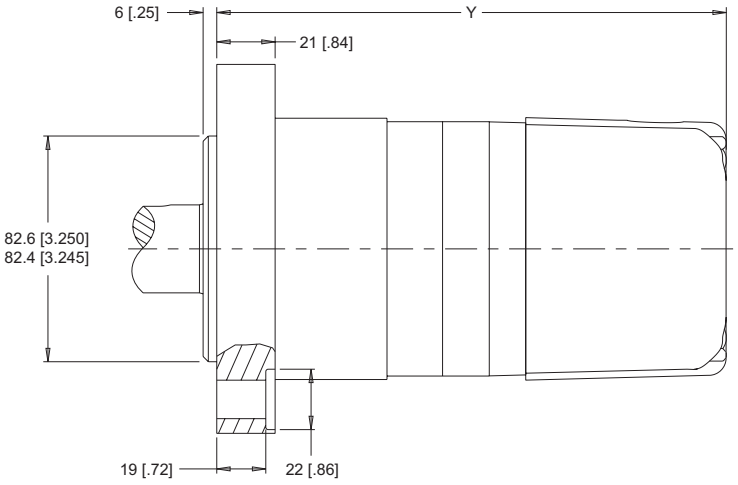
HOUSINGS

▶ Dimensions shown are without paint. Paint thickness can be up to 0.13 [.005].

