



MORGOIL BEARINGS AND FLAT MILL PRODUCTS

THE DOMINANT WORLDWIDE LEADER
IN LOAD-CARRYING BEARINGS

HISTORY

NO BEARING TECHNOLOGY HAS IMPACTED THE METALS INDUSTRY LIKE THE INNOVATIVE MORGOIL BEARING

The MORGOIL® Bearing has been the premier oil film bearing utilized in rolling mills for the metals industry since the early 1930's. In the 1970's and 1980's, Morgan Construction, a predecessor company of Primetals Technologies, developed KL® sleeve technology to improve bearing performance in rolling precision products and DF® sealing technology to eliminate oil leakage. In the extremely competitive 1990's, the company invested in the world's only backup roll oil film bearing test facility. Through the use of this facility and the design data generated, MORGOIL engineers have developed the KLX® sleeve to increase bearing capacity and provide a more cost-effective option.

The KLX is the latest evolution of the MORGOIL Bearing. It improves on all areas of the previous KL Bearing. The KLX offers higher load capacity for the same size bearing, and lower part counts to simplify maintenance and reduce both initial and operational costs. Intellectual property development and protection is a key focus as demonstrated by the extensive patent portfolio maintained by Primetals Technologies.

Primetals Technologies focuses on customer needs and can provide custom engineered solutions for all requests. The company also manufactures and reconditions other flat mill equipment, including automatic gauge control cylinders, shifting blocks, bending blocks, coiler mandrels and high capacity universal drives.

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MORGOIL KLX BEARING

THE LATEST GENERATION - PROVIDING A NEW LEVEL OF VALUE AND PERFORMANCE IN ROLLING MILLS

APPLICATIONS

- New mills
- Rebuilt mills requiring higher load capacity

DESIGN FEATURES

- Thin wall sleeve technology with less than 2.5 micron wall thickness variation
- New sealing technology
- Removable hydraulic mount (standard)
- Integral key for roll, sleeve and sleeve ring
- Housingless thrust bearing

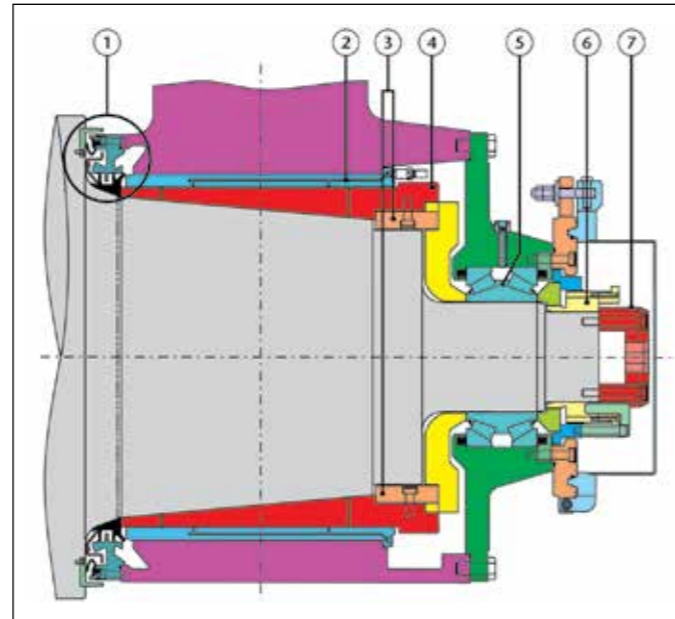
MAIN BENEFITS

- Higher capacity
- Smaller size
- Reduced cost
- Reduced operational cost

The central feature of the MORGOIL® KLX® Bearing is the thin walled sleeve, which better distributes rolling load and the resulting hydrodynamic pressure field, enabling an increase in capacity for the same size bearing. Figure 1 depicts the difference between a traditional KL® sleeve and a KLX sleeve. The body of the KLX sleeve is thinner, and the internal flange on the end of the sleeve has been removed.

Extensive testing of the KL and KLX designs have shown that all rolling mill bearings develop a wider than expected loading area due to small elastic deformations of the components. The KLX sleeve has been optimized to distribute rolling load more effectively, increasing the width of the load zone by up to 15%, while minimizing any increase in stress in the bearing.

Instrumented bearings and stress analysis have confirmed the improved performance of the KLX design. Figure 2 is a comparison of strain gauge results for the two sleeve configurations under typical operating conditions where θ_1 is the start of the load zone, and θ_2 is the end.



1. New sealing technology
2. High Strength Babbitt
3. Integral key for roll, sleeve and sleeve ring
4. Thin wall sleeve
5. Housingless thrust bearing
6. Removable hydraulic mount
7. Roll end adapter

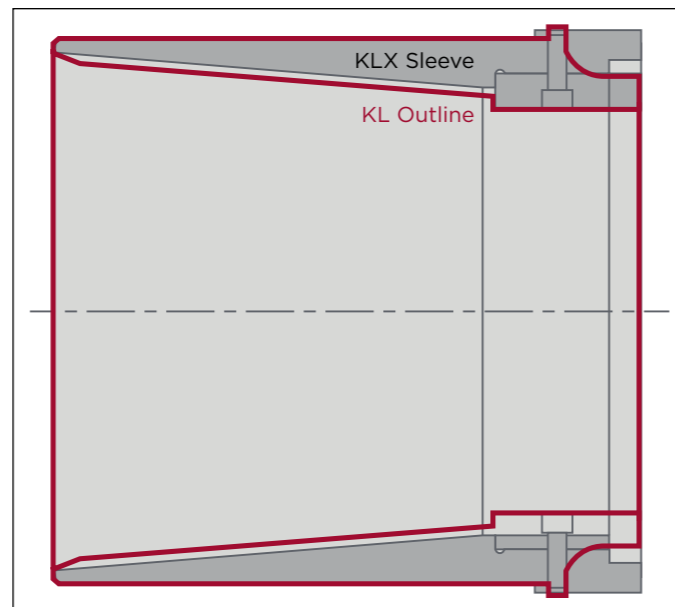


Figure 1 - KLX vs. KL sleeve comparison

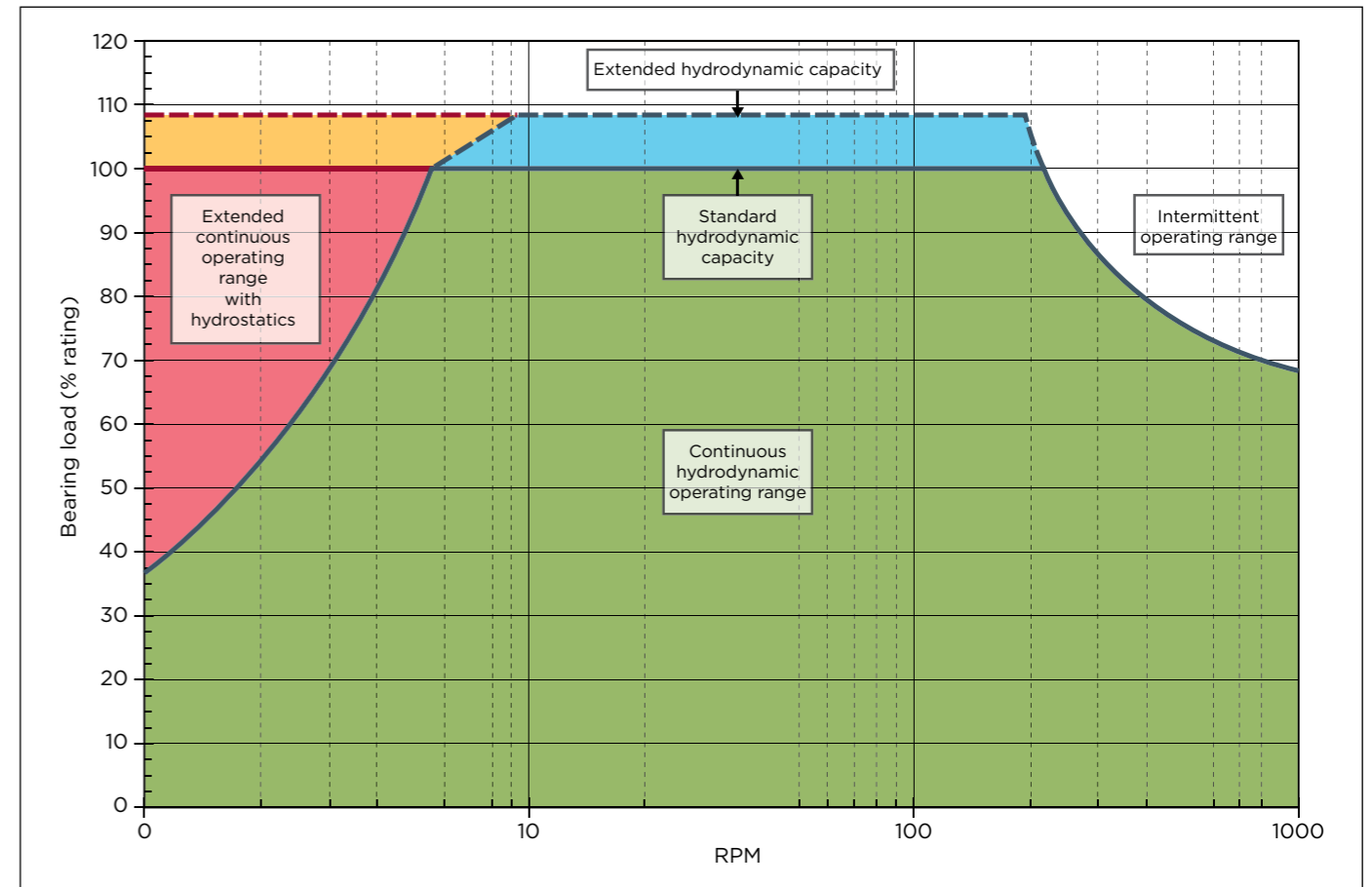


Figure 3 - Typical operating map for KLX Bearing

The elastic deflection, or flattening of the sleeve in the load zone, is what gives MORGOIL® Bearings their ability to carry very high loads. By encouraging this flattening in a controlled manner with the KLX® sleeve design, the load capacity of the bearing is increased. The thin-walled KLX design produces a performance benefit without sacrificing the accuracy of the bearing or the service life of the sleeve.

The KLX sleeve design results in a bearing of unprecedented range and capacity. Figure 3 shows a typical operating map of a KLX Bearing (note that actual operating ranges will vary depending on bearing size, features, and oil viscosity).

KLX Bearings operate most efficiently in the area marked "Continuous Hydrodynamic Operating Range," and all KLX Bearings can be operated up to their "Standard Hydrodynamic Capacity" within that range (green shaded area). The "Standard Hydrodynamic Capacity" is the normal maximum design load of the bearing. KLX Bearings can also operate at very low speed and stop under full load up to their "Standard Hydrodynamic Capacity" with the use of a hydrostatic system (pink area + green area).

KLX Bearings can tolerate transient loads up to their "Extended Hydrodynamic Capacity" (blue area), and can operate under specific mill conditions in this zone. If very high load capacity and very low operating speeds are required, KLX Bearings can be equipped with a high capacity hydrostatic system. Bearings with these special hydrostatic systems can be stopped and started up to the "Extended Hydrodynamic Capacity."

KLX Bearings can operate intermittently in the area marked "Intermittent Operating Range." Primetals Technologies experts should be consulted regarding operation in this area.

Bearing capacity is affected by mill type, operating conditions, and other factors; always consult MORGOIL specialists for specific applications.

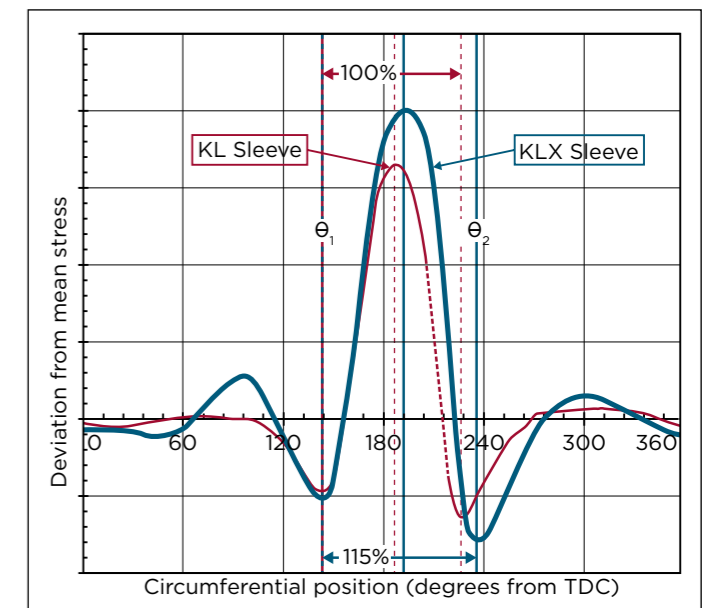


Figure 2 - Sleeve centerline circumferential stress

DEVELOPMENT

MORGOIL KLX BEARING

MORGOIL® Bearings have set the technological benchmark for others to follow since 1930. In order to continue this leadership position, we have invested heavily in development. A completely instrumented test stand, the MORGOIL mill simulator, was built to verify the performance of the KLX® Bearing. This facility, which is the only one of its kind in the world, enables MORGOIL to provide higher levels of performance at lower cost and continue its leadership position in the field of rolling mill bearing technology.

The MORGOIL mill simulator was designed specifically for development of the KLX Bearing. This facility allows testing of a full size 28"-76 KLX Bearing under conditions similar to those experienced in all types of mills. The mill simulator design uses a cantilevered shaft allowing an actual mill size and style chock/bearing assembly to be mounted and tested. The mill simulator utilizes a full size HAGC Cylinder for loading and contains over 120 channels of precision instrumentation. It also has a complete, highly controllable lubrication system including hydrostatic pumps so that all types of mills, under all conditions, can be simulated.

Extensive testing of the KLX prototypes under a variety of conditions has led to an unprecedented understanding of the physics behind oil film bearings under actual mill conditions. This in turn has led to a KLX oil film bearing optimized for harsh operating environments, with options designed for specific mill types, and for an initial investment cost less than previous keyless designs.



MORGOIL test stand, bearing end



MORGOIL test stand, control room

HIGH STRENGTH BABBITT

WHITE METAL BEARING MATERIAL

APPLICATIONS

- Mills with higher capacity bearings such as the KLX®
- Mills with impact loading such as plate mills

MAIN BENEFITS

- Allows higher loads for the same size bearing
- High compressive strength and low creep for extreme applications

With the continuing effort to reduce the size of mills while increasing their output, the specific load capacity of bearings has increased as well. To meet this need, MORGOIL® products include a new High Strength Babbitt (HSB) white metal bearing material. This proprietary babbitt results in significantly higher bearing capacity.

The major benefit of this material over both traditional babbitt and cadmium based babbitts is the significant improvement in compression strength and reduction of creep, while keeping the traditional high babbitt "imbedability," bond strength, and fatigue strength. Since cadmium babbitts are no longer available, MORGOIL HSB is an alternative to cadmium that can be used in many applications such as older MESTA mills, which initially required the higher strength properties of cadmium-based babbitt.



