FOUR POINT CONTACT SLEWING BEARING LUBRICATION & MAINTENANCE

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Slewing is defined as the rotation of an object about an axis. Thus a slewing ring bearing is a bearing used in slewing applications for transferring/supporting axial, radial, and moment loads, singularly or in combination, consisting of rings mounted with threaded fasteners, and usually having a gear integral with one of the rings.

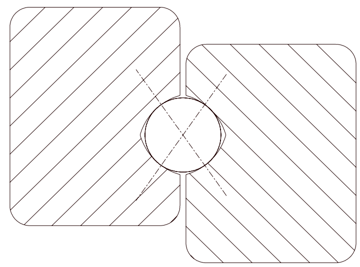
Slewing ring bearings with integral gears are purchased by some water and wastewater equipment manufacturers without the capability of manufacturing drives in house. These slewing rings are then assembled along with other components into a clarifier drive. Thus component drive assemblers are those that buy components designed and fabricated by others and assemble these pieces into drives. Drive manufacturers design and fabricate their own drives. The assemblers of component drive frequently claim ease of maintenance and reduced lubrication requirements as a benefit of these assembled slewing ring clarifier drives. Component drive assemblers minimize the required maintenance for these drives contrary to the slewing ring bearing manufacturers' recommended lubrication and maintenance procedures. In fact, many drive assemblers are unaware of or have actually ignored the slewing ring bearing manufacturers' recommendations concerning lubricants, frequency of re-lubrication, as well as types and frequency of maintenance inspections and services. For example, in outdoor, humid, dirty, or dusty applications, and for 24 hour continuous operation as found in clarifier applications; slewing ring manufacturers recommend the re-lubrication of grease lubricated slewing ring bearing as often as every eight (8) hours.

The failure to include the slewing ring manufacturer's vital lubrication and maintenance procedures in the component drive assembler's installation, operation, and maintenance instructions can result in the premature failure of the bearing, the gear, or both. An example of this deficiency is the absence of slewing ring mounting bolt annual inspection and re-tightening requirements. Loose mounting bolts leads to gear mesh misalignment and unusual loading of the bearing, which can result in a drive failure. Such unscheduled outages consume precious maintenance time, resources and funding that would otherwise not be required and thus available for scheduled maintenance or other functions.

All of the slewing ring bearings produced by the manufacturers presented here are excellent bearings. The component drive assemblers' application or misapplication of these bearings and the absence of the slewing bearing manufacturers' maintenance recommendations in drive assembler's installation, operation, and maintenance procedures, in short a failure to present the slewing ring bearing manufacturers' lubrication and maintenance recommendations to the end user is the true failure here.

SUMMARY

The lubrication requirements and re-lubrication interval for four point contact Gothic arch slewing ring bearings have been well established and have remained substantially unchanged for more than thirty years. See figure 1.

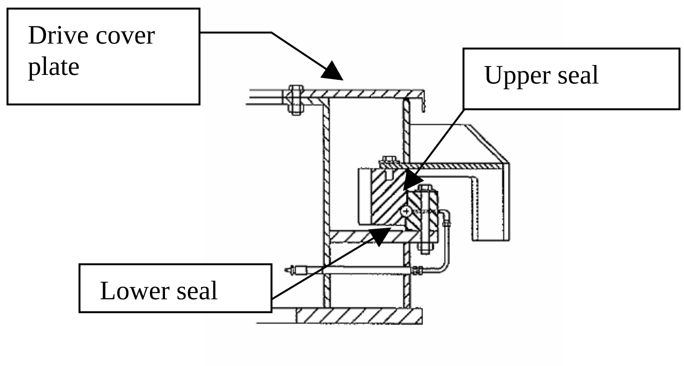


Four Point Contact
Gothic Arch Bearing
Figure 1

Unfortunately, there is a disparity between the recommendations of the manufacturers of these slewing bearings and drive suppliers that purchase and assemble these bearings in their clarifier component drives.

The manufacturers of four point contact Gothic arch slewing ring bearings are well known and include Avon Bearings Corporation; Rotek Incorporated; Kaydon Corporation, Inc.; SKF USA Inc.; and FAG Bearings Corporation. All of these manufacturers recommend grease re-lubrication periods between 50 and 100 hours of operation for these bearings when used in outdoor environments. This re-lubrication interval for grease lubricated bearings is further reduced for slewing ring bearings that are operated continuously, that is to say for 24 hours a day every day. In such cases the recommended re-lubrication interval is as short as every 8 hours.