2-HOLE, SAE A MOUNT

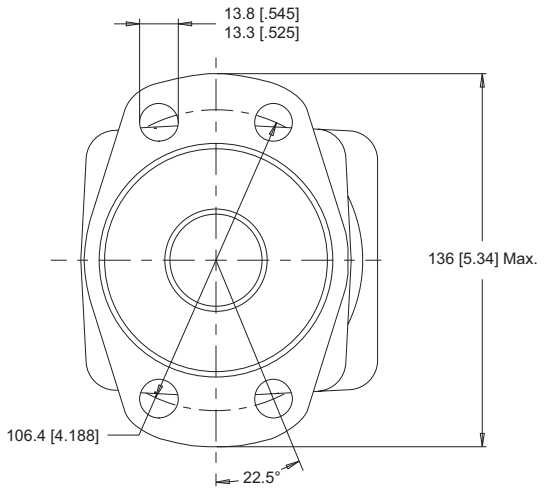
A0 End Ports **A7** Side Ports

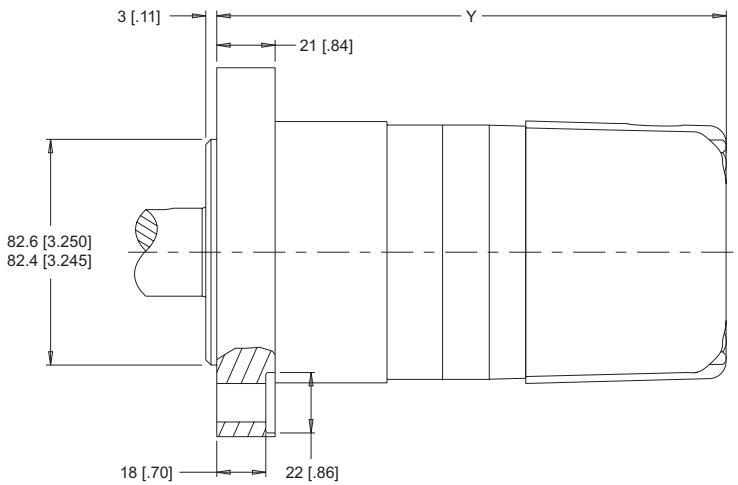




4-HOLE, MAGNETO MOUNT

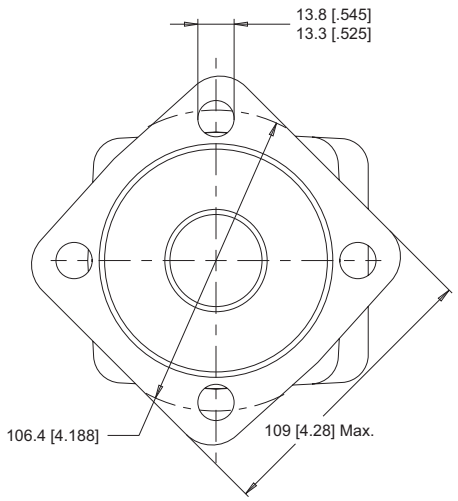
A2 End Ports **A8** Side Ports

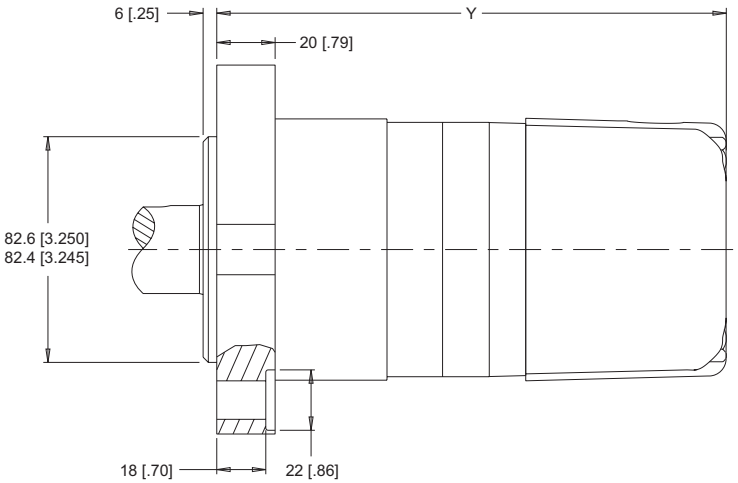




4-HOLE, SAE A MOUNT

AG End Ports **AH** Side Ports





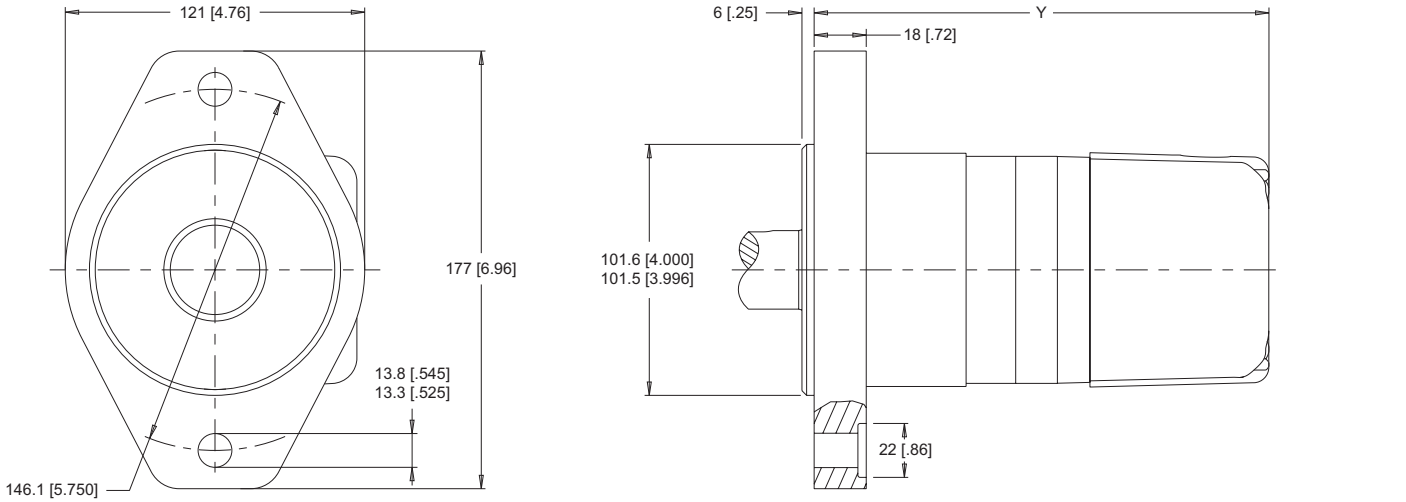
▶ Dimension Y is charted on page 24.

HOUSINGS

▶ Dimensions shown are without paint. Paint thickness can be up to 0.13 [.005].

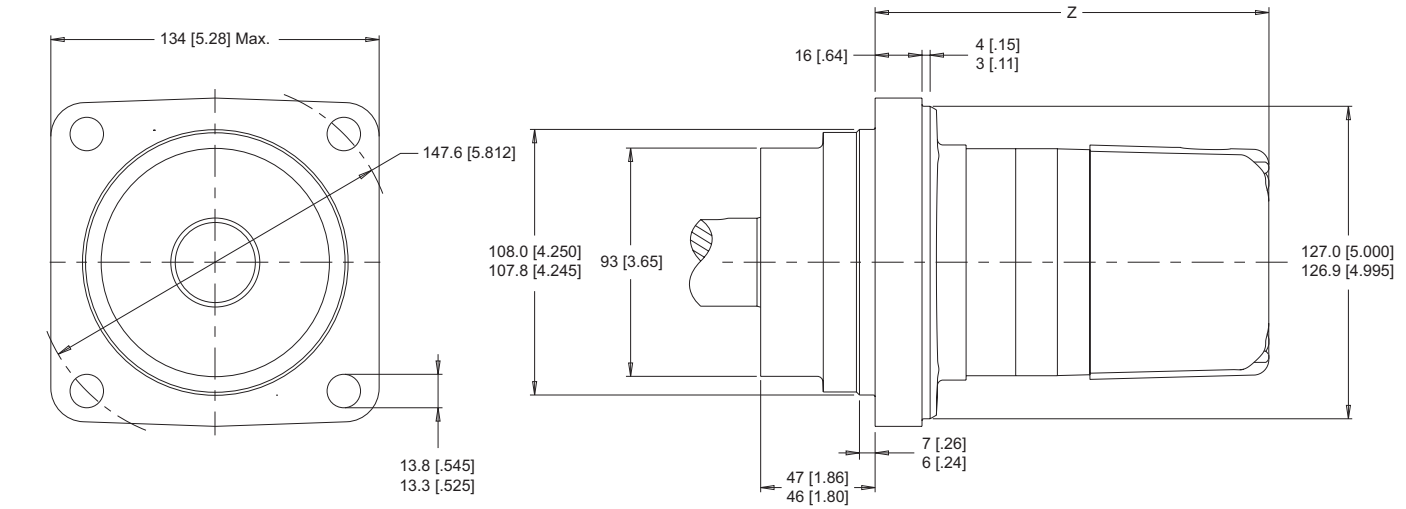
2-HOLE, SAE B MOUNT

B0 End Ports **B7** Side Ports



4-HOLE, 4.25" WHEEL MOUNT

Y2 End Ports **Y8** Side Ports



▶ Dimensions Y & Z are charted on page 11. Porting options listed on pages 12-13.