High Strength Babbitt welding process



MORGOIL bushing with High Strength Babbitt

APPLICATION GUIDE

MORGOIL KLX BEARING

When selecting bearings for a mill, the designer should, at a minimum, know the following:

- Type of mill and material to be rolled
- Number of mill stands
- Number of rolls per stand
- Maximum rolling force for each stand
- Maximum and minimum strip speed or RPM at each stand
- Maximum and minimum roll diameters and roll lengths
- Whether the mill stops under load

For assistance in selecting the proper bearing, fill out the mill inquiry form on page 14 and send it to Primetals Technologies.

SELECTION

Calculate the force on each bearing from the stand separating force (Bearing Force = $1/2 \times$ Total Separating Force, where Total Separating Force is equal to the maximum rolling load plus any additional load introduced by roll bending).

In the Standard Capacity Rating section of the MORGOIL® KLX® rating chart, find the smallest bearing that can accommodate the calculated bearing load.

- Start with the 76 series bearings, as they are a good balance of performance and cost effectiveness.
- Bearings in the 86 series can accommodate higher loads in the same mill housing and can be more cost effective, but use a longer roll.
- Bearings in the -86 series can accommodate higher loads in the same mill housing size and can be cost effective but use a longer roll and have higher roll neck stresses.

Once a size is determined, check that the minimum acceptable roll diameter (E_{min}) is equal to or below the minimum backup roll diameter for the mill. If not, choose the next-largest size bearing.

The maximum tapered neck diameter (Z) should be at least 55% of the maximum roll diameter; this is for neck stress considerations. If Z is less than 55% of the maximum backup roll diameter, then choose a larger size bearing.

LUBRICANT

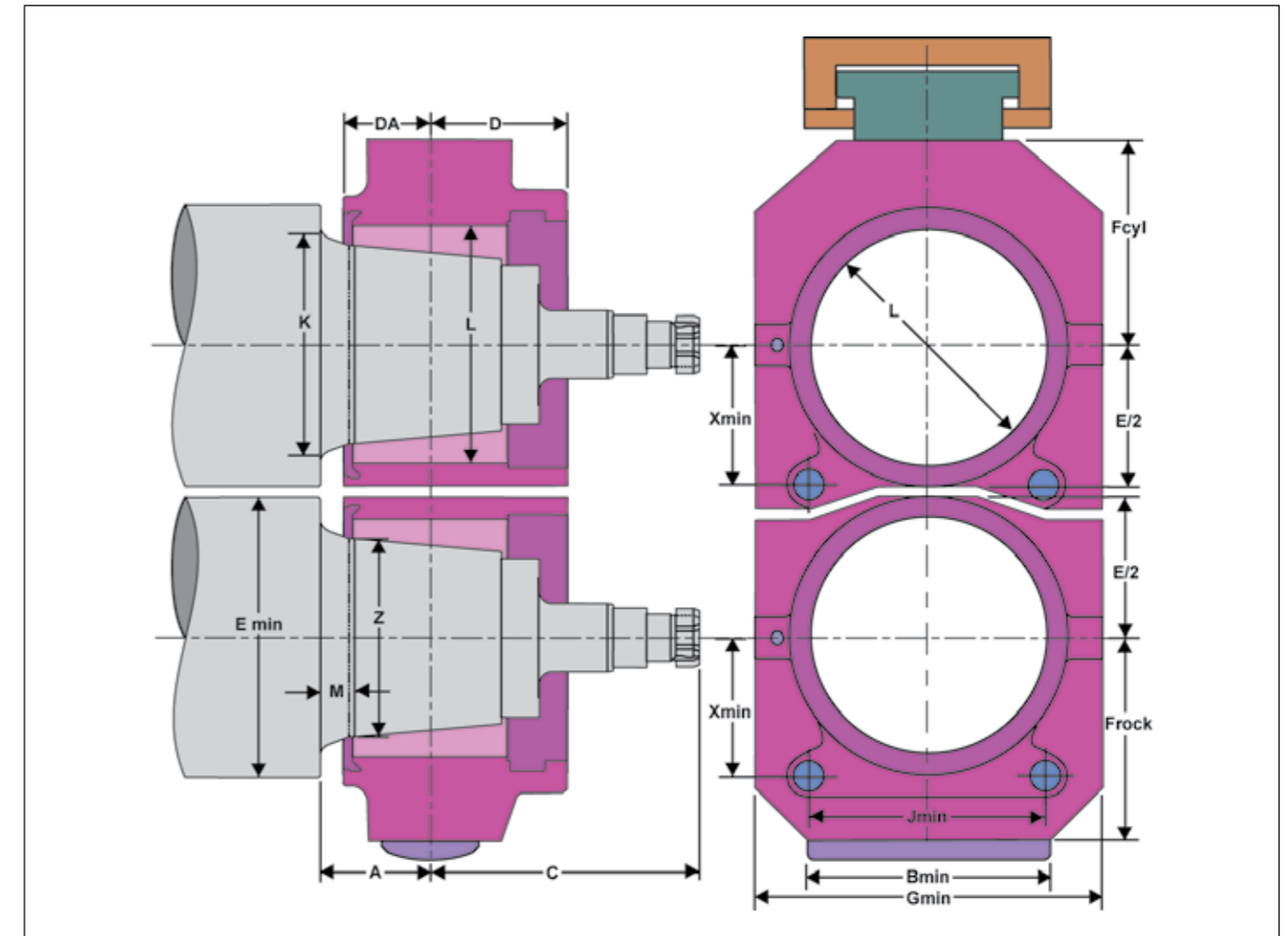
Almost as important as bearing size selection is lubricant selection, which is the responsibility of the bearing supplier. The following information is provided for background:

- High speed mills use lighter viscosity oil. A fast tandem cold mill may use ISO 220 cSt oil, a slower TCM may use 320 cSt oil.
- A slow, highly loaded hot strip mill may use ISO 680 cSt oil, where a hot mill that runs faster uses 460 cSt.
- A heavy reversing plate mill would generally use ISO 680 cSt oil, or ISO 460 cSt oil in a very cold climate.

When selecting an oil viscosity, low speed and high speed characteristics of the bearing must be checked. At high speed, the bearing could run at too high a temperature, requiring a lighter oil. At low speed, the oil film may be too thin and heavier oil may be needed. If very slow speed continuous operation, or extended stopping under load is required, hydrostatic assist may be the solution. With more than 10,000 mill stands built on MORGOIL oil film bearings, our engineers will assist the mill builder in examining the trade-offs between hydrostatic assist and oil selection to develop the most cost-effective bearing selection.

STRATEGIES

There are two major strategies in mill bearing selection: lowest initial cost or maximum parts commonality. Generally, the first few stands of a tandem mill have the highest rolling loads. To minimize the initial cost, the stands with higher load can use a larger bearing, where the more lightly loaded stands can use smaller bearings. This does introduce added spare parts and constraints on which stands particular bearings can be used. The other strategy is to select a bearing for the greatest load and use that throughout the mill. This can somewhat increase the initial cost, but it improves commonality between stands and reduces spare part requirements.



ROLL

- A Roll barrel to bearing centerline
- C Bearing centerline to outboard end of roll
- K Diameter where fillet taper would hit roll barrel
- E_{min} Minimum allowable roll diameter for bearing size
- M Roll barrel to sleeve taper length
- Z Max taper diameter

CHOCK

- DA Roll end of chock to chock centerline
- D Chock centerline to outboard end of chock
- F_rock Centerline of chock to bottom of chock when using rocker plate
- F_cyl Centerline of chock to top of chock when using hydraulic cylinder
- L Chock bore diameter
- E/2 Minimum distance from chock centerline to top or bottom of chock
- G_min Minimum chock width
- B_min Minimum rocker width

DRAINS

- X_min Minimum vertical distance from chock centerline to drain centerline
- J_min Minimum horizontal drain centerline distance

MILL UPGRADES

SLEEVES AND BUSHINGS

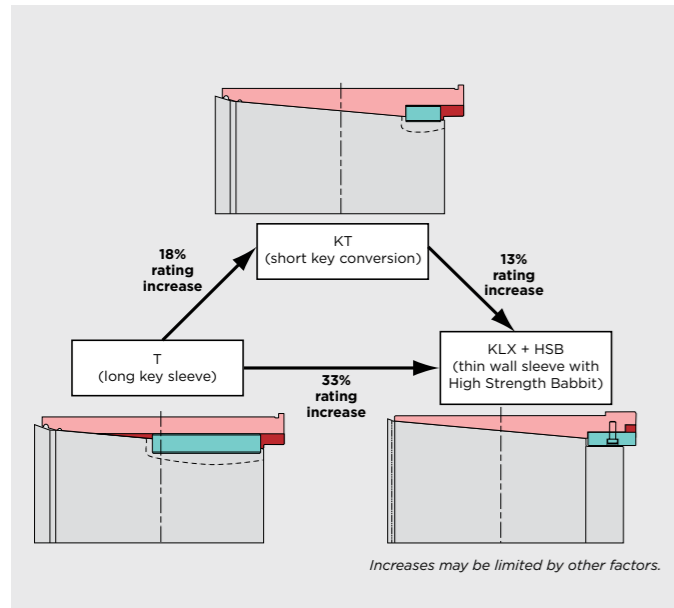


Figure 4 - Sleeve upgrade

SLEEVES

If a maximum mill separating force increase is needed along with improved strip quality, then an upgrade to the MORGOIL® KLX® bearing is needed, Figure 4. The KLX bearing uses the latest technology thin sleeve design allowing for larger roll necks and higher unit loading. This conversion requires new rolls and bushings, but the increase in capacity can be up to 45% over a T type bearing (under certain conditions and including other improvements). New rolls are needed to cope with neck stress because of the large rating increase; however, the KLX bearing fits within the existing chocks.

If an upgrade is needed, but not the full capacity of the KLX, the original MORGOIL long key T type bearing can be converted to a KT, or short key design sleeve, Figure 4. This common conversion effectively eliminates keyway effect along with allowing an 18% increase in load rating of the bearing. This conversion can use the existing rolls with new keyways while filling the old keyways.

These conversions are particularly attractive for older mills, where the mill operators want to bring a mill's capabilities up to that of a new mill, but don't want the cost of a new mill. In some upgrade scenarios, it is possible to increase the width of the mill without moving the housings. In most cases, KLX upgrades can increase roll neck size.

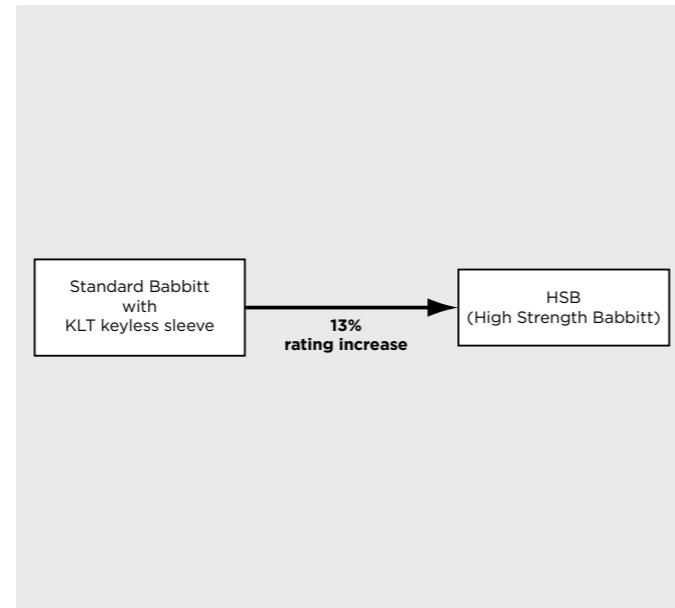


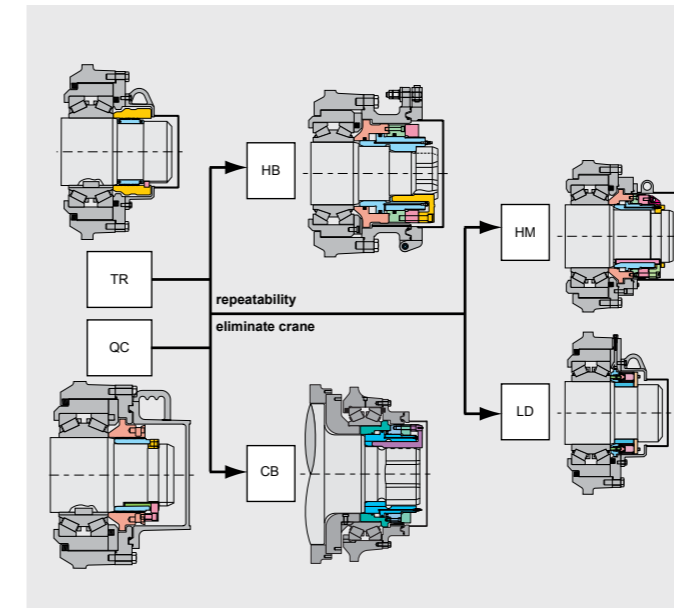
Figure 5 - Bushing upgrade

BUSHINGS

This conversion also helps bearing rating increase through the use of High Strength Babbitt (HSB) bushings, Figure 5. High Strength Babbitt can also be used as a viable substitute for cadmium bushings. Through the use of a short key conversion of the sleeve, combined with High Strength Babbitt bushings, ratings can be significantly increased. Upgrading old T bearings to special short key sleeves and HSB bushings can increase the rating by up to 33%.

MILL UPGRADES

LOCKING AND SEALING



Locking upgrade

LOCKING

There are many options when upgrading mill locking. All these upgrades improve bearing mounting accuracy, are quicker and safer to operate, and do not use overhead cranes. The exact lock choice depends on other upgrades planned for the bearing components.

Some of the conversions require new rolls or bolt-on roll ends. If existing rolls are being used, the HM or LD™ lock can be used as an alternative, although without the full convenience of the hydraulic-type locks. See the catalog lock sections for further details.

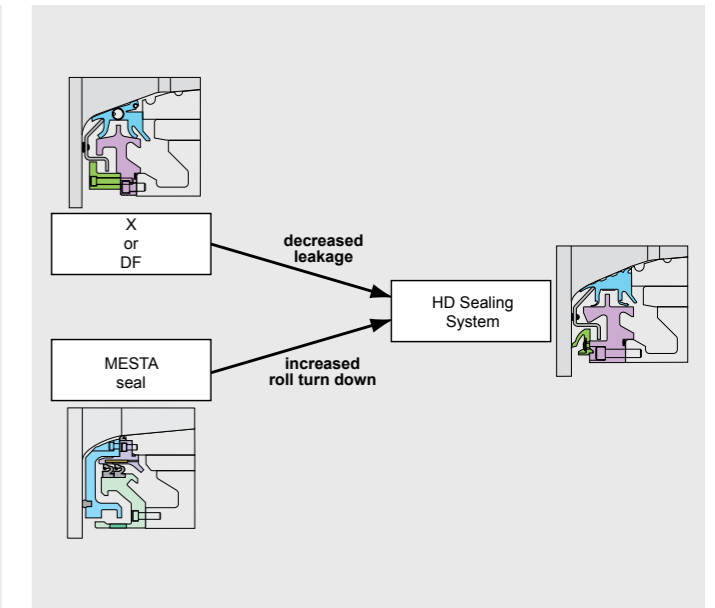


Figure 6 - Sealing upgrade

SEALING

As with the other major areas of the bearing, the sealing system has also seen several changes over the years. This conversion uses the latest developments in sealing, the HD Sealing System, Figure 6. It consists of the HD seal and ceramic coated seal end plate. The seal end plate also includes the latest drainback and venting features. The system also includes a coolant guard.

