

Technical Information

Orbital Motors Type WZ



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OPERATING RECOMMENDATIONS

OIL TYPE

Hydraulic oils with anti-wear, anti-foam and demulsifiers are recommended for systems incorporating Impro Fluidtek 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.

Impro Fluidtek recommends maintaining an oil cleanliness level of ISO 17-14 or better.

INSTALLATION & START-UP

When installing an Impro Fluidtek 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 over-pressurization. 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! - Impro Fluidtek 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.

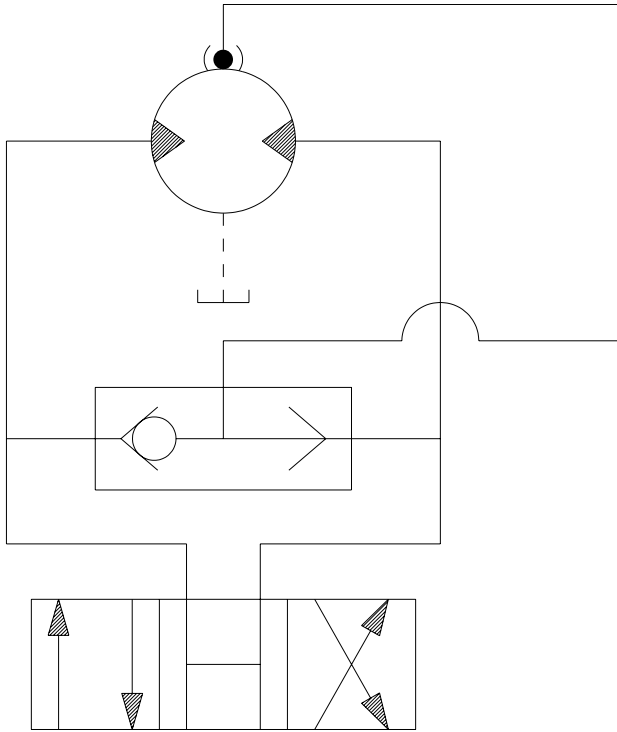
Caution! - Because it is possible for some large displacement motors to overpower the brake, it is critical that the maximum system pressure be limited for these applications. Failure to do so could cause serious injury or death. When choosing a motor/brake for an application, consult the performance 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 5. 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.

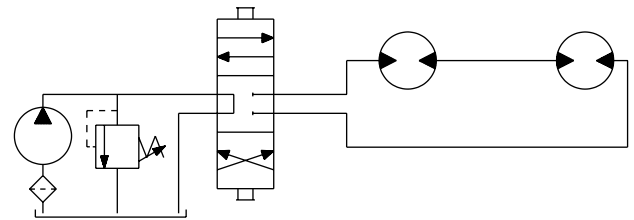
► NOTE: It is vital that all operating recommendations be followed. Failure to do so could result in injury or death.

MOTOR CIRCUITS

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

SERIES CONNECTION

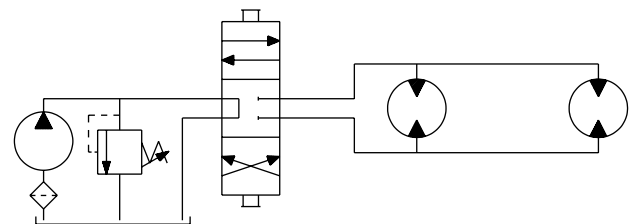
When motors are connected in series, the outlet of one motor is connected to the inlet of the next motor. This allows the full pump flow to go through each motor and provide maximum speed. Pressure and torque are distributed between the motors based on the load each motor is subjected to. The maximum 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.

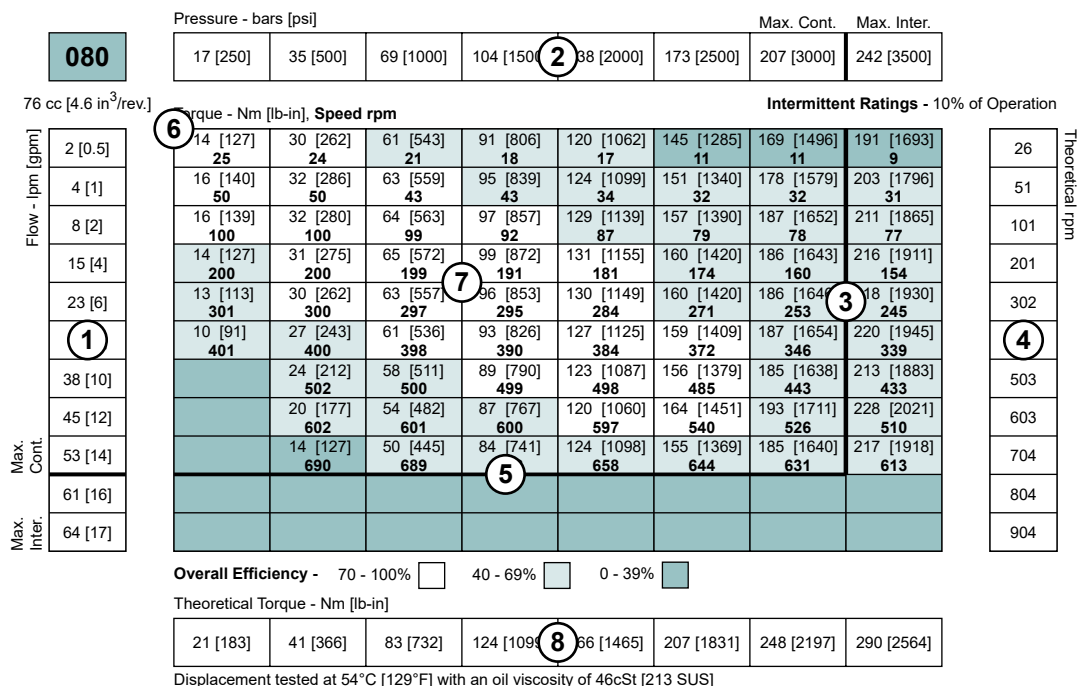


PARALLEL CIRCUIT

► 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 an Impro Fluidtek 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.



- Flow represents the amount of fluid passing through the motor during each minute of the test.
- Pressure refers to the measured pressure differential between the inlet and return ports of the motor during the test.
- The maximum continuous pressure rating and maximum intermittent pressure rating of the motor are separated by the dark lines on the chart.
- 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.
- The maximum continuous flow rating and maximum intermittent flow rating of the motor are separated by the dark line on the chart.
- 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.
- Areas within the white shading represent maximum motor efficiencies.
- 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.

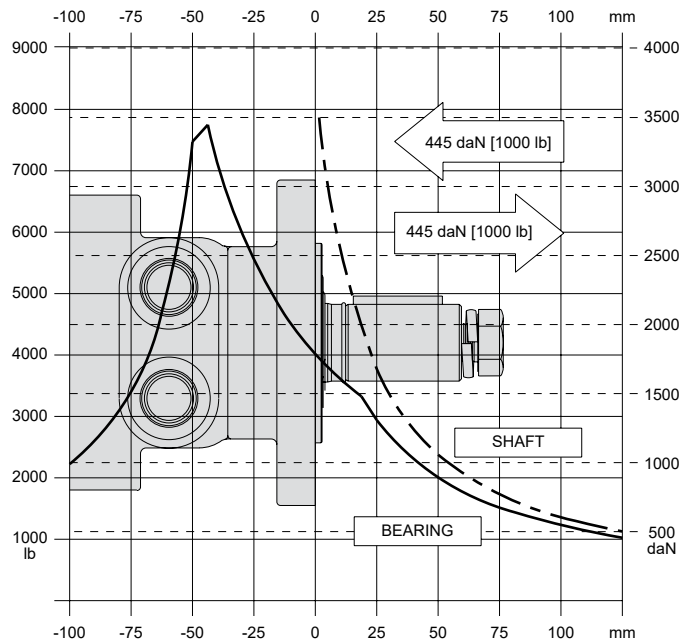
The bearing curves for each model are based on laboratory analysis and testing results constructed at Impro Fluidtek. The shaft loading is based on a 3:1 safety factor and 330 Kpsi tensile strength. The allowable load is the lower of the curves at a given point. For instance, one inch in front of the 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 $L_{10} = (C/P)^p [10^6 \text{ revolutions}]$

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
 GVW1,500lbs.
 weight over each drive wheel 425 lbs.
 rolling radius of tires 16 in.
 desired acceleration0-5 mph in 10 sec.
 top speed..... 5 mph
 gradability.....20%
 worst working surface..... poor asphalt

To determine maximum motor speed

$$\text{RPM} = \frac{2.65 \times \text{KPH} \times G}{r_m} \qquad \text{RPM} = \frac{168 \times \text{MPH} \times G}{r_i}$$

Where:

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

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

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:

$$\text{TE} = \text{RR} + \text{GR} + \text{FA} + \text{DP} \text{ (lbs or N)}$$

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.