LENGTH & WEIGHT CHARTS

Dimension Y is the overall motor length from the rear of the motor to the mounting flange surface and is referenced on detailed housing drawings listed on pages 23 & 24.

Y	SAE A & B Mounts	Magneto Mounts	Weight
#	mm [in]	mm [in]	kg [lb]
080	181 [7.12]	185 [7.27]	11.0 [24.2]
100	185 [7.27]	189 [7.42]	11.3 [24.9]
110	187 [7.36]	191 [7.51]	11.4 [25.1]
130	190 [7.49]	194 [7.64]	11.5 [25.3]
160	197 [7.74]	201 [7.89]	11.8 [26.0]
200	204 [8.04]	208 [8.19]	12.2 [26.8]
230	210 [8.28]	214 [8.43]	12.6 [27.7]
250	204 [8.04]	208 [8.19]	12.2 [26.8]
320	228 [8.99]	232 [9.14]	13.5 [29.7]
400	228 [8.99]	232 [9.14]	13.5 [29.7]
500	244 [9.60]	248 [9.75]	14.2 [31.2]

▶ Add 1.2 kg [2.6 lb] to the weight listed to the right for SAE B mount housings.

Dimension Z is the overall motor length from the rear of the motor to the mounting flange surface and is referenced on the detailed housing drawing above.

Z	Length	Weight
#	mm [in]	kg [lb]
080	141 [5.55]	12.2 [26.9]
100	145 [5.69]	12.5 [27.5]
110	147 [5.78]	12.6 [27.7]
130	150 [5.91]	12.7 [27.9]
160	157 [6.16]	13.0 [28.6]
200	164 [6.46]	13.4 [29.5]
230	170 [6.70]	13.8 [30.4]
250	164 [6.46]	13.4 [29.5]
320	188 [7.41]	14.7 [32.3]
400	188 [7.41]	14.7 [32.3]
500	204 [8.02]	15.4 [33.9]

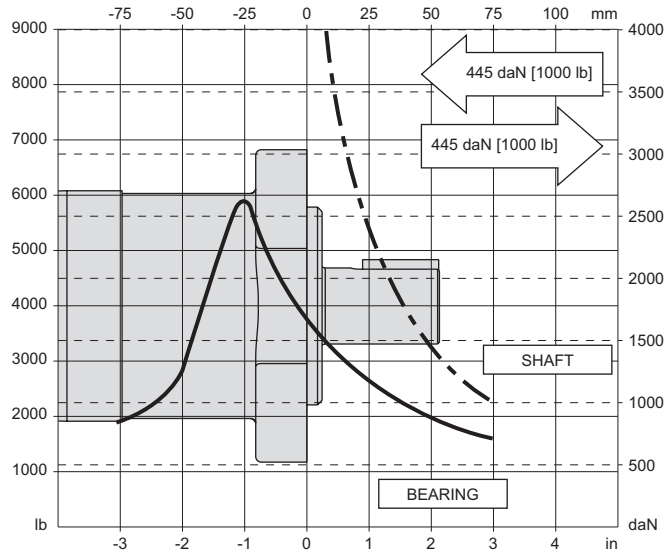
▶ 350 series motor weights can vary ± 1kg [2 lb] depending on model configurations such as housing, shaft, endcover, options etc.

TECHNICAL INFORMATION

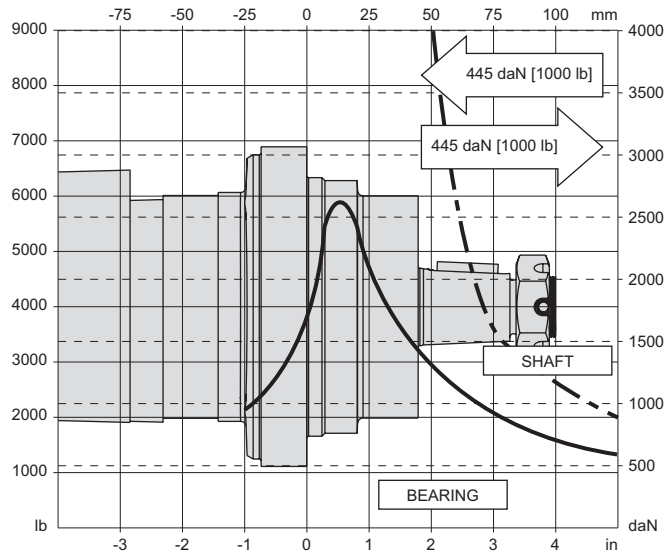
ALLOWABLE SHAFT LOAD / BEARING CURVE

The bearing curve represents allowable bearing loads for a B10 life of 2,000 hours at 100 rpm. The curve includes affects of 1,000 lbs inward/outward net thrust*. Radial loads for speeds other than 100 rpm may be calculated using the multiplication factor on page 7.

