KOP-FLEX® MILL GEAR SPINDLE

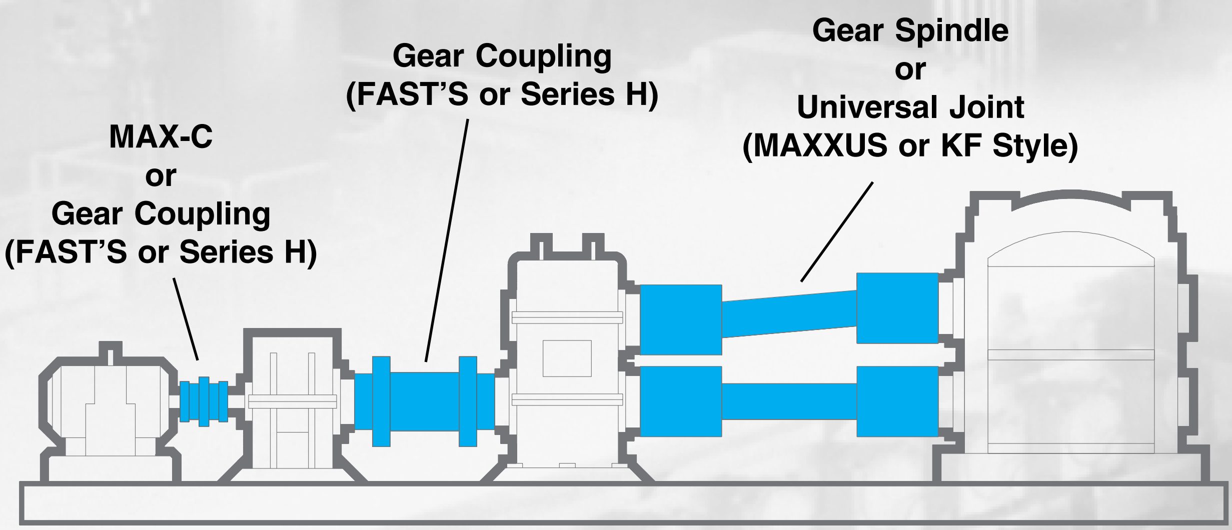
FOR ROLLING MILL APPLICATIONS...

Industries Served

Steel
Aluminum
Pulp & Paper

- ***High Torque Capacity***
- ***High Misalignment Capacity***
- ***Suitable for Reversing Applications***
- ***Withstands Moderate to Heavy Shock Loads***
- ***Highly Engineered in a Variety of Materials and Heat Treatment to Meet Your Demanding Mill Applications***

Typical Rolling Mill Configuration with Our Complete Selection



Gear Spindles

Ranging From
4 - 1/16" OD to 40 - 3/4" OD
(26,000 lb.-in.) (329,000,000 lb.-in.)

- **Over 50 Years of Operating Experience**
- **Reverse Engineering Capabilities**
- **Complete Service and Repair**
- **Inventory and Cost Control Programs**

Index:

For More Information

Visit www.kopflex.com

Optimizing gear tooth design to maximize performance

A spindle's load capacity depends on:
 (1) how well the gear teeth mesh
 (2) the physical properties of each tooth

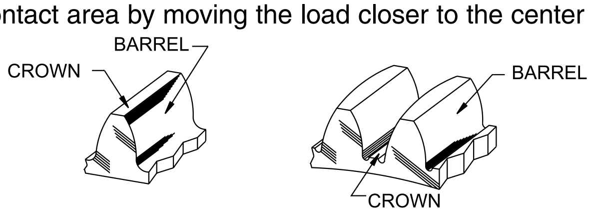
(1) *Gear mesh depends on misalignment and tooth shape*

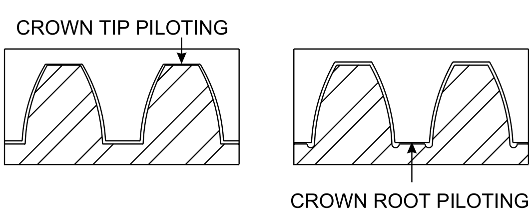
Misalignment - impacts the number of teeth in contact.

In the plane of misalignment, only a few opposing teeth on the spindle's hub gear contact the sleeve before torque is applied. As torque is applied, these gear teeth deflect which brings adjacent teeth into contact with the sleeve. The degree of misalignment partly determines the number of teeth in contact for a given amount of torque. The lower the angle, the more teeth in contact. Conversely, the higher the angle the fewer teeth in contact. The more teeth in contact, the greater the torque capacity.

Tooth shape - Manner of contact

We crown the flanks of spindle teeth and pilot either the tips or the roots. Proper flank crowning prevents tooth end bending, reduces contact stress, and increases the contact area by moving the load closer to the center of the tooth. Piloting and flank crowning also prevent jamming. Teeth could otherwise meet off center and lock under torque. Finally, piloting and flank crowning reduce the amount of backlash required, which can reduce the torque amplification factor. This improves the finish of the products being rolled.

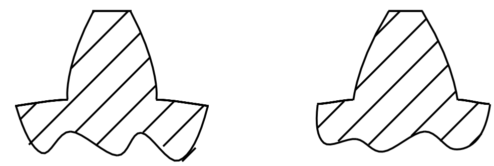




The required maximum angle of misalignment (usually the roll change angle) determines the amount of flank crown required. If the flank crown doesn't suit the roll change angle, teeth could break at roll change.

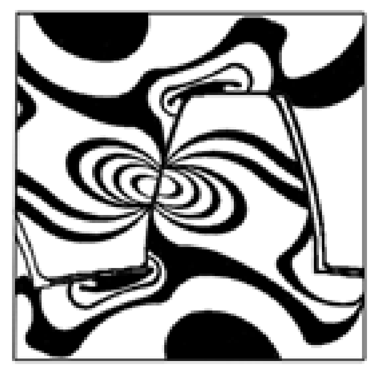
Tooth shape - Number of teeth in contact

Tooth thickness at the root (with misalignment and other factors) determines the amount the tooth will deflect under load. A certain degree of deflection will maximize the number of teeth in contact.



20° PRESSURE ANGLE **25° PRESSURE ANGLE**

Gear spindles commonly use a pressure angle of either 20° or 25°. A 20° pressure angle tooth is thinner at the root and will deflect more under load than a 25° tooth. On the other hand, a 25° tooth will resist tooth breakage better. In general, a 20° pressure angle is better for compressive load distribution (resistance to wear), while a 25° pressure angle will better resist tooth breakage.



HERTZ (CONTACT) STRESS ON GEAR TOOTH

Nitrided spindles tend to use 20° pressure angle teeth for a better load distribution, while carburized spindles tend to have 25° pressure angle teeth.
It's important to remember to NEVER MIX 20° AND 25° PARTS, since they will not fit together.

(2) How a spindle's physical properties affect load capacity

The physical properties of a spindle depend on the material, the heat treatment, and the process used to shape teeth after heat treatment.
Many alloys are used to make spindles, each with its own inherent core strength and other properties. Manufacturers then usually harden the teeth to increase wear resistance and strength, using either induction hardening, nitriding, or carburizing. The effects of each type of heat treatment differ for each alloy. One can't simply compare one material with another. You have to consider the material and treatment in combination.

Technical Advantages

Each of the three possible heat treatments distorts the shape of the gear teeth to some extent. Potentially affecting gear mesh.
KOP-FLEX can provide any combination of material, heat treatment, and process, but does not recommend induction hardening for any material, nor do we recommend AISI 1045 or AISI 4340, though you'll see these in other spindles. Induction hardening can cause localized distortion and may not yield uniform hardness. Even when nitrided, 4340 can have a poor wear surface and mediocre root strength. KOP-FLEX recommends various materials and heat treatments for different applications, see page 236 for details.

Material and heat treatment - Wear resistance

The harder a surface is, the more it resists wear. 500 BHN ($52R_c$) is approximately three times more wear resistant than 200 BHN, but 600 BHN is approximately twice as resistant as 500 BHN. Ask for these specifications when comparing spindles.

Material and heat treatment - Tooth strength

A gear tooth experiences its highest stress at the contact point and at the root. For gear spindles operating at high loads and high angles, the stress expected at the tooth contact point (Hertz stress) usually limits tooth design. For large spindles that operate highly loaded and over 1° misalignment, the core strength of most alloys is usually sufficient to handle the bending stresses at the root. But as the misalignment or load increases, it becomes necessary to increase root strength by carburizing, or to increase the surface hardness.

Shaping teeth after heat treatment - Maintaining good gear mesh and surface hardness

Since good gear mesh depends on the shape of the teeth, it's important to minimize the effects of the distortion caused by hardening the teeth.

Tooth Loading - Gear spindle teeth are simultaneously subjected to three basic loading conditions which can contribute to tooth failure: compressive (or Hertz) stress, bending stress, and a combined contact pressure/sliding velocity (or PV) component. Excessive compressive stresses lead to lubricant breakdown resulting in tooth distress (scoring, spalling, or worm tracking). High bending stresses, particularly at high angles, can lead to tooth breakage at the tooth ends. High pressure/velocity (PV) values generate high temperatures which result in accelerated wear and lubricant breakdown which can result in spalling, worm tracking, etc. All of these loading conditions must be considered in the design of a gear spindle. Our spindles are designed to balance each type of tooth loading, We select the right tooth with the right material and heat treatment to suit your application based on **over 50 years of experience in spindle design**.

Nitridizing causes the least amount of distortion. Teeth usually require no correction.

Carburizing usually produces the greatest strength, but it also can cause large distortions. Carburized spindles usually require correction after heat treatment. That means lapping or grinding…

Lapping versus grinding

Lapping is beneficial in that it removes material where needed, and it improves the surface finish. Also, lapping does not induce tensile stresses in the surfaces. Manufacturers usually lap gear spindle components as a set to provide the best possible gear mesh and optimum performance. Matching components should be indexed and kept together.

Grinding KOP-FLEX has developed a unique grinding process, CGG™, in which the hub and intermediate sleeve (ring gear) are ground without inducing tensile residual stresses in the tooth root. This maintains the bending fatigue strength, which would ordinarily be decreased by grinding.

Contact Ground Gear
with contact check at 3°
90-100% Gear Tooth in Contact
Excellent gear tooth flank finish

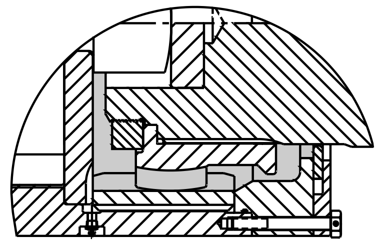
This approach also eliminates tensile stresses on the tooth flank, thereby preventing premature pitting and spalling. (See pages 237 and 238 for Contact Ground Gearing (CGG™) details.)

Main Drive Spindles
Design and Materials

Design

Gear spindles are available in four main configurations to solve the most difficult of applications, ranging from steel to aluminum to paper industries, usually in the main mill drive (Gearbox/Pinion to Roll, or Motor to Roll in direct drives):

- **LE and LB design:** The largest lube capacity of any gear spindle design available in the worldwide market today, can increase the life of gearing, reduce replacement cost and minimize unscheduled down time - all for a large cost savings to the mill!
- **ME and MB design:** Incorporates unique features that are not normally offered by others such as multiple lubrication ports, rising ring seal design, and many others.



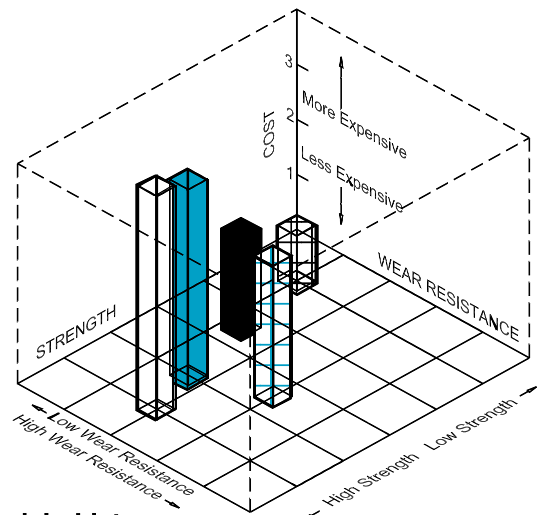
Largest Lube Capacity Available in the LE and LB Design (LE Design Shown)

Material

The physical capacities of a gear spindle depend on the material, heat treatment and the process used to finish the teeth after heat treatment.

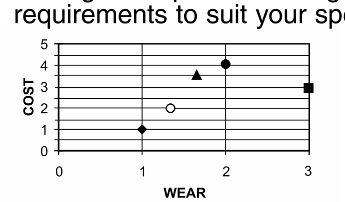
Many alloys are used to make spindles accommodate the combination of high torque and high operating misalignment and, in certain applications, high operating speed. The materials and heat treatments that are commonly used in mill spindle applications have relative strength, wear characteristics, and cost as shown in the following chart.

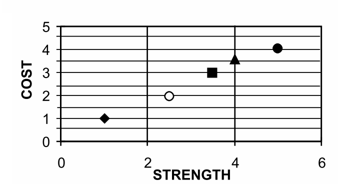
The gear spindle design must balance these requirements to suit your specific application needs.

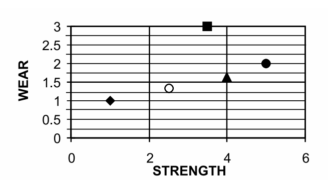


Materials List

- 1045 Carbon-Induction Hardened
- 4140 Alloy-Nitrided
- Nitralloy-Nitrided
- 4320 Alloy-Carburized
- 3310 Alloy-Carburized







Material	Strength	Wear	Cost
◆ 1045 Induction Hardened	1	1	1
○ 4140 Alloy Nitrided	2.5	1.33	1.78
■ Nitralloy Nitrided	3.5	3	2.56
▲ 4320 Alloy Carburized	4	1.65	3.56
● 3310 Alloy Carburized	5	2	4.06

*all units are relative units

Every installation has its own requirements for strength, core ductility, resistance to shock, wear surface lubricity, and case depth. KOP-FLEX designs maximize material benefits while minimizing cost. The following guide is a general recommendation.

Medium duty cold, temper, tube and bar mills

AISI 4140

- Heat treated and tempered for improved strength.
- Nitrided gearing, providing high surface hardness to resist wear and heat generation. Surface hardness of about 54 to 58 R_c. (BHN)

High speed cold mills and hot strip finishing mills

AISI 4140 or Nitralloy

- Heat treated and tempered for maximum strength.
- Nitrided gearing, providing high surface hardness to resist wear and heat generation. Surface hardness of about 54 to 65 R_c. (BHN)

This material provides a superior wear surface and a lower coefficient of friction. Less friction means less heat generation. Applications that combine high speeds and relatively high misalignment, such as high speed cold mills and hot strip finishing mills, cause high pressure-velocity (PV) values. High PV generates excessive heat which causes lubrication breakdown as well as tooth spalling and wear.

