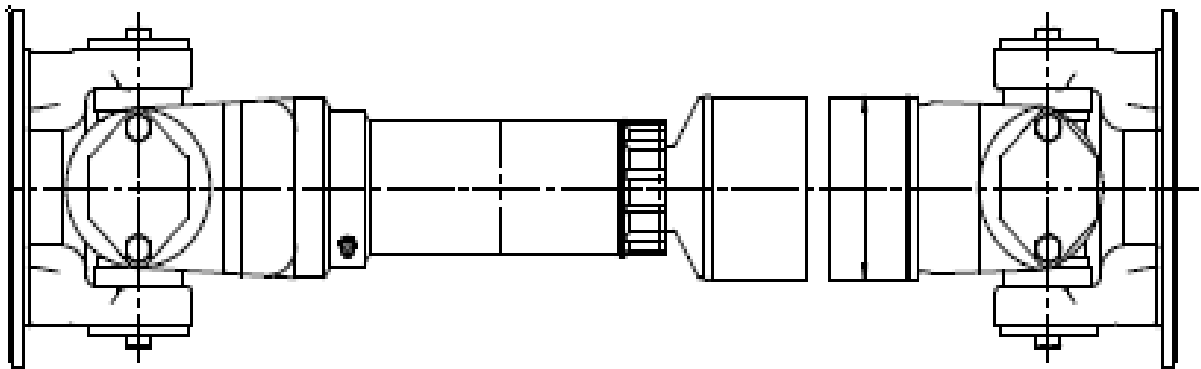




A Gorman-Rupp Company

**<FM> CERTIFIED RATINGS &  
INSTALLATION & MAINTENANCE MANUAL FOR  
FIRE PUMP DRIVESHAFTS**



**Patterson Pump Company**

**A GORMAN-RUPP COMPANY**

**PO Box 790**

**2129 Ayersville Road**

**Toccoa, GA 30577**

**(706) 886-2101**

**[www.pattersonpumps.com](http://www.pattersonpumps.com)**

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# Section 1 – General

## PATTERSON DIESEL DRIVEN – DRIVESHAFT RATINGS

With Evaluated HP and <FM> Required Service Factor

SHAFT SERIES	1470	1760	2100	2350	2400	2600	2800	3000
P2171	146	175	209	233				
P2181	285	341	407					
P3172	413	494						

SHAFT SERIES	STANDARD LENGTH	MAXIMUM AVAILABLE LENGTH
P2161	9.12" + .75" SLIP	36" + or - 2.44"
P2171	10.62" + .75" SLIP	36" + or -1.94"
P2181	13.4" + 1.12" SLIP	36" + or - 1.69"
P3172	18.11" + 1.58" SLIP	36" + or - 2.19"

The calculated end-use application horsepower, as adjusted by the service factor, shall not exceed the horsepower rating of the connecting shaft at the applicable speed.

Selection of the Flexible connecting drive shaft shall be based on rating of the driver and not the pump.

Although FM listed horsepower ratings are shown at specific speeds, PPC drive shafts can be applied at any intermediate speed. To determine the intermediate certified horsepower, make a linear interpolation from the PPC FM listed power chart.

## 1.2 Introduction

This manual provides information for the installation and maintenance of universal joint driveshafts intended for use with diesel engine drivers. Following proper installation and maintenance procedures produces the optimum results in shaft performance and safety.

Manuals should be considered part of the equipment. It is recommended to keep the manuals with the equipment. If the equipment is sold or traded, please transfer manuals to the new owner.

All personnel responsible for operation and maintenance of the equipment should read and thoroughly understand this manual.

Driveshafts shall be installed in accordance with the Standard for Installation of Stationary Pumps for Fire Protection, NFPA 20.

It is recommended that a torsional analysis be conducted on the actual drive system arrangement.

## 1.3 Safety Precautions

**Warning:** Read and understand all of the safety precautions and warnings before performing any repair. This manual contains the general safety precautions that must be followed to provide personal safety.

**Warning:** Rotating shafts can be dangerous. Keep hands, body parts, long hair, or loose fitting clothing clear at all times.

**Warning:** Rotating shafts can be dangerous. Follow all safety and lockout precautions during installation, maintenance and operation.

**Warning:** Perform a walk around inspection and alert all area personnel that the equipment will be starting before operation.

**Caution:** Consult applicable local and national safety codes for proper guarding of rotating members. Observe all safety rules when installing or servicing manual is for driveshafts only.

**Warning:** After performing maintenance, remove all tools and foreign materials, reinstall and securely fasten ALL guards, covers and protective devices.

## 1.4 Warranty

Limited Warranty does not cover failures or damage due to abuse or neglect and including, but not limited to: shipping damage, improper storage, improper installation, unauthorized modifications or lack of maintenance. Patterson Pump Company is not responsible for incidental or consequential damages.

## 1.5 Basic Guidelines to Universal Joint Driveshafts

Even though driveshafts have the unique capability of accepting both axial and offset movements, the following precautions must be taken:

1.4.1 They must work in pairs. A universal joint, working at an angle, will vibrate if it is not cancelled by another joint. The second joint (opposite side of the shaft) must be working at the same angle and in the same plane. (See Figures 1 & 2)

1.4.2 Joint angles must be equal within  $\frac{1}{2}$  degree. Joints, working in pairs will vibrate if they are not working at the same angle within  $\frac{1}{2}$  degree. (See Figure 2).

1.4.3 Yokes must be in phase (Figures 1 & 2). Joints, working in pairs, will vibrate if their yoke ears are not in the same plane.

1.4.4 Standard installation (Figure 1) requires that the input and output shafts be parallel.

1.4.5 In the alternate installation (Figure 2) the centerlines of the output and input shafts must intersect at the center of the driveshaft. Consult factory for installation using this method.

1.4.6 The universal joint operating angle shall be within 1-3 degrees.

1.4.7 To determine the correct amount of working angle; a) Measure the length in inches from centerline of yoke bore(s) to centerline of opposing yoke bore(s). b) Measure parallel offset between centerline of drive and driven shafts.

The actual offset shall measure 0.42 +/- 0.20 inches per 12 inches of shaft length. Following this offset relationship will yield an operating angle of 1-3 degrees.