SAE A, SAE B & MAGNETO MOUNTS



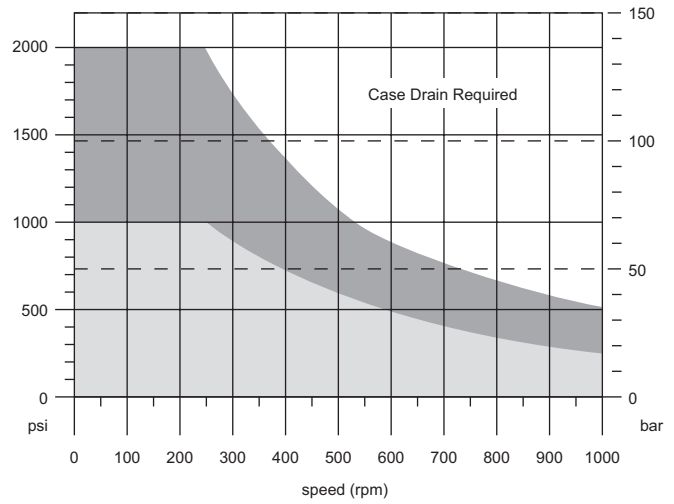
4.25" WHEEL MOUNT



▶ * Case pressure will push outward on the shaft. If case drain line is attached and routed directly to tank, case pressure should be negligible. If case drain line is not attached, case pressure will be nearly the same as motor return pressure. When case pressure is acting, the allowable inward axial load can be increased and the allowable outward axial load must be decreased at a rate of 59 kg / 7 bar [130 lb / 100 psi] for shaft codes 02, 10, 12, 20, 21, 22 & 23. The rate for shaft codes 28 & 31 is 78 kg / 7 bar [175 lb / 100 psi].

PERMISSIBLE SHAFT SEAL PRESSURE

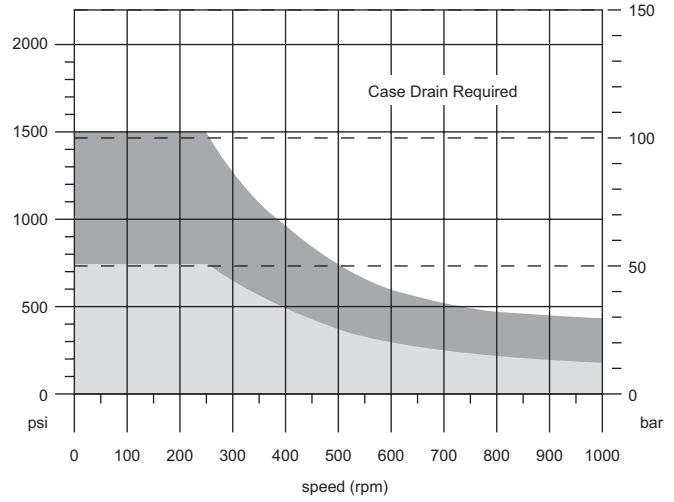
MOTORS WITH SHAFT DIAMETERS 1-1/4" OR LESS



Intermittent - Case Drain Optional

Continuous - Case Drain Optional

MOTORS WITH SHAFT DIAMETERS LARGER THAN 1-1/4"



Intermittent - Case Drain Optional

Continuous - Case Drain Optional

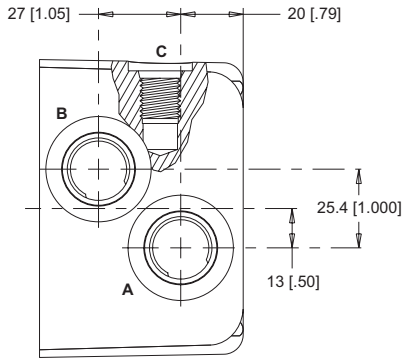
PORTING

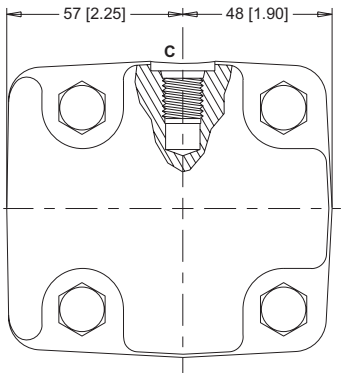
SIDE PORTED - OFFSET

1 Main Ports **A, B**: 7/8-14 UNF
Drain Port **C**: 7/16-20 UNF

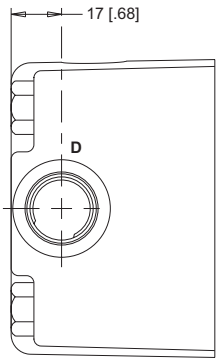
2 Main Ports **A, B**: G 1/2
Drain Port **C**: G 1/4

