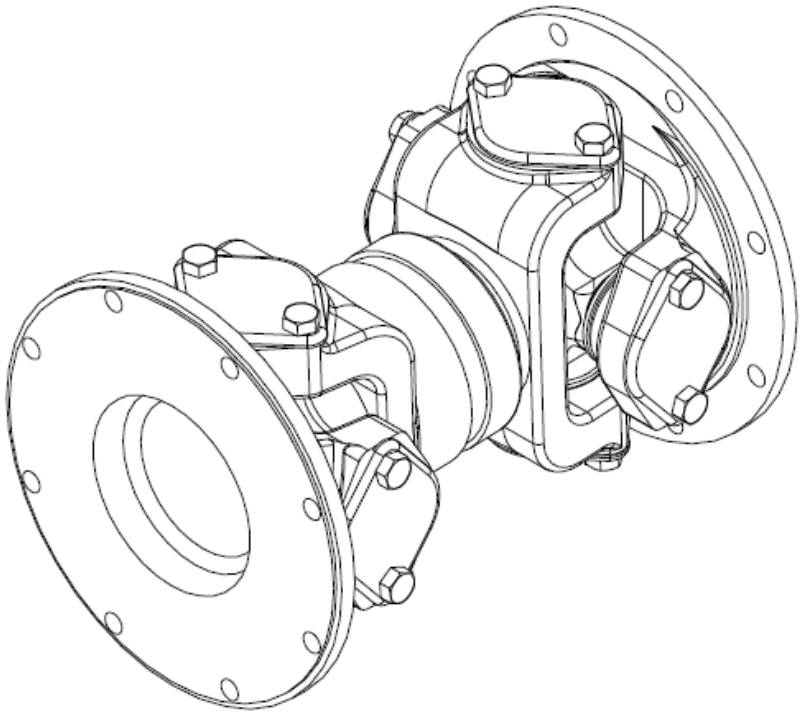
Fire Pump Applications

Installation & Maintenance Manual

Universal Joint Driveshafts



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Section 1 - General

1.1 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.

Cummins Fire Power 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.

1.2 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 couplings and driveshafts.

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

1.3 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. Cummins Fire Power is not responsible for incidental or consequential damages.

1.4 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)

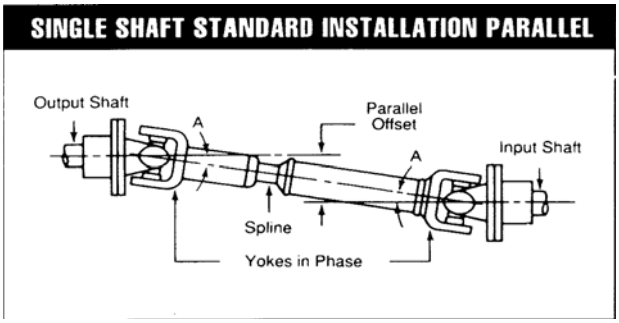

Figure 1

1.4.2 Joint angles must be equal within ½ degree. Joints, working in pairs will vibrate if they are not working at the same angle within ½ 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.

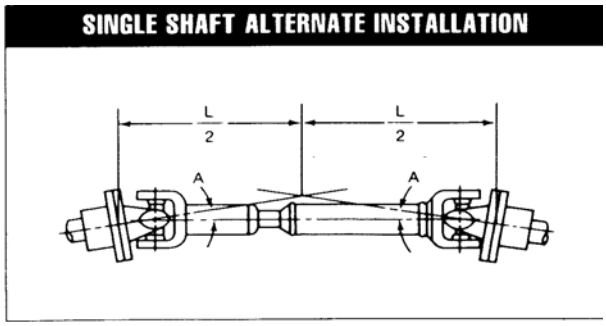

Figure 2

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.

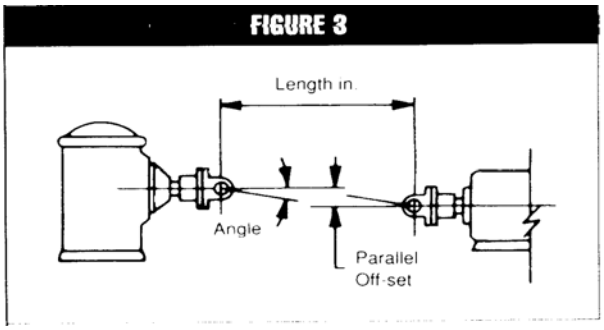

Figure 3

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.

