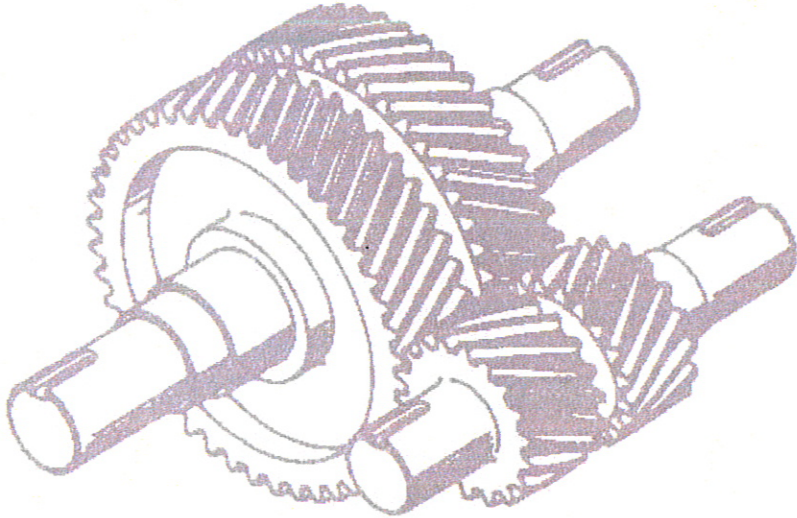


LUFKIN

Installation, Operation, & Maintenance Manual



WARNING

Failure to use this manual for guidance may result in injury to personnel and/or damage to equipment.

Lufkin Sales Order Number 106/204465
Lufkin Model N1800C
Lufkin Serial Numbers 120920-120931

York Process Systems

PO Number: P308988
RE: YPS SO# 294100

August 3, 2009



QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
== ISO 9001:2000 ==



Table of Contents

TABLE OF CONTENTS-----i

LIST OF FIGURES ----- iii

1 INTRODUCTION ----- 1

1.1 SCOPE..... 1
1.2 SAFETY PRECAUTIONS..... 1
1.3 EQUIPMENT DESCRIPTION 1
 1.3.1 Factory Testing..... 1
 1.3.2 Gearing 2
 1.3.3 Bearings..... 2
 1.3.4 Instrumentation..... 2
 1.3.5 Housing 2
 1.3.6 Lubrication 2

2 SAFETY SUMMARY ----- 4

2.1 GENERAL SAFETY PRECAUTIONS 4
2.2 SAFETY EQUIPMENT 5
 2.2.1 Wear Proper Safety Equipment 5
 2.2.2 Reduce Danger Of Damage To Hearing..... 5
2.3 REDUCE RISK OF ACCIDENTAL SHOCK 5
2.4 RESUSCITATION 5
2.5 POSSIBLE MISUSES OF EQUIPMENT 5

3 INSTALLATION ----- 6

3.1 RECEIPT OF SHIPMENT 6
3.2 STORAGE..... 6
 3.2.1 Corrosion Protection During Inoperative Periods 6
3.3 LIFTING, HANDLING..... 7
3.4 FOUNDATION 7
3.5 ADDITIONAL REQUIREMENTS..... 7
3.6 ALIGNMENT 8
 3.6.1 General 8
 3.6.2 Anticipation of Shaft Operating Positions..... 8
 3.6.3 Alignment Sequence..... 8
 3.6.4 Alignment Checking..... 9
3.7 TOOTH CONTACT CHECK 10

4 OPERATION ----- 11

4.1 LUBRICATION 11
4.2 OIL TYPE AND GRADE 11
4.3 CUSTOMER CHECK BEFORE START-UP..... 11
4.4 START-UP PROCEDURE 12
4.5. CUSTOMER CHECK AFTER START-UP 12
4.6 ALARM SWITCHES 14

5	PREVENTIVE MAINTENANCE-----	15
5.1	INTRODUCTION	15
5.2	DAILY MAINTENANCE.....	16
5.3	MONTHLY MAINTENANCE	16
5.4	QUARTERLY MAINTENANCE.....	16
5.4.1	Oil Analysis Guidelines.....	16
5.5	ANNUAL MAINTENANCE	17
5.6	OIL CHANGE INTERVALS.....	17
6	DISASSEMBLY-----	18
6.1	GENERAL.....	18
6.1.1	Lock Out/Tag Out Procedure	18
6.1.2	Visual Inspection	18
6.2	TOOLS REQUIRED	18
6.3	SPARE PARTS	18
6.4	REMOVAL OF GEAR COVER.....	19
6.5	REMOVAL OF PINION, GEAR, AND BEARINGS....	19
6.6	OIL SAMPLE COLLECTION.....	20
7	GEAR INSPECTION -----	21
7.1	TOOTH CONTACT CHECKING	21
7.1.1	Introduction	21
7.1.2	Why Check Tooth Contact	21
7.1.3	When to Check Tooth Contact	21
7.1.4	How to Check Tooth Contact	21
7.1.5	Soft Blue Method.....	21
7.1.6	Hard Blue Method	22
7.2	INTERPRETATION OF TOOTH CONTACT	22
7.3	GEAR CONDITION ASSESSMENT.....	23
7.3.1	Types of Gear Wear or Failure	24
7.3.2	Definition of Gear Failure	24
8	BEARING INSPECTION-----	25
8.1	BEARING TYPE.....	25
8.2	BEARING CONDITION ASSESSMENT	26
8.2.1	Bearing Clearance.....	26
8.2.2	Bearing Contact and Correction	27
8.2.3	Bearing High Spots.....	27
8.2.4	Flaking of Babbitt.....	27
8.2.5	Scoring.....	27
8.2.6	Wiping	28
8.3	REPLACEMENT BEARINGS	28
9	REASSEMBLY -----	29
9.1	PREPARATION.....	29
9.2	REASSEMBLY SEQUENCE	29
9.2.1	Bearing, Gear, and Pinion Assembly.....	29
9.2.2	Gear Cover Assembly.....	30

