Type SU/SD
High Speed Increasers and Reducers

Installation, Operation & Maintenance Instructions

P-6004-NG

Nuttall® Gear

An **Altra Industrial Motion** Company

Product Safety Information:

General - The information provided within this document is intended to give guidance to personnel responsible for selecting, installing, maintaining, and operating Nuttall Gear products. This information must be made available and reviewed by the aforementioned parties to ensure proper installation, safe operation, and proper maintenance of Nuttall Gear products is achievable. Provided below is a list of potential hazards that are not listed in any order relative to level of hazard.

Lifting - Follow the lifting instructions as outlined in this manual. Failure to follow these instructions may result in personal injury or death and/or damage to the product and/or surrounding equipment. Always keep clear of elevated loads.

Installation - Installation of all Nuttall Gear products must be performed by suitably qualified personnel in accordance with this manual, local code, and any other supplemental information that may be provided by Nuttall Gear for gear drives with non-standard or special features.

Maintenance - Follow the instructions provided in this manual for recommendations on maintenance frequency and renewal parts. Prior to commencing maintenance on any Nuttall Gear products or associated machinery, personnel must observe hazard warnings and ensure that all loads have been removed from the system and appropriate lockout / tag out procedures are being used. When replacing parts, use only authentic OEM parts supplied by Nuttall Gear. Use of non-OEM parts can lead to improper fits and premature and/or catastrophic failure. In some cases, these failures can lead to injury or death.

Guards - All rotating components (shafts, couplings, fans, etc...) must be safeguarded via rigidly constructed guards that are firmly secured. Guards must be designed and constructed as such to ensure physical contact with rotating or moving parts or entanglement is not possible.

Lubrication - Skin contact with certain lubricants or preservatives maybe harmful; when handling lubricants or preservatives, follow the lubricant manufacturer's recommendations. External machined surfaces of Nuttall Gear products may be protected with a rust inhibitor prior to leaving the manufacturing facility and will require removal at installation; always protect skin from coming in contact with rust inhibitor while removing. Contact Nuttall Gear for more information regarding rust inhibitor. All Nuttall Gear products are shipped without lubrication. Refer to this manual and/or contact Nuttall Gear for lubrication recommendations. Failure to follow lubrication recommendations may result in damage to product and in extreme cases may result in injury to personnel.

Burn Hazard - Operating machinery generates heat and may have external surfaces, and contain lubricants that are hot enough to cause burns. Care must be taken to avoid contact with hot surfaces and lubricants. When possible, allow machinery to sufficiently cool prior to contact.

Fire/Explosion - Lubrication vapors and mist will occur within the gearbox and may seep through openings creating a flammable environment. Do not use open flames or other ignition sources in or near areas that may be subject to lubrication vapors or mists. Contact the lubricant manufacturer for information regarding flammability of the lubricant. When exposed to excessive heat, some materials used in the construction of Nuttall Gear products (such as rubbers and plastics) may decompose and produce hazardous fumes. Care should be taken to avoid exposure to fumes and remains of overheated materials should be handled with the appropriate personal protective equipment. Regular cleaning is required to remove any dirt or dust deposits deeper than 5mm in order to facilitate proper cooling and avoid overheating and fire hazards.

Electric Hazard - Electrical shock may cause serious or fatal injury. Connection of electric motor to the main supply should be made by qualified personnel. Refer to the motor manufacturer for detailed information regarding proper motor connection and care.

Operation - All Nuttall Gear products are provided with a rating nameplate that details the operating conditions for which the product was designed. Operate the unit only at the ratings shown on the nameplate. Before exceeding any of these operational conditions, contact your Nuttall Gear representative for factory approval. Overloading and/or over speeding may result in damage to the unit and may cause injury to personnel. Where gear units provide a backstop facility, ensure that back-up systems are provided if failure of the backstop device would endanger personnel or result in property damage.

Noise - Gearboxes and other associated machinery may produce noise levels that are damaging to the hearing with prolonged exposure. Personnel should wear ear protection when working in areas where these noise levels may exist.

Note - The aforementioned information is based on the current state of knowledge and our best assessment of the potential hazards in the operation of the gear drives. For additional information and clarification, please contact the factory.

Safety Warning Symbols-

Caution – Dangers exist that could result in injury, death or damage to machinery.

Danger (Touch Hazard) – Entanglement in rotating components could result in serious injury or death.

Electrical Hazard – Electrical shock could result in serious injury or death.

Damaging Situation- Could result in damage to unit or associated equipment.

Contents:

Introduction:

The following instructions apply to all Nuttall Gear high speed increasers (SU) and high speed reducers (SD) and exclude Nuttall Gear's TDS Parallel / Right Angle reducers and Moduline Concentric gear drives. If a gear drive is furnished with special features, refer to the supplemental instructions shipped with the gear drive or contact your Nuttall Gear sales representative. This manual must be used in conjunction with the supplemental drawings that were supplied with the gear drive. Where a conflict exists between this manual and supplement gear drive drawings, the drawings take precedence.

The information provided within this Installation, Operation, and Maintenance (IOM) manual must be made available, reviewed and understood by all effected parties to ensure proper installation, safe operation, and proper maintenance of the product.

To protect the warranty of your Nuttall Gear product, installation and maintenance services must only be performed by trained personnel after reading and understanding all instructions that apply to the product (this IOM and supplemental literature provided by Nuttall Gear). Particular attention must be paid to all nameplates and warning tags.

CAUTION: Operate this gear drive only at the ratings shown on the nameplate. Before exceeding any of these operational conditions, contact your Nuttall Gear representative for factory approval.

The gear drive is designed according to the latest standards of the American Gear Manufacturers Association (AGMA), and was designed to meet the load conditions for the service ratings on the nameplate. Proper performance and service life of the gear drive depends on adherence to these operational ratings.

When communicating with your Nuttall Gear sales representative, make reference to the nameplate information and any other information that may be useful in identifying the gear drive.

Warranty:

Warning: Service and repair under warranty must be performed only by a Nuttall Gear authorized service shop; otherwise the warranty will become void.

Nuttall Gear warrants that the product furnished will be free of defects in material and workmanship for a period not to exceed one year from installation or eighteen months from shipment to the purchaser, whichever is soonest. Upon prompt notification and written substantiation that the equipment has been stored, installed, operated and maintained in accordance with Nuttall Gear recommendations and standard industry practices, Nuttall Gear will correct the non-conformity by repair or replacement, at its option, F.O.B. factory.

The warranties set forth in this provision are exclusive and in lieu of all other warranties whether statutory, express or implied (including all warranties of merchantability and fitness for particular purpose and all warranties arising from course of dealing or usage of trade), except of title and against patent infringement. The remedies provided above shall constitute complete fulfillment of all the liabilities of Nuttall Gear whether the claims of the purchaser are based in contract, in tort (including negligence), or otherwise with respect to, or arising out of, the product furnished hereunder.

The system of connected rotating parts—PRIME MOVER AND ACCESSORIES, GEAR DRIVE, AND DRIVEN EQUIPMENT—must be compatible; free from critical speeds, torsional or other types of vibration, within the operating range, regardless of the source of such vibration, and/or it's inducement. Nuttall Gear's responsibility is limited to providing a gear drive within normal commercial levels of vibration generation. Nuttall Gear is not responsible for the unsatisfactory operation or failure of the drive system, resulting from either the incompatibility of rotating components or the analysis required. The system responsibility remains with the purchaser, system builder or designer, unless Nuttall Gear has agreed to perform such analysis, and the nature of such vibrations is fully defined.

Those gear drives supplied with motor/gear couplings mounted must be final aligned by the installer. Nuttall Gear verifies that the motor and gear can be aligned; however, Nuttall Gear does not do final alignment, because of changes that occur during shipment handling as well as foundation variances.

The user is responsible for furnishing and installing any guards or other safety equipment needed to protect operating personnel, even though such safety equipment may not have been furnished by the seller with the equipment purchased.

Nuttall Gear, its contractors and suppliers of any tier, shall not be liable in contract, in tort (including negligence), or otherwise for damage or loss of other property or equipment, loss of profits or revenue, loss of use of equipment or power system, cost of capital, cost of purchased or replacement power or temporary equipment (including additional expenses incurred in using existing facilities), claims of customers of the purchaser, or for any special, indirect, incidental, or consequential damages whatsoever.