All of these manufacturers recommend that slewing ring bearings have new grease added during re-lubrication until old grease is passed through the bearing grease seals. In some applications, such as dusty, dirty or humid environments they recommend that new grease be added to the bearing until all contaminated grease is purged from the bearing and clean grease passes through the seal. Unfortunately many drive assemblers have made no provision for the visual or physical inspection of the purged grease as the bearing seals can only be seen after disassembly of the drive. Such disassembly usually requires the removal of the drive cover plate as well as the clarifier bridge. The strong possibility exists that the old deteriorated or contaminated grease will not be purged from the bearing but rather some amount of depleted grease will be retained within the bearing raceways to cause premature deterioration of the bearing and gear. The inaccessibility of the bearing seal also ensures that any purged grease will not be sampled and examined for contamination. See figure 2.



Grease Lubricated
Component Drive
Figure 2

Another problem arises with slewing ring clarifier drive applications. If grease, old or new, does purge from the upper bearing seal as the slewing ring bearing manufacturers intended. The purged grease will remain on the stationary ring until the drive cover plate and overlying structure are removed and the purged grease is physically removed. A second possibility is the grease will accumulate to the point that a portion of the purged grease will fall into the clarifier basin with each addition of new grease.

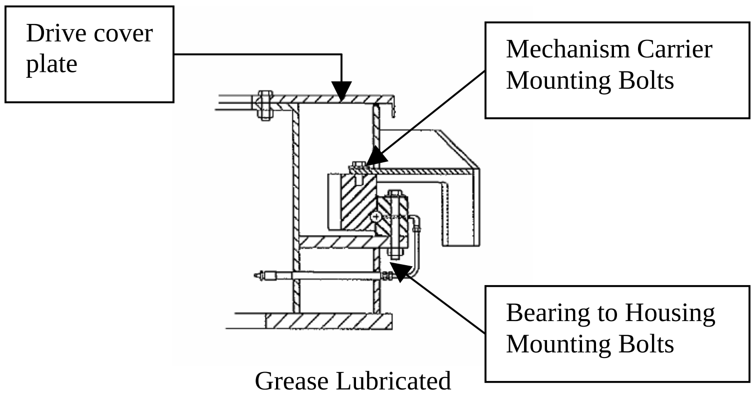
The lubricants normally recommended by most slewing ring manufacturers are greases, which are adequate for the primary application of the slewing ring bearing. Typically, slewing ring bearings are used in crane and other oscillating service. Many of these applications are intermittent. When the slewing ring bearing is employed in continuous operation, 24 hours per day, seven days per week, 52 weeks per year, for twenty years; at rotational speeds of 0.025 to 0.075 rpm; grease lubricants may not provide elastohydrodynamic lubrication, contacting surfaces separated by an oil film thicker than the combined height of the surface asperities; or mixed regime lubrication, contacting surfaces separated by an oil film thickness less than the combined height of the surface asperities. Thus the bearing balls and races and the gear tooth contacting surfaces would be lubricated in the boundary regime, in which the asperities or roughness peaks touch causing friction, wear, and localized heat.

Most, if not all, of the slewing ring bearing manufacturers recommend the use of oil bath lubrication for slowly rotating continuous operating enclosed bearings, where adequate sealing of the bearing enclosure exists. This is ignored by some component drive assemblers through a lack of familiarity with bearings and gears; a lack of understanding of friction, lubrication and wear; a lack of adequate sealing of the component drive housing; or in some cases intent or negligence. In some cases the assembled drive design is susceptible to leakage due to poor sealing of housing joints or use of improper seals or materials. Here grease does have an advantage by preventing or reducing leakage from enclosures inadequate for retaining oil.

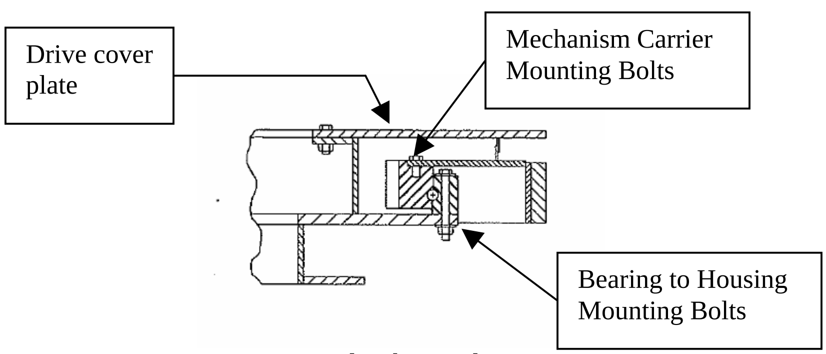
Walker Process Equipment prefers to use oil bath lubrication for both the turntable bearing and the gear set, as do most drive manufacturers and a few component drive assemblers. The lubricants recommended by Walker Process have high viscosities in order to establish the appropriate oil film separation of the rolling elements and the gear tooth surfaces for elastohydrodynamic lubrication. The viscosity of the oil may be varied from change out to change out to compensate for seasonal temperature variations. Walker Process also chooses oils with extreme pressure additives, which apply a friction and corrosion resistant film that is chemically bounded to the contact surfaces. These lubricants and additive packages are keyed to the clarifier drive application.

