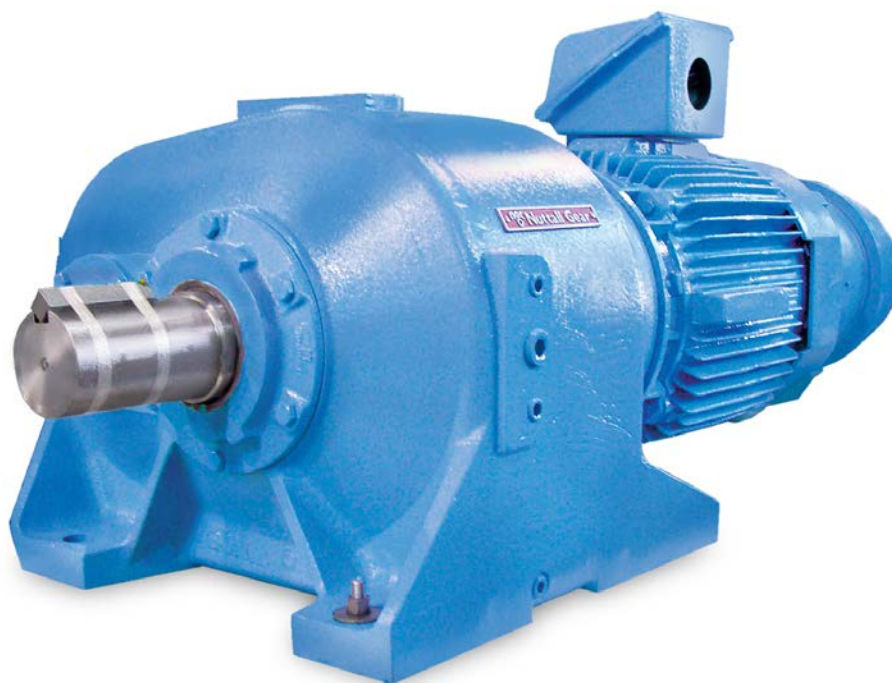


Moduline Concentric Shaft Speed Reducers

Installation Operation & Maintenance Instructions

P-6001-NG



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 units with non-standard or special features.

Maintenance - Follow the instructions provided in this manual for recommendations on maintenance frequency, unit dismantling, 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 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 - Risk of 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 units. 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 – Risk of electrical shock could result in serious injury or death.



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

Contents

Product Safety Information..... 2

Introduction..... 3

Warranty..... 4

Receiving & Handling..... 4

Weights..... 5

Storage..... 5

Installation..... 6

Lubrication..... 7

Oil Capacity..... 9

Start-Up..... 10

Trouble Shooting..... 10

Renewal Parts..... 11

Ratio Change..... 14

Fasteners..... 15

Engineering & Service..... 16

Introduction

The following instructions apply to all Nuttall Gear Moduline concentric shaft gear motors, gear reducers, and motor/reducer packages. If a unit is furnished with special features, refer to the supplemental instructions shipped with the unit or contact your Nuttall Gear sales representative. In some cases, special outline or assembly drawings may have been provided. In these cases, this manual is meant to be used in conjunction with the drawing(s) for that particular gearbox. Where a conflict exists between this manual and any supplied drawing(s) for a particular gearbox, the drawing(s) 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.



WARNING: Operate this unit 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 rated 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 unit 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 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 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 UNIT, 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 unit 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 units 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 unit 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 unit:

- o Never use shaft extensions for pushing or pulling of the unit.
- o Never drag the gear unit. Machined mounting surfaces will be marred and overstressing of the housing may occur.
- o Motor lifting lugs or eyebolt holes may be used to lift units only when additional load supporting methods are used, such as slings on low speed shafts. Never attempt to lift the entire unit by using the motor lifting lugs.
- o When lifting, distribute the load evenly to keep the unit from tilting. Spreader bars may be required to avoid stress on any piping and accessories mounted on the unit.
- o Never use piping for lifting or climbing.
- o If the unit is to be stored, refer to the storage instructions in this manual.

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

Reducer sizes 85 thru 98 that are equipped with a motor contain lifting holes in the main housing of the reducer and motor lifting lugs; these holes should be utilized in conjunction with the motor lifting lug for lifting the reducer. Reducer sizes 85 thru 98 that are not equipped with a motor, lifting holes in the main housing should be used for lifting the reducer. Reducer sizes 85 thru 98, the use of slings around the input and output shafts for lifting the reducer is not recommended. Reducer sizes 5 thru 76 that are equipped with a motor should be lifted with a sling around the output shaft in conjunction with the motor lifting lug. Reducer sizes 5 thru 76 that are not equipped with a motor should be lifted with slings around the input and output shafts. Lifting slings used must be non-damaging to the surface of the shaft(s) and must be secured in a manner that will ensure they are held as close as possible to the housing. Always secure loads in a manner that will prevent them from slipping out of lifting devices. Always stay clear of suspended loads. Listed below are approximate weights of various Moduline units; these weights do not include motors, motor supports, accessories, or lubrication.

Approximate Unit Weight in Pounds				
Unit Size	Single	Double	Triple	Quad
5 / 10	70	77	--	--
15 / 21	110	130	140	--
32	180	165	190	210
43	200	270	290	300
51 / 54	350	490	500	570
64	--	550	620	700
76	350	770	800	825
85 / 88	--	1,237	1,340	1,435
92	--	1,300	1,450	1,570
98	--	2,350	2,400	2,570

Storage

General

All internal and unpainted external surfaces of gear drives 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 spray or add rust inhibitor to exposed metal surfaces that may have had the protective coating removed in shipping and handling. To assure that 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. Units must always be stored free of loads or weights on output and input shafts. These instructions apply to the reducer only. If a motor is included in our drive package, motor operating maintenance and storage instructions are included with drawing transmittals and are also attached to the unit. These instructions must be carefully read and followed.

