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LUFKIN

HIGH SPEED GEARS

INSTRUCTION MANUAL



LUFKIN INDUSTRIES, INC.
LUFKIN, TEXAS

MEMBER OF AGMA

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SECTION I

GENERAL SPECIFICATIONS

1. ENGINEERING

The high speed digital computer is used to assist LUFKIN's design engineers in evaluating each design for maximum practical torque capacity based on the latest AGMA standards. In this analysis, tooth geometry is evaluated to give the user an optimum balance between tooth beam strength and maximum durability rating based on the physical dimension of the gear set.

2. APPLICATION

Type N and NM high speed gear units are used for both speed reducing and speed increasing service. These high speed units must be used when the pinion speed is higher than 3600 RPM or when the pitch line velocity is higher than 5000 feet per minute.

3. HOUSINGS

Housings are of controlled specification high tensile gray iron, carefully stress-relieved before machining for dimensional stability during machining and operating life. Housings are of two-piece construction with parting line between housing and cover accurately machined. Interior surfaces are thoroughly shot-blasted, cleaned, and painted to insure absolute freedom from foreign particles. Housings are designed for heavy duty service to provide maximum rigidity, assuring precision gear alignment. All housings are precision bored, and bore alignment is certified before assembly.

Fabricated steel housings are available on special order when required by the application.

Housing design incorporates the necessary oil piping for bearing and mesh lubrication.

4. GEARS

Type NM gears are the double helical type generated on Sykes gear machines. Type N unit gears are the double helical type cut on precision hobbing machines. The gear teeth are cut after the gear has been shrunk on its shaft and finish-turned or ground to assure concentricity between pitch circle and bearing journals. LUFKIN holds tooth profile, spacing, runout, and lead to precise tolerances to assure quiet, trouble-free operation. After hobbing, the gear and pinion is finish lapped. Finished gear assemblies are dynamically balanced to precision machinery standards. All gear blanks are made from high alloy, high tensile steel.

5. PINIONS

Except for very low ratios which result in large pinion diameters, pinions are made integral with their shafts. Material is high alloy, high tensile steel. Pinion shaft extensions are ground to nominal dimensions shown in rating tables in LUFKIN Catalog G-33A, with a tolerance of plus or minus .0005".

6. BEARINGS

Type NM Units -- the slow speed bearings are the self-aligning type mounted in bearing carriers. The high speed bearings are the centrifugally-cast babbitt type with a one-piece steel shell.

Type N Units -- the slow speed and high speed bearings are centrifugally-cast babbitt with a split steel shell. A flanged, babbitted thrust bearing is used on the low speed shaft for axial alignment and nominal amount of coupling thrust. When customer-specified thrust exceeds standard thrust capacity, a tilting pad or tapered land thrust bearing can be used. When required by operating conditions, high stability anti-whirl bearings are furnished.

7. EXTREME HIGH SPEED GEAR UNITS

LUFKIN manufactures all types of extreme high speed gear units for special applications. These units are available as both single and double helical designs and can be custom designed to the requirements of the application. These units generally use either through-hardened or case-hardened and ground gearing. Gear grinding is done by the Maag process for the ultimate in accuracy.

8. STRUCTURAL BASES

One-piece structural steel bases are available for mounting both the gear reducer and prime

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mover. These are fabricated by electric welding, using heavy section steel plate or structural sections, and are stress-relieved after welding. All bases are custom-built to suit each individual job. In some cases, common bases can be provided to accommodate the driven machine also.

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SECTION II

INSTALLATION

1. HANDLING

The gear unit should always be moved by rolling on bars or skates, or lifting it with slings through lifting lugs or eye bolts found on all LUFKIN gear units. Never lift or sharply pound on the shaft extension or lubrication piping as serious damage may result.

Every LUFKIN gear is test run with a break in oil that contains a rust preventer which will protect the internal parts for at least six months after it leaves Lufkin. Do not store gear outdoors. If the inoperative period is greater than six months, see Section VI Part 6, "Corrosion Protection During Inoperative Periods".

2. MOUNTING OF COUPLINGS

Before attempting to mount the coupling, inspect coupling bore and shaft diameter with a micrometer to determine that there is approximately .0005 inch per inch of diameter interference. Also, inspect the key and keyseat for proper fit, making certain that the key sits at the bottom of the shaft keyway and there is clearance at the top of the key. If the keyway extends past the coupling, the key should be split on the protruding end to fill only the keyway to maintain proper shaft balance.

Next, heat the coupling uniformly until there is sufficient clearance to place it on the shaft. It is important that the coupling be heated uniformly and that care is taken so that localized spots are not overheated (max. 500 degrees F.) An ideal way to do this is by using a heated oil bath. In placing the coupling on the shaft, do not pound directly on coupling with a steel hammer, but use lead or rawhide mallets so as not to damage coupling or shaft. A temporary spacer block is helpful in preventing the coupling from sliding too far onto the shaft.

3. FOUNDATION AND ALIGNMENT

Securing proper shaft alignment is one of the most important phases of setting up a high speed gear unit. Even though flexible couplings are used on the shaft extensions, any appreciable amount of misalignment can cause a multitude of gear problems ranging from non-uniform bearing and gear tooth wear to vibration and coupling problems. Therefore, it is essential that good alignment be maintained, and that thermal growth and bearing clearances be anticipated in shaft alignment. Allowable alignment error based on hot alignment check in the radial and axial direction may be taken from Section VIII, "Maximum Allowable Run-out, (TIR) Inches" - Table 1.

Obviously, to maintain alignment, the gear unit should be securely mounted to a suitable rigid foundation. Two of the more common foundations are the concrete foundation and soleplate combination, and the common bedplate.

The concrete foundation and soleplate combination is semi-permanent and allows for the removal of the gear housing at a later date without disturbing the permanent mounting pad. The elevation of the concrete foundation should allow for final grouting of the machinery once accurate alignment of the shafts is complete. LUFKIN recommends that a minimum of 1/16" of shims be used between the gear and soleplate to allow for final alignment.

The common baseplate is a rigid structural steel foundation common to both the gear unit and either the prime mover or the driven equipment. LUFKIN occasionally supplies the baseplate with the gear rough aligned to the prime mover or driven equipment. In this case, final alignment is necessary after the baseplate has been grouted in.

Generally, alignment should start with securing the driving or driven machine (whichever is more permanently settled) and aligning the gear unit to it. Jacking screw holes are provided on the base flange for bringing the gear unit to the same horizontal plane as the connecting shaft. Once there, the gear unit should be supported on broad, flat shims located adjacent to and on each side of the foundation bolt holes. Next, move the unit on its shims until the gear shaft is

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in the same vertical plane as the connecting shaft with the correct spacing between coupling hubs. (See Part 4, "Axial Positioning"). At this point, the running position of driven and driving shafts should be anticipated, (see Part 5, "Anticipation Of Shaft Operating Positions"). and final alignment established. Care should be taken in joining the two coupling halves to observe any coupling match marks, lubricate the coupling and check for free axial movement of pinion and gear. Before tightening the foundation bolts, be sure that the base sets evenly on all shims so that there will be no distortion after tightening the bolts. After tightening the bolts, check for distortion by placing a dial indicator on the gear housing foot near the bolt to be checked. If the housing foot moves when that bolt is loosened, then distortion is present and the housing needs more shims around that bolt. Similarly, align the third machine component to the gear and make tooth contact check (see Part 6 "Tooth Contact Check").

Before starting again for alignment with all three units bolted down and the gear doweled at the high speed end. At this time, a hot alignment check should be made by running the gear package until temperatures stabilize, shuting it down and taking indicator reading while the package is hot. After complete hot alignment is obtained,the gear unit should be redoweled to the foundation or base while the unit is running and temperatures are stabilized. The base flange of all LUFKIN gear units is drilled for dowel pins, but they must be reamed at assembly. After coupling alignment is established, place coupling guards in position. WARNING: Failure to use coupling guards may result in serious injury to personnel.

For information on the use of dial indicators in aligning shafts, see Section VIII.

4. SHAFT AXIAL POSITIONING

Normally, the gears of "N" units are located axially in the gear housing by either plain or tapered land babbitted thrust bearings. These thrust bearings are located on either side of the slow speed gear. The slow speed gear of an "NM" unit is axially located by locking one of the spherical roller bearings to both the housing and shaft. Sufficient clearance is provided to allow for normal thermal expansion of both the high and slow speed shafts. However, if axially rigid couplings or excessive thermal expansion is anticipated, additional clearance can be provided at the factory. Normally, the slow speed shaft should be axially positioned as far toward its mating shaft as possible before the coupling clearance is obtained during alignment procedures. However, if the prime mover is an electric motor that has a magnetic center, the magnetic center should be located and the gear positioned so there is equal clearance on either side of the magnetic center. Similarly, limited end float couplings are sometimes used to axially position the driving shaft. Here the running position should be determined and the clearance split on either side of that running position.

5. ANTICIPATION OF SHAFT OPERATING POSITIONS

As mentioned above, the final position of the shaft, under operating load and temperature, will differ from its position under no load and ambient temperature. This is due to thermal expansion of the gear housing and the direction of the bearing loading. The driven and driving machines also have thermal movement which must be either added or subtracted from the gear movement, depending upon the direction of the movements. For more detailed explanation of Shaft Operating Positions, see Section VIII.

6. TOOTH CONTACT CHECK

After all aligning has been done and prior to start-up, the tooth contact pattern should be checked. This may be done in two ways:

a. Clean the oil from several meshing teeth on both the gear and pinion, and apply a light coat of Prussian blue to the clean pinion teeth. Apply a drag to the slow speed shaft and mesh the blued teeth by rotating the pinion back and forth several times through the blued area. Inspect the impressions of Prussian blue on both gear and pinion. The tooth contact on the loaded side of the tooth should be evenly distributed across 80-85% of the face of both helixes. Vertically, the contact should cover 70% of the area from just above the root to slightly below the tip.

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b. Clean eight or ten pinion teeth and apply a coat of layout blue. Operate the unit for two hours under a light load, shut it down and remove the inspection cover to observe the areas on the pinion teeth where the blue has worn off. The contact should be the same as in Case a. See "Assembly" (Section VI, Part 5) for additional information on tooth contact patterns. If the contact is not satisfactory, the problem is usually due to gear housing distortion caused by drawing the housing down to a base that is not square with the housing. Be sure the gear housing sets evenly on all shims before tightening the foundation bolts.