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.

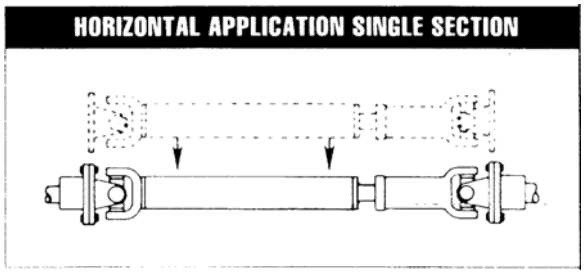

Figure 4

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

2.1.5 Lubricate all joints, 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.

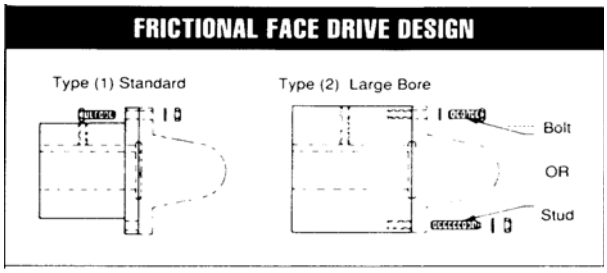

Figure 5

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).

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

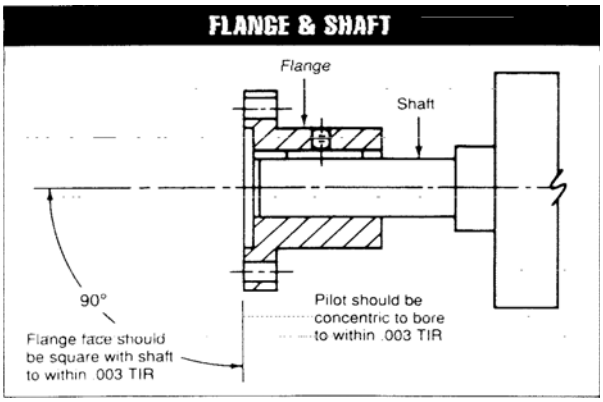

Figure 6

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.

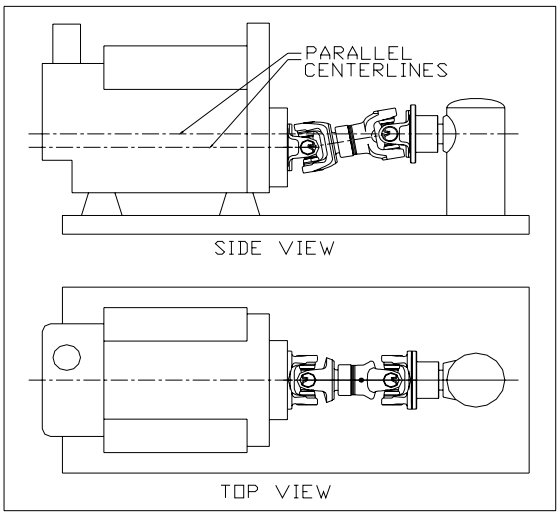

Figure 7

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 note 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.

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	Listed Shaft PN	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
1410	13417	2.36	0.04	0.012	13.5
1480	13418	2.27	0.04	0.012	19.5
1550	13419	2.78	0.05	0.017	29.5
1610	13420	3	0.05	0.018	44
1710	13421	3.17	0.05	0.022	54
1810	13422	3.77	0.06	0.027	78
1880	13423	4.08	0.07	0.032	142
U3101	13424	2.45	0.03	0.009	11
U3127	13427	3.64	0.04	0.013	27
U3126	13426	3.67	0.04	0.013	40
U3144	13428	4.46	0.04	0.016	45
U3158	13429	4.66	0.05	0.02	57
U3172	13430	4.87	0.05	0.023	74

**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:

Cummins Fire Power, LLC
875 Lawrence Drive
De Pere, WI 54115
Phone: 1-800-236-9750 in the US.

Fax: 1-920-337-9746

Please provide Engine serial number or the Driveshaft serial no. and tag information.