10	TROUBLESHOOTING	32
10.1	ABNORMALLY HIGH TEMPERATURE	33
10.2	LOW OIL PRESSURE.....	33
10.3	UNUSUAL OR EXCESSIVE NOISE	33
10.4	EXCESSIVE VIBRATION.....	34
10.5	FOAMING	34
10.6	NO SENSOR READINGS	34
11	NAMEPLATE DATA	35

List of Figures and Tables

Figure 1	Lifting provisions	7
Figure 2.	Expected maximum shaft vibration levels.....	12
Figure 3.	Expected maximum housing vibration levels.....	13
Figure 4.	Tooth contact patterns	23
Figure 5.	Standard N-Unit Bearings	25
Figure 6.	Pressure Dam Location.....	26
Table 1.	Equipment Description Chart	3
Table 2.	Standard Danger, Warning And Caution Symbols....	4
Table 3.	Maximum Allowable Run-Out (T.I.R.).....	9
Table 4.	Preliminary Alarm Settings	14
Table 5.	Maintenance Schedule Overview	15
Table 6.	Recommended Tightening Torques.....	30
Table 7.	Troubleshooting Tips.....	32

Introduction

1

QUALITY AND PERFORMANCE ARE PRIMARY CONCERNS AT LUFKIN.

The employees of LUFKIN Industries have made every effort to provide the customer with high quality, long lasting equipment which will give trouble-free service for many years provided it is operated within its designed capacity and is properly lubricated and maintained.

Reflecting its commitment to Quality, LUFKIN has been certified to ISO-9001 Det Norske Veritas Quality System Certificate, No. CERT-8443-2006-AQ-HOU-ANAB.

For further assistance from LUFKIN, please call or fax the following numbers:

<u>LOCATION</u>	<u>PHONE</u>	<u>FAX</u>
Customer Service (Parts, etc.)	(936) 637-5211	(936) 637-5883
Service Department	(936) 637-5307	(936) 637-5104
Repair Division	(936) 637-5413	(936) 637-5104
Engineering	(936) 637-5266	(936) 637-5774

1.1 SCOPE

The objective of this manual is to give general information on installation, lubrication, operation, maintenance, disassembly and reassembly of LUFKIN Industries N1800C gear units. In addition, there is supplementary information on unit storage, coupling alignment, oil characteristics, bearing wear, and gear wear. Any vendor supplied instruction manuals for accessory equipment are appended. Table 1 provides an overview of equipment features.

1.2 SAFETY PRECAUTIONS

Every effort has been made to place hazard warnings and explanatory or cautionary notes in appropriate parts of this text. It is strongly recommended that this manual be reviewed thoroughly before attempting to install, operate, service, or repair this equipment.

1.3 EQUIPMENT DESCRIPTION

This high speed gear unit is used for speed increasing service between an electric motor to a centrifugal compressor. For a cross section view of the gearing see the Parts List; for the general shaft arrangement, shaft ends, and hold down locations see the Installation Plan. The Mass Elastic drawing provides component weights and Wr^2 values. The electrical schematic is shown on the Wiring Diagram.

1.3.1 Factory Testing

Factory testing of LUFKIN gear units includes a detailed test of the gear at rated speeds with no load or partial load. Data recorded during testing may include bearing temperatures, shaft and housing vibration levels, oil flow and pressure, oil temperature, efficiency, and an analysis of sound level.

1.3.2 Gearing

LUFKIN gears are computer designed and rated according to the latest American Petroleum Institute (API) standards. Conservative service factors, based on API recommendations and on LUFKIN's experience, are applied to the ratings to ensure long gear life. N-type units have horizontally offset gearing. Most use double helical design utilizing hobbled and precision ground gear teeth.

Gears and pinions are made from high quality, through hardening grade alloy steel forgings. Gear teeth are cut after the gear has been shrunk on its shaft; the bearing journals are finish-turned and ground to assure concentricity between pitch circle and bearing journals. Pinions are made integral with their shafts except for very low ratios which result in large pinion diameters. Pinion and gear shaft extensions are ground to nominal dimensions with a tolerance of plus or minus 0.0005 inch (0.0127 mm.)

1.3.3 Bearings

The low speed and high speed bearings are centrifugally-cast babbitt with a split steel shell and high stability pressure dams. There is a flat babbitted thrust face on the low speed bearings to position the gear train.

1.3.4 Instrumentation

This unit is supplied with embedded temperature sensors, an accelerometer and vibration probes.

1.3.5 Housing

Housings are designed for heavy duty service to provide maximum rigidity, assuring precision gear alignment. All housings are precision bored; bore alignment is certified before assembly. Housing design incorporates the necessary oil piping for bearing and gear mesh lubrication.