The remedies of the purchaser set forth herein are exclusive and the liability of Nuttall Gear with respect to any contract, or anything done in connection therewith, such as the performance or breach thereof, or from the manufacture, sale, delivery, resale, or use of any equipment covered by or furnished under the contract, whether in contract, in tort (including negligence) or otherwise, shall not exceed the price of the equipment or part on which such liability is claimed.

In no event shall Nuttall Gear be responsible for providing working access to the defect, including the removal, disassembly, replacement or reinstallation of any equipment, materials or structure to the extent necessary to permit Nuttall Gear to perform its warranty obligations, or transportation costs to and from Nuttall Gear's factory or repair facility. The conditions of any tests shall be mutually agreed upon and Nuttall Gear shall be notified of, and may be present at, all tests that may be made.

Receiving & Handling:

Warning: Immediately upon receipt examine the gear drive for damage. Notify the carrier and your Nuttall Gear sales representative immediately if there is any evidence of shipping damage. Responsibility for reimbursement for losses or damages incurred during shipment remains solely with the transportation company.

CAUTION: When handling your Nuttall Gear drive:

- **Never use shaft extensions or pump housing for pushing, pulling, or supporting the weight of the gear drive.**
- **Never drag the gear drive. Machined mounting surfaces will be marred and overstressing of the housing may occur.**
- **Lift the gear drive using the lifting lugs or eyebolts provided with the gear drive. These lifting lugs or eyebolts are intended to lift only the gear drive.**
- **When lifting, distribute the load evenly to keep the gear drive from tilting. Spreader bars may be required to avoid stress on any piping and accessories mounted on the gear drive.**
- **Never use piping for lifting or climbing.**
- **If the gear drive is to be stored, refer to the storage instructions in this manual.**

Operating instructions for accessories mounted on the gear drive assembly are normally attached to the gear drive. Save all hardware, accessories, wiring diagrams and instruction information included with the gear drive.

Weights
For standard catalog designs, refer to the table below for approximate gear drive weights. These weights are approximate values for the gear drive only and do not include lubrication or lubrication systems. For a more accurate weight of your gear drive, refer to the outline and/or assembly drawing(s) that accompanied the gear drive or contact your Nuttall Gear sales representative.

Approximate Gear Drive Weight in Pounds

Gear Drive Size Prior to 1999	Gear Drive Size 1999 and Later	Approximate Weight in Pounds (Less lube system)
619-5	619-625	1,000
819-6	819-775	1,350
1023-8	1023-975	1,900
12-6	12-800	2,400
12-8	12-1000	2,500
12-10	12-1200	2,600
14-6	14-800	3,300
14-8	14-1000	3,500
14-10	14-1200	3,700
16-6	16-800	4,100
16-8	16-1000	4,300
16-10	16-1200	4,500
18-8	18-1000	5,200
18-10	18-1200	5,300
18-12	18-1400	5,600

Storage:

General
All internal and unpainted external surfaces of the gear drive have been treated at the factory, prior to shipment, with a rust preventative. The protective life of this rust preventative will vary with temperature fluctuations, atmospheric moisture content, degree of exposure to the elements during storage, and degree of contact with other objects. Inspect all machined surfaces and add rust inhibitor to any exposed metal surfaces that may have had the protective coating removed during shipping and handling. To assure the gear drive will operate satisfactorily at start-up, certain precautions must be taken by the customer upon receipt. The expected length of storage and the storage atmosphere dictate the maintenance schedule to be followed. Gear drives must be stored free of loads on both the output and input shafts. These instructions apply to the gear drive only. If a piping assembly is included with the gear drive, piping component accessory operating, maintenance and storage instructions are included with drawing transmittals and are also attached to the gear drive. These instructions must be carefully read and followed. **Outdoor storage is not recommended.**

Short Term Storage (Indoor)
If the gear drive will be stored for a period of 30 days or less, the following should be observed: Store in a clean, dry location with factory packaging intact, and with as nearly a constant temperature as possible. The gear drive should be elevated in a manner that will prohibit water or other liquids to come in contact with it. Avoid storing the gear drive in areas that are subject to extremes in temperature, vibrations, and humidity. If the gear drive will be secured to its storage surface, via the gear drive's mounting holes, the storage surface must be level to prevent twisting of the housing and subsequent damage to the gear drive. Gear drives should be stored in their operating orientation.

Long Term Storage (Indoor)
If the gear drive will be stored for a period longer than 30 days, the following should be observed: Store in a clean dry location with the gear drive elevated in a manner that will prohibit water or other liquids to come in contact with it. Avoid areas that are subject to extremes in temperature, vibrations, and humidity. If the gear drive will be secured to its storage surface, via the gear drive's mounting holes, the storage surface must be level to prevent twisting of the housing and subsequent damage to the gear drive. Gear drives should be stored in their operating orientation. Remove the breather and replace it with a pipe plug. Pack the entire seal area with grease, to form a vapor barrier, and seal with tape. A vapor-phase rust inhibitor such as Daubert Chemical, Nox-Rust Motorstor VCI-10, or equal, may be added to the recommended oil type in the amount of 10% of the total sump capacity. For wet sump designs, fill the gear drive to the recommended oil level. For dry sump designs, fill the gear drive to within one to two inches of the bearing bores. **Do Not Overfill.** By hand, slowly rotate the high speed shaft long enough to permit the low speed shaft to make at least one revolution. This should be done at least once every four weeks. Inspect the gear drive periodically and spray or add a rust inhibitor suitable for the anticipated storage conditions, as required. Prior to start-up, drain the storage oil mixture and replace with the recommended operating oil to the recommended level. **Do Not Overfill.**

Piping Assemblies
Some gear drives are supplied with a piping assembly designed to deliver lubrication to critical components, and/or to circulate oil through a cooler. These piping assemblies should be completely charged with the same storage oil as the gear drive. If the pump of the piping assembly is motor driven, momentarily jog the motor to circulate oil through the oil sprays and ports. Do not allow the pump motor to run continuously, as the reducer may become pressurized potentially causing shaft/seal vapor barriers to leak. For shaft driven pumps, small amounts of oil will be circulated through the system while hand turning the high speed shaft as noted above. Prior to start-up, drain the storage oil from the piping assembly and refill with the recommended oil type to the recommended level. Confirm oil sprays are not clogged and all filters and strainers are clean prior to start-up.

Installation:

The installation instructions within this manual are intended to be used in conjunction with the outline, general assembly, and schematic drawings that were supplied with the gear drive. If the supplied gear drive drawings and information in this manual present conflicting information, the information on the drawings takes precedence. The continuous efficient operation of a gear drive depends chiefly on four factors:

1. Proper type of foundation and correct mounting.
2. Correct alignment with the driven equipment.
3. Correct lubrication.
4. Full consideration of both preventative and operating maintenance.

CAUTION: Operate the gear drive only within the ratings shown on the nameplate. Review the application to confirm the gear drive will not be operated in conditions exceeding the nameplate rating.

DANGER: Selection and installation of guards, warning signs, or any provisions required to meet national and local safety codes are the responsibility of the user. Ensure all guarding, safety devices, and warning signs are in place prior to starting equipment. Failure to do this may result in serious injury or death.

CAUTION: All warning labels and instructions for installing and operating electrical equipment must be carefully read and followed. All electrical connections must be installed only by qualified personnel in strict accordance with the National Electric Code and local requirements. Compliance with all codes, laws and safety ordinances is the sole responsibility of the user.

Environmental Considerations

Gear drives should not be installed in locations of unusually high or low ambient temperatures. The normal ambient temperature range for high speed gear drive operation is 60°F to 100°F. If low ambient temperature causes sump temperatures to be below 60°F at start-up, special procedures to ensure proper lubrication are required. Refer to the "Abnormal Operating Conditions" or contact Nuttall Gear for specific details. Environmental conditions, including exposure to direct sunlight, high humidity, dust or chemicals suspended in the air are worthy of special consideration. A gear drive exposed to direct sunlight will run hotter than a gear drive in an identical application which is sheltered. Gear drives exposed to these and other adverse conditions should be referred to Nuttall Gear for specific evaluation and recommendations.