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

Where:

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

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

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:

$$\% \text{ Grade} = [\tan \text{ of angle (degrees)}] \times 100$$

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

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

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.

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

Where:

t = time to maximum speed (seconds)

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

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.

$$TE = RR + GR + FA + DP \text{ (lb or N)}$$

Example $TE = 33 + 300 + 34 + 0 \text{ (lbs)} = 367 \text{ lbs}$

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

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.

$$TS = \frac{W \times f \times ri}{G} \qquad TS = \frac{W \times f \times rm}{G}$$

(lb-in per motor) (N-m per motor)

Where:

f = coefficient of friction (see table 2)

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

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

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.

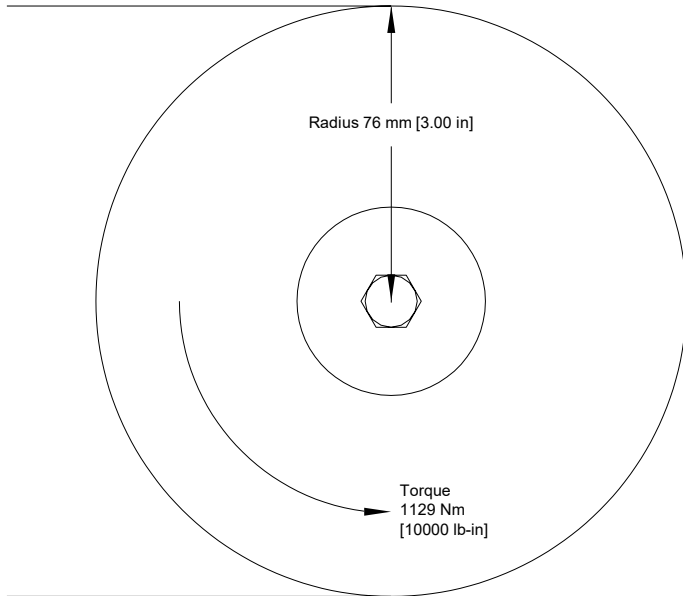
$$RL = \sqrt{W^2 + \left(\frac{T}{ri}\right)^2} \text{ lb} \qquad RL = \sqrt{W^2 + \left(\frac{T}{rm}\right)^2} \text{ kg}$$

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

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

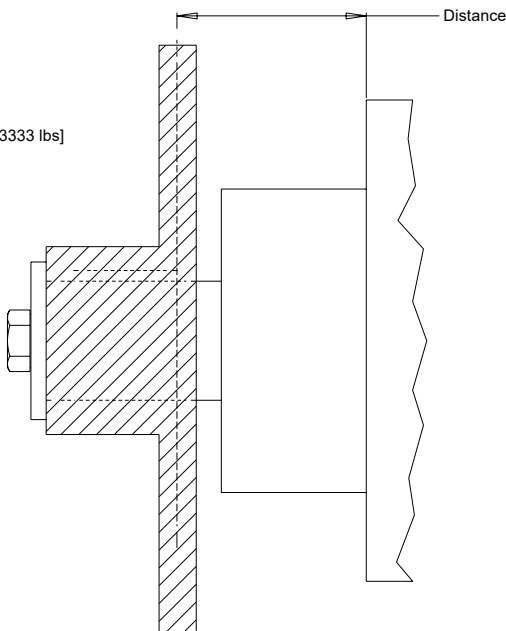
In many cases, pulleys or sprockets may be used to transmit the torque produced by the motor. Use of these components will create a torque induced side load on the motor shaft and bearings. It is important that this load be taken into consideration when choosing a motor with sufficient bearing and shaft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

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

$$\text{Side Load} = 14855 \text{ Nm [3333 lbs]}$$



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) =

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

Power In (HP) =

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

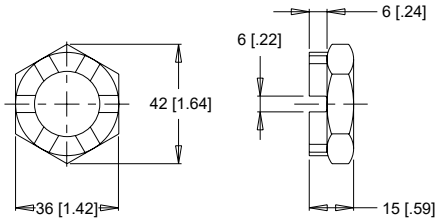
Power Out (HP) =

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

SHAFT NUT INFORMATION

35MM TAPERED SHAFTS
M24 x 1.5 Thread

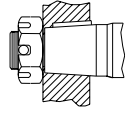
A Slotted Nut



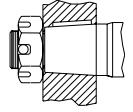
Torque Specifications: 32.5 daNm [240 ft.lb.]

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.



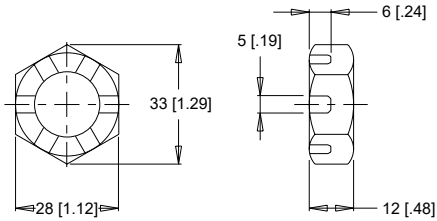
incorrect



correct

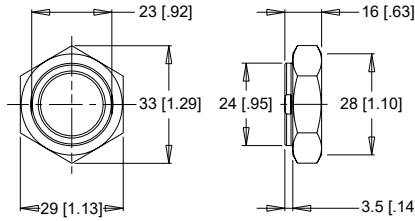
1" TAPERED SHAFTS
3/4-28 Thread

A Slotted Nut



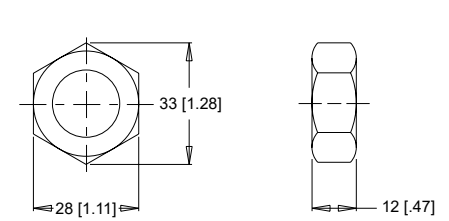
Torque Specifications: 20 - 23 daNm [150 - 170 ft.lb.]

B Lock Nut



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

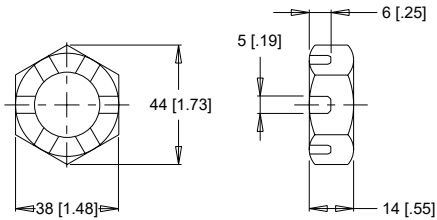
C Solid Nut



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

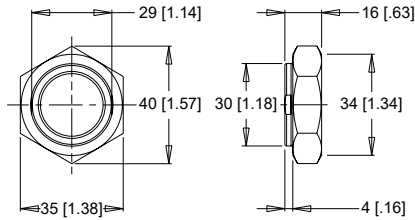
1-1/4" TAPERED SHAFTS
1-20 Thread

A Slotted Nut



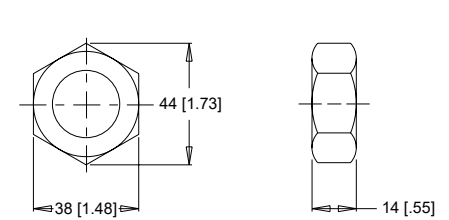
Torque Specifications: 38 daNm [280 ft.lb.] Max.

B Lock Nut



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

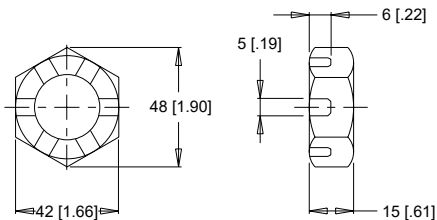
C Solid Nut



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

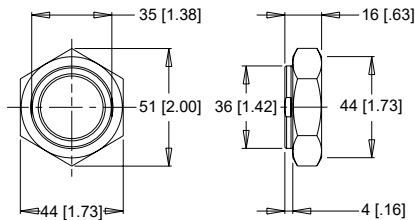
1-3/8" & 1-1/2" TAPERED SHAFTS
1 1/8-18 Thread

A Slotted Nut



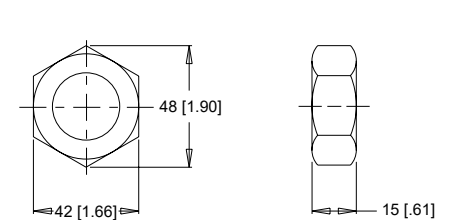
Torque Specifications: 41 - 54 daNm [300 - 400 ft.lb.]

B Lock Nut



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

C Solid Nut



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

OVERVIEW

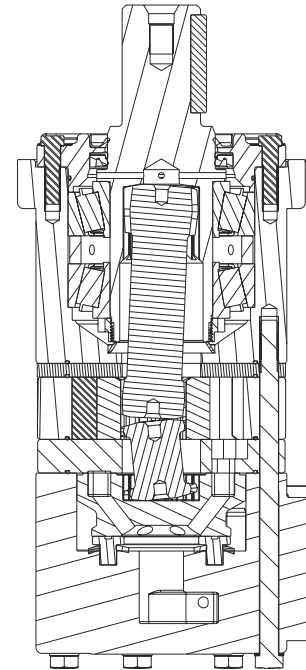
The WZ motor series targets mobile applications, augers, sprayers, trenchers and other applications that require higher torque in demanding situations. A three zone commutator valve ensures high volumetric efficiency while the roller gear set design ensures a smooth rotation and high mechanical efficiency. Integrated taper roller bearings improve radial load carrying capacity while the standard case drain and internal drain extend the life of the shaft seal. The WZ motor series comes with industry standard mounting and shaft options to interchange with similar motors in the global market.