The housing is a structure cast of controlled specification high tensile gray iron, stress relieved before machining for dimensional stability during machining and operating life.

Interior and exterior surfaces are shot-blasted, cleaned, and painted with red oxide primer to ensure freedom from foreign particles. The exterior of this unit is painted per customer specifications.

Inspection covers are provided for inspection and examination of all gear components, with a vent connection provided in the cover to maintain atmospheric pressure inside the gear housing.

1.3.6 Lubrication

The lubrication system for this unit is not supplied by LUFKIN. It is to be provided by the customer or others after delivery. Refer to the Installation Plan for gear unit oil supply. The unit is provided with connections for supplying oil to the bearings and to the gear mesh sprays. The unit requires an external lubrication system and reservoir. Refer to the Installation Plan for requirements of the lube system.

This unit is supplied with a shaft driven lube oil pump. This pump must be primed prior to start up. The pump suction line must be designed to minimize pressure drop throughout the line. Failure to keep suction line head loss to a minimum can cause suction line cavitation and premature pump failure.

Table 1. **EQUIPMENT DESCRIPTION CHART**

Specifications		Service Factor		Service HP
<ul style="list-style-type: none"> • AGMA 6011 • API 613 Fifth Edition 		AGMA	2.88	4000 HP
		API	1.4	2983 kW
Gearing		Bearings		Design Clearance
High Speed Pinion	Double Helical 57 teeth	HS - hydrodynamic with pressure dams		0.0055 – 0.0075 inch 0.1397 – 0.1905 mm
Low Speed Gear	Double Helical 104 teeth	LS - hydrodynamic with pressure dams		0.0070 – 0.0090 inch 0.1778 – 0.2286 mm
		Thrust Bearing		Endplay
		Babbitted Thrust Face		0.080 – 0.110 inch 2.032 – 2.794 mm
Reductions	Single	Lubrication		Weight
Parallel shaft speed	Increaser	Oil Type: AGMA Light Turbine ISO VG: 32		Unit – 6180 lbs (2803 kg)
Offset	Horizontal	Customer furnished lubrication system		Heaviest Maintenance Lift – 1622 lbs. (736 kg)
Heat treatment	Through Hardened	Speed		Housing
Cutting method	Hobbed	Input – 1772 RPM		cast iron with inspection covers
Tooth finish	CBN ground	Output – 3233 RPM		
Instrumentation and Accessory Equipment				
• Vibration probes	• Accelerometer	• Embedded temperature sensors	• Shaft Driven Lube Oil Pump	
Additional Information				
Center Distance: 18" Effective Face: 8.5" NDP: 5		Rotation: CW Prime Mover: Electric Motor Driven Equipment: Centrifugal Compressor		

Safety Summary 2

Table 2. Standard Danger, Warning, and Caution Symbols



DANGER:

DANGER notices are used to indicate an imminently hazardous situation. **Failure to comply will result in death or serious injury to personnel.**



WARNING:

WARNING notices are used to indicate a potentially hazardous situation. **Failure to comply could result in death or serious injury to personnel.**



CAUTION:

CAUTION notices are used to indicate a potentially hazardous situation. **Failure to comply may result in minor or moderate injury to personnel and/or damage to equipment.**

2.1 GENERAL SAFETY PRECAUTIONS

The following are general precautions that are not related to any specific procedures and therefore do not appear elsewhere in this publication. These are recommended precautions that personnel must understand and apply during many phases of operation and maintenance.

DANGER:



Never remove the inspection cover while the machinery is in operation. Always lock out/tag out all power sources while performing maintenance

Lock out/tag out procedures are fully explained in DISASSEMBLY

WARNING:



Never block the gear mesh by inserting material between the gear elements.

DANGER:



Never work on machinery that is still in operation or is still moving.

CAUTION:



WARNING:

Shaft and coupling guards must be securely in place before operation.

Only persons familiar with and proficient at servicing, installation, maintenance, operation, and assembly of gearing should be involved in those phases of use.

When manuals are supplied by a vendor for auxiliary or accessory equipment installed by LUFKIN, they are included in the appendix to this manual. **IMPORTANT: Read and observe all safety warnings and messages in vendor manuals.**

LUFKIN does not assume responsibility for proper guarding of shafting and couplings. LUFKIN may in some cases supply the guards; however, because of the position of the gear in the power train, the guards must also be attached to other equipment. **The user must ensure adequate guarding is provided and used in the power train.**

2.2 SAFETY EQUIPMENT

2.2.1 Wear Proper Safety Equipment

Personnel working with or near heavy equipment should wear safety equipment appropriate to the area in which they work:

- Safety glasses with side shields
- Appropriate hard soled shoes
- Appropriate head gear (hard hats)

2.2.2 Reduce Danger Of Damage To Hearing



CAUTION:

Use of hearing protection should be considered when working near any noisy equipment.

Gears and their connecting equipment may produce noise levels that are capable of causing hearing loss with long-term, unprotected exposure. The use of hearing protection equipment should be considered whenever working in areas containing equipment emitting high noise levels or noise at frequencies that are bothersome.

2.3 REDUCE RISK OF ACCIDENTAL SHOCK

Personnel working with or near high voltage should remove watches, rings, or any jewelry that could make physical contact with circuits.



DANGER:

Keep away from live circuits.

