Enclosed Gear Drive

MAINTENANCE MANUAL

HORSBURGH & SCOTT

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Horsburgh & Scott

ENCLOSED GEAR DRIVE MAINTENANCE MANUAL

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Horsburgh & Scott Headquarters are located at 5114 Hamilton Avenue, Cleveland OH 44114.

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Enclosed Gear Drive Installation

INSTALLATION

The unit should be mounted on a bedplate or base specially designed for this purpose. The mounting surfaces should be flat and rigid. All mounting bolt holes should be used with the size bolting indicated on the *Horsburgh & Scott Certified Dimension Drawing*.

When lifting the unit, use the lifting lugs or eye bolts provided. Never lift a gear drive by the shaft extensions. Care should be taken to prevent damage to lube lines and components when lifting. Always lift the gear drive flat and parallel and do not bump or jar shaft extensions.

Any irregularities that occur in the bedplate or base should be taken up by steel shims (see *Figure 1*). Shims should be of ample surface area and must be placed around the mounting base bolting. In some cases, jack screws are provided for leveling. Never tighten base bolts against a jack screw.

Following alignment of connecting shafts, the base bolts are tightened to the recommended values (see *Bolt Torque Chart*). Some gear drives have holes for dowel pins. Dowel holes should be drilled into the base after final alignment in opposite corners. Dowel pins provide quick realignment after removal of the unit for repair or service. When dowel pins are not used, shear blocks are recommended. Shear blocks should be installed on both sides and faces.

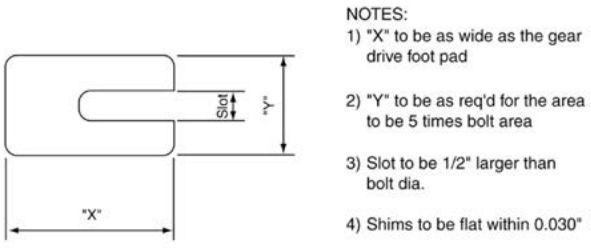
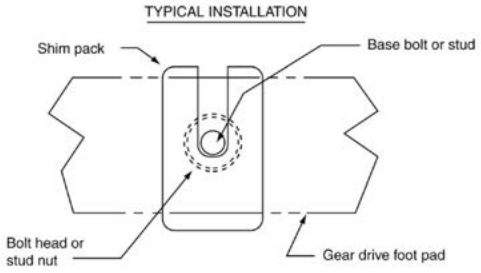


FIG. 1 PREFERRED BASE SHIM STYLE



Enclosed Gear Drive Installation

SHAFT CONNECTION & ALIGNMENT

In most cases, flexible couplings are mounted on shaft extensions of gear drives. The prime mover and driven equipment should be aligned to the gear drive within the coupling manufacturer's recommendations.

Shaft alignments should be checked in four places around the shaft at 90º. The correct gap must also be maintained. The gear drive must be level and secure before alignment of shafting begins.

Interference fits are recommended for couplings and devices mounted on shaft extensions. Heat these elements to approximately 250º – 300ºF. (if the design allows) before putting them on the shaft. Do not hammer against the shaft in any way – damage to bearings or gearing may result.

Keys should be fitted prior to installing couplings. Keys are to have a snug fit but not so as to cause stress in the shaft or coupling. Corners of keys should be chamfered, along with all radii and corners.

Connect equipment with bolts recommended by the manufacturer and tighten to the correct torque values. Lubricate per the manufacturer's specification.

Coupling Installation, Lubrication, & Maintenance

INTRODUCTION

These instructions apply to general applications of standard couplings only. Custom designed couplings may require special installations, alignment, and maintenance procedures. Careful attention to proper installation and alignment will help ensure trouble-free service life.

The main reason for taking time to properly align couplings is to prevent transmission of undesirable stresses and vibrations to shafting, bearings, couplings, and other connected equipment. Proper procedures upon initial installation will give maximum life with the least number of service problems.

CAUTION: The main source of power to the prime mover should always be locked out before any maintenance service work is started. Normal safety rules and procedures must be followed. All couplings must be guarded to protect against accidents from rotating machinery.

Coupling Installation, Lubrication, & Maintenance

INSTALLATION

The first step to installing couplings is to remove any packaging materials and disassemble the coupling. Clean all parts using a good quality solvent.

Shaft journals should be cleaned and inspected for burrs and signs of abuse that may cause problems during hub installation. Raised spots can be filed down and polished with emery paper. Key and keyway burrs should also be removed to prevent hanging up during assembly. It may be desirable to use a sealant around the key to prevent leakage of the lubrication grease during operation.

Carefully measure the widths and heights of keyways and key to determine that the hub will not bind- up on the key during assembly.

Measure the shaft and hub bore accurately to determine that the interference fit is to your drawings or written specifications.

Seal plates and O-rings should be placed on the shaft extension prior to the hubs. A light coat of oil or grease on the O-rings will aid in assembly over the hub later on. Care should be taken not to allow the heated hub to contact the O-rings.

The coupling hubs should be heated in an oven or oil bath to a maximum of 275ºF. The oil flash point must be 350ºF. or higher. A rosebud type heating torch can be used, but extra caution must be taken to avoid overheating and to keep the flames away from the teeth. Do not rest the hub on the teeth during heating! Slide the heated hub over the shaft and key, aligning the front face of the hub with the end of the shaft. Repeat the same procedure for the mating hub.

Coupling Installation, Lubrication, & Maintenance

INSTALLATION (CONTINUED)

The coupling hubs must be cool before the alignment procedure starts. Slide coupling sleeves over the hub before moving the equipment into place.

The first step is to bring the coupling halves to the gap specified by the manufacturer. Begin by adjusting the equipment for angular misalignment. If feasible, a dial indictor near the outside diameter on the face is the preferred method of alignment. An alternative method is to use a flat bar of constant thickness, along with feeler gauges, and check the gap between hub faces every 90º. Be sure to always measure to the same depth. The limits shown in *Table 1* should be followed as maximums, realizing that the closer to zero the alignment, the greater service life can be expected. Move one or both pieces of machinery to gain the required alignment. Exact or perfect alignment will cause lubrication problems; i.e., fretting. Close to zero alignment is good, perfect alignment is not good.

The next step is to align the coupling halves for parallel offset. Even though the faces may run true to each other, the axis of each half may not be collinear. The preferred method is to use a dial indicator. Mount the indicator on the outside diameter of one hub, and take readings off the outside diameter of the other hub. Rotate the hub that has the dial indicator mounted on it, taking note of the maximum total indicator reading (T.I.R.). The actual value of parallel offset is one half of the T.I.R. The alternative method involves using a straight edge across the hub outside diameters and measuring the gap with a feeler gauge. Be sure to check every 90º with this method.

After both alignment parameters have been measured and set, they should both be rechecked. When moving equipment to correct for one condition, it may adversely affect the other. Careful attention should allow for very accurate alignment.

Upon completion of the alignment, the coupling can be bolted together and lubricated. Prior to sliding the sleeve over the hub, the hub teeth should be packed with grease. The coupling sleeve can then be carefully engaged and slid over the hub. Be sure to install the flange O-ring before piloting the two flanges together. The bolts are fitted with close clearances between the flange holes. The flanges must be square to each other, and the holes in close relative position before the bolt is inserted. Place all the bolts in the flanges prior to any tightening.

At this time, the rear seal retainer plates should be installed. Be sure both O-rings are in place. A light coat of oil or grease will ease in sliding the larger O-ring over the hub. Install all the retainer bolts and tighten.

The flange bolts can now be tightened. All the bolts should be snugged so that the flanges are tight together. Alternating across the coupling will prevent cocking the sleeves and perhaps jamming the assembly.

Coupling Installation, Lubrication, & Maintenance

LUBRICATION

A good quality extreme pressure lubricating grease is recommended for all coupling applications. A sufficient amount of clean lubricant is required for long service life.

Frequency of lubrication depends upon service and the atmosphere around the equipment. Applications requiring more frequent lubrication are extreme temperature variations, moisture, heavy shock loads, and load reversals. The final lubrication schedule should be agreed upon by the equipment user and his lubricant supplier.

Extreme pressure greases are recommended for all applications. Horsburgh & Scott recommends a National Lubrication Grease Institute (NLGI), grade #1 for most applications where ambient temperatures range from 20º to 150ºF., and the loading is fairly constant. NLGI #0 is recommended for slow speeds and very high loads. Where there are several couplings on the same equipment, the NLGI #0 can be used for all couplings if required at certain points. For operating conditions outside of the ranges above, consult your lubricant supplier.

The coupling halves should be filled with grease using a pressure gun, with the grease fitting at 3 o'clock or 9 o'clock position. Grease should be added until it flows from the vent plug, located 180º from the inlet fitting. Rotate the coupling 180º and repeat the greasing procedure.

For general application, the lubricant should be reapplied at 6 month intervals. Special cases may require more frequent lubrication schedules.

Coupling Installation, Lubrication, & Maintenance

MAINTENANCE

Gear couplings require very little maintenance. Check periodically for leaks and loose bolts.

An annual inspection of the gear teeth is recommended for continuous duty applications where cycles are high. Remove all flange bolts and seal retainer bolts and slide both sleeves and retainers back to expose the gear teeth. Wipe all old grease off and inspect the teeth for pitting or cracks. Burrs can be filed off and rough surfaces smoothed over with emery paper. Be sure to clean all parts thoroughly before reassembly.

It is good practice to recheck alignment at this time. Coupling wear could be attributed to misalignment. Upon realignment and reassembly, the coupling life should be extended over one that was not serviced.

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Start-Up & Shut-Down Procedures

START-UP PROCEDURES

Every enclosed gear drive built by Horsburgh & Scott is spin tested at the nameplate speed under no load before it leaves the factory.

> **CAUTION:** Your gear drive is shipped without oil.

Follow the installation and shaft alignment methods as outlined in this manual and your unit is ready for start up. The unit is shipped with no oil and it must be filled to the proper level with the lubricant recommended on the nameplate. When a filler hole is not provided, the gear drive can be filled through the inspection opening. Remove the cover bolts and inspection cover. Do not allow any foreign material to enter the gearcase while adding oil. Add only enough oil to bring the level up to the level indicated.

