Impro Fluidtek

Technical Information

Orbital Motors
Type WZ

www.Improfluidtek.com

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TECHNICAL INFORMATION

HEAVY DUTY HYDRAULIC MOTORS

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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.

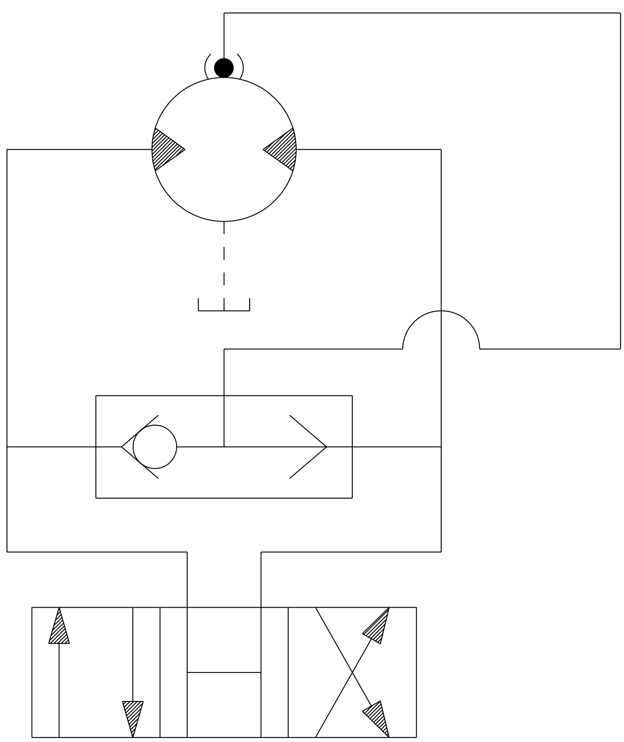
Caution! - Because it is possible for some large displacement motors to overpower the brake, it is critical that the maximum system pressure be limited for these applications. Failure to do so could cause serious injury or death. When choosing a motor/brake for an application, consult the performance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

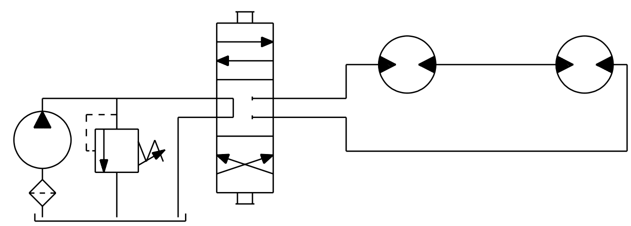
► NOTE: It is vital that all operating recommendations be followed. Failure to do so could result in injury or death.

MOTOR CIRCUITS

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

SERIES CONNECTION

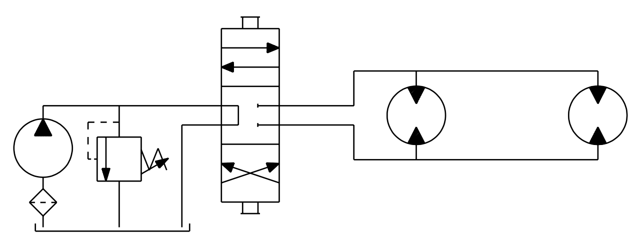
When motors are connected in series, the outlet of one motor is connected to the inlet of the next motor. This allows the full pump flow to go through each motor and provide maximum speed. Pressure and torque are distributed between the motors based on the load each motor is subjected to. The maximum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

080 — 76 cc [4.6 in^3/rev.]

Pressure - bars [psi] (Max. Cont.: 207 [3000]; Max. Inter.: 242 [3500])

Torque - Nm [lb-in], **Speed rpm** (6)

Intermittent Ratings - 10% of Operation

Flow - lpm [gpm]	17 [250]	35 [500]	69 [1000]	104 [150 (2)	38 [2000]	173 [2500]	207 [3000]	242 [3500]	Theoretical rpm
2 [0.5]	14 [127] **25**	30 [262] **24**	61 [543] **21**	91 [806] **18**	120 [1062] **17**	145 [1285] **11**	169 [1496] **11**	191 [1693] **9**	26
4 [1]	16 [140] **50**	32 [286] **50**	63 [559] **43**	95 [839] **43**	124 [1099] **34**	151 [1340] **32**	178 [1579] **32**	203 [1796] **31**	51
8 [2]	16 [139] **100**	32 [280] **100**	64 [563] **99**	97 [857] **92**	129 [1139] **87**	157 [1390] **79**	187 [1652] **78**	211 [1865] **77**	101
15 [4]	14 [127] **200**	31 [275] **200**	65 [572] **199**	99 [872] **191**	131 [1155] **181**	160 [1420] **174**	186 [1643] **160**	216 [1911] **154**	201
23 [6]	13 [113] **301**	30 [262] **300**	63 [557] (7) **297**	96 [853] **295**	130 [1149] **284**	160 [1420] **271**	186 [164 (3) **253**	18 [1930] **245**	302
(1)	10 [91] **401**	27 [243] **400**	61 [536] **398**	93 [826] **390**	127 [1125] **384**	159 [1409] **372**	187 [1654] **346**	220 [1945] **339**	(4)
38 [10]		24 [212] **502**	58 [511] **500**	89 [790] **499**	123 [1087] **498**	156 [1379] **485**	185 [1638] **443**	213 [1883] **433**	503
45 [12]		20 [177] **602**	54 [482] **601**	87 [767] **600**	120 [1060] **597**	164 [1451] **540**	193 [1711] **526**	228 [2021] **510**	603
Max. Cont. 53 [14]		14 [127] **690**	50 [445] **689**	84 [741] (5)	124 [1098] **658**	155 [1369] **644**	185 [1640] **631**	217 [1918] **613**	704
61 [16]									804
Max. Inter. 64 [17]									904

Overall Efficiency - 70 - 100% (white) 40 - 69% (light) 0 - 39% (dark)

Theoretical Torque - Nm [lb-in]

21 [183]	41 [366]	83 [732]	124 [109 (8)	66 [1465]	207 [1831]	248 [2197]	290 [2564]

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

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.