Do not replace components or make adjustments inside the equipment with the high voltage supply energized. Under certain conditions, dangerous potentials caused by charges retained by the capacitors may exist when power is off. To avoid casualties, always disconnect the power and discharge the circuit before touching it.

Under no circumstance should any person reach into an enclosure to service or adjust equipment when not in the company of someone who is capable of rendering aid in the event of an accident.

2.4 RESUSCITATION

Personnel working with or near high voltage should be familiar with modern methods of resuscitation. Such information may be obtained from the Bureau of Medicine and Surgery or the Red Cross.

2.5 POSSIBLE MISUSES OF EQUIPMENT

Following are some possible misuses of gear units that might be encountered. To prevent injury/death of personnel and/or damage to equipment, the operator should avoid:

- Overloading the gear (increasing torque above nameplate conditions.)
- Running the gear above rated speeds.
- Reversing rotation.
- Changing lubricant type or grade.
- Providing inadequate lubrication.
- Operating at temperatures above recommended levels.
- Operating with vibration above recommended levels.
- Misalignment of the unit.
- Operating unit with the pump not primed.

Installation

3

3.1 RECEIPT OF SHIPMENT

Equipment should be checked against shipping papers on receipt. The gear unit should also undergo a visual inspection to ensure that no damage has occurred during shipment. If you suspect that the unit may be damaged, contact LUFKIN for assistance. Check:

- Gear casing and shafts for signs of damage.
- Any gauges provided for cracks in the glass.
- Piping for dents, crimps, cracks or other damage.

A black coating of Equipment-Kote™ by Esgard, Inc., has been applied to all non-painted surfaces. Before installation, carefully remove the coating, using a safe solvent and a soft rag. Take care not to damage any oil seals or shafting while cleaning. All piping furnished by anyone other than LUFKIN should be carefully cleaned.

The Installation Plan drawing for the gear will show all customer piping connections as well as any electrical connections.

3.2 STORAGE

The gear is tested at LUFKIN with a break-in oil that contains a rust preventative (Interfilm Type 1™ by Esgard, Inc.) which will protect the internal parts for at least six months after shipment. Do not store the gear unit outdoors unless covered. If the inoperative period is greater than six months, see "Corrosion Protection During Inoperative Periods."

3.2.1 Corrosion Protection During Inoperative Periods

NOTE: Items 1 through 4 assume normal atmospheric conditions.

1. On new gear units shipped from LUFKIN, the rust inhibitor adhering to exposed surfaces should prevent corrosion of interior parts for at least six months with covered storage.
2. When the unit has been operated for a period of time with a recommended lubricating oil, the oil will protect interior parts for inoperative periods up to 30 days.
3. If additional down time is needed, the customer should hand spray oil on the gear mesh and manually rotate the gear unit shafts every 30 days to redistribute the oil and gain protection for 30 days.
4. If extended down time is expected and it is impractical to turn the shafts, a rust preventive type oil should be brushed or sprayed on the gear teeth. Any openings should be sealed with masking tape. A quality rust preventive oil should give 12 months protection against corrosion. This oil should be compatible with the operating oil, and it should be unnecessary to remove the rust preventive oil when the unit is started again.
5. For adverse conditions or long term storage, coat all parts with rust inhibitor compatible with operating oil and seal all openings.
6. A second method of long term storage is to disassemble the unit and coat each part with Cosmoline™ or equivalent. Before the unit can be placed in service, special cleaning with solvents will be necessary to remove all preservative from unit and parts.

3.3 LIFTING, HANDLING



WARNING:

Improper lifting techniques could cause damage to the gears and/or harm to personnel.



CAUTION:

Do not lift unit by either input or output shafts. Do not bump the shafts.

The gear unit should always be moved by rolling on bars or skates, or by lifting it with properly rated slings through two or four lifting lugs or rings on the top of the unit. See the Installation Plan or Table 1, "Equipment Description Chart" for lifting weights.

Never lift or sharply strike the shaft extensions.

Always exercise extreme caution while lifting any part of a gear unit. See Figure 1 for lifting provision locations.

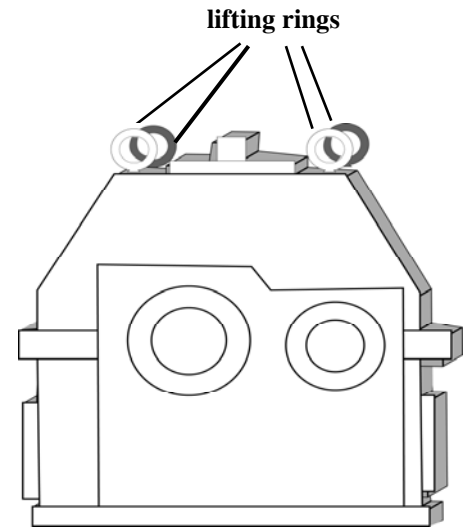


Figure 1 **Lifting provisions**

3.4 FOUNDATION



CAUTION:

Adequate foundation must be provided for proper alignment.

The unit must be mounted on a substantial foundation. One system uses a concrete base, a sole plate on the top of the concrete, about 1/8-inch (3mm) shim space, then the gear unit. The sole plate has tapped holes already in place so that bolts can be used to clamp down the feet of the gear unit (with the proper shims in place) at all positions.