If the current bearing has a DF® seal, the upgrade to HD sealing should be evaluated on an individual basis as to whether it would be cost-effective.

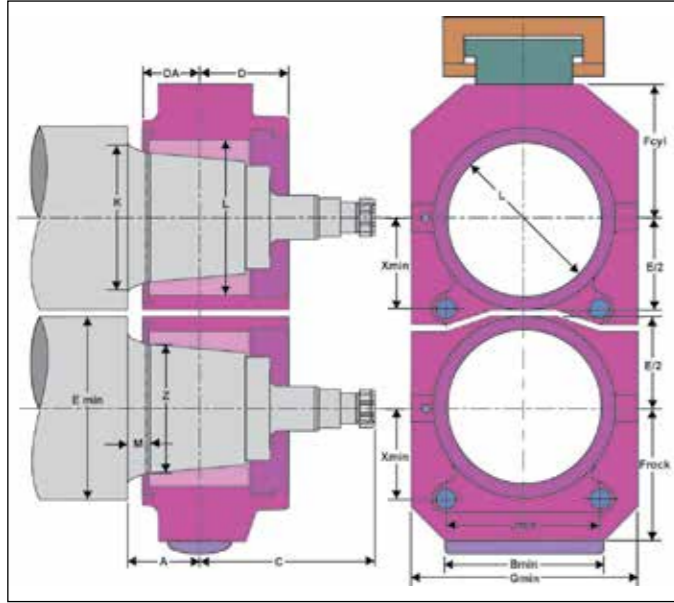
CONCLUSION

Upgrades, strategically planned between the mill operator and equipment supplier, can extend the life of a mill far into the future. MORGOIL® Bearing engineers work with customers to bring decades-old mills up to modern standards in an economical and operationally friendly manner. Conversions such as these help older mills compete with the quality of new mills and remain highly cost-effective. In many of these cases, mills have paid for the upgrade within a year through increased productivity and more efficient utilization of mill equipment.

With appropriate backup roll bearing upgrades, mills can increase capacity, allowing them to roll products that were not even considered before. Older oil film bearings and roller bearings have been successfully upgraded while reusing existing chocks, and in many cases rolls.

RATING AND DESIGN CHART

MORGOIL KLX BEARING



- Bearing rating is per side of mill stand.
Total Stand Force (TSF) is 2 x listed rating.
- F dimension for plain carbon steel chocks, consult MORGOL® engineering specialists for other materials.
- Dimensions are for removable mount.

NA. Consult bearing supplier

Bearing ratings are for optimum operating conditions and may be less depending on the application. Consult Primetals Technologies for specific applications.

KLX®	Rating ¹							
	Size	Series	Standard Capacity			Extended Capacity		
			lbs/1000	tonnes	kN	lbs/1000	tonnes	kN
28"	66	1,370	625	6,130	1,490	680	6,660	
	76	1,580	719	7,050	1,720	782	7,670	
	86	1,780	810	7,950	1,940	881	8,640	
30"	66	1,550	706	6,930	1,690	768	7,530	
	76	1,790	814	7,980	1,950	885	8,680	
	86	2,020	917	9,000	2,200	998	9,790	
32"	66	1,710	778	7,630	1,860	846	8,300	
	76	1,970	895	8,770	2,140	973	9,540	
	86	2,230	1,015	9,950	2,430	1,104	10,820	
34"	66	1,940	882	8,650	2,110	959	9,410	
	76	2,230	1,013	9,940	2,430	1,102	10,810	
	86	2,520	1,145	11,230	2,740	1,245	12,210	
36"	66	2,140	973	9,540	2,330	1,058	10,380	
	76	2,470	1,123	11,020	2,690	1,222	11,980	
	86	2,800	1,270	12,450	3,040	1,381	13,550	
38"	66	2,380	1,081	10,600	2,590	1,176	11,530	
	76	2,740	1,244	12,200	2,980	1,353	13,270	
	86	3,110	1,411	13,840	3,380	1,535	15,060	
40"	66	2,650	1,202	11,790	2,880	1,308	12,830	
	76	3,050	1,383	13,560	3,310	1,504	14,760	
	86	3,440	1,564	15,340	3,750	1,701	16,680	
42"	66	2,870	1,305	12,800	3,130	1,419	13,920	
	76	3,310	1,503	14,740	3,600	1,635	16,030	
	86	3,750	1,701	16,680	4,080	1,850	18,140	
44"	66	3,130	1,422	13,940	3,410	1,546	15,170	
	76	3,610	1,638	16,070	3,930	1,782	17,480	
	86	4,090	1,855	18,190	4,440	2,017	19,790	
46"	66	3,460	1,571	15,400	3,760	1,708	16,760	
	76	3,980	1,808	17,740	4,330	1,967	19,290	
	86	4,510	2,046	20,070	4,900	2,226	21,830	
48"	66	3,720	1,688	16,550	4,040	1,836	18,010	
	76	4,290	1,945	19,080	4,660	2,116	20,750	
	86	4,840	2,197	21,550	5,270	2,390	23,440	
50"	66	4,000	1,816	17,810	4,350	1,976	19,380	
	76	4,600	2,089	20,480	5,010	2,272	22,280	
	86	5,200	2,361	23,150	5,660	2,568	25,190	
52"	66	4,310	1,955	19,180	4,690	2,127	20,860	
	76	4,960	2,250	22,060	5,390	2,447	24,000	
	86	5,620	2,550	25,010	6,110	2,774	27,200	
54"	66	4,850	2,202	21,600	5,280	2,395	23,490	
	76	5,580	2,533	24,840	6,070	2,755	27,020	
	86	6,310	2,863	28,080	6,860	3,114	30,540	
56"	66	5,190	2,357	23,120	5,650	2,564	25,150	
	76	5,990	2,718	26,660	6,520	2,957	29,000	
	86	6,770	3,073	30,140	7,370	3,343	32,790	
58"	66	5,560	2,524	24,750	6,050	2,746	26,930	
	76	6,420	2,911	28,550	6,980	3,166	31,050	
	86	7,250	3,291	32,280	7,890	3,580	35,110	
62"	66	6,330	2,872	28,170	6,890	3,125	30,640	
	76	7,290	3,306	32,420	7,930	3,596	35,270	
	86	8,240	3,739	36,670	8,970	4,067	39,890	
66"	66	7,070	3,209	31,470	7,690	3,491	34,230	
	76	8,150	3,697	36,260	8,860	4,021	39,440	
	86	9,220	4,185	41,050	10,030	4,552	44,650	
70"	66	8,180	3,713	36,420	8,900	4,039	39,610	
	76	9,430	4,278	41,950	10,260	4,653	45,640	
	86	10,670	4,842	47,490	11,610	5,267	51,660	
74"	66	9,390	4,259	41,780	10,210	4,633	45,440	
	76	10,820	4,907	48,130	11,770	5,337	52,350	
	86	12,240	5,554	54,480	13,320	6,042	59,260	
78"	66	10,700	4,855	47,620	11,640	5,281	51,800	
	76	12,330	5,592	54,840	13,410	6,083	59,660	
	86	13,950	6,328	62,070	15,180	6,884	67,520	
80"	66	11,400	5,171	50,720	12,400	5,625	55,170	
	76	13,140	5,959	58,450	14,290	6,482	63,580	
	86	14,850	6,738	66,090	16,160	7,330	71,890	

KLX®	Roll										Chock				Drains					
	Size	Series	Unfactored Neck Stress		A	RM ³	K	Z	Emin	M	DA	D	F ²		L	E/2	Gmin	Bmin	Xmin	Jmin
			psi	MPa									hyd cyl	rocker						
28"	66	13,570	93.7	295	957	596.24	538	736	95	235	392	440	480	620	368	804	556	374	601	
	76	17,170	118.5	324	984					264	419	470	510							
	86	21,020	145.1	352	1010					292	445	500	535							
30"	66	13,340	92.1	307	968	632.24	574	778	95	247	403	465	515	660	389	850	588	398	644	
	76	16,920	116.8	338	997					278	432	500	540							
	86	20,770	143.4	368	1024					308	459	530	565							
32"	66	13,140	90.7	322	987	666.87	605	816	100	257	422	490	540	694	408	890	614	417	680	
	76	16,610	114.7	354	1017					289	452	525	565							
	86	20,590	142.1	387	1047					322	482	555	595							
34"	66	12,990	89.7	336	1000	706.87	645	860	100	271	435	520	575	738	430	942	650	443	728	
	76	16,440	113.5	370	1031					305	466	560	605							
	86	20,280	140.0	404	1062					339	497	590	635							
36"	66	12,950	89.4	352	1020	741.87	680	902	100	282	490	550	600	776	451	988	682	466	770	
	76	16,530	114.1	389	1054					319	524	585	635							
	86	20,410	140.9	425	1087					355	557	625	665							
38"	66	12,800	88.4	365	1031	779.87	718	960	100	295	501	580	635	818	480	1036	716	491	815	
	76	16,270	112.3	403	1066					333	536	615	670							
	86	20,240	139.7	442	1102					372	572	655	700							
40"	66	12,800	88.4	394	1054	830.79	758	1018	115	309	524	610	670	862	509	1088	750	517	863	
	76	16,220	112.0	434	1091					349	561	650	705							
	86	20,020	138.2	474	1127					389	597	690	740							
42"	66	12,670	87.5	405	1064	863.79	791	1060	115	320	534	635	695	898	530	1130	780	539	902	
	76	16,110	111.2	447	1102					362	572	680	735							
	86	19,940	137.6	489	1141					404	611	720	770							
44"	66	12,540	86.6	417	1085	899.79	827	1106	115	332	555	665	725	938	553	1178	812	562	945	
	76	15,970	110.2	461	1125					376	595	705	765							
	86	19,810	136.7	505	1165					420	635	750	805							
46"	66	12,440	85.9	432	1193	942.79	870	1154	115	347	583	695	765	986	577	1234	850	590	997	
	76	15,850	109.4	478	1235					393	625	745	805							
	86	19,660	135.7	524	1278					439	668	790	845							
48"	66	12,340	85.2	443	1208	975.79	903	1190	115	358	598	720	790	1022	595	1276	878	612	1036	
	76	15,760	108.8	491	1252					406	642	770	835							
	86	19,510	134.7	538	1295					453	685	820	875							
50"	66	12,290	84.8	455	1219	1009.79	937	1224	115	370	609	750	820	1060	612	1320	910	634	1077	
	76	15,650	108.0	504	1264					419	654	800	865							
	86	19,410	134.0	553	1309					468	699	850	910							
52"	66	12,160	83.9	467	1245	1046.79	974	1262	115	382	635	775	850	1100	631	1368	942	658	1121	
	76	15,520	107.1	518	1291					433	681	830	895							
	86	19,350	133.6	570	1339					485	729	880	945							
54"	66	12,040	83.1	488	1264	1107.79	1035	1324	115	403	654	825	905	1168	662	1446	996	697	1193	
	76	15,380	106.2	542	1313					457	703	880	950							
	86	19,120	132.0	596	NA					511	NA	935	1000							
56"	66	12,030	83.0	505	NA	1145.79	1073	1366	115	415	NA	855	935	1210	683	1496	1028	722	1238	
	76	15,440	106.6	562	NA					472	NA	910	985							
	86	19,200	132.5	618	NA					528	NA	970	1035							
58"	66	11,960	82.6	518	NA	1183.79	1111	1408	115	428	NA	880	970	1252						

MILL INQUIRY FORM

FOR PROPER BEARING SELECTION

Send to: Primetals Technologies 50 Prescott Street, Worcester, MA 01605, USA T +1 508 755-6111			
Date: _____		<input type="checkbox"/> Existing Mill <input type="checkbox"/> New Mill	
From: _____		Final Cust: _____	
Phone: _____		Location: _____	
Email: _____		Builder: _____	
Mill Type: _____		Mill Type: _____	
Material to be Rolled: _____			
Strip Width, minimum: _____ maximum: _____			
Does the mill stop under load? <input type="checkbox"/> Yes <input type="checkbox"/> No Duration of Stop: _____ Stopping Load: _____			
Stand Name	R/R, F1, etc. :		
Max Total Separating Force			
Work Roll	Diameter- max :		
	Diameter- min :		
	Body length :		
Intermediate Roll (If 6-high)	Diameter- max :		
	Diameter- min :		
	Body length :		
Backup Roll	Diameter- max :		
	Diameter- min :		
	Body length :		
Drive Motors	Power :		
	Min rpm :		
	Max rpm :		
Drive Gear Ratio			
Driven Roll			
Rolling Speed	Min :		
	Max :		
Existing Morgoil Bearings			
Exist. Lube Grade & °F/ °C			
Maximum cooling water temperature : _____ Electrical service frequency : _____			
Direction of material travel (from operators side) : _____			
Location of MORGIL thrust bearing : _____			
Other Information: _____			

BEARING OPTIONS: BUSHINGS

HYDROSTATIC BUSHINGS

APPLICATIONS

- Mills that start and stop under high loads
- Mills with sustained operation under high load

MAIN BENEFITS

- Operation under high loads and low speeds
- Compensation of sleeve to bushing misalignment

Hydrostatics are used in oil film bearings when sustained operation under high load and low speed is required, or when the mill is required to start under load after long stops.

A high pressure pump feeds lubricant from the MORGIL® lubrication system into the load zone of the bearing, assuring full film operation of the bearing under all rolling conditions, Figure 7.