## SINGLE SHAFT STANDARD INSTALLATION PARALLEL

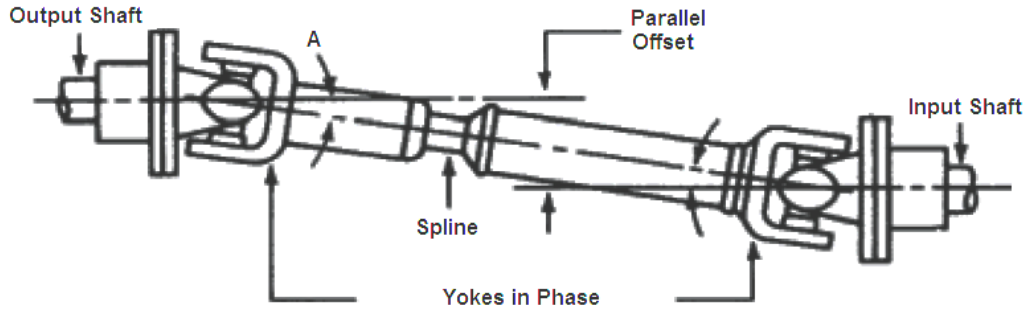


Figure 1

## SINGLE SHAFT ALTERNATE INSTALLATION

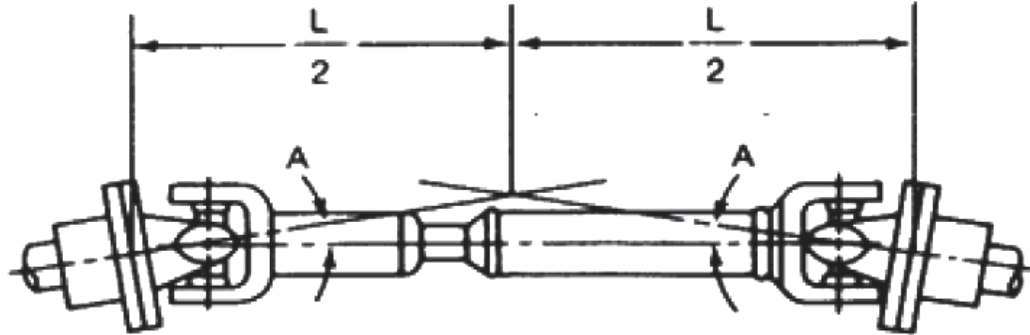


Figure 2

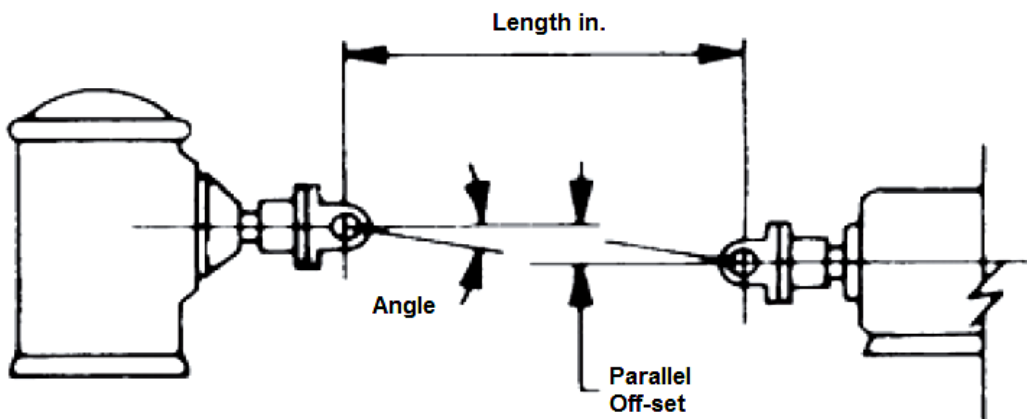


Figure 3

## Section 2 - Installation

### 2.1 Driveshaft Installation

2.1.1 Clean flange faces removing all paints or contaminants from the surface. Examine mating surfaces for any damage or nicks in the machine finish. Failure to properly clean the mating surfaces can result in premature driveshaft connection failure.

2.1.2 Inspect companion flanges for proper installation (see Section 2.2).

2.1.3 Compress driveshaft and place into position between mating flanges (see Figure 4). Large universal joint shaft assemblies are very heavy, use proper lifting equipment during installation. Carefully align pilot bore boss into/onto companion flange mating diameter. Align bolt holes on driveshaft flange with holes on companion flange. Secure flange to driveshaft with proper hardware. Extend shaft at slip section until pilot bore boss aligns with companion flange pilot bore boss. Align holes and secure flange.

2.1.4 Torque fasteners to proper specification (see Table B, pg.15).

2.1.5 Lubricate all joints and splines (where applicable) before startup. Lubricate until lubricant appears at all four bearing cap seals.

2.1.6 Verify offset and shaft operating angles.

2.1.7 Install proper shaft guarding prior to start up.

### 2.2 Companion Flange Installation

There are two types of mating flanges available for connecting the drive and driven unit shaft ends to the driveshaft. Type (1) SF standard flange accepts through bolting. Type (2) SLF large bore flange are drilled and threaded to accept fasteners or stud kit (see Figure 5). Stock bore companion flanges SF or SLF are bored with a plus 0.001" minus 0.000" tolerance and shall be a slip fit over mating shaft.

2.2.1 Align flange keyway with shaft key and gently tap flange onto shaft with soft face mallet. Take extreme care not to damage flange face or flange. If flange does not install easily, remove and retry. **Note:** The drive/driven shaft shall not extend out beyond the flange face or pilot bore/boss.

2.2.2 Tighten setscrew(s) to recommended torque (see Table C, pg. 15).

2.2.3 Check concentricity of companion flange face and pilot. Maximum allowable TIR is 0.003" on face and pilot (see Figure 6).