TYPICAL APPLICATIONS

Construction equipment, agricultural equipment, mining equipment, forestry equipment, associated attachments and more

SERIES DESCRIPTIONS

650/651 - Hydraulic Motor
Standard



FEATURES / BENEFITS

- Industry standard mounting and shaft options allows for easier system integration
- Integrated roller bearings provide higher radial load capacity
- Three zone commutator valving equates to higher volumetric efficiency
- Standard case drain and integral internal drain extends the overall life of the shaft seal.

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
195	196 [12.0]	770	866	151 [40]	170 [45]	584 [5168]	902 [7983]	205 [2975]	310 [4495]	310 [4495]
245	246 [15.0]	606	835	151 [40]	208 [55]	754 [6673]	1131 [10009]	205 [2975]	310 [4495]	310 [4495]
310	311 [19.0]	485	729	151 [40]	227 [60]	939 [8310]	1383 [12240]	205 [2975]	310 [4495]	310 [4495]
390	391 [23.9]	383	578	151 [40]	227 [60]	1171 [10363]	1698 [15027]	205 [2975]	310 [4495]	310 [4495]
490	490 [29.9]	307	459	151 [40]	227 [60]	1475 [13054]	1938 [17151]	205 [2975]	275 [3990]	310 [4495]
625	625 [38.1]	239	358	151 [40]	227 [60]	1501 [13284]	1901 [16824]	170 [2465]	221 [3205]	240 [3480]
735	735 [44.9]	201	303	151 [40]	227 [60]	1494 [13222]	1767 [15638]	140 [2030]	170 [2465]	205 [2975]
805	799 [48.8]	188	282	151 [40]	227 [60]	1640 [14514]	1821 [16116]	140 [2030]	170 [2465]	170 [2465]
985	983 [60.0]	151	228	151 [40]	227 [60]	1996 [17665]	2027 [17939]	140 [2030]	140 [2030]	170 [2465]

▶ 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

		Pressure - bar [psi]									Max. Cont.			Max. Inter.					
195		15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]								
196 cm ³ [12.0 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.												Intermittent Ratings - 10% of Operation					
Flow - lpm [gpm]	8 [2]	37 [327]	91 [805]	191 [1690]	284 [2513]	375 [3319]	460 [4071]	546 [4832]										38	
	15 [4]	36	34	29	25	21	18	15										77	
	30 [8]	37 [327]	95 [841]	194 [1717]	293 [2593]	390 [3452]	473 [4186]	566 [5009]	656 [5806]	738 [6531]	815 [7213]							153	
	45 [12]	74	72	67	63	57	53	48	43	39	32							230	
	61 [16]	37 [327]	95 [841]	198 [1752]	296 [2620]	395 [3496]	481 [4257]	577 [5106]	672 [5947]	772 [6832]	860 [7611]							311	
	76 [20]	149	147	143	138	132	127	108	112	106	98							388	
	91 [24]	35 [310]	97 [858]	203 [1797]	301 [2664]	402 [3558]	490 [4337]	583 [5160]	687 [6080]	779 [6894]	902 [7983]							464	
	106 [28]	226	221	216	210	203	196	188	180	174	165							541	
	121 [32]	32 [283]	90 [797]	197 [1743]	296 [2620]	399 [3531]	484 [4283]	584 [5168]	683 [6045]	780 [6903]	890 [7877]							617	
	136 [36]	305	304	301	295	291	286	275	265	256	248							694	
	151 [40]	28 [248]	85 [752]	192 [1699]	294 [2602]	396 [3505]	484 [4283]	584 [5168]	679 [6009]	778 [6885]	870 [7700]							770	
	170 [45]	383	374	373	368	368	355	350	341	330	321							867	
	Max. Max. Inter. Cont.	91 [24]		81 [717]	185 [1637]	293 [2593]	395 [3496]	482 [4266]	583 [5160]	676 [5983]	777 [6876]								
106 [28]			458	450	450	442	435	429	412	402									
Rotor Width	121 [32]		74 [655]	174 [1558]	285 [2522]	382 [3381]	470 [4160]	575 [5089]	676 [5983]	776 [6868]									
	136 [36]		540	532	518	517	516	501	490	476									
mm [in]	151 [40]		67 [593]	172 [1522]	276 [2443]	378 [3345]	470 [4160]	573 [5071]	672 [5947]	771 [6823]									
	170 [45]		616	615	613	607	598	561	551	535									
	136 [36]		64 [566]	170 [1505]	273 [2416]	372 [3292]	461 [4080]	565 [5000]	666 [5894]	760 [6726]									
	151 [40]		691	682	677	669	656	647	629	613									
	170 [45]		54 [478]	160 [1416]	261 [2310]	362 [3204]	452 [4000]	551 [4876]	651 [5761]										
			770	768	765	755	747	732	711										
			47 [416]	151 [1336]	248 [2195]	357 [3159]	440 [3894]	536 [4744]	633 [5602]										
			866	865	850	836	845	821	807										
			Torque - Nm [lb-in], Speed rpm																
			Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>																
			47 [414]	109 [966]	218 [1932]	328 [2899]	437 [3865]	530 [4693]	639 [5659]	749 [6626]	858 [7592]	967 [8558]							
			Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]																

		Pressure - bar [psi]									Max. Cont.			Max. Inter.					
245		15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]								
246 cm ³ [15.0 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.												Intermittent Ratings - 10% of Operation					
Flow - lpm [gpm]	8 [2]	47 [416]	120 [1062]	241 [2133]	370 [3275]	488 [4319]	583 [5160]	684 [6053]										30	
	15 [4]	29	28	26	23	20	18	15										61	
	30 [8]	49 [434]	114 [1009]	243 [2151]	371 [3283]	497 [4398]	606 [5363]	729 [6452]	852 [7540]	969 [8576]	1080 [9558]							122	
	45 [12]	59	57	55	50	48	45	41	36	29	23							183	
	61 [16]	47 [416]	112 [991]	243 [2151]	373 [3301]	502 [4443]	615 [5443]	741 [6558]	869 [7691]	992 [8779]	1105 [9779]							248	
	76 [20]	119	117	113	107	102	98	94	90	85	79							309	
	91 [24]	43 [381]	112 [991]	242 [2142]	375 [3319]	504 [4460]	623 [5514]	754 [6673]	885 [7832]	1013 [8965]	1131 [10009]							370	
	106 [28]	180	177	175	174	170	167	159	154	147	140							431	
	121 [32]	39 [345]	109 [965]	241 [2133]	371 [3283]	505 [4469]	617 [5460]	753 [6664]	890 [7877]	1010 [8939]	1125 [9956]							492	
	136 [36]	248	246	244	241	240	235	223	219	213	205							553	
	151 [40]	35 [310]	103 [912]	241 [2133]	367 [3248]	504 [4460]	616 [5452]	750 [6638]	889 [7868]	1009 [8930]	1125 [9956]							614	
	170 [45]	305	302	301	298	288	282	276	266	257	250							691	
	Max. Max. Inter. Cont.	91 [24]		99 [876]	234 [2071]	365 [3230]	497 [4398]	614 [5434]	741 [6558]	870 [7700]	1003 [8877]								
106 [28]			365	361	361	351	346	343	332	324									
Rotor Width	121 [32]		95 [841]	223 [1974]	355 [3142]	492 [4354]	612 [5416]	728 [6531]	866 [7664]	996 [8815]									
	136 [36]		422	420	415	410	405	394	389	380									
mm [in]	151 [40]		84 [743]	215 [1903]	348 [3080]	484 [4283]	596 [5275]	726 [6425]	855 [7567]	984 [8708]									
	170 [45]		483	481	479	472	466	458	448	440									
	189 [50]		76 [673]	207 [1832]	338 [2991]	475 [4204]	587 [5195]	721 [6381]	852 [7540]										
	208 [55]		553	551	546	540	535	525	518										
			65 [575]	199 [1761]	326 [2885]	457 [4044]	579 [5124]	713 [6310]	824 [7292]										
			606	602	600	594	590	588	585										
			52 [460]	184 [1628]	310 [2744]	441 [3903]	559 [4947]	698 [6177]	811 [7177]										
			683	678	675	670	661	658	646										
				172 [1522]	305 [2699]	431 [3814]	545 [4823]	681 [6027]											
				756	751	745	741	739											
				151 [1336]	281 [2487]	423 [3744]	528 [4673]	641 [5673]											
				835	830	823	817	811											
			Torque - Nm [lb-in], Speed rpm																
			Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>																
			59 [520]	137 [1213]	274 [2425]	411 [3638]	548 [4851]	666 [5890]	803 [7103]	940 [8316]	1077 [9529]	1214 [10741]							
			Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]																

► 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.