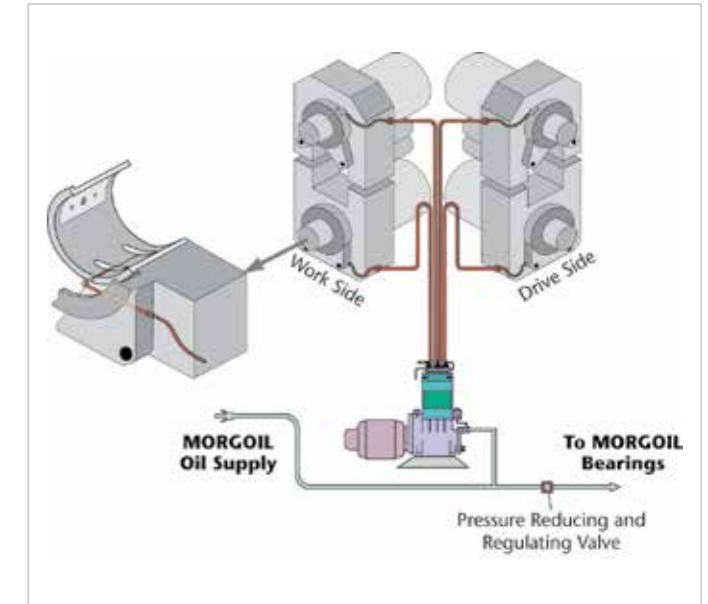


Figure 7 - Hydrostatic system

ADVANTAGES

- Constant oil flow under high pressure secures lowest friction coefficient (0,001 to 0,003) in the bearing under all operating conditions
- Reduced motor current peak during start after a long stand still and/or emergency stops
- Reduced maintenance cost, allowing fewer preventive maintenance bearing inspections per year
- Compensation of roll neck/sleeve to chock/bushing misalignment

COMPENSATION OF SLEEVE-BUSHING MISALIGNMENT

Under mill conditions where the alignment of the sleeve inside the bushing is disturbed, hydrostatic assist acts to correct the misalignment. Under misaligned conditions, as shown in Figure 8, flow out of the right hand pad tends to increase because of increased clearance due to sleeve tilting within bushing.

Increased flow through the right hand pad results in a higher pressure drop across the restrictors which are installed in all MORGIL hydrostatic bushings. Since the restrictors inlet pressures are equal, different pressure drops across the restrictors result in different restrictor outlet pressures. The higher pressure in the left hand pad compensates the misalignment of sleeve and bushing by exerting a righting movement in the bearing.

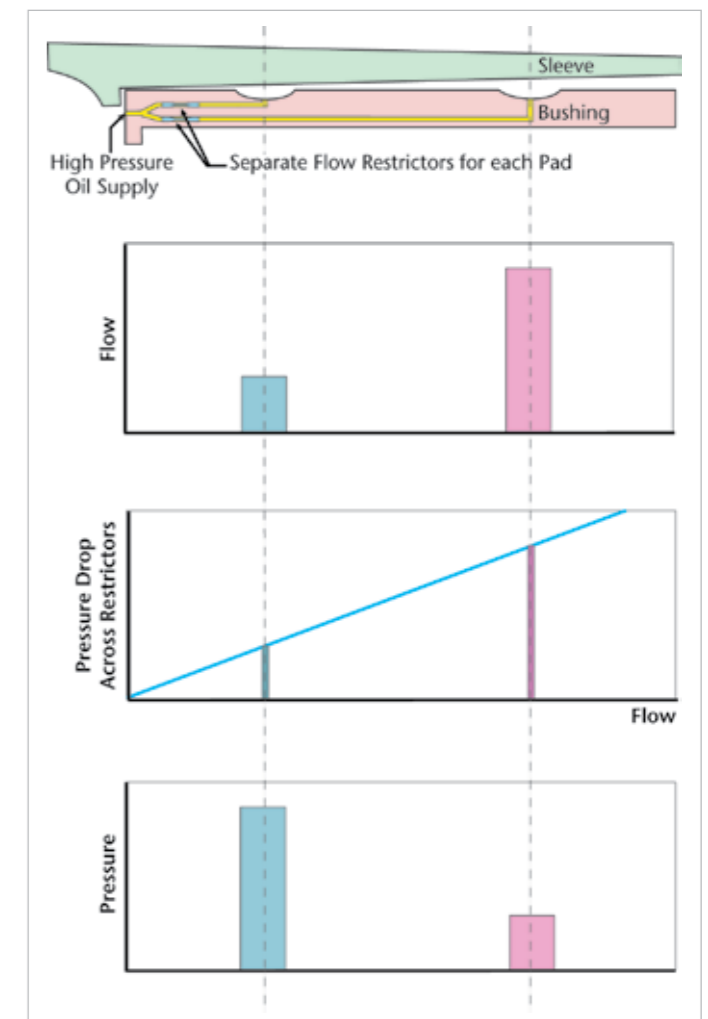


Figure 8 - Self-aligning ability of hydrostatics

BEARING OPTIONS: SEALING TECHNOLOGY

HD (HYDRODYNAMIC) NECK SEAL SYSTEM

APPLICATIONS

- All MORGOIL®, MESTA and MESTOIL bearings

• MAIN BENEFITS

- No leakage in or out of the bearing
- Ease of mounting and dismounting
- Cost effective

EFFECTIVE SEALING IS CRITICAL IN BEARING DESIGN

Sealing encompasses more than the elastomer sealing element. It is important that all components function together as a sealing system to address the total leakage issue. MORGOIL engineers have spent thousands of hours testing and evaluating various seals, seal end plate designs and features, and other components to offer several systems based on a specific mill's needs. Whether a mill is wet or dry, MORGOIL has an effective sealing solution.

The HD (Hydrodynamic) neck seal system is the most technologically sound sealing solution available. It builds on the years of sealing expertise MORGOIL has developed and pushes the design to new levels of performance. The seal has been designed to maintain proper hydrodynamic seal angles through the range of its travel. Extensive computer modeling as well as full-size testing has been undertaken to ensure the seal performs as expected. The seal remains effective under the difficult conditions encountered in all types of mills.

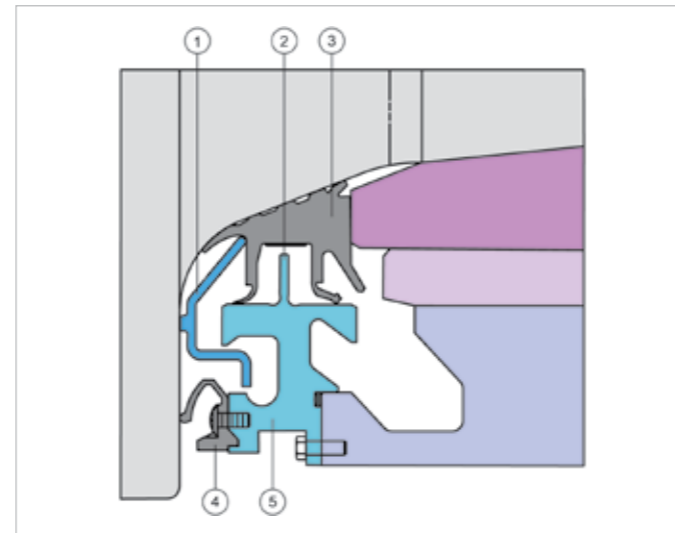
When used in conjunction with the new HD seal end plate, the HD sealing system provides an unmatched combination of several seal styles and material choices that can be used for different applications. There are also both wet and dry mill configurations.

The HD neck seal combines proven sealing technology with the latest sealing developments. The seal has been made much more rigid and remains in its proper position on the roll neck under the most severe conditions. Additionally, compliance ridges have been added to help the seal avoid the frictional force of the sleeve nose when mounting. The stainless steel band holds the seal at the proper diameter even under high rotational forces. Features such as the oil flinger are proven technologies.

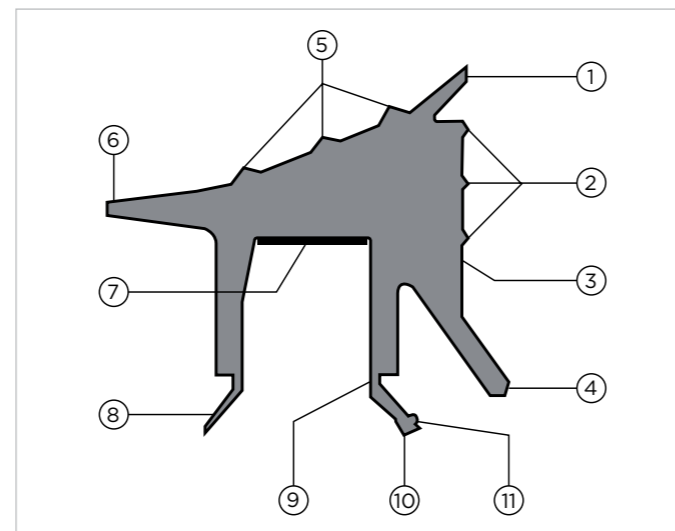
The water side leg has a light contact with the seal end plate to reduce frictional forces.

The oil side leg has been totally redesigned to function as a true hydrodynamic seal. The foot has been thickened to ensure that it pivots at the hinge. A stiffening ridge has been added to the back of the foot to help apply more contact force. In addition, the increased mass adds centrifugal force at higher speeds. The contacting area of the foot has been developed to provide a line contact under all operating conditions. The angles of the surfaces

at the contact point have been refined through computer simulation and testing to provide optimum sealing geometry.



1. Seal inner ring
2. Seal end plate dam
3. HD neck seal
4. Coolant guard
5. HD seal end plate



1. Sleeve side neck lip seal
2. Mounting compliance ridges
3. Solid seal body
4. Oil flinger
5. Three rings of neck contact support ridges
6. Fillet side neck lip seal
7. Stainless steel band
8. Light force water side foot
9. HD foot hinge
10. HD foot hydrodynamic contact ridge
11. HD foot stiffening ridge

This is the latest evolution of the MORGOIL® high performance sealing system. Multiple lines of defense have been included to ensure there is no leakage from this advanced design.

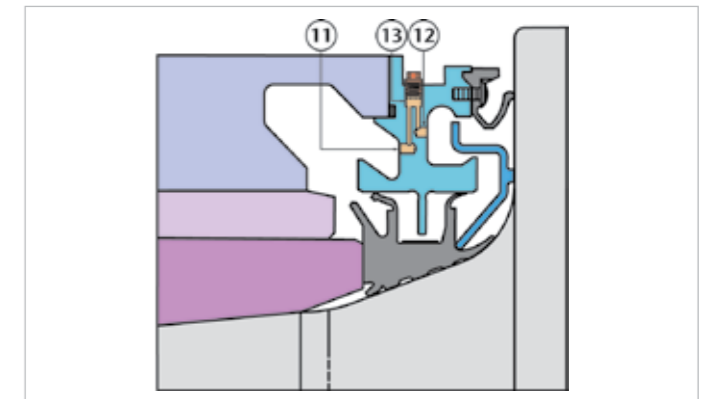
MAJOR HD SEALING SYSTEM COMPONENTS

- HD seal end plate
- HD neck seal
- Seal inner ring
- Coolant guard

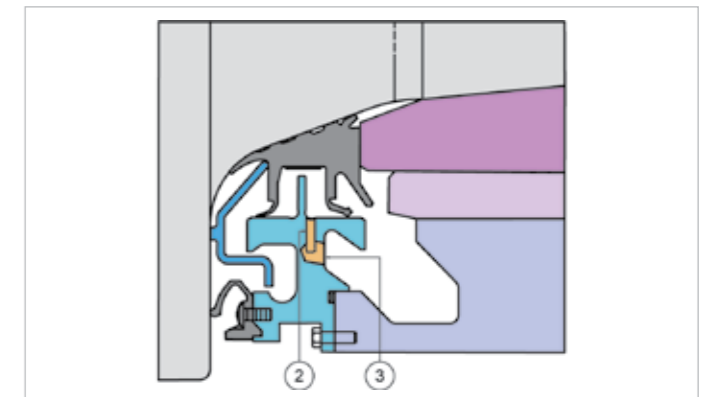
The heart of the system is the HD seal. The HD neck seal has evolved to be a model of economic sealing efficiency. In one piece, it seals the neck, sleeve, oil and water sides of the seal end plate and is a flinger. It is specially designed for the harsh mill operating conditions encountered by MORGOIL Bearings. This seal has been designed to be used in conjunction with the HD seal end plate.

Oil must follow a complicated path with many hindrances and traps to escape the sealing system. Oil must first evade the oil side HD seal leg (1). This lip has been optimized to provide a hydrodynamic seal under all operating conditions. If oil gets by this leg, the rotation of the seal drags the oil, circumferentially distributing it around the HD seal end plate. As the oil runs down the vertical sealing surface of the seal end plate, it is captured by the drainback wells (2) which are undercut areas next to the dam that collect the oil. The oil is then directed back into the chock through passages (3). Oil that eludes the drainbacks must then get over the dam (4). Oil that escapes the dam must next move past the water side (outer) seal leg (5), the second active sealing element. This seal leg also acts as a flinger, throwing the oil to the seal end plate surface on the outer side of the seal end plate. Oil that accumulates between the outer leg and dam travels to the inner collection well (6), which is located at the bottom of the seal end plate next to the dam. The inner collection well empties into an auxiliary drain (10) that is plumbed away from the rolled product. If oil gets by the outer seal leg, it collects on the seal inner ring (7) and is flung to the outer collection well (9). This well also empties into the auxiliary drain. The inner and outer collection wells and the auxiliary drain are optional features used only on dry mills. Next there is a coolant guard (8) that contributes to the labyrinth and is also the third active sealing element. This piece prevents coolant from entering the bearing.

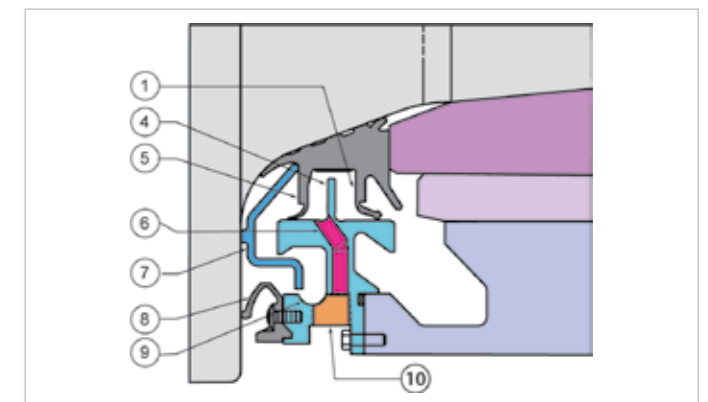
In addition to these features, there is a venting system to equalize pressure in the chock and sealing area to improve drainage. There is a chock side vent (11) and a seal side vent (12) that meet in an equalization chamber (13).