# HORIZONTAL APPLICATION SINGLE SECTION

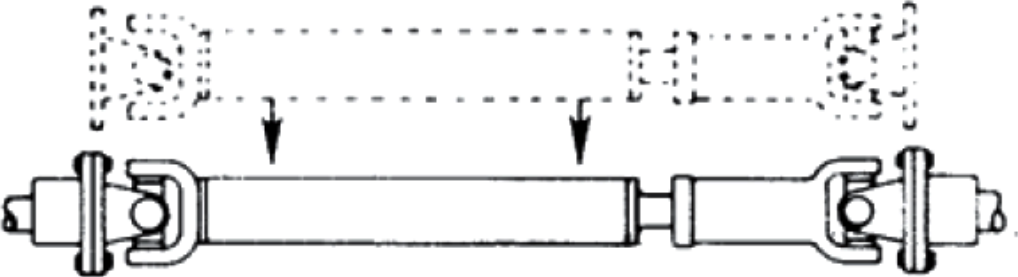


Figure 4

# FRICITIONAL FACE DRIVE DESIGN

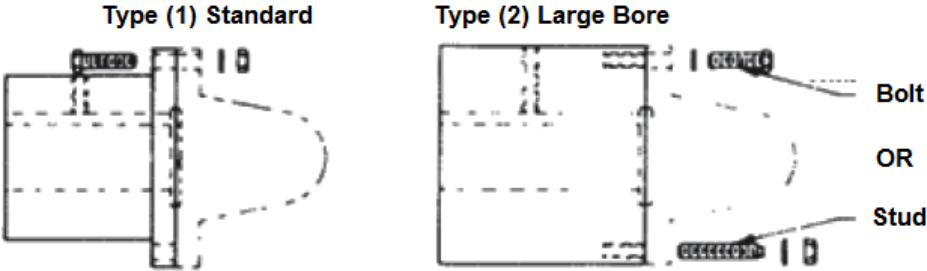


Figure 5

# FLANGE & SHAFT

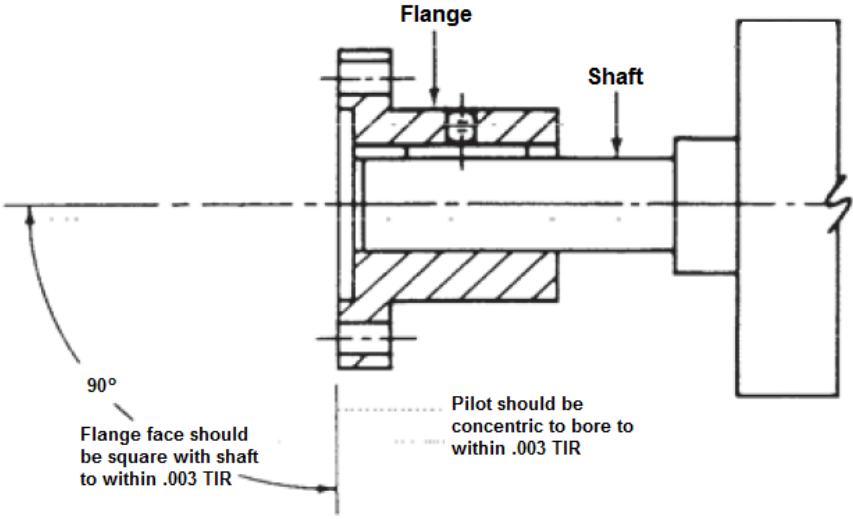


Figure 6



2.2.4 Thoroughly clean and inspect flange mounting face removing any oils, dirt, or contaminants.

### 2.3 Shaft Alignment

The procedure below is based on a fire pump installation where the engine crankshaft centerline is on the same centerline as the pump when examined from the top view and parallel in the side view (see Figure 7). If installation requires another configuration, please consult factory customer service for assistance. For all measurements vernier caliper or dial indicator will be needed.

#### 2.4 Vertical Offset

2.4.1 Position (rotate) shaft so that the inboard shaft yokes are vertical as shown (Figure 8a & 8c).

2.4.2 Measure distance from point A to B as shown (Figure 8a or 8c).

2.4.3 Measure distance from point C to D as shown in (Figure 8a or 8c).

2.4.4 On Table A locate row of shaft Part Number being aligned.

2.4.5 Raise or lower drive or driven unit until measurements AB & CD are within the Vertical Offset Tolerance range as noted in Table A.

2.4.6 When finished, measurements AB and CD must also have equal values within tolerance ranges identified in Table A.

#### 2.5 Horizontal Offset

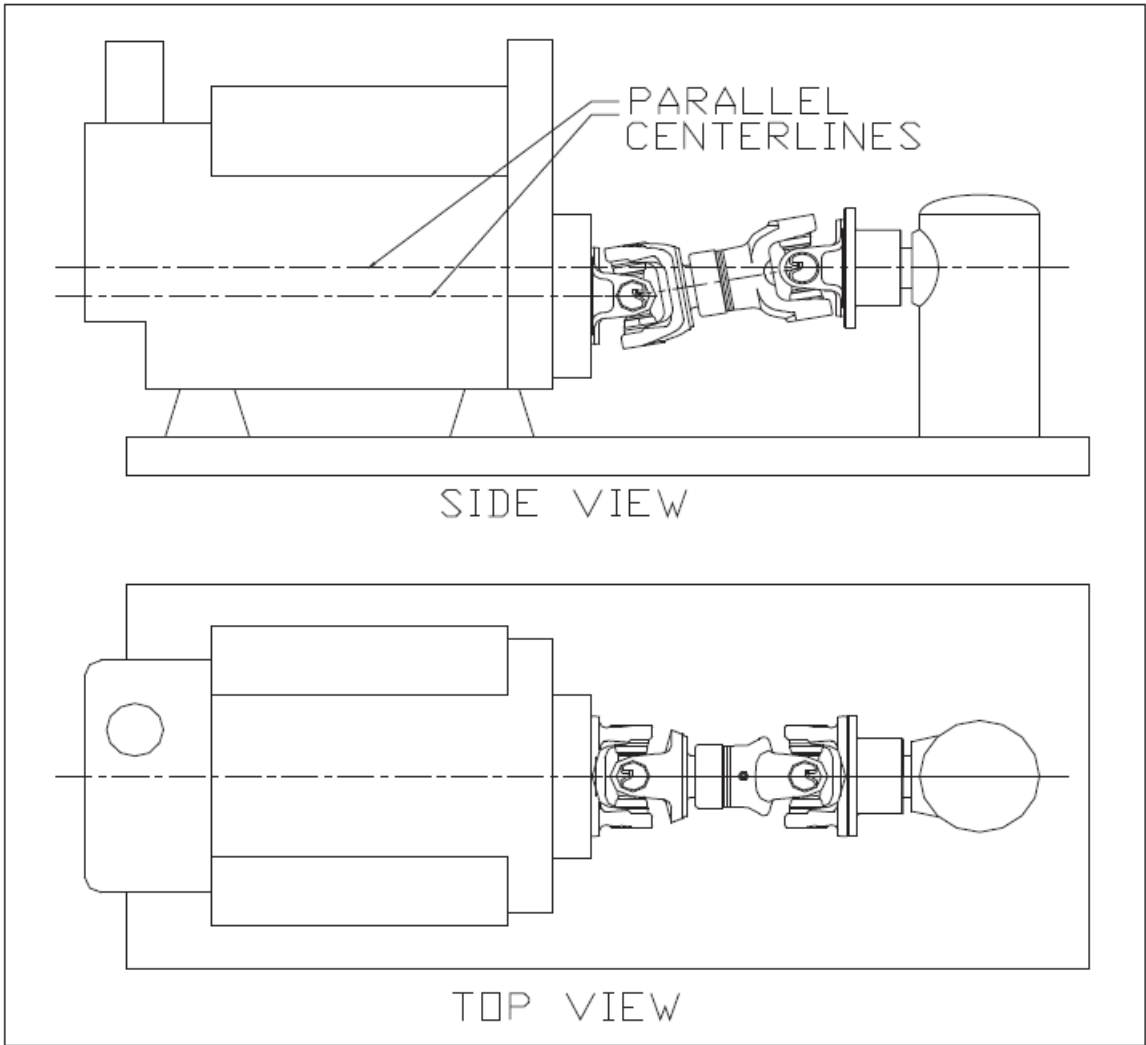
Because the centerlines of the crankshaft and pump unit are designed to be on the same centerline, the horizontal offset alignment check is to confirm near zero misalignment.