DISPLACEMENT PERFORMANCE

		Pressure - bar [psi]										Max. Cont.		Max. Inter.	
310		15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]				
311 cm ³ [19.0 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.										Intermittent Ratings - 10% of Operation			
Flow - lpm [gpm]	8 [2]	60 [531] 23	150 [1328] 22	312 [2761] 21	475 [4204] 19	626 [5540] 17	758 [6708] 15	899 [7956] 13	970 [8585] 11						24
	15 [4]	60 [531] 47	150 [1328] 45	319 [2823] 43	479 [4239] 42	628 [5558] 38	759 [6717] 35	906 [8018] 31	1039 [9195] 28	1183 [10470] 24	1323 [11709] 20				48
	30 [8]	60 [531] 94	147 [1301] 91	307 [2717] 87	473 [4186] 83	637 [5637] 79	769 [6806] 75	930 [8231] 71	1080 [9558] 69	1227 [10859] 67	1366 [12089] 61				96
	45 [12]	57 [504] 142	146 [1292] 141	304 [2690] 138	469 [4151] 137	633 [5602] 134	774 [6850] 130	939 [8310] 121	1093 [9673] 116	1243 [11001] 109	1383 [12240] 101				145
	61 [16]	52 [460] 193	142 [1257] 192	301 [2664] 186	466 [4124] 182	629 [5567] 176	766 [6779] 170	930 [8231] 164	1083 [9585] 157	1255 [11107] 151	1374 [12160] 145				196
	76 [20]	47 [416] 241	136 [1204] 246	295 [2611] 238	460 [4071] 231	624 [5522] 222	764 [6761] 216	928 [8213] 209	1079 [9549] 200	1246 [11027] 194					244
	91 [24]	38 [336] 293	133 [1177] 291	293 [2593] 286	457 [4044] 287	621 [5496] 278	762 [6744] 273	924 [8177] 266	1079 [9549] 257	1241 [10983] 249					293
	106 [28]	30 [266] 339	120 [1062] 338	280 [2478] 338	447 [3956] 334	614 [5434] 328	755 [6682] 323	919 [8133] 320	1078 [9540] 308	1234 [10921] 299					341
	121 [32]		113 [1000] 389	285 [2522] 383	443 [3921] 379	610 [5399] 366	750 [6638] 365	918 [8124] 361	1066 [9434] 354						389
	136 [36]		100 [885] 437	266 [2354] 430	435 [3806] 423	600 [5310] 419	747 [6611] 413	898 [7947] 412	1063 [9408] 403						437
	151 [40]		89 [788] 485	260 [2301] 483	422 [3735] 481	593 [5248] 473	730 [6461] 469	893 [7903] 456	1053 [9319] 449						486
	189 [50]		63 [558] 602	218 [1929] 599	385 [3407] 595	559 [4947] 592	694 [6142] 592	851 [7531] 591							608
227 [60]			181 [1602] 729	341 [3018] 721	508 [4496] 710	651 [5761] 707	812 [7186] 704							730	
Rotor Width		Torque - Nm [lb-in], Speed rpm													
36.3 [1.429] mm [in]		Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>													
		74 [657] 173 [1533] 346 [3066] 520 [4600] 693 [6133] 841 [7447] 1015 [8980] 1188 [10513] 1361 [12046] 1534 [13580]													
		Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]													

		Pressure - bar [psi]										Max. Cont.		Max. Inter.	
390		15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]				
391 cm ³ [23.9 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.										Intermittent Ratings - 10% of Operation			
Flow - lpm [gpm]	8 [2]	75 [664] 18	188 [1664] 18	387 [3425] 16	583 [5160] 14	774 [6850] 13	929 [8222] 11	1055 [9337] 9						19	
	15 [4]	76 [673] 37	188 [1664] 36	389 [3443] 35	589 [5213] 32	779 [6894] 29	966 [8549] 28	1158 [10248] 24	1345 [11903] 20	1523 [13479] 17				38	
	30 [8]	76 [673] 76	189 [1673] 75	391 [3460] 73	598 [5292] 70	797 [7053] 69	967 [8558] 62	1165 [10310] 57	1345 [11903] 52	1531 [13549] 49	1698 [15027] 46			77	
	45 [12]	72 [637] 113	183 [1620] 110	387 [3425] 107	592 [5239] 103	800 [7080] 98	977 [8646] 94	1171 [10363] 88	1368 [12107] 85	1552 [13735] 80				115	
	61 [16]	67 [593] 153	178 [1575] 153	380 [3363] 148	588 [5204] 146	795 [7036] 142	969 [8576] 139	1166 [10319] 132	1365 [12080] 126					156	
	76 [20]	60 [531] 192	172 [1522] 191	375 [3319] 186	583 [5160] 186	791 [7000] 183	962 [8514] 17	1166 [10319] 171	1364 [12071] 164					194	
	91 [24]	51 [451] 231	161 [1425] 231	367 [3248] 228	581 [5142] 222	784 [6938] 217	960 [8496] 210	1161 [10275] 203						233	
	106 [28]	42 [372] 270	155 [1372] 270	366 [3239] 265	574 [5080] 258	773 [6841] 251	948 [8390] 244	1149 [10169] 238						271	
	121 [32]	29 [257] 308	144 [1274] 304	350 [3098] 303	563 [4983] 298	775 [6859] 294	943 [8346] 286	1146 [10142] 280						309	
	136 [36]		131 [1159] 343	338 [2991] 339	549 [4859] 338	759 [6717] 331	928 [8213] 325	1132 [10018] 316						348	
	151 [40]		120 [1062] 383	324 [2867] 379	535 [4735] 378	740 [6549] 372	913 [8080] 365							386	
	189 [50]		81 [717] 478	289 [2558] 474	501 [4434] 471	713 [6310] 464	818 [7239] 455							483	
227 [60]			228 [2018] 578	437 [3867] 575	646 [5717] 568	809 [7160] 559							581		
Rotor Width		Torque - Nm [lb-in], Speed rpm													
45.6 [1.795] mm [in]		Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>													
		93 [826] 218 [1928] 436 [3855] 653 [5783] 871 [7710] 1058 [9362] 1276 [11290] 1494 [13218] 1711 [15145] 1929 [17073]													
		Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]													

► 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.

DISPLACEMENT PERFORMANCE

		Pressure - bar [psi]							Max. Cont.		Max. Inter.	
490		15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]		
490 cm ³ [29.9 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.							Intermittent Ratings - 10% of Operation			
Flow - lpm [gpm]	8 [2]	108 [956] 14	256 [2266] 14	498 [4407] 13	745 [6593] 12	975 [8629] 12	1173 [10381] 11					15
	15 [4]	111 [982] 30	256 [2266] 29	506 [4478] 28	766 [6779] 28	1018 [9009] 26	1220 [10797] 23	1469 [13001] 20	1728 [15293] 19	1938 [17151] 17		31
	30 [8]	109 [965] 60	249 [2204] 58	507 [4487] 57	767 [6788] 55	1019 [9018] 52	1229 [10877] 49	1475 [13054] 46	1749 [15479] 41			61
	45 [12]	104 [920] 90	245 [2168] 89	501 [4434] 86	762 [6744] 83	1018 [9009] 78	1237 [10947] 75	1489 [13178] 72				92
	61 [16]	94 [832] 122	238 [2106] 121	497 [4398] 119	761 [6735] 119	1017 [9000] 116	1251 [11071] 112	1502 [13293] 107				124
	76 [20]	85 [752] 153	231 [2044] 151	485 [4292] 149	751 [6646] 150	1007 [8912] 148	1236 [10939] 144					155
	91 [24]	73 [646] 185	215 [1903] 184	470 [4160] 183	738 [6531] 180	1000 [8850] 180	1229 [10877] 175					186
	106 [28]	59 [522] 215	203 [1797] 214	457 [4044] 213	723 [6399] 211	991 [8770] 205	1209 [10700] 200					216
	121 [32]		188 [1664] 246	446 [3947] 243	717 [6345] 240	980 [8673] 235	1199 [10611] 229					247
	136 [36]		171 [1513] 277	427 [3779] 276	695 [6151] 270	958 [8478] 270	1168 [10337] 260					278
	151 [40]		151 [1336] 307	409 [3620] 302	675 [5974] 299	935 [8275] 296	1157 [10239] 291					308
	189 [50]		98 [867] 385	359 [3177] 380	619 [5478] 378	899 [7956] 382						386
	227 [60]			293 [2593] 459	559 [4947] 456	816 [7222] 450						463
	Rotor Width		Torque - Nm [lb-in], Speed rpm Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>									
57.3 [2.256]		117 [1035]	273 [2416]	546 [4831]	819 [7247]	1092 [9662]	1326 [11733]	1599 [14149]	1872 [16564]	2145 [18980]		
mm [in]		Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]										