Foundation

A foundation or mounting, which provides rigidity and prevents weaving or flexing with resultant misalignment of the shafts, is essential to the successful operation of a gear drive. A concrete foundation should be used whenever possible and should be carefully prepared to conform with data regarding bolt spacing and physical measurements contained in the outline drawing supplied prior to delivery of the equipment. Grout steel mounting pads into the concrete base or foundation; mount the gear drive on these steel pads. **Do not grout the gear drive directly into the concrete base or foundation.** When the gear drive will be installed on structural foundation pads a supporting base plate of steel should be provided to obtain proper rigidity. These plates or pads should be of a thickness equal to or greater than the diameter of the hold down bolts.

Foundation Bolt Torque Recommendations

Gear drives must be securely bolted to their foundations with the specified bolt size. Bolts are to be SAE Grade 5 or equivalent fasteners. Do not lubricate fasteners, as this will promote loosening during operation. Tighten bolts per the torques listed below.

	Torque (Ft. Lbs.)			Torque (Ft. Lbs.)	
Bolt Size (UNC)	**Metal To Metal**	**Metal To Concrete**	**Bolt Size (UNC)**	**Metal To Metal**	**Metal To Concrete**
1/4	8	6	1-1/4	1,050	834
5/16	16	12	1-3/8	1,375	1,084
3/8	28	22	1-1/2	1,842	1,458
1/2	69	54	1-3/4	1,975	1,558
5/8	137	108	2	3,083	2,147
3/4	245	191	2-1/4	4,333	3,417
7/8	380	313	2-1/2	6,000	4,667
1	567	467	2-3/4	8,167	6,417
1-1/8	742	584	3	10,417	8,250

Bedplates

Bedplates are provided as common mounting surfaces that support several components when mounted on a proper foundation. Bedplates are also designed to facilitate alignment of those components. Because of the disparity of component sizes, bedplates are not designed to be self-supporting structures under all conditions. **They are not designed to provide a platform for lifting and transporting with all of the components mounted**, unless the assemblies are properly supported and balanced with appropriate material handling fixtures. There will be occasions when it will be necessary to remove some of the components for transport, and subsequently, reassemble the drive train in its final location. Nuttall Gear supplies the components on the bedplate assemblies rough aligned. However, due to possible shifting in transit or handling and the possible variances in foundation surfaces, **final alignment is the responsibility of the installer.** To align a bedplate supplied gear drive, the output shaft of the gear drive should be aligned with the driven shaft by moving and shimming the bedplate assembly. **This should not be accomplished by moving the gear drive on the bedplate.** Insure that all bedplate mounting points are properly shimmed for proper support to provide a solid level surface. Failure to do so may create a twist in the bedplate and could make final alignment of the drive components difficult. After aligning the gear drive output shaft and shimming between the bedplate and the foundation, the mounting bolts or lugs should be tightened and the bedplate firmly locked and grouted in place. Final alignment of the other bedplate components must now be completed.

Alignment
Frequently, the cause of bearing failure, shaft breakage, overheating, non-uniform gear tooth wear, vibrations, and noisy operations of equipment can be directly traceable to improper alignment. Special attention must be given to cold and hot alignment as well as the mounting of couplings. Gear drives are designed with a tolerance of +0 and -1 /16 inch between the shaft center and the bottom of the mounting feet; as a result shimming may be required. **The use of flexible couplings should not be considered as a means of compensating for improper alignment.** The initial alignment for this type of coupling should be equally accurate to that of a solid coupling. Flexible couplings are generally applied to absorb and prevent the transmission of critical vibrations and/or to permit small lateral movements without imposing undue stress to the connected equipment.

Prior to installing couplings, inspect coupling bores and shaft diameters to verify they meet the dimensions listed on the outline drawings. Inspect the key and keyways for proper, tight fit. The key should fit snugly into the coupling and shaft keyways, with a small clearance at the top of the key, in the coupling. The key should fill the entire keyway. Heat couplings uniformly, and shrink onto the shaft extension. **Do not heat parts above the manufacturers recommended limits.**

Caution: To avoid possible damage to the bearings and gears, couplings must not be installed onto the shaft extensions with a steel hammer. A rawhide, plastic, or soft metal driving device may be used to tap the low speed coupling into its proper location. Do not use a hammer of any type to drive the high speed coupling on; damage to the gear teeth may occur. Do not mount coupling further onto the shaft than its recommended engagement length.

Laser or optical alignment techniques are preferred. Coupling alignment by means of dial indicator is acceptable and should be per the following instructions. The indicator is clamped to one of the coupling halves. The coupling half with the indicator clamped to it is rotated slowly while the other coupling half remains stationary. To check for parallel alignment, the indicator probe is placed on the machined outside diameter of the stationary coupling half. The variation in the readings should be recorded as the coupling half is rotated in the operational direction of rotation. The difference in indicator readings between the two extremities in both the horizontal and vertical planes represents twice the error in parallel offset. The couplings may be brought into alignment by moving both horizontally and vertically the required amount. To check angular alignment, the indicator probe is placed on the machined face of the stationary coupling half. The variations in the readings should be recorded as the coupling is rotated in the operational direction of rotation. Correct alignment as needed. Nuttall Gear recommends a maximum of .002" operating misalignment, angular and offset, or the coupling manufacturers allowable, whichever is less.

When aligning the gear drive with the other equipment, care must be taken to insure the prime mover or driven equipment (whichever is the most difficult to adjust) is secured, and the other items aligned with it. The coupling should permit sufficient end movement of the equipment shafts so that they may operate within their normal axial design limits (i.e. a motor on true magnetic center). The standard gear drive has a ground thrust collar on the low speed shaft and flatland thrust bearings. The high-speed pinion shaft will move with the low speed gear and shaft assembly. The design end play for the low speed shaft is listed on the outline drawing. The gap between shaft ends should be set up with the gear and pinion shafts centered with respect to their total anticipated axial movement (thermal and mechanical). The standard gear thrust faces and bearing collars are designed for momentary centering forces only during start-up. Care must be taken to insure that the low speed gear is running at the center of its total endplay in a "hot" running condition, unless a special high capacity thrust bearing is included. Continuous engagement with the standard thrust bearing could result in damage to the gear thrust face or the thrust bearing. To determine if your gear drive has a special high capacity or a standard thrust bearing, refer to the gear drive drawings or contact the factory. It is essential that thermal growth of the gear drive and connected equipment be anticipated during shaft alignment. In addition, the operational centerline of each shaft should be taken into account during alignment. For thermal growth information on your gear drive, refer to the mass elastic drawing or contact the factory. After alignment has been secured through shimming, the equipment should be bolted down and alignment rechecked. It is of the utmost importance that the gear drive housing not be distorted when its mounting bolts are torqued. Each mounting foot must be checked individually to determine the proper amount of shims. Use broad, flat shims having a large area to support the foot. Flat shims of various thicknesses, slotted to slide around the foundation bolts should be used. All feet must be solidly supported before the mounting bolts are tightened. After alignment has been completed through shimming, the equipment should be bolted down and alignment rechecked. Check for housing distortion by placing a dial indicator on each gear drive mounting foot. The indicator should be clamped to the mounting surface, with the probe on the gear drive mounting foot. If the gear drive mounting foot moves when the bolt is loosened, then distortion is present and additional shimming is required for that gear drive mounting foot. When aligning the gear drive to the connected equipment, it is imperative to make both a cold and a hot alignment check. The cold alignment check as described above is made at ambient temperature. After this has been done and the gear drive has been doweled in the specified location on the high speed end, the gear drive should be brought to operating temperature, the apparatus should be stopped, and an accurate alignment check made while the equipment is still hot. There may be considerable differences in expansion between the driving and driven equipment. A readjustment in alignment as described above should be made to suit the hot running conditions. If these differences are not compensated for, operational difficulties may occur. Check coupling halves for match marks before joining the coupling halves. Lubricate the couplings, if required, per the manufacturers recommendations.

Start-Up:

Pre-start For Gear Drives in Storage

1. Replace the breather if it was removed for storage.
2. Remove all of the tape and grease applied to shaft seal areas during storage preparation.
3. Drain the storage lubricant from the gear drive and flush the gear drive prior to charging it with the recommended lubricant. If the gear drive cannot be flushed, contact your lubricant supplier to confirm the storage lubricant and operating lubricant are compatible.
4. Thoroughly inspect the gear drive, sump, and all accessories for damage.
5. Follow additional start-up steps as outlined below.