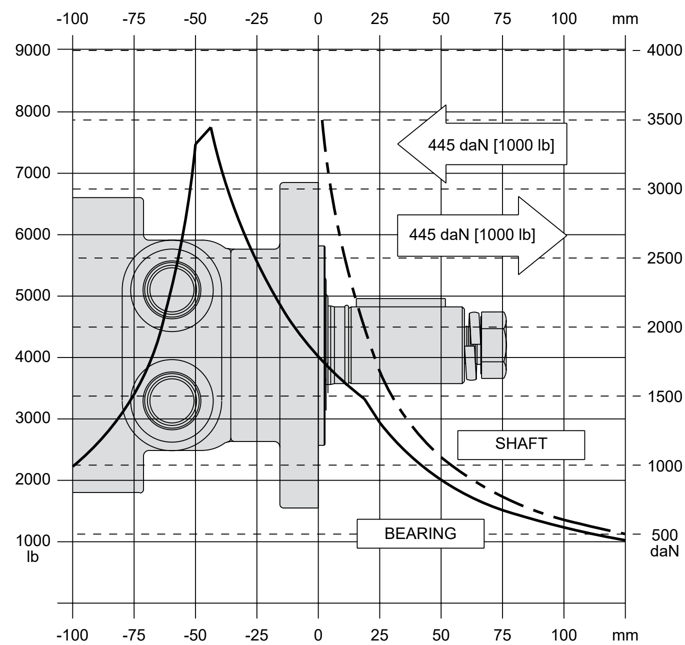
The bearing curves for each model are based on laboratory analysis and testing results constructed at Impro Fluidtek. The shaft loading is based on a 3:1 safety factor and 330 Kpsi tensile strength. The allowable load is the lower of the curves at a given point. For instance, one inch in front of the 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 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:

<u>Step One: Determine Rolling Resistance</u>

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

<u>Step Two: Determine Grade Resistance</u>

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.

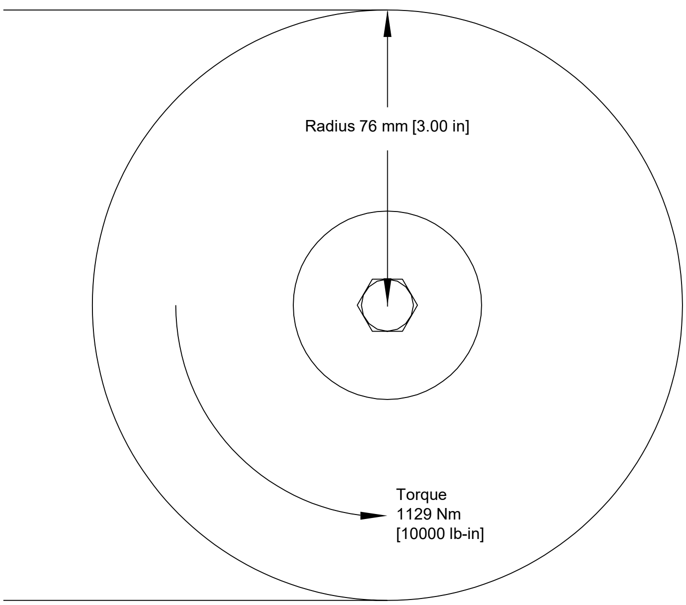
$$RL = \sqrt{W^2 + \left(\frac{T}{ri}\right)^2}\ lb \qquad RL = \sqrt{W^2 + \left(\frac{T}{rm}\right)^2}\ kg$$

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

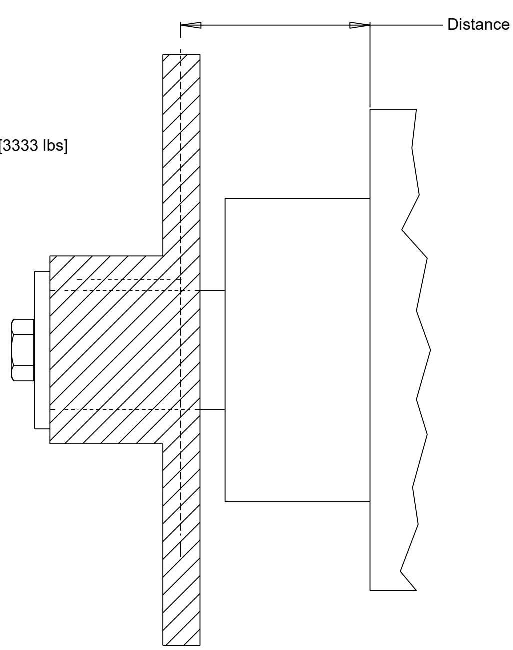
In many cases, pulleys or sprockets may be used to transmit the torque produced by the motor. Use of these components will create a torque induced side load on the motor shaft and bearings. It is important that this load be taken into consideration when choosing a motor with sufficient bearing and shaft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

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

Power In (HP) =

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

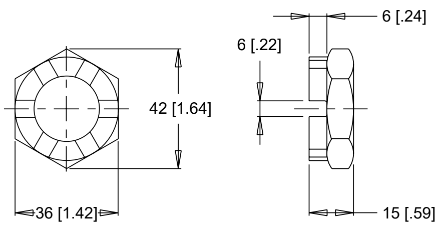
Power Out (HP) =

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

SHAFT NUT INFORMATION

35MM TAPERED SHAFTS
M24 x 1.5 Thread

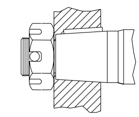
A Slotted Nut



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.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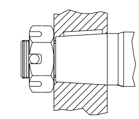
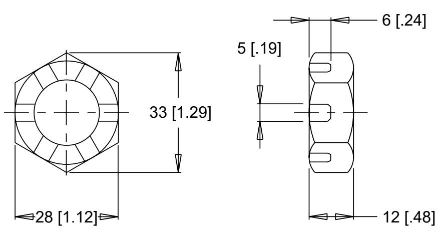