For drives with circulating oil lube systems, the lube motor should be started prior to turning over the gear drive. Allow the oil to circulate for at least 5 minutes. At this time, the flow to all sight feed oilers must be rechecked. Oilers are factory set but should be rechecked upon initial start up.

All leaks must be repaired at this time. Damage to lube lines caused during shipment or leaks at shaft seals must be repaired before the drive is put into service.

The gear drive can now be turned over. It is recommended that the unit be operated at nameplate speed, under a light load for several hours. After the initial break-in period, the oil level and flow, along with bearing temperatures, should be rechecked. Once satisfactory operation of all the elements is evident, the unit can be run under the rated load.

Start-Up & Shut-Down Procedures

SHUT-DOWN PROCEDURES

For extended shutdown periods, 1 week or more, the unit will require special lubrication procedures to ensure the machined surfaces are covered with a protective film of oil. The unit should be run for 15 minutes each week to ensure thorough lubrication of all internal parts.

For very long storage periods, when weekly runs will not be possible, the unit should be coated internally with a preservative. Mobil Oil Corporation, Mobilarma 524, is sufficient for six month storage. Longer periods require flushing and reapplication at six-month intervals.

Lubrication & Recommended Lubricants

GENERAL REQUIREMENTS

> **CAUTION:** Your gear drive is shipped without oil.

Units must be filled to the oil level indicator before starting. Each unit is equipped with a nameplate indicating the AGMA classification of oil to be used and the approximate number of gallons required. When units are furnished with dipsticks, the oil level will be indicated on the stick. If the dipstick is lost or misplaced, the recommended oil level is indicated on the nameplate and is made in reference to the split line of the housing. Check the oil level at regular intervals when the unit is warm and NOT running.

It is extremely important to use only a high grade oil of the proper viscosity. The viscosity range of the lubricant must be within the range of operating conditions of the gear drive. The pour point of the oil must be below the lowest expected ambient temperature in which the unit will operate. Lubricants of the straight mineral type are preferred for the majority of all speed reducer applications except worm gears. They should be high-quality, well-refined petroleum oils. The oil must not be corrosive to gears or bearings, must be neutral in reaction, free from grit or abrasives and have good defoaming properties. Good resistance to oxidation is also essential as the oil may be subjected to high operating temperatures. For worm gears, additions of 3% to 10% acidless tallow or similar animal fats are desirable.

Lubrication & Recommended Lubricants

EXTREME PRESSURE LUBRICANTS

Extreme pressure lubricants contain additives which increase the unit's load carrying capacity and tend to reduce the unit operating temperature. However, these lubricants are not as chemically stable as mineral lubricants and are generally not recommended for temperatures over 160ºF. Sludge may form, particularly when the atmosphere is contaminated with dust, extremely humid, chemically laden and when operating temperatures are high. To guard against this, it is recommended that the lubricant be changed at more frequent intervals than with mineral type lubricants.

SPLASH LUBRICATION

In splash lubricated units, the lubricant is picked up by fast moving gears and distributed to all gear tooth engagements and to troughs for lubricating shaft bearings. The oil level is placed at a height so that the gear having the highest velocity dips into the oil. Throwing action is quite violent and distributes oil to every part of the housing. The housing contours are such that natural drainage for the oil is downward where troughs catch and distribute oil to the bearings. Proper oil level is important. Too low a level will result in poor distribution and lack of lubrication. On the other hand, too high a level will result in unnecessary churning which wastes power, generates excessive heat, increases temperature and thins the oil.

CAUTION: If a unit is to be run for long periods at low speed during break-in periods for connected equipment, oil levels should be raised sufficiently to allow bearings to ride in the oil since the splash lubrication is relatively ineffective at low speeds. Reduce oil level to normal after resuming regular speeds.

Lubrication & Recommended Lubricants

CIRCULATING SYSTEM

The basic circulating type of system consists of an oil pump, either motor driven or speed reducer shaft driven, pressure gage or flow gages and the necessary piping. The housing serves as a mounting for the motor driven or shaft driven pump and supplies inlet oil to the pump. The piping is arranged to permit a stream of oil to be sprayed directly onto the teeth in certain critical areas and to lubricate the bearings. Oil filters are sometimes provided to keep the oil clean and free of impurities. Replace or clean elements following recommendations on the filter nameplate.

EXTREME AMBIENT TEMPERATURE APPLICATIONS

If ambient temperature conditions vary from the ranges shown in the table *AGMA Viscosity Recommendations for Splash Lubricated Units for Average Operating Conditions*, consult Horsburgh & Scott for recommendations. Unless otherwise advised, the AGMA viscosity recommendation that is stamped on the nameplate assumes an ambient temperature of 50ºF to 125ºF. Ambient temperature is defined as the air temperature in the immediate vicinity of the gear drive.

Gear drives exposed to the direct rays of the sun or other radiant heat sources will run hotter even though the ambient temperature may be within reasonable limits. These applications must be given special consideration such as the addition of heat shields or fans. If a speed reducer is to be used outdoors when temperature conditions vary considerably between summer and winter, it is recommended that the oil be changed to the proper viscosity for each season.

GREASE LUBRICATION OF BEARINGS

Pressure fittings are supplied for lubricating bearings that are not lubricated by the splash system. Frequency of lubrication will depend upon the amount of running time. Normal requirements would be to apply sufficient grease to form a film over the rollers and races. Greases should be compounded from a high grade soap and refined mineral oil free from acid, alkali and any abrasive filler. Sodium or lithium based greases are generally preferred. For operating temperatures in the range of 32ºF to 200ºF, we recommend a grease conforming to NLGI #1 Grease. Consult the factory if temperatures are outside this range.

Reference: Lubrication Tables

TABLE 4: VISCOSITY GRADE REQUIREMENTS

ISO VISCOSITY GRADE	MID-POINT KINEMATIC VISCOSITY AT 40°C, mm^2/s[1]	KINEMATIC VISCOSITY LIMITS AT 40°C, mm^2/s[1]		FORMER AGMA GRADE EQUIVALENT
		MIN	MAX	
ISO VG 32	32	28.8	35.2	0
ISO VG 46	46	41.4	50.6	1
ISO VG 68	68	61.2	74.8	2
ISO VG 100	100	90.0	110	3
ISO VG 150	150	135	165	4
ISO VG 220	220	198	242	5
ISO VG 320	320	288	352	6
ISO VG 460	460	414	506	7
ISO VG 680	680	612	748	8
ISO VG 1000	1000	900	1100	8A
ISO VG 1500	1500	1350	1650	9
ISO VG 2200	2200	1980	2420	10
ISO VG 3200	3200	2880	3520	11

NOTES

1. The preferred unit for kinematic viscosity is mm^2/s, commonly referred to as centistoke (cSt).

Extracted from ANSI/AGMA 9005-F16, Industrial Gear Lubrication with the permission of the publisher, the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314.

Reference: Lubrication Tables

TABLE 5: AGMA LUBRICANT NO. GUIDELINES FOR ENCLOSED HELICAL, BEVEL, & SPUR GEAR DRIVES [1]

PITCH LINE VELOCITY [2, 3] OF FINAL REDUCTION STAGE	AGMA LUBRICANT NO.'s [1, 4, 5] AMBIENT TEMP. ^{0}C, (^{0}F) [6, 7]			
	-40 to -10 (-40 to +14)	-10 to +10 (14 to 50)	10 to 35 (50 to 95)	35 to 55 (95 to 131)
Less than 5 m/s (1,000 ft/min) [8]	3 S	4	6	8
5 to 15 m/s (1,000 to 3,000 ft/min)	3 S	3	5	7
15 to 25 m/s (3,000 to 5,000 ft/min)	2 S	2	4	6
Above 25 m/s (5,000 ft/min) [8]	0 S	0	2	3

NOTES

1. AGMA lubricant numbers listed above refer to R & O and synthetic gear oil shown in table 4. Physical and performance specifications are shown in tables 1 and 3. EP or synthetic gear lubricants in the corresponding viscosity grades may be substituted where deemed acceptable by the gear drive manufacturer.

2. Special considerations may be necessary at speeds above 40 meters per second (8000 feet per minute). Consult gear drive manufacturer for specific recommendations.

3. Pitch line velocity replaces center distance as the gear drive parameter for lubricant selection. The corresponding table from the previous standard is included as annex B for reference.

4. Variations in operating conditions such as surface roughness, temperature rise, loading, speed, etc., may necessitate use of a lubricant of one grader higher or lower. Contact gear drive manufacturer for specific recommendations.

5. Drives incorporating wet clutches or overrunning clutches as backstopping devices should be referred to the gear manufacturer as certain types of lubricants may adversely affect clutch performance.

6. For ambient temperatures outside the ranges shown, consult gear manufacturer.

7. Pour point of lubricant selected should be at least 5ºC (9ºF) lower than the expected minimum ambient starting temperature. If the ambient starting temperature approaches lubricant pour point, oil sump heaters may be required to facilitate starting and ensure proper lubrication (see 5.1.6).

8. At the extreme upper and lower pitch line velocity ranges, special consideration should be given to all drive components, including bearing and seals, to ensure their proper performance.