WARNING: Nuttall Gear drives are shipped without oil. Prior to start-up, the gear drive must be filled with the proper amount of oil, selected in accordance with the operating conditions. See lubrication section of this manual for more information.

DANGER: Ensure all guarding, safety devices, and warning signs are in place prior to starting equipment. Failure to do this may result in serious injury or death.

CAUTION: All warning labels and instructions for installing and operating electrical equipment must be carefully read and followed. All electrical connections must be installed only by qualified personnel in strict accordance with the National Electric Code and local requirements. Compliance with all codes, laws and safety ordinances is the sole responsibility of the user.

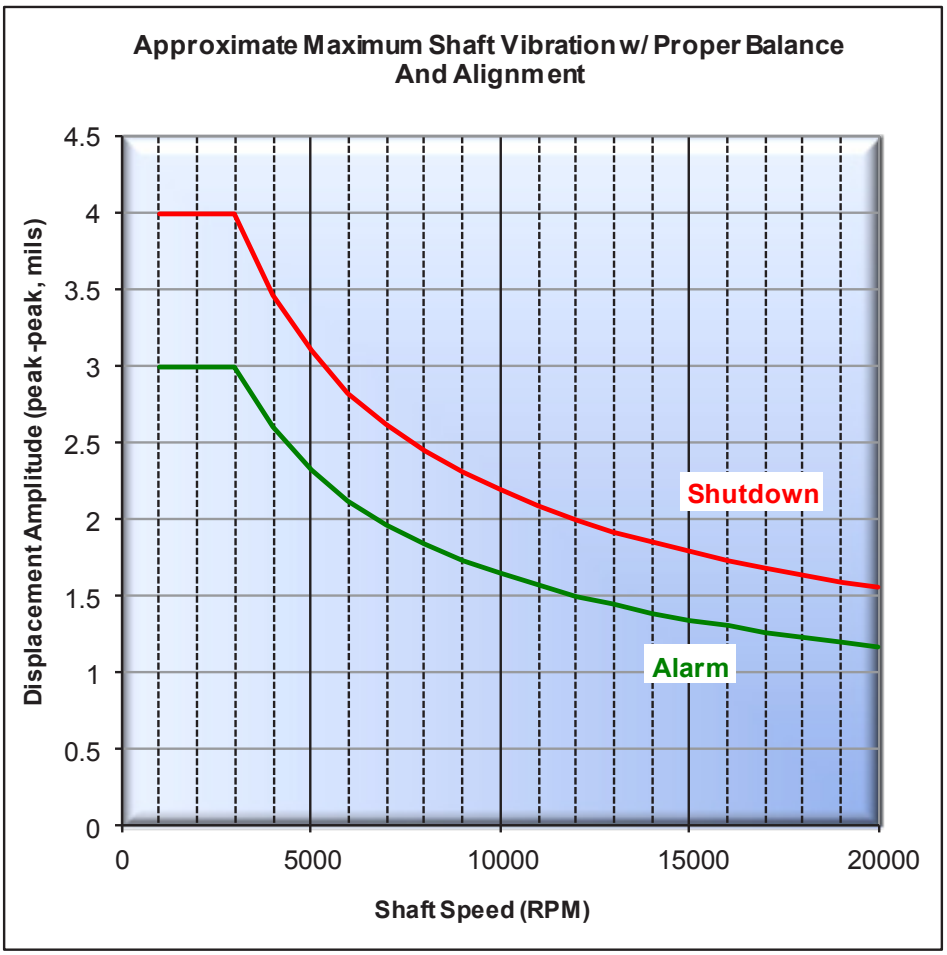
1. Before starting the gear drive, check for any signs of mechanical damage such as damaged piping or accessories.
2. Confirm all pipe plugs are securely tightened.
3. Fill the gear drive or auxiliary sump (if applicable) with oil to the proper level. The correct viscosity and the proper oil level can be found on the outline drawing.
4. Prime all pumps and piping and verify proper operation of all gauges and devices.
5. Confirm all electrical connections have been properly made and are in accordance with the equipment manufacturers' recommendations and are in strict compliance with the National Electric Code and local requirements. Confirm all accessories have been properly mounted.
6. Turn shafts by hand with a spanner wrench, making sure not to damage machined surfaces, to confirm there are no obstructions to rotation.
7. Check that all couplings are properly aligned, mounted, and keyed on shaft extensions.
8. Confirm the inspection cover is securely tightened and install guards for rotating equipment.
9. Check all external mounting bolts, screws, etc. to make sure they have not loosened in transit or handling.
10. For gear drives equipped with heaters for cold ambient temperature operation, turn the heater on and allow the oil temperature to rise to at least 60°F before start-up.
11. When starting the gear drive, start under as light a load as possible. Check for oil leaks, unusual sounds, excessive vibration, and excessive heat. If an operating problem develops, shut down immediately and correct the problem before restarting.
12. Check the rotation of the auxiliary oil pump motor (if supplied) for proper direction.

Placing the Gear Drive in Operation

1. Before coupling the driver and driven equipment to the gear drive, make certain all rotations are correct as indicated by the gear drive direction of rotation nameplate and the outline drawing. Note that the gear drive direction of rotation nameplate and the outline drawing indicate the same direction of rotation.
2. Oil inlet pressure and temperature to the gear drive should be monitored with gauges. It is recommended that the oil inlet pressure and temperature also be monitored electronically and connected to a control room alarm. The alarm and shut down settings should be as noted on the outline or lubrication schematic drawing.
3. Make oil connections as described on the outline drawing. Note on gear drives that do not have self-contained cooling systems, the oil pump (if supplied) discharge port must be piped directly to the oil inlet of the cooler or filter, whichever is further upstream in the system. Oil is not to be bypassed or diverted until after it has passed through the cooler and filter. The valve located near the gear mesh oil spray on pre 1999 gear drive designs is set at the factory and should not be adjusted without consulting the factory. Some 1999 and all later gear drive designs do not incorporate a gear mesh regulating valve. For more information regarding globe valve adjustment see "Globe Valve Gear Mesh Spray Adjustment".
4. If the gear drive is supplied with a lubrication system, prime the oil pump at the pump suction port indicated on the outline drawing. If the gear drive does not have an auxiliary oil pump for the initial startup, remove pipe plugs or gauges as required and fill components of the lube system to the extent possible without exceeding the normal operating oil level of the gear drive. This will aid in assuring lubrication to all bearings as soon as possible. Operate the gear drive or auxiliary pump until oil fills all lines. Stop the gear drive or auxiliary pump and recheck oil level and add oil as required. Gear drives with vertical sight gauge: with the gear drive shut down, fill to the oil level indicated next to the glass sight gauge. This is the static level. Gear drives with round sight gauge: with the gear drive shut down, fill to the center of the round sight gauge.
5. If there is an auxiliary lube system, the pump should also be primed and started prior to starting the gear drive. Make sure pump motor rotation is correct. This will insure that all lines are filled with oil before starting the gear drive. As the gear drive comes up to speed, the auxiliary lube system should shut down. If a main lube oil pump is supplied, mounted on the gear drive, it is sized to meet the design lubrication requirements of the system. The auxiliary lube system can be shut down either manually or electronically.
6. When an auxiliary sump (oil reservoir) is used, the gear drive oil drain must be piped directly to this device. This gravity drain must be maintained unrestricted so its flow capability will not be reduced.
7. The gear drive oil cooling system must be functioning properly; otherwise the gear drive may be damaged. Refer to the outline drawing for cooling medium requirements and connections. The oil cooler must be maintained in good operating condition, following the operating instructions of the cooler manufacturer.

Post Start-up
After starting the gear drive, check for excessive or unusual noise. Check the housing for excessive vibrations. Refer to “Vibration” for housing and shaft vibration recommendations. Check oil pressure and confirm there are no oil leaks. As mentioned above in “Alignment”, after the gear drive has been has run for several hours, it is desirable to check the hot alignment of the equipment involved. During the alignment check, while the gear drive is not operating, check the torque of the gear drive hub and flange bolts and confirm all piping unions are tight. After start-up, bearing temperatures, oil pressures, and vibrations should be closely monitored and a permanent record kept. Any significant change in recorded data should be investigated.