correct

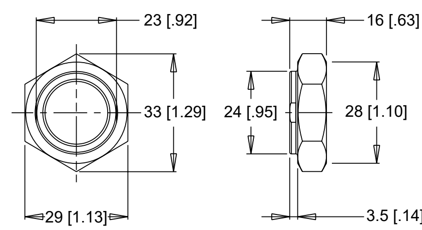
1" TAPERED SHAFTS
3/4-28 Thread

A Slotted Nut



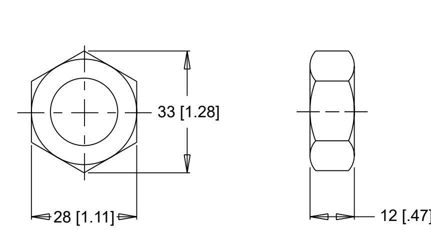
Torque Specifications: 20 - 23 daNm [150 - 170 ft.lb.]

B Lock Nut



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

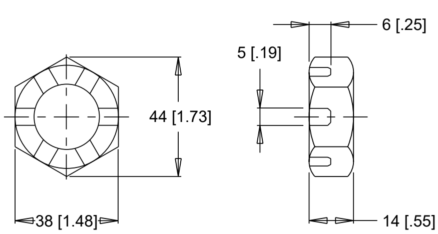
C Solid Nut



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

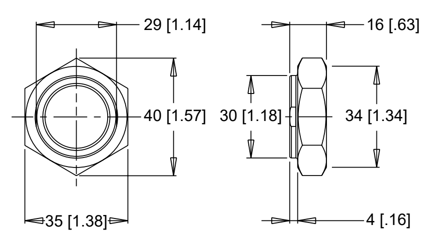
1-1/4" TAPERED SHAFTS
1-20 Thread

A Slotted Nut



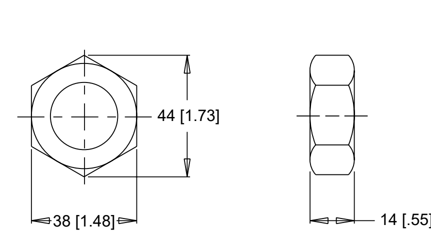
Torque Specifications: 38 daNm [280 ft.lb.] Max.

B Lock Nut



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

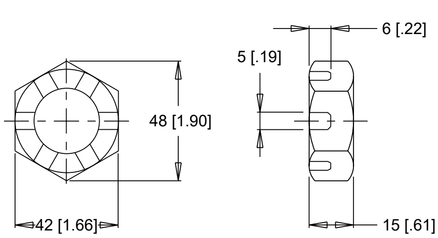
C Solid Nut



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

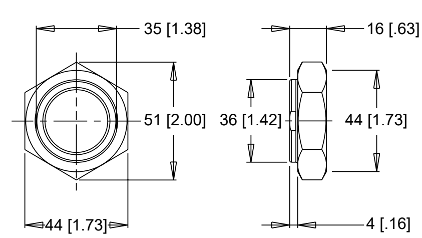
1-3/8" & 1-1/2" TAPERED SHAFTS
1 1/8-18 Thread

A Slotted Nut



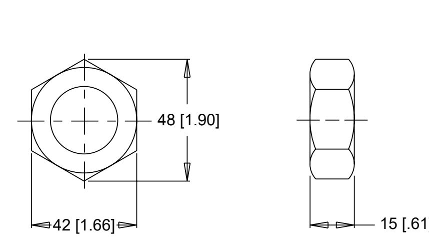
Torque Specifications: 41 - 54 daNm [300 - 400 ft.lb.]

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.

FEATURES / BENEFITS

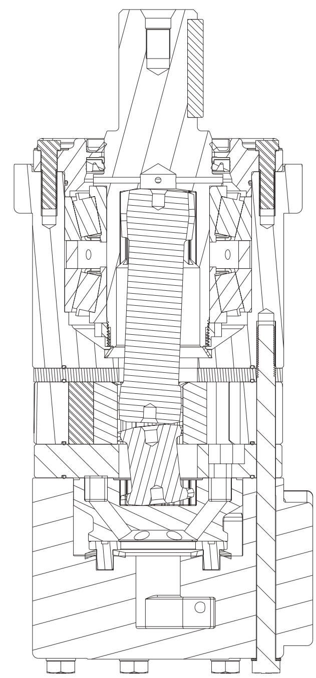
- Industry standard mounting and shaft options allows for easier system integration
- Integrated roller bearings provide higher radial load capacity
- Three zone commutator valving equates to higher volumetric efficiency
- Standard case drain and integral internal drain extends the overall life of the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

TYPICAL APPLICATIONS

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

SERIES DESCRIPTIONS

650/651 - Hydraulic Motor
Standard



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

195

196 cm³ [12.0 in³] / rev

Pressure - bar [psi] (Max. Cont. = 205 [2975]; Max. Inter. = 310 [4495])

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

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

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

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

Rotor Width mm [in]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]
22.8 [.898]	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]

245

246 cm³ [15.0 in³] / rev

Pressure - bar [psi] (Max. Cont. = 205 [2975]; Max. Inter. = 310 [4495])