Short Term Storage (Indoor)

If the gear drives are to 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. Unit should be elevated in a manner that will prohibit water or other liquids to come in contact with the base of the unit. Avoid storing unit in areas that are subject to extremes in temperature, vibrations, and humidity. If the unit will be secured to its storage surface, via the unit's mounting holes, the storage surface must be level to prevent twisting of the housing and subsequent damage to the unit.

Long Term Storage (Indoor)

If units are to be stored for a period longer than 30 days, the following should be observed:

1. Store in a clean dry location with the unit elevated in a manner that will prohibit water or other liquids to come in contact with the base of the unit. Avoid areas that are subject to extremes in temperature, vibrations, and humidity. If the unit will be secured to its storage surface, via the unit's mounting holes, the storage surface must be level to prevent twisting of the housing and subsequent damage to the unit.
2. Remove breather and replace with pipe plug.
3. Fill the gear drive to the recommended oil level with Shell VSI grade 68 oil or equal, heated between 110-120°F. Do Not Overfill. Immediately close openings to maintain vapors in the housing.
4. Rotate the high speed shaft slowly by hand long enough so that the low speed shaft makes at least one revolution at least once every four weeks.
5. Inspect the unit periodically and spray or add rust inhibitor suitable for anticipated storage conditions, as required.
6. Drain and replace with the recommended oil type prior to start-up.

Outdoor Storage

Note: OUTDOOR STORAGE IS NOT RECOMMENDED. When storage in a warehouse or enclosed building is not possible, the following should be observed:

1. Bring unit to an area in which the ambient temperature is greater than 50°F and allow to stand for a minimum of 24 hours.
2. Remove breather and replace with pipe plug. Seal the unit completely by sealing all air vents with pressure sensitive tape. Pack grease around the shafts near the contact seals and tape. Pack grease into the seal retainers and wrap tape against the seals.
3. Fill the gear drive to half the recommended oil level with Shell VSI grade 68 oil or equal, heated between 110-120°F. Immediately close openings to maintain vapors in the housing. **Do Not Overfill.**
4. Coat the entire exterior with a rust preventative.
5. Seal the unit in a moisture proof container with an adequate supply of desiccant inside to avoid moisture build-up. Unit must be elevated in a manner that will prohibit water or other liquids to come in contact with the base of the unit. If the unit will be secured to its storage surface, via the unit's mounting holes, the surface must be level to prevent twisting of the housing and subsequent damage to the unit.
6. The high speed shaft should be rotated slowly by hand long enough so that the low speed shaft makes at least one revolution at least once every four weeks.
7. Repeat operations 1 thru 4 every six months. The Shell VSI Grade 68 Oil may be drained, reheated and reused.
8. Do not store the unit in direct sunlight.

Installation

The continuous efficient operation of a gear unit 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 unit only within the ratings shown on the nameplate. Review the application to confirm the unit will not be operated in conditions exceeding the nameplate rating.



DANGER: Selection and installation of guard, 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

Units should not be installed in locations of unusually high or low temperatures. Adequate air flow is required for proper heat dissipation from the unit. Ambient temperatures must not exceed 100°F, unless supplemental means of cooling are supplied. Environmental conditions, including exposure to direct sunlight, high humidity, dust or chemicals suspended in the air are worthy of special consideration. Gear drives exposed to these and other adverse conditions should be referred to Nuttall Gear for special evaluation and recommendation.

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 unit. 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 Dimension Leaflet supplied prior to delivery of the equipment.

Grout steel mounting pads into the concrete base or foundation; mount the unit on these steel pads. Do not grout the unit directly into the concrete base or foundation. When the unit 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 units 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 on the following page.

Bolt Size (UNC)	Torque (Ft. Lbs.)		Bolt Size (UNC)	Torque (Ft. Lbs.)	
	Metal To Metal	Metal To Concrete		Metal To Metal	Metal To Concrete
¼	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
½	69	54	1-3/4	1,975	1,558
5/8	137	108	2	3,083	2,147
¾	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 unit, the output shaft of the reducer should be aligned with the driven shaft by moving and shimming the bedplate assembly. **This should not be accomplished by moving the reducer 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 reducer 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 bedplated components must now be completed.**

Alignment

Gear units are designed with a tolerance of +0 and -1/16 in. between the shaft center and the base, therefore, shimming may be required. 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 secured through shimming, the equipment should be bolted down and alignment rechecked. Heat up couplings, sprockets or pinions and shrink them onto shaft extensions when required, avoiding contact with the shaft seal. Do not heat parts above manufacturers recommended limits, or 300°F, whichever is lower.



Caution: To avoid severe damage to bearing and gears, couplings must never be hammered on to shaft extensions.

When the prime-mover is connected to the gear unit or the gear unit is connected to the driven equipment by means of a coupling, correct alignment cannot be overemphasized. This becomes of greater importance as speeds are increased or the drive is subjected to variations in load conditions. Misalignment, either parallel or angular, is one of the most frequent causes of bearing or shaft failures, noisy operation, or excessive operating temperatures due to the extra load imposed. A straight edge laid across the coupling member at the machined diameter, provided for alignment purposes, shows correct parallel alignment when the straight edge rests on both coupling members for their full length. Check this at four positions-90 degrees apart. The use of feeler gauges between coupling member faces is a common method of checking for correct angular alignment. Check at four positions-90 degrees apart. A more accurate alignment check is obtained by the use of dial indicators. This is done by clamping the indicator on one coupling member with the indicator stem resting on the other coupling member, then rotating the member holding the clamped indicator. To minimize overhung loads, pulleys and sprockets should be mounted as close to the gear case as possible. Tighten hardware for pulleys and sprockets in accordance with the manufacturer's recommendations.