STANDARD





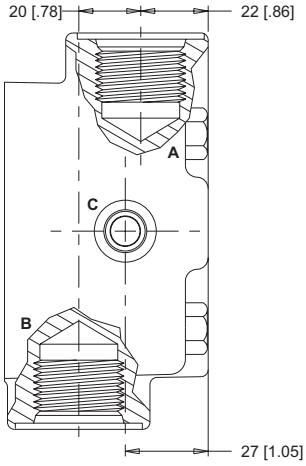
OPTIONAL

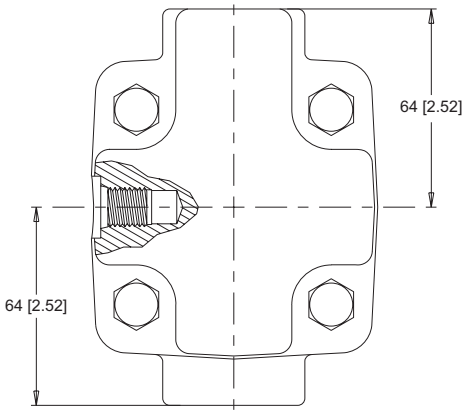


D: 10 Series/2-Way Valve Cavity 7/8-14 UNF

SIDE PORTED - 180° OPPOSED

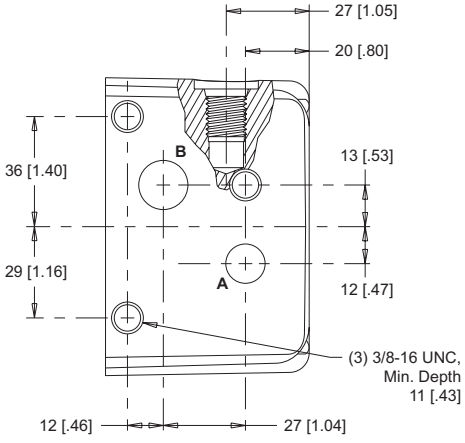
6 Main Ports **A, B**: 1 1/16-12 UN
Drain Port **C**: 7/16-20 UNF

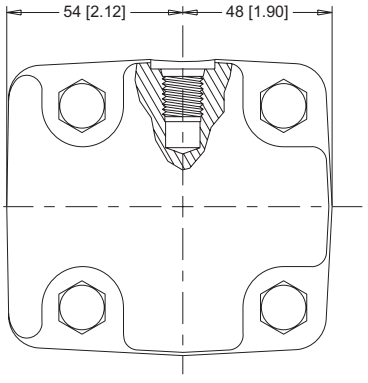




SIDE PORTED - OFFSET MANIFOLD

B Main Ports **A**: 12.7 [.500] Drill **B**: 15.9 [.625] Drilled
Drain Port **C**: 7/16-20 UNF



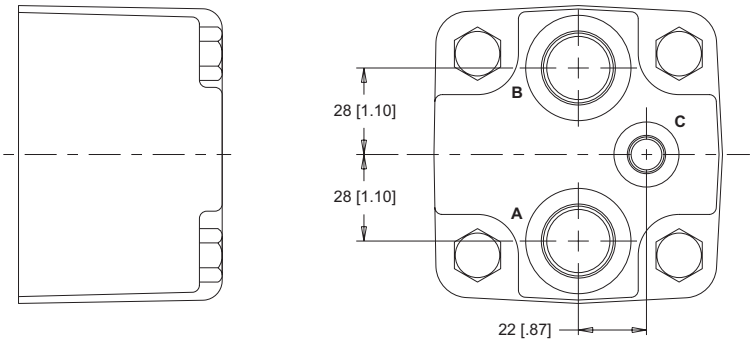


PORTING

END PORTED - ALIGNED

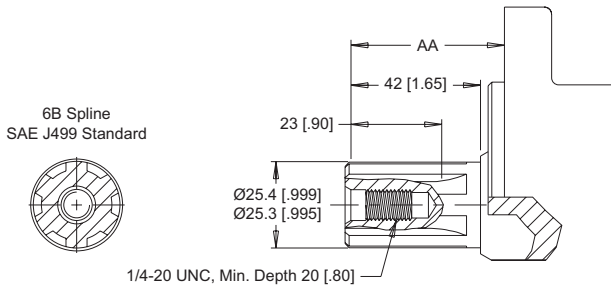
1 Main Ports **A, B**: 7/8-14 UNF
Drain Port **C**: 7/16-20 UNF

2 Main Ports **A, B**: G 1/2
Drain Port **C**: G 1/4



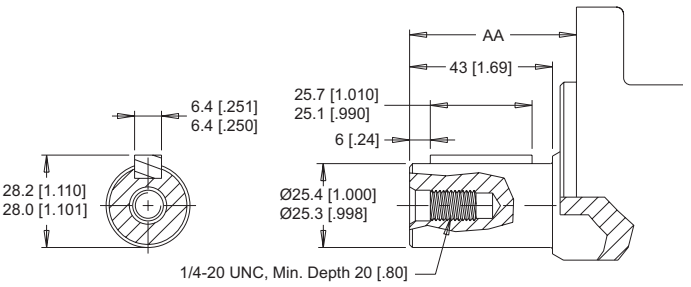
SHAFTS

02 1” 6B Spline



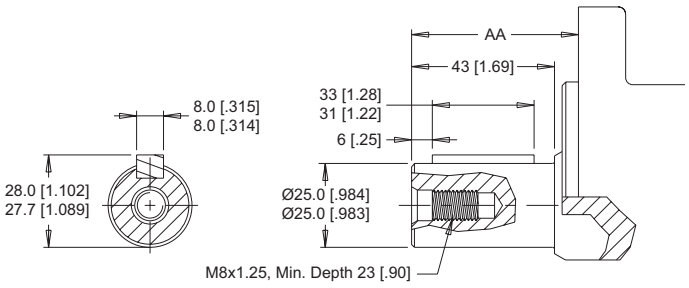
Max. Torque: 678 Nm [6000 lb-in]