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

Flow - lpm [gpm]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]	Theoretical rpm
8 [2]	47 [416] **29**	120 [1062] **28**	241 [2133] **26**	370 [3275] **23**	488 [4319] **20**	583 [5160] **18**	684 [6053] **15**				30
15 [4]	49 [434] **59**	114 [1009] **57**	243 [2151] **55**	371 [3283] **50**	497 [4398] **48**	606 [5363] **45**	729 [6452] **41**	852 [7540] **36**	969 [8576] **29**	1080 [9558] **23**	61
30 [8]	47 [416] **119**	112 [991] **117**	243 [2151] **113**	373 [3301] **107**	502 [4443] **102**	615 [5443] **98**	741 [6558] **94**	869 [7691] **90**	992 [8779] **85**	1105 [9779] **79**	122
45 [12]	43 [381] **180**	112 [991] **177**	242 [2142] **175**	375 [3319] **174**	504 [4460] **170**	623 [5514] **167**	754 [6673] **159**	885 [7832] **154**	1013 8965] **147**	1131 [10009] **140**	183
61 [16]	39 [345] **248**	109 [965] **246**	241 [2133] **244**	371 [3283] **241**	505 [4469] **240**	617 [5460] **235**	753 [6664] **223**	890 [7877] **219**	1010 [8939] **213**	1125 [9956] **205**	248
76 [20]	35 [310] **305**	103 [912] **302**	241 [2133] **301**	367 [3248] **298**	504 [4460] **288**	616 [5452] **282**	750 [6638] **276**	889 [7868] **266**	1009 [8930] **257**	1125 [9956] **250**	309
91 [24]		99 [876] **365**	234 [2071] **361**	365 [3230] **361**	497 [4398] **351**	614 [5434] **346**	741 [6558] **343**	870 [7700] **332**	1003 [8877] **324**		370
106 [28]		95 [841] **422**	223 [1974] **420**	355 [3142] **415**	492 [4354] **410**	612 [5416] **405**	728 [6531] **394**	866 [7664] **389**	996 [8815] **380**		431
121 [32]		84 [743] **483**	215 [1903] **481**	348 [3080] **479**	484 [4283] **472**	596 [5275] **466**	726 [6425] **458**	855 [7567] **448**	984 [8708] **440**		492
136 [36]		76 [673] **553**	207 [1832] **551**	338 [2991] **546**	475 [4204] **540**	587 [5195] **535**	721 [6381] **525**	852 [7540] **518**			553
151 [40] (Max. Cont.)		65 [575] **606**	199 [1761] **602**	326 [2885] **600**	457 [4044] **594**	579 [5124] **590**	713 [6310] **588**	824 [7292] **585**			614
170 [45]		52 [460] **683**	184 [1628] **678**	310 [2744] **675**	441 [3903] **670**	559 [4947] **661**	698 [6177] **658**	811 [7177] **646**			691
189 [50]			172 [1522] **756**	305 [2699] **751**	431 [3814] **745**	545 [4823] **741**	681 [6027] **739**				768
208 [55] (Max. Inter.)			151 [1336] **835**	281 [2487] **830**	423 [3744] **823**	528 [4673] **817**	641 [5673] **811**				846

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

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

Rotor Width mm [in]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]
28.7 [1.130]	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

310

311 cm³ [19.0 in³] / rev

Pressure - bar [psi] — Max. Cont.: 205 [2975]; Max. Inter.: 310 [4495]

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

Flow - lpm [gpm]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]	Theoretical rpm
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] (Max. Cont.)		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] (Max. Inter.)			181 [1602] **729**	341 [3018] **721**	508 [4496] **710**	651 [5761] **707**	812 [7186] **704**				730

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

Overall Efficiency - 70 - 100% (white) 40 - 69% (light) 0 - 39% (dark)

Rotor Width mm [in]										
36.3 [1.429]	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]

390

391 cm³ [23.9 in³] / rev

Pressure - bar [psi] — Max. Cont.: 205 [2975]; Max. Inter.: 310 [4495]

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

Flow - lpm [gpm]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	310 [4495]	Theoretical rpm
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] (Max. Cont.)		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] (Max. Inter.)			228 [2018] **578**	437 [3867] **575**	646 [5717] **568**	809 [7160] **559**					581

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

Overall Efficiency - 70 - 100% (white) 40 - 69% (light) 0 - 39% (dark)

Rotor Width mm [in]										
45.6 [1.795]	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

490

490 cm³ [29.9 in³] / rev

Pressure - bar [psi] (Max. Cont.: 205 [2975]; Max. Inter.: 275 [3990])

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

Flow - lpm [gpm]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]	Theoretical rpm
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] **274**	958 [8478] **270**	1168 [10337] **260**				278
Max. Cont. 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
Max. Inter. 227 [60]			293 [2593] **459**	559 [4947] **456**	816 [7222] **450**					463

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

Overall Efficiency - 70 - 100% (white) 40 - 69% (light) 0 - 39% (dark)

Rotor Width mm [in]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	240 [3480]	275 [3990]
57.3 [2.256]	117 [1035]	273 [2416]	546 [4831]	819 [7247]	1092 [9662]	1326 [11733]	1599 [14149]	1872 [16564]	2145 [18980]

Theoretical Torque - Nm [lb-in]

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

625

625 cm³ [38.1 in³] / rev

Pressure - bar [psi] (Max. Cont.: 170 [2465]; Max. Inter.: 221 [3205])

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

Flow - lpm [gpm]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	221 [3205]	Theoretical rpm
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
Max. Cont. 151 [40]		195 [1726] **238**	523 [4629] **236**	856 [7576] **232**					242
189 [50]			459 [4062] **301**	773 [6841] **299**					302
Max. Inter. 227 [60]			374 [3310] **358**	719 [6363] **356**					363

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

Overall Efficiency - 70 - 100% (white) 40 - 69% (light) 0 - 39% (dark)

Rotor Width mm [in]	15 [220]	35 [510]	70 [1015]	105 [1520]	140 [2030]	170 [2465]	205 [2975]	221 [3205]
73.1 [2.878]	149 [1320]	348 [3081]	696 [6162]	1044 [9243]	1393 [12325]	1691 [14966]	2039 [18047]	2198 [19455]

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.