Visit us on the web at:
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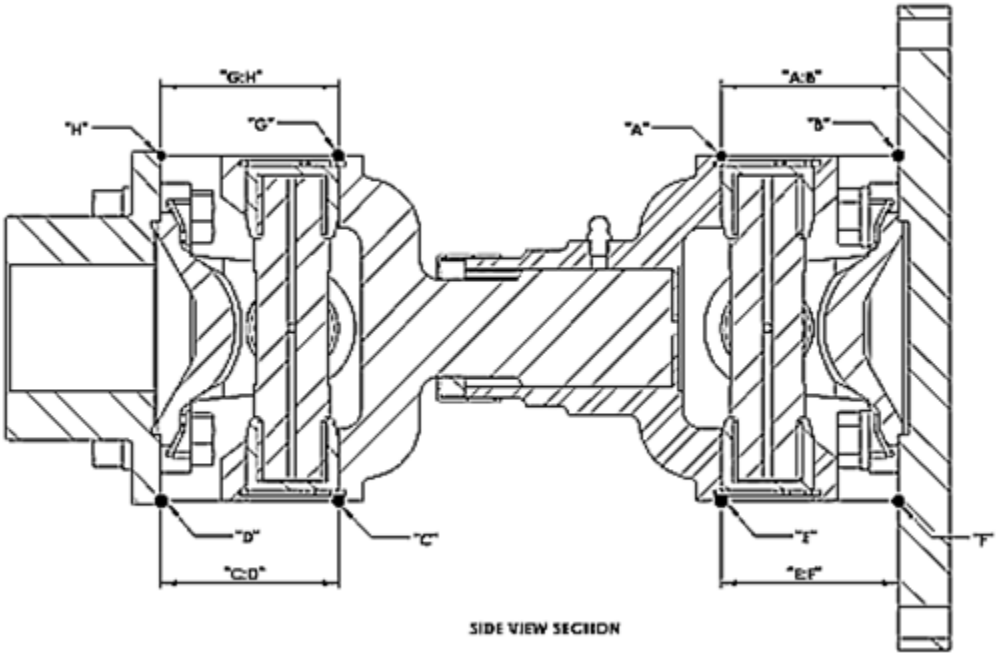
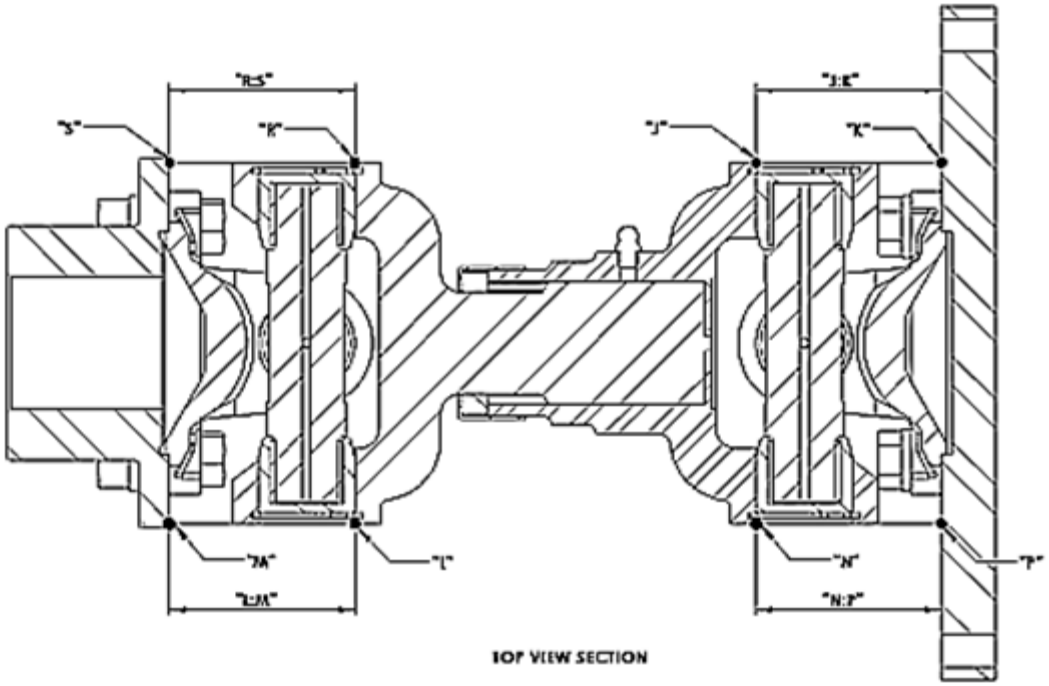
Series 1410 – 1550 (13418 – 13419)
Series U3101 – U3172 (13424 – 13430)