Once a general elevation is established above the concrete, the sole plate is grouted into place, leaving a space of about a 1/8-inch (3mm) between the top of the sole plate and the bottom of the gear unit feet. This shim space allows room for proper positioning of the gear unit for slow speed and high speed coupling alignment.

The most common system in use is a rigid structural steel baseplate with the gear mounted with either the driver or driven equipment or the gear and both the driver and driven equipment mounted. LUFKIN often supplies this type of baseplate, with the gear and other equipment rough aligned, requiring final alignment in the field.

The housing must not be twisted or in a bind as this will adversely affect tooth contact and will cause bearing edge loading. Use an adequate area of shims under all tie down bolts. In making up the shim pack, use as few shims as possible so the pack will not be "soft".

3.5 ADDITIONAL REQUIREMENTS

- Check all studs, capscrews and bolts for proper tightening.
- Ensure suction line is properly designed and fabricated.
- Ensure pump is primed prior to start up.

3.6 ALIGNMENT

3.6.1 General

Securing proper shaft alignment is one of the most important phases of setting up a gear unit. Any appreciable misalignment can cause a multitude of gear problems from excess bearing and gear tooth wear to vibration problems. Uncorrected misalignment can lead to catastrophic failure. Therefore, it is essential that thermal growth and shaft operating position in the bearings be anticipated during shaft alignment and that good alignment be maintained.

3.6.2 Anticipation of Shaft Operating Positions

The axial and radial running position of each shaft must be determined and set correctly. The running positions depend on operating load and temperature and will differ from the positions under no load and at ambient temperature because of thermal expansion of the gear housing and the direction of the bearing loading. A temperature rise of 30–70 degrees Fahrenheit (15–40 degrees Celsius) is within normal range. For expected movement and thermal growth values see the Installation Plan drawing. Couplings should be aligned axially to operate at thermal equilibrium with little or no loading due to coupling disc deflection.

The driven and driving machines also have thermal movement which must be either added or subtracted from the gear movement, depending upon the direction of the movements.

The gear may be initially centered in the housing by carefully prying the low speed gear through its full axial travel while measuring the distance with an indicator. The gear should be centered when it is positioned at half the full travel amount.

3.6.3 Alignment Sequence

The following sequence assumes that the foundation is level, the driving or driven machine (whichever is more permanently settled) is secured, and any shipping locks and covers are removed from the gear unit.

1. Level and secure the gear unit. Jacking screws holes are provided on the base flange for bringing the gear unit to the same horizontal plane as the connecting shaft.
 - Shim under the low machine to bring it to the proper height.
 - Move one unit until all are in the same plane as the connecting shaft.
2. Establish running position of driven and driving shafts, making sure journals are centered axially and vertically. NOTE: This unit is supplied with a visual indicator that is to be used in conjunction with specified dimensions on the installation plan to establish the gearbox center.
3. Connect gear unit shafts and coupling flanges.
 - Lubricate the couplings.
 - Care should be taken in joining the two coupling halves to observe any coupling match marks.
 - Allow for axial thermal growth. NOTE: Improper axial alignment may cause excessive overloads in one of the gear meshes, and lead to premature gear failure.
 - Keep outer diameter runout within recommended maximum allowable runout, total indicator reading (T.I.R.) In a close coupled condition, T.I.R. should not exceed the values in Table 3. When the shafts are not close coupled, contact LUFKIN.

Table 3a. **Maximum Allowable Run-Out, (TIR)**

Shaft Surface Velocity (fpm)	Outside Diameter, TIR (inches)	Face, TIR per inch of R (inches)
5000 and up	0.002	0.0004
3000 to 5000	0.004	0.0005
1500 to 3000	0.006	0.0006
500 to 1500	0.008	0.0008
500 and below	0.010	0.0010

Table 3b. **Maximum Allowable Run-Out, (TIR) METRIC**

Shaft Surface Velocity (m/s)	Outside Diameter, TIR (mm)	Face, TIR per mm of R (mm)
25.4 and up	0.05	0.010
15.2 to 25.4	0.10	0.012
7.6 to 15.2	0.15	0.015
2.5 to 7.6	0.20	0.020
2.5 and below	0.25	0.025

4. Check for free axial movement of the pinion and gear. Do not force shaft movement to the point of damaging the bearing shell.
5. Tighten foundation bolts.
 - Before tightening the foundation bolts, be sure that the base of the gear unit sets evenly on all shims so that there will be no distortion after tightening the bolts.
 - After tightening the bolts, check for distortion by placing a dial indicator on the gear housing foot near the bolt to be checked. If the housing foot moves more than 0.002 inch (0.05 mm) when that bolt is loosened, then distortion is present and the housing needs additional shims around that bolt.
6. Make a soft blue tooth contact check (see GEAR INSPECTION, “Soft Blue Method.”)

3.6.4 Alignment Checking

When the preliminary soft blue contact check is satisfactory, a hot alignment check should be made by running the gear train until temperatures stabilize, shutting it down and taking indicator readings while the package is hot (see GEAR INSPECTION, “Hard Blue Method.”)

If optical alignment equipment is available, the hot alignment check should be made with the package bolted together and running, using the optical alignment flats on the gear unit in conjunction with any optical alignment flats provided on the driving and driven equipment.