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DISPLACEMENT PERFORMANCE

735

735 cm³ [44.9 in³] / rev

Pressure - bar [psi] (Max. Cont.: 140 [2030]; Max. Inter.: 170 [2465])

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

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

Flow - lpm [gpm]	35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	155 [2250]	170 [2465]	Theoretical rpm
8 [2]	382 [3381] **9**	542 [4797] **9**	755 [6682] **8**	917 [8115] **8**	1113 [9850] **7**					10
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**	20
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**		41
45 [12]	371 [3283] **59**	534 [4726] **57**	754 [6673] **56**	915 [8098] **54**	1146 [10142] **53**	1304 [11540] **51**	1520 [13452] **49**			61
61 [16]	360 [3186] **81**	525 [4646] **79**	749 [6629] **78**	911 [8062] **77**	1137 [10062] **76**	1302 [11523] **74**				83
76 [20]	348 [3080] **101**	511 [4522] **101**	737 [6522] **100**	908 [8036] **99**	1130 [10001] **97**	1295 [11461] **94**				103
91 [24]	336 [2974] **122**	495 [4381] **120**	721 [6381] **119**	886 [7841] **119**	1114 [9859] **117**					124
106 [28]	316 [2797] **143**	483 [4275] **142**	708 [6266] **140**	881 [7797] **139**	1101 [9744] **137**					144
121 [32]	294 [2602] **164**	462 [4089] **162**	683 [6045] **162**	856 [7576] **161**	1083 [9585] **160**					165
136 [36]	280 [2478] **181**	450 [3983] **181**	671 [5938] **180**	844 [7469] **179**						185
Max. Cont. 151 [40]	260 [2301] **201**	420 [3717] **201**	645 [5708] **200**	810 [7169] **199**						205
189 [50]		356 [3151] **252**	578 [5115] **252**	746 [6602] **249**						257
Max. Inter. 227 [60]			503 [4452] **303**	660 [5841] **301**						309

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

Rotor Width mm [in]	35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	155 [2250]	170 [2465]
86.2 [3.394]	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]

805

799 cm³ [48.8 in³] / rev

Pressure - bar [psi] (Max. Cont.: 140 [2030]; Max. Inter.: 170 [2465])

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

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

Flow - lpm [gpm]	35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	155 [2250]	170 [2465]	Theoretical rpm
8 [2]	396 [3505] **9**	554 [4903] **8**	763 [6753] **8**	908 [8036] **7**	1133 [10027] **6**	1266 [11204] **5**				9
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**	19
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**		38
45 [12]	401 [3549] **54**	575 [5089] **54**	416 [7222] **53**	999 [8841] **53**	1240 [10974] **52**	1416 [12532] **50**	1635 [14470] **46**			56
61 [16]	392 [3469] **74**	565 [5000] **73**	805 [7124] **73**	986 [8726] **73**	1228 [10868] **72**	1429 [12647] **66**				76
76 [20]	379 [3354] **93**	551 [4876] **93**	792 [7009] **92**	971 [8593] **92**	1215 [10753] **91**	1421 [12576] **84**				95
91 [24]	359 [3177] **111**	533 [4717] **111**	778 [6885] **111**	957 [8469] **110**	1196 [10585] **109**					114
106 [28]	334 [2956] **131**	513 [4540] **131**	755 [6682] **130**	939 [8310] **129**	1177 [10416] **127**					133
121 [32]	327 [2894] **149**	500 [4425] **148**	738 [6531] **146**	910 [8054] **145**	1160 [10266] **143**					151
136 [36]	300 [2655] **168**	478 [4230] **166**	717 [6345] **165**	901 [7974] **163**						170
Max. Cont. 151 [40]	275 [2434] **188**	457 [4044] **185**	696 [6160] **184**	876 [7753] **182**						189
189 [50]	185 [1637] **236**	373 [3301] **236**	613 [5425] **234**	798 [7062] **233**						237
Max. Inter. 227 [60]		296 [2620] **282**	527 [4664] **281**	697 [6168] **280**						284

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

Rotor Width mm [in]	35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	155 [2250]	170 [2465]
70.0 [2.756]	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]

► 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

985

983 cm³ [60.0 in³] / rev

Pressure - bar [psi] — Max. Cont.: 140 [2030]

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

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

Flow - lpm [gpm]	15 [220]	35 [510]	50 [725]	70 [1015]	85 [1235]	105 [1520]	120 [1740]	140 [2030]	Theoretical rpm
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
Max. Cont. 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
Max. Inter. 227 [60]			357 [3159] **228**	639 [5655] **227**	844 [7469] **227**				231

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

Rotor Width								
86.2 [3.394]	235 [2077]	548 [4846]	782 [6923]	1095 [9692]	1330 [11769]	1643 [14538]	1877 [16615]	2190 [19384]

mm [in] — Theoretical Torque - Nm [lb-in] Displacement tested at 54°C [129°F] with an oil viscosity of 46cSt [213 SUS]

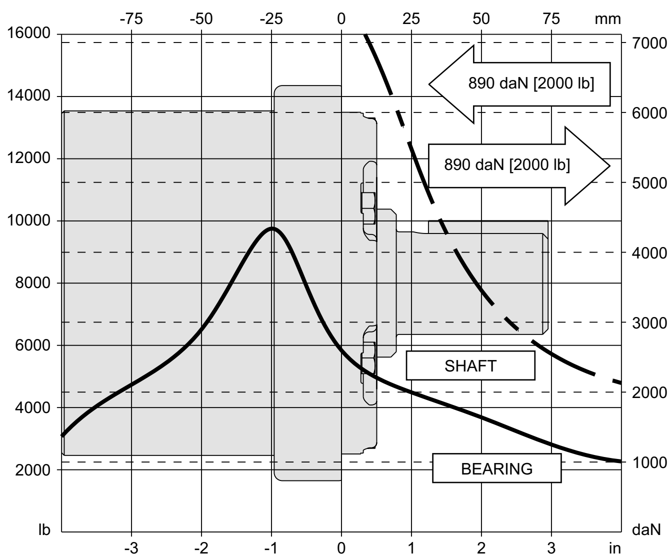
▶ Performance data is typical. Performance of production units varies slightly from one motor to another. Operating at maximum continuous pressure and maximum continuous flow simultaneously is not recommended.