Reference: Lubrication Tables

TABLE 5 (B1): VISCOSITY GRADE [1] AT BULK OIL OPERATING TEMPERATURE FOR OILS HAVING A VISCOSITY INDEX OF 90 [2] FOR SPUR, HELICAL, AND BEVEL GEARS

OPERATING TEMP ^{0}C	PITCH LINE VELOCITY, mm^2/s^{3,4}							
	1.0-2.5	2.5	5.0	10.0	15.0	20.0	25.0	30.0
10	32							
15	46	32						
20	68	46	32					
25	68	46	32					
30	100	68	46	32				
35	100	100	68	46	32			
40	150	100	68	46	32	32	32	
45	220	150	100	68	46	46	46	32
50	320	220	150	100	46	46	46	32
55	460	220	150	100	68	68	68	46
60	460	320	220	150	68	68	68	46
65	680	460	320	220	150	100	100	68
70	1000	680	320	220	150	100	100	68
75	1500	680	460	320	220	150	150	100
80	2200	1000	680	460	220	220	220	150
85	3200	1500	1000	460	320	220	220	150
90	3200	2200	1000	680	460	320	320	220
95		3200	1500	1000	460	460	320	220
100		3200	2200	1000	680	460	460	320

NOTES

1. *Consult gear, bearing, and lubricant suppliers if a viscosity grade of less than 68 or greater than 680 is indicated.*
   Review anticipated cold start, pea, and operating temperatures, service duty and range of loads when considering these viscosity grades.
   Select the viscosity grade that is most appropriate for the anticipated stabilized bulk oil operating temperature range.
   Baseline stabilized bulk oil operating temperature and bearing lubrication requirements.
2. *This table assumes that the lubricant retains its viscosity characteristics over the expected oil change interval. Consult the lubricant supplier if this does not apply.*
3. *Determine pitch line velocity of all gearsets. Select viscosity grade for critical gearset taking into account cold startup conditions.*
4. *For pitch line velocities greater than 30 m/s see ANSI/AGMA 6011 [18]*

Lubricants with a VI of 90, as typically found in mineral-oil based gear lubricants, are suitable for use where ambient and operating sump temperatures are relatively constant. Varying start-up temperatures, intermittent operation, or both typically require a higher VI unless oil sump temperatures a re controlled by other means.

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Reference: Lubrication Tables

TABLE 5 (B2): VISCOSITY GRADE [1] AT BULK OIL OPERATING TEMPERATURE FOR OILS HAVING A VISCOSITY INDEX OF 120 [2] FOR SPUR, HELICAL, AND BEVEL GEARS

OPERATING TEMP ^{0}C	PITCH LINE VELOCITY, mm^2/s^{3,4}							
	1.0-2.5	2.5	5.0	10.0	15.0	20.0	25.0	30.0
10	32							
15	46	32						
20	68	46	32					
25	68	46	32	32				
30	100	68	46	32	32			
35	100	100	68	46	32	32	32	
40	150	100	68	46	32	46	32	32
45	220	150	100	68	46	46	46	46
50	320	220	150	100	68	68	46	46
55	460	220	150	100	68	68	68	46
60	460	320	220	150	68	68	68	46
65	680	460	320	220	150	100	100	68
70	1000	680	320	220	150	100	100	68
75	1500	680	460	320	220	150	150	100
80	2200	1000	680	460	220	220	220	150
85	3200	1500	1000	460	320	220	220	150
90	3200	2200	1000	680	460	320	320	220
95		3200	1500	1000	460	460	320	220
100		3200	2200	1000	680	460	460	320

NOTES

1. *Consult gear, bearing, and lubricant suppliers if a viscosity grade of less than 68 or greater than 680 is indicated.*
   Review anticipated cold start, pea, and operating temperatures, service duty and range of loads when considering these viscosity grades.
   Select the viscosity grade that is most appropriate for the anticipated stabilized bulk oil operating temperature range.
   Baseline stabilized bulk oil operating temperature and bearing lubrication requirements.
2. *This table assumes that the lubricant retains its viscosity characteristics over the expected oil change interval. Consult the lubricant supplier if this does not apply.*
3. *Determine pitch line velocity of all gearsets. Select viscosity grade for critical gearset taking into account cold startup conditions.*
4. *For pitch line velocities greater than 30 m/s see ANSI/AGMA 6011 [18]*

Lubricants with a VI of 120, as typically found in mineral-oil based gear lubricants, are suitable for use where ambient and operating sump temperatures are relatively constant. Varying start-up temperatures, intermittent operation, or both typically require a higher VI unless oil sump temperatures a re controlled by other means.

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Reference: Lubrication Tables

TABLE 5 (B3): VISCOSITY GRADE [1] AT BULK OIL OPERATING TEMPERATURE FOR OILS HAVING A VISCOSITY INDEX OF 160 [2] FOR SPUR, HELICAL, AND BEVEL GEARS

OPERATING TEMP ^{0}C	PITCH LINE VELOCITY, mm^2/s^{3,4}							
	1.0-2.5	2.5	5.0	10.0	15.0	20.0	25.0	30.0
10	32	32						
15	46	32	32					
20	68	46	32					
25	68	46	32	32				
30	100	68	46	32	32			
35	150	100	68	46	32	32	32	
40	150	100	68	46	32	32	32	
45	220	150	100	68	46	46	32	
50	220	150	100	68	46	46	46	32
55	320	220	150	100	68	68	46	32
60	460	220	220	100	68	68	68	46
65	460	320	220	150	100	100	68	46
70	680	460	220	150	100	100	100	68
75	680	460	320	220	10	150	100	68
80	1000	680	320	220	150	150	150	100
85	1500	680	460	320	220	220	150	100
90	1500	1000	680	320	220	220	220	150
95	2200	1500	680	460	320	320	220	150
100	3200	1500	1000	460	320	320	220	150

NOTES

1. *Consult gear, bearing, and lubricant suppliers if a viscosity grade of less than 68 or greater than 680 is indicated.*
   Review anticipated cold start, pea, and operating temperatures, service duty and range of loads when considering these viscosity grades.
   Select the viscosity grade that is most appropriate for the anticipated stabilized bulk oil operating temperature range.
   Baseline stabilized bulk oil operating temperature and bearing lubrication requirements.
2. *This table assumes that the lubricant retains its viscosity characteristics over the expected oil change interval. Consult the lubricant supplier if this does not apply.*
3. *Determine pitch line velocity of all gearsets. Select viscosity grade for critical gearset taking into account cold startup conditions.*
4. *For pitch line velocities greater than 30 m/s see ANSI/AGMA 6011 [18]*

Lubricants with a VI of 160, such as typically found in PAO based gear lubricants, are generally suitable for use in a wider range of ambient and operating sump temperatures. Extreme variations in start-up, operating sump temperatures, or both may require a higher VI unless oil sump temperatures are controlled by other means.

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Reference: Lubrication Tables

TABLE 5 (B4): VISCOSITY GRADE [1] AT BULK OIL OPERATING TEMPERATURE FOR OILS HAVING A VISCOSITY INDEX OF 240 [2] FOR SPUR, HELICAL, AND BEVEL GEARS

OPERATING TEMP ^{0}C	PITCH LINE VELOCITY, mm^2/s^{3,4}							
	1.0-2.5	2.5	5.0	10.0	15.0	20.0	25.0	30.0
10	46	46						
15	68	46	32					
20	68	68	32	32				
25	100	68	32	32				
30	100	68	32	32	32			
35	150	68	68	46	32	32		
40	150	100	68	46	32	32	32	
45	220	100	100	68	46	32	32	
50	220	100	100	68	46	46	46	32
55	320	150	150	68	68	46	46	32
60	320	150	150	100	68	68	46	46
65	460	220	150	100	100	68	68	46
70	460	320	220	150	100	68	68	46
75	680	320	220	150	100	100	68	68
80	680	460	220	150	100	100	100	68
85	1000	460	320	220	150	100	100	68
90	1000	680	320	220	150	150	100	100
95	1000	680	460	320	150	150	150	100
100	1500	1000	460	320	220	150	150	100

NOTES

1. *Consult gear, bearing, and lubricant suppliers if a viscosity grade of less than 68 or greater than 680 is indicated.*
   Review anticipated cold start, pea, and operating temperatures, service duty and range of loads when considering these viscosity grades.
   Select the viscosity grade that is most appropriate for the anticipated stabilized bulk oil operating temperature range.
   Baseline stabilized bulk oil operating temperature and bearing lubrication requirements.
2. *This table assumes that the lubricant retains its viscosity characteristics over the expected oil change interval. Consult the lubricant supplier if this does not apply.*
3. *Determine pitch line velocity of all gearsets. Select viscosity grade for critical gearset taking into account cold startup conditions.*
4. *For pitch line velocities greater than 30 m/s see ANSI/AGMA 6011 [18]*

Lubricants with a VI of 240, such as typically only found in PAG based gear lubricants, are generally suitable for the most extreme variations of start-up and operating sump temperatures. Even so, oil sump temperatures may need to be controlled by other means if temperatures are so low as to prevent proper flow or so high as to be damaging to other components of the gearbox.

Reference: Lubrication Tables

TABLE 6 (B5): ISO VISCOSITY GRADE GUIDELINES FOR ENCLOSED CYLINDRICAL WORMGEAR DRIVES [1, 2]

PITCH LINE VELOCITY OF FINAL REDUCTION STAGE	ISO VISCOSITY GRADES		
	AMBIENT TEMPERATURE, °C		
	-40 to -10	-10 to +10	+10 to +55
Less than 2.25 m/s	220	460	680
Above 2.25 m/s	220	460	460

NOTES

1. Wormgear applications involving temperatures outside the limits shown above, or speeds exceeding 2400 rpm or 10 m/s sliding velocity should be addressed by the manufacturer. In general, for higher speeds a pressurized lubrication system is required along with adjustments in the recommended viscosity grade.

2. This table applies to lubricants with viscosity index of 100 or less. For lubricants with viscosity index greater than 100, wider temperature ranges may apply. Consult the lubricant supplier.

Extracted from ANSI/AGMA 9005-F16, Industrial Gear Lubrication with the permission of the publisher, the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314

Reference: Lubrication Tables

TABLE 7 (B6): ISO VISCOSITY GRADE GUIDELINES FOR ENCLOSED GLOBOIDAL WORMGEAR DRIVES [1, 2]

CENTER DISTANCE OF FINAL REDUCTION STAGE	WORM SPEED OF FINAL REDUCTION STAGE, RPM	ISO VISCOSITY GRADES			
		AMBIENT TEMPERATURE, °C			
		-40 to -10	-10 to +10	10 to 35	35 to 55
Up to 305 mm	< 300	460	680	1000	1500
	300 - 700	320	460	680	1000
	> 700	220	320	460	680
Over 305 mm to 610 mm	< 300	460	680	1000	1500
	300 - 500	320	460	680	1000
	> 500	220	320	460	680
Over 610 mm	< 300	460	680	1000	1500
	300 - 600	320	460	680	1000
	> 600	220	320	460	680

NOTES

1. Wormgear applications involving temperatures outside the limits shown above, or speeds exceeding 2400 rpm or 10 m/s sliding velocity, should be addressed by the manufacturer. In general, for higher speeds a pressurized lubrication system is required along with adjustments in recommended viscosity grade.