Hot strip and roughers

AISI 8620, AISI 4320, or AISI 9310/3310

- Carburized, quenched, and tempered, providing a deep hard case and high strength over a ductile shock resistant core. Core Hardness of 300 to 360 BHN.
- Surface finished by machine lapping or profile grinding of both the internal and crowned flank external gear to reduce distortion from carburizing. Surface hardness of about 58-65 R_c after lapping or grinding. This provides maximum tooth contact for extended operating life.

Improved Contact Ground Gear (CGG™) Tooth

KOP-FLEX Inc., an Emerson Power Transmission brand, introduces an industry breakthrough... Contact Ground Gearing (CGG™) for Rolling Mill Gear Spindles.

CGG™ corrects carburized tooth distortion in the internal and external gear tooth flanks. The CGG™ benefits include:

- Optimum tooth form for external and internal gearing
- Optimum tooth contact
- Optimum torque capacity
- Optimum gear life

Contact Ground Gearing was developed to satisfy the changing needs of the steel industry as a result of increased torque and misalignment of gear spindles.

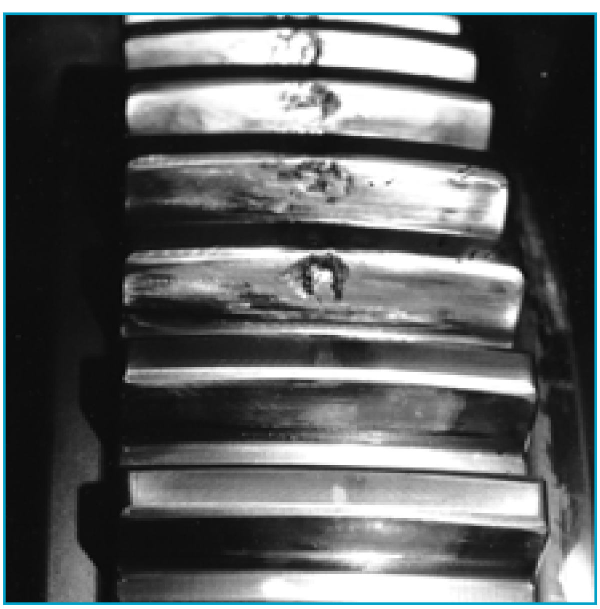
What will CGG™ do for your mill?

- CGG™ gearing ground to AGMA 10-11 for improved wear life and reduced tooth spalling
- Unique process and tooth design (patent pending) reduced tensile stress due to grinding
- Grinding increases number of teeth in contact, resulting in longer operating life
- More teeth in contact equals greater torque capacity and larger service factor
- Reduced maintenance cost and down time
- Reduced distortion through grinding flank correction

The evolution of gear spindle design

During the mid 60's KOP-FLEX® brand couplings pioneered the use of gear spindles in hot rolling and cold rolling mills. Over the years the basic design has remained constant with the exception of the tooth hardening processes.

Original designs employed high carbon steels which were induction hardened. The associated quench process resulted in distortion. To reduce the distortion, Nitriding was introduced. Nitriding provides a hard case R_C 55/64 and very little distortion. The case ranges from .015" to .030" (0.38-0.76mm). This process was good for fine pitch gearing in bar, rod and cold mills. For roughing mill and hot strip mill spindles with course pitch teeth a deeper case is required. These spindles employ carburized gearing which produces deep cases .060" to .250" (1.5-6.4mm) R_C 55/62. Again like induction hardening during the quench operation distortion occurs to the actual tooth and also pitch diameter.



Misalignment causes spalling

During operation gear spindles are subject to high misalignment. At 2 degrees misalignment, only 40% of the teeth carry the load. The limited number of teeth carrying the load combined with the distortion resulting from carburizing can cause some teeth to be more highly loaded. This can result in subsurface shear and spalling. The result of this distortion shows up as areas of spalling (see photo at left).

For More Information

Visit www.kopflex.com

Improved Contact Ground Gear (CGG™) Tooth

SOLUTIONS FOR DISTORTION

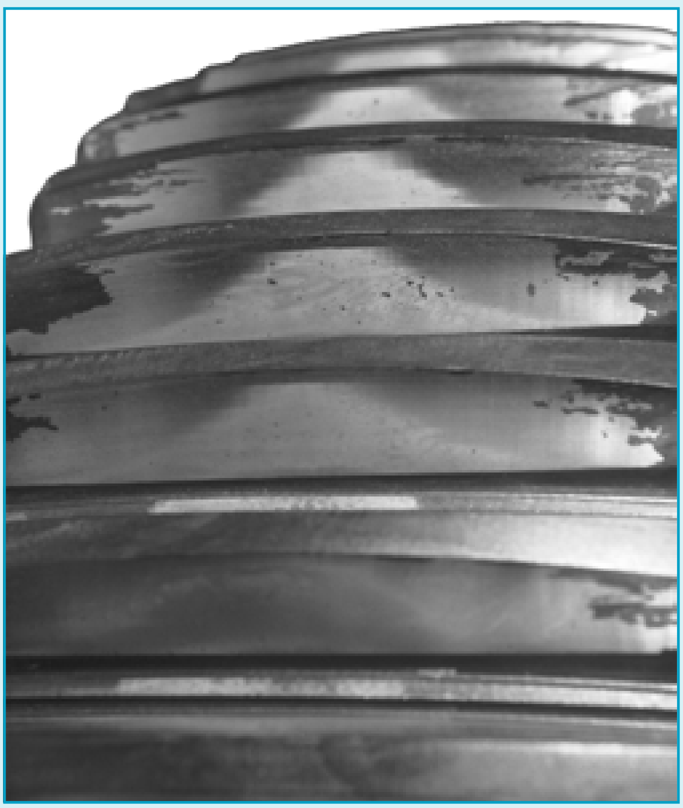
Correct distortion by lapping

One method of correcting distortion is lapping. The rubbing of the external tooth with the internal tooth using an abrasive medium to “wear the parts in” or remove the high spots. The difficulty here is the parts are lapped in matched sets and are not corrected to the initial pitch circle and tooth geometry.

The Contact Ground Gear Solution

The CGG™ process involves a unique tooth geometry which is carburized, and then the flanks of the internal straight tooth and the flanks of the external crowned tooth are ground. This grinding corrects tooth and profile distortion. The correction results in an AGMA 10-11 gear. It also provides a much improved tooth surface finish 32 RMS.

The combination of all these factors results in more uniform tooth loading and longer life. This CGG™ process can be introduced to the gear sets of your existing spindles. Increase the spindle torque capacity and effectively increase gear set life with uniform tooth loading.



Contact Ground Gear (CGG™)
with contact check at 3° 90-100% Gear Tooth in Contact
Excellent gear tooth flank finish

Carburized Gearing
with blue contact check at 3°
20-40% gear teeth in contact

Lapped Gearing
with blue contact check at 3°
60-70% gear teeth in contact
Good finish, corrected for carburizing distortion

KOP-FLEX-designed CGG™ carburized gear spindles, with internal and external tooth flank ground, are currently operating in mills in North America.

Guide for preliminary size selection

1. Calculate torque (T_s) to be transmitted:

$$T_s \text{ (lb.-in.)} = \frac{\text{HP per spindle} \times 63{,}025}{\text{RPM}} \times \frac{\text{Service Factor (Table 1)}}{\text{Misalignment Factor (Table 2)}}$$

Table 1 Service Factor (Main Drive Spindles)

APPLICATION	Suggested Selection Factors SF_e	Suggested Selection Factors SF_y
Auxiliary Mill Equipment: Coilers, Levelers, Pinch Rolls, Tinning Lines, Pickle Lines Wire, Small Bar & Rod Mills: All Stands. Medium Bar & Section Mills: Finishing Stands.	1.5	2.5
Cold Mills: Non-Reversing. Medium Bar & Section Mills: Roughing Stands. Large Bar & Section Mills: Finishing Stands.	1.75	3.0
Hot Strip Mills: Non-Reversing Finishing Stands. Cold Mills: Reversing. Large Bar & Section Mills: Non-Reversing Roughing Stands.	2.0	4.0
Hot Strip Mills: Non-Reversing Roughing Stands. Edgers, Non-Reversing.	2.5	5.0
Hot Strip Mills: Reversing Roughing Stands. Large Bar & Section Mills: Reversing Roughing Stands. Edgers, Reversing. Steckel Mills.	3.0	6.0
Reversing Slab, Plate and Blooming Mills.	4.0	8.0

Table 2 Misalignment Factors

Misalignment (Degrees)	Factor
1.0	1.00
1.5	0.84
2.0	0.70
2.5	0.60
3.0	0.50
4.0	0.40
5.0	0.30
6.0	0.20

- For angles greater than 3° consult KOP-FLEX.

KOP-FLEX uses specialized computer programs that will select gear spindles custom-designed for your application.

2. Select size and type from Table 2 under the appropriate operating misalignment angle. Torque capacity (T_c) must be greater than T_s ($T_c > T_s$).

3. After selecting a size, confirm that the minimum roll diameter is greater than the spindle outside diameter shown on pages 240 through 243.
Consult KOP-FLEX for final size selection.

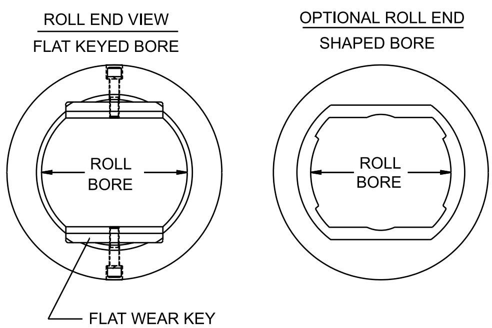
Table 3 Gear Tooth Capacity at 1 degree misalignment (Tc)

Size	Alloy AISI 4140 Nitrided		Alloy Nitralloy Nitrided		Alloy AISI 8620 Carburized		Alloy AISI 3310 Carburized	
	Endurance Limit (lb-in)	Yield Limit (lb-in)	Endurance Limit (lb-in)	Yield Limit (lb-in)	Endurance Limit (lb-in)	Yield Limit (lb-in)	Endurance Limit (lb-in)	Yield Limit (lb-in)
4.0	796000	1804000	1109000	2806000	1365000	2888000	1874000	4913000
4.5	1183000	2636000	1649000	4100000	2029000	4220000	2784000	7178000
5.0	1621000	3448000	2259000	5363000	2780000	5520000	3815000	9390000
5.2	1859000	4213000	2591000	6552000	3188000	6745000	4375000	11473000
5.7	2300000	5213000	3205000	8108000	3945000	8346000	5413000	14196000
6.0	2756000	6280000	3841000	9767000	4727000	10054000	6487000	17102000
6.4	3260000	7389000	4543000	11492000	5591000	11830000	7673000	20122000
6.8	3969000	8996000	5531000	13991000	6807000	14403000	9342000	24498000
7.2	4763000	10796000	6638000	16791000	8169000	17285000	11211000	29400000
8.0	6367000	14432000	8873000	22446000	10920000	23106000	14986000	39302000
8.5	7762000	17670000	10817000	27482000	13312000	28290000	18269000	48120000
9.0	9303000	21086000	12964000	32795000	15955000	33759000	21896000	57422000
9.5	11029000	24999000	15370000	38881000	18915000	40024000	25959000	68078000
10.0	12939000	29328000	18031000	45613000	22191000	46955000	30454000	79867000
10.5	15039000	34087000	20958000	53015000	25792000	54574000	35397000	92827000
10.8	15482000	35092000	21575000	54578000	26552000	56183000	36440000	95564000
11.5	19255000	43646000	26833000	67882000	33023000	69878000	45320000	118858000
12.0	22051000	49981000	30729000	77735000	37818000	80021000	51901000	136110000
12.7	26124000	59214000	36405000	92095000	44803000	94803000	61488000	161254000
14.0	35647000	80800000	49676000	125667000	61136000	129363000	83902000	220038000
15.0	41823000	94800000	58283000	147441000	71728000	151778000	98438000	258163000
16.0	53436000	121123000	74466000	188381000	91644000	193921000	125771000	329847000

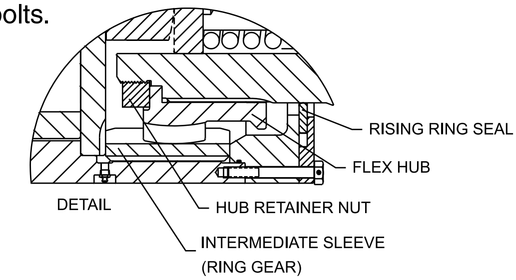
Notes:
Endurance Limit == Torque capacity based on 1 degree misalignment.
Yield Limit == Based on 85% yield limit of the material.
Alloy materials other than shown above is available to suit your applicaton - consult KOP-FLEX.
Torque value subject to change.

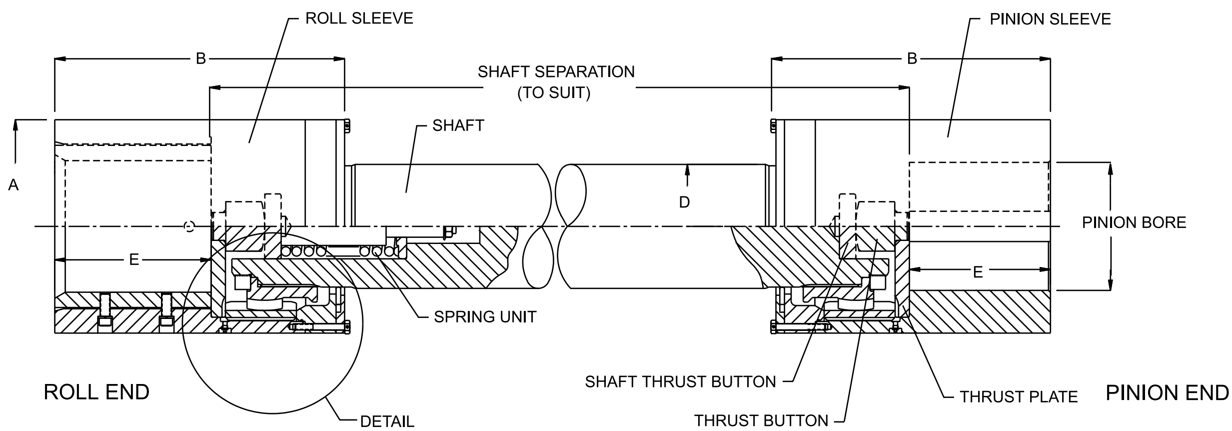
LE Series - Main Drive Spindles

LE Series (Mill Element, seal on Shaft)



- Roll and pinion casing with replaceable gear element (ring gear)
- Splined replaceable hubs with retainer nut
- Maximum grease reservoir
- Floating seal on spindle shaft
- Thrust buttons on centerline of gear mesh
- Hub designed with angle limiter to protect the end ring bolts.