2.5.1 Position (rotate) the shaft so that the inboard yokes are horizontal (Figure 8b or 8d).

2.5.2 Measure distance from point J to K as shown (Figure 8b or 8d).

2.5.3 Measure distance from point L to M as shown (Figure 8b or 8d).

2.5.4 See Table A and identify the proper row with applicable values of the shaft that is being installed.



**Figure 7**

P3172

Vertical Offset Sectional View

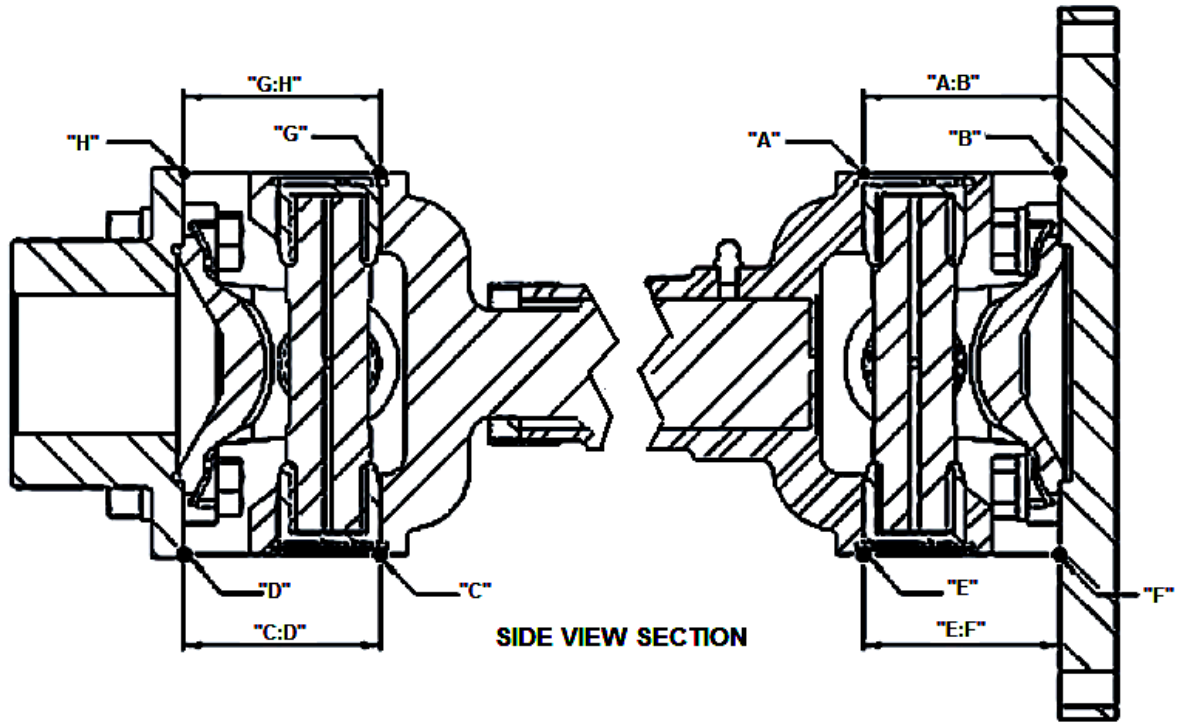
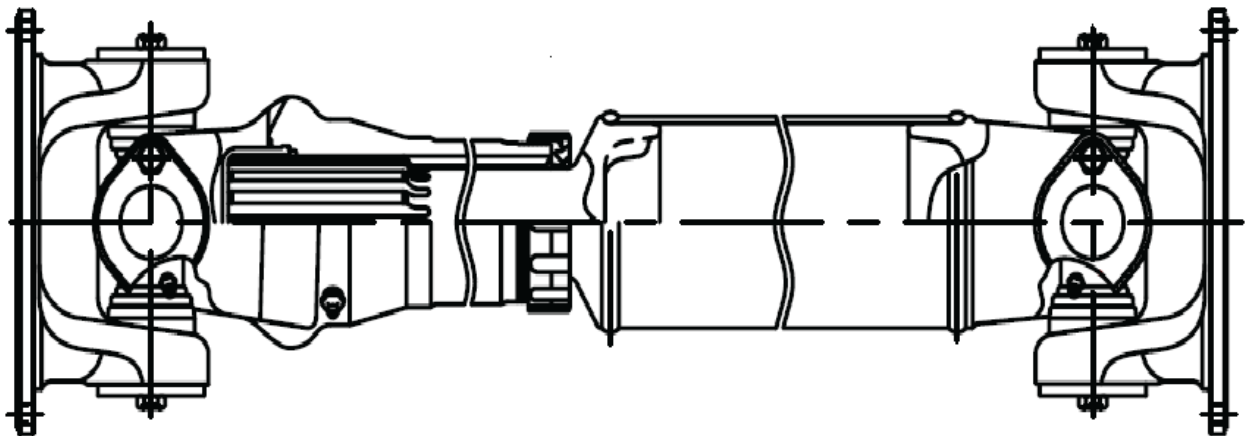