2. This table applies to lubricants with viscosity index of 100 or less. For lubricants with viscosity index greater than 100, wider temperature ranges may apply. Consult the lubricant supplier.

Extracted from ANSI/AGMA 9005-F16, Industrial Gear Lubrication with the permission of the publisher, the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314

Enclosed Gear Drive Maintenance Schedule

FIRST WEEK

- [ ] Check all bolting and re-tighten if necessary.
- [ ] Check oil level while unit is not running.
- [ ] Remove inspection cover and examine gear teeth for undue wear.
- [ ] With unit running, observe shaft extensions for axial or radial runout.
- [ ] Inspect unit for oil leaks.
- [ ] Check operating temperature.

FIRST MONTH

- [ ] Drain unit and discard oil.
- [ ] Fill with a good grade of flushing oil, SAE 10.
- [ ] Operate unloaded for approximately fifteen minutes.
- [ ] Drain out flushing oil.
- [ ] Replace filter element, if so equipped.
- [ ] Refill with proper quantity and quality of oil.
- [ ] Operate unit for a few minutes.
- [ ] Check oil level.

Enclosed Gear Drive Maintenance Schedule

FIRST MONTH

- [ ] Drain and discard oil.
- [ ] Flush with a good grade of flushing oil, SAE 10.
- [ ] Replace filter element, if so equipped.
- [ ] Remove inspection cover and examine gear teeth for undue wear.
- [ ] Check breather element, clean or replace as necessary
- [ ] Refill with the proper quantity and quality of oil.
- [ ] Operate for a few minutes, check oil level.
- [ ] Check all bolting and retighten if necessary.

ANNUALLY

- [ ] Repeat semi-annual maintenance inspection. If conditions warrant, a complete disassembly and inspection may be required.
- [ ] Drain and disconnect couplings.
- [ ] Follow disassembly procedures.

Disassembly & Assembly

DISASSEMBLY

The first step before any maintenance procedures on a gear drive is to shutdown and lockout the prime mover.

Disconnect all couplings.

Depending on the atmosphere in which the unit operates, a thorough cleaning of the gear drive and the surrounding area may be required. It is imperative that the drive be clean to prevent dirt from entering the lubrication system.

Drain and discard oil and oil filter.

If the gear drive is equipped with a circulating lube system, all lines to retaining plates must be disconnected at the plates, along with any lines that may connect the upper half of the housing to the lower half of the housing. This may include electrical wiring to flow switches and/or pressure switches.

Remove all housing flange bolts, studs, and all bolts in the retaining plates above the split line. Loosen all bolts in the retaining plates below the split line, and tap the plates loose.

Remove the upper half of the housing, using the lifting lugs provided, taking care to ensure that it lifts straight up without cocking. Be sure not to hit any of the rotating elements while removing the upper housing half; this may damage bearings, gear teeth, or the sealing surface. Place the housing top on clean soft wood, never directly on a concrete floor.

Disassembly & Assembly

DISASSEMBLY (CONTINUED)

Shafts that need to be removed that have extensions will have gaskets, shims and retaining plates. These items should be wired together for bearing adjustment during reassembly.

Sketch or photograph the arrangement of the extension shafts since some reducers can be assembled either right or left hand.

Starting at the input pinion, slowly lift the shaft out of the lower half of the housing, allowing the shaft to rotate and the gear teeth to come out of engagement slowly. The shaft should be lifted straight up and parallel to its position in the drive.

Repeat the same procedure for each shaft, taking care not to damage gear teeth of bearings.

Thoroughly clean the interior of the lower half of the housing, making sure all dirt has been removed. Also, clean all rotating elements, gears and bearings. Extreme care must be taken when cleaning bearings if they are to be reused. Use a generous amount of a good quality solvent and then use compressed air to remove the solvent from between the rollers and cage

NOTE: Take proper precautions when using compressed air.

Disassembly & Assembly

ASSEMBLY

Before any assembly work is performed, all internal elements of the gear drive should be inspected. All gear teeth, bearing cups, and bearing rollers should be visually checked for signs of excessive wear. Check housing bores for signs of wear due to rotating bearing cups. Replace bearings as necessary at this time. Contact Horsburgh & Scott at 216-431-3900 for gear elements that need to be replaced. Also, inspect and replace all shaft seals as needed.

Begin assembling the gear drive by checking to make sure the interior of the housing is clean and dry of any solvents.

Coat the internal surface of the bearing cup with a light film of grease. Starting with the output shaft, lower the shaft assembly into the lower half of the housing. If the unit has single row taper or radial roller bearings, the bearing cups should be on the cones at this time. Carefully place the shaft assembly in its bore, making sure the bearing is not cocked and that it seats squarely in the bore.

In the case of spherical or double row roller bearing, a locking pin may be used, and if so, it must be aligned with the counterbore in the bearing outer cup. In some cases, the bearing may be locked by a lock and lube pin through the top half of the housing.

If the unit is being assembled with all used parts, bearing clearance adjustments may not be required. If any new parts are on the shaft assembly, bearing clearance will have to be checked and set.

NOTE: If factory made gaskets are not available, a good quality manila paper cut to size will be acceptable. Gaskets/shims are never used between the retaining plate and the bearing cup.

After setting the axial end play, rotate the shaft to seat the bearings and be sure there is no binding within the bearings

Follow the same procedure for all shaft assemblies in the gear drive, setting the bearings for each shaft as detailed above. Be sure to allow the shafts to rotate and the teeth to mesh as each shaft is placed in its respective bore.

Disassembly & Assembly

ASSEMBLY (CONTINUED)

When all shafts are in the housing, slowly rotate the input pinion, noting the freedom of movement. Check each mesh for smooth engagement. Inspect gear teeth again to make sure no damage was caused during the assembly.

NOTE: Bearing cartridges may have been desirable in the original design. When bearing cartridges are used, they must be assembled on the shaft with the bearing and then set into the housing as an assembly. Oil lubrication supply and drain holes must be aligned, along with any bearing locking pins.

Clean and wipe the surfaces at the housing split, taking care not to get any dirt inside the housing or in the bearings. Lightly file and sand any nicks or burrs on the split surfaces.

NOTE A: Any Horsburgh & Scott reducer unit built prior to February 7, 1983, was designed with a .010" gasket in the housing split. Upon reassembly of these units, a gasket of equal thickness must be used to maintain bore sizes.

NOTE B: Any Horsburgh & Scott reducer unit built after February 7, 1983, does not have the gasket on the split. These units use GE-RTV Silicone Rubber Adhesive sealant on the split. During reassembly, a single .125" bead is used around the entire split surface. Be careful not to allow excess sealant to contaminate bearings when the housing is clamped together.

Disassembly & Assembly

ASSEMBLY (CONTINUED)

Loosen all lower retaining plate bolts. Lift the upper half of the housing, being sure it lifts straight and parallel. Clean the sealing surface of the upper housing. Slowly lower the upper half of the housing onto the lower half, taking care not to hit the gearing and bearings. If the housing has tapered pins on the split, align these and lower the housing. On later designs, face pins are used instead of tapered dowel pins on the housing split. These pins must be in place before lowering the top half of the housing.

Insert bolts in the retaining plates above the split and tighten the retaining plate bolts evenly. Be sure the plate rests flat against the housing. Bolts should be tightened in an even manner, alternating across the retaining plate and then alternating across the gear drive.

Insert all bearing boss bolts/nuts and all flange bolts before tightening. Start tightening at the center bearing boss bolts alternating across the housing and finish with the flange bolts. Tighten all bolting to recommended torque values for the particular bolt size.

Connect all lube lines and electrical components.

Fill the gear drive to the recommended level with the grade of oil specified on the nameplate.

For drives with circulating lube systems, start the system and make preliminary adjustments to the sight feed oilers.

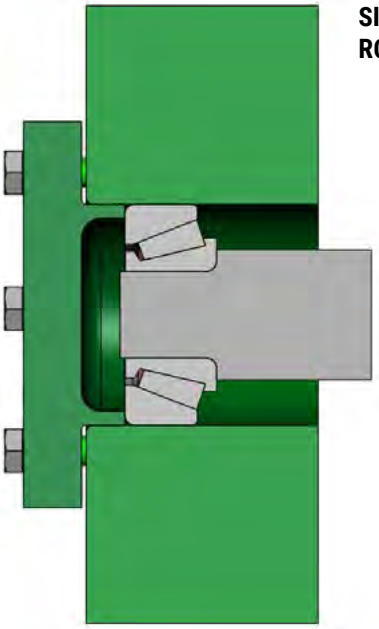
Reconnect couplings and follow startup procedures.

Bolt Torque Chart

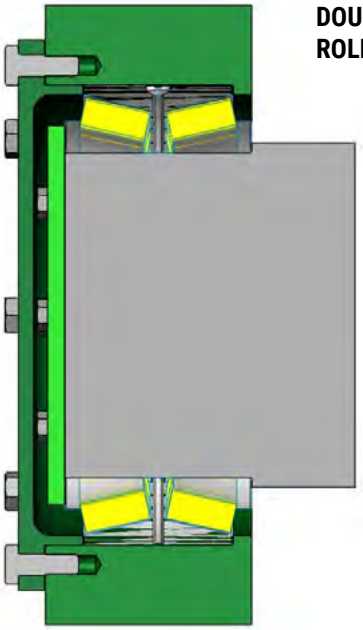
BOLT SIZE (U.N.C.)	TORQUE (FT. - LBS)
3/8" – 16	17.5
1/2" – 13	51
5/8" – 11	98
3/4" – 10	175
7/8" – 9	320
1" – 8	515
1-1/4" – 7	820
1-1/2" – 6	1480
1-3/4" – 5	1810
2" – 4	2725
2-1/2" – 4	5450
3" – 4	9760

Bearing Adjustment

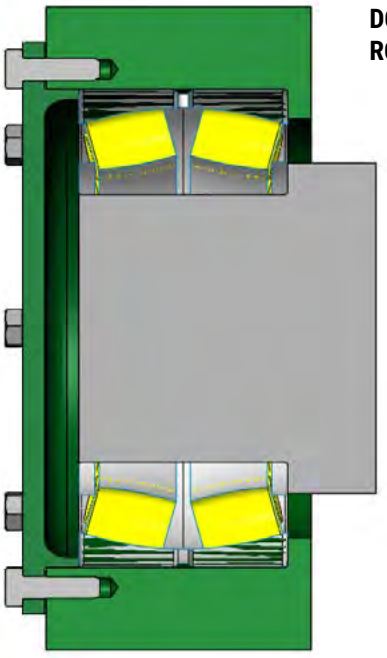
THREE BASIC TYPES USED IN MEDIUM & LARGE INDUSTRIAL GEAR DRIVES:



SINGLE ROW TAPERED ROLLER BEARINGS



DOUBLE ROW TAPERED ROLLER BEARINGS



DOUBLE ROW SPHERICAL ROLLER BEARINGS

Bearing Adjustment

SINGLE ROW TAPERED ROLLER BEARINGS

Shaft assemblies mounted on single row tapered roller bearings are designed to absorb both radial and thrust loads. Correct bearing clearance is maintained by gaskets or shims which are located between the housing and the bearing retaining plates.