LE Dimensions (inches)

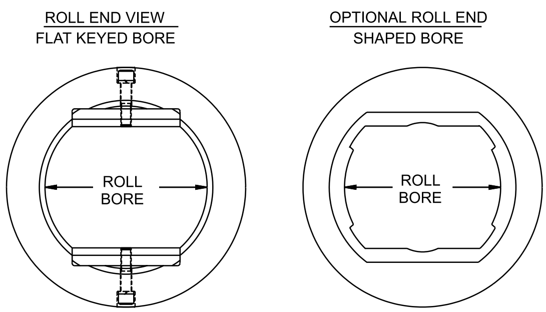
Size	A	B	D	E	Pinion Sleeve		Roll Sleeve		
					Max. Bore	Standard Keyways	Max. Bore with Flat Wear Keys	Max. Bore with Shaped Bore	Max. Flats Dimension
4.0	11.00	13.50	6.50	6.75	7.81	2 x 3/4	8.00	8.88	6.67
4.5	12.50	15.00	7.50	7.50	8.88	2 x 3/4	9.00	10.00	7.52
5.0	14.00	17.50	8.00	8.75	10.00	2 1/2 x 7/8	10.38	11.13	8.36
5.2	14.50	18.28	8.25	9.14	10.25	2 1/2 x 7/8	10.75	11.38	8.55
5.7	15.38	19.25	9.00	9.63	11.00	3 x 1	11.50	12.50	9.40
6.0	16.25	20.50	9.50	10.25	11.75	3 x 1	12.00	13.25	9.96
6.4	17.25	21.50	10.00	10.75	12.50	3 x 1	12.75	14.13	10.62
6.8	18.25	23.25	10.50	11.63	13.13	3 1/2 x 1 1/4	13.75	14.75	11.09
7.2	19.63	24.50	11.50	12.25	14.13	3 1/2 x 1 1/4	14.50	15.75	11.84
8.0	21.50	27.50	12.00	13.75	15.50	4 x 1 1/2	16.13	17.75	13.35
8.5	23.25	29.00	13.00	14.50	16.63	4 x 1 1/2	17.13	18.75	14.10
9.0	24.75	30.50	14.00	15.25	17.63	4 x 1 1/2	18.00	20.00	15.04
9.5	25.75	32.00	15.00	16.00	18.25	5 x 1 3/4	18.88	21.00	15.79
10.0	27.00	34.00	15.50	17.00	19.50	5 x 1 3/4	20.13	22.00	16.54
10.5	28.50	35.50	16.50	17.75	20.38	5 x 1 3/4	20.88	23.00	17.29
10.8	30.00	36.50	17.00	18.25	21.50	5 x 1 3/4	21.50	24.00	18.05
11.5	31.00	39.00	18.00	19.50	22.25	6 x 2	23.00	25.00	18.80
12.0	32.00	40.25	19.00	20.13	22.88	6 x 2	23.75	26.00	19.55
12.7	34.00	42.50	20.00	21.25	24.75	6 x 2	25.13	27.50	20.68
14.0	37.00	47.00	22.00	23.50	26.75	7 x 2 1/2	27.64	30.00	22.56
15.0	38.00	47.75	24.00	23.88	27.25	7 x 2 1/2	28.13	31.00	23.31
16.0	40.75	54.00	25.00	27.00	30.00	7 x 2 1/2	31.75	33.50	25.19

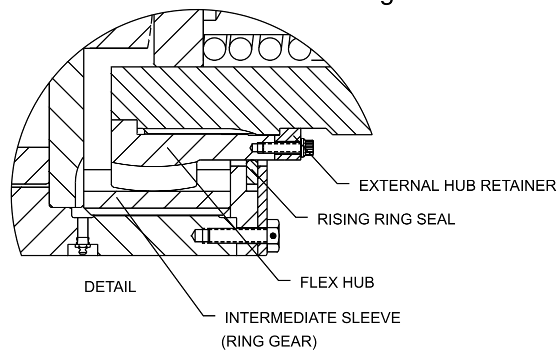
Dimensions given are approximate. The actual dimensions will depend on the application and will be given on a General Arrangement drawing.

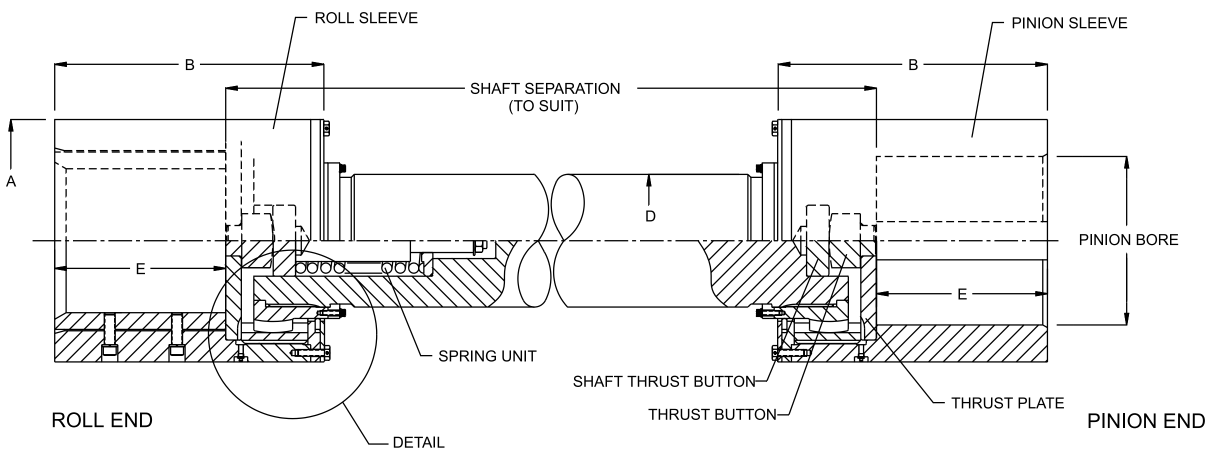
ME Series - Main Drive Spindles

ME Series
(Mill Element, seal on Hub)

- Roll and pinion casing with replaceable gear element (ring gear)
- Splined replaceable hubs with exterior bolting
- Floating seal on hub body
- Thrust buttons on centerline of gear mesh







ME Dimensions (inches)

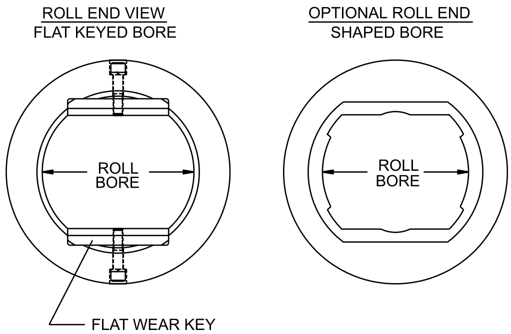
Size	A	B	D	E	Pinion Sleeve		Roll Sleeve		
					Max. Bore	Standard Keyways	Max. Bore with Flat Wear Keys	Max. Bore with Shaped Bore	Max. Flats Dimension
4.0	11.00	13.50	6.00	6.75	7.81	2 x 3/4	8.00	8.88	6.67
4.5	12.50	15.00	6.75	7.50	8.88	2 x 3/4	9.00	10.00	7.52
5.0	14.00	17.50	7.50	8.75	10.00	2 1/2 x 7/8	10.38	11.13	8.36
5.2	14.50	18.28	8.00	9.14	10.25	2 1/2 x 7/8	10.75	11.38	8.55
5.7	15.38	19.25	8.25	9.63	11.00	3 x 1	11.50	12.50	9.40
6.0	16.25	20.50	8.75	10.25	11.75	3 x 1	12.00	13.25	9.96
6.4	17.25	21.50	9.00	10.75	12.50	3 x 1	12.75	14.13	10.62
6.8	18.25	23.25	9.75	11.63	13.13	3 1/2 x 1 1/4	13.75	14.75	11.09
7.2	19.63	24.50	10.50	12.25	14.13	3 1/2 x 1 1/4	14.50	15.75	11.84
8.0	21.50	27.50	11.75	13.75	15.50	4 x 1 1/2	16.13	17.75	13.35
8.5	23.25	29.00	12.50	14.50	16.63	4 x 1 1/2	17.13	18.75	14.10
9.0	24.75	30.50	13.00	15.25	17.63	4 x 1 1/2	18.00	20.00	15.04
9.5	25.75	32.00	14.00	16.00	18.25	5 x 1 3/4	18.88	21.00	15.79
10.0	27.00	34.00	15.00	17.00	19.50	5 x 1 3/4	20.13	22.00	16.54
10.5	28.50	35.50	16.00	17.75	20.38	5 x 1 3/4	20.88	23.00	17.29
10.8	30.00	36.50	17.00	18.25	21.50	5 x 1 3/4	21.50	24.00	18.05
11.5	31.00	39.00	18.00	19.50	22.25	6 x 2	23.00	25.00	18.80
12.0	32.00	40.25	19.00	20.13	22.88	6 x 2	23.75	26.00	19.55
12.7	34.00	42.50	20.00	21.25	24.75	6 x 2	25.13	27.50	20.68
14.0	37.00	47.00	22.00	23.50	26.75	7 x 2 1/2	27.64	30.00	22.56
15.0	38.00	47.75	23.50	23.88	27.25	7 x 2 1/2	28.13	31.00	23.31
16.0	40.75	54.00	25.00	27.00	30.00	7 x 2 1/2	31.75	33.50	25.19

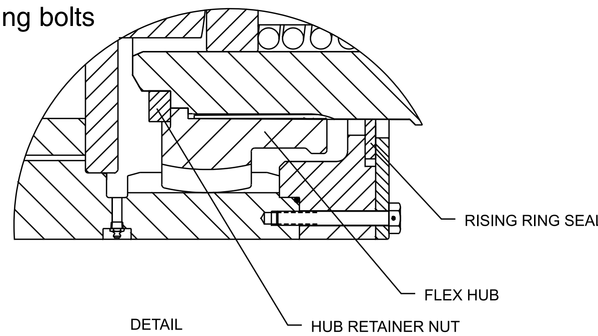
Dimensions given are approximate. The actual dimensions will depend on the application and will be given on a General Arrangement drawing.

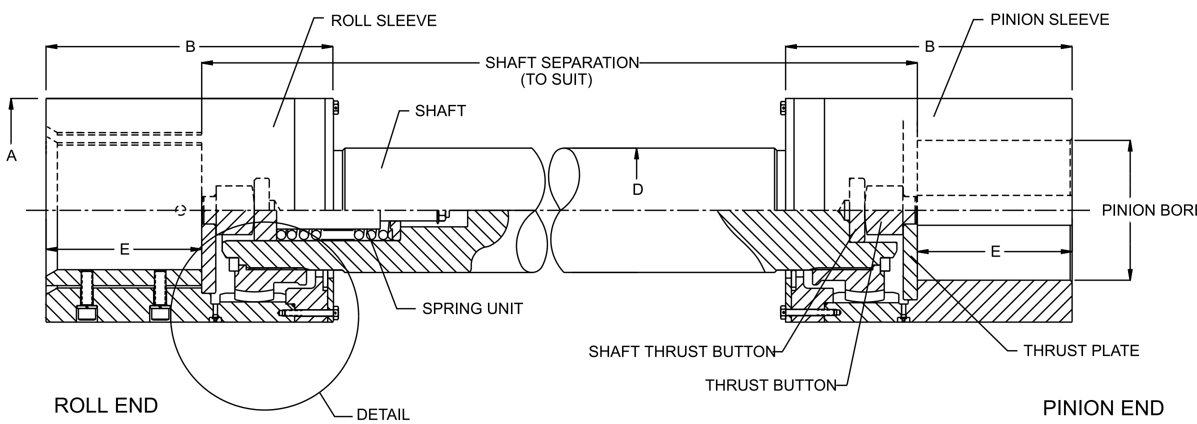
LB Series - Main Drive Spindles

LB Series
(Mill Basic, seal on Shaft)

- One-piece roll and pinion casing
- Splined replaceable hubs with retainer nut
- Maximum grease reservoir
- Floating seal on spindle shaft
- Thrust buttons on center line of gear mesh
- Hub designed with angle limiter to protect the end ring bolts







LB Dimensions (inches)

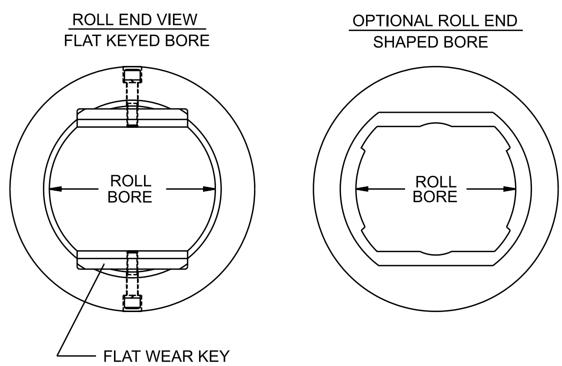
Size	A	B	D	E	Pinion Sleeve		Roll Sleeve		
					Max. Bore	Standard Keyways	Max. Bore with Flat Wear Keys	Max. Bore with Shaped Bore	Max. Flats Dimension
4.0	10.00	20.00	6.50	6.75	7.13	1 3/4 x 3/4	7.38	8.00	6.00
4.5	11.25	22.50	7.50	7.50	8.00	2 x 3/4	8.25	9.00	6.75
5.0	12.50	25.00	8.00	8.75	8.88	2 x 3/4	9.25	10.00	7.50
5.2	12.75	25.50	8.25	6.80	9.13	2 1/2 x 7/8	9.50	10.25	7.69
5.7	13.88	27.76	9.00	9.63	10.00	2 1/2 x 7/8	10.25	11.00	8.25
6.0	14.75	29.50	9.50	10.25	10.50	2 1/2 x 7/8	11.00	11.75	8.81
6.4	15.75	31.50	10.00	10.75	11.25	3 x 1	11.63	12.50	9.40
6.8	16.50	33.00	10.50	11.63	11.75	3 x 1	12.25	13.13	9.87
7.2	17.75	35.50	11.50	12.25	12.63	3 x 1	13.13	14.25	10.69
8.0	19.63	39.25	12.00	13.75	14.00	3 1/2 x 1 1/4	14.50	15.75	11.84
8.5	20.88	41.75	13.00	14.50	14.88	3 1/2 x 1 1/4	15.38	16.75	12.59
9.0	22.00	44.00	14.00	15.25	15.75	4 x 1 1/2	16.25	17.50	13.16
9.5	23.50	47.00	15.00	16.00	16.75	4 x 1 1/2	17.38	18.75	14.09
10.0	24.63	49.25	15.50	17.00	17.50	4 x 1 1/2	18.25	19.75	14.84
10.5	25.75	51.50	16.50	17.75	18.38	5 x 1 3/4	19.00	20.50	15.41
10.8	26.25	52.50	17.00	18.25	18.75	5 x 1 3/4	19.50	21.00	15.78
11.5	27.12	54.24	18.00	19.50	19.38	5 x 1 3/4	20.00	21.70	16.31
12.0	28.50	57.00	19.00	20.13	20.38	5 x 1 3/4	21.00	22.75	17.12
12.7	29.75	59.50	20.00	21.25	21.50	5 x 1 3/4	22.00	23.75	17.86
14.0	32.50	65.00	22.00	23.50	23.25	6 x 2	24.00	26.00	19.56
15.0	34.00	68.00	24.00	23.88	24.25	6 x 2	25.00	27.25	20.50
16.0	36.50	73.00	25.00	27.00	26.00	7 x 2 1/2	27.00	29.25	22.00