The oil bath facilitates lubricant change out; removal of contaminants from the region of bearing contact and gear mesh; examination of the expended lubricant for contaminants; drive maintenance; and long service life. This is not the case with grease products.

Component drives utilizing slewing rings must also remove the drive cover plate and any overlying structure to gain access to the slewing ring attachment fasteners. These fasteners must be inspected and re-tightened annually according to slewing ring bearing manufacturers maintenance recommendations. The slewing ring bearing manufacturers also require that all loads be removed from the slewing ring bearing prior to re-tightening the mounting bolts. This requires that the cage and arm mechanism must be disconnected from the component drive slewing ring bearing. As the bridge must also be removed, the most likely procedure for removing the external loads imposed on the slewing ring bearing by the clarifier mechanism would be to drain the basin and crib the arms and cage. The cage supports would then have to be removed from the slewing ring bearing or the cage carrying plate. See figures 3 & 4.

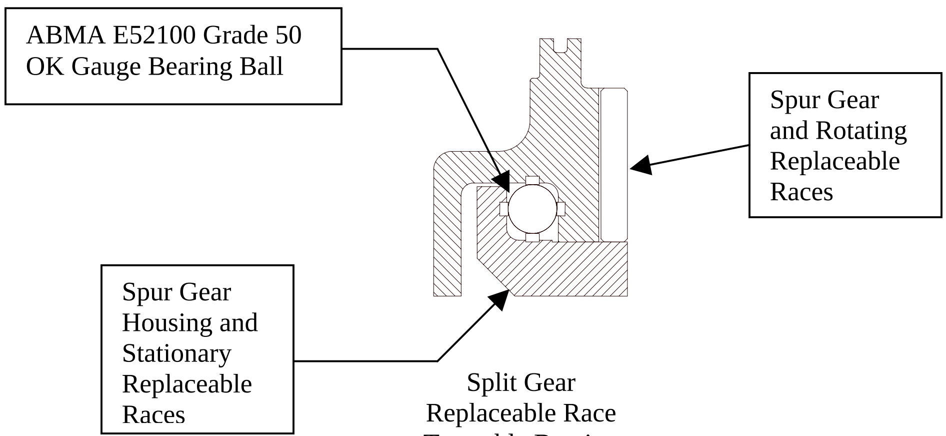


Grease Lubricated
Component Drive
Figure 3



Oil Lubricated
Component Drive
Figure 4

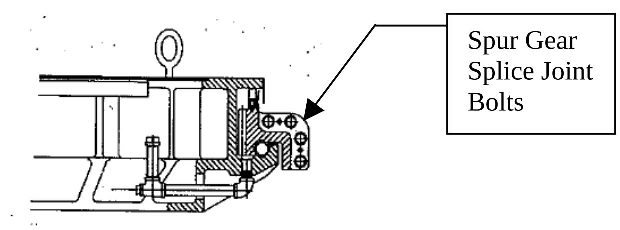
The necessity to disassemble the drive to inspect slewing ring bearing mounting bolt tightness does not apply to the Walker Process split ring clarifier drive design, which does not require internal bearing fasteners. The split ring design allows for removal of the spur gear if necessary without removing the bridge or overlying structure. The turntable bearing stationary replaceable races are press fit into the spur gear housing while the rotating replaceable races are press fit into the spur gear body. See figure 5.