WARNING: Proper bearing clearance is essential. Too loose of an adjustment will cause the gear shaft to be out of alignment and will result in noise or vibration. Too tight of an adjustment may cause bearing pre-load which may lead to premature bearing failure.

If a unit is reassembled without any new parts, the gasket thickness at each retaining plate should remain the same, but must be verified. If any new parts are installed on any shaft assembly, it will be necessary to check for the proper bearing clearance.

Single row, tapered roller bearings are adjusted with the housing cover removed as follows:

Bolt one of the retaining plates to the housing with the gasket thickness approximately equal to the original gasket thickness or approximately 0.030".

Bolt the opposite retaining plate to the housing without any gaskets and snug only enough until shaft has 0.000" to 0.00" axial end play. Make sure plate is drawn up evenly and that the bearing cups are seated properly in the bores. A cocked bearing cup or retaining plate will result in false bearing alignment. Rotate the shaft assembly slightly back and forth to properly seat the bearing rollers.

Measure the gap as shown in *Figure 3*. Check at several points to make sure the plate is square with the housing.

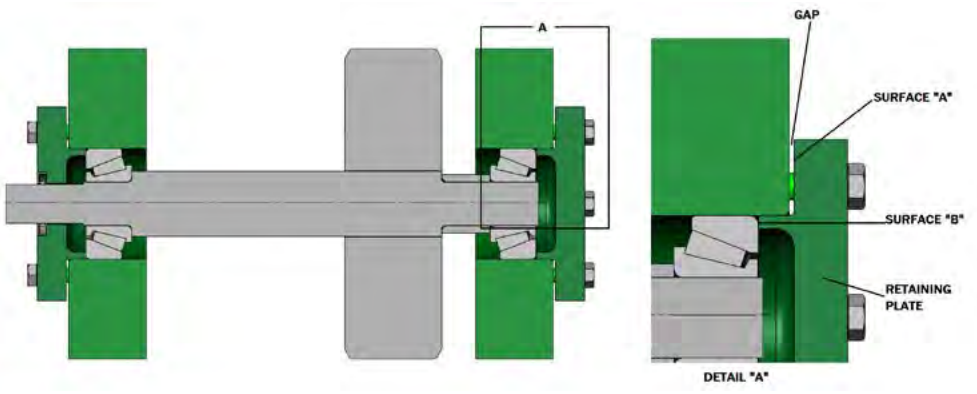


FIG. 3 BEARING ADJUSTMENT

Bearing Adjustment

SINGLE ROW TAPERED ROLLER BEARINGS (CONTINUED)

Add 0.005" – 0.008" to this measured gap to determine the total gasket thickness required.

Install gaskets between surface 'A' of retaining plate and housing. Tighten bolts and check for bearing clearance. Adjust axial float per the following *Shaft Axial End Play Adjustment* chart.

SHAFT AXIAL END PLAY ADJUSTMENT CHART

INPUT RPM	INPUT SHAFT TOTAL AXIAL END PLAY	INTERMEDIATE & OUTPUT SHAFT TOTAL AXIAL END PLAY
0 to 1200 1201 to 2500 Above 25009	0.004" / 0.006" 0.005" / 0.007" Consult factory	0.003" / 0.005" 0.003" / 0.005" Consult factory

Occasionally, it may be necessary to machine the retaining plates at the surfaces 'A' and / or 'B' if it is not possible to make the bearing adjustment by means of gaskets alone. If machining is done, care must be taken to make sure surfaces 'A' and 'B' remain parallel to each other.

If factory made gaskets are unavailable, it is acceptable to use a good quality incompressible manila paper cut to size. Our practice is to use at least a 0.005" thick gasket but no more than 0.030" total thickness at any one retaining plate. No gaskets are ever used at surface 'B'. All shafts should rotate freely when finished.

Bearing Adjustment

SINGLE ROW TAPERED ROLLER BEARINGS (CONTINUED)

Prior to February 7, 1983, Horsburgh & Scott units were machined and assembled with 0.010” gasket on the housing split surface. If, during any disassembly, this gasket requires replacement, it must be replaced with a material of the same thickness in order to maintain the original bore sizes. Any good quality gasket paper is acceptable provided it is uniform in thickness and has minimum compressibility.

Units manufactured after February 7, 1983 do not have the gasket. These units were assembled with a thin coating of GE-RTV Silicone Rubber Adhesive sealant at the split surface. Whenever a unit is disassembled, the old silicone coating must be removed either by a solvent or scraping prior to assembly. Surfaces must be clean and inspected carefully for nicks or dents which may cause separation between the housing flange.

Apply a single 0.125” diameter bead of the silicone sealant around the entire split surface. Any amount in excess of this may squeeze out and contaminate bearings or foul lubrication systems. Housing sections must be assembled no more longer than 5 minutes after the silicone material is applied. Otherwise, the silicone will not squeeze down to the minimum thickness that is required to maintain the original machining tolerances.

Bearing Adjustment

DOUBLE ROW TAPERED BEARINGS

All double row tapered roller bearing that include a spacer, type TDO, come from the factory as a set. These are an assembly and parts must not be interchanged; even between bearings of the same size. In most Horsburgh & Scott designs involving double row tapered roller bearings, one bearing is fixed in the housing and the other will float. This is to allow for thermal expansion of the parts of the gear drive as they reach operating temperature.

In some designs, the cup of the bearing may have a counterbore to be aligned with a pin in the bottom of the housing bore. This pin prevents the cup from rotating and must be aligned as the shaft is being placed into the bore. The bearing cup may also be locked by a lock and lube pin installed in the top half of the housing.

Begin by installing the recommended .005” minimum gasket/shim on the retaining plate for the fixed bearing. The fixed bearing can be identified by the shoulder in the housing bore that the cup of the bearing rests against. Install the retaining plate with the bolts for the lower half of the housing. Tighten the bolts to ensure that the bearing cup is captured between the shoulder in the bore and the lip of the retaining plate.

Using a feeler gauge, determine the gap between the housing and the retaining plate.

Add to the gap .002” and install the correct gasket/shim thickness on the retaining plate. Tighten the lower half bolts evenly to the recommended torque values. Recheck the gap between the housing and retaining plate. Adjust the gasket/shim thickness as necessary.

NOTE: The maximum recommended gasket/shim thickness on any one retaining plate is .030”. Should more than .030” be required to take up the gap, the retaining plate lip should be machined to reduce the required gasket/shim thickness, see *Figure 4*.

Bearing Adjustment

DOUBLE ROW TAPERED BEARINGS (CONTINUED)

The retaining plate on the floating bearing side of the shaft requires the minimum gasket/shim thickness of .005". The plate should be mounted and clearance checked between the bearing cup and the lip of the retaining plate. The minimum is .030". Adjust as necessary by adding gasket/shims to that retaining plate.

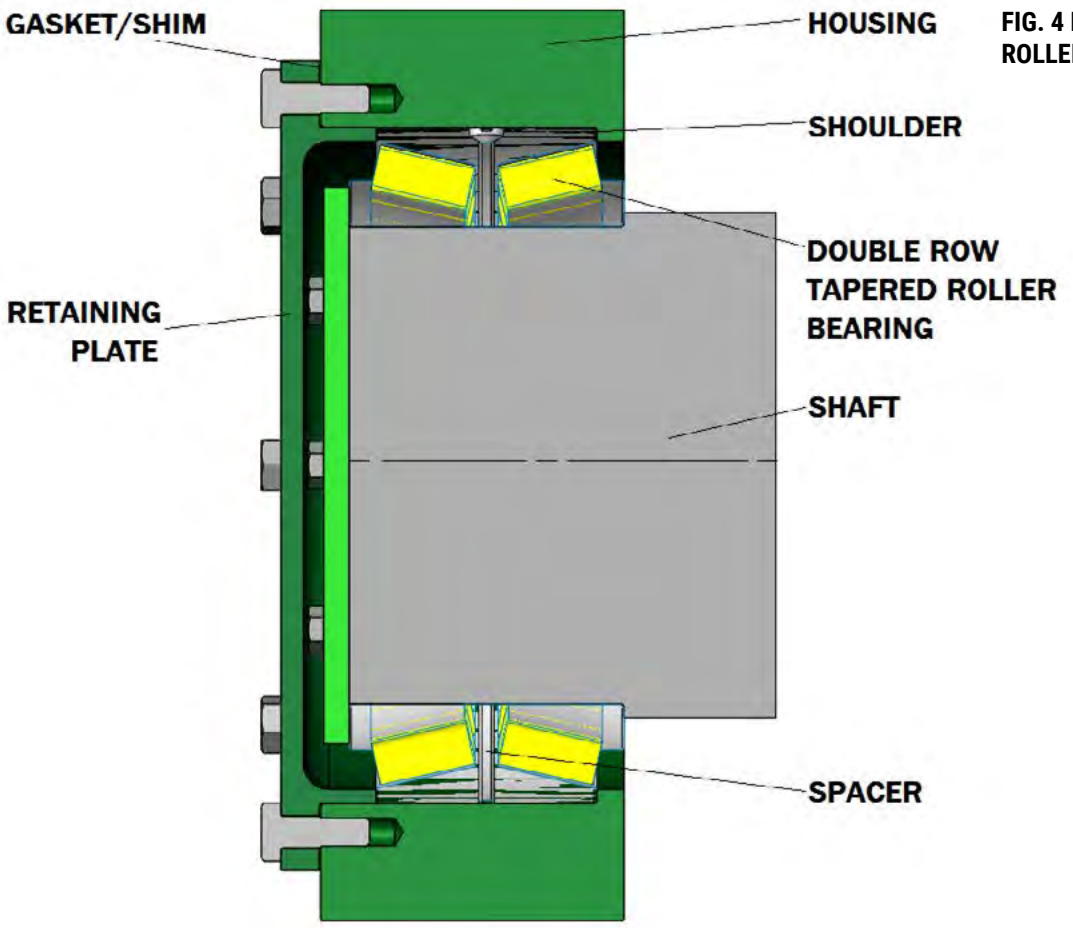


FIG. 4 DOUBLE ROW TAPERED ROLLER BEARING

Bearing Adjustment

DOUBLE ROW SPHERICAL BEARINGS

Some designs by the Horsburgh & Scott Company employ double row, spherical roller bearings. These bearings are a one piece assembly and all bearings carrying the same catalog number are interchangeable.