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SECTION III

LUBRICATION

1. GENERAL INFORMATION

In most gear drives, lubrication serves three basic functions:

a. To separate tooth surfaces and prevent metal-to-metal contact, thereby reducing friction and wear. The contact action between gear teeth is a combination of rolling and sliding. If an oil film does not prevent contact of the mating surfaces, high spots of metal touch each other due to surface roughness of each tooth. This metal-to-metal contact develops high localized temperatures, and results in welding of the two high spots. As sliding continues, the welded surfaces pull apart, adhere to one surface, and eventually break loose. After many cycles of the welding and fracture process, the surface is deteriorated and wear is accelerated.

b. To remove heat losses at the gear mesh. At high pitchline velocities, approximately 80% of the oil applied to the gear mesh is used to remove heat from the teeth while the remainder forms an oil film separating the tooth surfaces. In high speed gear units, a pinion tooth may go through mesh several hundred times a second and generate heat with each meshing. The heat generated must be removed before it can sink into the gear blank and possibly anneal the gear teeth or cause thermal distortion of the gear. Generally, oil is sprayed into the outgoing mesh where it absorbs heat and is thrown back into the sump without going through the mesh. If the oil is sprayed into the mesh, more heat may be produced due to the shearing and churning in the mesh.

c. To remove heat produced in the bearings. The oil removes the heat generated by the shearing of the oil film in the journal bearing, and minimizes wear by separating the journal and bearing.

2. TYPE AND GRADE

The lubricating oils used in LUFKIN gear units should be high grade, high quality, well-refined petroleum oils. It is essential that the oils be clean and non-corrosive to gears and bearings. They must be neutral in reaction and possess good defoaming properties. When operating temperature is high, the oil must have good resistance to oxidation.

Straight mineral type lubricants should be used under normal operating conditions. The nameplate found on all LUFKIN gear units specifies the AGMA lubricant number and viscosity of the oil to be used in that particular gear unit. NOTE: Do not change grades of oil without approval by LUFKIN. Generally, the wet sump units will use AGMA No. 2 lubricant (300 SSU at 100 degrees F.) where the ambient temperature is 50 degrees F. to 125 degrees F. and AGMA No. 1 (220 SSU at 100 degrees F.), when the ambient temperature is 15 degrees F. to 60 degrees F. Dry sump units use light turbine oil (150 SSU at 100 degrees F.)

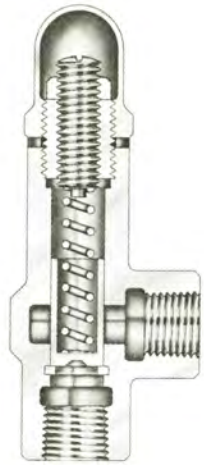
When a new gear unit is started in operation, the oil should be drained at the end of two weeks and the case and filter thoroughly flushed. The original oil may be used for refilling only if it has been filtered. Under ordinary operating conditions, the oil should be changed every 2500 hours of operation or every six months, whichever occurs first. If oil needs to be added between oil changes, care should be taken to avoid mixing different brands of oil. In some cases, the additives in the mixture are not compatible and form sludge.

It is very important to the successful and satisfactory operation of a gear unit that careful attention be given to proper lubrication, and that the lubricant be kept clean. Every precaution should be taken to prevent water and foreign particles from entering the gear case. In unusually dusty atmospheres and where there is rapid rise and fall in temperatures causing excessive condensation inside the case, it will be necessary to change the oil more frequently than specified above. The only sure way of determining the condition of the oil is to have a sample of it checked at a laboratory. Most oil suppliers furnish this service free of charge.

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A. Lubrication Pump



B. Relief Valve



C. Oil Filter



D. Oil Cooler

FIG. 1 - LUBRICATION SYSTEM COMPONENTS

3. LUBRICATION SYSTEM COMPONENTS
(See FIG. 1)

The heart of the lube system of a standard LUFKIN high speed gear unit is normally a shaft-driven positive displacement pump. The pump (A) creates a positive pressure in the lube system which will normally vary from 15 to 30 PSI. This pressure is set at the factory by adjusting the relief valve (B) on the end of the unit, and should require no further adjustment. After leaving the discharge port of the pump, the oil enters a filter (C) which removes small particles from the oil before they can cause problems in the gear mesh or bearings. Next, the oil enters the oil cooler (D) where the oil is cooled prior to returning to the gear unit. The water flow to the oil cooler should maintain the oil temperature out of the cooler between 110 degrees F. and 140 degrees F. for standard units. The operating temperature of the gear unit will be established after several hours of operation, and should be recorded as a norm to check against periodically. Should the temperature vary from the norm more than 20 degrees, the cause should be investigated immediately.

(See FIG. 2 for cutaway view of unit housing showing typical lube system.)

(See FIG. 3 for LUFKIN standard lubrication schematic.)

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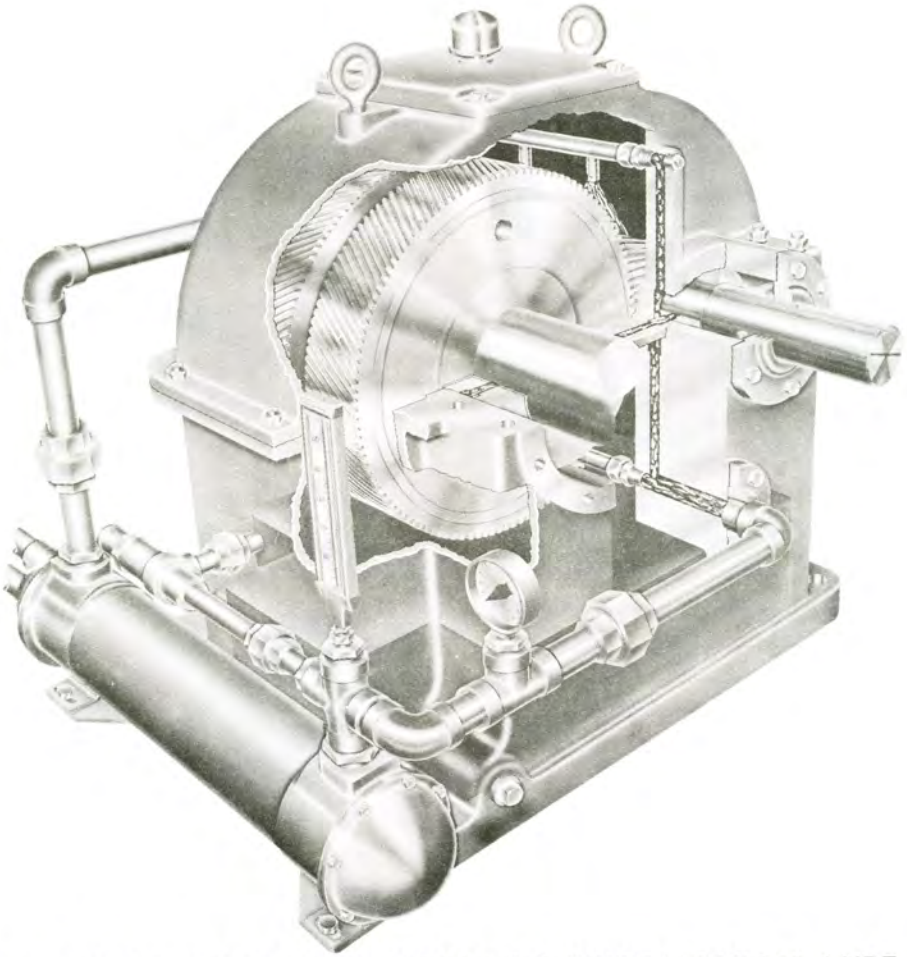


FIG. 2 - CUTAWAY VIEW OF UNIT HOUSING SHOWING TYPICAL LUBE SYSTEM

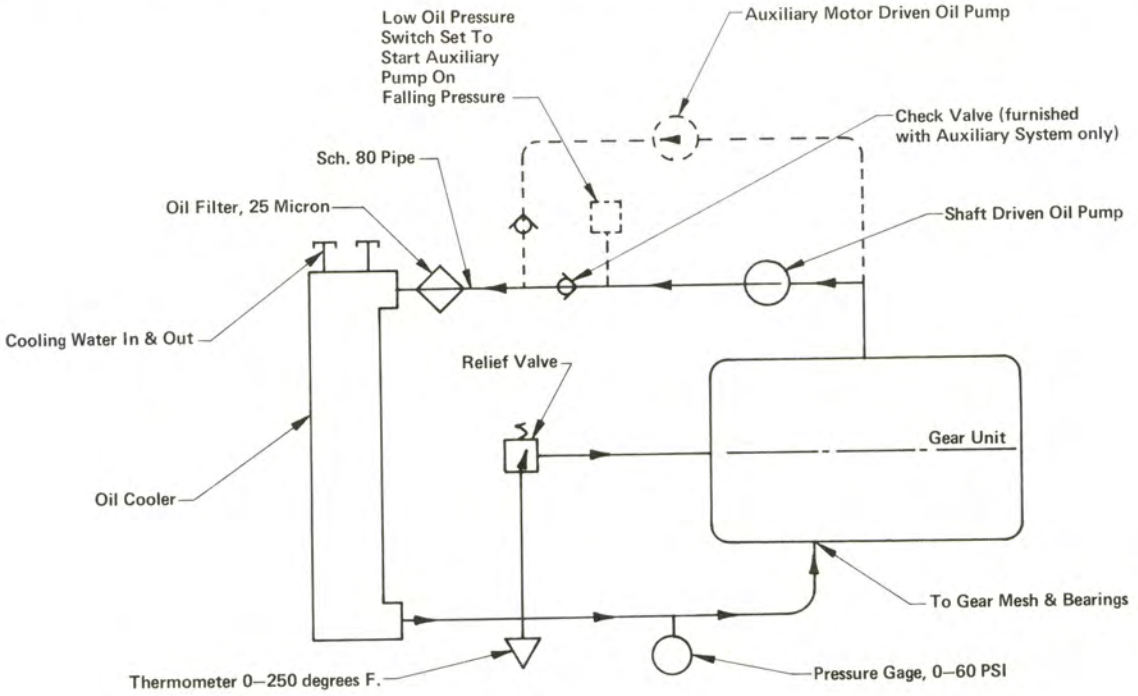
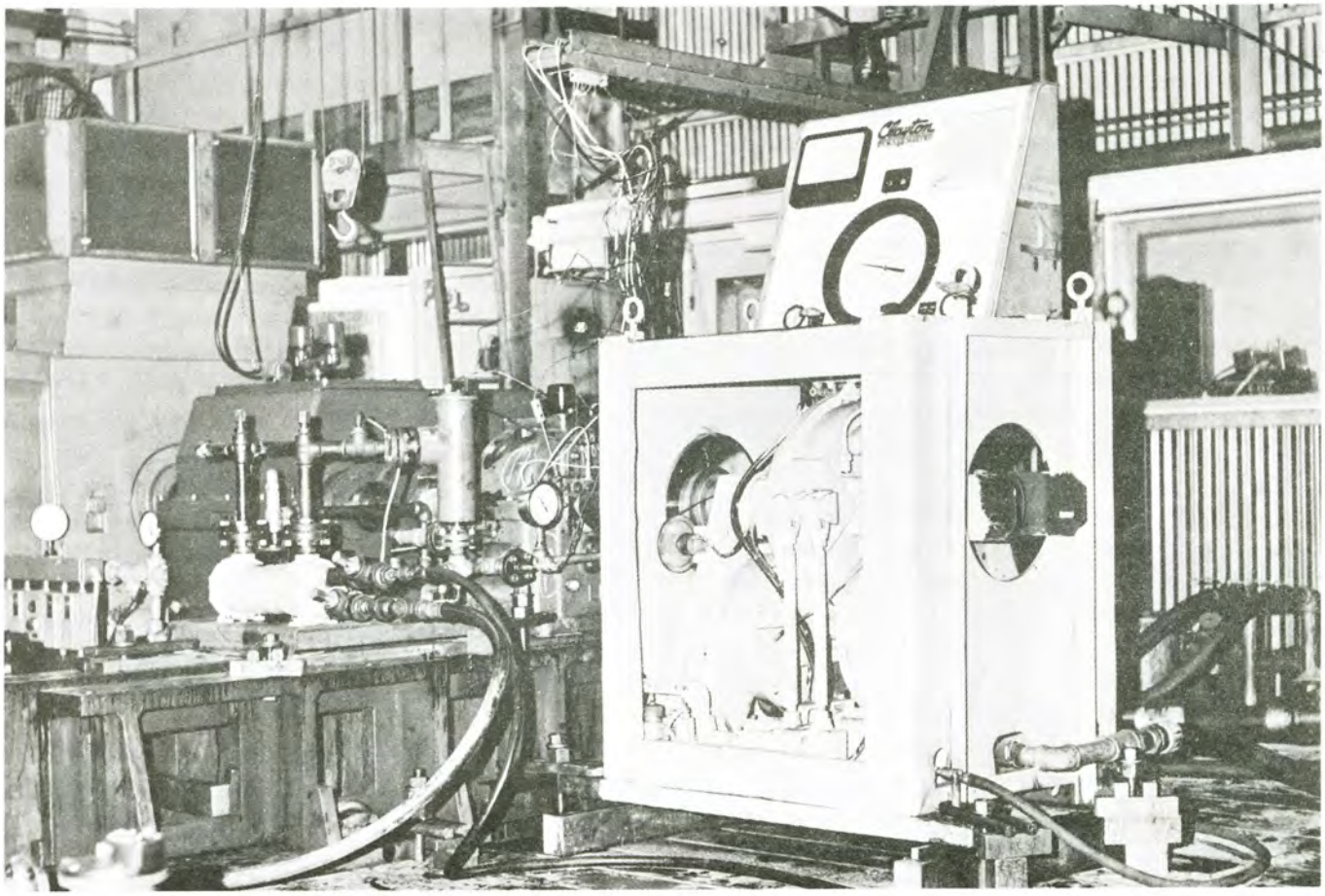