After complete hot alignment is obtained, the gear unit should be doweled to the foundation or base while the unit is running and temperatures are stabilized. The base flange is drilled for dowel pins, but they must be reamed at assembly. Locate the dowels under both ends of the most critical shaft. (usually the high speed pinion). Do not use more than two dowel pins and do not put dowel pins on both ends of the unit.

**WARNING:**

Failure to use coupling guards may result in serious injury to personnel.

After coupling alignment is established, place coupling guards in position and secure.

3.7 TOOTH CONTACT CHECK

After completing the alignment and prior to start-up, the tooth contact pattern should be checked. See GEAR INSPECTION for instructions on performing a soft blue check and how to interpret results.

**CAUTION:**

Proper tooth contact must be obtained before the unit is put into operation.

During testing at the plant, layout blue is applied to the gear teeth so that in the field the contact obtained on the test stand may be verified. The soft blue check after field alignment should match the hard blue contact pattern left on the gears from the Test Stand.

After completing the start-up procedure outlined in OPERATION, run the unit for two hours under a light load, shut it down and remove the inspection cover to observe the areas on the pinion where the blue has worn off.

If the contact is not satisfactory, the problem is possibly due to gear housing distortion caused by drawing the housing down to a base that is not square with the housing. Be sure the gear housing rests evenly on any shims before tightening the foundation bolts.

4.1 LUBRICATION

At the time of shipment, LUFKIN coats interior gear parts with a rust preventative oil. This oil should be compatible with the operating oil, and it should not be necessary to flush the unit prior to putting in lubricating oil.

In the gear drive, lubrication serves three basic functions:

1. To separate tooth surfaces and prevent metal-to-metal contact, thereby reducing friction and wear.
2. To remove heat losses at the gear mesh.
3. To remove heat produced in the bearings.

It is very important to the successful and satisfactory operation of a gear unit that careful attention be given to proper lubrication, and that the lubricant be kept clean. Every precaution should be taken to prevent water and foreign particles from entering the gear case. If the oil does become contaminated by water or foreign particles, it should be analyzed and changed, if necessary, or cleaned and reconditioned.

4.2 OIL TYPE AND GRADE



CAUTION:

Do not change grades of oil without approval by LUFKIN.

The lubricating oil must be high grade, high quality, well refined petroleum oil. Straight mineral type lubricant should be used. Consult LUFKIN before using any synthetic lubricants.

Also, it is essential that the oil be clean and non-corrosive to gears and bearings. It must be neutral in reaction, possess good defoaming properties, and also have good resistance to oxidation.

LUFKIN specifies AGMA Light Turbine oil on the Parts List and Installation Plan drawings, as well as on the unit nameplate. Also see INTRODUCTION, "Lubrication". It is useful to take a baseline analysis of the oil being put into the unit for later comparison.

4.3 CUSTOMER CHECK BEFORE START-UP

1. Check all instrumentation and lubrication connections.
2. Check that all necessary piping and accessory wiring is complete.
3. Check the lubricating system for correct type and quantity of oil.
4. Check for correct shaft alignment. See INSTALLATION.
5. Check for foundation bolt tightness. See INSTALLATION.
6. Check tooth contact. See GEAR INSPECTION.
7. Check that coupling guards and inspection covers are in place.
8. Ensure pump is primed.

4.4 START-UP PROCEDURE



WARNING:

Coupling guards and inspection covers must be secured BEFORE start-up.

The minimum start up temperature for the oil in the gear unit is 70°F (21°C.) It is best to start the unit with an oil temperature as close to operating conditions as possible. Gears starting up with oil temperature below 70°F (21°C) may require additional care to ensure oil is flowing to the mesh and bearings. It may be advisable at low temperatures to slowly start-up or run oil through an auxiliary pumping system (if available) to pre-warm it.



CAUTION:

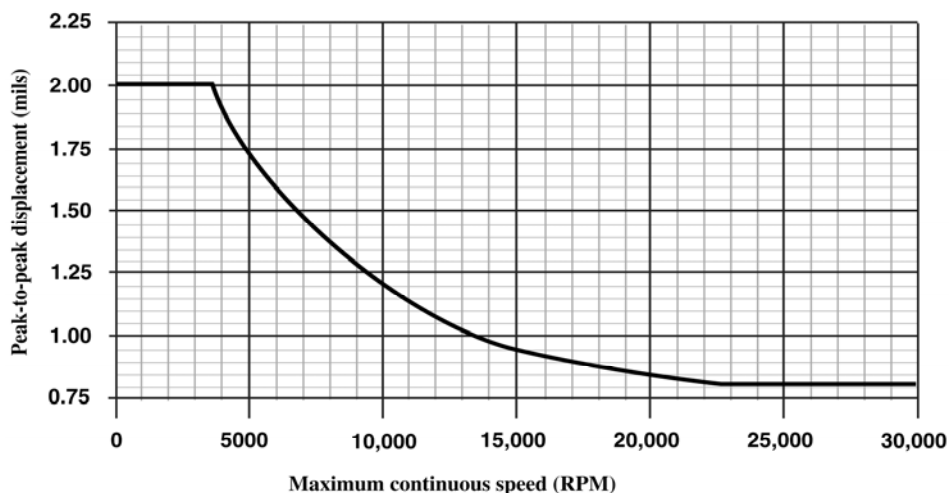
Operation of the gear unit with no oil will result in damage.