		Pressure - bar [psi]							Max. Cont.		Max. Inter.	
625		15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	221 [3205]			
625 cm ³ [38.1 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.							Intermittent Ratings - 10% of Operation			
Flow - lpm [gpm]	8 [2]	130 [1151] 11	314 [2779] 11	629 [5567] 10	945 [8363] 10	1261 [11160] 9						12
	15 [4]	133 [1177] 23	317 [2805] 23	636 [5629] 22	959 [8487] 21	1279 [11319] 20	1460 [12921] 19					24
	30 [8]	124 [1097] 47	309 [2735] 47	625 [5531] 46	947 [8381] 46	1265 [11195] 44	1474 [13045] 41	1785 [15797] 38	1901 [16824] 36			48
	45 [12]	115 [1018] 71	303 [2682] 70	624 [5522] 69	942 [8337] 67	1252 [11080] 65	1501 [13284] 63	1788 [15824] 60				72
	61 [16]	106 [938] 96	294 [2602] 94	622 [5505] 94	936 [8284] 91	1251 [11071] 89	1526 [13505] 87					98
	76 [20]	97 [858] 121	280 [2478] 121	618 [5469] 120	933 [8257] 119	1247 [11036] 114						122
	91 [24]	81 [717] 145	269 [2381] 144	600 [5310] 143	927 [8204] 140	1239 [10965] 136						146
	106 [28]	65 [575] 169	252 [2230] 168	585 [5177] 167	911 [8062] 164	1223 [10824] 163						170
	121 [32]		235 [2080] 190	569 [5036] 188	877 [7761] 187	1183 [10470] 185						194
	136 [36]		216 [1912] 214	545 [4823] 212	866 [7664] 210							218
	151 [40]		195 [1726] 238	523 [4629] 236	856 [7576] 232							242
	189 [50]			459 [4062] 301	773 [6841] 299							302
	227 [60]			374 [3310] 358	719 [6363] 356							363
	Rotor Width		Torque - Nm [lb-in], Speed rpm Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>									
73.1 [2.878]		149 [1320]	348 [3081]	696 [6162]	1044 [9243]	1393 [12325]	1691 [14966]	2039 [18047]	2198 [19455]			
mm [in]		Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]										

► 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.

DISPLACEMENT PERFORMANCE

		Pressure - bar [psi]						Max. Cont.		Max. Inter.	
735		35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	155 [2250]	170 [2465]	
735 cm ³ [44.9 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.						Intermittent Ratings - 10% of Operation			
Flow - lpm [gpm]	8 [2]	382 [3381] 9	542 [4797] 9	755 [6682] 8	917 [8115] 8	1113 [9850] 7					
	15 [4]	385 [3407] 19	555 [4912] 18	768 [6797] 17	925 [8186] 16	1140 [10089] 16	1290 [11417] 15	1490 [13187] 14	1635 [14470] 13	1767 [15638] 11	
	30 [8]	371 [3283] 39	537 [4752] 38	756 [6691] 38	922 [8160] 36	1142 [10107] 35	1297 [11478] 33	1494 [13222] 31	1680 [14868] 27		
	45 [12]	371 [3283] 59	534 [4726] 57	754 [6673] 56	915 [8098] 54	1146 [10142] 53	1304 [11540] 51	1520 [13452] 49			
	61 [16]	360 [3186] 81	525 [4646] 79	749 [6629] 78	911 [8062] 77	1137 [10062] 76	1302 [11523] 74				
	76 [20]	348 [3080] 101	511 [4522] 101	737 [6522] 100	908 [8036] 99	1130 [10001] 97	1295 [11461] 94				
	91 [24]	336 [2974] 122	495 [4381] 120	721 [6381] 119	886 [7841] 119	1114 [9859] 117					
	106 [28]	316 [2797] 143	483 [4275] 142	708 [6266] 140	881 [7797] 139	1101 [9744] 137					
	121 [32]	294 [2602] 164	462 [4089] 162	683 [6045] 162	856 [7576] 161	1083 [9585] 160					
	136 [36]	280 [2478] 181	450 [3983] 181	671 [5938] 180	844 [7469] 179						
	151 [40]	260 [2301] 201	420 [3717] 201	645 [5708] 200	810 [7169] 199						
	189 [50]		356 [3151] 252	578 [5115] 252	746 [6602] 249						
	227 [60]			503 [4452] 303	660 [5841] 301						
Rotor Width		Torque - Nm [lb-in], Speed rpm									
86.2 [3.394] mm [in]		Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>									
		409 [3623] 585 [5176] 819 [7247] 994 [8800] 1228 [10870] 1404 [12423] 1638 [14494] 1813 [16047] 1989 [17599]									
		Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]									

10	Theoretical rpm
20	
41	
61	
83	
103	
124	
144	
165	
185	
205	
257	
309	

		Pressure - bar [psi]						Max. Cont.		Max. Inter.	
805		35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	155 [2250]	170 [2465]	
799 cm ³ [48.8 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.						Intermittent Ratings - 10% of Operation			
Flow - lpm [gpm]	8 [2]	396 [3505] 9	554 [4903] 8	763 [6753] 8	908 [8036] 7	1133 [10027] 6	1266 [11204] 5				
	15 [4]	394 [3487] 18	570 [5045] 18	804 [7115] 17	977 [8646] 16	1196 [10585] 15	1362 [12054] 14	1572 [13912] 13	1709 [15125] 11	1821 [16116] 11	
	30 [8]	413 [3655] 36	582 [5151] 35	808 [7151] 35	1004 [8885] 33	1242 [10992] 31	1404 [12425] 30	1640 [14514] 26	1803 [15957] 24		
	45 [12]	401 [3549] 54	575 [5089] 54	416 [7222] 53	999 [8841] 53	1240 [10974] 52	1416 [12532] 50	1635 [14470] 46			
	61 [16]	392 [3469] 74	565 [5000] 73	805 [7124] 73	986 [8726] 73	1228 [10868] 72	1429 [12647] 66				
	76 [20]	379 [3354] 93	551 [4876] 93	792 [7009] 92	971 [8593] 92	1215 [10753] 91	1421 [12576] 84				
	91 [24]	359 [3177] 111	533 [4717] 111	778 [6885] 111	957 [8469] 110	1196 [10585] 109					
	106 [28]	334 [2956] 131	513 [4540] 131	755 [6682] 130	939 [8310] 129	1177 [10416] 127					
	121 [32]	327 [2894] 149	500 [4425] 148	738 [6531] 146	910 [8054] 145	1160 [10266] 143					
	136 [36]	300 [2655] 168	478 [4230] 166	717 [6345] 165	901 [7974] 163						
	151 [40]	275 [2434] 188	457 [4044] 185	696 [6160] 184	876 [7753] 182						
	189 [50]	185 [1637] 236	373 [3301] 236	613 [5425] 234	798 [7062] 233						
	227 [60]		296 [2620] 282	527 [4664] 281	697 [6168] 280						
Rotor Width		Torque - Nm [lb-in], Speed rpm									
70.0 [2.756] mm [in]		Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>									
		445 [3939] 636 [5627] 890 [7878] 1081 [9566] 1335 [11817] 1526 [13505] 1780 [15756] 1971 [17444] 2162 [19132]									
		Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]									

9	Theoretical rpm
19	
38	
56	
76	
95	
114	
133	
151	
170	
189	
237	
284	

► 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.