Vibration
Shaft and housing vibrations should be monitored, recorded and reviewed periodically. Any significant changes in vibration should be investigated. The vibration information provided in this section should not be used in place of any vibration information that has been provided on the gear drive drawings. If the gear drive has been equipped with shaft vibration probes, or has been equipped with provisions for either shaft vibration probes or housing vibration accelerometers, the recommended limits for these measurement devices will be noted on the gear drive outline drawing. The graph below provides shaft vibration limits (displacement, peak to peak, mils) as a function of shaft speed (RPM). This graph displays two curves that provide approximate alarm and shutdown values at various shaft speeds. Housing velocities are typically measured near bearings and are done in the vertical, horizontal, and axial directions. In general, for most standard gear drive designs, the overall unfiltered housing velocity limits should be .3 in/sec (zero to peak) for alarm and .5 in/sec (zero to peak) for shutdown. Further diagnosis of excessive housing vibrations can be achieved through filtering the individual frequencies to determine their origination.



Maintenance:

WARNING: Prior to commencing maintenance on any Nuttall Gear product or associated machinery, personnel must observe hazard warnings and ensure that all loads have been removed from the system and appropriate lockout / tag out procedures are being used.

CAUTION: Operating machinery generates heat and may have external surfaces, and contain lubricants that are hot enough to cause burns. Care must be taken to avoid contact with hot surfaces and lubricants.

Lubrication:

WARNING: Gear drives are shipped from the factory without oil. Fill "wet sump" gear drives (gearboxes with self-contained lube systems), sump and piping, to the proper level before operating.

WARNING: Do not overfill beyond the indicated oil level; excess lubrication may result in overheating, leaks, misting and thinning of the oil and may cause subsequent damage to the gear drive.

CAUTION: Never attempt to add or replace oil while the gear drive or auxiliary pump is running.

General

Lubricating oil for use in high speed gear drives must be premium quality petroleum based oils meeting the minimum physical and performance specifications listed in the table below. They must be non-corrosive to gears and babbitt lined bronze or steel backed bearings, neutral in reaction, free from grit and abrasives, have good antifoaming and oxidation resisting properties, and have a high demulsibility factor. Performance and life of the gear set and bearings are dependent upon the use of proper lubricants, maintaining the correct oil level and flow, and oil changes when required. Refer to the outline drawing for the recommended lubricant viscosity and estimated volume. Contact Nuttall Gear before using synthetic oils or special additives. Do not use extreme pressure (EP) oils.

Minimum Physical and Performance Specification For R & O Gear Lubricants

Property	Test procedure	Criteria for Acceptance		
Viscosity	IS03104 / ASTM D 445	Must be as specified in this listing		
Viscosity Index	IS02909 / ASTM D 2270	90 minimum		
Oxidation Stability	IS04263 /ASTM D 943	Hours to reach a neutralization number of 2.0*		
		AGMA Grade 0, 1, 2		Hours (min): 1500
Rust Protection	IS07120 / ASTM D 665B	No rust after 24 hours with synthetic sea water		
Corrosion Protection	IS02160 / ASTM D 130	#1 b strip after 3 hours at 121°C (250° F)		
Foam Suppression	ASTM D 892 Must be within these limits:	Max volume of foam (ml) after:		
		Sequence 1 24°C (75°F)	75	10
		Sequence 11 93.5°C(200°F)	75	10
		Sequence III 24°C (75°F)	75	10
Demulsibility	ASTM D 2711 *Must be within these limits:	Max percent water in the oil after 5-hour test.		0.5%
		Max cuff after centrifuging		2.0 ml
		Min total free water collected during test		30.0 ml
Cleanliness	None	Must be free of visible suspended or settled contamination		

High speed gear drives are designed to operate with a pressurized system that provides lubrication and cooling to the gears and bearings. An oil circulating pump and heat exchanger are important components in the lubrication system. On gear drives manufactured prior to 1996, oil pressure is factory set at 10-15 psi to the gear mesh spray, and 23-27 psi to the bearings, and should not need further adjustment. Gear drives manufactured after 1996 have a common manifold and are set at 18-22 psi. Refer to the outline drawing supplied for each gear drive for recommended lubricant viscosity, cooling medium flow and temperatures required for proper lubrication and cooling of the gear drive. Some SU/SD gear drives built in 1999 and all after 1999 are designed with internal piping and orifices that determine the oil flow at a given inlet pressure. Gear drives supplied "dry sump" (less lube system) will have the oil flow, supply pressure, oil type, inlet temperature, and the heat rejection rate specified on the outline drawing for lube system sizing. The importance of the cooling system to the proper functioning of a high-speed gear drive cannot be over emphasized. Because of the high speeds involved, the thermal radiating capacity of the gearcase is insufficient to maintain safe operating temperatures. Consequently, an auxiliary means of cooling the lubricating oil and the gearcase is necessary. Heat exchangers are selected to have sufficient capacity to maintain safe operating temperatures for the specified cooling medium temperature and flow rate, and ambient conditions. Whatever cooling is obtained through the natural radiation of the gearcase provides an additional margin of safety.

Abnormal Operating Conditions

A rise and fall in temperature may produce condensation. Dust, dirt, chemical particles, or chemical fumes may also react with the lubricant resulting in the formation of sludge. Sustained sump temperatures in excess of 180°F (82°C) may result in accelerated degradation of the lubricant. When operating under these conditions, the lubricant should be analyzed more frequently and changed when required. The recommended lubricant viscosity, which is shown on the outline drawing, has been selected to meet the operating requirements of the gear drive at steady state operating conditions. Cold temperature operation is not recommended. Preheating the lubricant may be necessary if the lubricant start-up temperature is below 60°F. In some circumstances, preheating the lubricant may be achieved by allowing the auxiliary pump to run for a period of time. In circumstances where enough heat cannot be generated through the auxiliary pump, using a lubricant heater will be necessary.

Oil Changes

All gear drives are shipped from the factory without oil. Proper lubrication maintenance is vital to gear drive performance throughout its design life. After a period of 500 hours or four weeks of initial operation, whichever is first, the gear drive should be thoroughly drained, flushed, and refilled in accordance with this manual. The interior surfaces should be inspected where possible, and all traces of foreign material removed. The strainer and filter, if present, should be checked and/or cleaned at this time. NOTE: If the strainer is below the oil level, then the gear drive must be drained of oil in order to clean it. The new charge of lubricant should be added and circulated to coat all internal parts. Under normal operating conditions, the lubricant should be changed every 2500 hours or six months, whichever occurs first. This change frequency can be extended if analysis of oil samples indicates very limited degradation or contamination. Many oil suppliers offer periodic oil testing to monitor and determine the health of the oil. This service can provide an excellent means of predictive maintenance by monitoring the level of iron, dirt, water and other contaminant content suspended within the oil. The level of particle content that is permissible differs from gear drive to gear drive and from application to application. Typically, it is recommended that a trending procedure be performed to determine the gear drive's steady state level of iron content. When this steady state level has been determined, an excessive particle content test result may indicate the gear drive is in need of maintenance. In some cases, the oil change intervals may be extended based on favorable results of an oil analysis.

Cleaning and Flushing

The lubricant should be drained immediately after shut down while the gear drive is at operating temperature. If necessary, the gear drive should be cleaned with a flushing oil that is compatible with the operating lubricant. Used lubricant and flushing oil should be completely removed from the system to avoid contaminating new oil. The use of a solvent should be avoided unless the gear drive contains deposits of oxidized or contaminated lubricant which cannot be removed with the flushing oil. When persistent deposits necessitate the use of a solvent, a flushing oil should then be used to remove all traces of solvent from the system.

Oil Filling Instructions

Drain all oil from the gear drive, pumps, external piping, and cooler, and follow "Cleaning and Flushing" instructions as outlined above prior to refilling the gear drive with new oil. New oil is added to the gear drive through the inspection cover, which may require its removal. Care should be taken to ensure the inspection cover has been properly sealed when it is replaced. Fill the gear drive to the proper oil level as described in the "Start-Up" section of this manual, making sure all external piping, coolers, and pumps are filled prior to confirming the final oil level.