Split Gear
Replaceable Race
Turntable Bearing
Figure 5

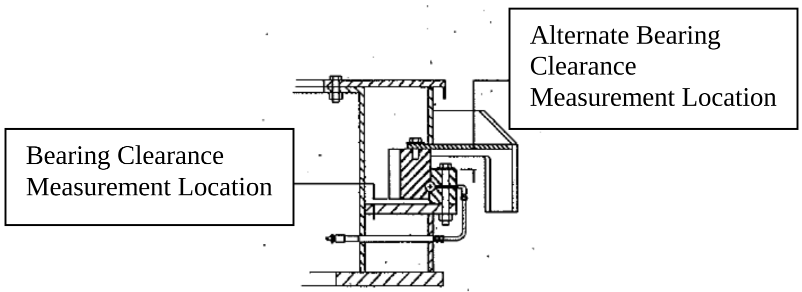
The split gear splice joint strength is designed to exceed the AGMA Momentary Peak Torque of the spur gear, thus ensuring the joint is as strong as the gear itself and requiring no decrease in the ANSI/AGMA Continuous Torque Rating, as is sometimes suggested by the component drive assemblers.

Thus Walker design precludes the need to disassemble the drive and any structure supported above and below the drive as is the case with an assembled slewing ring bearing and gear drive in order to perform the slewing ring bearing manufacturers' recommended inspections and maintenance actions. See figure 6.

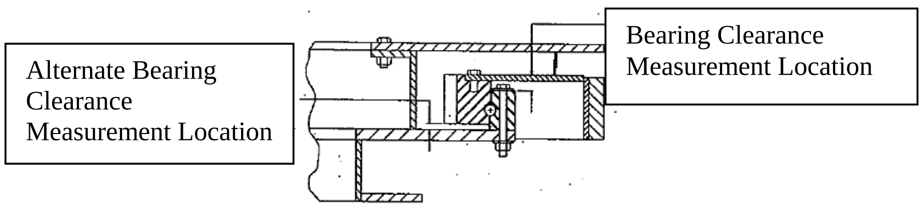


Walker Process
Split Internal Spur Gear Drive
Figure 6

Slewing ring bearing manufacturers recommend that a baseline bearing clearance measurement be taken at the time of installation and annual measurements there after to determine changes in bearing clearances. During the recommended annual inspection of the tightness of the mounting bolts, clearance measurements could also be made. The difference between the annual inspection measurements and the baseline measurement is the clearance increase due to wear. See figures 7 & 8.

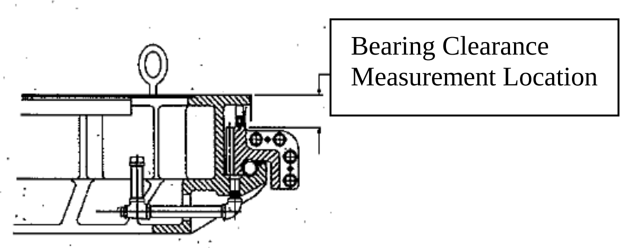


Grease Lubricated
Component Drive
Figure 7



Oil Lubricated
Component Drive
Figure 8

The Walker Process Equipment internal spur gear clarifier drive main turntable bearing clearance baseline and annual measurements are taken without disassembling the drive. The measurement can be made from the top of the spur gear housing using a bridge gauge and feeler gauges. A baseline measurement may be taken at anytime during installation without the need to expose the drive internals as is the case with the component assembled drives. Subsequent measurements to determine bearing clearance increase may also be made without disassembling the drive or removing the clarifier bridge. This is true because the Walker Process clarifier drive is specifically designed and manufactured for water and wastewater circular collectors. See figure 9.



Walker Process
Split Internal Spur Gear Drive
Figure 9

As can be seen, it is actually the split ring drive designed and fabricated by a clarifier equipment manufacturer that has the greatest ease of lubrication and maintenance, short of abandoning recommended proper lubrication and maintenance altogether.

DISCUSSION

The lubrication recommendations for Gothic arch four point contact slewing ring bearings have not changed much over time. In SIFCO BEARINGS Design Guide & Catalog [(1)], Sifco, successor to Formmet Corporation, 1981, and predecessor of Avon Bearings Corporation, 1988, included on page 20 the heading 'Lubrication' preceding the following statement:

> 'Unless otherwise specified, Sifco turntable bearings are packed with Grade 0 extreme pressure grease at the factory. For normal low speed, heavy loaded applications; periodic relubrication with Grade 2 extreme pressure lube is recommended. For operation below 32 ^{o}F, Grade 0 is recommended.
>
> In order to provide protection under heavy loads, these EP lubricants are quite viscous. They impose substantial frictional torque that may be objectionable in lightly loaded applications such as manually rotated turntables. Torque may be reduced in such lightly loaded applications by the use of low viscosity ball bearing grease. The EP lubes are not required if bearing loading is less than 25 percent of catalog capacity.
>
> Bearings are equipped with one or more grease fittings. It is preferable to rotate the bearing while greasing in order to uniformly distribute the lube and to most effectively flush out the old lube and contaminants. In many applications it will be necessary to install an extension tube to one lube port in order to bring the fitting to a location which can be safely lubed while the bearing is rotating. The bearing should be turned through two full revolutions while greasing through any one fitting.
>
> If the bearing cannot be rotated during greasing, it should be lubricated through each fitting. Greasing should be continued until clean grease can be seen exiting the seals.'