FIGURE 8A



P3172

Horizontal Offset Sectional View

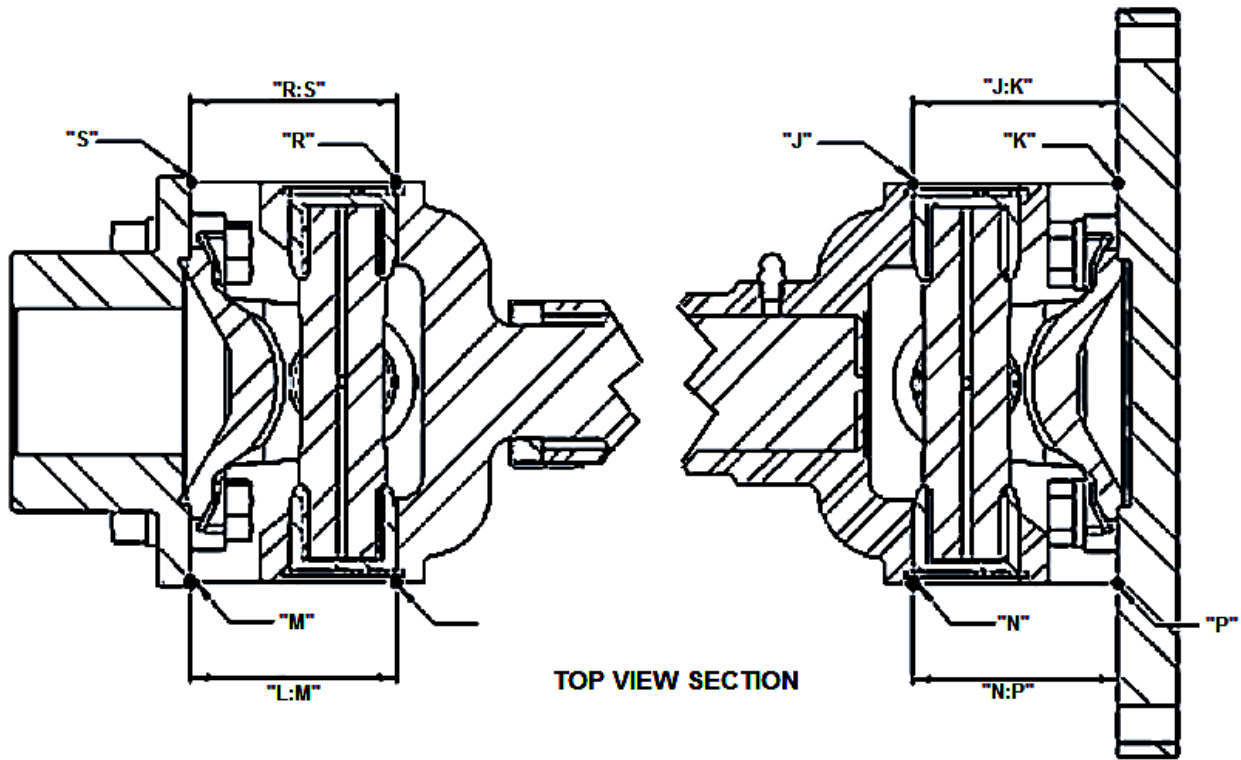
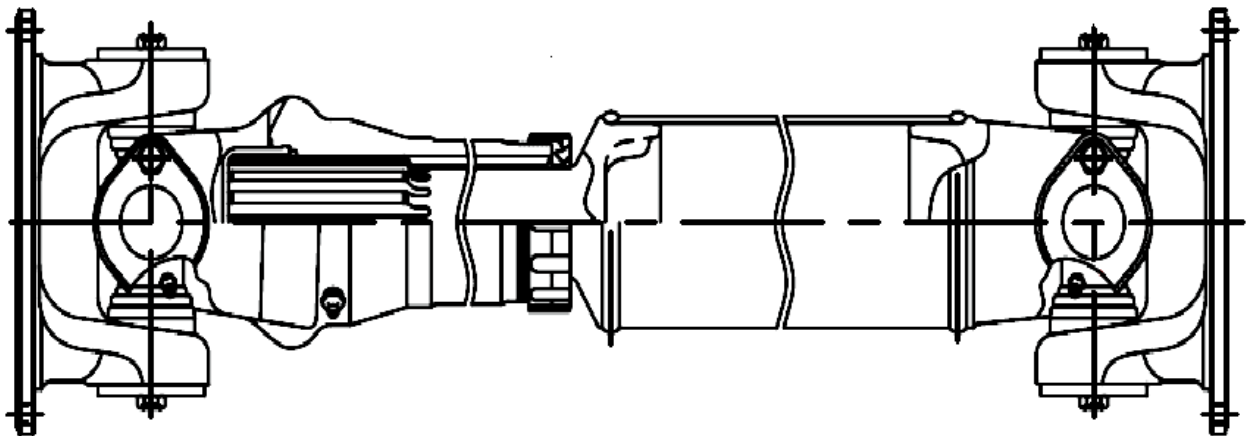