Vertical Offset Sectional View
Figure 8a

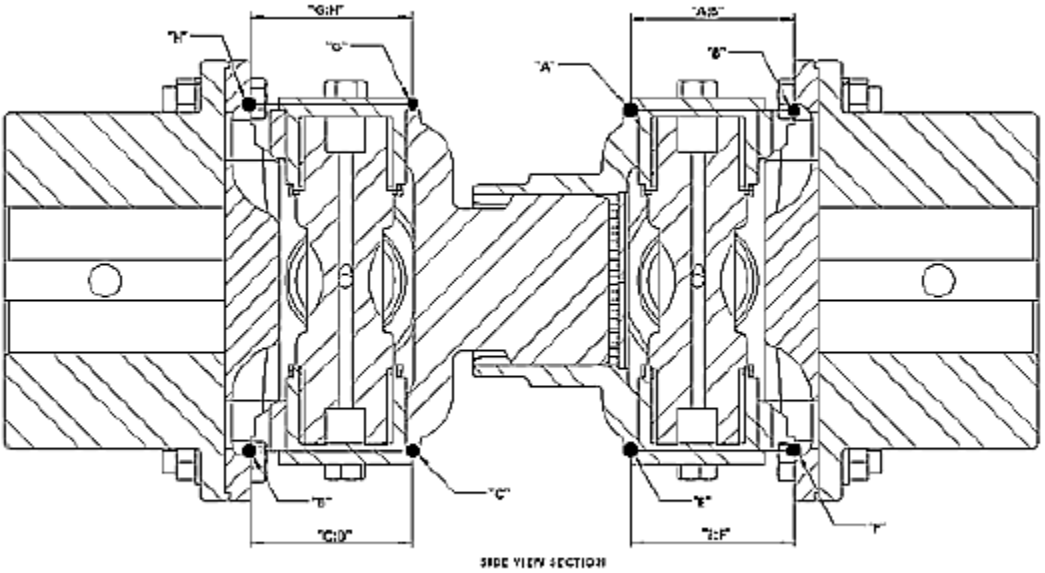


Horizontal Offset Sectional View
Figure 8b

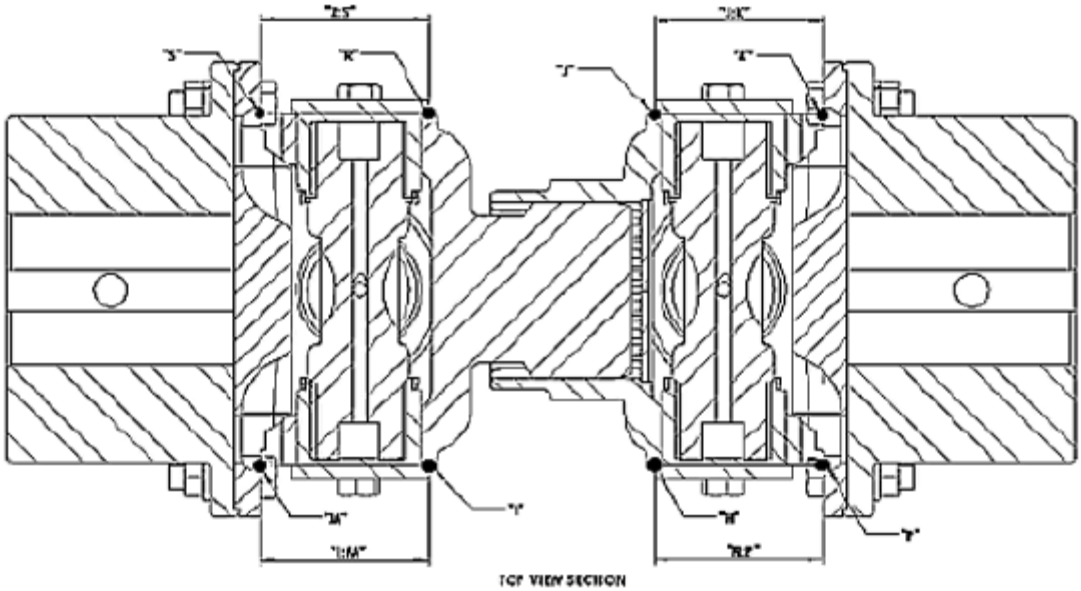


Series 1610 – Series 1880 (13420-13423) Only

Vertical Offset Sectional View
Figure 8c



Horizontal Offset Sectional View
Figure 8d



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.

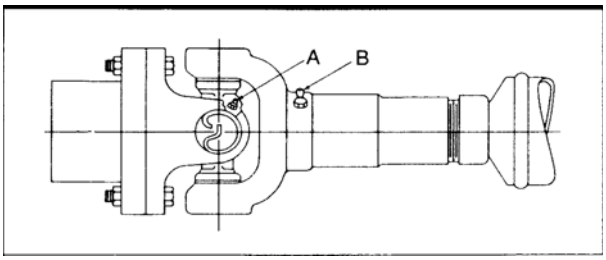


Figure 9

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 Series 1410-1880 (13418 – 13423) 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 Series U3101-U3172 (13424-13430) are Rilsan coated and are maintenance free for the spline section only.

Table B

Flange Fastener Torque Values

Shaft Series	Thread Size	Grade (Class)	Dry Torque Value
1410	7/16 – 20	8	75 lb x ft
1480	1/2 – 20		110 lb x ft
1550	1/2 – 20		110 lb x ft