TECHNICAL INFORMATION

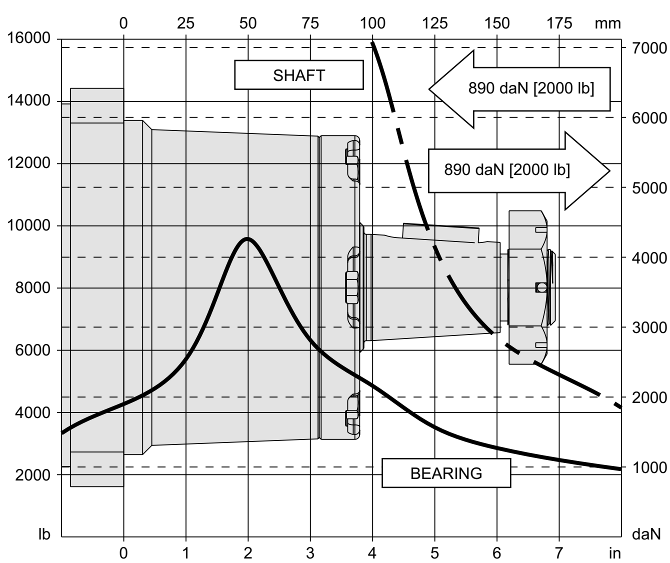
ALLOWABLE SHAFT LOAD / BEARING CURVE

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

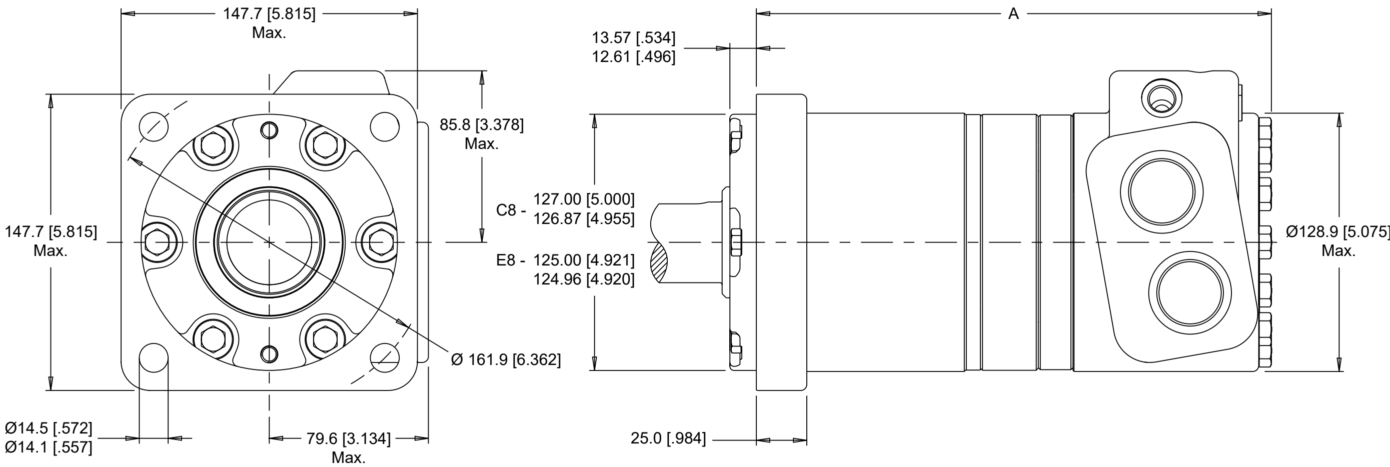
RPM	FACTOR	RPM	FACTOR
50	1.23	500	0.62
100	1.00	600	0.58
200	0.81	700	0.56
300	0.72	800	0.50
400	0.66		

HOUSINGS

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

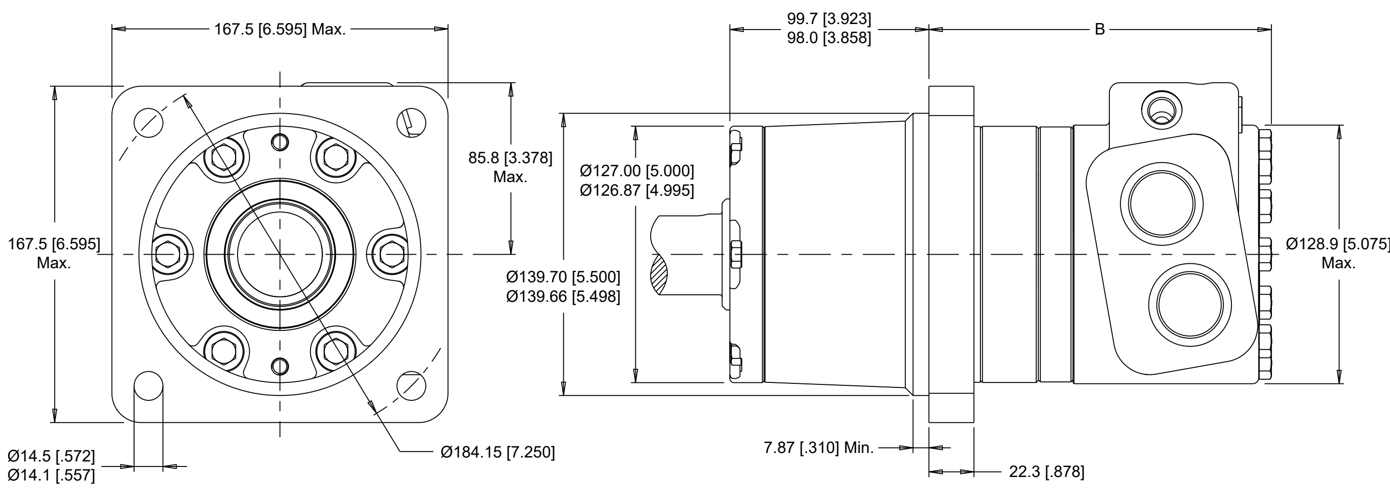
4-HOLE, SAE C MOUNT

C8 Side Ports **E8** Side Ports



4-HOLE, WHEEL MOUNT

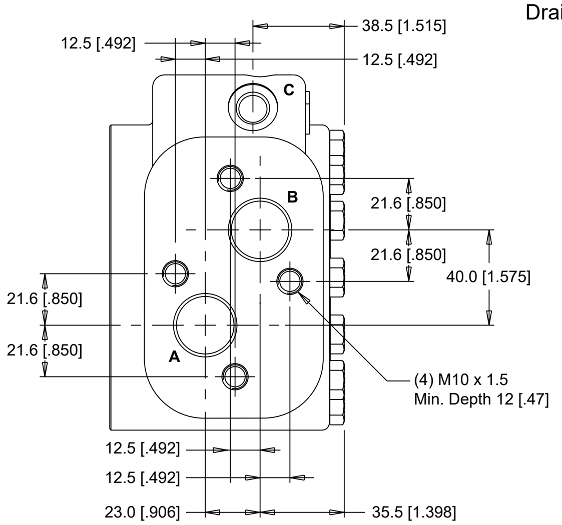
W8 Side Ports



▶ Dimension A & B are charted on page 18.