Warning: Do not over tighten belts or chains; reducer bearing life may be significantly reduced if belts and chains are too tight.

Install pulleys and sprockets on driver/driven equipment so that they run true. Guards should be mounted over couplings, pulleys, and sprockets after final alignment is completed.

Lubrication



Warning: Gear units are shipped from the factory without oil. Fill unit to the proper level before operating. Failure to do so will result in damage to the unit.

Maximum performance and long life of the gear unit are dependent upon the use of the proper lubricant, maintaining the correct oil level, and performing regular oil changes. At oil changes, units may require flushing prior to refilling. Suppliers of industrial lubricants, not service stations, should be contacted to supply suitable lubricants to meet the proper AGMA (American Gear Manufacturers Association) specifications.

Units should be filled to the oil level as shown on the outline drawing or as indicated on the unit with the AGMA lubricant listed below. The lubricant may be straight mineral oil or synthetic oil. Lubricants must be compatible with seal materials used in the construction of the unit. They must be non-corrosive to gears and bearings, neutral in reaction, free from grit or abrasives, and have good antifoaming and oxidation resisting properties. Refer to AGMA 9005 for more detailed information on lubricant property requirements. For applications where loads, speeds, or temperatures are abnormal, Nuttall Gear should be contacted for specific recommendations.

Oil Sump Temperature

Gear drives operating in the ambient temperature range described in the table below generally produce oil sump temperatures of not more than 180°F. This sump temperature is considered maximum because lubricants begin to lose their lubrication properties as temperatures exceed 180°F. These lubrication recommendations exclude applications such as those gear drives installed in the food and drug industry where a possibility exists for incidental contact between the lubricant and the product being processed.

Lubricant Recommendation

Ambient Temperature Range*:			
-40°F to 0°F (-40°C to -20°C)	-20°F to +25°F (-30°C to -5°C)	15°F to 60°F (-10°C to +15°C)	50°F to 125°F (10°C to 50°C)
Contact factory	ISO VG 68 – 100 (AGMA 2 – 3)	ISO VG 100 – 150 (AGMA 3 – 4)	ISO VG 150 – 220 (AGMA 4 – 5)

*The ambient temperature range is defined as the air temperature in the immediate vicinity of the gear drive.

Lubricant Viscosity Ranges (for rust and oxidation inhibited gear oils)

ISO Viscosity Grade	AGMA Lubricant No.	CST Viscosity (mm ² /s) at 40°C	SSU Viscosity at 100°F
VG 68	2	61.2 to 74.8	284 to 347
VG 100	3	90 to 110	417 to 510
VG 150	4	135 to 165	626 to 765
VG 220	5	198 to 242	918 to 1122

Lubricant Band Name Cross Reference

ISO Grade	VG 68 (AGMA 2)	VG 100 (AGMA 3)	VG 150 (AGMA 4)	VG 220 (AGMA 5)
Chevron Regal (R & O)	68	100	150	220
Shell Turbo Oil	68	100	150	220
Gulf Harmony Oil	68	100	150	220
Sun Oil Sunvis	931	951	975	999
Mobil DTE	Heavy Medium	Heavy	Extra Heavy	BB

Note: All oils listed are non-EP. EP gear lubricants in the corresponding viscosity grade may be used where the user believes a continuous sustained heavy duty loading exists. Consult a lube oil specialist. EP lubricants must not be used in backstops.

Oil Changes

Proper lubrication maintenance is vital to gear drive performance throughout its design life. After the first 500 hours or four weeks of operation, whichever occurs first, the gear drive should be thoroughly drained, flushed, and refilled with the proper lubricant. 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 gearbox to gearbox and from application to application. Typically, it is recommended that a trending procedure be performed to determine the gearbox's steady state level of iron content. When this steady state level has been determined, an excessive particle content test result may indicate the unit 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

Ideally, the lubricant should be drained while the gear drive is at operating temperature. The gear drive should be thoroughly flushed with flushing oil. Completely remove used lubricant and flushing oil from the system to avoid contaminating the new oil. Solvents should only be used if the gear drive contains deposits of oxidized or contaminated lubricant that could not be removed with the flushing oil.



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.

When persistent deposits necessitate the use of a solvent, flushing oil should be used to remove all traces of the solvent from the system prior to charging the unit with fresh oil. Where possible, the interior surfaces of the unit should be inspected for traces of foreign material and cleaned as necessary. The new charge of lubricant should then be added and circulated to coat all internal parts.

Oil Filling Instructions

- o Units with standpipes: Drain oil from unit through drain plug opposite of standpipe; follow Cleaning and Flushing instructions as noted above. Replace drain plug and remove breather. Remove pipe cap from stand pipe. Add oil through standpipe until oil level is maintained at top edge of standpipe. Replace breather and cap after filling.
- o Units without standpipes: Drain oil from unit through drain plug at lowest location; follow Cleaning and Flushing instructions as noted above. Replace drain plug and remove breather. Remove pipe plug adjacent to oil level nameplate. Add oil through breather opening until oil starts to flow over edge of opening at oil level nameplate. Replace plug and breather.