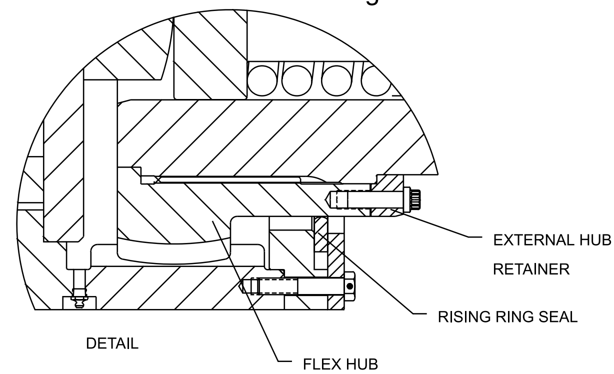
Dimensions given are approximate. The actual dimensions will depend on the application and will be given on a General Arrangement drawing.

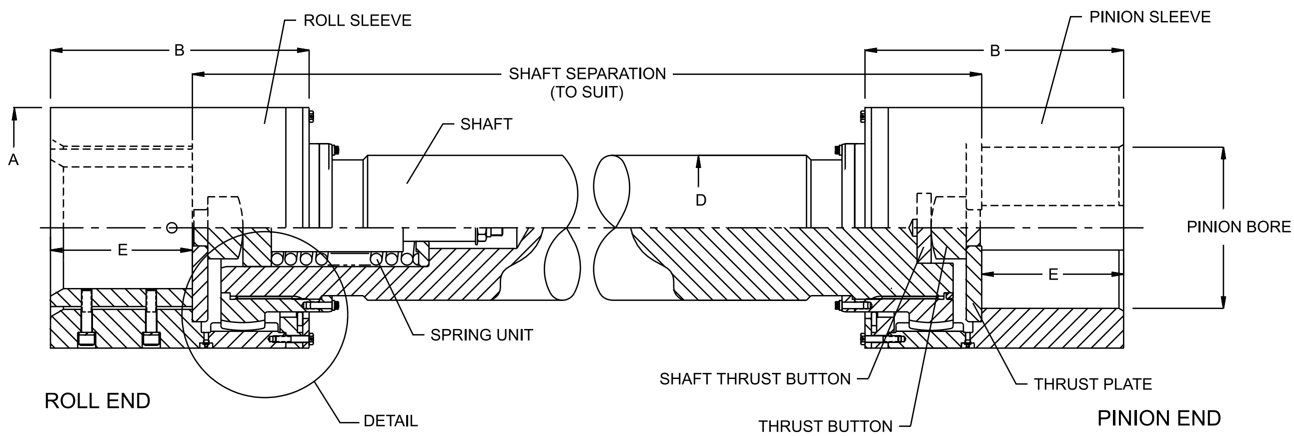
MB Series - Main Drive Spindles

MB Series (Mill Basic, seal on Hub)

- One-piece roll and pinion casing
- Splined replaceable hubs with exterior bolting
- Floating seal on hub body
- Thrust buttons on centerline of gear mesh







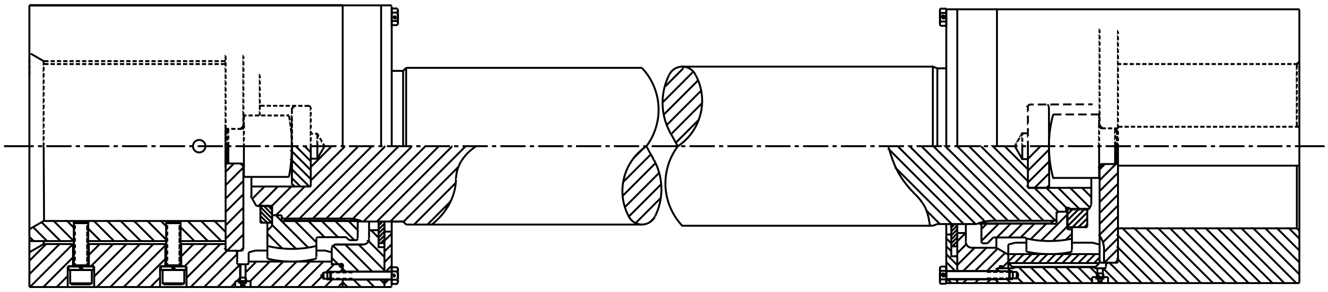
MB Dimensions (inches)

Size	A	B	D	E	Pinion Sleeve		Roll Sleeve		
					Max. Bore	Standard Keyways	Max. Bore with Flat Wear Keys	Max. Bore with Shaped Bore	Max. Flats Dimension
4.0	10.00	20.00	6.00	6.75	7.13	1 3/4 x 3/4	7.38	8.00	6.00
4.5	11.25	22.50	6.75	7.50	8.00	2 x 3/4	8.25	9.00	6.75
5.0	12.50	25.00	7.50	8.75	8.88	2 x 3/4	9.25	10.00	7.50
5.2	12.75	25.50	8.00	6.80	9.13	2 1/2 x 7/8	9.50	10.25	7.69
5.7	13.88	27.76	8.25	9.63	10.00	2 1/2 x 7/8	10.25	11.00	8.25
6.0	14.75	29.50	8.75	10.25	10.50	2 1/2 x 7/8	11.00	11.75	8.81
6.4	15.75	31.50	9.00	10.75	11.25	3 x 1	11.63	12.50	9.40
6.8	16.50	33.00	9.75	11.63	11.75	3 x 1	12.25	13.13	9.87
7.2	17.75	35.50	10.50	12.25	12.63	3 x 1	13.13	14.25	10.69
8.0	19.63	39.25	11.75	13.75	14.00	3 1/2 x 1 1/4	14.50	15.75	11.84
8.5	20.88	41.75	12.50	14.50	14.88	3 1/2 x 1 1/4	15.38	16.75	12.59
9.0	22.00	44.00	13.00	15.25	15.75	4 x 1 1/2	16.25	17.50	13.16
9.5	23.50	47.00	14.00	16.00	16.75	4 x 1 1/2	17.38	18.75	14.09
10.0	24.63	49.25	15.00	17.00	17.50	4 x 1 1/2	18.25	19.75	14.84
10.5	25.75	51.50	16.00	17.75	18.38	5 x 1 3/4	19.00	20.50	15.41
10.8	26.25	52.50	17.00	18.25	18.75	5 x 1 3/4	19.50	21.00	15.78
11.5	27.12	54.24	18.00	19.50	19.38	5 x 1 3/4	20.00	21.70	16.31
12.0	28.50	57.00	19.00	20.13	20.38	5 x 1 3/4	21.00	22.75	17.12
12.7	29.75	59.50	20.00	21.25	21.50	5 x 1 3/4	22.00	23.75	17.86
14.0	32.50	65.00	22.00	23.50	23.25	6 x 2	24.00	26.00	19.56
15.0	34.00	68.00	23.50	23.88	24.25	6 x 2	25.00	27.25	20.50
16.0	36.50	73.00	25.00	27.00	26.00	7 x 2 1/2	27.00	29.25	22.00

Dimensions given are approximate. The actual dimensions will depend on the application and will be given on a General Arrangement drawing.

Design Variations

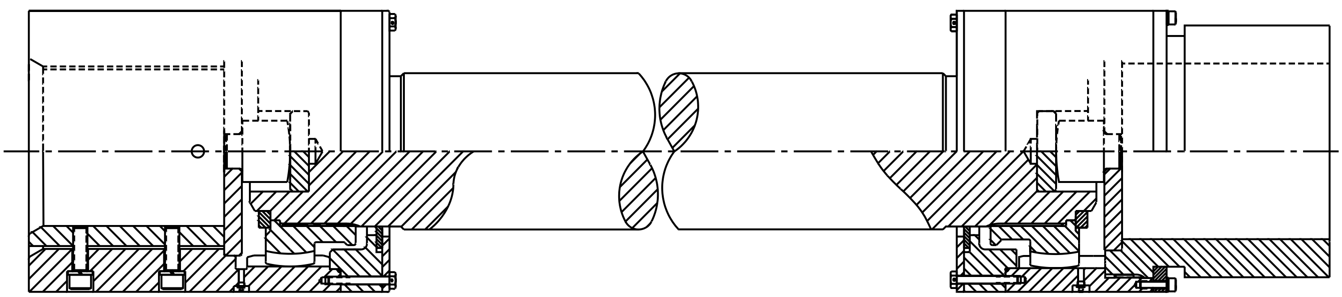
Combination



Roll End LB | Pinion End LE

This design is commonly used where the roll end cannot accommodate a gear element due to limited roll diameter. The pinion end retains the element for economical gear replacement.

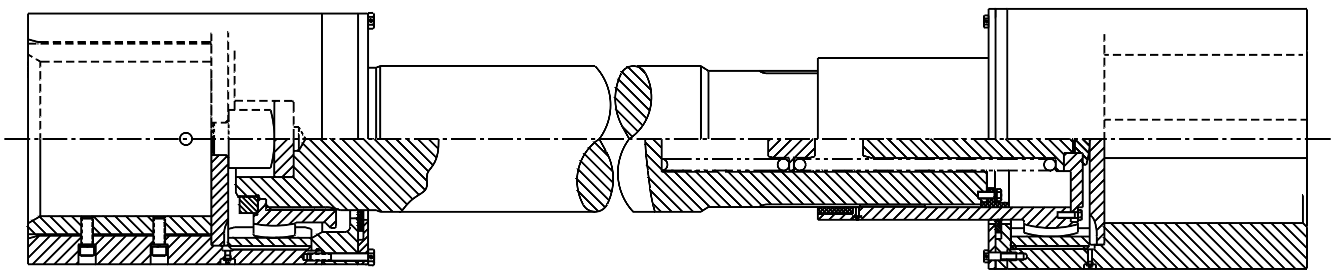
Adapter Design



Roll End LB | Pinion End (Adapter Type)

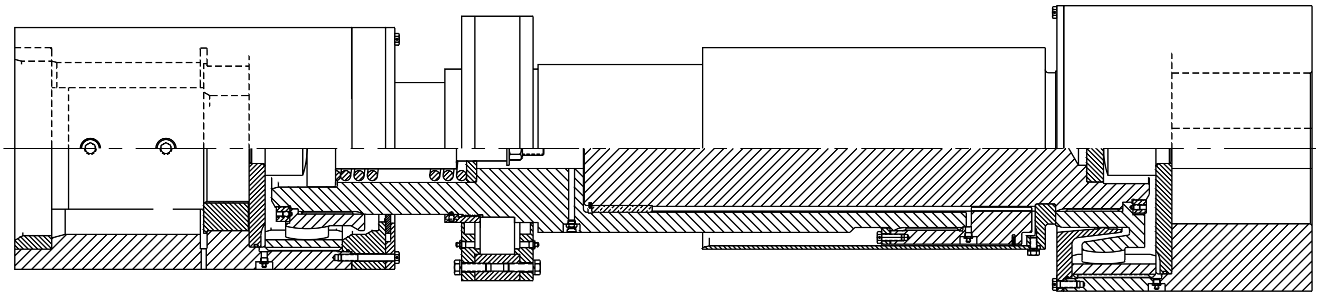
Allows for economical gear replacement on the pinion end within a limited envelope.