Oil Capacity

For approximate oil capacity of your Nuttall Gear drive, refer to the outline drawing or contact your Nuttall Gear sales representative. Listed below are approximate oil capacity values in U.S. gallons for standard gear drives and do not include piping assemblies. This information is provided for assisting with estimating approximate oil volume requirements; always fill gear drives to the prescribed oil level as outlined in the "Oil Filling Instructions" section of this manual. If your Nuttall Gear drive was accompanied with an outline drawing that contains an oil volume that is different than what is specified below, the drawing takes precedence.

Approximate Oil Capacity in U.S. Gallons for Standard Gear Drives.

Gear Drive Size Prior to 1999	Gear Drive Size 1999 and Later	Approximate Oil Capacity
619-5	619-625	11
819-6	819-775	12
1023-8	1023-975	26
12-6	12-800	11
12-8	12-1000	13
12-10	12-1200	15
14-6	14-800	17
14-8	14-1000	20
14-10	14-1200	22
16-6	16-800	27
16-8	16-1000	30
16-10	16-1200	34
18-8	18-1000	38
18-10	18-1200	42
18-12	18-1400	46

Assembly and Disassembly

WARNING: Prior to commencing maintenance on any Nuttall Gear product or associated machinery, personnel must observe hazard warnings and ensure that all loads have been removed from the system and appropriate lockout / tagout procedures are being used.

CAUTION: Correct assembly is critical to safe and reliable operation. Improper reassembly may result in unsafe operation, damage to equipment and invalidate the warranty. It is recommended that Nuttall Gear be contacted for service that requires disassembly and reassembly of the gear drive.

WARNING: When operating conditions are to be changed (RPM, power, ratio, rotation, etc), Nuttall Gear should be consulted for new rating data, design considerations, any hard/software required, and a new nameplate.

The following instructions apply to standard SU/SD high speed gear drives only. In addition to standard mechanic's tools, the following equipment is required: hoist, slings, torque wrenches, feeler gauges and dial indicator(s). New seals, gaskets, and bearings may be required. See the general assembly drawing for part numbers and contact factory for price and availability. Be sure to de-energize all electrical equipment, including the prime mover prior to performing any disassembly. Clean external surfaces of the gear drive before removing the cover to prevent contaminants from falling into the gear drive. Record mounting dimensions and location of accessories for reference when reassembling. Match mark couplings. To remove the gear drive from its operating area, disconnect all connected equipment and lift gear drive from its foundation by means of the lifting lugs.

Cover Removal

1. Depending on the service to be performed and the type of lubrication system used, the oil may or may not need to be drained from the gear drive. Contact the factory for recommendations of appropriate actions with regards to this matter.
2. Disconnect all piping and wiring connected to the cover.
3. Remove bolts holding the pump support end cap to the gearcase, and remove the end cap and the pump from the gear drive. Remove bolts holding the high speed and the low speed end caps from the gear drive and remove the end caps. Note that most high and low speed shaft seals are split design, and can be removed from the shaft without removing the coupling. If the gear drive has an external tilt pad thrust bearing, it should be removed at this time. Remove the housing end cap and unscrew the locknut retaining the thrust collar. Remove the thrust bearing housing, thrust bearing, and thrust collar key from the low speed shaft.
4. Remove all parting line bolts and tap out the dowel pins. Back off or remove any vibration probes or temperature sensors. Use either the lifting lugs or eye bolts that were provided with the gear drive to lift the upper housing from the lower housing. Use the jack screw holes in the upper housing to aid in breaking the seal. Lift the cover straight up approximately 1/2 inch. **Care must be taken to ensure the upper housing does not hit the either the pinion or the gear as this could DAMAGE THE TEETH.**
5. If the upper bearing halves remain in the upper housing, carefully remove them and protect them from damage. Mark all parts for proper location when reassembled. If bearings are to be reused, they must be returned to their original location and radial position. If embedded temperature sensors are present, take care not to damage lead wires.

Removal of Gearing

1. Place a sling around the high speed pinion shaft. Take up just enough slack to take the weight off the bearings. Lift the shaft straight up taking care not to damage the teeth of either member.
2. Lift the gear and shaft assembly with a sling, taking care not to damage the teeth. Never rest the outside diameter of the gear or the pinion, or the polished fits of the low speed shaft or the pinion on hard surfaces. Wood blocks should be used.
3. If the gearing is to be replaced, both the gear/shaft assembly and pinion must be replaced as a set. This being the case, new bearings, seals, and gaskets are recommended.
4. Lower bearing halves can now be removed from the lower housing (again, check for embedded temperature sensors). If the bearing halves are to be reused, carefully mark their location so they can be returned to their original location.

Assembly

1. Remove all sealing compounds and/or gaskets from the upper and lower housing. Clean internal oil passages, oil sump, and inside of upper housing with a suitable solvent. Clean bearings with a high quality solvent, and dry before use. Inspect bearings carefully and replace if worn or questionable.
2. Reverse the disassembly instructions listed above. Check that bearings are seated properly in the housing, and in the same positions noted during disassembly. While lowering the low speed shaft assembly into the lower housing, take care not damage the babbitt covered thrust faces of the low speed bearings (for standard thrust face low speed bearings).
3. Check bearing contact using Prussian Blue. Acceptable contact should be 80% axially and 30% radially of each bearing half. Bearings showing contact at either end of the bore should be corrected. For new bearings, see “Bearing Replacement”.
4. Check gear and pinion alignment, and confirm that both are free to rotate. Check gear tooth contact using Prussian Blue. Tooth marking should be uniform throughout the central portion of each tooth flank. Minimum contact should be 80% across the face of each helix hand.
5. Check the endplay of the low speed shaft using a dial indicator. Endplay design tolerances are shown on the outline drawing. See “Bearing Replacement” for shimming procedures on pre 1999 gear drives.
6. Lubricate the shaft bearing journals and reinstall upper bearing halves into upper housing. Confirm back of thrust faces are seated against the upper housing to ensure they do not contact the thrust collars on the low speed gear.
7. Place a bead of sealer, such as Loctite 515, on the parting line of the lower housing with the exception of the area between the bearings. Circle all studs to assure sealing of oil. In the area between the bearings, the sealant should be applied to the upper housing only on pre 1999 gear drives to keep sealant from getting into the oil groove in the upper housing. On some 1999 gear drives, and all gear drives made after 1999, the sealer needs to be applied to the lower housing only. Make sure sealant does not block oil passages or enter the bearing bores.
8. Carefully lower the cover on the lower housing, **using caution not to bump the gears.** Obtain accurate location of the upper housing relative to the lower housing by tapping the tapered dowel pins in place before torqueing any parting line bolts.
9. Before torqueing the parting line bolts, push the low speed shaft to one side of the housing and tighten both bolts adjacent to the low speed bearing, that the shaft/ gear assembly is seated against, just enough to hold the bearing in place. Next, push the low speed shaft to the opposite side of the housing and repeat the above procedure. This ensures that the low speed bearings are properly seated against the housing to maintain correct endplay if flat face thrust bearings are used. Tighten the parting line bolts uniformly using the correct torque values; **do not tighten one side of the housing bolting completely and then the other.** Confirm proper endplay has been achieved by placing a dial indicator against the end of the low speed shaft after the parting line bolts have been torqued to their recommended values.
10. If an external tilt pad thrust bearing is being used it should be installed at this time. Assemble the bearing in its housing and slip over the end of the low speed shaft. Install the thrust collar key. Bolt the thrust bearing housing to the gear housing. Tighten the locknut and set screws. Design endplay is specified on the outline drawing and can be obtained by shimming between the thrust bearing housing and its end cap.
11. Install the labyrinth shaft seals making certain the oil drain hole is located at the bottom. Check the clearance with a feeler gauge to make sure the shafts do not touch the labyrinths. Install end caps.
12. Most gear drives manufactured after 1993, include a pump coupling design with a rubber insert. When installing the lube oil pump with this design, make certain the rubber coupling insert is properly aligned with the coupling hubs. Gear drives manufactured prior to 1993, and some more recent gear drives built to duplicate designs originally built prior to 1993, use pin type couplings. Make certain the two pins on the pump coupling line up with the two holes in the low speed shaft. Lubricate the pump coupling drive pins by packing grease into the two holes in the low speed shaft. Rework on the coupling is required

if the holes in the low speed shaft or the pins show signs of wear. For more information on pin type pump coupling inspection and repair, see “Pin Type Coupling Recommendations”.