The 1997 Avon Bearings Corporation Design Guide & Catalog [(2)] on page 20 also has the heading 'Lubrication' with identical wording of the 1981 Sifco text, except 'Avon' is substituted for 'Sifco' in the first sentence.

Both of these publications on page 20 under the subheading 'Lubrication Frequency' state:

> 'Equipment in storage or used very seldomly should be relubricated at least every six months.
>
> Equipment operating frequently in extreme environments should be lubricated at least every 8 hours.
>
> Most applications fall between the above extremes. Relubrication every 50 to 100 operating hours is a popular initial recommendation for most slow speed, intermediate rotation applications. If the old grease is noted to be in good condition and free of contaminants, the interval may be extended. Conversely, if the old lube is contaminated or deteriorated, the interval should be shortened.'

Under the subheading 'Gear Lubrication' on page 20 both publications state:

> 'Enclosed gearing may be lubricated with the same grease which is recommended for the bearing.'

Both publications, SIFCO BEARINGS Design Guide & Catalog [1] and Avon Bearings Corporation Design Guide & Catalog [2], contain identical tables:

Recommended Lubricants

Bearing				
Supplier	Trade Name	For Operation Below 32 ^{o}F & For Storage	For Operation Above 32 ^{o}F	Gear
CHEVRON	Dura Lith	EP0	EP2	Pinion Grease MS
EXXON	Lidok	EP0	EP2	Surret N 80K
MOBIL	Mobilux	EP0	EP2	Mobiltac E
SHELL	Alvania	EPR0	EP2	Omala H
SOHIO	Bearing Guard	LT0	2	Gear RP O.G.
SUN	Prestige	740EP	742EP	Sun EP Compound 250 SP
TEXACO	Multifak	EP0	EP2	Crater Fluid
UNION	Unoba	EP0	EP2	Geariti HVY

It is interesting to note that the 2000 edition of Avon Bearings Engineering Guide and Catalog[3], includes a picture of a sectioned WesTech Clarifier Drive on page 1-3 of their publication entitled 'Avon Bearings – Large Diameter Turntable Bearings' which is listed on the table of contents for the Section 1: Introduction and Bearing Styles.

In the Avon Bearings Engineering Guide and Catalog[3] on page 2-16 with the heading 'Lubrication, Maintenance and Storage' under the subheading 'Lubrication' states:

> 'The bearing raceway should be lubricated with a heavy-duty extreme pressure grease. A list of suggested manufacturers and trade names is shown for convenience. Please note that these are not the only manufacturers of this type of grease.

SUPPLIER	TRADE NAME
Mobil	Mobilux EP Grease
Gulf Oil	Gulfcrown EP Grease
Shell	Alvania EP Grease

> Minimum re-lubrication whether or not the bearing is used is every six months. Slow rotating, intermittently used equipment should be re-lubricated at least after every 100 hours of use. Equipment that is turning continuously or operating in an adverse environment should be re-lubricated every 8 hours of use, or more often if required.
>
> While adding grease the bearing should be rotated to spread the grease throughout.'

Under the subheading 'Lubrication of the Gear' this publication states:

> 'If the gear bearing has an integral gear, the gear should be coated with an appropriate grease. Mobil Gear Lube 275 or Gearite HVY supplied by Union Oil Company are some suggested greases for manually applied exposed gearing.

> If the gear is enclosed, protected or shrouded (except enclosed gear boxes) the same grease as is used for the bearing raceway may be used for the gear.
>
> Because the meshing action of the gear teeth and pinion teeth tends to push the grease out of the critical areas, the gear should be lubricated more often than the bearing. Small amounts of the lubricant should be applied to the point of mesh between the gear and the pinion.
>
> Slow rotating, intermittently used gears should be re-greased every eight hours, more often for moderate to fast rotating or continuous operating gears. The gear should be rotated while lubricating for even distribution.'

In the next section under the heading 'Maintenance' and subheading 'General Maintenance', the publication states:

> 'Periodically perform a visual inspection at a minimum of every six months. Inspect the seals to ensure they are properly inserted into their grooves and that they are wholly intact and preventing contaminants from entering the bearing.
>
> Bolts should be checked periodically to ensure proper pre-tension. Improperly pre-tensioned bolts can fail, causing damage to the equipment and/or harm to human life.'