Axial Adjustment for Roll Shifting



Roll End LE | Pinion End ME

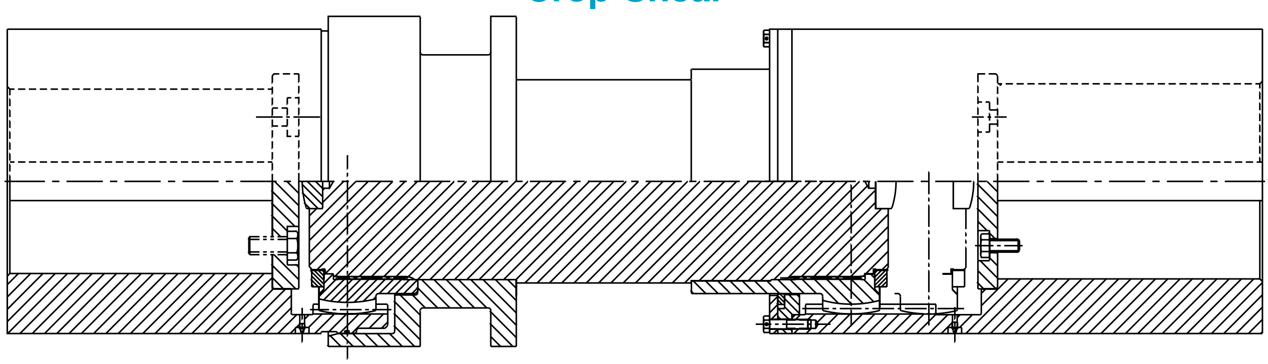
Axial Travel for Vertical Roll/Stand Removal



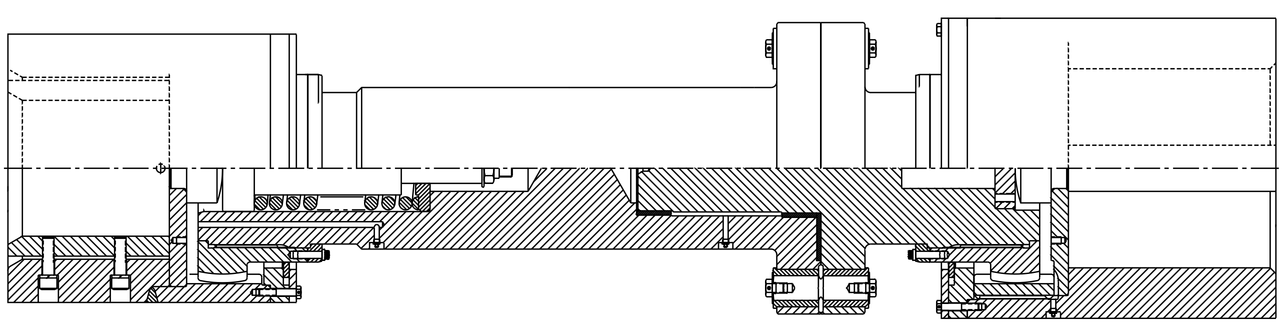
Roll End

Pinion End

Crop Shear



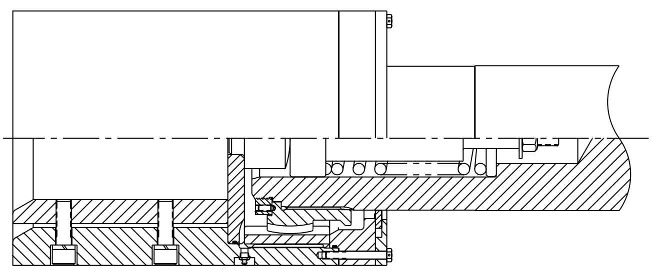
Overload or Shear Design

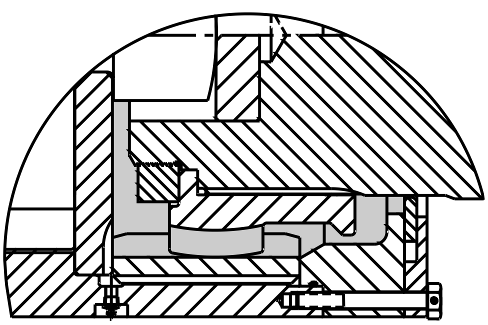


Design Features and Options

Large Lube Reservoir: (LE and LB design)

By sealing on the spindle shaft OD and not the flex hub OD, the KOP-FLEX gear spindle design has a large lube reservoir to allow larger grease capacity, which in turn will reduce wear. Most designs of gear spindles, which seal on the hub OD, have small lube capacity compared to the KOP-FLEX design. See the figure below showing our 'LE' spindle seal design. By sealing on the shaft, 'LE' and 'LB' designs can provide this larger lube reservoir.

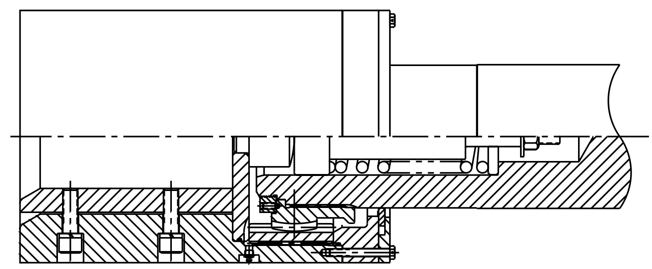




Largest Lube Capacity Available in the LE and LB Design (LE Design Shown)

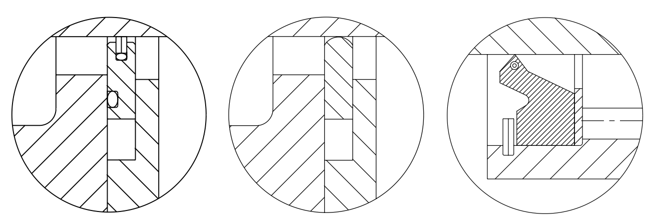
Replaceable Gearing

One of the main features of the LE or ME design is replaceable gearing on both the roll and pinion ends. Gear spindles are designed with replaceable flex hubs and intermediate sleeves that are easy to replace and most economical to stock as required. The primary advantage of replaceable gearing is low cost of maintenance because if the gearing wears out, you need only replace the flex hub and/or the Intermediate Sleeve (Ring gear) instead of the entire roll end or pinion end casing.



Floating Seal Design

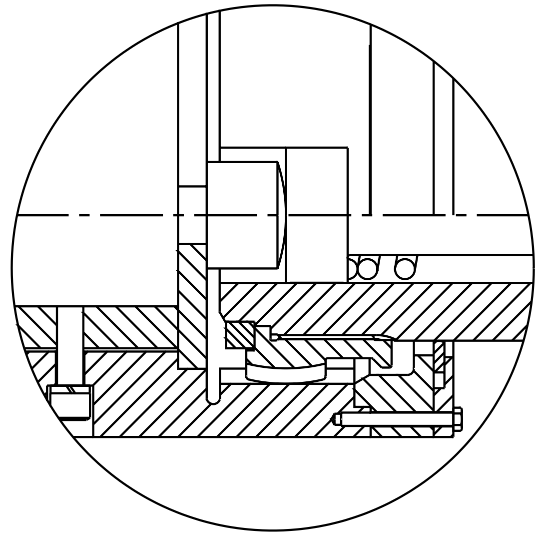
The KOP-FLEX standard seal for gear spindles is a floating (rising ring or piston ring) type seal which floats up and down in the seal cavity to accommodate misalignment of the spindle during operation. This design has worked very well for over 25 years in mills all over the world. Also, the seal itself is made of filled nylon which reduces the damage to the surface it rides on from being damaged. Again, the seal is on the shaft for the LE and LB design, unlike your typical gear spindle design. Three different seal designs that we typically use are shown at the right.



Piston Spirolox Seal Ring **Piston Seal Ring** **Lip Seal**

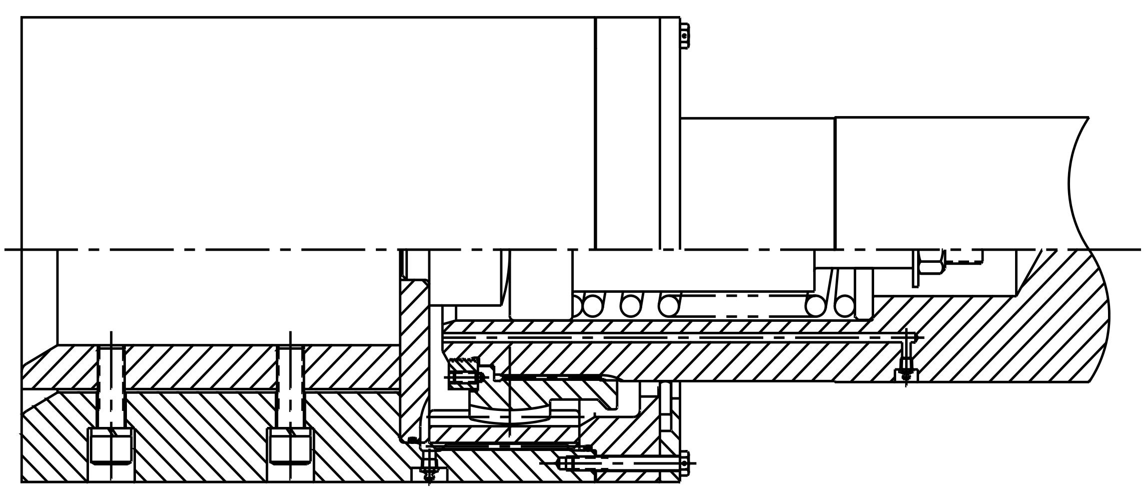
Thrust Button on Center Line of Gearing

A thrust button is designed with a spherical surface that is located at the center line of working gear tooth, which is the misalignment point. This allows the thrust button to accommodate misalignment without jamming under motion as off center buttons do. In addition, the thrust button is positioned to allow the lubricants to flow throughout during misalignment. The thrust buttons are designed to be replaceable components made from heat treated material - options available are alloy steel heat treated, and nitrided or carburized depending on the application.



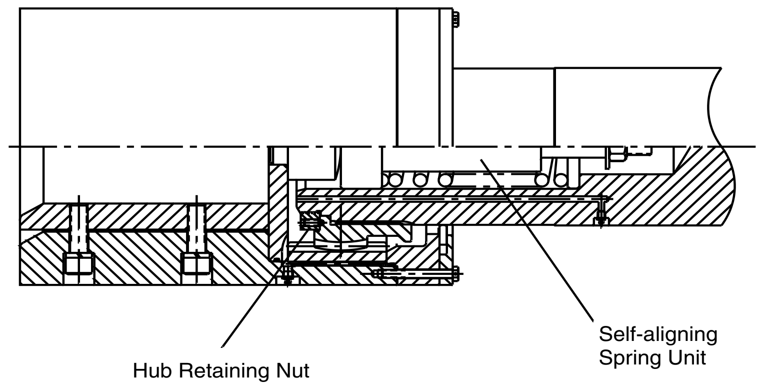
Multiple Lubrication Points

KOP-FLEX gear spindle design allows for easy lubrication. The lubrication fittings are typically located on the outside diameter (OD) of the Roll and Pinion end casings. KOP-FLEX can also incorporate a lubrication point on the body of the shaft as an **option** to allow easy lubrication of the gearing. The lubrication points on the shaft are easily accessible and are at a diameter where they are usually unhindered by ancillary equipment in the mill.



Self-aligning Spring Unit (Spring Loaded Thrust Button)

The KOP-FLEX design includes a self-aligning spring unit as an option that will keep the roll end casing erect (straight-parallel to the mill floor) during roll change, to allow the rolls to be inserted without the need to support the roll end casing. The gear spindle roll end casing will stay in the same position as when the roll is removed. The spring is designed to be a replaceable component without any modification to the assembly, or the spring unit can be used as a shock absorbing unit.

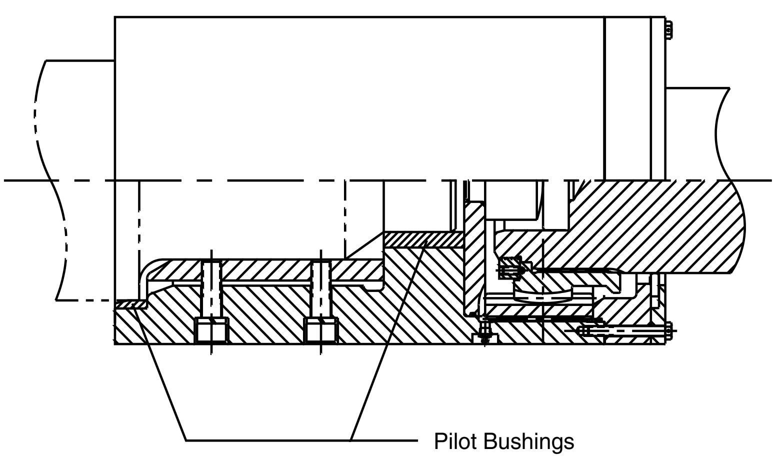


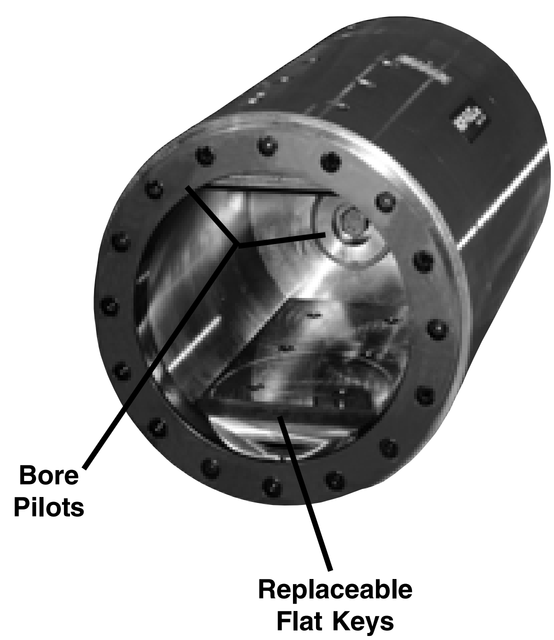
Hub Retainer Nut

The LE and LB design incorporates threaded/screwed on hub retainer ring. This design eliminates the need for the external bolting of the hub on the center shaft as shown on pages 241 and 243 for ME and MB designs respectively. These bolts can break during operation due to thrust loads during roll change. The KOP-FLEX-design eliminates this bolt breaking problem, by using a nut that is screwed on the end of the shaft to hold the hub to the center shaft. This nut is held by retaining screws that prevent the nut from backing off.

Piloted Bores

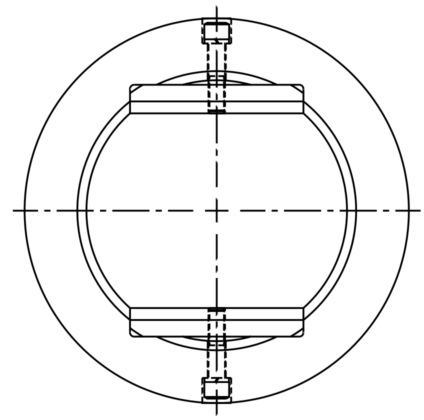
Roll end bores with pilots provide the best fit and can prevent the roll end sleeve from rocking and thus prevent wear and damage to the roll end replaceable keys or shaped bore. The life of the gear spindles can be increased by including pilot bushings.





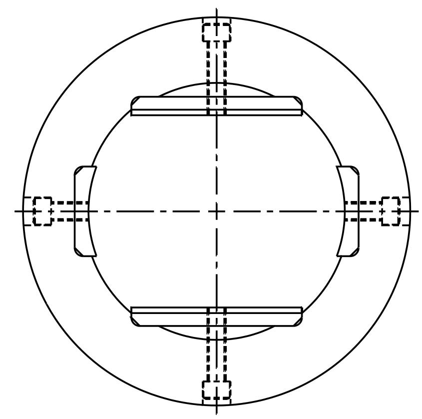
Roll End Bore Designs

Replaceable Flat Keys



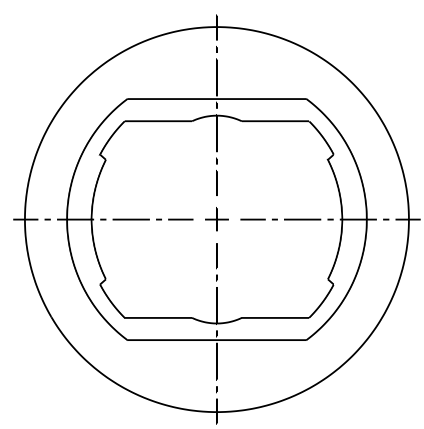
This design is most commonly used in gear spindles in the rolling mills. The roll end bore of the spindle is designed to fit the shape of the roll neck which has two flat and two round surfaces. The advantage of this design is it allows for replaceable flat wear keys that can be replaced in the field without having to throw away the entire roll sleeve when the flat area wears due to normal operation.