Begin by installing one retaining plate with the minimum .005” gasket/shim. Install and tighten the bolts in the retaining plate for the lower half of the housing.

With the retaining plate drawn tight, force the shaft against the retaining plate until the outer bearing race is touching the hub projection of the retaining plate. Be sure the bearing race is seated against the projection around the entire diameter.

Using a feeler gauge, determine the gap between the retaining plate flange and the housing bearing boss. Add .016” – .020” to the measured gap and install the necessary gasket/shim, see Figure 5. The maximum gasket/shim thickness is .030”. In order to maintain this gasket/shim thickness, it may be necessary to divide the required shims between the two retaining plates. The important factor is that the overall gap remain the same. It may be necessary to machine the hub projection of the retaining plate to remain within the desired gasket/shim range. After machining, the lip must be parallel to the face of the retaining plate against the bearing boss, and perpendicular to the hub projection on the retaining plate.

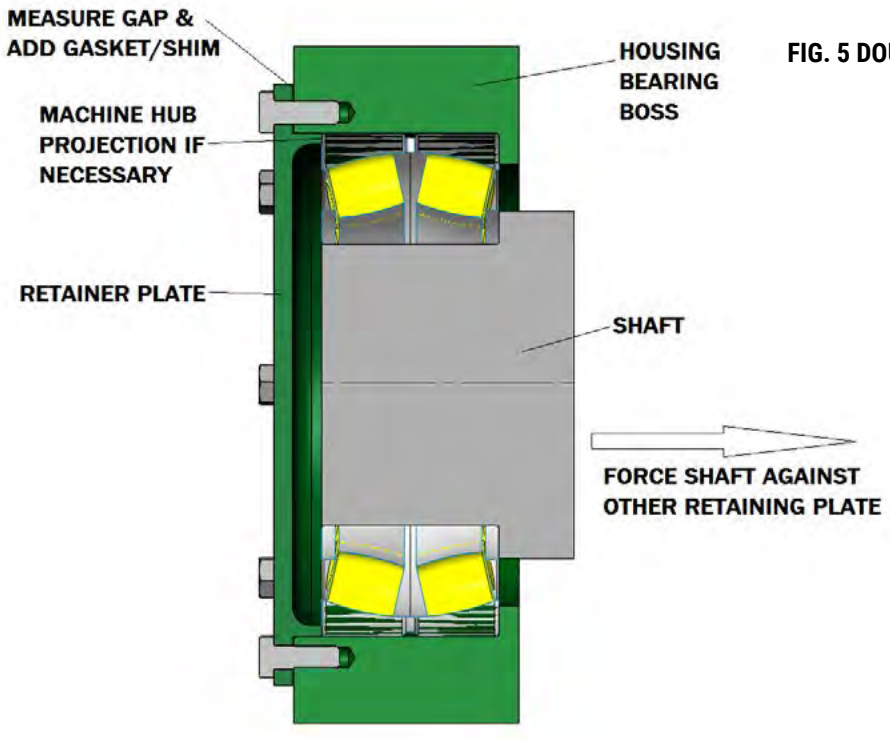


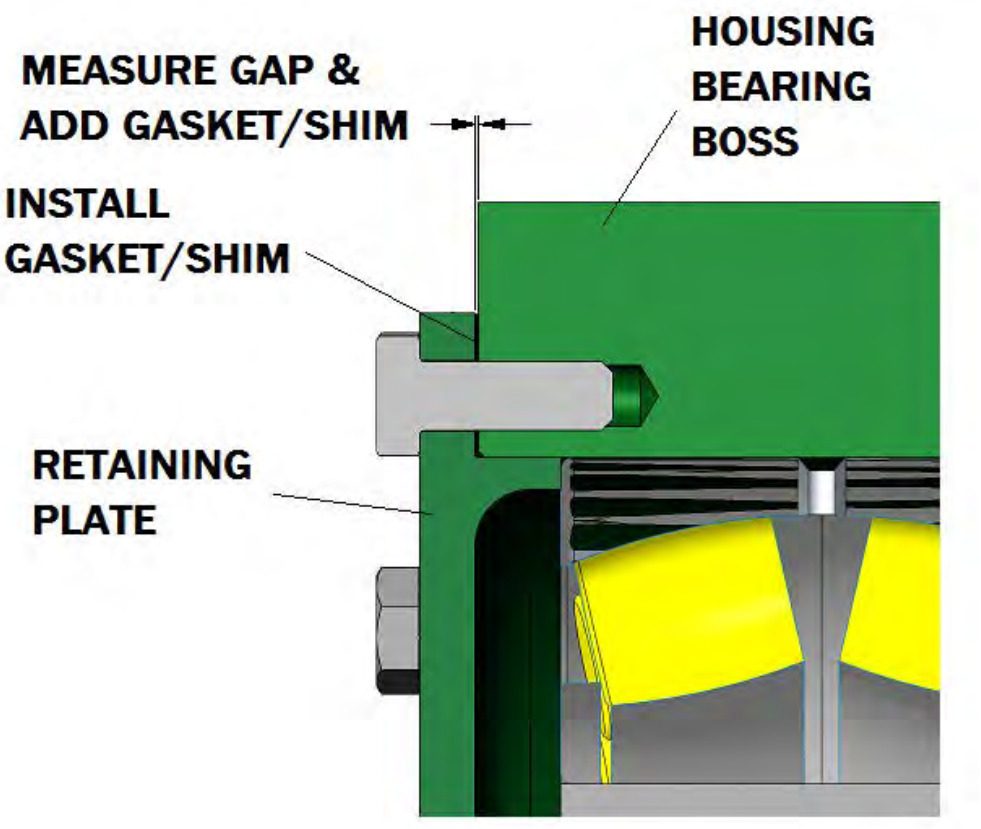
FIG. 5 DOUBLE ROW SPHERICAL BEARING

Bearing Adjustment

DOUBLE ROW SPHERICAL BEARINGS (CONTINUED)

After adding the required gasket/shim to the retaining plates and tightening to the correct torque, recheck the clearance gap. The measured gap between the opposite bearing outer race and the hub projection should be .016". Adjust the gasket/shim thickness as necessary, see *Figure 6*.

FIG. 6 DOUBLE ROW SPHERICAL BEARING



Bearing Adjustment

BEVEL CARTRIDGES

Cartridges with single row bearings are generally more difficult and time consuming to set the end play. It is important to take the time necessary to insure that these bearings are set correctly. These bearings are installed in the opposite direction as compared to the other gear drive shaft bearings. The bevel pinion is located on the cartridge shaft. The bevel gear is located on the shaft in the unit.

To set the end play, the bearings must be absolutely clean and dry. Install the bearing cone, nearest the bevel pinion, using normal heating or pressing methods. Install both bearing cups in the cartridge. Place the shaft vertically on a work bench, sitting on the bevel pinion. Place the cartridge over the shaft, mating the bearing just installed. Make sure the cartridge inside face is toward the pinion. Place three 1" strips of .001" or .0015" steel shim stock, about 6" long, over the upper cup in the cartridge. Heat the second bearing cone and install it so that the shims are held in place between the cup and the rollers of the cone. Install the lock nut but do not tighten it down while the bearing is hot. When the bearing is at room temperature, remove the three shims being careful not to tear them. Cartridge end play at this point will be about .015" to .020". Install an indicator base on the cartridge with its stylus on the shaft and measure end play by raising and lowering the shaft while holding the cartridge fixed to the workbench. Adjust the end play by tightening the lock nut a small amount each time. Rotate the bearings through several revolutions between each movement of the locknut. Carefully move the locknut in small amounts until the correct end play of .003" – .006" is obtained.

It is required to set the backlash when installing bevel cartridges. To set the backlash install the cartridge in the housing with about .030" in shims between the flange of the cartridge and the housing. Note the proper location of the drain lines, lube holes, and slots if so equipped. Ensure the match marks, x-xx, line up between the mating teeth. They are located on the edge of the widest part of the teeth. All other shaft end plays should already be set. The correct amount of backlash is marked on the edge of the gear. With the indicator stylus on the working surface of the pinion tooth at the thickest part, heel area, hold the gear rigid and move the pinion back and forth noting the indicator movement. Add or remove shims from the cartridge flange until the correct amount of backlash is achieved. In some cases, the bevel gear may have to be moved axially to obtain the correct backlash. This is done by removing a shim from a retaining plate and placing a shim of the same thickness on the opposite plate. The shaft will have moved in the direction the shim moved, and exactly the same distance as the shim thickness.

To check the contact pattern, apply a thin coat of prussian blue to the bevel pinion and rotate it through the mesh to transfer blue to the gear. A contact pattern located from the toe, thinner section of the tooth, to the center of the tooth is ideal under no load conditions.

Bearing Adjustment

WORM GEAR DRIVES

Worm gear drives are right angle drives having a worm, a screw-thread like shaft, and a gear, larger in diameter, usually bronze. Worm gear drives have single row tapered roller bearings.