11. Chock side vent
12. Seal side vent
13. Equalization chamber



2. Drainback well
3. Passage to direct oil back to chock



1. Oil side HD seal leg
4. Seal end plate dam
5. Water side seal leg
6. Inner collection well (dry mills only)
7. Seal inner ring as labyrinth and flinger
8. Coolant guard
9. Outer collection well (dry mills only)
10. Auxiliary drain to be plumbed away (dry mills only)

BEARING OPTIONS: SEALING TECHNOLOGY

DRY MILL SEALING

APPLICATIONS

- Dry mills with tapered neck bearings

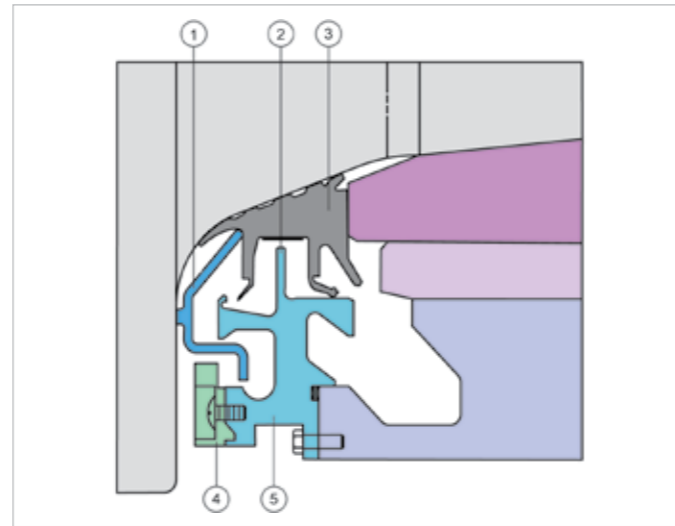
MAIN BENEFITS

- No leakage in or out of the bearing
- Ease of mounting and dismounting
- Cost effective

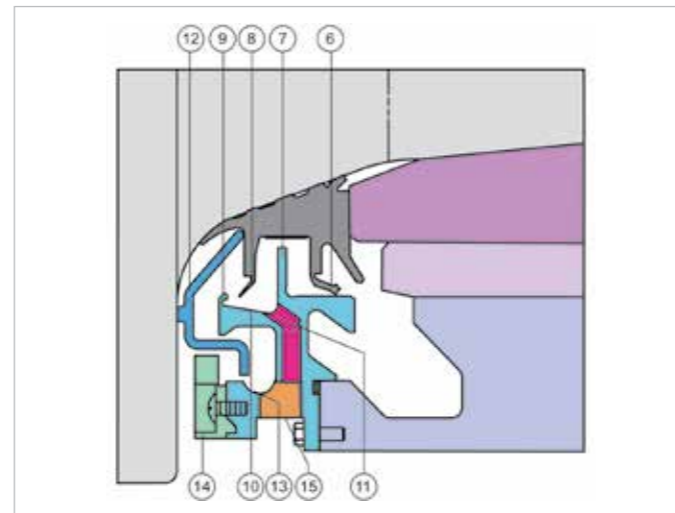
MORGOIL® uses a slightly different system for the special requirements of dry mill sealing. The outer leg of the neck seal receives no lubrication, neither coolant nor oil. Therefore this leg cannot come in contact with a stationary surface. If it does, the heat generated by unlubricated friction could cause the seal lip to experience unacceptably high temperatures.

Essentially, the oil side seal system operation is the same, but the differences are on the outboard side of the dam. As with the wet seal, the oil must first evade the oil side HD seal leg (6). This lip has been optimized to provide a hydrodynamic seal under all operating conditions. If oil gets by the this leg, the drainbacks, as explained in the wet sealing section, capture the oil. Oil that eludes the drainbacks must then move past the dam (7). Oil that escapes the dam is then thrown outward by the outer side seal leg (8) acting as a flinger to the sloped surface (10) on the outer side of the seal end plate. From the horizontal centerline to the bottom of the seal end plate, the sloped surface guides oil to the inner collection well (11), which is located at the bottom of the seal end plate next to the dam. The sloped surface also has a hooked lip (9) at the outer edge that keeps oil from flowing over. Additionally, in the upper half of the seal end plate, the hooked lip will hold and direct oil downward by surface tension until the oil follows the drainage path through the inner collection well. The inner collection well empties into an auxiliary drain (15) that is plumbed away from the rolled product. If oil gets by the hooked lip, it collects on the seal inner ring (12) and is flung to the outer collection well (13). This well also empties into the auxiliary drain. There is also a seal outer ring (14) that contributes to the labyrinth and outer collection well. A coolant guard can be used in place of the seal outer ring in the case of combination wet and dry rolling.

In addition to these features, dry mill sealing offers the same venting system used in the wet sealing system.



1. Seal inner ring
2. Seal end plate dam
3. HD neck seal
4. Seal outer ring
5. HD seal end plate



6. Oil side HD seal leg
7. Seal end plate dam
8. Outer HD seal leg as flinger
9. Hooked lip to prevent fluids from dripping
10. Sloped surface to collect fluids at dam
11. Inner collection well
12. Seal inner ring as labyrinth and flinger
13. Outer collection well
14. Seal outer ring as part of labyrinth and well
15. Auxiliary drain to be plumbed away

BEARING OPTIONS: LOCKING

HYDRAULIC BAYONET (HB) MOUNT

APPLICATIONS

- All mills

MAIN BENEFITS

- Easy operation and accurate mounting
- Consistent mounting force for improved strip quality
- Safe and quick mounting and dismounting
- No crane or external tools needed
- Mechanical locking feature
- Improved mill productivity

The MORGOIL® Hydraulic Bayonet mount is our premier mounting and locking device. The Hydraulic Bayonet mount provides extremely easy and accurate mounting combined with chock removal, and has decades of field experience on hundreds of mill stands around the world. The mount is operated by an external hydraulic power pack.

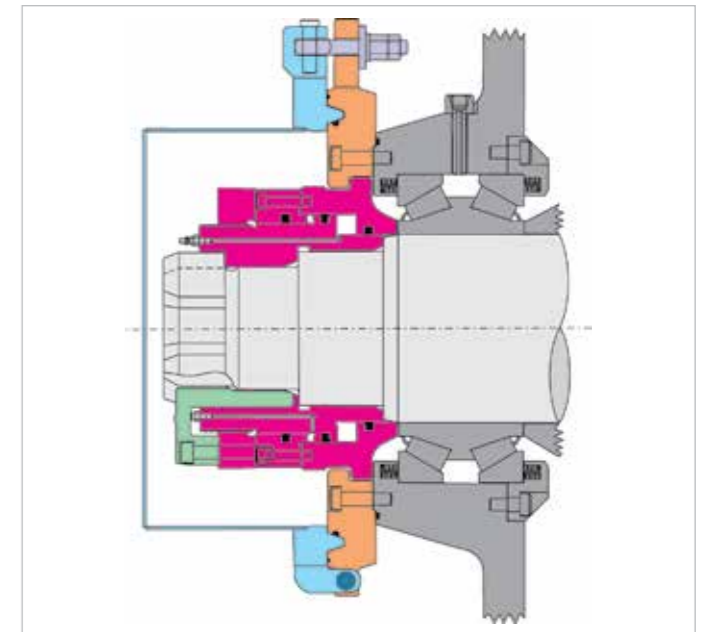
The complete Hydraulic Mount assembly stays with the chock when the roll is dismounted for grinding. When mounting, it locks onto the roll through a bayonet end. To mount the bearing, the mounting port is pressurized and the lock ring tightened. The hydraulic pressure is removed and a locking segment inserted.

Removal is accomplished by reversing the procedure. The locking segment is removed, the mounting port is pressurized and the lock ring is loosened. The dismount port is then pressurized and the chock and bearing as a unit are pushed off the roll. The dismount pressure is removed, the lock rotated one quarter turn to disengage the bayonet, then the chock is removed from the roll.

This is an excellent lock to use when grinding rolls in chocks since it consistently holds the bearing in its proper position.



Hydraulic Bayonet mount piston



Hydraulic Bayonet mount

BEARING OPTIONS: LOCKING REMOVABLE MOUNT (RM)

APPLICATIONS

- Multi-stand mills

MAIN BENEFITS

- Easy, accurate mounting
- Mounting and dismounting
- Lower cost

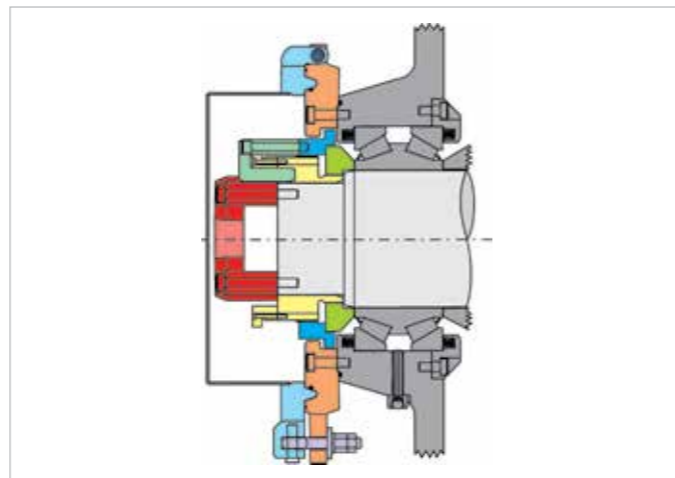
The Removable Mount is the most cost-effective way of achieving hydraulic mounting and dismounting on multi-stand mills. This system separates the hydraulic mounting components from the mechanical locking components so that only one set of hydraulic cylinders is needed. The hydraulic mounting unit, which provides both the mounting and dismounting function in the same tool, is moved from chock to chock as bearings are mounted or dismounted. The Removable Mount tool attaches to the roll through an internal bayonet and locks to the threaded ring through an external bayonet.

The threaded ring assembly stays with the chock and engages with the roll through a bayonet. Once this is done, the RM tool attaches to the roll and threaded ring. It is pressurized to mount the bearing, and the lock ring tightened to lock it in place. The hydraulic pressure is removed and the RM tool taken off the roll. A locking segment is then inserted. Removal is achieved by reversing the procedure.

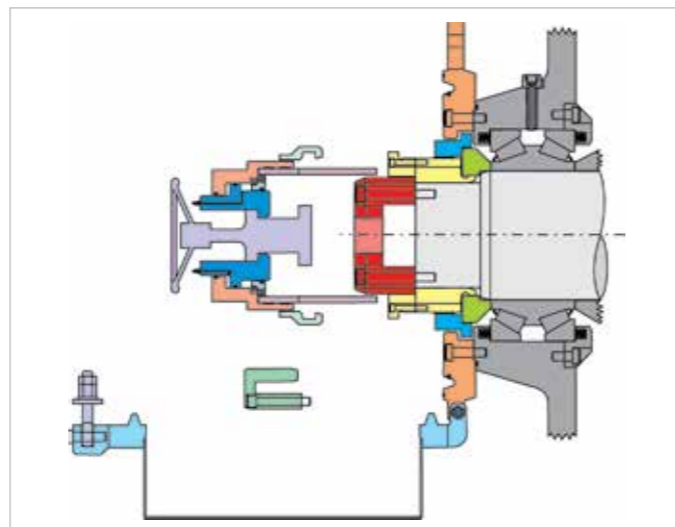
The Removable Mount has the same performance benefits as the HB mount, such as consistent mounting force, but at a reduced initial cost in multi-stand mills. Only one hydraulic mount/dismount tool is required per thrust bearing size. The mechanical locking components also result in shorter roll end than the traditional Hydraulic Mount design. Bolt-on roll end options make this mounting system a viable option for both retrofits and new mill installations.



Removable Mount mounting tool



Removable Mount running components



Removable Mount mounting tool alignment

BEARING OPTIONS: LOCKING COMPACT BAYONET AND REMOVABLE MOUNT

APPLICATIONS

- All mills Compact Bayonet mount (CB)
- Multi-stand mills Compact Removable mount (CR)

MAIN BENEFITS

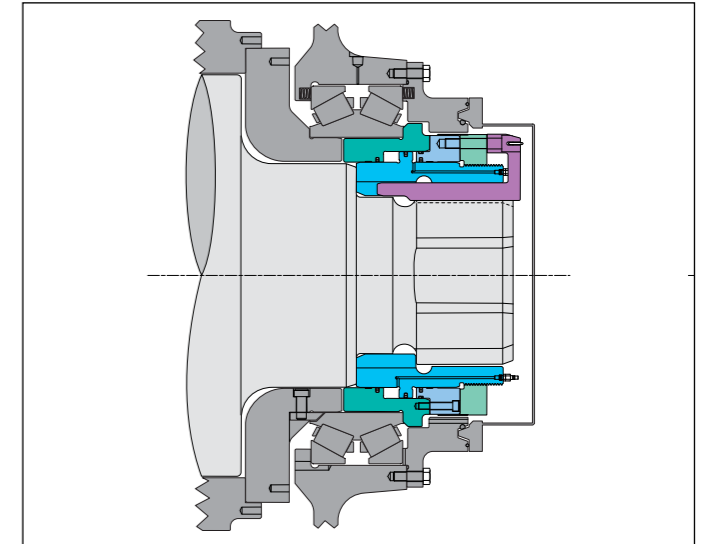
- Shortest possible roll length
- Easy operation and accurate mounting
- Consistent mounting force for improved strip quality
- Safe and quick mounting and dismounting
- No crane or external tools needed
- Mechanical locking feature
- Easy, accurate mounting
- Hydraulic mounting and dismounting

The CB and CR locks are similar to each other in the same way as the HB is similar to the RM. The CB contains all hydraulic components while the CR uses an external tool with the hydraulic components.

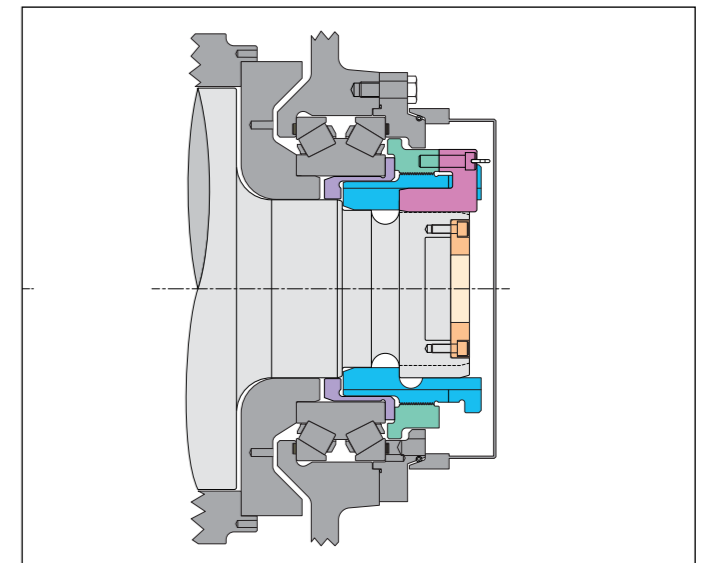
The Compact Bayonet mount (CB) allows for a shorter roll length than with the HB mount. This is because part of the sleeve ring and lock are under the thrust bearing. A thrust bearing with larger inner diameter is used to facilitate the positioning of components. The CB contains the same hydraulic components as the HB; however, the positioning under the thrust bearing allows the shorter roll length.

The CB-RM lock gives the shortest possible roll length. It is a combination of the CB lock and the RM. All hydraulic components are included with the RM tool. Shifting the location of these parts to the RM tool allows for even shorter rolls than with the CB.

Bolt-on roll ends can be used with either of these locks.