FIG. 3 – LUFKIN STANDARD LUBRICATION SCHEMATIC
(Dashed Lines Indicate Optional Auxiliary System)

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SECTION IV

NEW UNIT CHECK-OUT



1. FACTORY CHECK-OUT

Every LUFKIN high speed gear unit is carefully inspected and tested before it leaves the factory. Standard testing includes running the gear at operating speed with no load. During testing a check is made on housing vibration, bearing temperatures, seal and lubrication piping leaks, lubrication system operation and finally, tooth contact and backlash.

Also available at extra cost is a detailed test of the gear at rated speed and normally, at 10% overspeed with no load, partial load or full load. Data recorded during this type test includes bearing temperatures, shaft and housing vibration levels, oil flow and pressure, oil temperature in and out of gear, and a complete sound level analysis.

2. CUSTOMER CHECK BEFORE STARTING

a. Check the lubrication system for the correct type and quantity of oil. (See LUBRICATION.)

b. Check that pump is primed to minimize the time necessary to build up a positive oil pressure. (Pressure should build up in 10-15 seconds. If pressure does not develop, stop unit and determine the problem.) When an electric driven oil pump or some other remote pump provides lubrication for the gear, it is a good idea to run that pump a few minutes prior to start-up to provide initial lubrication during start-up.

c. Check rotation. Be sure that the gear unit will rotate in the direction for which it is

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intended. The oil pump is unidirectional and must rotate in the direction indicated by the arrow. If other direction is desired, it will be necessary to replace the pump with one of the opposite rotation from our LUFKIN plant.

d. Check for free turning of the shafts.

e. Check for correct coupling alignment.

f. Check to see that all necessary piping and accessory wiring is complete.

g. Check for correct water flow and temperature through the oil cooler.

h. Check for foundation bolt tightness.

i. Check tooth contact (Section II, Part 6).

j. WARNING: Coupling guards and inspection covers should be secured BEFORE start-up.

3. CUSTOMER CHECK AFTER START-UP

a. Run gear unit at light load and reduced speed if possible while checking for proper lubrication. After the unit has been running approximately 15 seconds, the oil pressure should be no less than 15 PSI. If there is a noticeable drop in oil pressure after several hours of operation, clean the oil filter. Occasionally, lint will clog the filter after initial start-up. The later models of LUFKIN "N" and "NM" gears utilize a filter which indicates when it needs cleaning.

b. Watch the bearings for a sudden high temperature rise which could indicate a bearing problem. In general, the bearing temperature rise should be no more than 50 degrees F. above the inlet oil temperature or a maximum of 195 degrees F.

c. Run gear under full load and speed and check for unusual noise, vibration, oil temperature and bearing temperature. Normal vibration limits are shown in Fig. 4 for the shafts, and Fig. 5 for the gear housing. After temperature stabilization, the oil temperature downstream from the oil cooler should generally be no hotter than 140 degrees F. (Some special units are designed to operate with oil inlet temperatures up to 180 degrees F.)

d. After unit has run several hours (6 or 8) under load, shut it down, check coupling alignment, tighten any bolts that may be loose, and recheck tooth contact.

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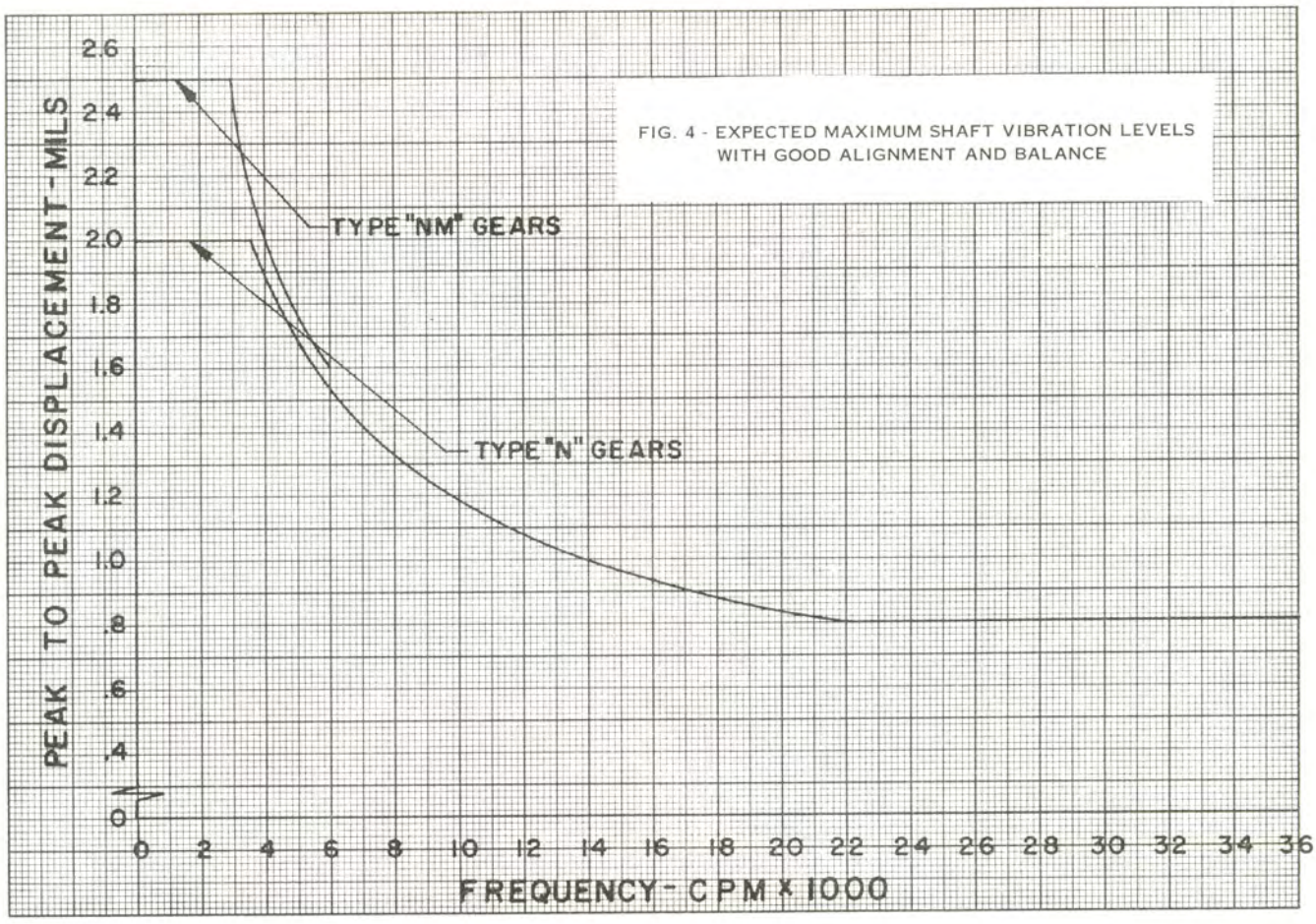