Bore Liners - Flat Keys and Round Wear Liners



Bore liners are offered as an option to a provide greater degree of replaceable components. Both the flat and round wear liners can be replaced. This design offers the most flexibility in terms of components that can be replaced in the field. Again, the purpose behind the wear liners is to preserve the roll end sleeve for economical reasons.

Shaped Bore



A shaped bore option is normally preferred by customers for roughing stand application in the hot strip mill (generally not used in the finishing stands or in cold mill). The shaped bore typically provides for a stronger bore, but when it wears the entire roll sleeve has to be replaced or repaired by welding, as opposed to replaceable wearable components - flat keys and round wear liners. One of the advantages shaped bores offer is a stronger bore than the ones with replaceable keys since the bolts in the replaceable keys could break during roll change or adversely impact load in the mill. Therefore, generally in applications with high impact load or high impact roll change practices, shaped bores are a preferred choice.

For More Information

Visit www.kopflex.com

Lubrication and Troubleshooting

Straight talk on spindle lubrication and trouble-shooting

How often should I lubricate?
Normally once a week. However, frequent roll change causes a loss of lubricant. You may have to lubricate more under these circumstances, or possibly less under ideal conditions.

How often should I inspect?
You should completely disassemble and inspect each spindle at least once per year. We recommend that you use a spindle manufacturer to do this for you. We can repair worn spindles for less than the cost of a new one (see pages 254 and 255).

What type of grease should I use?
Use a non-lead grease with a minimum soap base of anhydrous calcium or lithium. The grease also should have additives for lubricity, rust prevention, adhesion, and extreme pressure. The base oil viscosity should be a minimum of 150 SUS at 210° F (100° C).

KOP-FLEX recommends WAVERLY* Torque Lube "A", which was developed especially for gear spindles (see pages 204-206). For high speed applications consult KOP-FLEX.

Why do spindles fail and what can I do to prevent failure?
There are three main causes of spindle failure: lubrication problems (causing normal wear, abrasive wear, scoring, and welding), sub-surface shear failures (pitting and spalling), and tooth breakage.

Lubrication related failures: Since gear teeth slide against each other during normal operation, some wear is inevitable, but premature or excessive wear is unacceptable. Wear can be classified as normal, abrasive, and scoring. Normal wear is usually slow and progressive and occurs over the service life of the teeth. Abrasive wear is usually rapid. Surface damage yields fine particles which rapidly accelerate tooth wear. Scoring usually occurs when the lubricant breaks down (or is ineffective for other reasons). Heat is generated, localized welding can occur, then destructive scoring takes place which is followed by torn out material, leaving pockets on gear tooth flanks. Poor contact and poor lubrication cause such problems. Here are five factors that contribute to lubrication related failures:

CAUSE	CURE
(1) Using the wrong grease or not enough grease	(1) Use special spindle grease, not bearing grease. Fill properly.
(2) Grease leaks from the seal	(2) Check seals periodically. Consider replacing a lip seal with an all-metal rising ring seal.
(3) Rolling fluid washes grease from the gearing	(3) Check the sealing of the thrust plate.
(4) High pressure-velocity (PV) values. A combination of high operating speeds and/or high misalignment causes high PV. High PV causes extreme temperatures, which cause the lubrication to break down.	(4) Use gearing with greater surface hardness, high operating speeds, high misalignment capacity, and a low coefficient of friction to address high PV, which causes extreme temperatures,(and breaks down lubricant). Increase the number of teeth under load to reduce the contact pressure on each tooth. Correct distortion by lapping or grinding.
(5) Poor tooth contact. When few teeth are in contact, these teeth carry a disproportionate load. This then causes metal-to-metal contact, which generates localized hot spots (heat) and produces localized welding that causes tooth distress, destructive scoring, and welding. Poor tooth contact is due to either high operating misalignment or improper tooth shape (usually caused by heat treat distortion). Gears are often carburized to improve their strength but this distorts the teeth.	(5) If operating angles exceed the gear spindle's design capacity, redesign the spindle. If misalignment is within original expectations, check the number of teeth in contact. If the number is too low it's likely the teeth were excessively distorted during surface hardening (typical of induction hardened or carburized teeth) and not properly corrected by lapping or grinding.

Troubleshooting and Reverse Engineering

Sub-surface failure (pitting and spalling): Since spindle gear teeth see high repetitive loads, pitting and spalling is common, particularly at high angles or in spindles with poor tooth contact. Repeated cycles cause more pitting and further erosion of the surface (spalling). Large spalls sometimes look like "worm tracks." If the case is not deep enough to support the high repetitive loads, the case sometimes cracks (crushes like asphalt). This eventually causes pieces of the surface to break away, leaving voids, which can also look like "worm tracks."

CAUSE	CURE
(1) **Poor tooth contact.** When few teeth are in spindle's contact, these teeth carry a disproportionate load. This then causes sub-surface cracking, which can produce pits and eventually spalls that cause tooth in distress. Poor tooth contact is due to either high operating misalignment or improper tooth shape (usually caused by heat treat distortion). Gears are often carburized to improve their strength, but this distorts the teeth.	(1) If operating angles exceed the gear design capacity, redesign the spindle. If misalignment is within expectations, check the number of teeth contact. If the number is too low, it's likely the teeth were excessively distorted during surface hardening (typically induction hardening or carburization) and not properly corrected by lapping or grinding. You will have to rehab the spindle.
(2) If tooth contact is good, the **case is too thin** and it crushes under the load. Either the surface treatment isn't deep enough, or the core is too soft to support the case.	(2) Increase the core hardness of the base material (e.g. change to Nitralloy), or change from nitrided to carburized teeth. The case depth for nitriding is 0.015"- 0.030" (0.38 - 0.76 mm), while the case depth for carburizing is 0.060"-0.250" (1.5 - 6.4 mm).

TOOTH BREAKAGE: Gear teeth can break at either the end or the root (base).

CAUSE	CURE
(1) **Root breakage due to poor surface heat treatment.** It is difficult to induction harden crowned teeth. Ends of teeth are thin. Therefore the depth of hardening varies across the tooth. This can produce stress risers and root cracking.	(1) Change to a more predictable surface treatment, such as nitriding, which produces uniform case depth throughout the tooth.
(2) **Root breakage due to excessively high torque loads** or high impact loads at high angles.	(2) Switch from nitriding to carburizing. Change the grade of carburizing material to improve the combined case-core strength in bending. Switch to lapped or ground carburized gear teeth to improve load distribution.
(3) **End breakage** generally occurs when you exceed the spindles static misalignment capacity (normally the roll change angle). A spindle cannot bend more than it droops when you remove the roll. Forcing the spindle to bend more will break the ends of the teeth.	(3) Specify a spindle with a larger static misalignment capacity, or alter your roll change practices to reduce the roll change angle, or use an LE or LB spindle design which bottoms out at the end rings rather than wedging teeth (our standard spindles incorporate this feature).

For more information on any aspect of spindle design, operation, or maintenance, call your sales engineer at 410-768-2000. To learn about how we can help you inventory spares and setup preventive maintenance, see pages 254 & 255.

Replacing existing equipment through reverse engineering

KOP-FLEX is in a unique position to reproduce any existing spindle, including those of our competitors. We have over 80 years of experience and are considered among the finest coupling engineers in the world. Our Computer Aided Manufacturing routinely produces components to the tightest tolerances.

We can accurately reproduce any spindle or its parts, including crown tip piloted or root piloted gear teeth, using any material or heat treatment you require. In addition, we will recommend improvements in material, heat treatments, and finish suited to your specific application.

Extended service life and minimized maintenance requirements

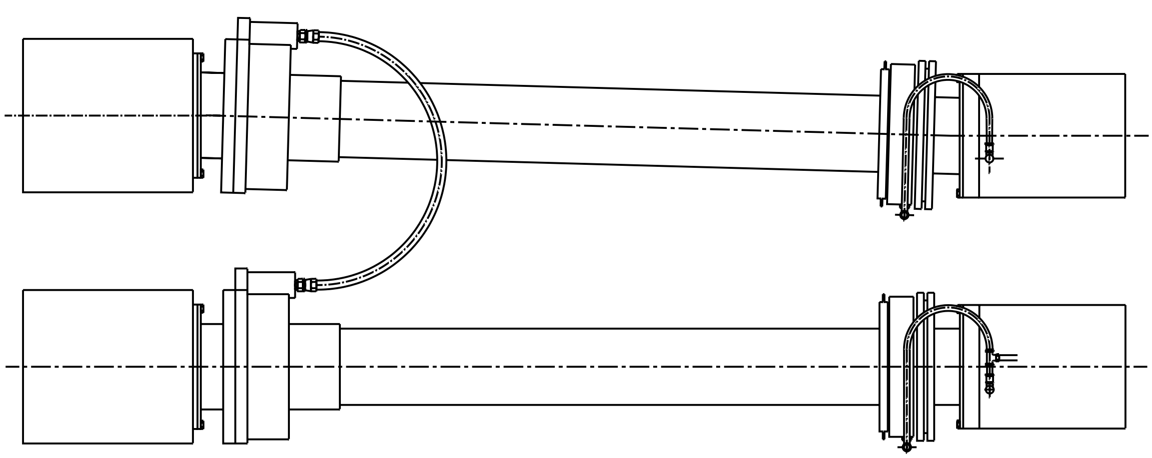
Gear spindles often fail due to welding of the gear teeth, which is caused by excessive heat. (Heat generated by the rolling and sliding of the components isn't dissipated fast enough). Historically, gear spindle designers have tried to offset the effects of excessive heat by improving materials, surface treatments, and lubricants. But some high speed, high powered mills push the limits of these improvements.

For example, gear spindle grease lubricants use a high viscosity base oil of 3,300 SUS at 100°F (38°C). But under working conditions the temperature reaches 200°F or more. That causes the viscosity of grease to drop drastically. At 210°F (99°C), the viscosity is 150 SUS or lower.

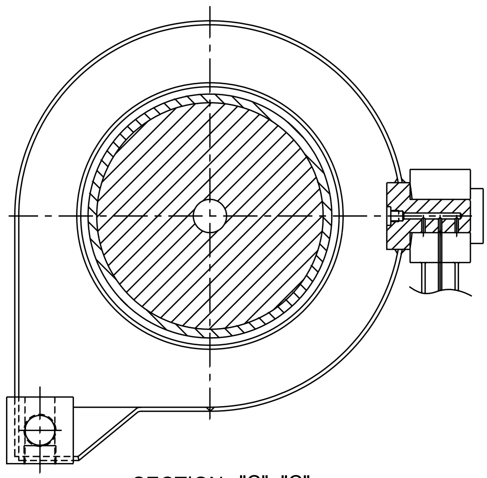
This drop in lubricant viscosity shortens the service life of traditional spindles. Besides that, you have to add grease frequently. Using grease as a lubricant is problematic: grease is a fire hazard and it's harmful to the environment. Clean-up is becoming expensive. A "circulating oil" type spindle cuts heat generation, extends service life, minimizes maintenance, and reduces fire and environmental dangers.

In a circulating oil spindle, oil is pumped from a reservoir, through a filter, into the gear mesh, and back into the reservoir. Thanks to good seals, the oil flows in a closed loop, minimizing spillage. The spindle can share the same oil as the pinion stand or another compatible system.

The benefits of a circulating oil system in such an application are dramatic. For example, a highly viscous oil (2,100 SUS at 100°F (38°C)) will remove most excess heat under operating conditions. It will remain at about 100°F and retain it's viscosity. That greatly extends gear spindle life, and since it is a closed system, maintenance is minimized. It only needs to be cleaned and inspected annually, and seals replaced as necessary.

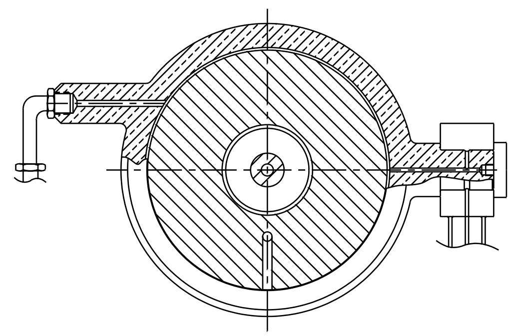


Circulating Oil Spindle



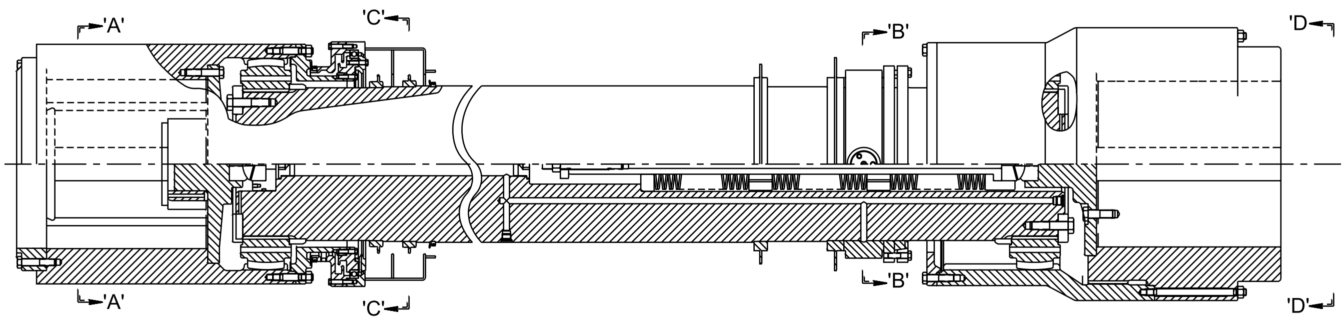
SECTION "C"~"C"

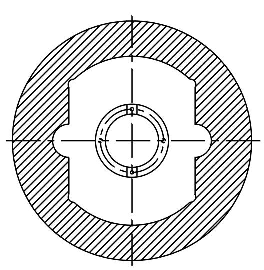
OIL CATCH BOX



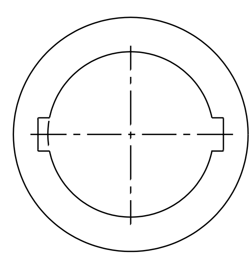
SECTION "B"~"B"

LUBE RING





SECTION "A"~"A"



VIEW "D"~"D"

BOTH KEYWAYS IDENTICAL

For More Information

Visit www.kopflex.com

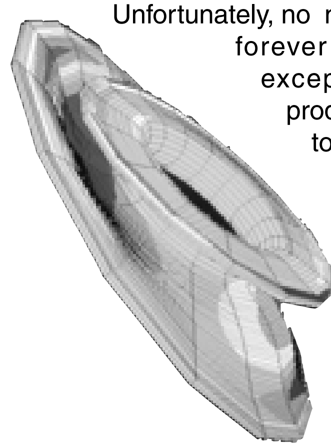
Repair and Maintenance Program

Question: How do you end headaches and save money with preventive maintenance?