Start unit at reduced speed and load if possible. Monitor bearing temperatures, housing and shaft vibrations, and oil pressure to ensure acceptable conditions are maintained. Ensure shaft driven pump is operating acceptably. Increase speed until operating values are reached. Continue monitoring to assure acceptable temperatures, pressure and vibration. Note: There are times that vibration levels will exceed expected limits until temperatures have stabilized and/or loads have approached normal.

4.5. CUSTOMER CHECK AFTER START-UP

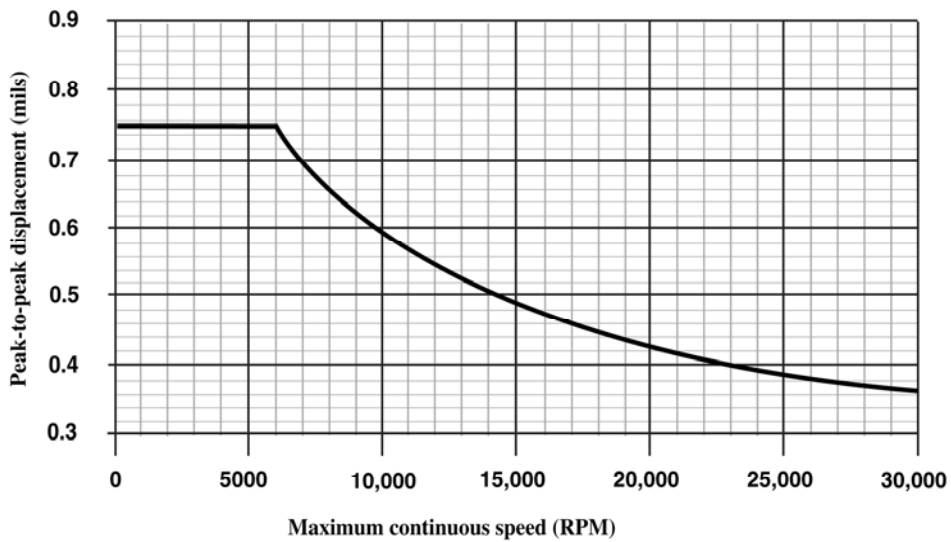
1. Run gear unit at light load while checking for adequate lubrication.
2. Watch the bearings for a sudden high temperature rise which could indicate a bearing problem.
3. Run gear under full load and speed and check for unusual noise and vibration. Expected maximum shaft vibration level for the N1800C may be found in Figure 2, and the expected maximum housing vibration in Figure 3.

Figure 2



Expected maximum shaft vibration levels for N Units with good alignment and balance.

Figure 3



Expected maximum housing vibration levels for N Units with good alignment and balance.

4. Also check oil temperature and bearing temperature. See “Alarm Switches” below for starting alarm settings. After temperature stabilization, the oil temperature into the gear unit should generally not exceed the oil inlet temperature stated on the Installation Plan drawing.
5. After unit has run for two hours under load, shut it down, check coupling alignment, check and tighten any bolts that may be loose, and recheck tooth contact.

4.6 ALARM SWITCHES

The preliminary settings offered in Table 4 below are above the expected operating level of the gear unit. However, actual field operating levels of the gear unit may be higher or lower than expected values. Therefore, the values in Table 4 are preliminary and may be decreased or increased to better suit actual field operating levels. When lower values are used Lufkin need not be consulted; however, when the values are increased over those listed in Table 4 consult Lufkin for suitability.

Table 4. Preliminary Alarm Settings		
Sensor	Alarm	Shutdown
Accelerometer Casing Velocity	6 G's 0.3 in/sec peak (7.6 mm/sec)	---To be established--- 0.5 in/sec peak (12.7 mm/sec)
Vibration Probes Shaft Vibration <i>Shaft Speed, RPM</i>		
0<N≤5000	2.5 mils (0.063 mm)	4.0 mils (0.102 mm)
5000<N≤8000	2.0 mils (0.051 mm)	3.0 mils (0.076 mm)
8000<N≤14,000	1.75 mils (0.044 mm)	2.5 mils (0.063 mm)
Probe type RTD or thermocouple in bearing shell	200°F (93°C)	215°F (102°C)
Bi-metal thermometer in bearing shell	180°F (82°C)	195°F (91°C)
Embedded RTD or thermocouple in bearing shell	225° F (107° C)	240° F (116° C)
Oil inlet	150°F (66°C)	160°F (71°C)
Unit sump or drain line	175°F (79°C)	190°F (88°C)

Preventive Maintenance

5

LUFKIN recommends following the detailed maintenance schedule on the next few pages for most operating conditions.

5.1 INTRODUCTION

The Scheduled Maintenance instructions in this manual are intended to provide a guide for minimum operations required to ensure years of trouble-free operation. Table 5 gives an overview of scheduled maintenance.

Table 5. **Maintenance Schedule Overview**

DAILY	MONTHLY
<ul style="list-style-type: none"> • check oil temperature • check oil pressure • check vibration • check noise • check for oil leaks 	<ul style="list-style-type: none"> • check operation of auxiliary equipment • check operation of alarms • check tightness of foundation bolts • check for oil contamination
QUARTERLY	ANNUALLY
<ul style="list-style-type: none"> • analyze oil sample 	<ul style="list-style-type: none"> • check bearing clearance • check endplay • check tooth contact pattern • check coupling • check alignment • check pump drive coupling
OIL CHANGE	
<ul style="list-style-type: none"> • 2500 hours of operation OR • every six months 	

If major repairs should be needed on this gear unit, it is best to return it to the factory. If time is not available for factory repairs, LUFKIN has available capable field servicemen who can perform on site analysis and repair.