The lubricants recommended, Mobilux EP Grease, Gulfcrown EP Grease, and Alvania EP Grease. Mobilux EP Grease is available in NLGI numbers 000, 00, 0, 1, 2, & 3. Gulfcrown EP Grease is available in NLGI numbers: 00, 0, 1, 2, & 3 while Shell Alvania EP is available in NLGI numbers 1 & 2.

The Mobilux EP Grease NLGI numbers 00, 0, 1, 2, &3 have a viscosity rating of 160 cSt @ 40 ^{o}C. Mobilux EP 460 is NLGI number 2 has a viscosity rating of 460 cSt @ 40 ^{o}C. Mobilux EP 023 is NLGI number 000 has a viscosity rating of 320 cSt @ 40 ^{o}C.

Gulfcrown EP 00, 0, 1, No. 2, & No.3 have a viscosity rating of 180 cSt @ 40 ^{o}C.

The Shell Alvania EP Grease, NLGI 1 & 2 have ISO Viscosity Grade 150 or a viscosity rating of 150 cSt @ 40 ^{o}C.

At normal clarifier operating speeds the lubricating oils in all of these greases fall short of the viscosity necessary to provide sufficient elastohydrodynamic film thickness, See Rolling Bearing Lubrication [(4)] page 4 and page 12, to separate the surfaces of the bearing rolling elements and the raceways or the gear and pinion teeth in mesh with the possible exception of Mobilux EP 460. However, Moblilux EP 460 is an NLGI No. 2 grease it is not likely the thickener will flow significantly and will not provide sufficient oil to the surfaces in contact. This function is better performed by an oil bath in which the oil viscosity can be chosen to have a value ranging as high as 800 cSt @ 40 ^{o}C for summer service and as low as 150 cSt @ 40 ^{o}C for winter conditions.

Rotek, another supplier of slewing ring bearings, in their 1978 publication BEARING STORAGE, INSTALLATION, AND LUBRICATION[(5)] under the heading 'LUBRICATION' states:

> 'Periodic lubrication is necessary to insure long life and proper performance. The required frequency of lubrication varies with the type of equipment and the amount of usage. Some recommendations for lubricants are given below.
>
> Typical recommendations for greasing intervals vary according to operating conditions.

Generally the following lubrication intervals are recommended:

Ball bearings under light service	Every 100 operating hours
Ball bearings under heavy service or for a production type application (e.g., excavators, grab cranes, magnet cranes, etc.) or where a high degree of reliability is required.	Every 40 operating hours
Roller bearings	Every 40 hours

Use shorter intervals between greasings in tropical areas or where there is high humidity, dust, or wide ranges in temperature, or when there is continuous rotation.'

The last paragraph in this section states:

'Under extremely dusty or dirty conditions, sufficient grease should be added to flush out contaminated grease. Under less severe conditions, add grease until it appears at the seal.'

Rotek makes lubrication recommendations similar to those of Avon, in Rotek's 1977 Catalog 77, Design Guide and Catalog, Large-diameter ball and roller bearings [(6)]. On page 27 under the heading 'Lubrication' the publication states:

'Virtually all Rotek bearings are equipped with lubrication fittings – at least one for each row of rolling elements. Details are shown on proposal drawings.

For any application where the bearing is loaded near its capacity, we recommend the use of an extreme pressure, Grade 2 lubricant. The table below lists a number of popular brands. EP-2 greases with molybdenum disulfide additives may also be used.

Lightly loaded bearings may be lubed with any good quality anti-friction bearing grease. This may offer a reduced frictional torque. "Lightly loaded" refers to applications where the maximum load is less than 1/3 of the bearing's nominal capacity. Such loading frequently occurs in continuous rotation applications where the bearing is selected on the basis of dynamic capacity rather than static capacity as listed in this catalog.

The required frequency of lubrication varies greatly with the application.

Regreasing not only replaces old grease, it helps in flushing out contaminants and condensation. Obviously, these are more of a concern in outdoor applications subjected to heavy contamination than in well-protected indoor applications. For typical applications such as construction machinery, where low speed, intermittent rotation is involved, suggested frequency of lubrication is every 50 operating hours on excavators and every 100 operating hours on cranes. Operating hours refers to total time that the machine is in use, not to bearing rotation.

For other applications, an interval of every 100 operating hours is suggested as a starting point. If, during relubrication, it is seen that the exiting grease is in good condition and free of contaminants, the interval may be extended.