DISPLACEMENT PERFORMANCE

		Pressure - bar [psi]							Max. Cont.	
985		15 [220]	35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	
983 cm ³ [60.0 in ³] / rev		Intermittent Ratings are below and to the right of the BOLD line.							Intermittent Ratings - 10% of Operation	
Flow - lpm [gpm]	8 [2]	216 [1912] 7	502 [4443] 7	714 [6319] 7	994 [8797] 6	1192 [10549] 6				8
	15 [4]	214 [1894] 15	508 [4496] 14	740 [6549] 14	1066 [9434] 14	1228 [10868] 13	1514 [13399] 12	1690 [14957] 9	1996 [17665] 7	15
	30 [8]	213 [1885] 30	510 [4514] 30	725 [6416] 29	1022 [9045] 29	1244 [11009] 28	1536 [13594] 24	1708 [15116] 22	2027 [17939] 20	31
	45 [12]	204 [1805] 45	501 [4434] 44	723 [6399] 44	1006 [8903] 44	1234 [10921] 43	1523 [13479] 42	1746 [15452] 42		46
	61 [16]	187 [1655] 61	481 [4257] 60	709 [6275] 60	990 [8762] 60	1217 [10770] 60	1516 [13417] 59			62
	76 [20]	172 [1522] 77	455 [4027] 76	686 [6071] 75	977 [8646] 74	1195 [10576] 74	1487 [13160] 74			77
	91 [24]	152 [1345] 92	433 [3832] 92	662 [5859] 90	957 [8469] 90	1185 [10487] 88	1478 [13080] 88			93
	106 [28]	130 [1151] 108	415 [3673] 108	650 [5753] 106	940 [8319] 104	1157 [10239] 103	1460 [12921] 102			108
	121 [32]	106 [938] 121	399 [3531] 121	605 [5354] 121	909 [8045] 120	1147 [10151] 118				123
	136 [36]		356 [3151] 138	601 [5319] 135	884 [7823] 135	1107 [9797] 133				138
	151 [40]		345 [3053] 151	541 [4788] 151	845 [7478] 150	1070 [9470] 148				154
	189 [50]		239 [2115] 190	461 [4080] 189	744 [6584] 189	982 [8691] 187				192
227 [60]			357 [3159] 228	639 [5655] 227	844 [7469] 227				231	
Rotor Width		Torque - Nm [lb-in], Speed rpm							Overall Efficiency - 70 - 100% <input type="checkbox"/> 40 - 69% <input type="checkbox"/> 0 - 39% <input type="checkbox"/>	
86.2 [3.394] mm [in]		235 [2077]	548 [4846]	782 [6923]	1095 [9692]	1330 [11769]	1643 [14538]	1877 [16615]	2190 [19384]	
		Theoretical Torque - Nm [lb-in]							Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]	

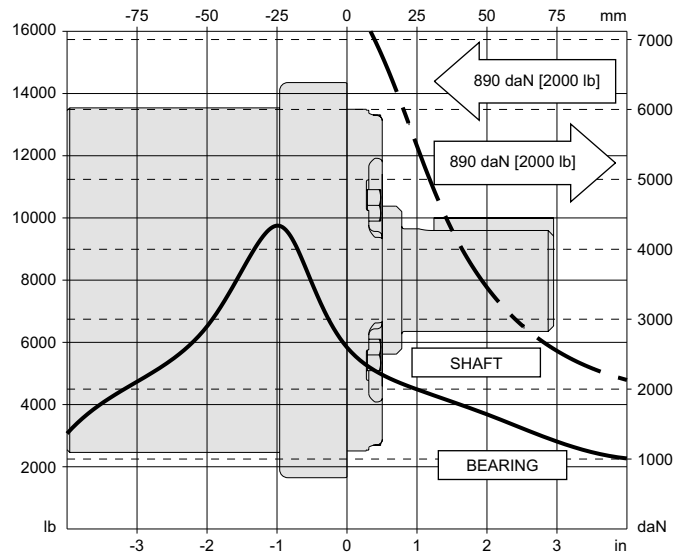
► Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended.

TECHNICAL INFORMATION

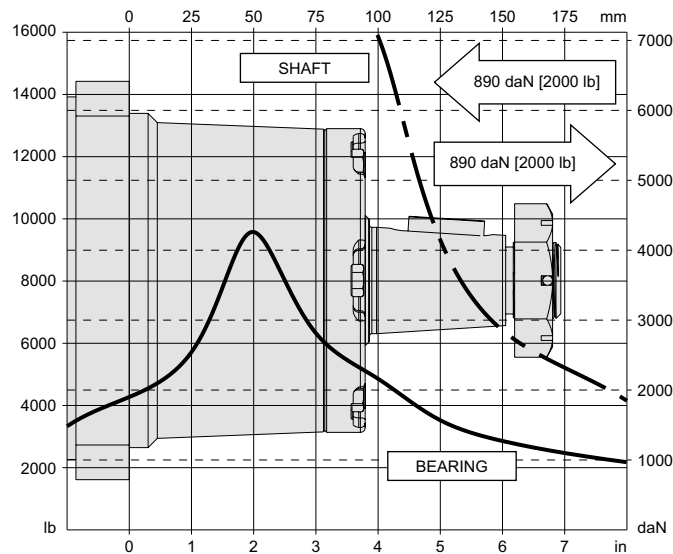
ALLOWABLE SHAFT LOAD / BEARING CURVE

The bearing curve represents allowable bearing loads based on ISO 281 bearing capacity for an L_{10} life of 2,000 hours at 100 rpm. Radial loads for speeds other than 100 rpm may be calculated using the multiplication factor table below.

SAE C MOUNTS



WHEEL MOUNTS



LENGTH & WEIGHT CHART

Dimensions A & B are the overall motor lengths from the rear of the motor to the mounting flange surface and are referenced on detailed housing drawings listed on page 19.

A		
#	Length	Weight
	mm [in]	kg [lb]
195	249 [9.81]	24.3 [53.6]
245	255 [10.04]	24.6 [54.2]
310	263 [10.34]	25.1 [55.3]
390	272 [10.71]	26.0 [57.3]
490	284 [11.17]	27.1 [59.7]
625	300 [11.79]	28.4 [62.4]
735	313 [12.31]	29.6 [65.3]
805	296 [11.67]	28.3 [62.4]
985	313 [12.31]	29.6 [65.3]

B		
#	Length	Weight
	mm [in]	kg [lb]
195	164 [6.44]	24.3 [53.6]
245	170 [6.68]	24.6 [54.2]
310	177 [6.98]	25.1 [55.3]
390	187 [7.34]	26.0 [57.3]
490	198 [7.80]	27.1 [59.7]
625	214 [8.43]	28.4 [62.4]
735	227 [8.94]	29.6 [65.3]
805	211 [8.30]	28.3 [62.4]
985	227 [8.94]	29.6 [65.3]

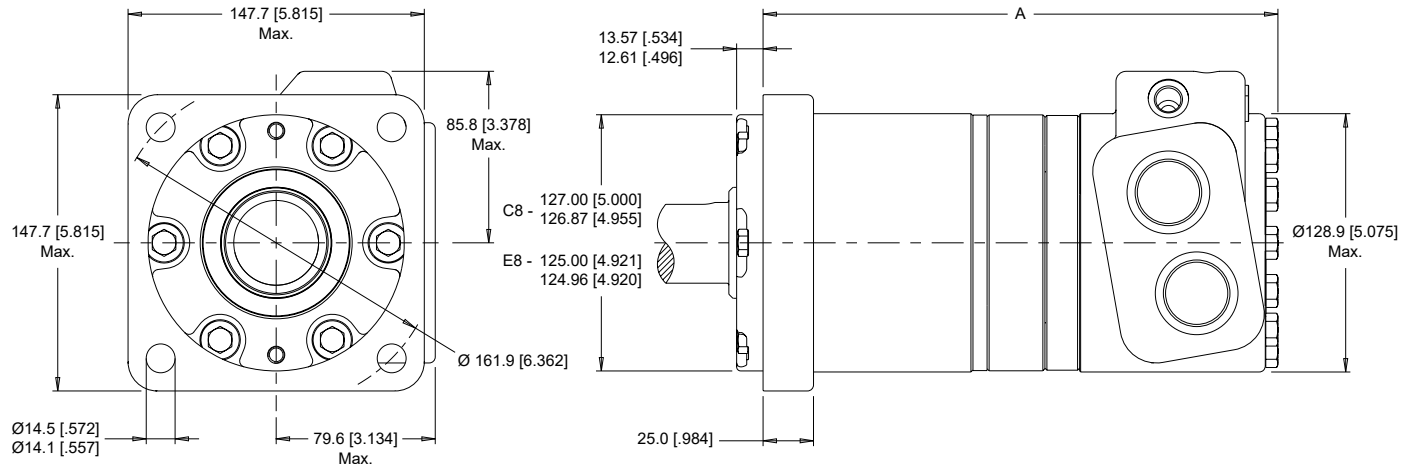
BEARING LOAD MULTIPLICATION FACTOR TABLE			
RPM	FACTOR	RPM	FACTOR
50	1.23	500	0.62
100	1.00	600	0.58
200	0.81	700	0.56
300	0.72	800	0.50
400	0.66		