FIGURE 8b



# P2161-P2181

## Vertical Offset Sectional View

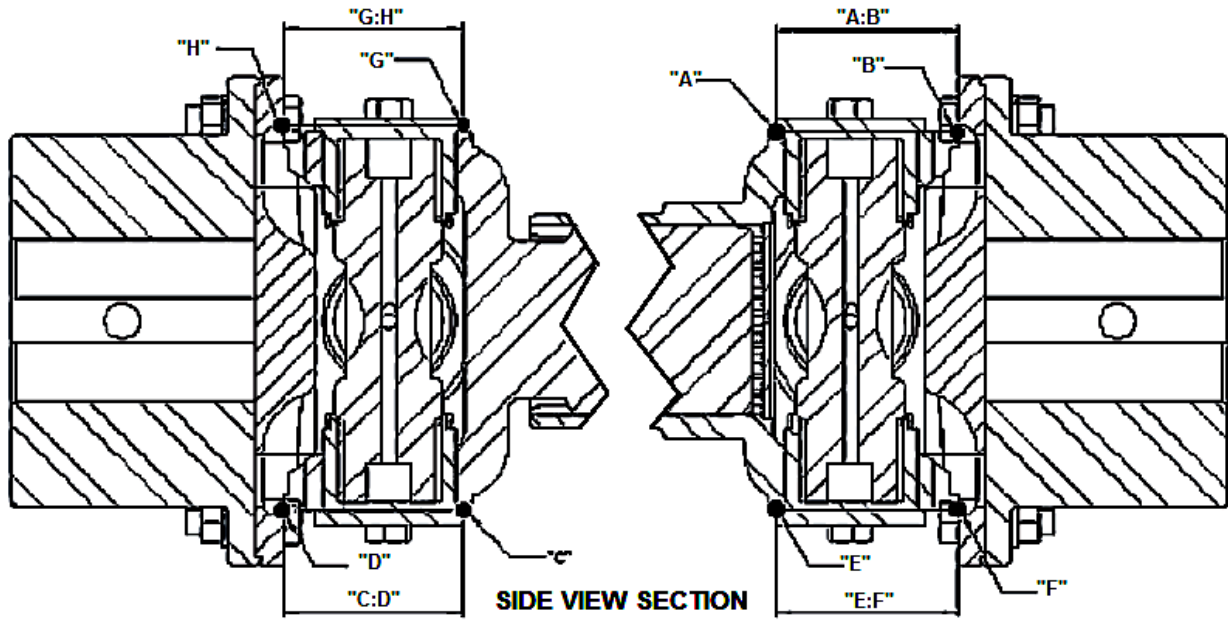
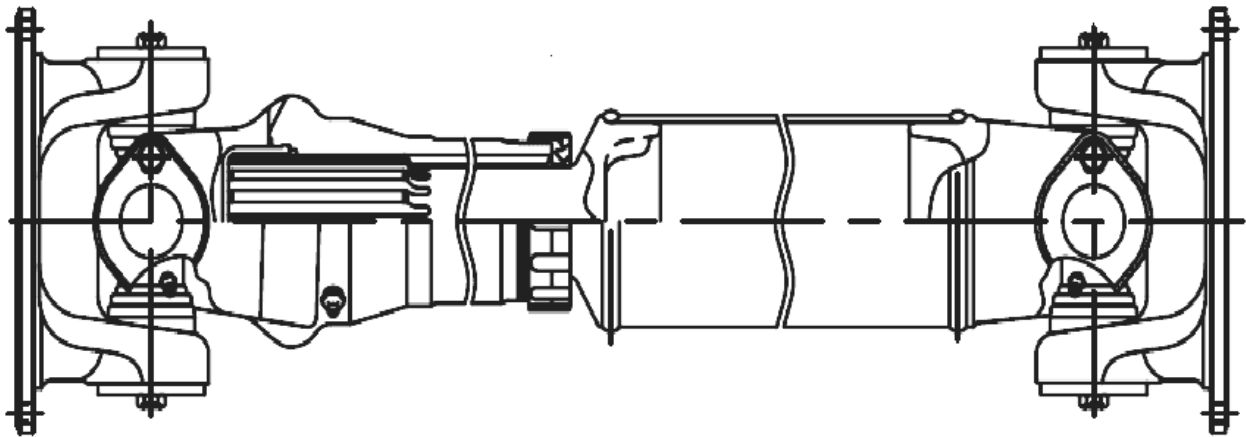


FIGURE 8c



P2161-P2181

Horizontal Offset Sectional View

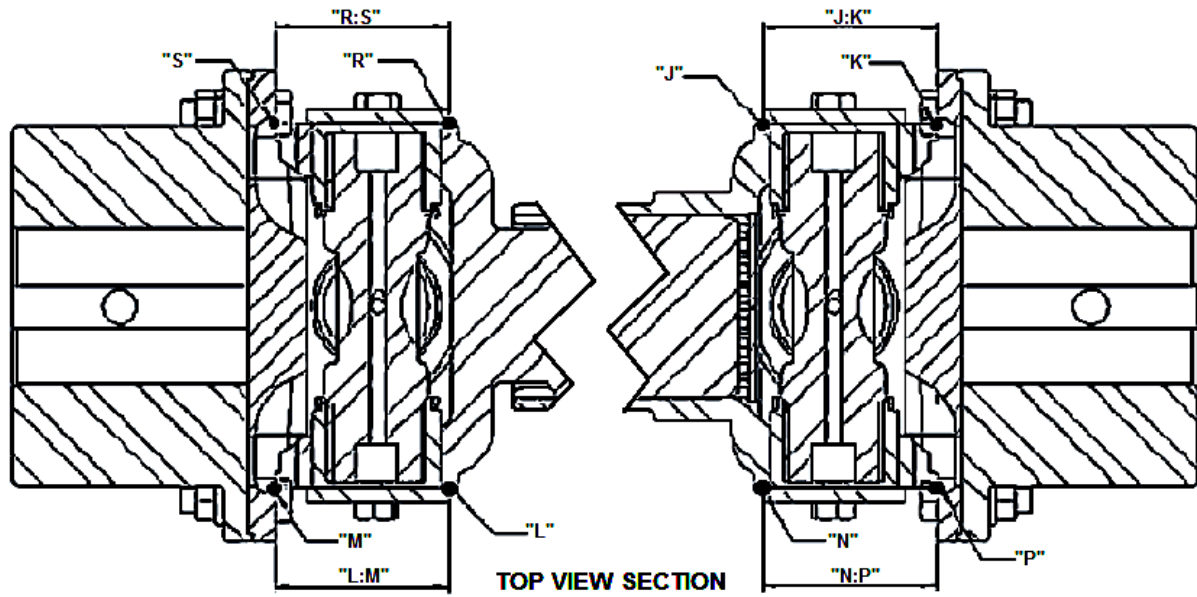
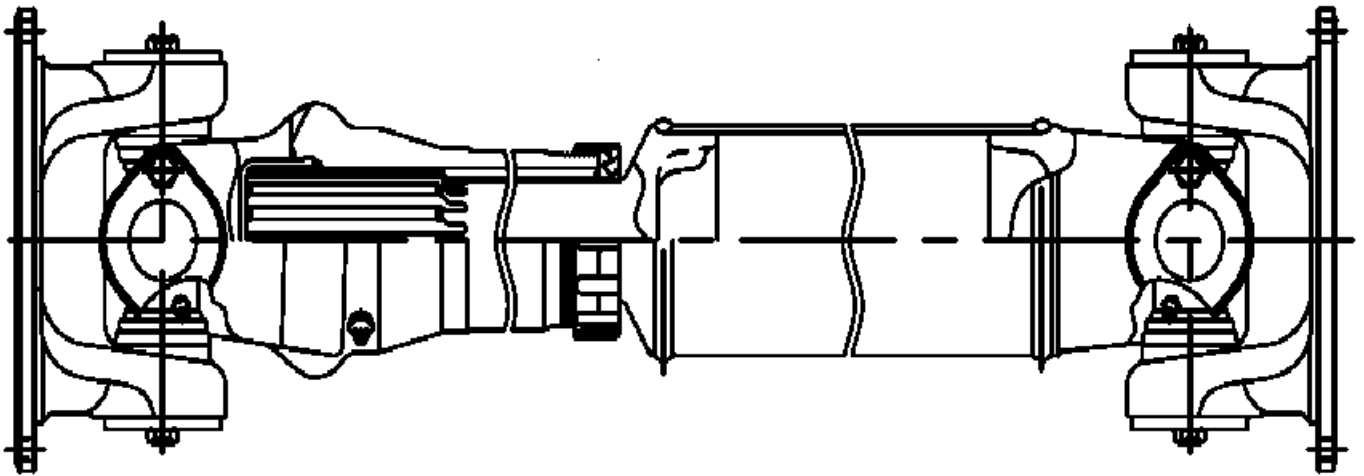


Figure 8d



2.5.5 Measured values at the four positions referenced (JK, LM, NP, RS) may not vary more than the published tolerance in the column listed as Horizontal Offset Tolerance as noted in Table A.