Answer: Team-up with KOP-FLEX.
You want your couplings to function for as long as possible. KOPFLEX is committed to producing a durable product and will help you stay up and running with a predictive, proactive, and preventive maintenance program. Let the leader in couplings design a program to suit your needs. The fact is that you can repair a coupling, gear spindle or universal joint for about half the cost of buying new. It takes special design, fabrication, quality control and operations know-how. Don't trust your highly engineered product to just any repair shop. Demand KOP-FLEX.

KOP-FLEX service technician inspecting gear coupling

Let an expert provide you with both an analysis and a recommendation



Unfortunately, no mechanical product can last forever and couplings are no exception. While KOP-FLEX products are designed and built to last, many applications are so severe that rapid wear and/or coupling damage may occur.
KOP-FLEX has the largest and most experienced engineering staff in the industry, with an arsenal of modern analysis tools at our disposal including FEA, an in-house R&D center, and a staff focused solely on couplings. Let our technical experts go beyond mere failure analysis by providing our recommendations on how to prevent future coupling problems.

Case Study:
At one major Midwest steel plant, our management program has reduced the spindle maintenance cost per ton of rolled steel to less than half of what it once was. When you consider the tangible, direct-cost savings, reduced down-time and extended component life, you can see how coming to KOP-FLEX can reward you with big savings.

KOP-FLEX Service Centers offer:

- **Repair and refurbishment**
- **Expert failure analysis**
- **Cost savings through consultation**
- **Field technical support**

For More Information

Visit www.kopflex.com

Repair and Maintenance Program

Custom-Tailored Inventory and Maintenance Management Program Saves Money and Prevents Downtime

Are you currently spending too much money on spare parts inventory?

Is parts storage a hassle?

KOP-FLEX will inventory your spindle, coupling and universal joint stock and develop a usage profile.

KOP-FLEX will work with your staff to develop a usage profile and then we'll inventory parts appropriate to maximizing plant performance. Spindles, couplings and universal joints can then be shipped from our facility to you within 12 to 24 hours. You benefit via added convenience and reduced inventory investment.

KOP-FLEX not only repairs and refurbishes but offers a special program to enable peak plant efficiency:

- Company representatives will meet with you to understand your needs and your current inventory of gear spindles and heavy duty couplings
- A usage profile is developed
- Safety levels for components are established
- KOP-FLEX will inventory components vital to your operations, eliminating the initial capital expenditure and the cost associated with carrying inventory
  - Inventory is managed on an ongoing basis for a nominal fee
  - Regular review of your stock will help you reach your desired inventory levels

Look to KOP-FLEX, the industry leader in couplings, to keep your plant running smoothly and efficiently. Call one of our representatives today about designing a custom program for you.

A damaged gear ring is machined off a spindle roll sleeve; The cost to repair is typically about half the cost of replacement

Following the replacement of internal gear teeth, a refurbished size #30 (78 inches diameter) gear coupling sleeve is ready for shipment

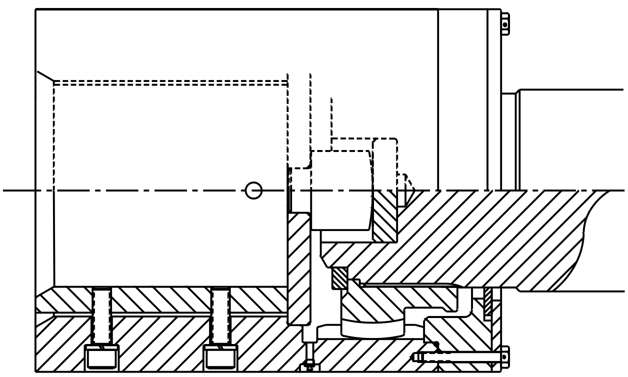
Additional benefits of a KOP-FLEX repair, inventory and maintenance management program:

- Customized to your needs - KOP-FLEX can design a program that accommodates many functional areas: Operations, Maintenance and Procurement
- You save three ways - KOP-FLEX will bear inventory carrying cost, diminish your taxable assets and reduce capital expenditures on the wrong spare parts
- KOP-FLEX will monitor inventory usage and requirements
- KOP-FLEX will reduce unscheduled downtime by optimizing a changeout schedule that takes your needs into consideration
- Pricing can be predetermined to avoid surprises and help you manage your budget

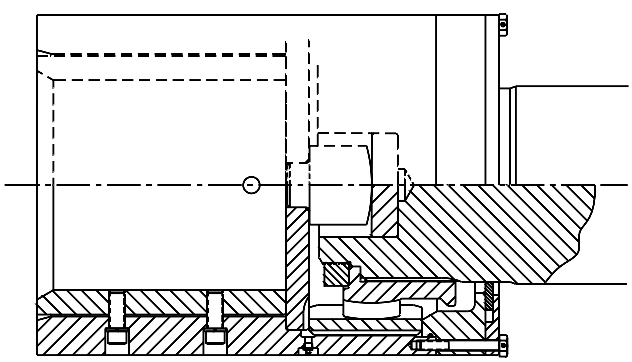
To discuss these and the many other benefits of a KOP-FLEX program, call us today. You're closer than you think to saving money and preventing unanticipated downtime.

"L" Series Main Drive Gear Spindle Features

KOP-FLEX has pioneered many features seen in today's spindles – Replaceable Gear elements, Sleeve aligning springs, the "Rising Ring seal", and most recently, Contact Ground Gearing (CGG™). For main drive gear spindles for rolling mill applications, we recommend using the "L" series spindle, the culmination of 50+ years experience in the industry. The "L" series is available with either nitrided or carburized gearing.



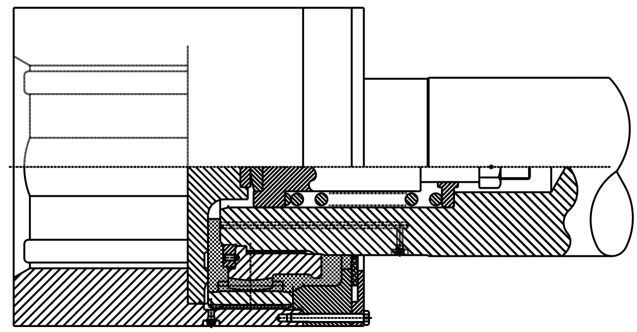
Roll End LB



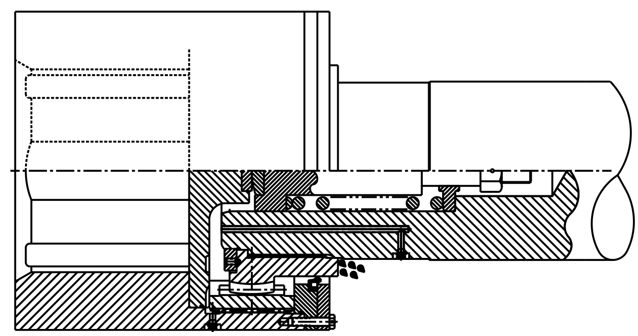
Roll End LE

Visit www.kopflex.com

"L" series spindles are classified into two different types – "LB" & "LE". This designation defines the configuration of the gearing. The "B" in "LB" means basic and the "E" in "LE" means element. Although both the "LB" & "LE" have a replaceable flex hub, the "LE" has a replaceable gear ring (intermediate sleeve) which is more cost effective to replace when compared to the repair of the roll sleeve gearing in the "LB".



"L" Design - Larger Grease Capacity



Typical Competitor Design
Reduced Grease Capacity

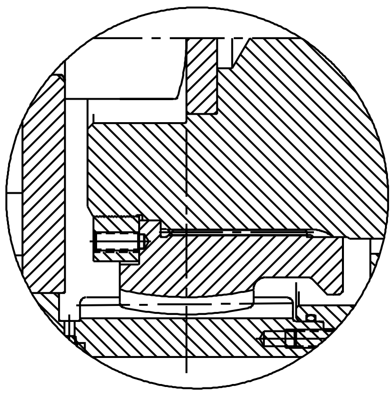
The "life blood" of any gear spindle is lubrication. The "L" spindle is superior in design when compared to the competition due to the increased lubrication area. The "L" spindle seals on the shaft rather than the flex hub. Besides a larger lube capacity, this sealing arrangement encapsulates the flex hub to shaft spline connection, which avoids fretting wear of the spline and keeps moisture from damaging the spline.

For any assistance call Customer Service or Engineering at 410-768-2000 or email coupling specialists at coupling-engineering@emerson-ept.com

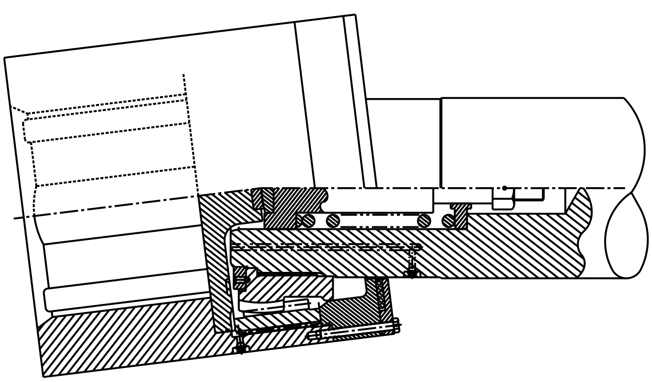
"L" Series Main Drive Gear Spindle Features

Additional Features:

- Replaceable thrust buttons to ensure alignment around the center of the gearing.

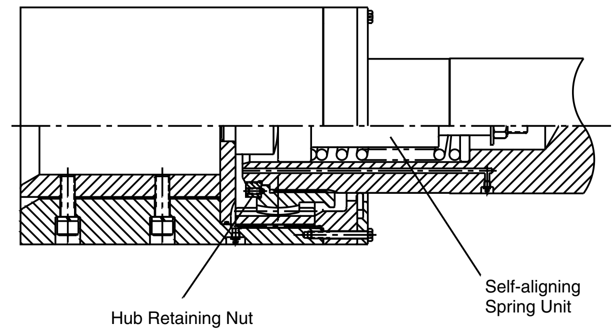


- Rising ring seal maintains a positive seal on the shaft under misalignment, where lip seals may open up under misalignment.
- Bump on flex hub creates a positive stop and prevents breakage of teeth due to over misalignment.

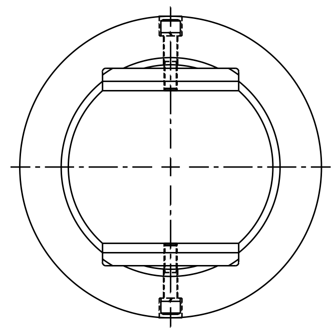


Tooth End Breakage due to over-misalignment

- Self-aligning spring unit, keeps the roll end casing erect during roll changes (support of roll casing not required).

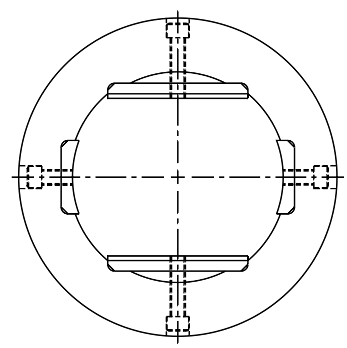


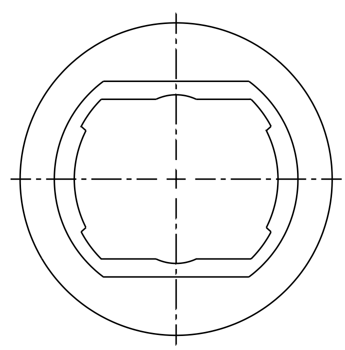
- Multiple roll end bore designs available.



Replaceable Flat Keys

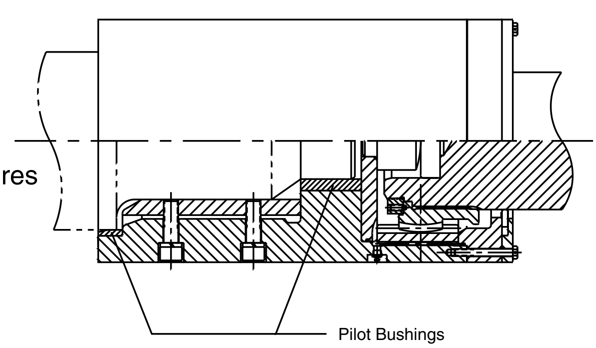
Replaceable bore liners & flat keys





Shaped Bore

Piloted Bores



Auxiliary Spindles SF and SL Series

We manufacture two types of auxiliary spindles for high misalignment applications:

- ***SF (spindle flange) Series***
- ***SL (spindle leveler) Series***

Design Features:

- Accommodates 6° static misalignment per flex half
- Crowned tooth tips and faces to ensure uniform load distribution at varying misalignments.

Seal Design:

- The large radial displacement lip seal supplied as standard provides adequate lubrication retention for most applications.
- For severe applications (high heat, high misalignment, or high speed) we offer an exclusive all-metal, rising ring seal. This seal is non-perishable and provides a positive seal that maintains a larger lubrication reservoir.

Alloy Steel Hubs and Sleeves:

- We manufacture hubs and sleeves from high nickel, alloy steel (not carbon steel) for higher core strength.
- Two-step hardening process:
  - Through hardening for increased core strength
  - Nitriding of teeth and sealing area for reduced wear and coefficient of friction. ***We are the only manufacturer to offer seal surface nitriding as a standard feature!***
- Superior to induction hardened carbon steel spindles:
  - Greater core strength makes for a stronger spindle and increased service life.
  - Nitriding produces less distortion than induction hardening, resulting in better load distribution.

Selection Procedure

1. Calculate torque (T_s) to be transmitted:

$$T_s \text{ (lb.-in.)} = \frac{HP \times 63{,}025}{RPM} \times \text{Service Factor (See Table 4)}$$

2. Select size and type from Table 5 under the appropriate operating misalignment angle. Torque capacity (T_c) must be greater than T_s ($T_c > T_s$). Consult KOP-FLEX to verify your selection.
3. Check pages 260 & 261 for dimension & bore capacity.