FIG. 4 - EXPECTED MAXIMUM SHAFT VIBRATION LEVELS WITH GOOD ALIGNMENT AND BALANCE

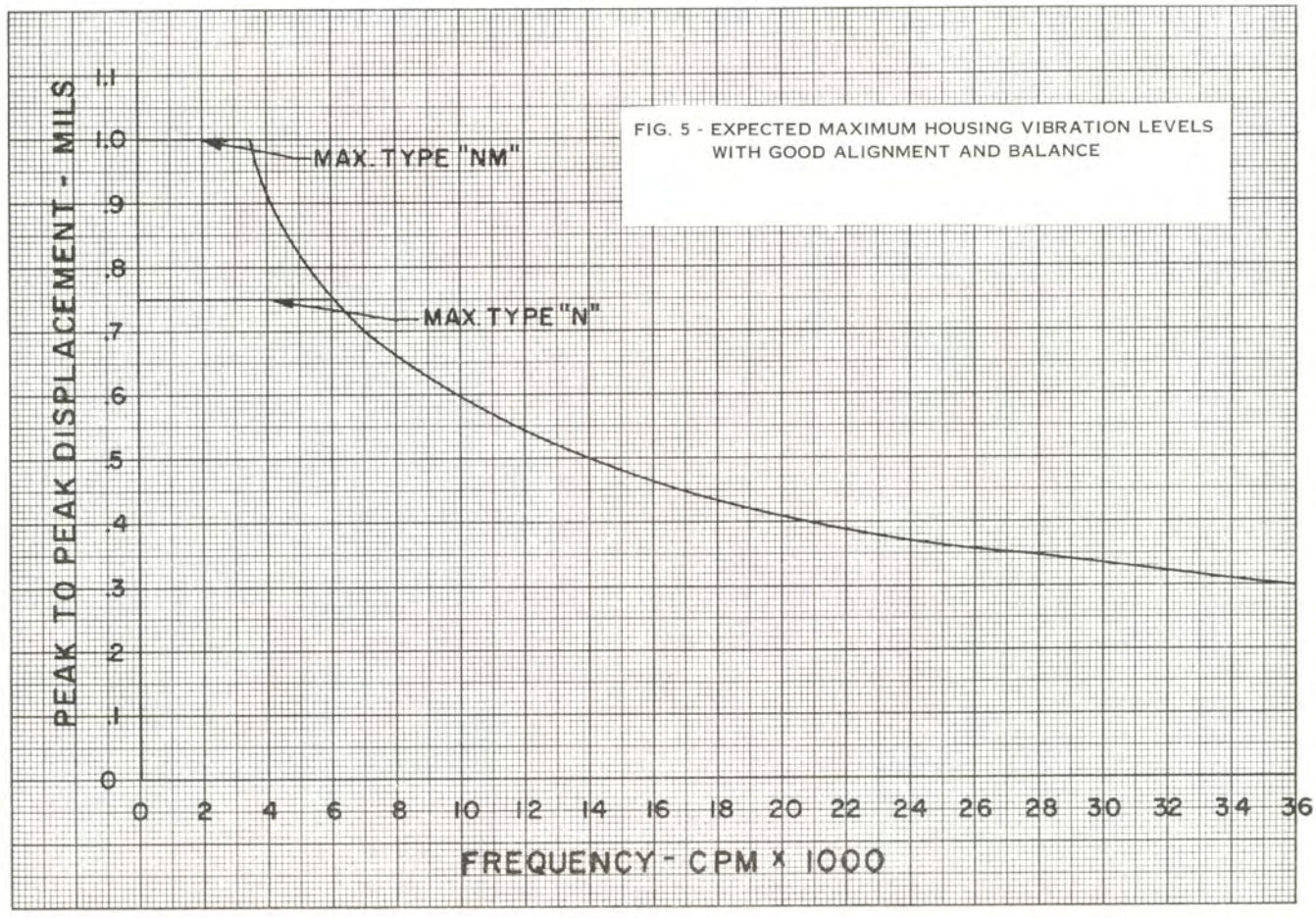


FIG. 5 - EXPECTED MAXIMUM HOUSING VIBRATION LEVELS WITH GOOD ALIGNMENT AND BALANCE

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SECTION V

COMMON GEAR PROBLEMS, THEIR CAUSES AND CURES

1. ABNORMALLY HIGH TEMPERATURE

a. High oil temperature can be caused by an inadequate water flow through the heat exchanger, or by cooling water that is too hot. Check the technical data sheet (Section IX) or Installation Plan data for water flow and temperature.

b. If the oil level in the gear box is so high that the gear runs in the oil, then the resulting churning action will heat up the oil. Check the oil level in the sight gauge and remove oil if necessary.

c. Insufficient bearing clearance may cause high temperature by restricting the oil flow through the bearing. This possible problem should be considered only with replacement bearings since the original bearings are carefully checked at the factory. Check bearing clearance (Section VI, Part 3a) and compare with correct clearance in technical data sheet.

d. If the gear housing should get coated with a foreign material that will not permit natural heat removal by convection, then high temperature may result. To prevent this, the unit should be cleaned periodically.

e. Obviously, a high ambient temperature will cause abnormally high temperature. To prevent this, allow for adequate ventilation around the gear.

f. If the oil flow to the bearings and gear mesh is below normal (indicated by below normal oil pressure), then the heat created by friction at the mesh and bearings will cause abnormally high temperatures. To correct this situation, check the lubrication system (see Part 3 below) for the problem. Maintaining proper oil flow will carry heat to the heat exchanger where excess heat will be removed from the system.

g. Coupling misalignment can cause high operating temperature by introducing unnecessary friction to the gear box. This may be corrected by maintaining proper coupling alignment.

2. UNUSUAL NOISE

a. One common cause of unusual noise is worn parts. If a part wears enough to cause slack in the system, then the slack may be heard as a rattle or noise of some sort. A mechanic's stethoscope may be used to pinpoint the worn part which should be replaced.

b. A coupling that is out of alignment may also cause noisy operation. The misaligned coupling causes misalignment in the gear train which produces noise or vibrations. The coupling should be immediately realigned before damaging wear occurs.

3. LOW OIL PRESSURE

a. One possible cause of low oil pressure is the use of a lubricant which has a viscosity less than that for which the lube system was designed. There are several orifices in the lube system which are sized for lubricants with a particular viscosity. A lubricant with less than normal viscosity will pass through the orifices without building up pressure. This situation can be prevented by using the lubricant designated on the name plate of the gear unit. Abnormally low viscosity may also result from high lubricant temperatures. (See Part 1 on abnormally high temperatures.)

b. A clogged oil filter will also cause low oil pressure. Cleaning the filter will allow more oil to flow through it, thus bringing the oil pressure back to normal.

c. Another cause of low oil pressure is pump cavitation. Should the oil level in the sump

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get so low that the pump suction line sucks both air and oil, then the oil pressure will drop off. This problem may be cured by maintaining proper oil level in the sump.

d. Another cause of low oil pressure is an air leak in the suction line to the pump. This situation is similar to pump cavitation in that air gets in the oil and results in low oil pressure. To remedy this problem, check and tighten all pipe fittings in the suction line.

e. Worn bearing may also cause low oil pressure. In effect, the bearings are orifices which, if enlarged by wear, will pass more oil than the lube system was designed for, thus creating low oil pressure. If low oil pressure caused by worn bearing is suspected, check bearing clearances and replace any worn bearings.

f. An incorrect relief valve setting may also cause low oil pressure by venting the pump discharge line back to the sump before proper pressure is built up. The relief valve may be reset by adjusting the spring adjusting screw under the cap. (See Lubrication System Components, Section III, Part 3).

4. EXCESSIVE VIBRATIONS

a. Loose foundation bolts may cause the gear unit to vibrate. This may be prevented by checking the tightness of the bolts periodically (See Section VI, "Maintenance").

b. Any unbalanced rotating part may also cause excessive vibrations. In this case, the amplitude and frequency of vibration is directly proportional to the rotational speed of the unbalanced part. In checking for unbalanced parts, make certain that full length half-keys are used in all exposed keyways, and that the correct type of coupling is used. (Check with coupling manufacturer.)

c. A foundation that is not sufficiently rigid may also cause vibration problems. To correct this, reinforce the foundation.

d. At certain speeds a rotating shaft will become dynamically unstable, and the resulting vibrations and deflections that occur may cause damage to the gear unit. The speeds at which the shaft becomes unstable are called the critical speeds. They are a function of the shaft geometry and the type and spacing of the supporting bearings.

LUFKIN engineers analyze high speed shafting to assure that the operating speed of the gear unit is at least 20% away from the lateral critical speed of the shaft. From the above discussion, it is obvious that if vibrations due to lateral critical speeds are to be avoided, then care must be taken to avoid running the shafts over the speed for which they were designed. Also, LUFKIN should be consulted if the coupling type is changed, as the coupling weight is inversely proportional to the critical speed of the shaft.

e. Torsional vibrations may be caused by operating the gear unit with a driver or driven machine which is not torsionally compatible; that is, a system in which the inherent torsional vibrations do not dampen out, but build to damaging proportions.

A mass elastic drawing is made on each high speed unit LUFKIN manufacturers. This drawing is given to the customer, and he is responsible for analyzing the complete system for torsional problems.

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SECTION VI

MAINTENANCE

1. PREVENTIVE MAINTENANCE

Good preventive maintenance habits will prolong the life of the gear unit and possibly help in detecting trouble spots before they cause serious damage and long down time. WARNING: When working near rotating elements, be certain prime mover is turned off and locked. The following schedule is recommended for most operating conditions:

a. Daily Maintenance
   1. Check the oil level.
   2. Check the oil temperature and pressure against previously established norms.
   3. Check for unusual vibration and noise.
   4. Check for oil leaks.

b. Weekly Maintenance
   1. Inspect filter for possible flow obstructions.

c. Monthly Maintenance
   1. Check operation of auxiliary equipment and/or alarms. CAUTION: Do not operate auxiliary oil pump and shaft driven pump at the same time for an extended period of time.
   2. Clean air breather.
   3. Check tightness of foundation bolts.
   4. Clean filter.

d. Semi-Annual Maintenance
   1. Check gear tooth wear.
   2. Check coupling alignment.
   3. Check zinc pencils in heat exchanger.

e. Annual Maintenance
   1. Check heat exchanger for erosion, corrosion, or foreign material.
   2. Check bearing clearance and end play.
   3. Check tooth pattern.
   4. Check condition of oil and change, if necessary.

2. DISASSEMBLY

NOTE: Any work done on a LUFKIN gear during the warranty period without LUFKIN's consent, permits cancellation of warranty.

During disassembly, refer to the installation plan and parts list furnished with this instruction manual, along with the drawings found in this text. Disassemble in the following manner:

a. Disconnect the piping from the shaft-driven oil pump by loosening the pipe unions on either side of the pump, Also, disconnect any other piping or wiring that joins both the gear housing and the housing cover.

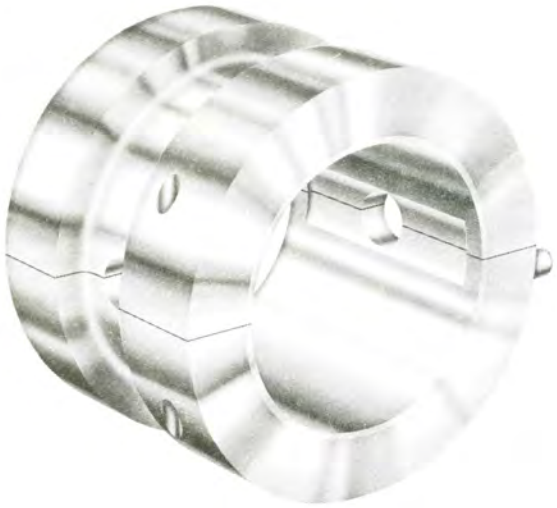
b. Next, remove the cap screws holding the pump adapter, high speed and slow speed shaft seals, and end caps to the gear unit. Move each of the above away from the gear housing. Mark all pieces so they may be replaced correctly.

c. Next, remove all nuts and dowel pins on the parting line. Take care to remove all the dowel pins which are located under the flush plugs between the bores and on each end of the unit. (See your parts list for the exact number of dowels.) If the gear unit has a Kingsbury thrust bearing, it should be removed at this point. Remove the thrust bearing housing end plate and take off the lock nut retaining the thrust collar. Now pull the thrust bearing housing and bearing off the shaft.

d. Remove any bearing thermometers or probes which could be damaged in removing the cover.

e. Next, break the parting line seal by using jacking screw holes located on each end of the gear unit. Attach a crane or hoist to the eye bolts in the cover and lift the cover straight up about 1/4". Check the upper bearing halves to see if they are stuck in the cover. If they are, carefully pry them loose before they fall out and become damaged. Now, lift the cover off the gear housing taking care not to damage the gears, and set it on timbers that will not mar the machined parting line.