**Table A**

Shaft Series	Vertical Offset Measurement AB & CD (inches)	Vertical offset Tolerance (+ or - ) (inches)	Horizontal Offset Tolerance (+ or -) Jk, LM, NP & RS (inches)	Weight in lbs per PN series
<b>P2171</b>	<b>3.17</b>	<b>0.05</b>	<b>0.022</b>	<b>54</b>
<b>P2181</b>	<b>3.77</b>	<b>0.06</b>	<b>0.027</b>	<b>78</b>
<b>P3172</b>	<b>4.87</b>	<b>0.05</b>	<b>0.023</b>	<b>74</b>

\*\*Measurement taken from yoke side of flange face to far side of universal bearing plate as shown in the referenced Figures 8a-8d which are to be used for measuring instruction.

For parts and service inquiries, please contact:

Patterson Pumps  
 10000 E. 1st Avenue  
 Denver, CO 80231  
 Phone: 1-800-368-6666 in the US.

[www.pattersonpumps.com](http://www.pattersonpumps.com)

Please provide pump nameplate serial number.

Visit us on the web at:  
[www.pattersonpumps.com](http://www.pattersonpumps.com)

## Section 3 - Lubrication

### 3.0 Lubrication

The majority of premature universal joint and slip spline failures are due to improper lubrication. Proper lubrication practice flushes contaminants from the bearings promoting maximum functional life. A high quality NLGI Grade 2 EP lithium grease is recommended for both universal joint and slip splines. *Note:* Do not use lubricants with molybdenum disulfide additives in universal joint bearings.

Lubrication intervals vary depending on the application, installation environment, and operating conditions. Continuously operating assemblies should be lubricated every 200 operating hours. Limited usage joints should be lubricated every 6 months in protected environmental conditions, every 60 days in harsh environments.

### 3.1 Lubrication Procedure

3.1.1 Using the proper NLGI Grade 2 lubricant, purge all four bearing seals of the universal joint. Pressure fill universal joint through fitting "A" in Figure 9. This flushes contaminants from each bearing assembly and assures all four are filled completely.

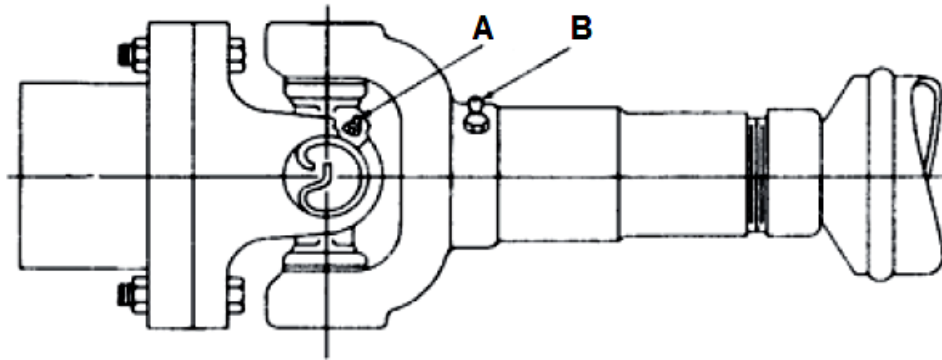
*Note:* If any seal fails to purge, move the driveshaft from side to side and then re-apply pressure to the fitting.

3.1.2 Lubricate slip splines through fitting "B" on the shaft assembly. Only shafts stamped "B" require spline lubrication using the following procedure. Cover the vent hole and pressure fill the spline shaft until grease purges the shaft seal.

*Note:* On applications where spline shafts traverse in cold conditions, care must be taken to purge excess grease from the cavity immediately after lubricating. Failure to do so can cause excess axial pressure on components resulting in damage to the driveshaft or mating parts.

*Note:* Shafts stamped "B" and coated spline require spline lubrication.





**Figure 9**

<b>Table B</b>			
<b>Flange Fastener Torque Values</b>			
Shaft Series	Thread Size	Grade (Class)	Dry Torque Value
P2171	3/8-24	8	45 lb x ft
P2181	7/16-20		75 lb x ft
P3172	M16-20	10.9	215 lb x ft

<b>Table C</b>		
<b>Set Screws Tightening Torques</b>		
Key Width	Thread Size	Torque Value
Below .313	1/4 - 28	6 lb x ft
.313 to .500	3/8 - 16	20 lb x ft
.501 to .750	1/2 - 13	50 lb x ft
Over .751	3/4 10	170 lb x ft

## Section 4 – Inspection Guidelines

### 4.0. Inspection Guidelines

NOTE: Shaft assemblies must be inspected annually to maintain peak performance and safety.

4.1 Check companion flanges for attachment to mating shaft. Verify that setscrews remain secure.

4.2 Check fastener connection between companion flange and driveshaft. Torque to the specified values as detailed in Table B.

4.3 Check universal joints for excessive endplay. The allowable amount is 0.006 inches. Use dial indicator if any looseness is perceived.

4.4 Check slip spline for radial movement. Side to side movement in spline section shall not be more than 0.007 inches in any direction.

4.5 Inspect overall length of shaft as referenced in Section 7 to determine that it is within the required tolerance.

4.6 Visually inspect for any damage to shaft seal, universal joint seals, spline end plug, universal joint retaining rings or spun bearing caps.

4.7 If any of the defects in Sections 4.3 to 4.5 are found, the shaft shall be removed from service, replaced, and returned to the factory for repair.

**Warning:** Rotating shafts can be dangerous. Follow all safety and lockout precautions during installation, maintenance, and operation. Proper guarding required. Consult local safety regulations for compliance.

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## Section 5 – Application

### Calculations

$$\text{Rated Torque} = \frac{\text{Max Torque}}{5252}$$

$$\text{Rated HP} = \frac{\text{Rated Torque} \times \text{RPM}}{\text{Service Factor (SF)}}$$

For centrifugal fire pump application

5.1 A service factor is applied to the calculated end-use application torque. The calculated end-use application torques, as adjusted by the service factor, shall not exceed the torque rating of the flexible coupling or connecting shaft at the applicable speed.