1610	3/8 – 24		45 lb x ft
1710	3/8 – 24		45 lb x ft
1810	7/16 – 20		75 lb x ft
1880	5/8 – 18		230 lb x ft
U3101	M8 - 1.25	10.9	25 lb x ft
U3126	M12 - 1.75		90 lb x ft
U3127	M12 - 1.75		90 lb x ft
U3144	M14 - 2.0		140 lb x ft
U3158	M14 - 2.0		140 lb x ft
U3172	M16 - 2.0		215 lb x ft

Table C

Setscrew Tightening Torques

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 – General Inspection

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. See Figure 10 for inspection diagram. 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.

Figure 10

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.

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)

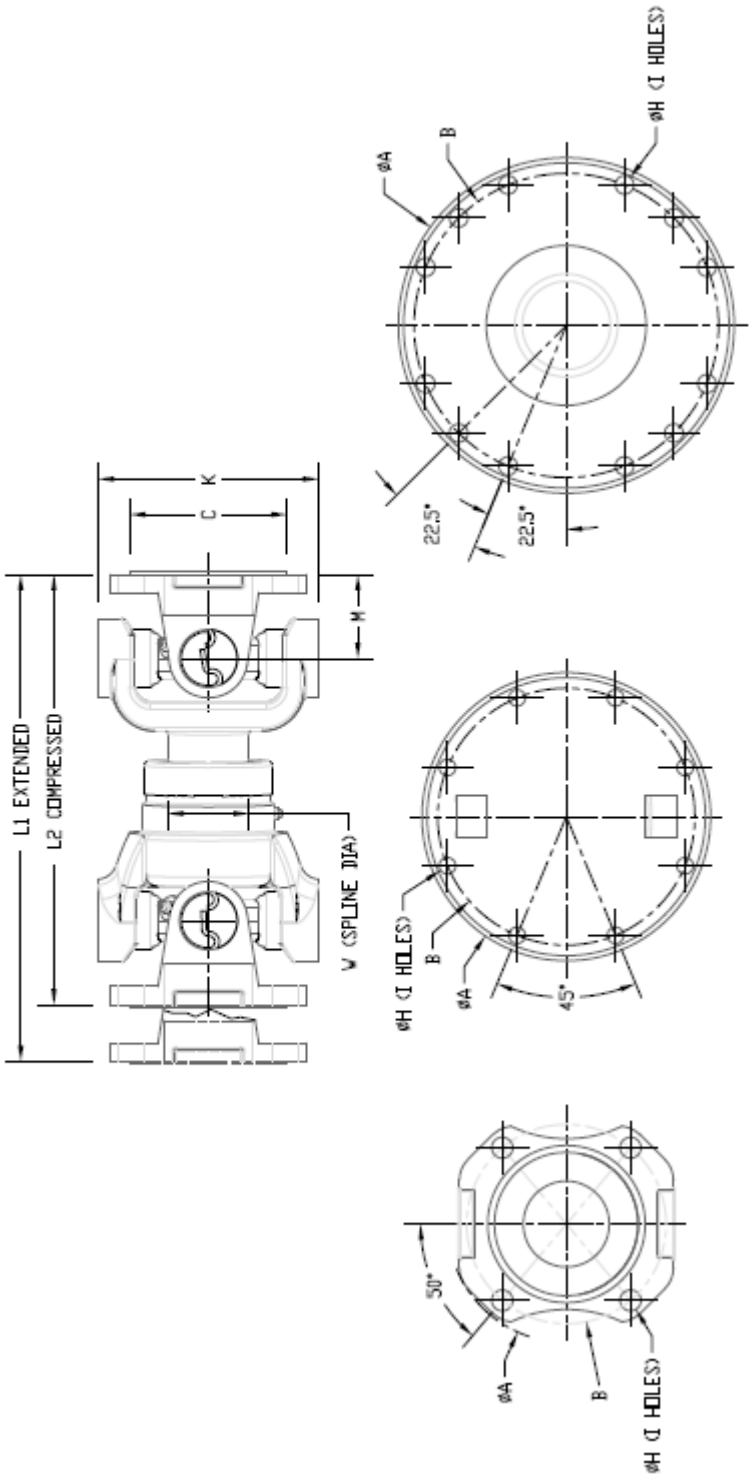
5.2 Selection of Flexible connecting driveshaft shall be based on rating of the driver and not the pump.