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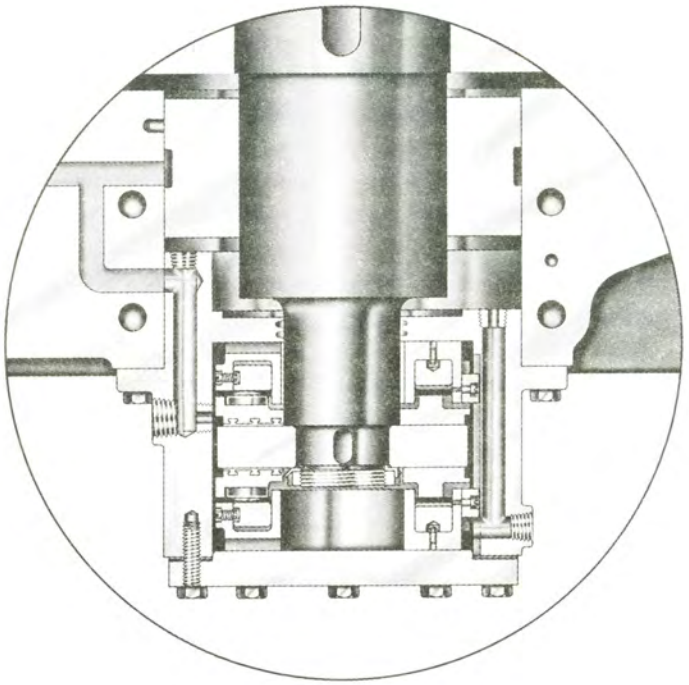
A. STANDARD JOURNAL BEARING



C. FLAT FACE THRUST BEARING WITH RADIAL GROOVES



B. PRESSURE DAM BEARING



D. KINGSBURY THRUST BEARING - SECTIONAL VIEW

FIG. 6 — TYPES OF BEARINGS

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f. Removal of gearing from housing is not required if only bearing replacement or unit inspection is needed. Bearings can be removed and replaced by rolling shells out of housing. Do not remove more than one bearing at a time; replace bearing after inspecting it and prior to inspection of the other bearings. If removal of gearing is required, wire the bearing halves together by running the wire around the oil groove of the bearing. Mark the location of each bearing with its housing bore so that it may be returned to the original location. NOTE: The gear and pinion must be removed from housing to inspect or replace "NM" type bearings.

g. Remove the pinion first by using a soft sling on each side of the mesh. Taking care not to damage the teeth, place the pinion on a soft surface such as wood. Remove the gear by placing eye bolts in lifting holes or by attaching a soft sling in the absence of lifting holes, and lifting with an overhead crane.

3. BEARING DISCUSSION AND INSPECTION
(See Fig. 6 for types of bearings)

The standard journal bearings used on LUFKIN's high speed gear units are split, steel-backed, babbitt-lined journal bearings (A); however, when operating speeds or loads make oil-whirl possible, LUFKIN normally uses pressure dam journal bearings (B). The pressure dam bearing is designed for a particular direction of rotation; therefore, care should be taken at assembly to assure correct rotation. The pressure dam grooves are normally found on the pinion bearings only. However, the gear bearings on some of the smaller units may also require pressure dam grooves in some cases. The grooves are positioned on the unloaded side of the bearing journal as shown in FIG. 7. Type "NM" gears are furnished with one-piece, steel-backed, babbitt-lined journal bearings on high speed shaft only.

To axially locate the gear train and to take any nominal thrust created by external loads, LUFKIN normally uses flat face with radial grooves (C), tapered land or Kingsbury thrust bearings (D) located on the slow speed shaft of "N" units, and tapered roller bearings on "NM" units. The "N" unit thrust areas are sized so that the maximum continuous thrust pressure on a flat face bearing is 75 PSI, while that for a tapered land is 150 PSI.

Carefully inspect bearings and journals for uneven wear or damage. If required, polish journals using belt type crocus cloth and remove any high spots. Sleeve and thrust bearing should be thoroughly inspected for (a) correct clearance, (b) high spots, (c) flaking of babbitt, (d) scoring and (e) wiping.

a. Bearing Clearance
The journal bearings used in LUFKIN high speed gears must have clearance between the journal and the bearing. The amount of clearance necessary depends on the oil viscosity, the journal speed and the bearing loading. LUFKIN engineers consider each of these parameters in calculating a bearing clearance that will produce hydrodynamic lubrication as well as a flow of oil sufficient to cool the bearing. The required clearance for your particular unit may be found in the technical data sheet.

Measurement of bearing clearances may be done by lifting the shaft and measuring the distance traveled with a dial indicator or by using feeler gages, or plastic gage material.

Some wear should be expected, especially on a gear unit that is stopped and started frequently. The bearing may be considered operational as long as the measured clearance does not exceed the design clearance by more than .004 to .005". NOTE: If high shaft vibration develops, this clearance increase may not be acceptable.

The thrust bearing clearance provides room for the formation of an oil film between the bearing face and the gear hub, and for thermal expansion of the shafting. Normally, wear of the thrust bearing is not very critical unless it is enough to cause loss of oil pressure in the lubrication system. Measurement of thrust bearing clearance wear may be done by pushing the slow speed shaft axially to one side of the unit against the dial indicator.

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The end play of the high speed shaft may be determined by holding the slow speed gear stationary and measuring the axial movement of the pinion against the gear. This value should be added to the thrust bearing clearance to obtain the total end play of the high speed shaft.

b. Bearing High Spots

Evidence and location of high spots in the bearing are indicated by bright spots or areas. These spots are caused by wear resulting from a ruptured oil film around the high point. Bright spots should be lightly scraped and polished with fine steel wool or crocus cloth until they blend in with the rest of the bearing. CAUTION: Do Not Use Sand Paper. To check the bearing contact, install lower half of the bearing in the housing with the journal and thrust face clean and dry. Check O.D. of bearing with a .0015 feeler gauge to be sure lower half is seated in the housing. Apply a light coat of Prussian blue to the journal and to each thrust face. The journal should show blue transfer for a minimum of 80% of bearing length. Thrust faces should show a minimum contact of 60% of load area. Contact may be spread out to desired amount by removing high spots using a bearing scraper and fine steel wool or crocus cloth for polishing. Repeat the checking process until contact area is satisfactory.

c. Flaking of Babbitt

Flaking of babbitt in the load area of the bearing is caused by vibration or shock loading of the bearing material which cause the babbitt to fatigue and break loose from the steel shell. Not only do the flakes cause scoring as they pass through the bearing, but they also contaminate the oil. In the advanced stages of flaking, the load carrying area of the bearing is destroyed and the bearing must be replaced. However, if flaking is caught in the early stages, the bearing may be repaired by scraping and polishing. Whatever the case, the cause of vibration or hammering should be corrected before the unit is put back into service.

d. Scoring

Scoring is the scratching or marring of the bearing babbitt and/or the journal riding in the bearing, and is caused by dirt or metal particles in the oil which passes through the bearing. A little scoring is not serious, and the bearing may be polished with fine steel wool to remove any rough edges caused by scoring. Any foreign particles imbedded in the babbitt which could score the journal should be carefully picked out, and that area should then be polished smooth. Scoring becomes serious when it significantly reduces the bearing area. In this case, the bearing should be replaced and the gear unit drained and flushed out with a solvent.

e. Wiping

Wiping is the melting and wiping away of a spot or area of the babbitt due to bearing temperatures rising above the pour point of the babbitt. These abnormal bearing temperatures may be caused by the following: (1) insufficient bearing clearances, (2) insufficient oil pressure, (3) excessively high oil temperature in the bearing, (4) a high spot in the bearing, (5) extreme bearing loading caused by poor bearing contact or a gear mesh failure. If wiping is localized in a small spot, the bearing may be repaired by scraping and polishing the spot until it blends in with the remainder of the bearing; otherwise, the bearing must be replaced.

Before replacing a wiped bearing, determine the cause of the wipe and correct. If new bearings are necessary, the following precautions should be taken:

(1) Remove all nicks and burrs from the housing and bearing shell.

(2) Be sure that journal and thrust faces are free of nicks and high spots. These can be removed using a fine hone and polishing with crocus cloth.

(3) Obtain the proper bearing contact as described in (b) above.

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(4) After bearings are fitted and lower halves are installed in housing, check the radial clearance using plastic gauge material available in most supply stores. Check thrust clearance by barring shaft axially while an indicator pointer is positioned against the shaft.

4. GEAR INSPECTION

During the initial operating period of a set of gears, minor tooth imperfections will be smoothed out, and the working surfaces will polish out under normal operating conditions; however, the life of a gear set may be seriously shortened by the following problems: (a) poor coupling alignment, (b) dirty lube oil, (c) insufficient lubrication, (d) poor tooth contact and, (3) overloading the teeth.

Listed below are several common types of gear wear or failure and a short description of each. These descriptions extracted from "American Standard Nomenclature Of Gear-Tooth Wear And Failure" (ASA B6.12-1964) with the permission of the publisher, The American Gear Manufacturers Association, 1330 Massachusetts Avenue, N.W., Washington, D.C. 20005. Additional information with pictorial illustrations may be found in this bulletin.

a. Scoring

The term scoring has been selected as preferable to other terms such as scuffing, seizing, galling, etc. It is the rapid removal of metal from the tooth surfaces caused by the tearing-out of small contacting particles that have welded together as a result of metal-to-metal contact, and the scored surface is characterized by a torn or dragged and furrowed appearance with markings in the direction of sliding. Sometimes surface roughness of foreign matter passing through the mesh will cause localized yielding on the mating profile, without tearing as such, with a similar furrowed appearance as a result of the "plowing" action. It may be localized initially and spread if the causative condition is not corrected. Sometimes, particularly in the case of misalignment, the damage may cease and the surface becomes smoother as the contact area spreads and more load-carrying face is brought into contact. Scoring is usually caused by rupture of the oil film resulting from load concentration at localized contact areas. Excessive unit loading or an unsuitable lubricant has the same effect. Sometimes scoring can be arrested by smoothing up the roughened area by filing or stoning, or by use of a different type or grade of lubricant.

b. Surface Fatigue

Surface fatigue is the failure of the material as a result of repeated surface or sub-surface stresses that are beyond the endurance limit of the material. It is characterized by the removal of metal and the formation of cavities. These cavities may be small and remain quite small; they may be small initially and then combine or increase in size by continued fatigue; or they may be of considerable size at the start.

c. Initial Pitting

Initial pitting is the type of surface fatigue which may occur at the beginning of operation and continue only until the overstressed local high areas of the surface have been reduced, thus obtaining sufficient area of contact to carry the load without further impairment. It usually occurs in a narrow band just below or at the pitchline. Such pitting is not serious since it is corrective and nonprogressive.

d. Destructive Pitting

Destructive pitting is a form usually starting below the pitchline, progressively increasing in size and number of pits until smoothness of operation is impaired. The remaining surface fails in a similar manner, and finally the tooth shape is destroyed. The pits constitute stress raisers which may lead to failure by fatigue breakage. Large pits formed by the joining of smaller adjacent pits are due to failure of the material between them and constitute a form of spalling.

e. Fatigue Breakage

Fatigue breakage is the most common type of failure by breakage. It results from repeated bending stresses that are above the endurance limit of the material. Such

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stresses can result from poor design, overload, misalignment, or from inadvertent stress raisers such as notches, surface or subsurface defects, etc. It originates as a crack on the loaded side usually in the fillet at the edge of the face, and progresses to complete failure either along the root or diagonally upward across the tooth. Fatigue fractures are usually characterized by a series of clam shell contour lines and a focal point in an area that is smooth by comparison. In the case of a subsurface point of origin, the eye (focal point) at the bottom of the cavity is highly polished.