13. Reinstall piping and all wiring disconnected during disassembly. Confirm that the shaft driven pump (if supplied) is installed, oriented the same as it was prior to removal, for the proper rotation.
14. Make all pre-startup, and post startup checks listed in this manual.

Bearing Replacement

For bearing replacement, the following procedures should be followed in conjunction with the disassembly and assembly instructions listed above. Replacement bearings are available and manufactured to the same extreme accuracy as the original bearings furnished with the gear drive. When installing replacement bearings, the recommended practice is to first make sure that the bearing shell fits snugly in the case bore, that is, to make sure that no burrs or nicks are protruding from the bearing shell or from the bore in the upper and lower halves of the gear case which would prevent a good sliding fit. Place one bearing half into each of the lower case bores. Blue the bearing journals of one shaft sparingly with Prussian blue and place shaft carefully in lower half bearings. Roll the shaft in the bearing to obtain a contact marking. Lightly scrape any high spots to obtain 80% contact along the length and 30% radially of each bearing half. Scrape to remove any end contact of the bearing and shaft. The same procedure should be followed for the upper bearing halves. Turn the upper housing upside down to perform the above bearing fitting. Refer to the outline drawing of your particular gear drive for exact tolerances. To adjust endplay on pre-1999 gear drives with flat face bearings, remove the low speed gear and shaft from the gear drive. Shims are located under one thrust plate which must also be removed. To increase endplay, shims must be removed, and to decrease endplay, shims must be added. On gear drives late 1999 and afterwards, with flat face thrust bearings, endplay adjustment is not possible.

Total diametral clearance between the bearings and the shaft should be measured and recorded. This clearance can be measured using different methods. On pre-1999 gear drives, one way is to assemble all bearing halves and shafts into the lower housing. Using plastigage on top of the shafts, assemble upper bearing halves, upper housing, and tighten bolts to recommended torque. Remove upper housing and upper bearing halves and measure the plastigage to determine clearance. An alternate method is to assemble the bearing halves into the upper and lower housing and bolt together without the gearing. After tightening the housing bolts to the required torque, measure and record the inside diameter of each bearing and the outside diameter of each bearing journal on the high and low speed shafts. Compare the respective dimensions to determine the clearance. On an assembled gear drive, another procedure is to lift the shaft and measure its vertical movement with a dial indicator as close to the seal as possible. This will give an inflated value but should be fairly close. Care should be taken not to damage the bearing babbitt. On most late 1999 and later gear drives the bearings are thick walled, doweled together and are not “crushed” to achieve proper clearance. Their bore diameter can be measured in or out of the gear housing. Design clearances are based on lubricant viscosity, load, and journal velocity. Refer to the mass elastic drawing or contact the factory for these values. Worn fixed geometry bearings may exceed design clearances .003-.004” as long as shaft vibration levels remain acceptable.

Pin Type Coupling Recommendations

Some legacy high speed gear drive designs employ a pin type coupling for driving the shaft driven lubrication pump. If you are uncertain as to whether or not your gear drive employs this type of coupling, consult the factory for assistance. Pin type pump couplings should be inspected and maintained during regular maintenance outages. Inspection of the pump coupling will require removal of the oil pump from the gear drive. For pin couplings and drive holes that will not be replaced, it is important that the coupling pins are reassembled in to the same drive holes that they were in prior to disassembly; to ensure this match-mark the coupling during the disassembly process. Coupling wear should be measured and evaluated using the replacement criteria below.

- Pin coupling replacement is required if the minimum pin diameter measurement is .375” or less, where the design pin diameter is .500”. Or wear on either of the pins is not uniform along the engaged length or there are signs of fracture. When reinstalling the coupling hub on to the pump shaft, locate the coupling hub face flush with the end of the pump shaft. Pack the drive holes of the low speed shaft with a high quality EP #2 grease and reassemble the pump to the gear drive. Note: The pin size as noted above is a standard design. However, there are some special coupling designs that are in operation with different pin sizes. If you have a coupling design that is different than what is noted above, contact the factory for assistance with determining acceptable wear limits. If you are unsure of the coupling design that you have, contact the factory for assistance. Please have the nameplate information readily available when contacting the factory for assistance.
- Drive hole replacement on the low speed shaft is required if the maximum drive hole diameter measurement is .750” or greater, where the design drive hole diameter is .563”. Or wear on either of the drive holes is not uniform along the engaged length. If drive hole replacement of the low speed shaft is required, it will be necessary to remove the low speed shaft from the gear drive to drill new holes. Refer to “Removal of Gearing”. Drill new drive holes starting at 90 degrees apart from the existing holes. New drive hole diameter will be .563” located on a 1.875” or 2.000” circular pattern, depending on the size of the gear drive, located 180 degrees apart from one another and should be reamed with a 63 RMS finish. The drive hole depth should be .500”. New drive hole circular pattern should be concentric with the bearing journal fit diameter within .002”. As noted above, pack the drive holes of the low speed shaft with a high quality EP #2 grease and reassemble the pump to the gear drive. Note: The drive hole size as noted above is a standard design. However, there are some special coupling designs that are in operation with different size drive holes. If you have a coupling design that is different than what is noted above, contact the factory for assistance with determining acceptable wear limits. If you are unsure of the coupling design that you have, contact the factory for assistance. Please have the nameplate information readily available when contacting the factory for assistance.

Globe Valve Gear Mesh Spray Adjustment

Some legacy high speed gear drive designs employ a globe valve to control the amount of lubricating oil that is supplied to the gear mesh. The globe valve is located in the piping line that directly feeds the gear mesh spray head and has been factory set to deliver a prescribed amount of lubrication to the gear mesh at a pressure of 10-15psi. After the valve has been set at the factory, the handle is removed and a lock shield is installed to prevent incidental changes to the preset. If you are unsure as to whether or not your gear drive employs this feature, contact the factory with the gear drive’s nameplate information. In the event the globe valve has come out of adjustment, or if it is replaced, it will be necessary to follow this procedure to ensure the gear mesh is adequately lubricated. Failure to provide adequate lubrication to the gear mesh will result in premature failure of the meshing gears. This procedure should be performed with the oil pump running at full speed. If the gear drive does not have a motor driven auxiliary pump, it will be

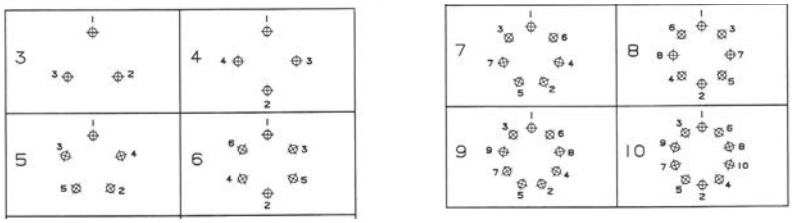
necessary to run the gear drive unloaded at full speed. The operator should verify that there will be some oil supplied to the gear mesh while performing this procedure; the gear mesh should never be allowed to run dry.

The gear mesh globe valve needs to be adjusted to provide 10-15 psi of pressure to the gear mesh. If there is no gauge and no port in which to install a gauge between the valve and gear drive, then it will be necessary to adjust the flow based on visual inspection of the spray; the adjustment should provide a copious oil flow to the gear mesh. This is defined as an oil spray capable of flooding the mesh with a moderately strong oil flow at full speed, but not with a pressure high enough to cause the oil to be excessively ricocheted back off potentially creating an under lubricated scenario. To adjust the gear mesh delivery oil pressure, it is sometimes necessary to adjust both the gear drive's pressure relief valve and the gear mesh globe valve. For information regarding the required operating system oil pressure range, refer to the outline drawing and/or lube schematic.