Compact Bayonet mount (CB)



Compact Removable mount (CR)

BEARING OPTIONS: LOCKING CONVERSIONS HM LOCK

APPLICATIONS

- Oil film backup rolls: MORGOIL® 'QC' lock replacement
- Roller bearing backup rolls
- Work rolls with thrust bearings

FEATURES

- Fully hydraulic, double acting
- Lock encapsulated in chock for quickest operation
- Pivoting locking arms
- Mechanical lock nut which withstands severe axial forces
- Integral key prevents rotation
- Highest quality sealing
- Dedicated pump system with pressure control

BENEFITS

- Exact repeatable mounting force
- High force hydraulic dismount capability
- Quicker and much safer operation
- Eliminates crane tightening
- Improves mill productivity
- Improves finished product quality



MORGOIL HM lock

BEARING OPTIONS: LOCKING CONVERSIONS LD BACKUP ROLL LOCK

APPLICATIONS

- Oil film backup rolls: direct MORGOIL® 'TR' lock replacement
- Roller bearing backup rolls

FEATURES

- Fully hydraulic, single acting
- Lock encapsulated in chock for quickest operation
- Pivoting locking arms
- Highest quality sealing
- Dedicated pump system with pressure control

BENEFITS

- Exact repeatable mounting force
- Quicker and much safer operation
- Eliminates crane tightening
- Improves bearing component lives
- Improves mill productivity
- Improves finished product quality



MORGOIL LD™ lock on backup roll

BEARING OPTIONS: LOCKING CONVERSIONS SL LOCK

APPLICATIONS

- Oil film backup rolls: direct MORGOIL® 'TR' lock replacement

FEATURES

- Fully hydraulic, double acting
- Lock encapsulated in chock for quickest operation
- Pivoting locking arms
- Mechanical lock nut which withstands severe axial forces
- Highest quality sealing
- Dedicated pump system with pressure control

BENEFITS

- Exact repeatable mounting force
- Quicker and much safer operation
- Eliminates crane tightening
- Improves bearing component lives
- Improves mill productivity
- Improves finished product quality



MORGOIL SL lock

BEARING OPTIONS: LOCKING CONVERSIONS LD WORK ROLL LOCK

APPLICATION

- Work rolls : Replacement for mechanical locks with minor modifications

FEATURES

- Single acting hydraulic/spring loaded mounting
- Lock encapsulated in chock for quickest operation
- Pivoting locking arms
- Dedicated pump system with pressure control

BENEFITS

- Exact repeatable mounting force
- Quicker and much safer operation
- Eliminates labor intensive tightening requirements
- Improves bearing component lives
- Improves mill productivity
- Improves finished product quality



MORGOIL LD™ lock on work-up roll

BEARING ALTERNATIVES

KL BEARING

APPLICATIONS

- Additions to existing mills with KL® Bearings

MAIN BENEFITS

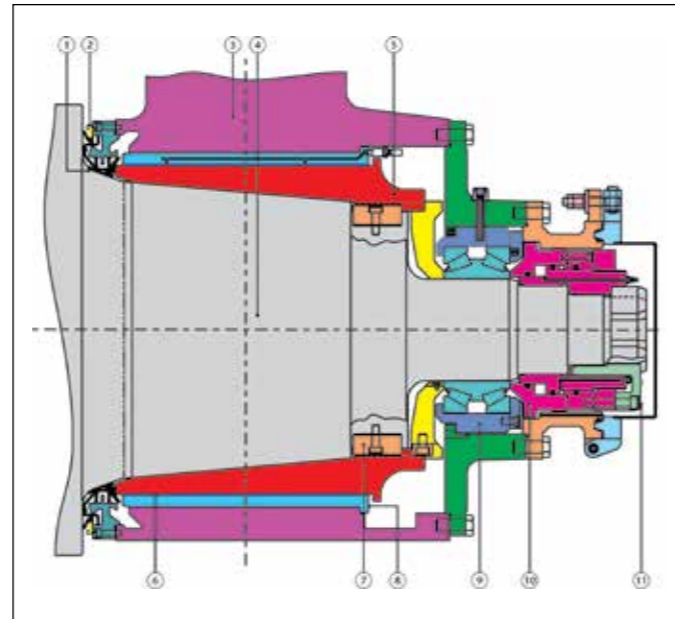
- Compatibility with existing bearings

The MORGOIL® KL® Bearing had been installed in many mills prior to the introduction of the KLX® Bearing. It has proven its capability and durability under all applications. MORGOIL continues to offer the KL Bearing for customers that wish to maintain compatibility with other existing bearings.

When first offered, the KL provided an advanced level of technology. It features a tapered neck, keyless sleeve, Hydraulic Bayonet lock, and DF® seal. The tapered neck permits easy bearing mounting and dismounting, as no special chocking equipment is needed. Additionally, all critical bearing parts are protected when the bearing is off the roll neck. The sleeve features keys that are located out of the load zone and therefore do not affect roll force variation. The Hydraulic Bayonet mount provides easy and consistent bearing mounting and is still an option offered with the KLX Bearing. The DF neck seal has been a proven sealing solution for many years and provides the basis for the current advanced sealing systems.

The KL Bearing should be selected over the KLX Bearing only when compatibility with existing equipment is an issue. In any other situation, the KLX Bearing is a better choice.

The KLX draws upon KL Bearing technology and moves it to a new level of cost-effective performance. The KLX offers more bearing performance in a smaller package at reduced cost.



1. DF neck seal
2. Coolant seal
3. Chock
4. Roll neck
5. Sleeve
6. Babbitt
7. Key
8. Bushing
9. Thrust bearing assembly
10. Hydraulic Bayonet lock
11. Locking segment

KL®	Rating ¹	Roll										Chock				Drains									
		Size	Series	lbs/1000	tonnes	kN	Unfactored Neck Stress		A	HB	K	Z	Emin	M	DA	D	F ²		L	E/2	Gmin	Bmin	Xmin	Jmin	
						psi	MPa		C							hyd cyl	rocker								
28"	67	1.127	511	5,010	13,660	94.3	275	840								370	425	455	595	350	780	510	355	550	
	75	1.282	572	5,610	16,690	115.2	300	855								385	445	475							
	84	1.413	641	6,290	20,240	139.7	325	880								410	465	495							
30"	67	1.292	586	5,750	12,990	89.7	295	855		597	520	750	120		225	380	450	485	635	375	815	560	380	600	
	75	1.446	656	6,430	15,770	108.9	320	875							250	400	475	505							
	84	1.618	734	7,200	19,020	131.3	345	900							275	425	495	530							
32"	67	1.489	666	6,530	13,080	90.2	310	870		631	555	790	120		240	400	480	515	675	395	865	585	405	650	
	75	1.645	746	7,320	15,800	109.1	335	890							265	420	505	540							
	84	1.841	835	8,190	19,000	131.2	360	910							290	440	530	560							
34"	67	1.658	752	7,370	13,070	90.2	325	885		666	590	840	120		255	410	510	550	715	420	915	635	430	700	
	75	1.857	842	8,260	16,000	110.4	355	910							285	435	535	570							
	84	2.079	943	9,250	19,420	134.1	385	940							315	465	560	595							
36"	67	1.859	843	8,270	12,960	89.5	345	1060		707	630	890	125		270	470	540	580	760	445	965	660	455	700	
	75	2.082	944	9,260	15,590	107.4	370	1080							295	490	565	605							
	84	2.331	1,057	10,370	19,070	131.6	405	1110							330	520	595	630							
38"	67	2.073	940	9,220	12,810	88.4	355	1065		742	665	950	125		280	475	575	615	805	475	1015	685	480	750	
	75	2.320	1,052	10,320	15,550	107.3	385	1090							310	500	600	640							
	84	2.597	1,178	11,550	18,990	131.1	420	1120							345	530	630	670							
40"	67	2.295	1,041	10,210	12,650	87.3	370	1090		780	705	1000	125		290	500	600	645	845	500	1065	735	510	800	
	75	2.569	1,165	11,430	15,310	105.7	400	1120							320	525	630	670							
	84	2.878	1,305	12,800	18,650	128.7	435	1145							355	555	660	700							
42"	67	2.531	1,148	11,280	12,420	85.7	390	1100		827	740	1050	140		305	510	630	675	885	525	1120	760	535	800	
	75	2.833	1,285	12,600	15,150	104.6	425	1130							340	540	660	705							
	84	3.173	1,439	14,110	18,370	126.8	460	1160							375	570	690	735							
44"	67	2.778	1,260	12,360	12,380	85.5	400	1115		860	775	1090	135		315	525	660	710	930	545	1170	815	560	850	
	75	3.109	1,410	13,830	15,060	104.0	435	1145							350	555	690	740							
	84	3.482	1,579	15,490	18,420	127.2	475	1180							390	590	725	770							
46"	67	3.036	1,377	13,500	12,490	86.2	425	1140		902	810	1150	145		340	545	690	740	970	575	1220	840	585	900	
	75	3.398	1,541	15,110	15,120	104.4	460	1165							375	575	720	770							
	84	3.806	1,726	16,930	18,410	127.1	500	1200							415	610	760	805							
48"	67	3.305	1,499	14,700	12,280	84.6	435	1155		939	850	1180	145		335	565	720	775	1015	590	1270	890	610	950	
	75	3.700	1,678	16,480	14,630	102.4	470	1185							370	595	755	805							
	84	4.143	1,879	18,430	18,200	125.6	515	1220							415	630	790	840							
50"	67	3.588	1,627	15,980	12,250	84.6	450	1165		976	885	1230	150		350	575	755	810	1090	615	1320	915	635	1000	
	75	4.015	1,821	17,860	14,930	103.1	490	1200							390	610	790	840							
	84	4.496	2,039	20,000	18,250	126.0	535	1240							435	650	825	880							
52"	67	3.879	1,759	17,250	12,470	86.1	470	1340		1009	920	1260	145		368	625	780	835	1095	630	1370	965	660	1050	
	75	4.342	1,969	19,310	15,150	104.6	510	1380							408	665	815	870							
	84	4.884	2,206	21,640	18,480	127.4	555	1420							453	705	855	910							
54"	67	4.183	1,897	18,610	12,420	85.7	485	1360		1047	955	1290	150		390	645	810	870	1160	645	1420	990	685	1100	
	75	4.683	2,124	20,830	15,190	104.9	530	1400							435	685	850	905							
	84	5.246	2,379	23,330	18,480	127.4	575	1440							480	725	890	945							
56"	67	4.593	2,083	20,430	11,940	82.4	505	1380		1108	1015	1350	150		415	665	850	910	1195	675	1475	1015	710	1150	
	75	5.140	2,331	22,860	14,550	100.4	550	1420							460	705	890	950							
	84	5.757	2,611	25,610	17,780	122.7	600	1465							510	750	930	990							
60"	67	5.272	2,391	23,450	11,600	80.1	525	1580		1184	1095	1440	145		425	690	910	975	1275	720	1575	1095	760	1200	
	75	5.901	2,676	26,250	14,100	97.3	570	1620							470	730	950	1015							
	84	6.611	2,998	29,410	17,320	119.6	625	1665							525	775	995	1060							
64"	67	5.998	2,720	26,680	11,560	79.8	555	1615		1259	1170	1520	145		455	725	990	1065	1390	760	1675	1170	810	1350	
	75	6.714	3,045	29,880	14,110	97.4	605	1655							505	765	1035	1110							
	84	7.521	3,411	33,450	17,240	119.0	660	1695							560	815	1090	1160							
68"	67	6.679	3,029	29,710	11,160	77.0	575	1765		1335	1245	1640	144		450	820	1045	1125	1440	820	1780	1250	865	1450	
	75	7.477	3,391	33,280	13,690	94.5	630	1815							505	870	1095	1175							
	84	8.375	3,798	37,250	16,800	116.0	690	1865							565	920	1155	1225							
70"	67	7.382	3,348	32,840	11,380	78.6	600	1795		1390	1300	1690	144		475	850	1095	1180	1510	845	1860	1285	890	1500	
	75	8.237	3,736	36,640	13,860	95.7	655	1845							530	900	1150	1230							
	84	9.189	4,158	40,780	16,850	116.3	715	1895							595	950	1210	1285							
72"	67	7.784	3,521	34,530	11,160	77.0	610	1815		1430	1340	1730	144		485	880	1125	1210	1550	865	1910	1320	915	1550	
	75	8.692	3,942	38,660	13,730	94.8	670	1865							545	920	1180	1265							
	84	9.735	4,415	43,300	16,860	116.4	735	1920							610	975	1240	1325							
74"	67	8.349	3,786	37,140	11,160	77.0	630	1830		1480	1390	1780	144		505	885	1165	1255	1600	890	1980	1360	940	1600	
	75	9.341	4,236	41,550	13,680																				

BEARING ALTERNATIVES

N BEARING

APPLICATIONS

- Low to moderate separating force applications
- Cold mills
- Aluminum mills

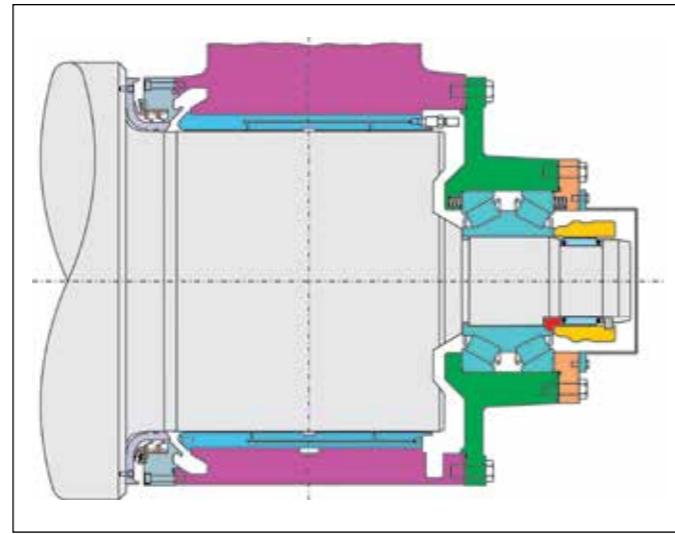
MAIN BENEFITS

- High roll grinding accuracy
- Lower initial cost

For many years the primary backup roll bearing has been the MORGOIL® tapered sleeve and babbitted bushing design. This bearing has provided both the ease of assembly and the ruggedness needed in tough mill environments of all types of rolling applications. However, for cases of lightly loaded, moderate to high-speed mills, the robust tapered sleeve bearing may not be the most cost-effective option. As a result MORGOIL offers a design that uses no sleeve and runs directly on the roll neck, as shown in the accompanying figure. Because there is no sleeve to deflect and spread the rolling load, sleeveless N type bearings always have a lower load capacity than other bearings of the same size. However, sleeveless N type bearings are ideally suited for some applications.

Besides simplicity of design and existing proven MORGOIL technologies like babbitted bushings and hydrostatic assist, this bearing also offers lower initial cost since the number and complexity of components are considerably reduced. This bearing is ideal for low to moderate separating force applications such as high-speed aluminum mills and steel temper pass mills. This bearing can also be used in cold reduction mills and tandem cold mills where there is sufficient space to accommodate it. N type bearings are normally equipped with dual load zone bushings.

The N Bearing is ideal for applications requiring high roll grinding accuracy, since grinding directly on the backup bearing journals has been shown to result in the lowest total indicated runout. Due to the requirement of grinding directly on the roll journals, it is highly recommended that hydrostatic supports be used during roll grinding.