It should be understood that the above-mentioned types of wear do not necessarily constitute failure, for failure is a matter of degree or rate of progression. It is recommended that before a questionable gear set is considered inoperative, a periodic examination be made with photographs or carbon impressions to determine whether or not the observed condition is progressive. As mentioned before, good tooth contact is essential to long gear life. To check the tooth contact, see Section II, Part 6.

5. ASSEMBLY

a. Before reassembling the gear unit, carefully clean the interior of the gear housing, the internal parts and the parting line.

b. Next, check the bearing shells, the parting line, and the housing bores for any burrs or nicks which should be removed with a fine file. Before installing bearings, please note that they are matched marked and ARE NOT interchangeable.

c. Now install lower half of plain sleeve bearing (the half with roll pin in it) in the housing in the position for which it was marked at disassembly. Check with a .0015 feeler gauge to see that lower halves are seated. CAUTION: If new bearings of the pressure dam type are used, care should be taken to see that they are assembled for the correct rotation. (See FIG. 6). Next, assemble the thrust bearing around its proper journal using heavy wire around oil groove to hold the bearing together on the shaft. NOTE: Do not attempt to install shafts with lower halves of thrust bearing in the housing. To do so may damage babbitted thrust faces. Lift the low speed gear with thrust bearings in place, and place the assembly in its correct location in the gear housing. Now, remove the wire and the top halves of the thrust bearings. Place the pinion in mesh with the gear, and set it in its bearings.

d. Bearings should be checked for correct bearing contact using Prussian blue as described in Section VI, Part 3b. This may be done by rolling out one shell at a time for inspection of blue transfer.

e. After bearing contact is satisfactory, the gear tooth contact may be corrected by scraping and polishing one of the bearings loaded in the lower half. This procedure will spread the contact along the face width. FIG. 7, Page 20 gives the direction of loading for the various conditions of rotations and gear unit types. For example, if you wish to spread the gear tooth contact in condition (A), you should scrape one of the bearings under the gear since these bearings are loaded in the lower half. Scrape that bearing which, when lowered, will spread the contact across the face of the gear. Scraping for contact should be limited to .001" of babbitt thickness. Before putting the cover on the gear unit and after scraping, the bearings should be liberally lubricated with clean lube oil to provide for initial start-up lubrication.

f. Coat split line with small bead of sealer such as Loctite No. 49 plastic gasket (orange container). Circle all studs to assure sealing of oil. CAUTION: Do not block oil passages with the sealer. Lower cover over studs with care so as not to damage gearing. Check thermocouples or thermometer for hole line up at this point -- it may be necessary to remove cover and turn a bearing slightly. Install tapered dowels and draw cover down uniformly.

g. If a Kingsbury thrust bearing is used, it should be mounted at this time. (See FIG. 6, Part D). Assemble the bearing in the housing and position the assembly over the shaft extension, piloting the thrust

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housing into the gear housing. Set the thrust collar key and draw the locknut and washer up tight against the thrust collar. The correct thrust bearing end play may be found in the data section of this manual. This end play may be obtained by shimming the end plate of the thrust housing.

h. Attach the oil pump to the gear housing by stabbing the pump tang or coupling into its mating half. Pack the coupling drive with grease to reduce wear.

i. Mount the shaft seals, end plates, and any other auxiliary equipment which may have been disconnected during disassembly. Note that bearing thermometers should be positioned so that the tip rests on the bearing material. The bearing shell may need to be turned slightly so that the thermometer holes in the housing cover and bearing line up permitting the thermometer to return to its original position.

6. CORROSION PROTECTION DURING INOPERATIVE PERIODS

a. On new gear reducers shipped from our plant, the rust inhibitor adhering to exposed surfaces should prevent corrosion of interior parts for at least six months. However, LUFKIN cannot assume responsibility for corrosion damage occuring after the rust inhibitor has been removed by the gear lubricant or passage of time.

b. When the user adds the recommended lubricating oil and the reducer is operated for a period of time, the oil should protect interior parts for inoperative periods up to 30 days.

c. If additional down time is needed, the customer should spin the reducer every 30 days to redistribute the oil to the non-submerged parts and gain another 30 days protection.

d. If extended down time is expected and it is impractical to spin the reducer, a rust preventive type oil should be brushed or sprayed on the gear teeth and bearings. Any openings such as breathers or labyrinth seals should be sealed with masking tape. A quality rust preventive oil should give 12 months protection against corrosion. This oil should be compatible with the operating oil, and it should be unnecessary to remove the rust preventive oil when the reducer is started again.

e. For adverse conditions or long term storage seal all openings and fill unit completely full of oil. The oil can be the normal operating lubricant. When the equipment is to be used, the seals must be removed and the oil level dropped to the proper operating level.

f. A second method for long term storage is to disassemble the unit and coat each part with Cosmoline or equivalent. Before unit can be placed in service, special cleaning with solvents will be necessary to remove all preservatives from unit and parts.

NOTES:

(1) Options (a) through (d) assume normal atmospheric conditions.

(2) LUFKIN can furnish trade names of rust preventative oils as well as the proper lubricating oils.

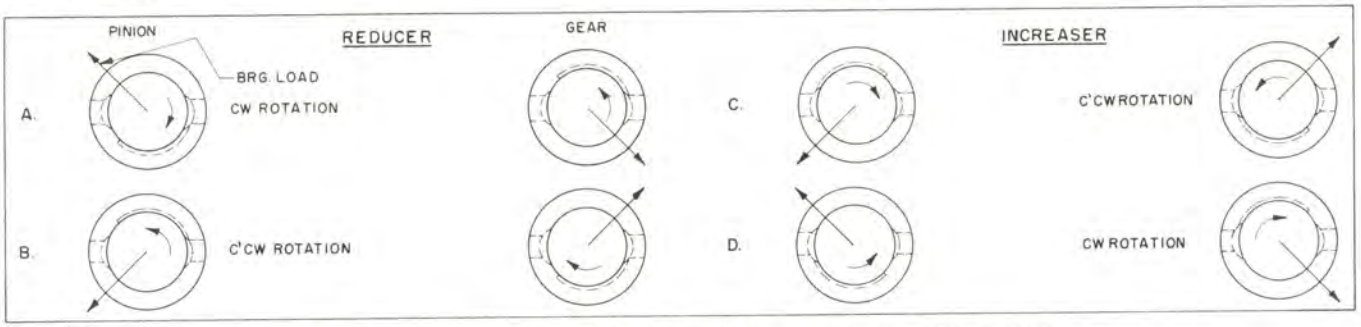


FIG. 7 - PRESSURE DAM BEARING GROOVE LOCATION

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SECTION VII
AUXILIARY EQUIPMENT

Various types of auxiliary equipment may be used with LUFKIN gear units to safeguard their operation. For example, a high oil temperature switch may be used to monitor the lube oil temperature into the bearing. When that temperature reaches a predetermined level, the switch sounds an alarm. Another example is a low oil pressure switch. This switch sounds an alarm and/or starts an auxiliary oil pump which maintains the proper oil pressure should the main oil pump fail. Another piece of safety equipment that is becoming more popular now is non-contact proximity probes. These probes may be mounted on the gear unit to monitor vibration levels of the shafts and thus predict bearing or gear problems before they cause serious trouble.

The trip levels of the above switches vary with the speed and conditions of the gear unit; however, the levels for your particular gear unit may be found on the installation plan provided with each gear unit, or by requesting a complete data sheet from LUFKIN. A sample data sheet is shown in Section IX. Other types of auxiliary equipment are available such as: oversize lube oil pumps, thermocouples, oil heaters, couplings, coupling guards, sound enclosures, soleplates, etc.

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SECTION VIII
SHAFT AND COUPLING ALIGNMENT

1. JOURNAL RUNNING POSITIONS

FIG. 8 shows the position of the journal centers after the gear unit reaches operating temperature and loads. When alignment is started, these mechanical and thermal movement values should be calculated and recorded on the figure for future reference.

2. THERMAL & MECHANICAL MOVEMENT

Thermal movement can be calculated by multiplying the co-efficient of thermal expansion (.00000655 - cast iron) times the distance involved; either vertical height or horizontal offset, by the anticipated temperature rise above ambient. Normally, the temperature rise will range from 30 degrees to 70 degrees F. when an ambient temperature of 90 degrees F. is assumed.

Mechanical movement must be estimated from journal clearances and direction of rotation.

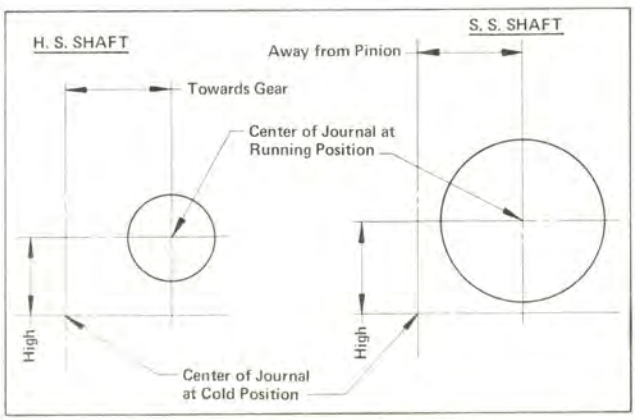


FIG. 8 - JOURNAL POSITIONS

3. ALIGNMENT

The thermal and mechanical movements have been determined as .007 vertical and .002 horizontal toward the gear in the example illustrated in FIG. 9. Using these values, the cold indicator reading should be as shown in FIG. 10. This example assumes that the pump remains in the ambient condition. If this is not true, the indicator readings must be corrected for the pump movement.

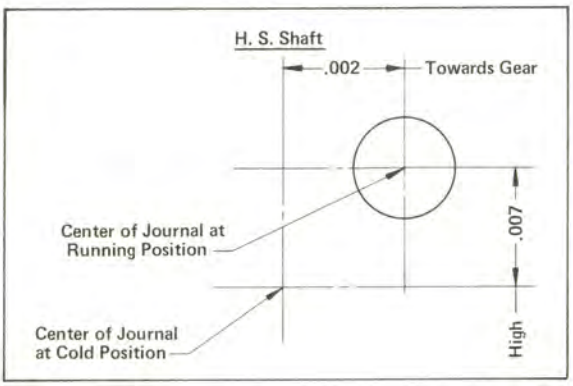


FIG. 9 - EXAMPLE OF THERMAL MOVEMENT
(This example assumes that the driver or driven machine remains in the ambient condition.)