Set the end play to .003” – .005” on both worm and gear shafts by either adding or removing shims from the retaining plates. Always rotate the shaft to insure the bearing are seated when making an adjustment.

To check contact pattern apply a thin coat of prussian blue to the worm threads. Rotate the worm several revolutions in both directions to transfer blue to the gear. A contact pattern centrally located on the gear tooth and about 50% is considered normal under no-load conditions. To change the contact pattern, adjust the position of the gear axially by removing a shim from one retaining plate and installing exactly the same thickness on the opposite retaining plate. This will move the gear in the direction the shim moved and exactly the amount of the shim thickness. If the unit runs in both directions, be sure the contact pattern is the same on both sides of the gear teeth.

Bearing Adjustment

WORM GEAR DRIVES WITH BALL, SPHERICAL, OR STRAIGHT ROLLER BEARINGS ON THE WORM SHAFT & SINGLE ROW TAPERED BEARINGS ON THE GEAR SHAFT

The worm shaft end play is set by installing the thrust side retaining plate without any shims. The thrust side retaining plate can be identified by the longer pilot and, in most drives, a larger bearing. Snug all bolts only tight enough to insure that the bearing is captured, then loosen the bolts and retighten them only hand tight. Using a feeler gage, measure the amount of the gap between the retaining plate and the housing. Add 0.005” to that figure for the total amount of shims to install. If there is no gap between the retaining plate and housing, the retaining plate surfaces must be machined. The end of the pilot that touches the bearing, and the inside of the flange that touches the gaskets, are the areas to be machined. Machine 0.030” more off the flange area. The two surfaces must be parallel to each other within 0.002”.

Seal Diagrams

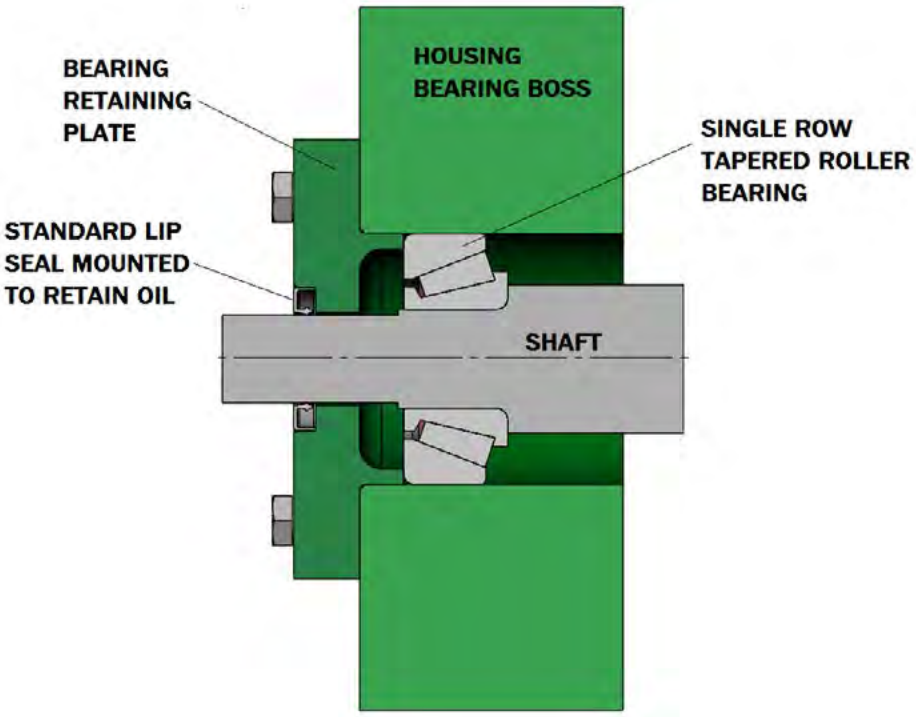


FIG. 7 STANDARD OIL SEAL

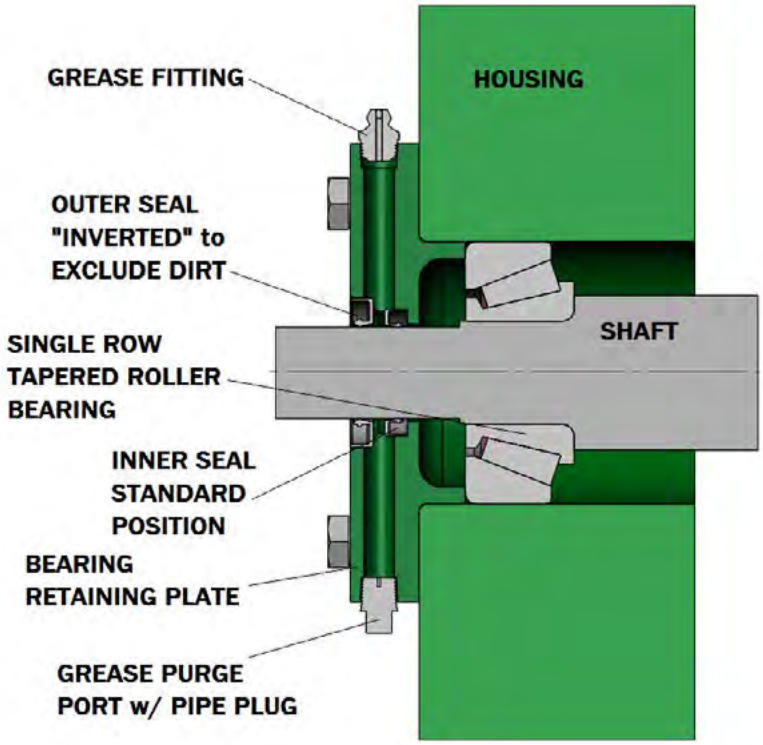


FIG. 8 DUAL GREASED PURGED SEAL

Seal Diagrams

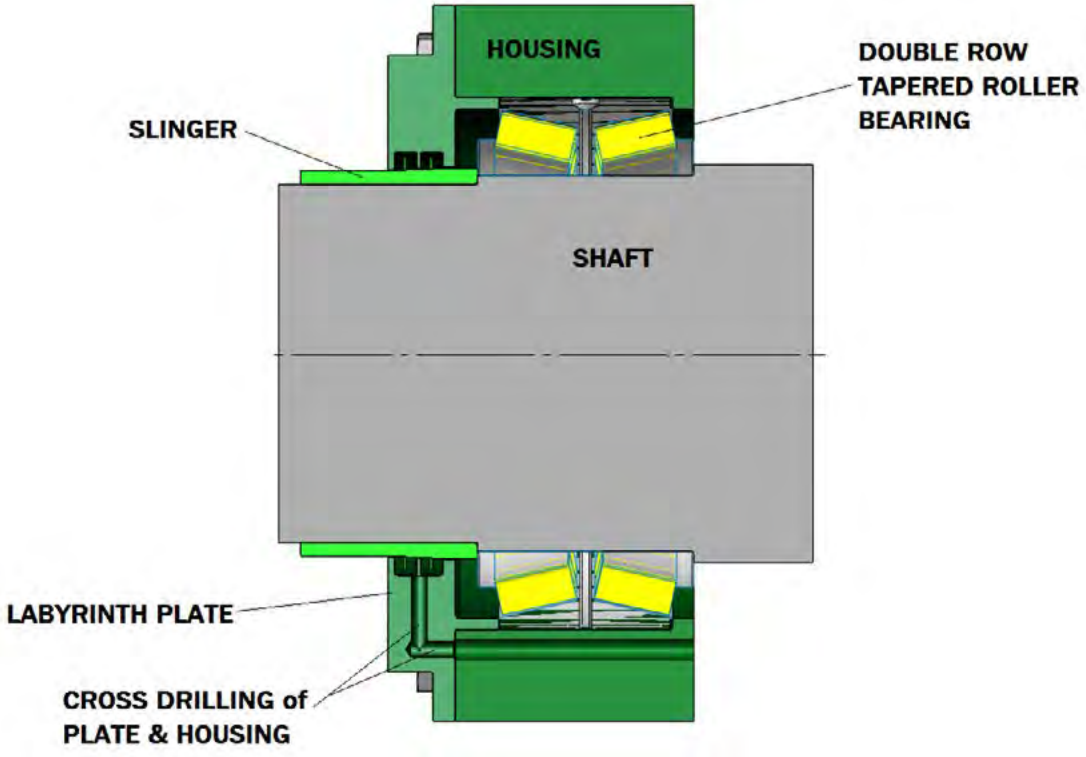


FIG. 9 LABYRINTH OIL SEAL

Long-Term Storage

LONG-TERM STORAGE PROCEDURE

When it is expected that enclosed gear drives are to be stored for extended periods of time, 6 months or longer, special precautions are required. The internal rotating elements of all gear drives are sprayed with Mobil Oil Corporation's Mobilarma 247 before they leave the plant. This internal spray coating is good for approximately 6 months of indoor storage. (Consult Horsburgh & Scott for outdoor storage procedures.) For longer storage periods, it is required that the gear drive be filled with Mobilarma 247, or equivalent, until all geared elements are entirely submerged, within 30 days of shipment.

Mobilarma 247 has been selected as the storage medium primarily for its rust preventative properties. Suited best for protection of finely finished parts for shipment and storage, its rust preventatives are light- bodied petroleum solvents with polar rust preventative, water displacement and finger neutralizing additives. Although not mechanically strong as a lubricant, Mobilarma 247 is generally compatible with recommended lubricating fluids and need not be flushed from the unit when preparing for operation with the recommended lubricating medium. Should an alternative storage product be considered, its compatibility with Mobilarma 247 (sprayed internally prior to shipment), and the housing internal paint (Sherwin-Williams Kem-Aqua #70P is standard), must be verified, and is the responsibility of the party selecting the storage medium.

The following steps are required prior to completely filling the gear drive for long term storage.

Verify that the cap for the oil level dipstick or stand pipe is tight. If the unit has a sight glass oil level gage, the atmospheric vent hole will also need to be made oil tight to prevent leakage.

If not in the unit top, remove the breather from housing and plug the breather hole, install breather in the fitting provided for storage.

Check that all retaining plate, housing flange, bearing boss, and inspection plate bolts are tight.