BEARING ALTERNATIVES

SN BEARING

APPLICATIONS

- High accuracy cold mills
- Aluminum mills

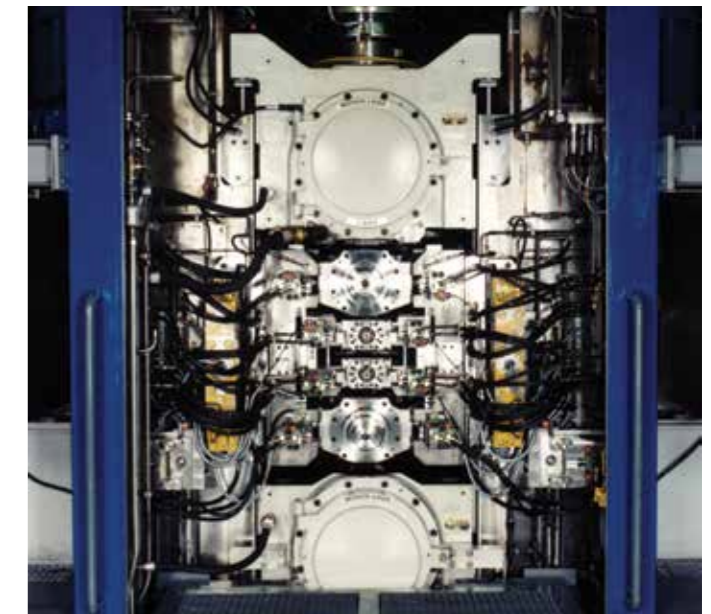
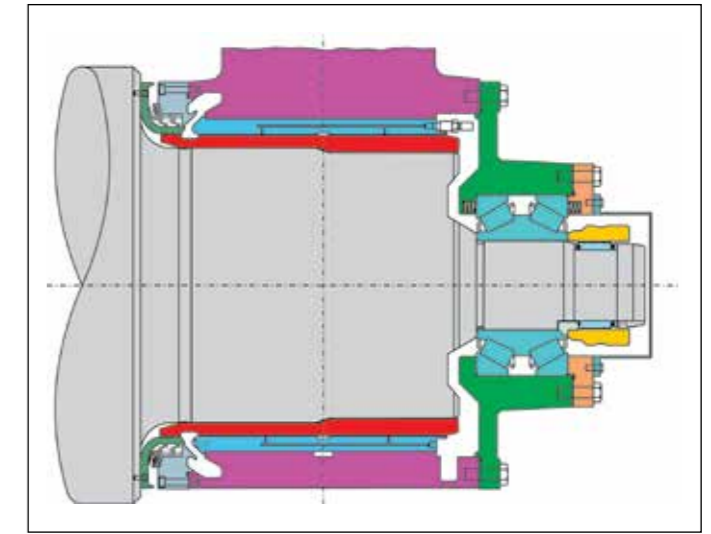
MAIN BENEFITS

- Higher load capacity than N Bearing
- Highest degree of roll grinding accuracy

The SN Bearing is a sleeved straight neck bearing. It is similar to the N type bearing except that it uses a thin-walled sleeve shrunk onto the cylindrical neck of the backup roll. The thin-walled sleeve gives the SN Bearing a higher load capacity than the N Bearing. The thin sleeve on the SN Bearing is specially hardened for high wear resistance and long operating life.

The SN Bearing is ideal for any application requiring the highest degree of grinding accuracy. The backup rolls of SN Bearings are ground on the cylindrical sleeve surface to provide the minimum possible level of grinding runout. The hardened surface of the sleeve provides for the longest possible life of the bearing surface.

SN Bearings are supplied with dual load zone bushings as standard equipment. They are ideal for all types of high accuracy cold mills. They have also been successfully applied to hot aluminum mills.



6-High reversing cold mill with 30"-76 SN Bearings

LUBRICATION SYSTEMS

Lubrication systems supply oil film bearings with the proper amount of oil, at the proper temperature, allowing the bearings to operate at peak capacity for many years. A properly designed and installed modern lubrication system will also run for many years with minimal maintenance. MORGOIL® supplies newly designed, preassembled lubrication systems built specifically for MORGOIL Bearings.

Recent design changes extended to the oil system include: the optional application of new super-demulsifying oil to speed the separation of oil and water; the optional application of vacuum dehydrators for emulsified water removal and reconfiguration of oil skid designs to reduce cost through lower cost components.

SUPER DEMULSIBILITY (SD) OILS

Oils that can shed water more quickly and minimize emulsification have been a goal of the lubrication industry for many years. These oils are now available for bearing applications through leading suppliers. Besides offering better water removal at lower temperature, SD oils also offer the chance to reduce the number of components needed in several classes of mills. For example, the traditional hot finishing mill would have two oil tanks - one in operation and the other in a “rest” or standby mode during which the oil temperature had been raised to take out the emulsified water. With SD oil a single tank can be used, thus saving space and cost of oil as well as power for heating.

SKID MOUNTED MORGOIL LUBRICATION SYSTEM

MORGOIL engineering has been working to provide oil systems that are more cost-effective. Figure 9 is a diagram of a typical new design skid-mounted MORGOIL lubrication system. Using similar components from a library of available parts, MORGOIL is now able to offer lower cost oil systems with very little installation effort at the site. The skid can be landed and piped to the stands with no need to assemble the components on site. Even for larger applications, such as hot strip mills, the prepackaged concept has both design and cost benefits.

The figure and photos show a multiple oil feed pump configuration skid. By using several same-size screw pumps of lower rating, the need for 100% pump redundancy is eliminated along with component cost reductions, because the smaller pumps are less expensive. It also saves customer electrical power reserve requirements since only a fraction of the total pumping power comes on at any one time. Also, because the motors and pumps are smaller, the cost of spares is reduced.

VACUUM DEHYDRATORS

Traditionally, centrifuges have been used to separate oil and impurities. However, because of the inherent mechanical reliability issues of centrifuges, much effort has been expended over the years to try and find a non-mechanical solution to oil treatment. The vacuum dehydrator now offered in the MORGOIL portfolio fills that need. The dehydrator uses vacuum and heat to extract the unwanted elements in the oil. Since there are only a few moving mechanical parts, reliability is significantly improved, and the system can be left in operation continuously. This system is offered in a portable version and in a skid-mounted version for permanent installation. Dehydrators are not necessary in systems that use SD oil.



Vacuum dehydrator



Dehydrator shown with optional lifting frame

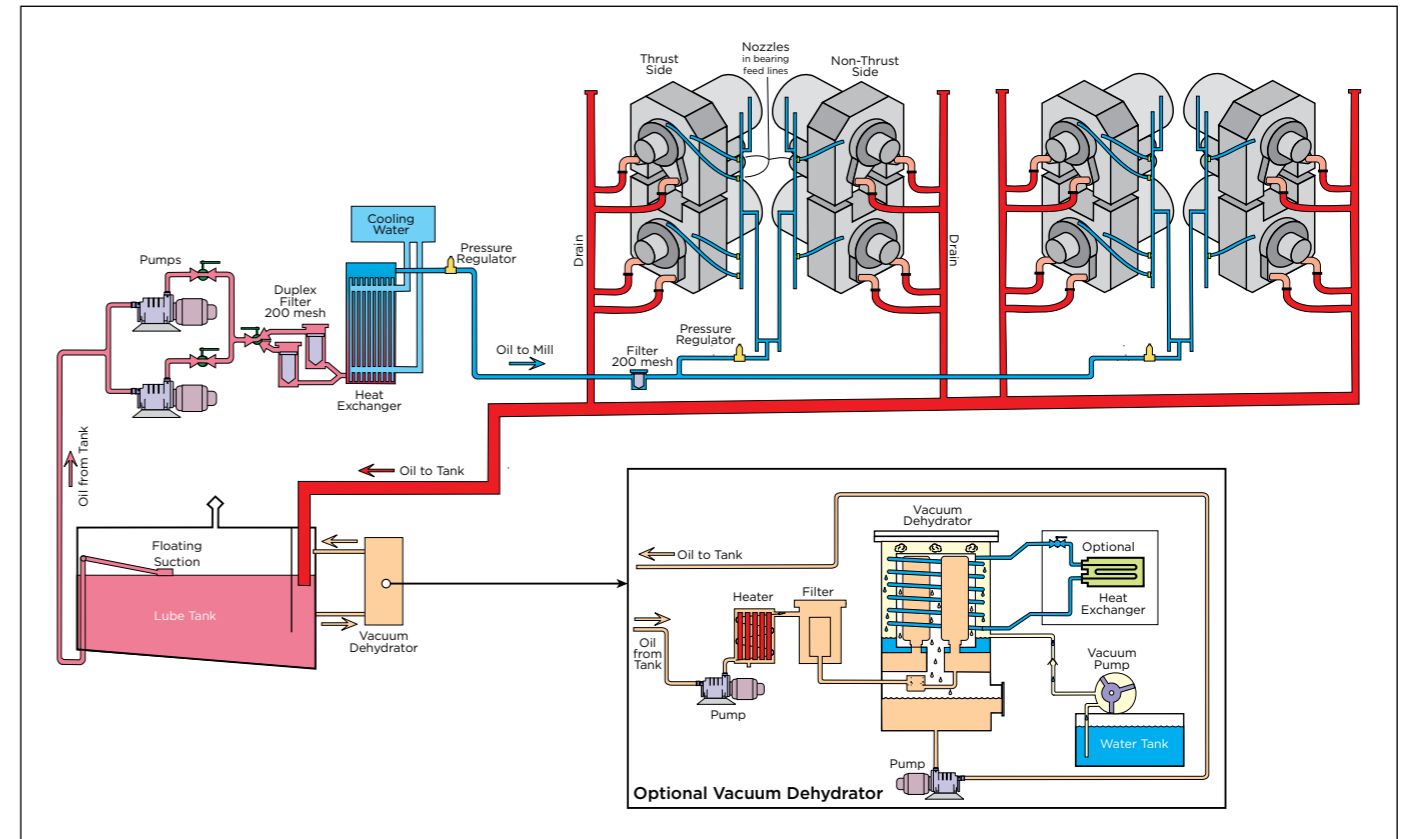


Figure 9 - Multi-stand lubrication system



Lubrication system

HAGC CYLINDERS, SHIFTING AND BENDING BLOCKS

Just as MORGOIL® Bearings support the rolling mill separating force, Hydraulic Automatic Gauge Control (HAGC) Cylinders support this same load. These HAGC Cylinders must operate under conditions of extreme load and heavy impact in a difficult environment. Under these conditions, HAGC Cylinders must provide precise, accurate motion with fast response and minimum friction. For mills to maintain high levels of strip quality, these cylinders must be kept in top condition, which means rebuilding them at regular intervals. The MORGOIL team at Primetals Technologies excels at rebuilding HAGC Cylinders and works with many companies to develop preventative maintenance programs. The MORGOIL services portfolio has several levels of reconditioning to meet customer needs. As part of the rebuild procedure, cylinders are checked for leakage and friction-tested under load to meet rigorous standards and ensure like-new performance. Over the past several years, MORGOIL engineers have reconditioned hundreds of cylinders for numerous customers.

From reconditioning to total new designs, the MORGOIL engineering group can provide the high level of service that is required for this important component of your mill stand. Whether new or reconditioned, our customers can be confident that they will receive years of trouble-free cylinder performance.

Using the same manufacturing and testing facilities, MORGOIL experts recondition, engineer and manufacture other precision hydraulic units such as shifting and bending blocks.

TESTING FACILITY

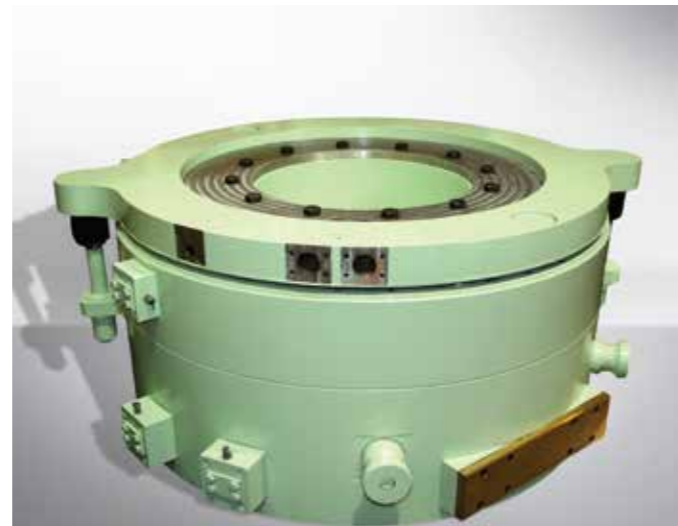
The MORGOIL HAGC Cylinder test facilities at Primetals Technologies consist of restraining frames, hydraulic systems and instrumentation. The frames were designed using finite element analysis to simulate mill housings, and they react in an elastic manner to loads of up to 2275 MT (5,000,000 lbs).

SELECT CUSTOMER LIST

AHMSA	Jinan Steel
AK Steel	Lloyds Steel
Alcan	Logan Aluminum
Alcoa	Mittal Steel
Arcelor Mittal	Novelis
Erdemir	Nucor Steel
Essar/Algoma	SSAB
Gallatin Steel	Steel Dynamics
HYLSA	Ternium
IPSCO Steel	US Steel
ISPAT Steel	Wise Alloys



HAGC Cylinders before and after reconditioning



HAGC Cylinder



HAGC Cylinder testing facility

MANDRELS/REELS

With hundreds of references worldwide, on all types of mills, Primetals Technologies is the leading supplier of mandrels and reels for both hot and cold mill applications.

The mandrel/reel is one of the most complex and critical pieces of equipment in the entire rolling mill and is subject to some of the most hostile conditions. It is essential to have the most robust and reliable design, utilizing the finest quality materials for the longest operational service life, maximizing mill availability.

Finished coil quality critically depends on the design and condition of the mandrel, which must facilitate quick cinching of the head end, producing a tightly wound coil, free of impact marks and telescoping with minimum yield loss.

Primetals Technologies manufactures new state-of-the-art mandrels and reels within our world-class manufacturing facilities as well as providing a comprehensive reconditioning service. Design improvements can be implemented during the reconditioning cycle, which will improve performance, reliability and maintainability.

MILL APPLICATIONS

- Hot strip mills and wide Steckel mills
- Cold strip mills (multi-stand and reversing)
- Strip processing and finishing lines

BENEFITS

- Maximize mill availability
- Optimize reliability and maintainability
- Improve finished product quality



UNIVERSAL DRIVES, GEAR SPINDLES AND GEAR COUPLINGS

Universal Drive systems have set the standard for the industry since they were first introduced. The Universal Drive system is a comprehensive spindle assembly designed for the challenging conditions and high performance standards of today's rolling mills. At the heart of the Universal Drive system is the MX Universal joint, the latest generation design of the Primetals Technologies Universal joint. We handle all aspects of Universal Drive systems supply, from custom design and engineering through manufacture, installation and maintenance.