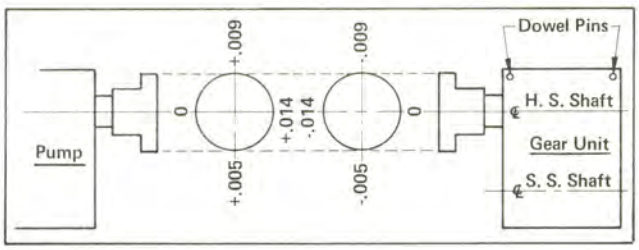


FIG. 10 - IDEAL COLD ALIGNMENT

4. METHOD OF CHECKING ALIGNMENT

After unit has reached operating temperatures, coupling halves should be separated and alignment checked and indicator readings recorded as quickly as possible. NOTE: A coupling alignment worksheet has been included in the back of this section for recording readings.

The most accurate method of checking alignment in the ambient condition is by clamping a spanner arm to one of the shafts (shaft "B" in FIG. 11) and spanning the indicator arm across to the mating shaft or coupling hub. For flanged type couplings, use two dial indicators for reading outside diameter and face as illustrated in FIG. 11. (Other types of couplings may require set-up variations.) Proceed in the following manner:

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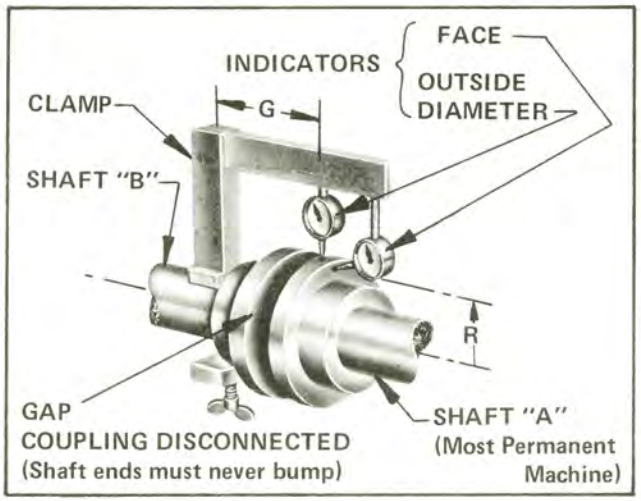


FIG. 11 - COUPLING ALIGNMENT

a. Perform check for indicator arm sag (see FIG. 12).

b. Record approximate "R" dimension.

c. Record ambient temperature.

d. Hand rotate shaft "B" around shaft "A". (Always rotate the gear shafts in the direction that they will turn under load.) Do not reverse rotation during alignment check.

e. Record the outside diameter and face indicator readings at 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock positions. Shift shaft "B" into the same relative axial position prior to each face reading (that is, with prize bar, move shaft axially in one direction until all axial clearance is removed).

f. Correct alignment as needed. Consider also the anticipated thermal and mechanical changes as discussed in Part 2.

5. CHECKING INDICATOR ARM SAG

Prior to taking indicator readings for coupling alignment check, the indicator arm that clamps to the shaft must be checked for possible gravity sag. This spanner device must be rigid enough to minimize deflection due to weight of the arm and indicators. The check can be made by using the following method, as illustrated in FIG. 12.

a. Rotate clamp while attached to shaft, observe change in outside diameter indicator reading at 90 degree positions.

b. When changes in indicator readings dictate, reduce sag by (1) keeping "G" dimension as short as possible (2) using light weight indicators and (3) using one indicator at a time.

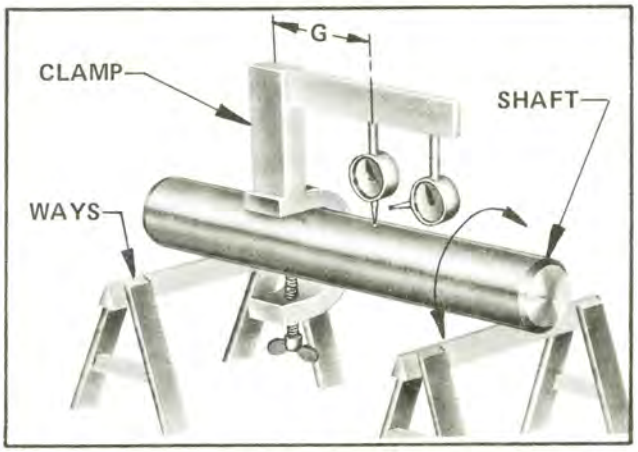


FIG. 12 - CHECKING INDICATOR ARM SAG

6. HOT ALIGNMENT CHECK

After all components have run long enough to stabilize operating temperatures, a hot alignment check should be made as quickly as possible. Indicator clamps for bridging across the coupling sleeves and/or hubs should be installed as shown in FIG. 13. This method allows the hot alignment check to be made without disconnecting the coupling halves. Proceed with hot alignment check in the following manner:

a. Record ambient temperature and oil sump temperature on worksheet provided at back of this section.

b. Rotate shafts in the direction they were designed to operate under load conditions.

c. Record the approximate "R" dimension and the outside diameter and face readings at 90 degree intervals starting at 12 o'clock. NOTE: Readings and correction requirements should be noted before unit temperatures reach ambient conditions.

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d. Correct alignment as needed.

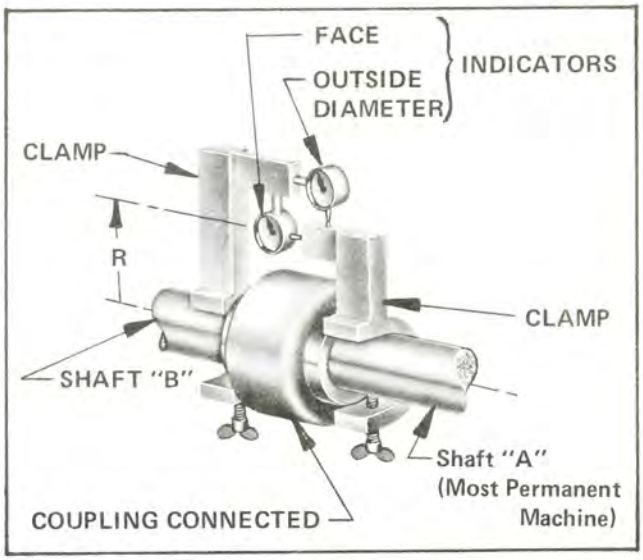


FIG. 13 - HOT ALIGNMENT CHECK

Work machinery until operating temperatures are stabilized, then:

(1) Quickly install clamps and indicators at both couplings.
(2) Hand rotate shafts in the direction they will turn.
(3) Record the approximate "R" dimension and the outside diameter and face readings at 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock.

NOTE: The maximum allowable run-out, total reading (TIR) inches can be found in Table 1.

Shaft Surface Velocity	Outside Diameter, TIR	Face, TIR
5000 fpm and up	.002	.0004 per inch of R
3000 to 5000 fpm	.004	.0005 per inch of R
1500 to 3000 fpm	.006	.0006 per inch of R
500 to 1500 fpm	.008	.0008 per inch of R
500 fpm and down	.010	.0010 per inch of R

TABLE I. - MAXIMUM ALLOWABLE RUN-OUT, (TIR) INCHES

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COUPLING ALIGNMENT (Work Sheet)

	DRIVER	COUPLING	LUFKIN L/O	COUPLING	DRIVEN
Mfg.					
Model					
Serial					

COLD CHECK Temperature _____°F. Ambient

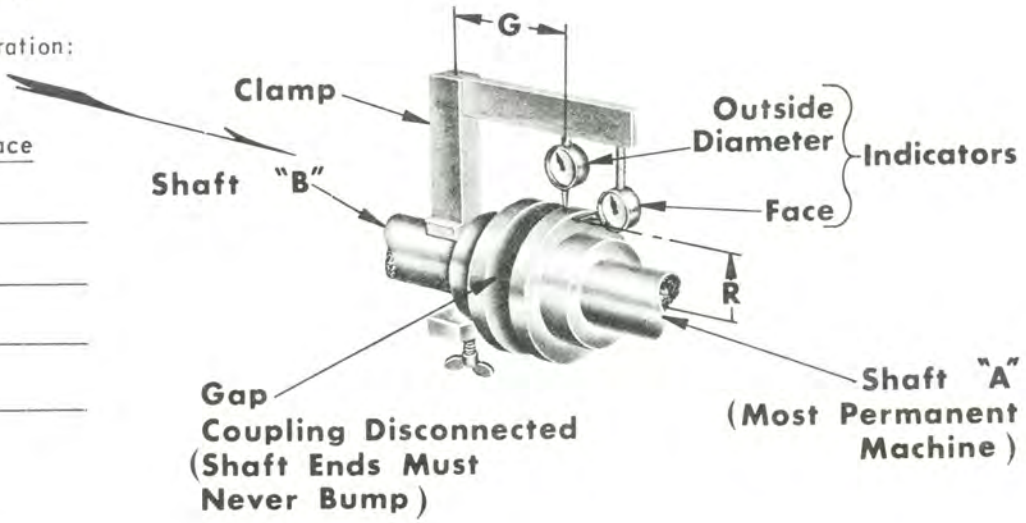
Rotate Shaft "B" around Shaft "A"

Viewed from Left End of Illustration:

Position	*Outside Diameter	*Face
12 o'clock		
3 o'clock		
6 o'clock		
9 o'clock		

*plus or minus

Record Arm "R" _____



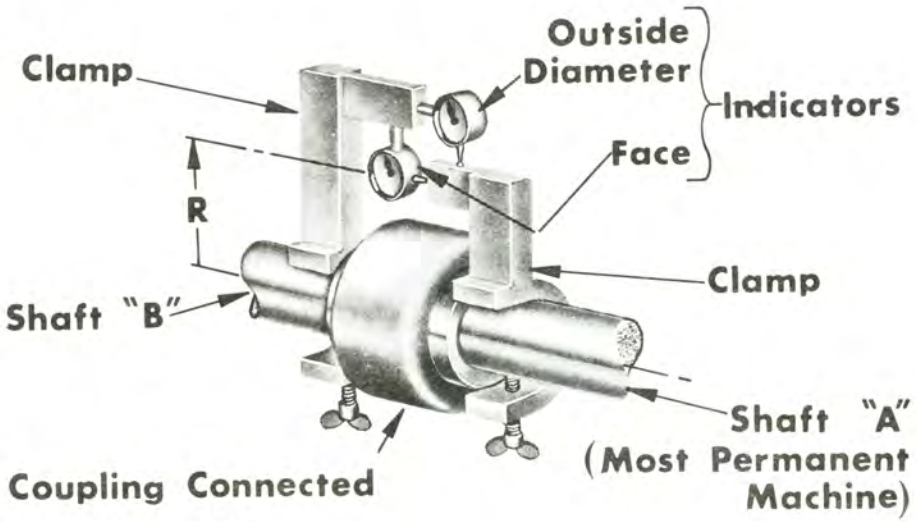
HOT CHECK Temperature____°F. Ambient, _____°F. Sump Oil

Rotate Shaft "B" and Shaft "A"

Position	*Outside Diameter	*Face
12 o'clock		
3 o'clock		
6 o'clock		
9 o'clock		

*plus or minus

Arm R _____



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SECTION IX

TECHNICAL DATA SHEET

Data Sheet For N_____ C– _____

Parts List: _____
Installation Plan: _____
Mass Elastic Drawing: _____

NAME PLATE DATA:

Ratio: _____ Serial No.: _____
Input RPM: _____ Output RPM: _____
Catalog Rating: _____ HP Service Rating: _____ HP
Service Factor: _____ Purchase Order No.: _____
Use AGMA No. _____ Oil (_____ SSU @ 100 degrees F.)
Cooling Water Required: _____ GPM @ _____degrees F.