Section 6 - Application Charts

Shaft Series	Shaft PN	Rated Speed RPM		1470	1760	1800	1900	2100	2250	2300	2350	2600	2800	3000
1410	**13417**	Rated Torque	ft/lb	379	359	-	-	341	-	-	330	320	-	-
			N-m	43	41	-	-	39	-	-	37	36	-	-
1480	**13418**	Rated Torque	ft/lb	499	473	-	462	448	-	-	434	420	-	-
			N-m	56	53	-	52	51	-	-	49	47	-	-
1550	**13419**	Rated Torque	ft/lb	625	592	-	579	562	-	-	543	526	515	505
			N-m	71	67	-	65	63	-	-	61	59	58	57
1610	**13420**	Rated Torque	ft/lb	950	950	-	950	946	-	-	915	887	868	850
			N-m	107	107	-	107	107	-	-	103	100	98	96
1710	**13421**	Rated Torque	ft/lb	1200	1200	-	1200	1200	1200	1200	-	-	-	-
			N-m	136	136	-	136	136	136	136	-	-	-	-
1810	**13422**	Rated Torque	ft/lb	1525	1525	-	1525	1525	-	-	-	-	-	-
			N-m	172	172	-	172	172	-	-	-	-	-	-
1880	**13423**	Rated Torque	ft/lb	2158	2046	2034	-	-	-	-	-	-	-	-
			N-m	244	231	230	-	-	-	-	-	-	-	-
U3101	**13424**	Rated Torque	ft/lb	433	410	-	-	389	-	-	376	365	-	-
			N-m	49	46	-	-	44	-	-	42	41	-	-
U3126	**13426**	Rated Torque	ft/lb	950	950	-	950	950	-	-	950	950	950	944
			N-m	107	107	-	107	107	-	-	107	107	107	107
U3127	**13427**	Rated Torque	ft/lb	549	549	-	549	549	-	-	549	549	-	-
			N-m	62	62	-	62	62	-	-	62	62	-	-
U3144	**13428**	Rated Torque	ft/lb	1200	1200	-	1200	1200	-	1187	-	-	-	-
			N-m	136	136	-	136	136	-	134	-	-	-	-
U3158	**13429**	Rated Torque	ft/lb	1525	1493	-	1459	1416	-	-	-	-	-	-
			N-m	172	169	-	165	160	-	-	-	-	-	-
U3172	**13430**	Rated Torque	ft/lb	2200	2177	2163	-	-	-	-	-	-	-	-
			N-m	249	246	244	-	-	-	-	-	-	-	-

Note: All rated torque values have been tested with a Diesel Engine Driver. Torque Ratings within the stated speed ranges are determined by use of linear interpolation between torques and have been developed at minimum and maximum speeds. Driveshafts are designed for minimum B-10 Life of 5000 Hours.