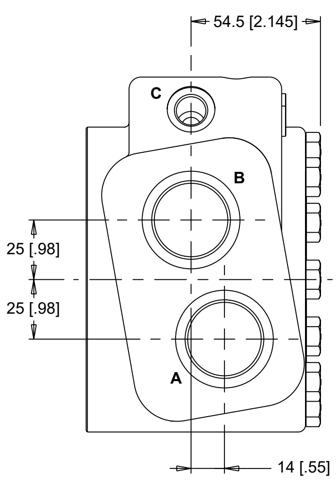
PORTING

SIDE PORTED - OFFSET MANIFOLD



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

SIDE PORTED - OFFSET

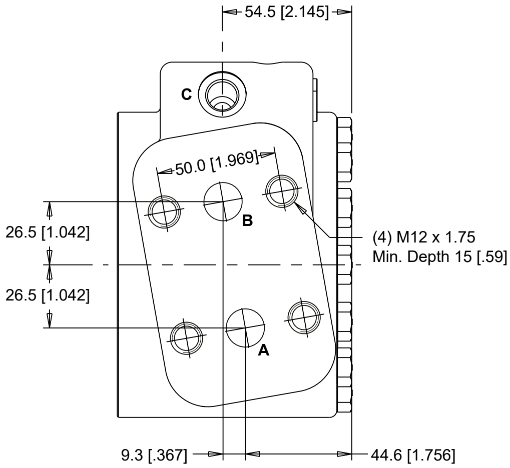


8	Main Ports **A, B**:	G 1
	Drain Port **C**:	G 1/4
J	Main Ports **A, B**:	M33 X 2
	Drain Port **C**:	M14 X 1.5
9	Main Ports **A, B**:	1 5/16-12 UN
	Drain Port **C**:	7/16-20 UNF
P	Main Ports **A, B**:	M33 X 2
	Drain Port **C**:	G 1/4

PORTING

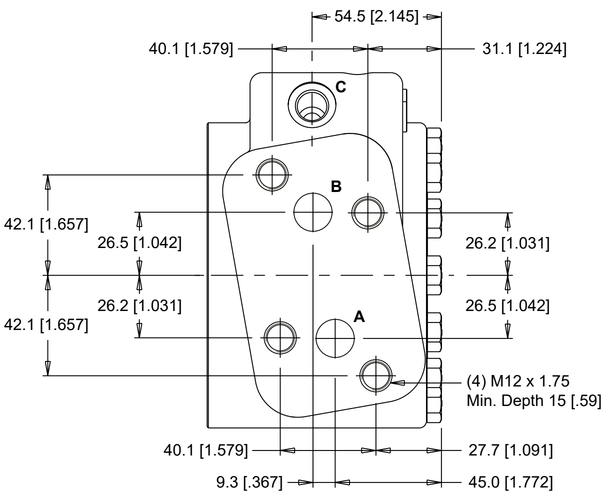
SIDE PORTED - STANDARD MANIFOLD

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



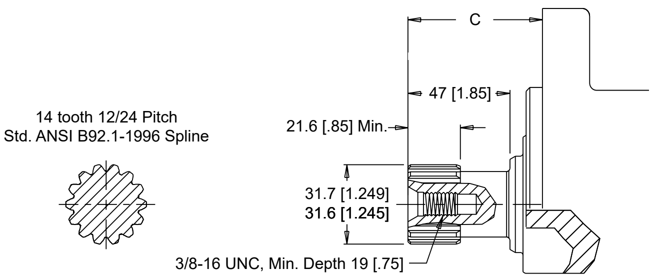
SIDE PORTED - OFFSET MANIFOLD

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



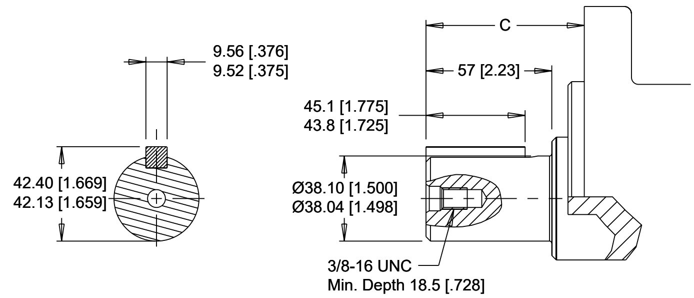
SHAFTS

23 14 Tooth Spline



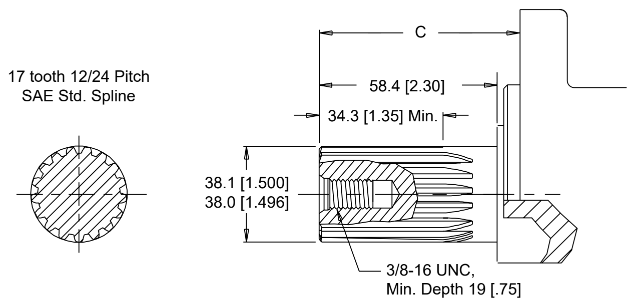
Max. Torque: 2070 Nm [18400 lb-in]