10 1” Straight



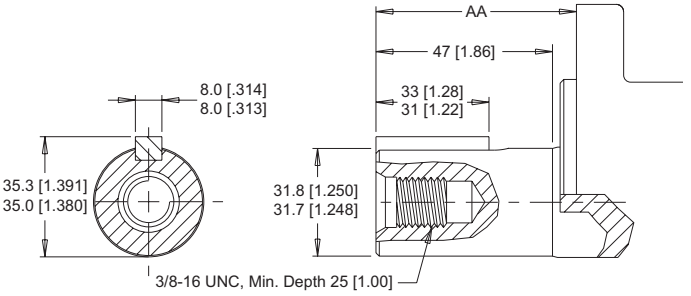
Max. Torque: 655 Nm [5800 lb-in]

12 25mm Straight



Max. Torque: 678 Nm [6000 lb-in]

20 1-1/4” Straight

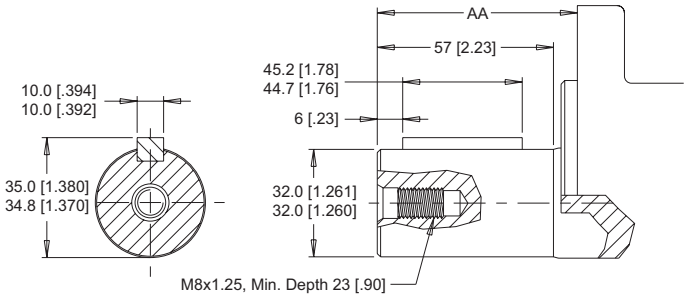


Max. Torque: 881 Nm [7800 lb-in]

▶ Dimension AA is charted on page 28.

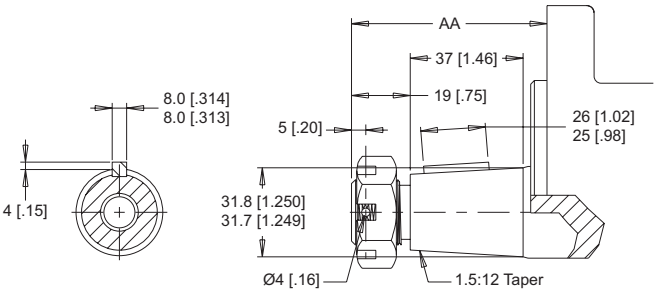
SHAFTS

21 32mm Straight



Max. Torque: 881 Nm [7800 lb-in]

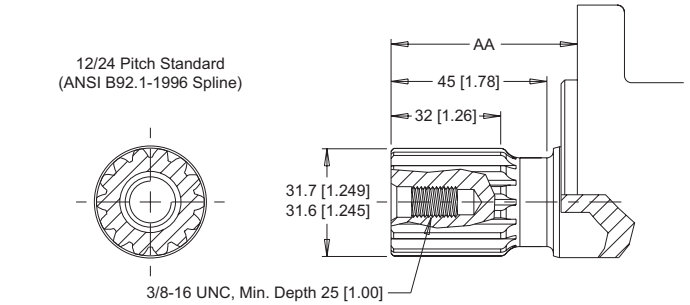
22 1-1/4" Tapered



▶ A slotted hex nut is standard on this shaft.

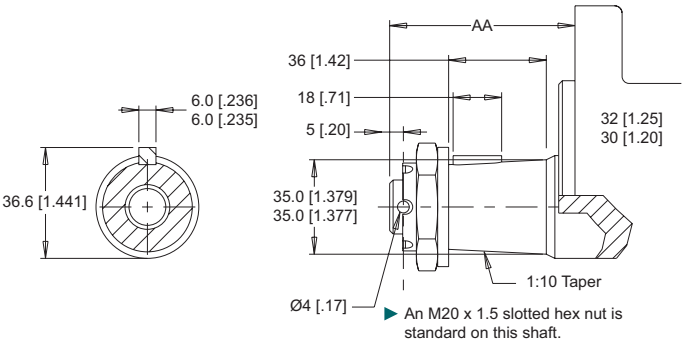
Max. Torque: 881 Nm [7800 lb-in]

23 14 Tooth Spline



Max. Torque: 881 Nm [7800 lb-in]

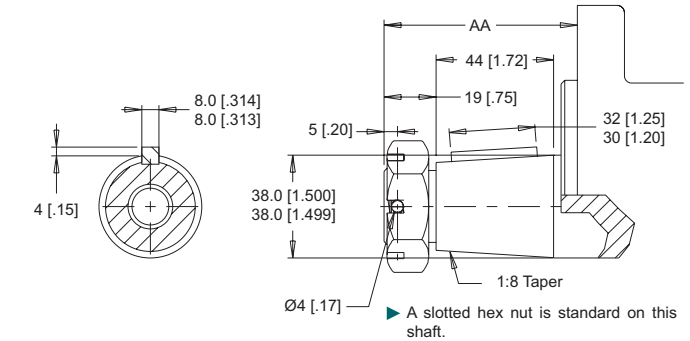
28 35mm Tapered



▶ An M20 x 1.5 slotted hex nut is standard on this shaft.

Max. Torque: 881 Nm [7800 lb-in]

31 1-1/2" Tapered



▶ A slotted hex nut is standard on this shaft.

Max. Torque: 881 Nm [7800 lb-in]

MOUNTING / SHAFT LENGTH CHART

Dimension AA is the overall distance from the motor mounting surface to the end of the shaft and is referenced on detailed shaft drawings above as well as shafts on page 27.