Table 4- Service Factors (Auxiliary Drive Spindles)

Load	Driven Equipment	Service Factor	
		Non-Reversing	Reversing
Steady (Light-No-Shock)	General: Pumps, Fans Paper Mills: Bleachers, Coaters	1.25	1.5
Medium Shock	Cold Mills Small Bar & Rod Mills Steel Mills: Auxillary Equipment, Coilers, Levelers, Pinch Rolls, Tinning Lines, Pickle Lines Paper Mills: Line Shafts	1.5	2.25
Moderate Shock	Hot Mills Section Mills Large Bar and Rod Mills Paper Mills: Dryers,Couch Rolls, Pulp Grinders, Barkers, Calendar	1.75	2.75
Heavy Shock	Steel Mills: Runout Tables Paper Mills: Barkers, Calendar, Press Rolls,Feed Roll Drives	2.0	3.0

Table 5 — Model 6 Degree Series SF and SL Gear Spindle Specification

Size	Series SF OD (inches)	Series SL OD (inches)	Alloy AISI 4140 Nitrided Gearing							
			Normal Torque Capacity (lb-in) of spindle gearing for Misalignments Indicated							
			Tn 1 deg	Tn 1.5 deg	Tn 2 deg	Tn 3 deg	Tn 4 deg	Tn 5 deg	Tn 6 deg	Tms Shaft
1.5	6.00	4.00	26320	22400	18400	12800	10400	8000	5600	14000
2.0	7.00	5.00	52080	44000	36800	25600	20800	16000	10400	28500
2.5	8.38	6.00	87520	73600	61600	44000	35200	26400	17600	50600
3.0	9.44	7.00	149040	125600	104000	74400	59200	44800	29600	91300
3.5	11.00	8.00	241360	202400	168800	120800	96800	72800	48800	136000
4.0	12.50	9.00	350400	294400	244800	175200	140000	104800	70400	194000
4.5	13.62	10.00	492480	413600	344800	245600	196800	148000	99200	308000
5.0	15.31	11.62	659360	553600	461600	328800	263200	197600	132000	404000
5.5	16.56	12.62	878640	738400	615200	439200	351200	264000	176000	584000
6.0	18.00	14.00	1246720	1047200	872800	622400	498400	374400	250400	732000
7.0	20.75	15.75	1694800	1424000	1186400	845600	677600	508800	340000	1092000

⚠CAUTION Capacities are of gearing only. If selection torque exceeds Tms (limit of shafting) then an alloy shaft may be required. - Consult KOP-FLEX.

Auxiliary Spindles Interchange

Why KOP-FLEX® Brand Couplings?

- SF and SL standard gear spindles are manufactured from AISI 4140 steel nitrided gearing, which provides longer service life than competing induction hardened gearing.
- We offer an optional all-metal rising ring seal for positive lubricant retention (lip seals are standard).
- We nitride the seal surface to extend service life. Our competitors don't offer this as a standard feature.
- Custom designs on request.
- Carbon or alloy shafts as required.
- ±6° misalignment capacity per gear mesh.

Easy interchange with other auxiliary spindle manufacturers

Table 6 - Auxiliary Spindle Size to Size Interchange Guide

SL Series

KOP-FLEX® BRAND COUPLINGS	AMERIDRIVES* SL	AJAX*/RENOLD* DS
1.5	4	150
2	5	200
2.5	6	250
3	7	300
3.5	8	350
4	9	400
4.5	10	450
5	11 5/8	500
5.5	12 5/8	550
6	14	600
7	15 3/4	700

SF Series

KOP-FLEX® BRAND COUPLINGS	AMERIDRIVES* SF	AJAX*/RENOLD* D-100
1.5	6	150
2	7	200
2.5	8 3/8	250
3	9 7/16	300
3.5	11	350
4	12 1/2	400
4.5	13 5/8	450
5	15 5/16	500
5.5	16 9/16	550
6	18	600
7	20 3/4	700

Note:
*AMERIDRIVES is a trademark of Amerdrives, Inc.
*AJAX or *RENOLD is a trademark of Renold Public Limited Company.
*AMERIDRIVES and *AJAX/RENOLD data is based on their respective published catalogs.
Data subject to change.
These trade names, trademarks and/or registered trademarks of others are used herein for product comparison purposes only, are the property of their respective owners and are not owned or controlled by Emerson Power Transmission Corporation (EPT). EPT does not represent or warrant the accuracy of this document.

Auxiliary Spindles
SF Series

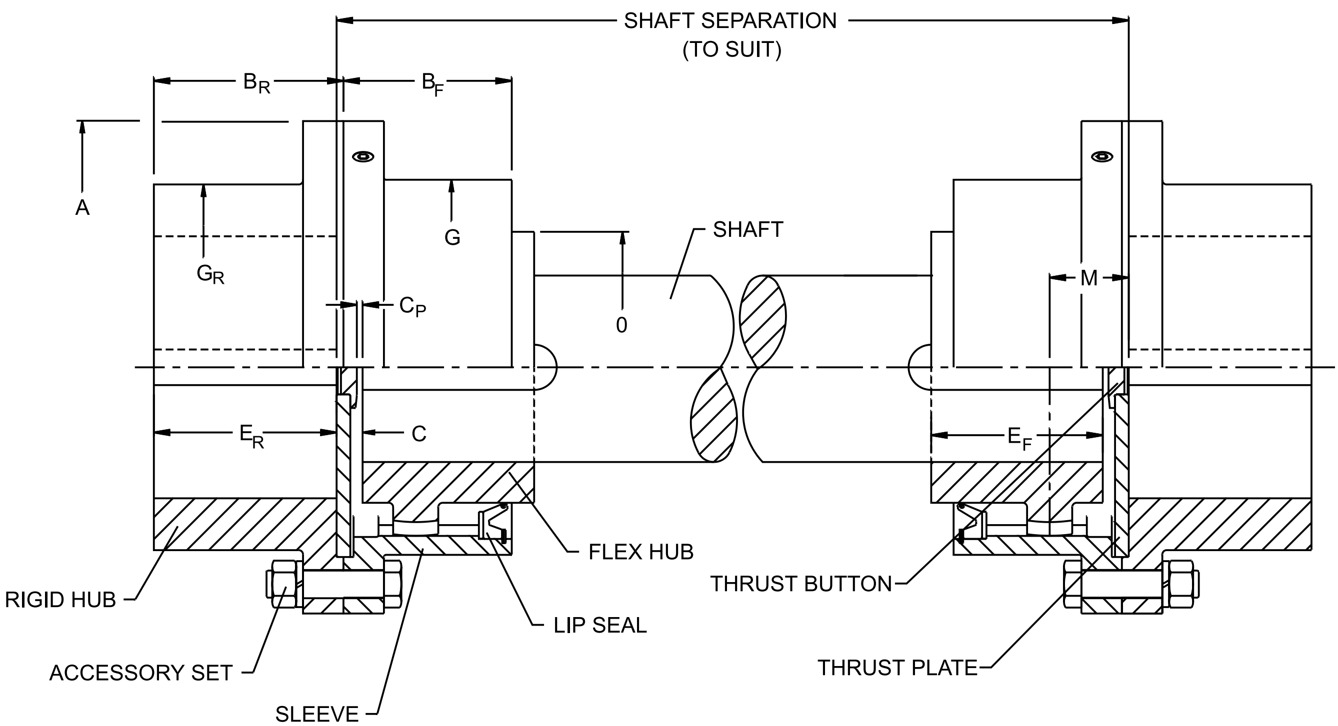
SF Series - 6° flange type auxiliary spindle

Applications

Use Our 6° SF spindles on auxiliary equipment:
- Pinch rolls and tension bridles
- Continuous casters
- Pickle and galvanizing lines
- Paper machines
- Rubber Calenders
- Compactors/bricketters

Features

- Exposed bolt furnished standard (shrouded bolt design on request)
- Lip seal furnished standard, optional all-metal rising ring seal
- Custom designs on request



6° SF Specifications (inches)

Size	Maximum Bore with Standard Keyway		Dimensions											
	Flex	Rigid	A	B_F	B_R	C	C_P	D	E_F	E_R	G	G_R	O
1.5	1.875	2.625	6.00	2.22	1.94	0.34	0.06	2.00	2.31	1.84	3.94	3.81	2.62
2.0	2.375	3.250	7.00	2.62	2.38	0.37	0.09	2.50	2.81	2.28	4.94	4.81	3.38
2.5	2.875	4.000	8.38	2.78	3.00	0.50	0.12	3.00	3.03	2.91	5.88	5.75	4.00
3.0	3.500	4.750	9.44	3.31	3.56	0.50	0.12	3.75	3.59	3.47	6.88	6.75	4.88
3.5	4.000	5.500	11.00	3.97	4.12	0.53	0.15	4.25	3.94	4.03	8.00	7.75	5.62
4.0	4.625	6.250	12.50	4.31	4.62	0.72	0.15	4.75	4.38	4.44	9.25	9.00	6.50
4.5	5.375	7.250	13.63	4.66	5.25	0.72	0.16	5.50	4.75	5.06	10.38	10.12	7.50
5.0	6.000	8.500	15.31	5.28	5.88	0.75	0.19	6.00	5.50	5.69	11.56	11.38	8.50
5.5	6.625	8.000	16.75	6.31	7.16	0.82	0.19	7.00	6.50	6.97	12.69	10.75	9.25
6.0	7.125	8.750	18.00	7.00	7.66	0.88	0.25	7.50	7.25	7.47	13.88	11.50	10.00
7.0	8.500	10.000	20.75	8.00	9.00	1.06	0.25	8.00	8.38	8.75	16.06	13.38	12.00

Auxiliary Spindles
SL Series

SL Series - 6° leveler type auxiliary spindle

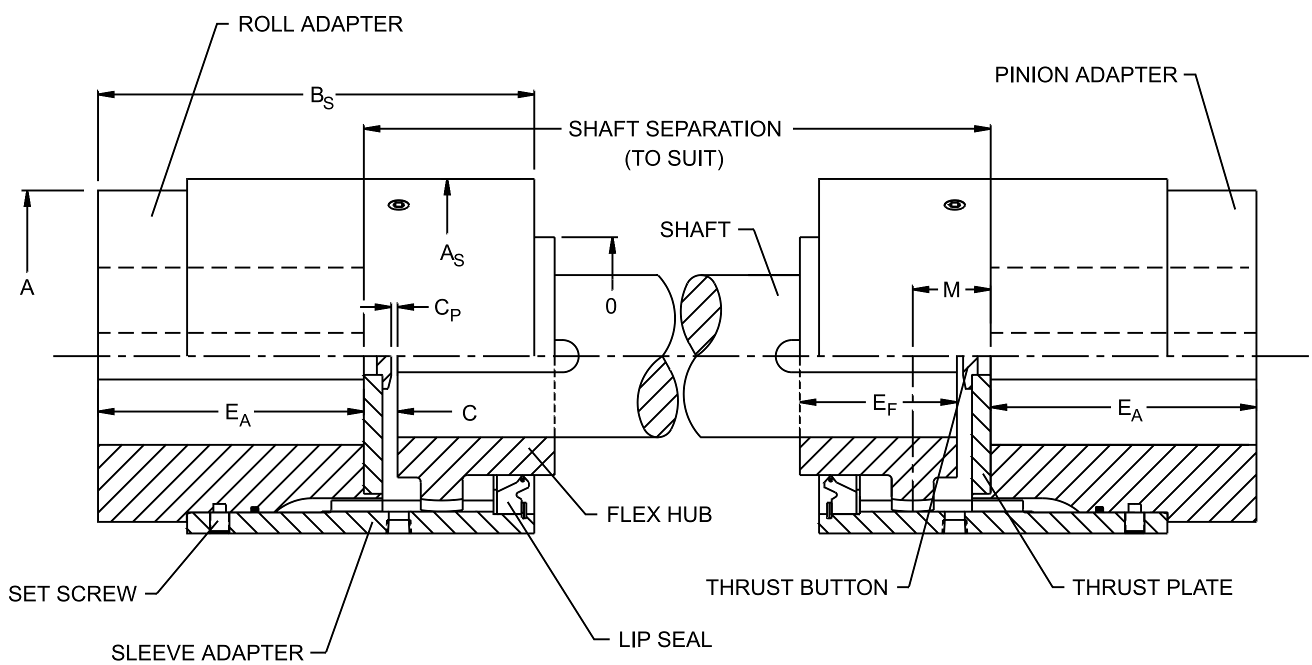
Applications

Use our 6° SL spindles on auxiliary equipment with space (outside diameter) constraints:

- Levelers and flatteners
- Tube mills
- Side trimmers
- Tension and payoff reels
- Pinch and brush rolls
- Coilers and uncoilers

Features

- Adapter designed for quick roll change
- Lip seal furnished standard, optional all-metal rising ring seal
- Custom-designs on request
- We use a setscrew to retain the sleeve on the adapter hub, rather than the troublesome retainer ring used by some competitors



6° SL Specifications (inches)

Size	Maximum Bore with Standard Keyway		Dimensions								
	Flex	Adapter	A	A_S	B_S	C	C_P	D	E_A	E_F	O
1.5	1.875	2.375	3.88	4.06	5.38	0.34	0.06	2.00	3.00	2.31	2.62
2.0	2.375	3.000	4.88	5.00	6.62	0.37	0.09	2.50	3.88	2.81	3.38
2.5	2.875	3.500	5.88	6.00	7.53	0.50	0.12	3.00	4.50	3.03	4.00
3.0	3.500	4.250	6.88	7.19	8.84	0.50	0.12	3.75	5.25	3.59	4.88
3.5	4.000	5.000	7.88	8.00	10.75	0.53	0.15	4.25	6.88	3.94	5.62
4.0	4.625	5.750	8.88	9.00	11.69	0.72	0.15	4.75	7.12	4.38	6.50
4.5	5.375	6.438	9.81	10.38	12.12	0.72	0.16	5.50	8.62	4.75	7.50
5.0	6.000	7.125	11.38	11.62	14.97	0.75	0.19	6.00	9.38	5.50	8.50
5.5	6.625	7.875	12.38	12.62	16.88	0.82	0.19	7.00	10.25	6.50	9.25
6.0	7.125	9.000	13.75	14.00	18.56	0.88	0.25	7.50	11.25	7.25	10.00
7.0	8.500	10.000	15.50	15.75	21.75	1.06	0.25	8.00	13.50	8.38	12.00