HOUSINGS

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

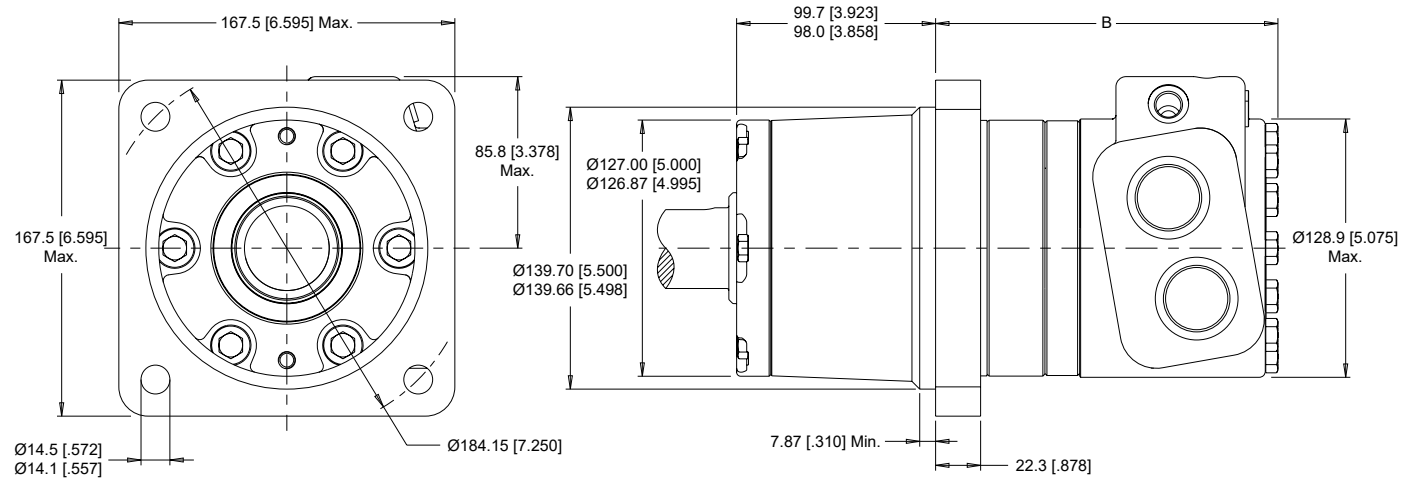
4-HOLE, SAE C MOUNT

C8 Side Ports **E8** Side Ports



4-HOLE, WHEEL MOUNT

W8 Side Ports



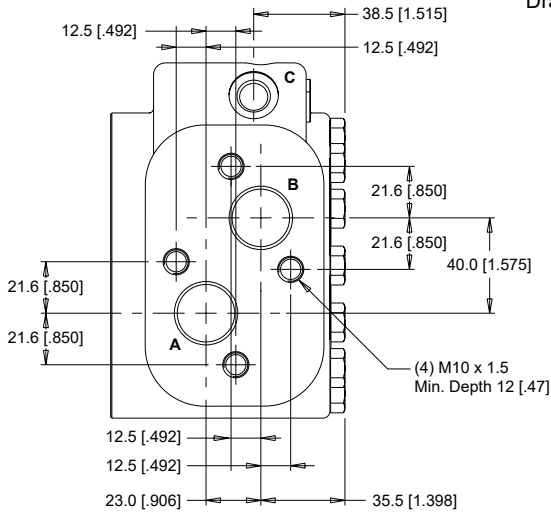
► Dimension A & B are charted on page 18.

WZ(650/651 Series)
Heavy Duty Hydraulic Motor

PORTING

SIDE PORTED - OFFSET MANIFOLD

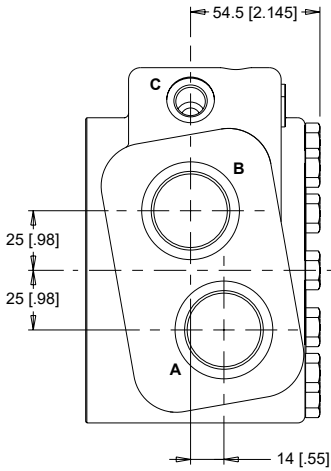
- 7** Main Ports **A, B:** G 3/4
 Drain Port **C:** G 1/4



SIDE PORTED - OFFSET

- 8** Main Ports **A, B:** G 1
 Drain Port **C:** G 1/4
- J** Main Ports **A, B:** M33 X 2
 Drain Port **C:** M14 X 1.5

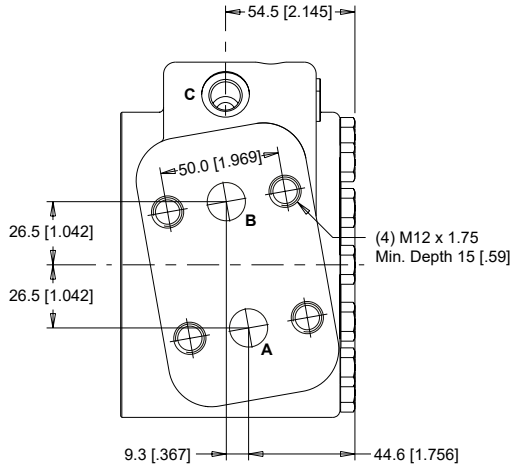
- 9** Main Ports **A, B:** 1 5/16-12 UN
 Drain Port **C:** 7/16-20 UNF
- P** Main Ports **A, B:** M33 X 2
 Drain Port **C:** G 1/4



PORTING

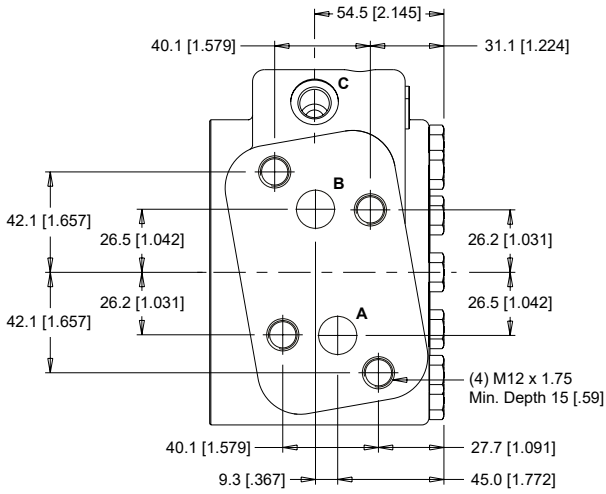
SIDE PORTED - STANDARD MANIFOLD

L Main Ports **A, B**: 16 [.63] Drilled
Drain Port **C**: M14 X 1.5



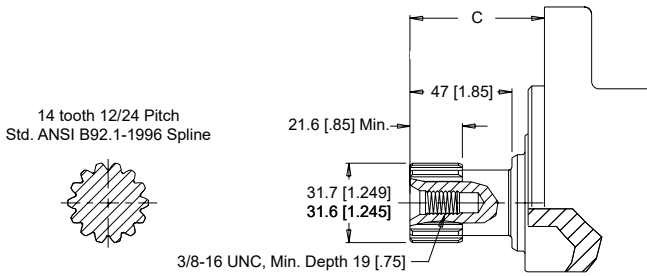
SIDE PORTED - OFFSET MANIFOLD

M Main Ports **A, B**: 16 [.63] Drilled
Drain Port **C**: M14 X 1.5



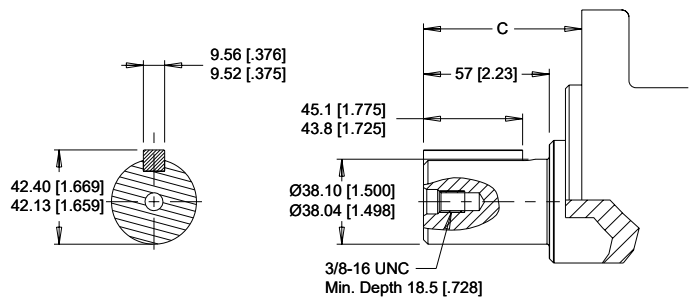
SHAFTS

23 14 Tooth Spline



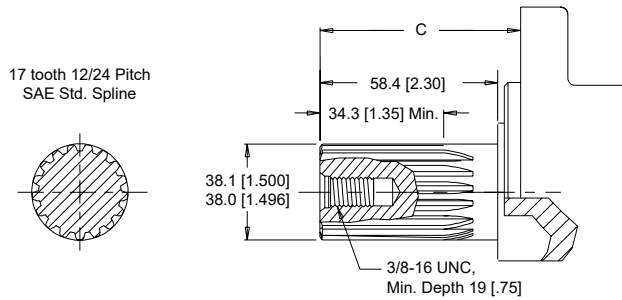
Max. Torque: 2070 Nm [18400 lb-in]

30 1-1/2" Straight



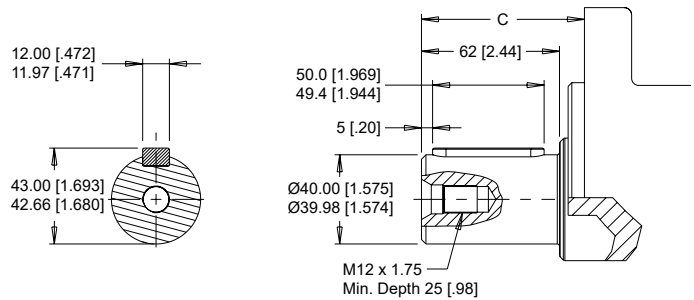
Max. Torque: 2230 Nm [19800 lb-in]