If possible, the bearing should be rotated during greasing. Grease is then spread uniformly throughout the bearing and the old lube is purged to the greatest possible extent. Provision should be made in equipment design to permit regreasing with complete safety to the operator. Frequently this will require installation of extension lines to bring the lube fittings out to a safe location. See Manual 680.

If the bearing cannot be continuously rotated during regreasing or if it must be lubricated when it is not rotating, additional fittings are required in order to distribute the grease around the raceways.

For continuous operation at speed over 1000 feet per minute, oil lubrication may be required. Oil lubrication minimizes internal friction and oil circulation may be necessary to dissipate frictional heat at high speeds.'

The following lubricants are recommended		
	RACE	GEAR
SHELL	ALVANIA EP = 2	CARDIUM EP Compound C
EXXON	RONEX WB	SURRETT Fluid 30
TEXACO	MULTIFAK EP = 2	CRATER 2x Fluid 3x Fluid
MOBIL	MOBILUX EP = 2	MOBILTAC E
UNION	UNOBA EP = 2	GEARITE Hvy
SUN	PRESTIGE 742 EP	GEAR Compound = 407
Other lubricants of the same quality of other manufacturers may also be used. The gear lubricants specified are suitable for manual application in low–speed outdoor use.		

In the Rotek publication Engineering Data For Selecting Large Diameter Bearings[7], on page 27, entitled "Lubrication and Maintenance", under the subheading "Lubricants" beginning with the second paragraph, the publication states:

'When employing other lubricants, the user must therefore obtain confirmation from the lubricant manufacturer or supplier that the grease he has chosen is suitable for the intended application and that its properties are at east {*sic*} equivalent to those of the greases listed in the Table. It must be guaranteed that the lubricant will not undergo any change in its composition and this also applies to future deliveries.

When automatic lubricating systems are used, the lubricant manufacturer must confirm pumpability. For applications at very low temperatures, special greases are required.

Other lubricants from other manufacturers may be used provided they are equivalent to those listed and are compatible with non-metallic components.

The gear lubricants specified are suitable for manual application in low-speed outdoor use.'

On the same page under the subheading of 'Lubricating intervals', the publication states:

'Lubricating intervals are to be selected according to operating conditions; generally every 100 operating hours, roller bearings every 50 operating hours. Shorter lubricating intervals must be used in tropical regions, in the presence of high humidity, dust or dirt and significant fluctuations in temperature, and where there is continuous rotation.'

The RKS Groupe SKF in their catalog 3135E, SKF: RKS slewing rings[8], provide information on mounting, maintenance, and lubrication in addition to selection information. On page 75 of this publication SKF lists lubricants equivalent to those listed by Avon and Rotek. On page 76, SKF presents relubrication intervals and volumes in chart format. Unfortunately, the chart ends at 70 hours per week with a relubication interval of less than seven days. If one were to extrapolate from this chart for 168 hours per week or continuous rotation, the relubrication interval would become 2 ½ days or 60 hours. This is well within the range of Avon and Rotek for protected service. Both Avon and Rotek reduce this to 8 hour intervals for outdoor, dusty, dirty, or humid conditions.

In Engineering Data For Selecting Large Diameter Bearings[7] under the subheading 'Checking of Bolts' also on page 27, the publication states:

> 'To compensate for settling phenomena, it is necessary to retighten the bolts with the specified tightening torque. During this operation the bolt connection must be relieved of all tensile stresses coming from external forces. This check must be carried out after approximately 100 operating hours at the latest. Thereafter, checking should be repeated approximately every 600 operating hours or every 3 months.
>
> Under special operating conditions, or if specific test instructions so require, the interval between checks should be adapted accordingly.'

On page 77 of SKF: RKS slewing rings[8], it is recommended that the mounting bolts be re-tightened between 2 weeks and 3 months after commissioning; re-tighten bolts after one year or after every 2,000 hours (11.9 wks) of operation; replace and tighten bolts after 7 years or every 14,000 hours (19.4 months) of operation and repeat cycle.

Verifying and tightening of the slewing ring mounting bolts of course requires the drive to be disassembled to obtain access to the fasteners. The clarifier bridge would have to be removed to remove the drive cover plate as with the Avon and Rotek bolt inspection and tightening requirements.