CAUTION: Never attempt to add or replace oil while the unit is running.



WARNING: Do not overfill beyond the indicated oil level; excess lubrication may result in overheating and subsequent damage to unit.



WARNING: Do not use lubricants of the EP type or those containing slippery additive such as Molybdenum disulphide and graphite in a backstop.

Cold Temperature Conditions

Lubrication, either by splash or pump, must be given special attention if the gear drive is to be started or operated at temperatures below which the oil can be effectively splashed or pumped. Preheating the oil may be necessary under these low ambient temperature conditions. Nuttall Gear should be informed when gear drives are to operate outside the individual temperature ranges listed below. Gear drives operating in cold areas must be provided with oil that circulates freely and does not cause high starting torques. An acceptable low temperature gear oil, in addition to meeting AGMA specifications, must have a pour point at least 5°C (10°F) below the minimum expected ambient temperature, with a viscosity low enough to permit the oil to flow freely at the start up temperature, but high enough to carry the load at the operating temperature. When the lubricant selected does not provide proper lubrication for the expected ambient temperature range, the gear drive should be equipped with a sump heater to bring the oil up to a temperature at which it will circulate freely for starting. The heater watt-density should be selected to avoid excessive localized heating which could result in rapid degradation of the lubricant.

Abnormal Operating Conditions

Ambient temperature fluctuations may result in condensation build-up in the unit. 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 may result in accelerated degradation of the lubricant and excessive gear wear. When operating under these conditions the lubricant should be analyzed more frequently and changed when required.

Grease Lubrication of Seals and Bearings

On units supplied with special seals for hazardous dust conditions, fittings are provided for flushing away contaminated grease from seals. Grease should be applied at regular lubrication change periods or more frequently depending upon severity of dust. On some units, fittings are provided for grease lubrication of the input shaft outboard bearing. To lubricate, remove the drain pipe plug on the input bracket and add grease (with hand operated gun) to the grease fitting located on the end cap until clean grease starts to flow from drain hole. When grease replenishment has been completed, replace the drain plug. Grease used for these applications should be a high quality NLGI (National Lubricating Grease Institute) approved grade 2 grease and should be applied at regular lubrication intervals. On units supplied with internal backstops, fittings are provided for the input shaft outboard bearing and backstop. To lubricate, remove drain pipe plug on input bracket only and add grease (with hand operated gun) to fitting on end cap until clean grease starts to flow from drain hole on input bracket. When grease replenishment has been completed, replace the drain plug on the input bracket. Remove drain pipe plug on end cap, and grease until grease starts to flow from drain hole on end cap. When grease replenishment has been completed, replace the drain plug. Mobilgrease XHP222 or equivalent grease should be used for these applications and applied at regular lubrication change periods. Listed below are approximate oil capacity values in U.S. gallons for standard floor mounted horizontal units that do not

incorporate auxiliary cooling and/or forced lubrication systems. This information is provided for assisting with estimating approximate oil volume requirements; always fill units to the prescribed oil level as outlined in the Lubrication section of this manual.

Approximate Oil Capacity in U.S. Gallons for Standard Floor Mounted Horizontal Units

Unit Size	Single Reduction	Double Reduction	Triple Reduction	Quad Reduction
5 / 10	0.5	0.75	-	-
15 / 21	0.7	1.5	1.6	-
32	1.2	2.5	2.7	2.9
43	2.0	3.7	3.9	4.1
51 / 54	2.5	6.2	6.9	7.1
64	-	6.4	7.2	7.4
76	3.5	10.7	11.5	11.7
85 / 88	-	14.1	14.4	14.6
92	-	19.3	19.6	19.8
98	-	22.5	22.8	23.0

NOTE: All values are approximate. Always fill the unit to the level marked on the gear unit itself. Do not overfill.

Start-Up

Pre-start For Units in Storage

1. Replace breather if removed during storage period.
2. Remove all tape applied in storage preparation.
3. Drain all oils applied during storage; Shell VSI Grade 68 is soluble in recommended lubricating oils. However, flushing of the unit is still recommended prior to charging the unit with new oil.
4. Thoroughly inspect unit and all accessories for damage.
5. Follow additional start-up steps as outlined below.



WARNING: Nuttall Gear units are shipped without oil. Prior to start-up, the unit must be filled with the proper amount of oil, selected in accordance with the operating conditions.



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. Add the correct amount of oil to the gear unit. Fill to the top of the stand pipe or oil level fill line while the unit is not operating. Replace the standpipe cap or oil level plug.
2. For units with additional piping systems (auxiliary cooling and/or forced lubrication systems), momentarily operate the unloaded unit until all lines have been charged with oil. Stop the unit and recheck the oil level and add oil as required. Repeat until required static oil level has been achieved.
3. Confirm proper backstop rotation via hand rotating uncoupled motor (for motor installed backstops) or hand rotating uncoupled unit input shaft (for unit installed backstops).
4. Turn the shafts by hand to confirm there are no obstructions to rotation.
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. Check all external mounting bolts, screws, etc. to make sure they have not loosened in transit or handling.
7. Check that all couplings, sprockets, pulleys, etc. are properly aligned, lubricated, mounted and keyed on shaft extensions.
8. Confirm all pipe plugs are securely tightened.
9. For units equipped with oil heaters, turn the heater on and allow the oil temperature to rise at least to 40°F before start-up.
10. Momentarily operate the motor to check for proper shaft rotation; reverse leads if necessary. Reconnect coupling. Reducers with piggyback motors should be started very carefully with the output shaft coupling disconnected. If the output shaft does not rotate, reverse the motor direction and retest. When proper rotation has been achieved, reconnect the coupling.
11. Start unit under as light a load as possible. If rotation of the unit is limited to one direction only, a tag on the housing must be provided to inform effected persons of the proper direction of rotation.
12. The machinery should be checked frequently for unusual sounds, oil leaks, excessive vibration and excessive heat. If an operating problem develops, shut down immediately and correct the problem before restarting.