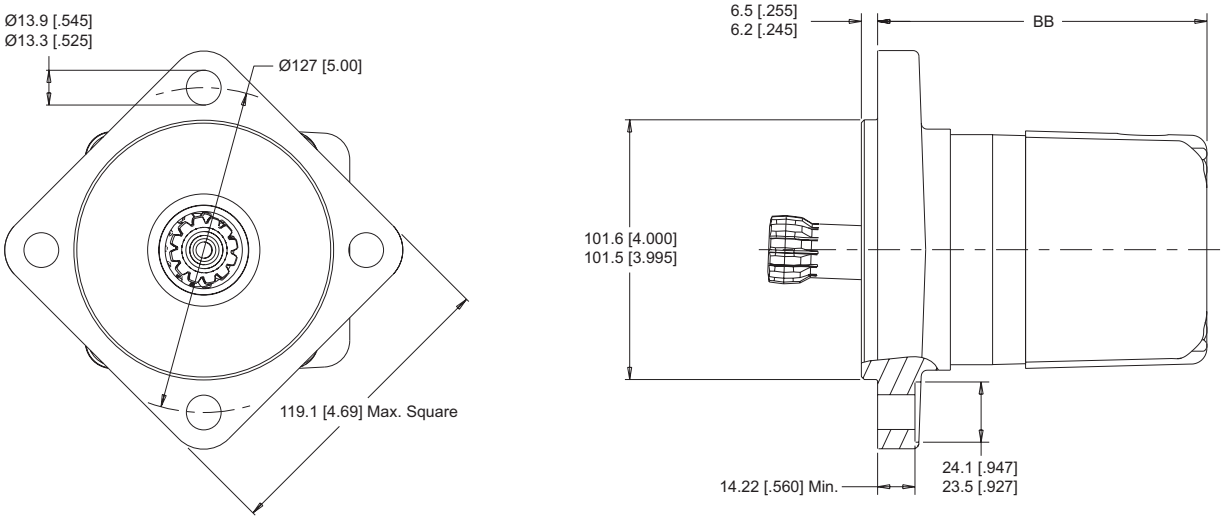
▶ Shaft lengths vary ± 0.8 mm [.030 in.]

AA	SAE A & B Mounts	Magneto Mounts	Wheel Mounts
#	mm [in]	mm [in]	mm [in]
02	51 [2.00]	47 [1.85]	91 [3.58]
10	51 [2.00]	47 [1.85]	91 [3.58]
12	51 [2.00]	47 [1.85]	91 [3.58]
20	55 [2.17]	52 [2.03]	96 [3.76]
21	65 [2.54]	61 [2.39]	105 [4.12]
22	64 [2.51]	60 [2.36]	104 [4.09]
23	55 [2.17]	52 [2.03]	96 [3.76]
28	N/A	N/A	107 [4.20]
31	N/A	N/A	123 [4.86]

HOUSINGS

4-HOLE, 4.00" PILOT MOUNT

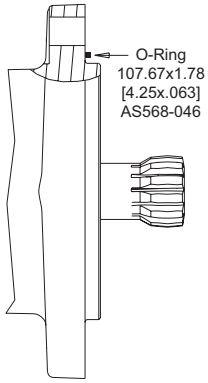
S2 End Ports **S8** Side Ports



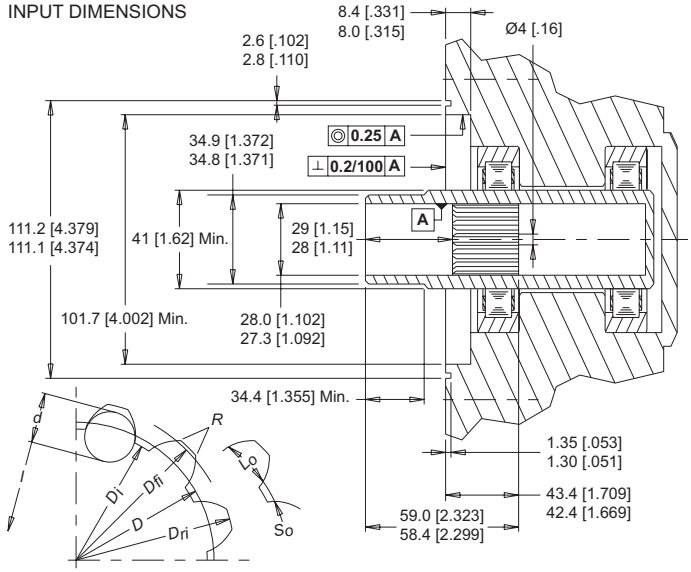
SHAFTS

0B Cardan (For Use With S2 & S8 Mounts)

Fillet Root Side Fit
Number of Teeth 12
Pitch 12/24
Pressure Angle ..... 30°
Pitch Diameter *D* ..... 25.4 [1.000]
Base Diameter ..... 21.997 [.8660]
Major Diameter D_{rj} ..... 27.74 [1.092] - 27.59 [1.086]
Form Diameter (Min.) D_{fj} ..... 26.93 [1.060]
Minor Diameter D_i ..... 23.224 [.9143] - 23.097 [.9093]
Space Width (Circular) L_o*
Max. Actual ..... 4.318 [.1700]
Min. Effective ..... 4.216 [.1660]
Fillet Radius *R* ..... 0.76 [.030] - 0.64 [.025]
Max. Distance Between Pins *I* .... 19.190 [.7555] - 19.020 [.7488]
Pin Diameter *d* ..... 4.496 [.1770]
with 3.38 [.133] Flat for Root Clearance.