33 17 Tooth Spline



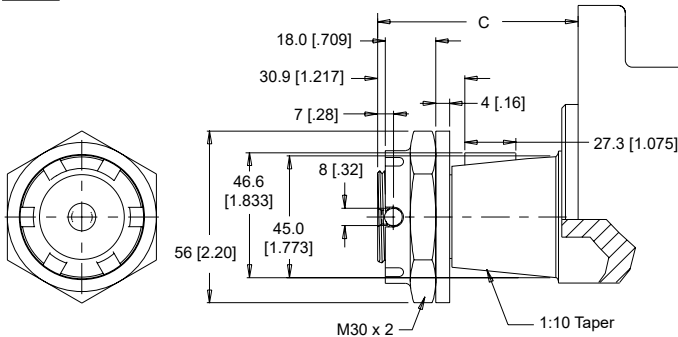
Max. Torque: 2250 Nm [19900 lb-in]

36 40mm Straight



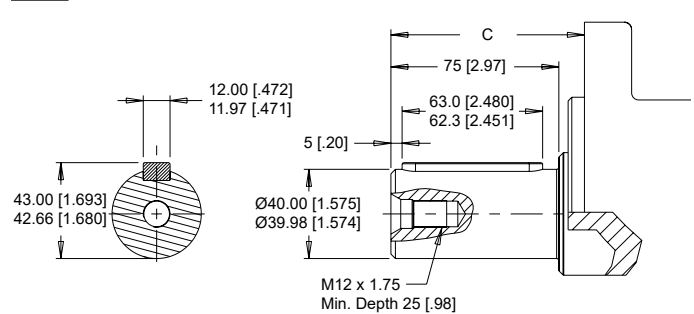
Max. Torque: 2700 Nm [24000 lb-in]

38 45mm Tapered



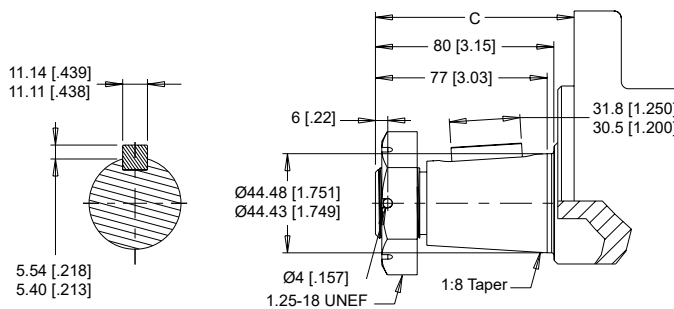
Max. Torque: 3950 Nm [35000 lb-in]

54 40mm Straight Extended



Max. Torque: 2700 Nm [24000 lb-in]

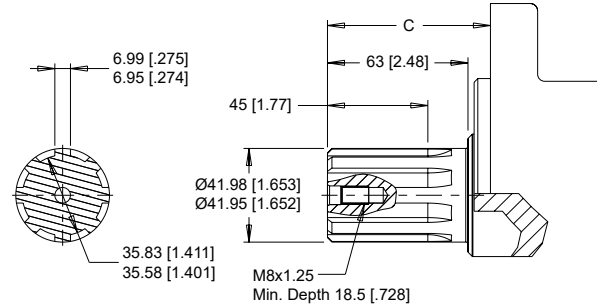
64 1-3/4" Tapered



Max. Torque: 2107 Nm [18650 lb-in]

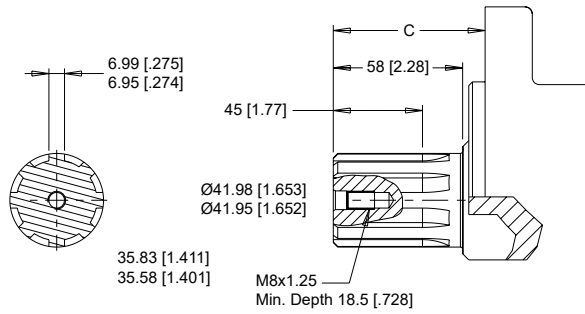
▶ A slotted hex nut is standard on this shaft.

K2 8D Spline Extended



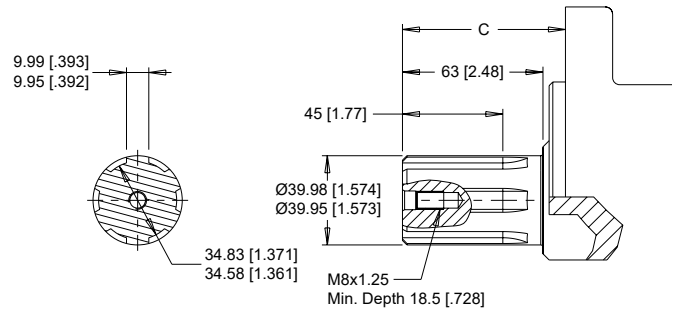
Max. Torque: 2250 Nm [19900 lb-in]

K3 8D Spline



Max. Torque: 1328 Nm [11750 lb-in]

K4 6D Spline



Max. Torque: 1328 Nm [11750 lb-in]

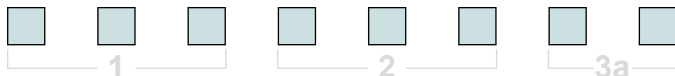
MOUNTING / SHAFT LENGTH CHART

Dimension C is the overall distance from the motor mounting surface to the end of the shaft and is referenced on detailed shaft drawings above.

C #	SAE C Mounts	Wheel Mounts
	mm [in]	mm [in]
23	64 [2.51]	149 [5.87]
30	77 [3.02]	162 [6.39]
33	68 [2.69]	153 [6.02]
36	79 [3.11]	164 [6.47]
38	N/A	189 [7.45]
54	93 [3.66]	178 [7.01]
64	95 [3.74]	180 [7.10]
K2	79 [3.11]	164 [6.47]
K3	74 [2.91]	159 [6.28]
K4	79 [3.11]	164 [6.47]

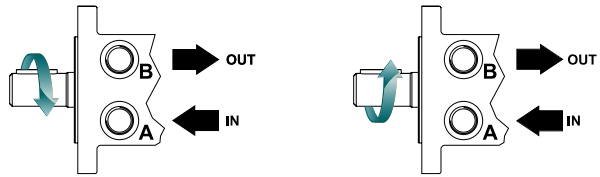
► Shaft lengths vary ± 0.8 mm [.030 in.]

ORDERING INFORMATION



1. CHOOSE SERIES DESIGNATION

- 650** Standard Rotation
- 651** Counterclockwise Rotation



► The 650 & 651 series are bi-directional. Reversing the inlet hose will reverse shaft rotation.

2. SELECT A DISPLACEMENT OPTION

- | | |
|---|---|
| 195 196 cm ³ /rev [12.0 in ³ /rev] | 625 625 cm ³ /rev [38.1 in ³ /rev] |
| 245 246 cm ³ /rev [15.0 in ³ /rev] | 735 735 cm ³ /rev [44.9 in ³ /rev] |
| 310 311 cm ³ /rev [19.0 in ³ /rev] | 805 799 cm ³ /rev [48.8 in ³ /rev] |
| 390 391 cm ³ /rev [23.9 in ³ /rev] | 985 983 cm ³ /rev [60.0 in ³ /rev] |
| 490 490 cm ³ /rev [29.9 in ³ /rev] | |

3a. SELECT MOUNT TYPE

- ▼ **SIDE MOUNT**
- C8** SAE C Mount (5" Pilot)
 - E8** SAE C Mount (125mm Pilot)
 - W8** Wheel Mount

3b. SELECT PORT SIZE

- ▼ **SIDE PORT OPTIONS**
- 7** G 3/4 Offset Manifold
 - 8** G 1 Offset
 - 9** 1 5/16-12 UN Offset
 - J** M33 x 2 Offset, M14 Drain
 - L** Drilled Manifold
 - M** Drilled Offset Manifold
 - P** M33 x 2 Offset, G1/4 Drain

► For options not listed in the table above, please contact us with your requirements



4. SELECT A SHAFT OPTION

- | | |
|---------------------------|----------------------------------|
| 23 14 Tooth Spline | 54 40mm Straight Extended |
| 30 1-1/2" Straight | 64 1-3/4" Tapered |
| 33 17 Tooth Spline | K2 8D Spline Extended |
| 36 40mm Straight | K3 8D Spline |
| 38 45mm Tapered | K4 6D Spline |

5. SELECT A PAINT OPTION

- A** Black
- B** Black, Unpainted Mounting Surface
- Z** No Paint

6. SELECT A VALVE CAVITY / CARTRIDGE OPTION

- A** None

7. SELECT AN ADD-ON OPTION

- A** Standard

8. SELECT A MISCELLANEOUS OPTION

- AA** None