Trouble Shooting

Operating Temperature

Moduline gear drives are designed for a 100°F rise in temperature over the ambient temperature, but not to exceed 180°F. If the unit is operated in the sun and/or at high ambient temperatures, auxiliary cooling may be required. In these instances, please contact your Nuttall Gear sales representative for assistance.

Noise

By nature, all gear units produce some type of noise during operation. Normal gear noises that are generally observed are either a low pitch rumble or a high whine from the high speed mesh. 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. A new gear unit may be initially noisy and then quiet down after a reasonable period of service; normal wear has taken place and teeth have established a well defined run-in-pattern. 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, 21, 22, 23
Oil leakage	1, 2, 3, 4, 5, 7, 9, 12, 13, 18, 19, 20, 22, 23
Gear wear	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 22, 23
Bearing failure	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20
Shaft failure	1, 6, 7, 8, 9, 10, 11, 12, 15, 16, 20, 21, 23
Excessive noise	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 21, 22, 23

Potential Cause	Action
1. Unit overload	Reduce the loading.
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 the unit size and ambient temperature.
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 adjustment	Too few or too many shims cause incorrect bearing clearance. Contact the factory for correct end play, checking technique, and tolerance. Shafts should turn freely when disconnected from the load.
7. Improper coupling alignment	Disconnect couplings, check spacing between shafts, and check alignment. Realign as required.
8. Incorrect coupling	Rigid couplings can cause shaft failure. Replace with a coupling that provides flexibility and lateral play.
9. Excessive operating speed	Reduce the speed.
10. Torsional or lateral vibrations	Vibration can occur through a particular speed range known as the critical speed. Contact the factory for specific recommendations.
11. Extreme repetitive shocks	Apply couplings capable of absorbing shocks.
12. Improper lubrication of bearings	Verify that all bearings are receiving adequate amounts of lubricating oil, or grease.
13. Improper storage or prolonged shutdown	Destructive rusting of bearings and gears will be caused by storage or prolonged shutdown in humid conditions. If rust is found, unit must be disassembled, inspected and repaired.
14. Excessive backlash	Contact factory.
15. Misalignment of gears	Contact pattern to be a minimum of 75% 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. Worn oil seals	Check oil seals and replace if worn.
20. Loosely bolted covers	Check all bolted joints and tighten if necessary.
21. Motor related	Verify actual operating conditions are consistent with motor nameplate.
22. Excessive ambient temperature	Shield unit from direct sunlight, and maintain proper air flow around the gear unit.
23. Excessive overhung load	Move the pulley or sprocket closer to the housing. Check for excessive tension in belts or chains.

Renewal Parts

The parts lists on the following pages provide information organized by unit type. A cut-a-way view of the gear unit is shown with the parts individually identified by item number and description.

Instructions

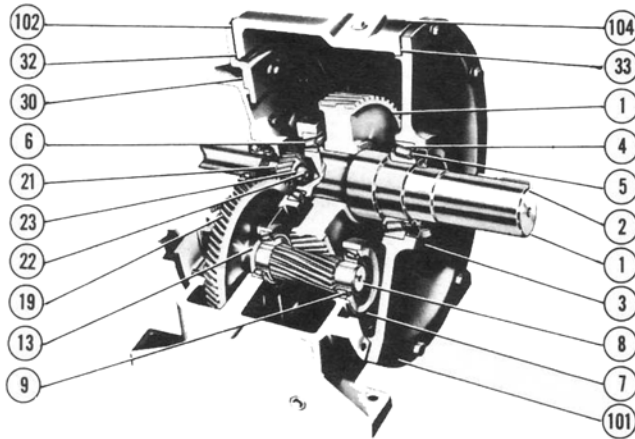
In order to obtain renewal parts for your gear unit:

1. Record all of the information off of the gear unit nameplate (refer to the illustration at the right).
2. Refer to the correct illustrations and/or assembly drawing for the description of the required parts.
3. Contact your nearest Nuttall Gear Sales Office.

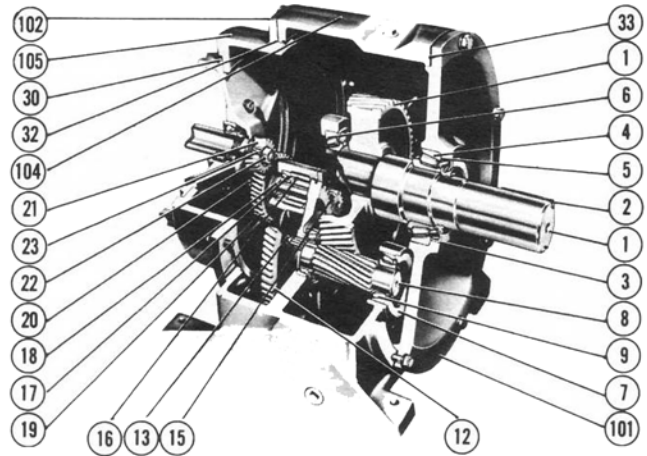
SHOP ORDER:	
CATALOG NO.:	
SERVICE HP:	RATIO:
SERVICE FACTOR:	OUTPUT RPM:
FIGURE NO.:	
	