INPUT DIMENSIONS



▶ The recommended shaft material is SAE 8620 or similar case hardening steel such as 20 MoCr4 (900 N/mm^2) hardened to 59 - 62 HRc to a depth of 0.762 - 1.016 [.030 - .040].
*Dimensions apply after heat treatment.

LENGTH & WEIGHT CHART

Dimension BB is the overall motor length from the rear of the motor to the mounting flange surface and is referenced on the detailed housing drawing above.

BB	Length	Weight
#	mm [in]	kg [lb]
080	124 [4.88]	12.2 [26.8]
100	128 [5.04]	12.5 [27.5]
110	130 [5.14]	12.6 [27.8]
130	134 [5.27]	12.8 [28.2]
160	140 [5.52]	13.3 [29.2]
200	148 [5.82]	13.6 [29.9]
230	154 [6.06]	14.0 [30.8]
250	148 [5.82]	13.6 [29.9]
320	172 [6.77]	15.0 [32.9]
400	172 [6.77]	15.0 [32.9]
500	187 [7.37]	15.8 [34.7]

▶ 350 series short motor weights can vary ± 1kg [2 lb] depending on model configurations such as housing, shaft, endcover, options etc.

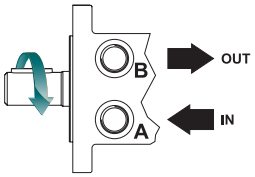
WS (350/351 Series)
Heavy Duty Hydraulic Motor

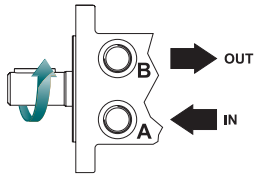
ORDERING INFORMATION

1			2			3a		3b		4		5	6	7		8	

1. CHOOSE SERIES DESIGNATION

350	Clockwise Rotation	**351**	Counterclockwise Rotation





▶ The 350 & 351 series are bi-directional. Reversing the inlet hose will reverse shaft rotation.

2. SELECT A DISPLACEMENT OPTION

080	80 cm^3/rev	[4.9 in^3/rev]	**230**	229 cm^3/rev	[14.0 in^3/rev]
100	100 cm^3/rev	[6.1 in^3/rev]	**250**	248 cm^3/rev	[15.1 in^3/rev]
110	112 cm^3/rev	[6.8 in^3/rev]	**320**	322 cm^3/rev	[19.6 in^3/rev]
130	129 cm^3/rev	[7.9 in^3/rev]	**400**	396 cm^3/rev	[24.2 in^3/rev]
160	161 cm^3/rev	[9.8 in^3/rev]	**500**	495 cm^3/rev	[30.2 in^3/rev]
200	201 cm^3/rev	[12.3 in^3/rev]			

3a. SELECT MOUNT TYPE

▼ **END MOUNT**

A0	2-Hole, SAE A Mount
A2	4-Hole, Magneto Mount
AG	4-Hole SAE A Mount
B0	2-Hole SAE B Mount
S2	4-Hole Short Motor Mount
Y2	4-Hole Wheel Mount

▼ **SIDE MOUNT**

A7	2-Hole, SAE A Mount
A8	4-Hole, Magneto Mount
AH	4-Hole SAE A Mount
B7	2-Hole SAE B Mount
S8	4-Hole Short Motor Mount
Y8	4-Hole Wheel Mount

▶ The S2 and S8 Mounts are only available with the 0B cardan shaft.

3b. SELECT PORT SIZE

▼ **END PORT OPTIONS**

1	7/8-14 UNF Aligned
2	G 1/2 Aligned

▼ **SIDE PORT OPTIONS**

1	7/8-14 UNF, Offset
2	G 1/2, Offset
6	1 1/16-20 UN, 180° Opposed
B	Drilled Offset Manifold

4. SELECT A SHAFT OPTION

0B	Cardan	**21**	32mm Straight
02	6B Spline	**22**	1-1/4” Tapered
10	1” Straight	**23**	14 Tooth Spline
12	25mm Straight	**28**	35mm Tapered
20	1-1/4” Straight	**31**	1-1/2” Tapered

▶ The 28 and 31 shafts are only available on the AG, AH, Y2 and Y8 mounts.

5. SELECT A PAINT OPTION

A	Black
B	Black, Unpainted Mounting Surface
Z	No Paint

▶ The S2 and S8 mounts are only available with no paint.

6. SELECT A VALVE CAVITY / CARTRIDGE OPTION

A	None	**F**	121 bar [1750 psi] Relief
B	Valve Cavity Only	**G**	138 bar [2000 psi] Relief
C	69 bar [1000 psi] Relief	**J**	173 bar [2500 psi] Relief
D	86 bar [1250 psi] Relief	**L**	207 bar [3000 psi] Relief
E	104 bar [1500 psi] Relief		

▶ Valve cavity is only available on side ports 1 & 2.

7. SELECT AN ADD-ON OPTION

A	Standard
B	Lock Nut
C	Solid Hex Nut

8. SELECT A MISCELLANEOUS OPTION

AA	None
AC	Freeturning Rotor
MA	Mounting Rotated 90°
MB	Freeturning Rotor With Mounting Rotated 90°

▶ Rotated mounting not available on the 4-Hole SAE A & wheel mounts