Service Factor (SF) = 1.5 (6 Cylinders or More-diesel engine)

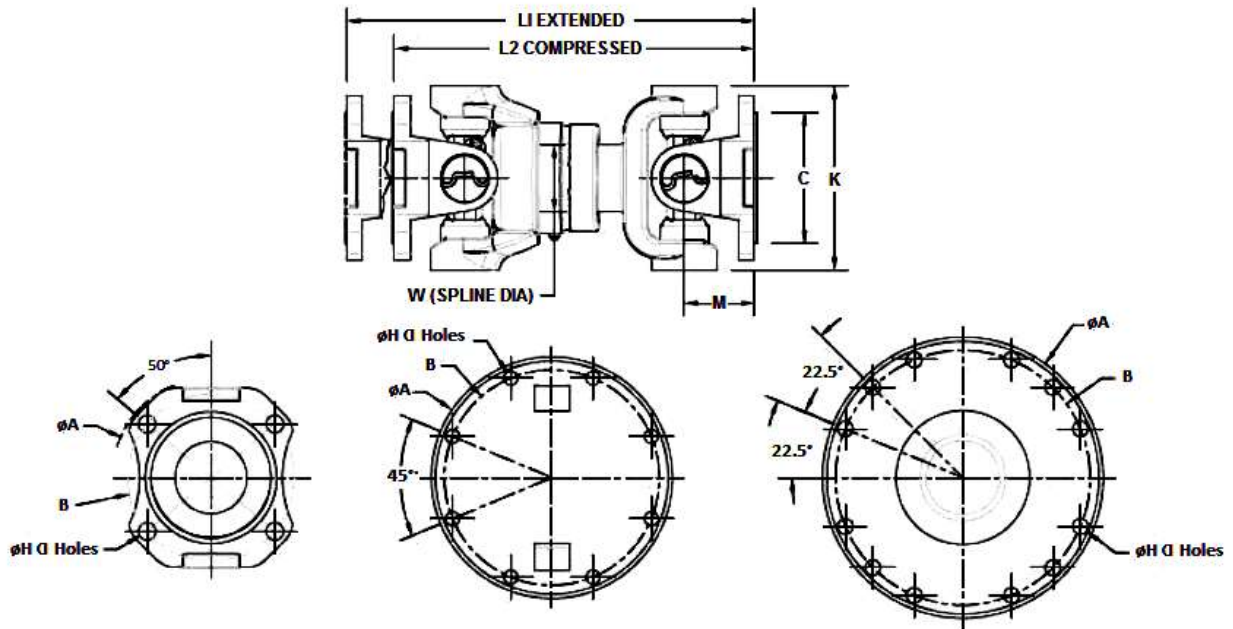
Service Factor (SF) = 2.0 (5 Cylinders or Less-diesel engine)

5.2 Selection of Flexible connecting driveshaft shall be based on rating of the driver and not the pump.

## Section 6 – Application Charts

Shaft Series	Rated Speed RPM		1470	1760	1800	1900	2100	2250	2300	2350	2600	2800	3000
P2171	Rated Torque	ft/lb	1200	1200	-	1200	1200	1200	1200	-	-	-	-
		N-m	136	136	-	136	136	136	136	-	-	-	-
P2181	Rated Torque	ft/lb	1525	1525	-	1525	1525	-	-	-	-	-	-
		N-m	172	172	-	172	172	-	-	-	-	-	-
P3172	Rated Torque	ft/lb	2200	2177	2163	-	-	-	-	-	-	-	-
		N-m	249	246	244	-	-	-	-	-	-	-	-

## Section 7 – Dimensional Attributes



DIMENSION DATA INCHES										
SERIES	L1	L2	A	B	C	H	I	K	M	W
P2171	11.8	10.63	8.00	7.25		.41	8	6.09	2.00	3.25
P2181	14.56	13.44	7.99	7.25	7.75	.44	12	7.56	2.59	3.25
P3172	19.69	18.11	7.99	7.25	7.75	.44	12	6.32	3.94	2.95

## **Important Notice about vertical turbine applications:**

NFPA 20 states the following;

7.5.1.6.1 For drive systems that include a right angle gear drive, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above or below the operating speed of the pump and drive.

7.5.1.6.2 The torsional analysis specified in 7.5.1.6.1 shall include the mass elastic characteristics for a wetted pump with specific impeller trim, coupling, right-angle gear, flexible connecting shaft, and engine, plus excitation characteristics of the engine.

## TROUBLE SHOOTING GUIDE

PROBLEM	CAUSE	SOLUTION
<b>VIBRATIONS</b>	Operating near critical or half critical speed resonance	Consult Patterson. Rework using different tube sizes
	Operating at or near driver or driven equipment natural frequency	Consult Patterson
	Driver or driven components out of balance	Consult Patterson
	Pump noise	Consult Patterson
	Shaft yokes not in phase	Disassemble and align yoke.
	Flange faces not seated	Check for burrs or grit and reseal. Check tightening torque for all fasteners.
	Operating speed within a torsional vibration mode	Perform torsional analysis. Consult Patterson
	Driver and driven shafts/Companion flange not parallel within 1°	Align and adjust, shim structure if necessary
	Driver and driven shaft run-out	Consult Patterson
	Flange face or pilot run-out exceeding .005" TIR	Check fit, if exceeds consult Patterson
	Exceeding maximum joint acceleration	Reduce angle and/or speed
	Dry or brinelled (needle bearing indentations)	Replace defective joints / Check lubrication. Review operating parameters
	System resonance/vibration Perform vibration analysis	Consult Patterson
	Excessive radial movement at the slip yoke or binding movement	Lack of lubrication, overload condition. Consult Patterson Pump Company.
.Companion flange, fastener loose	Secure fastener / Check for vibrations	
<b>FLANGE SLIPPING OFF SHAFT</b>	Set screw over keyway tightened improperly	Tighten set screw
	Exceeding weight limitations for stock bored flanges/shaft diameter undersize	Add additional set screw or replace with interference fit bore flange/locking collar



PATTERSON PUMP COMPANY  
Post Office Box 790 • Toccoa, Georgia 30577  
U.S.A.(706) 886-2101  
[www.pattersonpumps.com](http://www.pattersonpumps.com)  
E-mail: [marketing@pattersonpumps.com](mailto:marketing@pattersonpumps.com)

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