BEARING DATA:

H. S. Bearing Clearance: _____ "
L. S. Bearing Clearance: _____ "
Thrust Bearing Clearance: _____ "

ALIGNMENT DATA:

Vertical Movement: H. S.: _____ L. S.: _____
Horizontal Movement: H. S.: _____ L. S.: _____

Values are tabulated assuming unit is doweled on
H. S. end with a temperature rise of____degrees F.

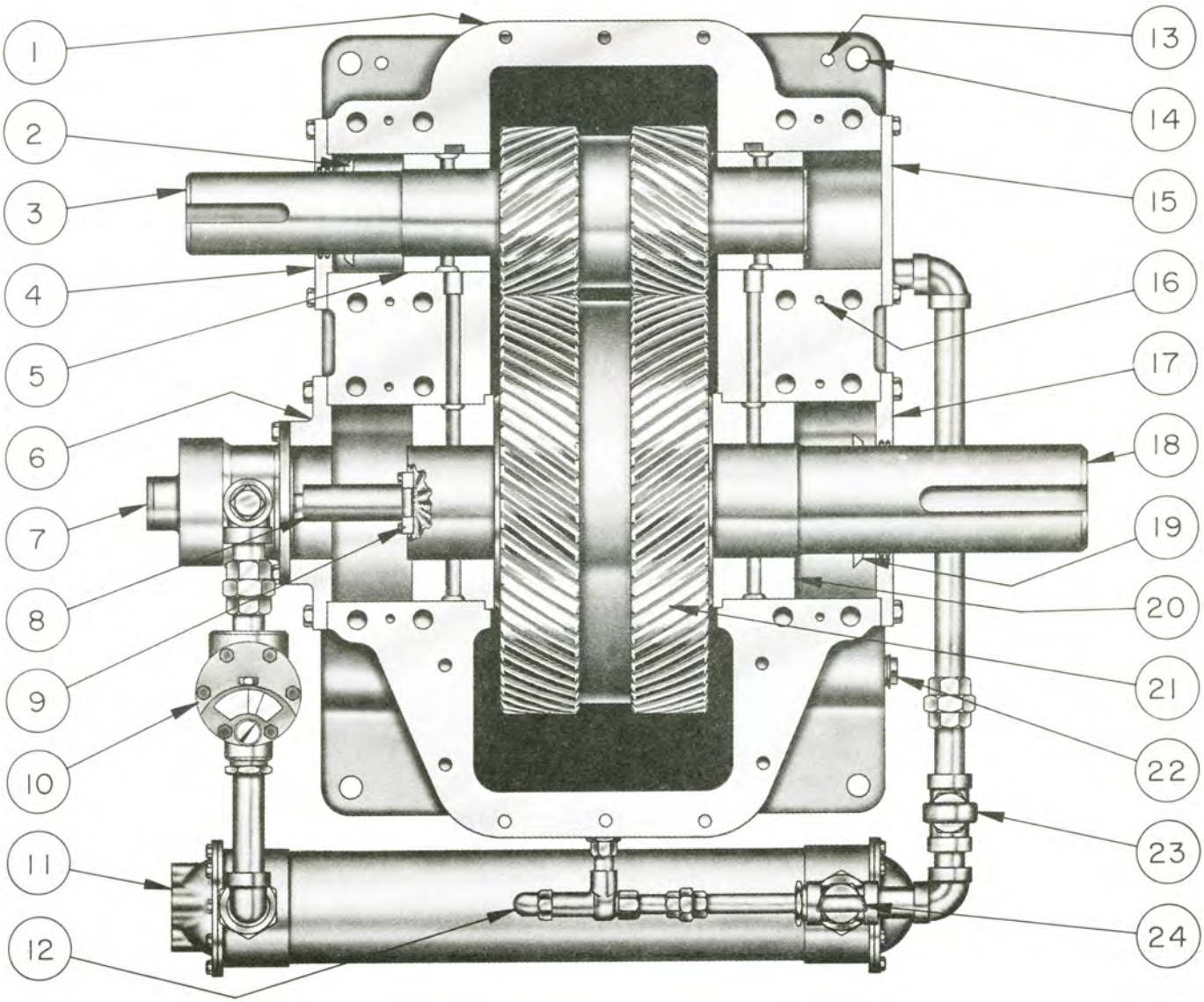
SET POINTS FOR PROTECTIVE EQUIPMENT:

Low Oil Pressure: Alarm _____ Shutdown _____
High Oil Temperature: Alarm _____ Shutdown _____
High Bearing Temperature: Alarm _____ Shutdown _____

NOTE: The above data sheet will be furnished upon request, complete with all technical data for each LUFKIN "N" or "NM" gear unit.

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SECTION X
TYPE "N" HIGH SPEED GEAR

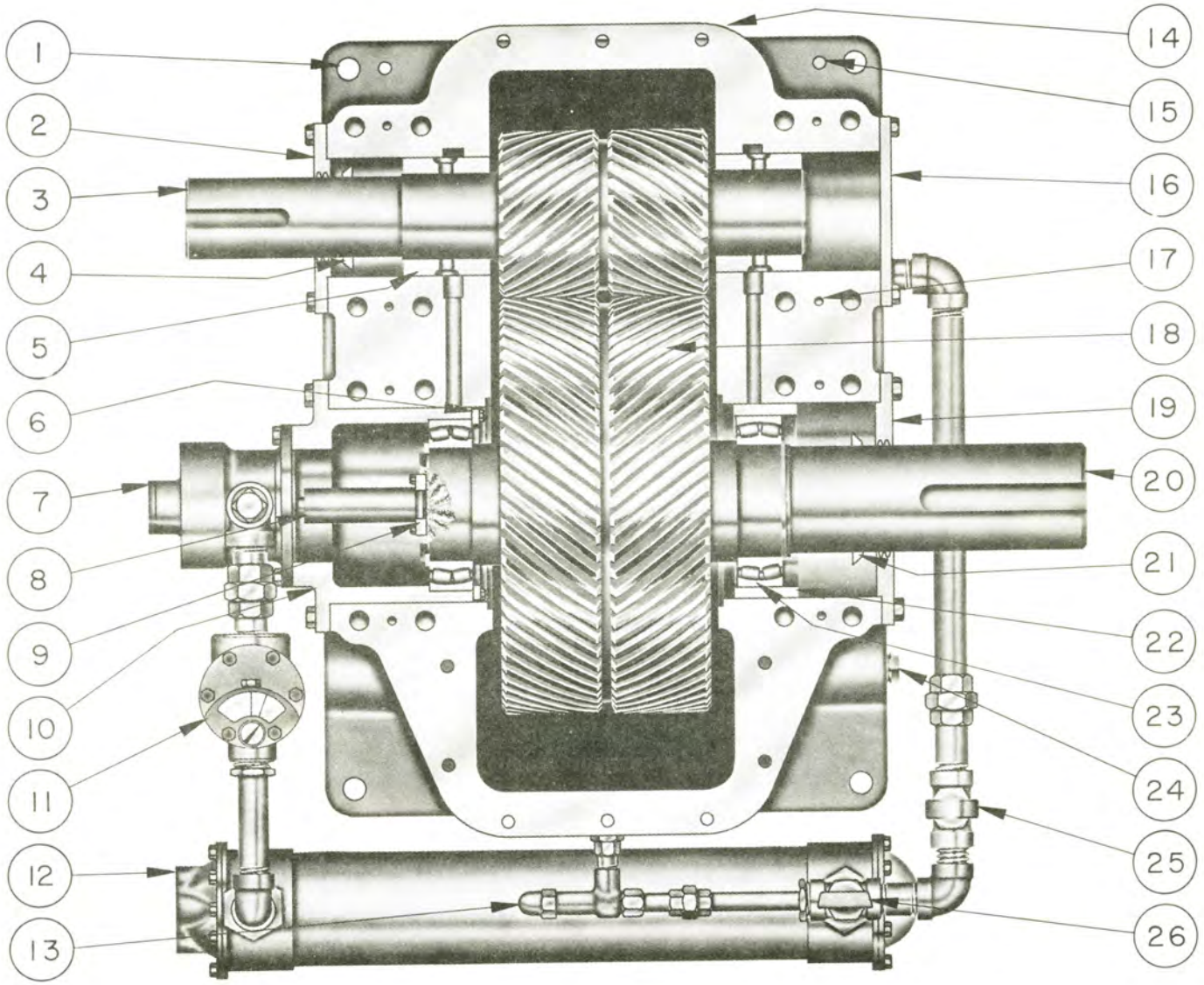


DESCRIPTION OF PARTS

1. Housing Assembly
2. H. S. Slinger
3. H. S. Pinion
4. H. S. Seal Cap
5. H. S. Bearing
6. Pump Adapter
7. Oil Pump
8. Pump Coupling
9. Pump Drive Plate
10. Oil Filter
11. Oil Cooler
12. Relief Valve
13. Dowel Pin
14. Foundation Bolt
15. H. S. End Cap
16. Taper Pin
17. L. S. Seal Cap
18. L. S. Shaft
19. L. S. Slinger
20. L. S. Bearing
21. L. S. Gear
22. Pipe Plug
23. Pressure Gage
24. Thermometer

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SECTION XI
TYPE "NM" HIGH SPEED GEAR



DESCRIPTION OF PARTS

1. Housing Assembly
2. H. S. Slinger
3. H. S. Pinion
4. H. S. Seal Cap
5. H. S. Bearing
6. Pump Adapter
7. Oil Pump
8. Pump Coupling
9. Pump Drive Plate
10. Oil Filter
11. Oil Cooler
12. Relief Valve
13. Dowel Pin
14. Foundation Bolt
15. H. S. End Cap
16. Taper Pin
17. L. S. Seal Cap
18. L. S. Shaft
19. L. S. Slinger
20. L. S. Bearing
21. L. S. Gear
22. Pipe Plug
23. Pressure Gage
24. Thermometer

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