Fill the unit with Mobilarma 247 rust preventative medium, or equal, through the top inspection cover, until all geared elements are entirely submerged. Replace the inspection cover and tighten bolts.

Grease all seals and bearings that require grease lubrication.

Quarterly visual inspection of the oil level is required. Although no leaking is expected, some static weeping may occur at machined interfaces and assembled joints. It may be necessary at some time during the storage period, to add storage medium in order to maintain the proper level. With completely submerged rotating elements, no specific requirements for shaft rotation during the storage period is necessary.

Long-Term Storage

PREPARATION FOR OPERATION AFTER LONG-TERM STORAGE

Following a lengthy storage period, the following steps must be taken, prior to start-up:

Drain storage medium through housing drain plug provided. It may be necessary to loosen the top inspection cover or retaining plates to allow air to enter and oil to drain. Replace drain plug.

Remove plug from breather hole and install breather into crankcase flange.

Grease all seals, and grease all bearings that require grease lubrication.

For vertical shaft units, drain the internal dry well through the drain line provided at the end of the housing. Drain all lower shaft bearings through the drain line provided.

Fill to proper operating oil level with the operating lubricant. If Mobilarma 247 has been selected as the storage medium, flushing of the storage medium is generally NOT required due to compatibility with most recommended operating lubricants.

Gear Misalignment Patterns

SPUR & HELICAL GEARS

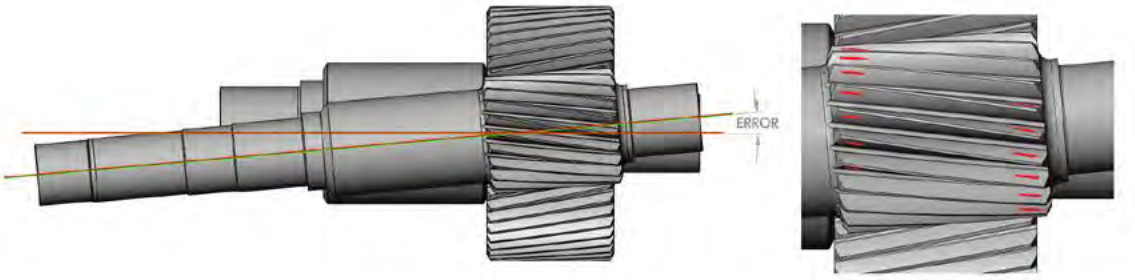


FIG. 10 SHAFT CENTERS OUT OF PARALLEL

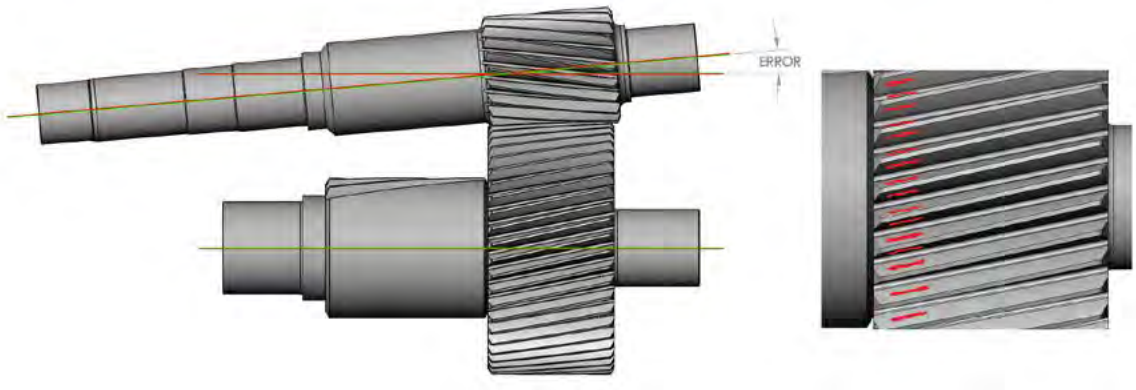


FIG. 10 SHAFT CENTERS OUT OF PLANE

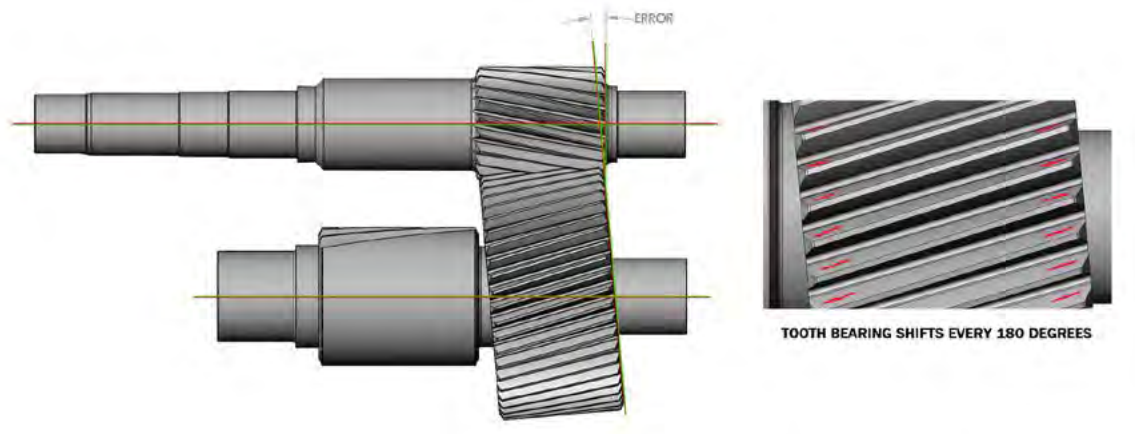


FIG. 10 GEAR NOT ROTATING ON TRUE CENTERS

Gear Misalignment Patterns

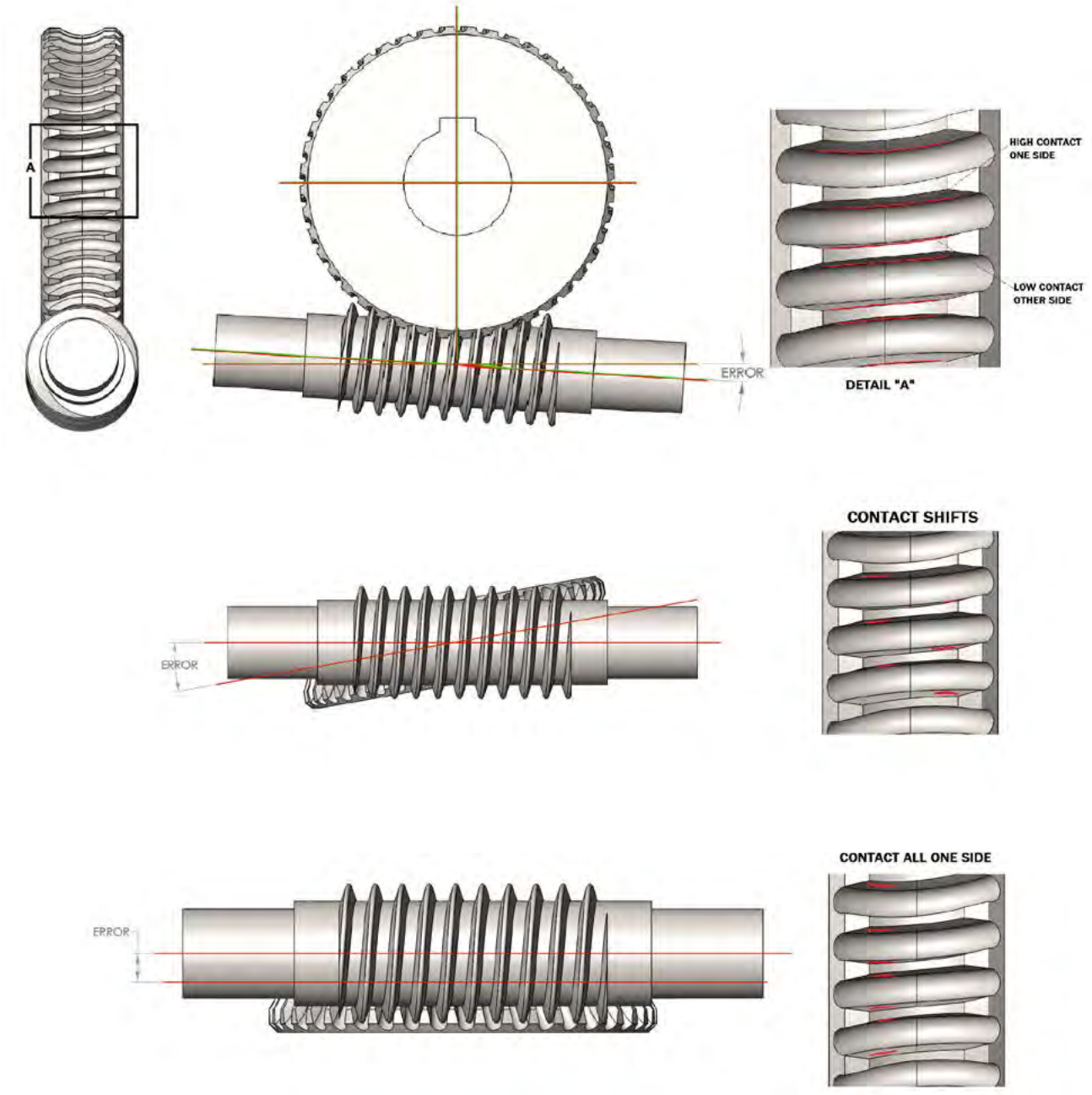
DOUBLE HELICAL

FIG. 11 ACCEPTABLE GEAR MESHES

Gear Misalignment Patterns

WORM GEAR

FIG. 12 WORM GEAR



Additional Resources

AGMA TERMINOLOGY OF WEAR & FAILURE STANDARD

The ANSI/AGMA Standard 1010-F14, *Appearance of Gear Teeth - Terminology of Wear and Failure* is helpful for diagnosing gear tooth problems. The AGMA Standards Store allows purchase of electronic copies (in PDF format) of current AGMA standards. Immediately following your order, you will receive an e-mail allowing you to download the documents you purchase. If you would prefer a hard copy of a document, see the contact information for the AGMA Online Store. Visit the AGMA Online Store at www.agma.org.