Unlike the slewing ring bearing component drive which must be disassembled and the clarifier bridge removed at least annually to inspect the tightness of the bearing mounting or assembly bolts; the Walker bearing has the benefit of a design specifically for water and wastewater clarifiers that has eliminated these bolts and thus eliminated the annual or more frequent disassembly of the drive. The split ring joint fasteners may be examined without disassembly of the drive or removal of the clarifier bridge. The fastener torque is clearly shown on the Walker Process Equipment drawings found in the Installation, Operation, and Maintenance Instructions furnished with the equipment. This information is also retained in the WPE records and is available if the IOM manuals are not.

In Engineering Data For Selecting Large Diameter Bearings[7], under the subheading 'Checking of the raceway system' on page 27, the publication states:

> 'When delivered, large-diameter bearings have clearances which ensure good running properties and functional safety. After a prolonged period of time, clearances will increase. It is therefore necessary to check these clearances at certain intervals. (See pages 24-25)'

On the previous pages, 24 and 25, the maximum allowable bearing clearance increases are discussed. The bearing clearance must be determined during installation and recorded for future use. The measurements should be repeated every twelve months as a minimum and under identical conditions. For a 68 inch diameter bearing track with 1.574 inch balls, the single row four point contact ball bearing slewing ring vertical clearance increase (depression) allowable is 0.0805 inches. For a 49 inch track or raceway with the same size ball, the allowable clearance is 0.0767 inches.

In the Avon Bearings Engineering Guide and Catalog[3] pages 2-14 and 2-15 discuss maximum allowable bearing clearance increases. The bearing clearance must be determined during installation and recorded for future use. The measurements should be repeated every twelve months as a minimum and under the same conditions. For a 70 inch diameter bearing raceway with 1.50 inch balls, the single row four point contact ball bearing slewing ring vertical clearance allowable increase is 0.074 inches. For a 50 inch raceway with the same size ball, the allowable clearance increase is 0.071 inches.

These allowable wear values are significantly greater than the 0.050 inches maximum allowable wear recommended by WPE for 46.5 inch, 65.0 inch, and 85.0 inch diameter bearing raceways with 1.50 inch balls. Excessive raceway wear can lead to misalignment of the gear teeth increasing the potential for tooth wear and increased stresses.

In order to obtain either the initial or subsequent clearance measurements, the slewing ring bearing assembled drive must be disassembled to perform the clearance measurements. It should be noted that to disassemble the drive, the clarifier bridge must also be removed. If the wear is found to have heavily increased, the time between measurements should be shortened. Should the initial clearance measurements not be taken or become lost, the progressive wear will not be known.

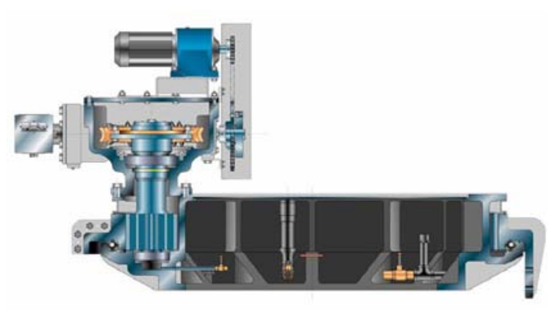
Walker Process has a fixed dimension that can be easily measured to establish the increase in bearing clearance without taking or recording initial measurements. The WPE clearance measurements unlike those for the slewing ring bearing drive assemblers, can be taken with the drive intact and immediately ready for operation upon completion of the measurement.

As with the bearing clearance examination and mounting bolt re-tightening, checking the slewing ring bearing seals for purged grease requires the disassembly of the slewing ring bearing drive. The Walker drive is oil bath lubricated and the oil can be drained; samples taken if required; the housing flushed if necessary; and the lubricant recharged without disassembly of the drive or removal of the bridge.

The oil bath allows for the seasonal change of lubricant viscosity consistent with maintaining the elastohydrodynamic film necessary to prevent wear and to validate the L_{10} Bearing Life calculations. Contaminated grease and/or grease with improper lubricating oil viscosity may remain unpurged in the slewing ring bearing clarifier drive causing increased wear and reducing the bearing L_{10} Life.

The component assembled drive utilizes a slewing ring bearing and integral internal or external spur gear that is designed for a broad and varying field of applications from mobile and fixed cranes to merry-go-rounds, Avon Bearings Engineering Guide and Catalog[(3), ‘]Applications’ on pages 2-3 & 2-4.

The Walker Process clarifier drive is designed for the water and wastewater industry, and more specifically for circular collector applications such as clarifiers, thickeners and dissolved air floatation units.



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(1) SIFCO BEARINGS DESIGN GUIDE & CATALOG, ©1987, SIFCO Bearings, Subsidiary of SIFCO INDUSTRIES, INC.

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