The Universal Drive system has been developed to offer state-of-the-art drive mechanisms for rolling mills. Every application is custom-engineered using modern CAD-CAM systems. High strength alloy steels are used for critical components such as cross pieces, yokes, intermediate sections and coupling hubs, to provide superior fatigue cycle characteristics ensuring reliability in operation. Today's Universal Drive systems offer the highest torque capability available for a given swing diameter.

OPTIONS AND ADVANTAGES

- Available swing diameters up to 1300 mm (51.18 inches)
- Torque capacities up to 788 m-T (5,700,000 ft-lbs)
- Offset angles up to 15 degrees
- Removable bearing assemblies for lower cost and easier maintenance
- Splined or rigid intermediate sections to suit the specific application

Primetals Technologies is equipped to handle every aspect of supply when it comes to drive systems.

SUPPLIED DRIVE ELEMENTS INCLUDE

- Advanced MT and MRK universal joints
- Splined shafts or fixed-length shafts
- Drive hubs and adapter plates
- Roll hubs with locking features, and with or without replaceable liners

GEAR SPINDLES

Primetals Technologies mill gear spindles are available with fixed or telescopic intermediated shafts capable of transmitting very high torques with working angles up to 3°. The innovative material and compact design make our mill gear spindles ideal for both unidirectional and reversible drives of stands throughout the mill.

GEAR COUPLINGS

Primetals Technologies FGC series gear couplings feature crowned gear teeth designed to ensure conditions of misalignment in a larger contact surface. The displacement of the used profile determines the increase of the thickness of the tooth and therefore the resistance of the teeth.



Universal drive system featuring Hirth coupling



Gear spindles for all mill applications



Gear couplings for all mill applications

MORGOIL SERVICES FULL SERVICE WORLD WIDE SUPPORT

INSTALLATION

When a new mill is being erected or there is a major mill upgrade, the Primetals Technologies service team is available to be on site to assist in the proper installation of MORGOIL® equipment. This can include complete bearing assembly, inspection of completed assemblies, and calibration of equipment. Mating mill equipment can also be checked to ensure proper interaction that can affect bearing performance.

It is our goal to deliver a flawless installation that will provide a timely mill start up.

SERVICE

Once bearings have been in operation, our MORGOIL service personnel are available to perform routine inspection of bearings and related equipment. These inspections can help to find any issues that could affect mill performance. The bearings can reveal the effects of other faulty mill equipment, so regular bearing inspections can improve mill uptime. Additionally, our service representatives can keep mill personnel abreast of the latest improvements in technique and equipment that can help improve mill efficiency.

TRAINING

It is important for roll shop personnel to understand bearing operation, bearing assembly techniques, bearing interaction with other mill equipment, and basic bearing troubleshooting. MORGOIL service engineers from Primetals Technologies are equipped to provide training seminars at individual mills to help roll shops in this endeavor. The goal is to eliminate any bearing issues that could arise from improper maintenance, helping to keep operational costs down.

PREVENTATIVE MAINTENANCE

Primetals Technologies has a field service group that specializes in mill equipment monitoring to assist with preventative maintenance. They can audit all mill equipment, not just the bearings, to assist the mill in maximizing uptime and minimizing equipment failure.

RECONDITIONING

Once it has been determined that mill equipment has worn past acceptable limits, the MORGOIL team can provide reconditioning services to bring this equipment back to like-new condition. These services can range from simple disassembly and inspection to total rebuild of chocks or other equipment. Primetals Technologies understands mill operation and machinery and can breathe new life into used equipment.

SPARES AND SERVICE AGREEMENT

The combination of our service expertise with our supply of superior quality spares result in MORGOIL spares partnership programs. This is the most cost-effective way to manage MORGOIL equipment.



PREDICTIVE MAINTENANCE SERVICES

MAXIMIZE MILL UTILIZATION

MAIN BENEFITS

- Maximize mill utilization
- Known equipment condition
- Reduce maintenance cost
- Plan maintenance activities with proper timing and parts
- Avoid catastrophic failures

Today, most flat mill operators realize the importance of designing and implementing a predictive maintenance program. The debate remains how to implement it, and to what extent predictive maintenance technologies include vibration monitoring, oil analysis, thermography, balancing of critical equipment, etc. Predictive maintenance tasks are performed online and do not require stopping or decreasing production. In a typical steel plant, critical equipment in most areas must be monitored, including steel making and casting areas, hot strip mills, cold mills and processing lines.

Predictive maintenance (PDM) is the practice of using noninvasive techniques (known machine parameters) to predict the failure of a machine or system. The use of predictive technologies led industry professionals to recognize that many failures give advance warning through changes of machine or system parameters, such as vibration and temperature. Predictive maintenance programs are designed to identify and adapt to the failure modes for each machine or component. A successful predictive maintenance program will result in increased equipment utilization, reduced spare parts inventory, elimination of catastrophic failures, increased productivity, and a more efficient maintenance organization.

VIBRATION ANALYSIS

Some major decisions are based on the results of vibration monitoring analysis, such as when to let equipment run, or when to rebuild, what spare parts to stock and when

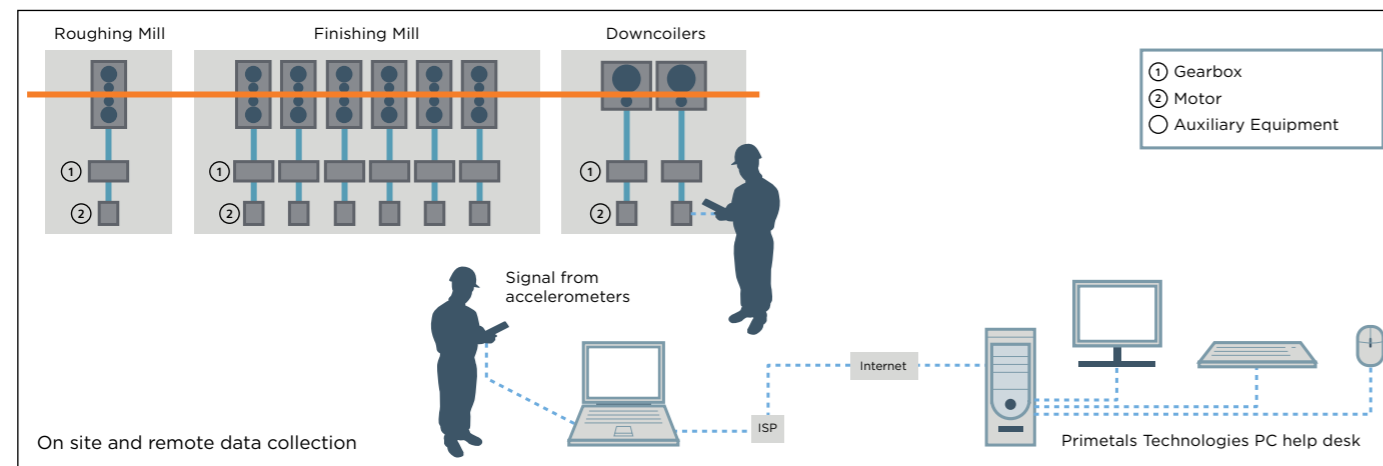
to shut down. The decision to partner with the best, most accurate and reliable provider will have critical implications for the performance of any mill, both long- and short-term.

ON SITE VIBRATION SERVICES

- Annual vibration contracts
- Vibration data collected by customer or our technicians, usually on a monthly basis
- Monthly reporting to customer
- Vibration analysis and balancing on mill site lubrication system audits and analysis
- Periodic oil sampling of critical lube systems, performed either by customer or field technicians
- Oil quality analysis, including cleanliness, water, viscosity, additives, and total acid number
- Determining lubricant condition through certified lab analysis
- Verifying system operation including pressure and temperature controls and regulation

ADDITIONAL SUPPORT

- Balancing and alignment
- Machinery diagnostics and root cause analysis
- Motor testing
- Oil analysis
- Infrared thermography
- Bearing failure analysis
- Mechanical and lubrication audits
- Field service assistance
- On site training
- Reconditioning services
- Engineering support/review
- Upgrades



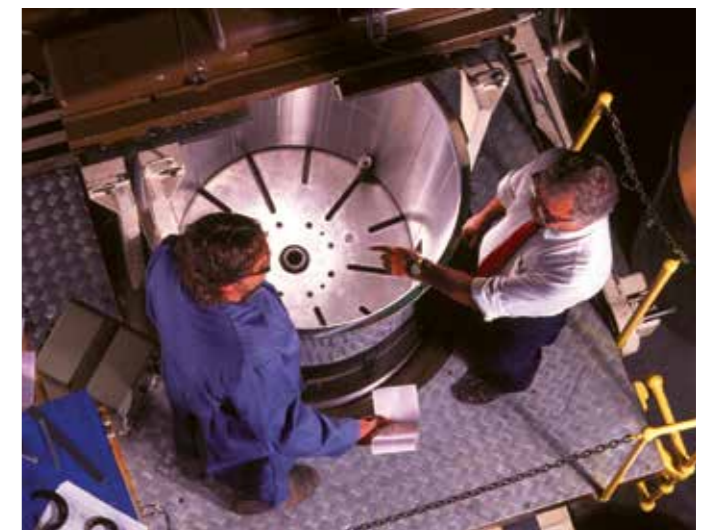
MANUFACTURING

Primetals Technologies is ISO 9001 certified and has continuously strived to improve quality and customer satisfaction at its predecessor company's Worcester, Massachusetts location for more than 125 years. MORGOIL products, first invented in Worcester, Massachusetts, USA, are manufactured today in a 280,000 sq ft facility that is uniquely qualified to handle all new and reconditioning work for any mill equipment, not just bearings. Our workshop is equipped with state-of-the-art turning, milling, drilling and grinding equipment, and our highly skilled machinists are able to consistently achieve the tight tolerances and fine finishes this equipment demands. Components are assembled to ensure proper fit and function, and our technicians can provide extensive testing that ensures the equipment meets customer requirements and will function correctly when installed.

In addition to our full service facility in Worcester, Primetals Technologies has subsidiaries that manufacture mill components in India, Brazil, U.K. and Shanghai, China. Equipment is supplied from the various locations based on local content, price, and delivery. All facilities are continuously monitored and maintain strict quality standards.

Shown on this page is the MORGOIL sleeve grinder that is currently installed in Worcester. This custom designed, precision machine can simultaneously grind the ID and OD of a sleeve providing wall thickness variation of less than 2.5 microns. A sister machine is also installed Primetals Technologies Shanghai, China.

Whether new or reconditioned, our customers can be confident that they will receive years of trouble-free operation with equipment supplied by Primetals Technologies.

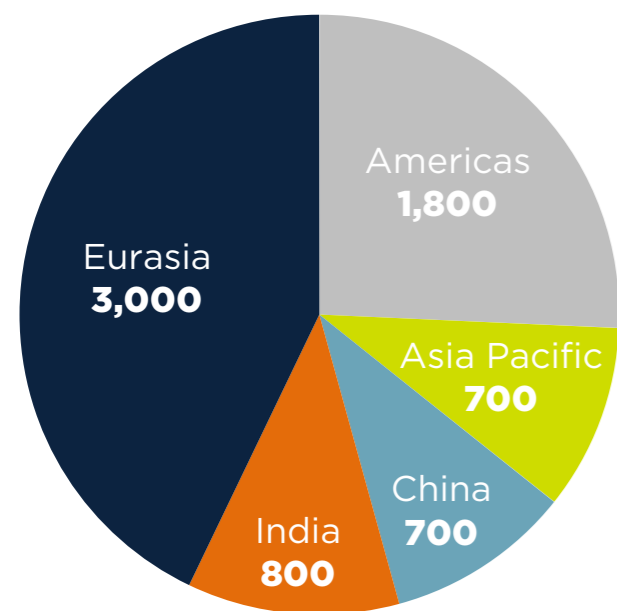


GLOBAL NETWORK

Around 7,000 employees of Primetals Technologies are based in more than 40 company offices, engineering, workshop and service centers to provide immediate support to our customers whenever required. With the added backing from the international office network of the parent companies Siemens and Mitsubishi Heavy Industries, more than 300 group sites located in some 190 countries are at the service of our customers.



EMPLOYEES WORLDWIDE*



*Approximate values

MORGOIL BEARING REFERENCE LIST

THE PREMIER BEARING IN ROLLING MILLS FOR THE METALS INDUSTRY

MORGOIL® Bearings are currently installed on approximately 3352 stands in 1178 mills, and remain the premier rolling mill bearing for the metals industry. They are installed in both ferrous and non-ferrous mills of all sizes. Below is a breakdown of mills by type.



MORGOIL® Bearing equipped finishing stand at Allegheny Technologies Incorporated's new hot rolling plant located in Brackenridge, PA, USA. These 58-86 MORGOIL KLX® Bearings are the highest load capacity backup roll bearings employed on a hot strip mill.

ACTIVE MORGOIL AND MESTA MILLS

HOT MILLS

Mill type	Mills	Stands
Hot strip mill	236	1677
Steckel / Plate/ Rougher	216	236
ESP mill	5	40
Total	457	1953

COLD MILLS

Mill type	Mills	Stands
Tandem cold mill	189	798
Temper mill	196	247
Other	336	354
Total	721	1399

*Totals through 2015

MORGOIL BEARING RECENT SELECT REFERENCE LIST

Operating company	Mill type	Mill builder
Rizhao ESP #1-#5	ESP	Primetals
Allegheny Technologies	HSM	Primetals
Big River Steel	HSM	SMS
Ha Tinh	HSM	Primetals
SAIL Bokaro	HSM	Primetals
voestaline Stahl	TCM	Primetals
USS POSCO	TCM	Primetals
ArcelorMittal Nipon Steel	HSM	SMS
Wickede Westfalenstahl	RCM	SMS
Steel Dynamics	TCM	SMS
Shandong Rizhao	HSM	SMS
Northstar	HSM	Danieli
AHMSA	Steckel	Primetals
Steel Technologies	RCM	Butech Bliss
voestaline Stahl	Plate	BUMA
Essar Steel	HSM	SMS
ArcelorMittal	HSM	Primetals
Thyssen Krupp	HSM	Primetals
POSCO Krakatau	Plate	Primetals
AK Steel	TCM	SMS

Operating company	Mill type	Mill builder
Nippon Steel	Plate	Primetals
Baosteel Special Steel	Steckel	SMS
Salzgitter	Skin Pass	Primetals
Iskenderun	HSM	Primetals
Ternium	RR	Danieli
Dongkuk Steel	Plate	Primetals
Dragon Steel	HSM	Primetals
ArcelorMittal Ugine	Skin Pass	
Baosteel	Plate	SMS
Essar Steel	Plate	Primetals
Hyundai	HSM	Primetals
Baosteel	Plate	SMS
POSCO	Plate	Primetals
Angang	Plate	CFHI
ALCOA	TCM	MESTA
COSIPA	HSM	Primetals
Rasselstein	DCR	SMS
Magnitagorsk	Plate	SMS
Baosteel Special Steel	Plate	Erzhong
NUCOR	TPM	SMS

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Brochure No.: T10-3-N312-L2-P-V2-EN

Printed in USA

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