IN ACCORDANCE WITH AGMA STANDARDS	
NUTTALL GEAR RECOMMENDS MOBILE LUBRICANTS	
NUTTALL GEAR	
NIAGARA FALLS, NY	www.nuttallgear.com

Integral Gearmotors (Type G)

Double Reduction Sizes 05D thru 98D



Triple Reduction Sizes 21T thru 98T



Part No.	Part Description	Part No.	Part Description
A. LOW SPEED COMPONENTS - Consists of:		A. LOW SPEED COMPONENTS - Consists of:	
	Low Speed Gear Set - Includes: ① ②		Low Speed Gear Set - Includes: ① ②
1	L.S. Gear and Shaft Assembly	1	L.S. Gear and Shaft Assembly
2	L.S. Shaft Key	2	L.S. Shaft Key
8	L.S. Pinion Shaft	8	L.S. Pinion Shaft
	Low Speed Bearing Set - Includes: ① ②		Low Speed Bearing Set - Includes: ① ②
4	L.S. Shaft Outer Bearing	4	L.S. Shaft Outer Bearing
5	L.S. Shaft Bearing Shims	5	L.S. Shaft Bearing Shims
6	L.S. Shaft Inner Bearing	6	L.S. Shaft Inner Bearing
7	L.S. Pinion Shaft Bearing Retainer	7	L.S. Pinion Shaft Bearing Retainer
9	L.S. Pinion Shaft Bearings ① ②	9	L.S. Pinion Shaft Bearings ① ②
13	L.S. Pinion Shaft Locking Device.....	13	L.S. Pinion Shaft Locking Device.....
C. HIGH SPEED COMPONENTS - Consists of:		B. INTERMEDIATE COMPONENTS - Consist of:	
	High Speed Gear Set - includes ① ②		Intermediate Gear Set - includes ① ②
19	H.S. Gear	12	Intermediate Gear
21	H.S. Pinion	15	Intermediate Pinion Shaft
22	H.S. Pinion Shaft Nut.....		Intermediate Bearing Set - Includes ① ②
23	H.S. Pinion Shaft Spacer.....	17	Intermediate Bearings
		18	Intermediate Shims
	D. OIL SEALS and GASKETS - Includes ① ②	16	Intermediate Pinion Shaft Spacer.....
3	L.S. Shaft Oil Seal	20	Intermediate Pinion Shaft Locking Device
30	Motor Flange Gasket		C. HIGH SPEED COMPONENTS - Consists of:
32	Adapter Gasket		High Speed Gear Set - Includes ① ②
33	L.S. Cover Gasket	19	H.S. Gear
	E. HOUSING PARTS	21	H.S. Pinion
101	Low Speed Cover.....	22	H.S. Pinion Shaft Nut.....
102	Adapter (if required).....	23	H.S. Pinion Shaft Spacer.....
104	Gear Housing.....		D. OIL SEALS and GASKETS - includes ① ②
		3	L.S. Shaft Oil Seal
		30	Motor Flange Gasket
		32	Adapter Gasket
		33	L.S. Cover Gasket
			E. HOUSING PARTS
		101	Low Speed Cover.....
		102	Adapter (if required).....
		104	Gear Housing.....
		105	Triple Reduction Housing.....

① Available only in sets.

② Order as Redi-Pak

Order Information

When ordering renewal parts read the following from the nameplate:

1. Style Number

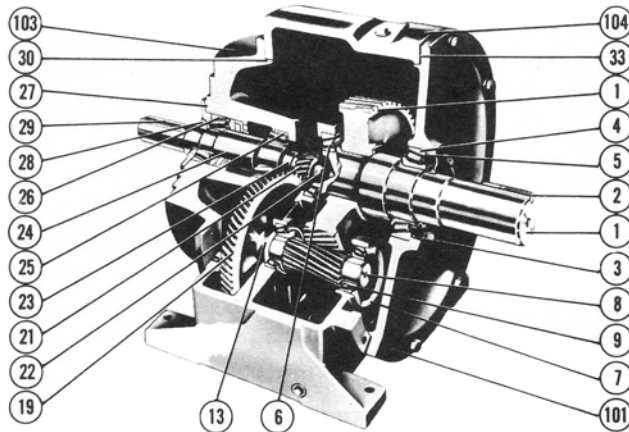
2. Motor Frame (if needed)

3. Gear Box Size and Reduction

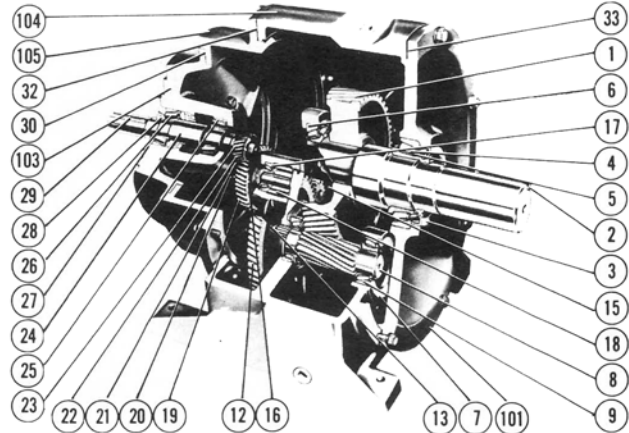
Plus: Order by part number and description

In-Line Speed Reducers (Type R) & All-Motor Gearmotors (Type U)