Section 7- Dimensional Attributes



DIMENSION DATA (INCHES)

MODEL P/N	L1	L2	A	B	C	H	I	K	M	W
13417	10.25	9.50	4.83	3.75	2.75	0.44	4	4.44	1.69	1.50
13418	9.50	8.50	5.63	4.75	3.75	0.50	4	4.44	1.50	2.25
13419	10.75	9.75	5.65	4.75	3.75	0.50	4	5.25	2.00	2.50
13420	9.88	9.13	6.87	6.12	6.63	0.39	8	5.31	1.94	2.67
13421	11.38	10.63	8.00	7.25	7.75	0.41	8	6.09	2.00	3.25
13422	14.56	13.44	7.99	7.25	7.75	0.44	12	7.56	2.59	3.25
13423	14.63	13.63	9.74	8.25	7.00	0.63	8	8.09	2.50	4.17
13424	10.63	9.84	3.94	3.31	2.24	0.32	6	3.56	1.81	1.65
13427	14.59	13.41	5.91	5.12	3.54	0.47	8	4.63	2.87	1.89
13426	19.30	17.72	5.91	5.12	3.54	0.47	8	4.53	2.76	2.17
13428	17.72	16.14	7.09	6.12	4.33	0.56	8	5.19	3.54	2.17
13429	17.13	15.75	7.09	6.12	4.33	0.56	8	5.85	3.62	2.44
13430	19.69	18.11	7.99	7.25	7.75	0.44	12	6.32	3.94	2.95

Section 8 – Troubleshooting

	Cause:	Solution:
8.1	Flange Loose on Shaft	
	1. Set screw over keyway not tightened	1. Remove and inspect set screw. Replace if damaged. Reassemble with new or original and torque set screw.
	2. Weight limitations exceeded for bored flanges or shaft diameter undersized.	2. Add additional set screw or replace flange with interference fit bore.
8.2	Vibration	
	1. Companion flange or fastener loose.	1. Remove and inspect set screw. Replace if damaged. Reassemble with new or original and torque set screw.
	2. Driveshaft mounting fasteners loose.	2. Remove and inspect fasteners, drive shaft and flange face for burs, paint and debris. Clean or de-bur face. Replace damaged fasteners. Reassemble and torque to specifications.
	3. Flange faces not seated.	3. Remove driveshaft fasters. Inspect components for burs, paint and debris. Clean or de-bur face. Reassemble and torque to specification.
	4. Flange face or pilot run-out exceeding .005” TIR.	4. Inspect for run-out. Consult factory if out of specification.
	5. Excessive radial movement at the slip yoke or binding movement.	5. Lack of adequate lubrication or overload condition. Consult factory.
	6. Dry or brinelled (needle bearing indentations).	6. Replace defective joints. Review and recheck the working angle of shaft.
	7. Driveshaft yokes out of phase.	7. Disassemble and realign yoke.
	8. Exceeding maximum joint acceleration.	8. Reduce angle and/or reduce speed. Secure fastener and inspect for vibrations.
	9. Driven shaft or driver run-out.	9. Consult with equipment manufacturer.
	10. Driver or driven shafts/companion flange not parallel within 1 degree.	10. Align and adjust. Shimming structure may be necessary.
	11. Driver or driven components out of balance.	11. Consult with equipment manufacturer.
	12. Operating at or near driver or driven equipment natural frequency.	12. Consult with equipment manufacturer.
	13. Operation near critical or half cycle speed resonance.	13. Consult with equipment manufacturer. Resizing of driveshaft may be required.
	14. Operation speed within a torsional vibration mode.	14. Perform torsional vibration analysis. Consult manufacturer for assistance if needed.
	15. System resonance or vibration.	15. Perform torsional vibration analysis. Consult manufacturer for assistance if needed.
	16. Pump noise.	16. Consult with pump manufacturer.