30 1-1/2" Straight



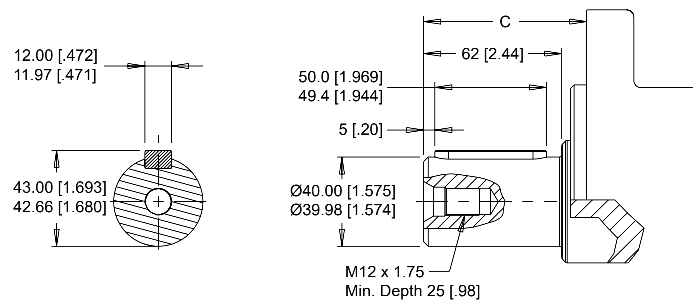
Max. Torque: 2230 Nm [19800 lb-in]

33 17 Tooth Spline



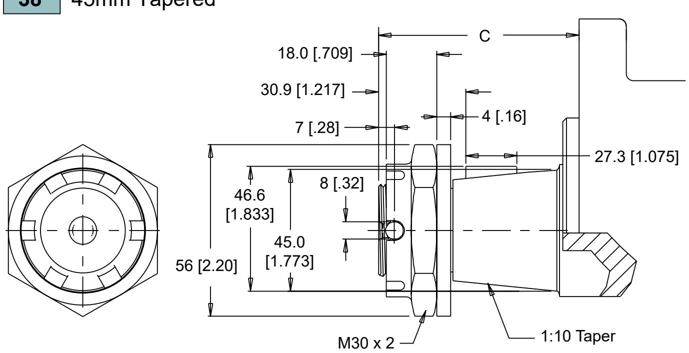
Max. Torque: 2250 Nm [19900 lb-in]

36 40mm Straight



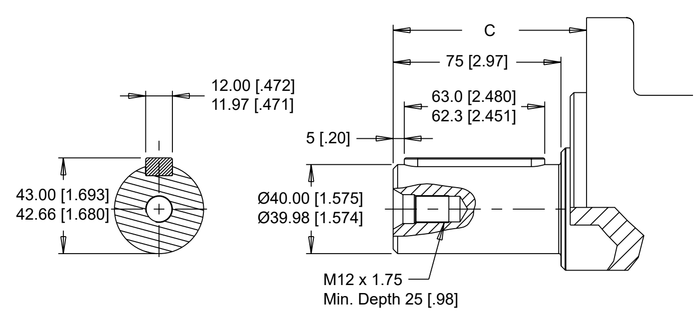
Max. Torque: 2700 Nm [24000 lb-in]

38 45mm Tapered



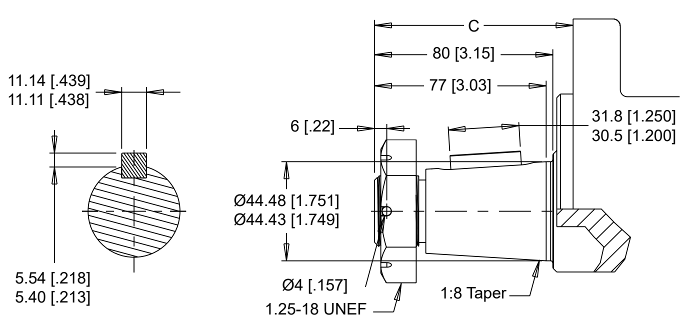
Max. Torque: 3950 Nm [35000 lb-in]

54 40mm Straight Extended



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

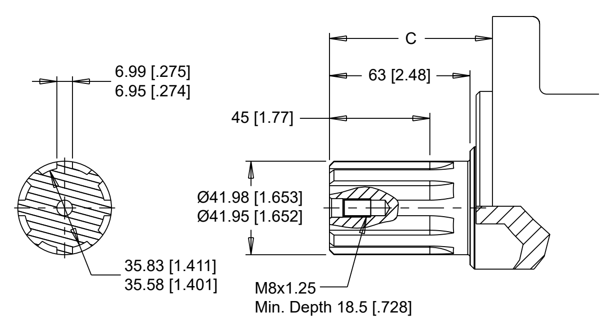
64 1-3/4" Tapered



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

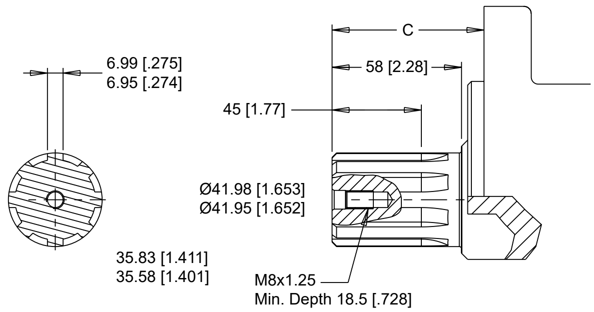
▶ A slotted hex nut is standard on this shaft.

K2 8D Spline Extended



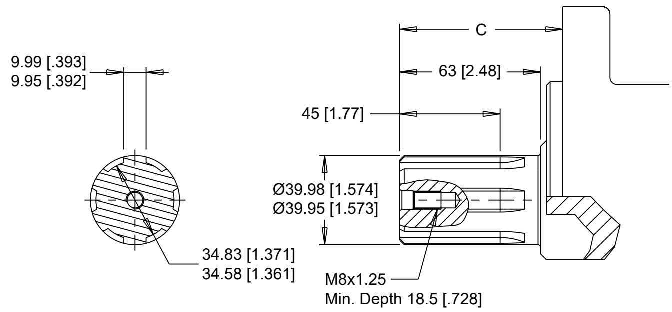
Max. Torque: 2250 Nm [19900 lb-in]

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.

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

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]

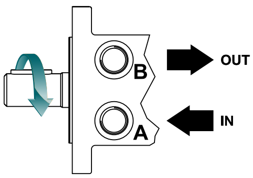
Impro Fluidtek

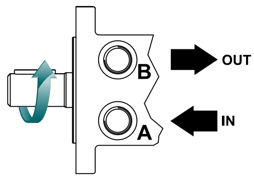
ORDERING INFORMATION

1			2			3a		3b	4		5	6	7	8	

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

4. SELECT A SHAFT OPTION

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

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