Adjustment procedure: First, adjust the globe valve slightly to obtain the required oil pressure; closing the globe valve will increase the system pressure, while opening the globe valve will decrease the system pressure. Next, check the oil spray being delivered to the gear mesh. If visual inspection is required, this must be done through the inspection cover. The safest way to do this is to fit the opening with a temporary Plexiglas cover. If the spray to the mesh is adequate, no further adjustment is required. If the spray is less than adequate, adjust the globe valve open to increase the oil flow to the gear mesh. Doing this will decrease the system pressure. To increase the system pressure into the required range, it will be necessary to adjust the gear drive's pressure relief valve by turning the adjusting screw clockwise. To reduce the system pressure, adjust the pressure relief valve by turning the adjusting screw counterclockwise. Once the system pressure has been confirmed, again check the spray to the gear mesh. If further adjustments are necessary, repeat the instructions as outlined above.

Fasteners:

Fastener Tightening Sequence



The following torque values are to be used in conjunction with the above fastener tightening sequences for end covers, seal cages, shaft guards, inspection covers, and housing parting line bolts, unless otherwise specified on the drawing or assembly instructions. Torque values for lubricated fasteners are to be used when fasteners are coated with thread locking compounds.

Grade 5 Fastener Tightening Torques

Diameter	Dry Fastener (foot-lbs)		Lubricated Fastener (foot-lbs)	
UNC	Min.	Max.	Min.	Max.
1/4	7	8	4	5
5/16	14	17	8	10
3/8	25	31	15	19
7/16	40	49	24	30
1/2	60	75	36	45
9/16	87	109	52	65
5/8	120	150	72	90
3/4	213	266	128	160
7/8	344	430	206	258
1	515	644	309	386
1-1/8	635	794	381	476
1-1/4	896	1,120	538	672
1-3/8	1,175	1,469	705	881
1-1/2	1,560	1,949	936	1,170
1-3/4	1,829	2,286	1,097	1,372
2	2,750	3,438	1,650	2,063
2-1/4	4,022	5,027	2,413	3,016
2-1/2	5,500	6,875	3,300	4,125
2-3/4	7,457	9,321	4,474	5,592

Renewal Parts:

For renewal parts, refer to the general assembly and piping assembly drawings that were included in the drawing transmittal and service book package, or contact the factory for a list of recommended spare parts. To assist your Nuttall Gear representative with properly identifying your gear drive please record all of the information from the gear drive's nameplate (refer to the nameplate illustration below).

Trouble Shooting:

WARNING: Prior to commencing maintenance on any Nuttall Gear product or associated machinery, personnel must observe hazard warnings and ensure that all loads have been removed from the system and appropriate lockout / tagout procedures are being used.

Noise
By nature, all gear drives produce some type of noise during operation. Normal gear noises that are generally observed are either a low pitch rumble, in a lightly loaded gear drive, or a high whine depending on the gear design and operating speed. Learn to distinguish between normal gear noise and symptomatic gear noise which could be an indication of a larger problem. Remember, sound is often amplified by the type of mounting or can be induced by coupled equipment. As part of a good preventative maintenance program, always record changes in noise levels and operating temperatures.

Problem	Potential Causes
Excessive operating temperature	1, 2, 3, 4, 5, 6, 7, 9, 12, 18, 20, 21
Oil leakage	1, 2, 3, 4, 5, 7, 9, 12, 13, 18, 19, 21
Gear wear	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 21
Bearing failure	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 19, 20
Unusual noise	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 20, 21

Potential Cause	Action
1. Gear drive overload	Reduce loading if possible. If not, consult the factory for possible solutions.
2. Incorrect oil level	Verify that the oil level is correct. Too little or too much oil can cause high temperature.
3. Wrong oil grade	Use only the AGMA grade oil as specified for that gear drive's specific operating conditions. Refer to the outline drawing for oil recommendation.
4. Contaminated oil	If oil is oxidized, dirty, or has high sludge content, change the oil.
5. Clogged breather	Clean breather regularly.
6. Improper bearing clearance	Too large or too small bearing clearance. Contact the factory for design clearances, methods of checking, and allowable tolerances. Shafts should turn freely when disconnected from the drive train.
7. Improper coupling alignment	Disconnect couplings, check spacing between shafts, and check alignment. Realign as required.
8. Incorrect coupling	Consult coupling manufacturer to confirm proper coupling was selected for the application.
9. Excessive operating speed	Reduce speed if possible. Consult the factory for speeds in excess of design (ref. nameplate).
10. Torsional or lateral vibrations	Numerous conditions can develop that may contribute to changes in vibration levels. If the cause is not easily identifiable consult the equipment vendor(s) for specific recommendations. Vibration can occur through a particular speed range known as the critical speed. Contact the factory for specific recommendations.
11. Extreme repetitive shocks	Verify source and reason. Torsionally softer couplings may be required.
12. Improper lubrication of bearings	Verify the proper amount and type of oil is being supplied to the gear drive at the specified pressure.
13. Improper storage or prolonged shutdown	If rust and/or corrosion is evident on bearing shells, gearing, or other parts, gear drive should be disassembled and problem areas corrected before start-up.
14. Excessive backlash	Contact factory.
15. Misalignment of gears	Contact pattern to be a minimum of 80% of face.
16. Housing twisted or distorted	Verify proper shimming or stiffness of the foundation.
17. Gear tooth wear	Contact factory.
18. Open drains	Tighten drain plugs.
19. Loosely bolted covers	Check all bolted joints and tighten if necessary.
20. Driver or driven equipment	Verify actual operating conditions are consistent with original design and the nameplate data.
21. Excessive ambient temperature	Shield gear drive from direct sunlight, and maintain proper air flow around the gear drive.

Engineered Solutions, Field Service, In-House Rebuild & Repair

Engineered Solutions

Proven history of analysis & design of unique custom solutions for virtually all industrial applications. Wide ranging application experience - Ultra low speed (175,000:1 ratio) to ultra high speed (45,000 RPM) with output torques to 6,000,000 in-lbs.

Design of spur, helical, double helical, bevel and worm gearing. Lubrication system design - Internal splash / channeling, force fed, pressurized / cooling systems with instrumentation. Sleeve bearing design and rotor dynamic analysis.

Reverse engineering of reducers, helical and worm gearing. Redesign and Rerate of existing designs of Nuttall Gear, Delroyd Worm Gear, and competitors products. Complex solid modeling & drafting.

Field Services

Maintenance - Routine lubrication service and end-play adjustments.

Inspections- Evaluate condition of gearing, shafts, bearings, seals, and lubrication systems.

Trouble Shooting- Root cause analysis for vibration, noise, premature gear wear, and oil leaks.

Repairs - Short-term emergency repairs and long-term permanent repairs can be made on site.

Torque Measurements – Record torque under actual operating conditions using telemetry (transmitter and receiver). Training Seminars that cover all phases of repair in a hands-on environment: Inspection, teardown, reassembly, and testing.

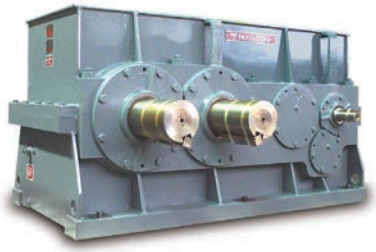
Rebuild & Repair

Comprehensive Inspection and evaluation of gearing, housings, bearings, and lubrication systems. Repair / Rework of Returned Components. Complete rebuild of Nuttall Gear, Delroyd Worm Gear, and Westinghouse units. Ability to also rebuild most competitors' units- All complete rebuilds are returned in new condition and include a new factory backed warranty.

Trouble Shooting- Root cause analysis for vibration, noise, premature gear wear, and oil leaks.

In-House Testing - No load testing capabilities for all units with temperature, sound, and vibration measurements of critical components. Load testing available in some cases.



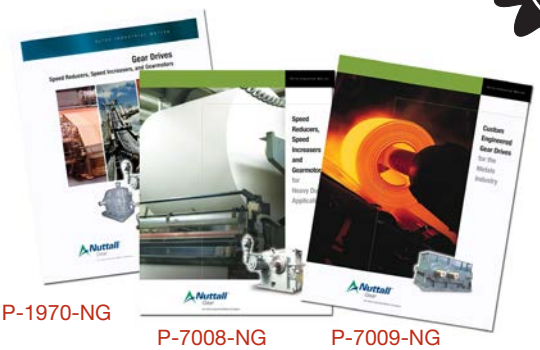



Nuttall Gear is an ISO9001:2008 Certified Company

Member of AGMA

visit us online at
www.nuttallgear.com

Find our latest product literature online



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Nuttall® Gear

*An **Altra Industrial Motion** Company*

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