Double Reduction Sizes 05D thru 98D



Triple Reduction Sizes 21T thru 98T

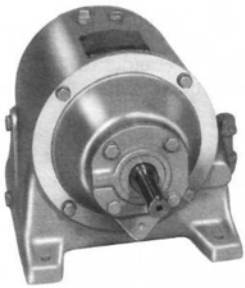


Part No.	Part Description	Part No.	Part Description
A. LOW SPEED COMPONENTS - Consists of:		A. LOW SPEED COMPONENTS - Consists of:	
	Low Speed Gear Set - Includes: 2 3		Low Speed Gear Set - Includes: 2 3
1	L.S. Gear and Shaft Assembly	1	L.S. Gear and Shaft Assembly
2	L.S. Shaft Key	2	L.S. Shaft Key
8	L.S. Pinion Shaft	8	L.S. Pinion Shaft
	Low Speed Bearing Set - Includes: 2 3		Low Speed Bearing Set - Includes: 2 3
4	L.S. Shaft Outer Bearing	4	L.S. Shaft Outer Bearing
5	L.S. Shaft Bearing Shims	5	L.S. Shaft Bearing Shims
6	L.S. Shaft Inner Bearing	6	L.S. Shaft Inner Bearing
7	L.S. Pinion Shaft Bearing Retainer	7	L.S. Pinion Shaft Bearing Retainer
9	L.S. Pinion Shaft Bearings 2 3	9	L.S. Pinion Shaft Bearings 2 3
13	L.S. Pinion Shaft Locking Device.....	13	L.S. Pinion Shaft Locking Device.....
C. HIGH SPEED COMPONENTS - Consists of:		B. INTERMEDIATE COMPONENTS - Consists of:	
	High Speed Gear Set - includes 2 3		Intermediate Gear Set - includes 2 3
19	H.S. Gear	12	Intermediate Gear
21	H.S. Pinion	15	Intermediate Pinion Shaft
22	H.S. Pinion Shaft Nut.....		Intermediate Bearing Set - Includes 2 3
23	H.S. Pinion Shaft Spacer.....	17	Intermediate Bearings
24	H.S. Shaft.....	18	Intermediate Shims
29	H.S. Shaft Key.....	16	Intermediate Pinion Shaft Spacer.....
	High Speed Bearing Set - includes: 2 3	20	Intermediate Pinion Shaft Locking Device
25	H.S. Shaft Inner Bearing		C. HIGH SPEED COMPONENTS - Consists of:
26	H.S. Shaft Outer Bearing		High Speed Gear Set - Includes 2 3
27	H.S. Shaft Shims	19	H.S. Gear
	D. OIL SEALS and GASKETS - Includes 2 3 ..	21	H.S. Pinion
3	L.S. Shaft Oil Seal	22	H.S. Pinion Shaft Nut.....
28	H.S. Shaft Oil Seal	23	H.S. Pinion Spacer.....
30	H.S. Bracket Gasket	24	H.S. Shaft.....
33	L.S. Cover Gasket	29	H.S. Shaft Key.....
	E. HOUSING PARTS		High Speed Bearing Set - includes: 2 3
101	Low Speed Cover.....	25	H.S. Shaft Inner Bearing
103	High Speed Bracket.....	26	H.S. Shaft Outer Bearing
104	Gear Housing.....	27	H.S. Shaft Shims
2	Available only in sets.		D. OIL SEALS and GASKETS - includes 2 3
3	Order as Redi-Pak		L.S. Shaft Oil Seal
Ordering Information		3	H.S. Shaft Oil Seal
When ordering renewal parts read the following from the nameplate:		28	H.S. Shaft Oil Seal
1. Style Number		30	H.S. Bracket Gasket
2. Gear Box Size and Reduction		32	Triple Reduction Housing Gasket
Plus: Order by part number and description		33	L.S. Cover Gasket
			E. HOUSING PARTS
		101	Low Speed Cover.....
		103	High Speed Bracket.....
		104	Gear Housing.....
		105	Triple Reduction Housing.....

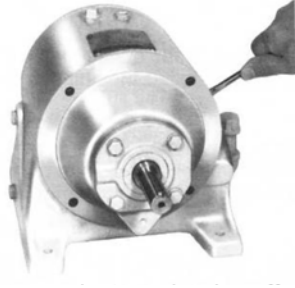
Ratio Change



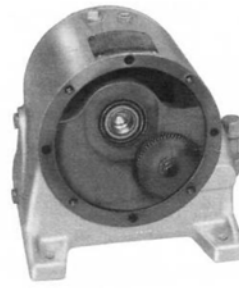
CAUTION: Prior to commencing maintenance on any machinery, personnel must observe hazard warnings and ensure that all loads have been removed from the system and appropriate lockout / tag out procedures are being used. Ratio changes may be made without disconnecting the unit from the driven equipment. Increasing the ratio in the change set raises the output torque and lowers the output RPM. Nuttall should be contacted to determine whether the unit has sufficient torque capacity at the new ratio. Decreasing the ratio in the change set lowers the output torque and raises the output RPM. The prime mover and application should be checked since higher horsepower may require at the higher output RPM. Nuttall should be contacted if prime mover horsepower is to be increased. When ordering new gears for a ratio change, the complete nameplate data on the gear drive should be supplied for positive identification along with the desired ratio. In the majority of units a change in total ratio is accomplished by changing the ratio in only one set of gears. This set of “change gears” has splined fits for ease of removal. The following procedure should be followed in changing ratios.



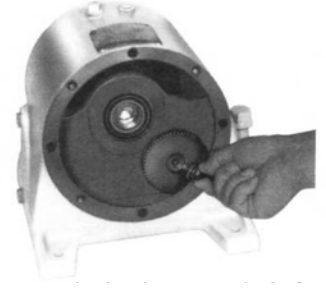
1. Begin disassembly at the input shaft end by removing the hex head bolts that secure the input bracket.



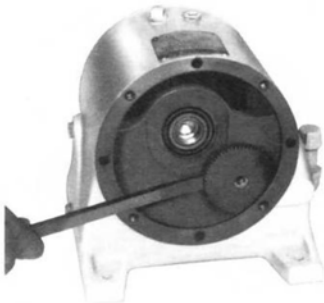
2. Pry the input bracket off using a screw driver at the inset between the bracket and housing.



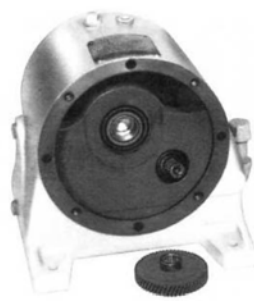
3. Remove the input bracket revealing the high speed gear. If gasket is damaged, remove and clean surfaces.



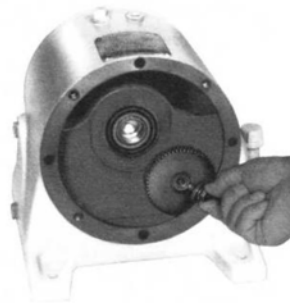
4. Lock the low speed shaft from rotating using a spanner wrench. Remove the hex bolt and washers that secure the high speed gear.



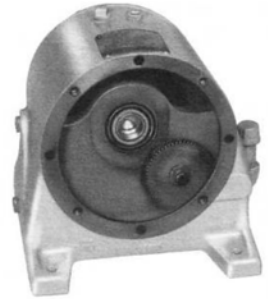
5. Pry the high speed gear off the splined shaft using a pry-bar.



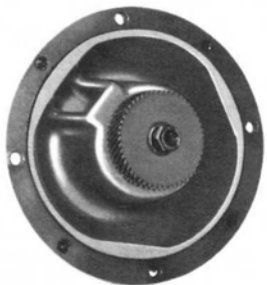
6. The new high speed gear and spacer are now ready to be placed on the splined shaft.



7. Place the original spacer and the new high speed gear on the splined shaft and secure with the hex bolt and its washers.



8. Shown here is the completed assembly with the new high speed gear.



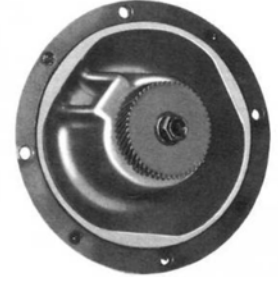
9. The next step is to change the high speed pinion. Lock the high speed shaft from rotating using a spanner wrench. Remove the hex head nut that secures the high speed pinion.



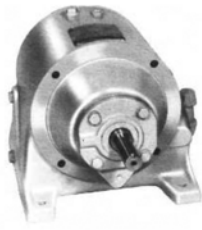
10. Pry the high speed pinion off the splined shaft using a pry-bar.



11. The new high speed pinion is now ready to be placed on the splined shaft.



12. Place the new high speed pinion on the splined shaft and secure with the hex head nut. If the gasket was damaged, apply RTV to the clean surface in lieu of using a gasket.



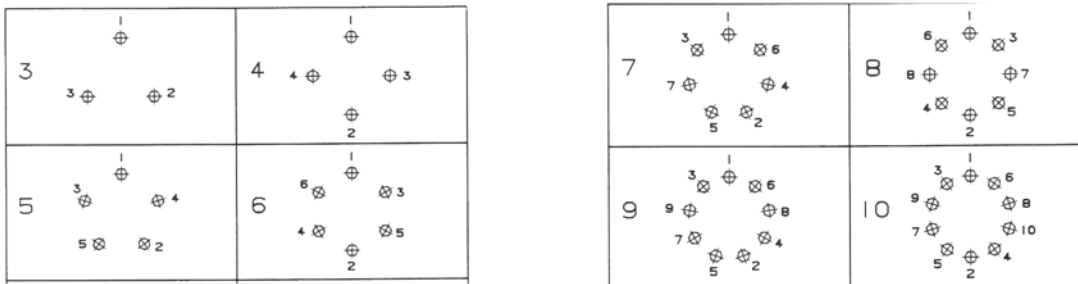
13. Reassemble the input bracket to the housing and line up mounting holes. Be sure lube opening is in proper position (180° from application floor).

14. Change the nameplate to show the correct ratio, output RPM and reducer style number.

15. On Reducers with an output speed of 125 RPM and faster, a standpipe must be installed to indicate the proper oil level. Remove the pipe plug at the base of the housing and install the standpipe.

Fasteners

Fastener Tightening Sequence



The following torque values are to be used for end covers, seal retainers, shaft guards, inspection covers, and housing split 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)	
	Min.	Max.	Min.	Max.
UNC				
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

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.

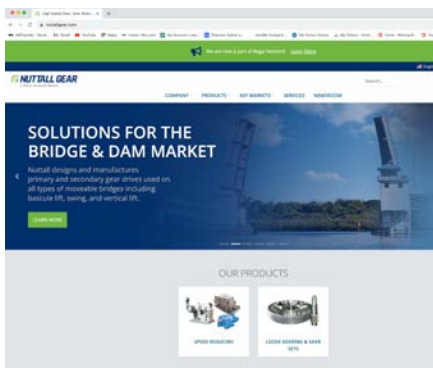
Trouble Shooting- Root cause analysis for vibration, noise, premature gear wear, and oil leaks.

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.



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Member of AGMA



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