If the customer desires to repair the equipment, the parts list furnished with the gear unit and the information in this manual should be studied carefully.

Good preventive maintenance habits will prolong the life of the gear unit and will help in detecting trouble spots before they cause serious damage and long down time.

5.2 DAILY MAINTENANCE

- Check the oil temperature and pressure against previously established norms.
- Check for unusual vibration and noise.
- Check for oil leaks.

5.3 MONTHLY MAINTENANCE

- Check operation of auxiliary equipment and/or instrumentation and alarms.
- Check tightness of foundation bolts.
- Check oil for possible contamination. A sample should be obtained from the floor of the gear case.

5.4 QUARTERLY MAINTENANCE

- The greatest advantage to oil analysis is that it can detect many failures before they are catastrophic. The only way to do this is to take frequent samples and have them evaluated immediately. Monitor the results. **If a change is noted, respond accordingly.**

Take oil sample and submit for laboratory analysis. Compare the results to the initial baseline analysis done when oil was first put into the unit. It is recommended that the oil be changed in the following cases:

5.4.1 Oil Analysis Guidelines

- **The total acid number increases by 2.** For example: new oil might have a total acid number of 0.4. When this number increases to 2.4 or above, the oil should be changed. This acid number increase is associated with oxidation of the oil which results in oil breakdown.
- **A rapid change in viscosity is noted.** Gear oil is "sheared" as it lubricates the meshing gear teeth. This shearing eventually causes the oil to thin out and lose its film thickness. A rapid decrease could mean oxidation. A decrease of 10% is excessive.
- **The water content is more than 0.1%.** Water in oil causes the oil to lose its film strength and also will cause corrosion to gear elements and bearings.
- **The silicon content is above 50 parts per million.** This signifies the oil is dirty.
- **The iron content is above 200 parts per million.** This indicates contamination from gear wear particles.
- **A rapid increase is noted in any of the wear elements.** As a guide, if rapid increases of any of the following materials are detected, the probable origins of that material are listed.
 - **Alloy Steel**—Gear teeth, bearings
 - **Mild Steel**—Oil pump, slinger, or baffle rubbing gear case
 - **Cast Iron**—Oil pump
 - **Aluminum**—Oil seal, seal guards or carriers
 - **Babbitt**—Journal bearings

5.5 ANNUAL MAINTENANCE

- Check bearing clearance and endplay.
- Check tooth contact pattern.
- Visually inspect couplings and check alignment.
- Inspect tags and labels showing replacement part numbers. Replace if necessary.
- Inspect warning signs and labels. Replace if necessary.

5.6 OIL CHANGE INTERVALS

Under normal operating conditions, the lubricating oil should be changed every 2500 hours of operation or every six months, whichever comes first. The unit should be drained by removing the drain plugs (see the Installation Plan for location.)



DANGER:

When working near rotating elements, be certain that the driving and driven equipment are securely locked out.

Complete oil changes for units with large capacity oil systems are sometimes impractical. In this case, draining the oil system, cleaning the reservoir and/or gear sump, and then recharging the system with the original oil that has been cleaned and reconditioned may be sufficient. If this approach is taken, LUFKIN strongly recommends routine oil analysis so that any breakdown of the oil being reused can be detected before affecting gear operation.

Disassembly

6

During disassembly, refer to the Installation Plan and Parts List furnished for the gear unit.

6.1 GENERAL

NOTE: Any work done on equipment during the warranty period without the written approval of an authorized LUFKIN representative could void the warranty.

6.1.1 Lock Out/Tag Out Procedure



DANGER:

When working near rotating elements, be certain prime mover is turned off and locked out/tagged out.

1. Identify the energy sources used and all control devices.
2. Notify all affected personnel.
3. Turn OFF all operating controls.
4. Lock out or tag out all switches and energy controls in “off” or “safe” positions.
5. Test all operating controls to make sure no power is getting to equipment.
6. Perform required maintenance.

6.1.2 Visual Inspection

The following sequence is for complete disassembly. Visual inspection of the gearing through the inspection cover may provide the information necessary to determine the cause of a problem without complete disassembly.

6.2 TOOLS REQUIRED

For disassembly and reassembly, several commonly available tools may be required. No special tools or fixtures are required for the housing and gears, and no tools for assembly/disassembly are provided by LUFKIN. Following is a list of some tools that will be helpful.

- Crane or hoist, along with soft slings or chains
- Eyebolts
- Dial indicator
- Pry bar
- Crocus cloth or fine steel wool
- Wrenches, screwdrivers, torque-wrench
- Prussian blue or similar dye for tooth contact check
- Loctite™ No. 549 Plastic Gasket

6.3 SPARE PARTS

Parts such as gaskets should be replaced when disassembly is performed. Contact LUFKIN Customer Service or a sales office for a list of recommended spare parts for the gear unit. Refer to the Parts List for a complete list of unit part numbers and descriptions.

6.4 REMOVAL OF GEAR COVER

Throughout the disassembly sequence, observe carefully what may have occurred inside the unit and record the position and condition of any failed parts. Note any parts, bolts, nuts, or holes that are numbered or match marked; they must be reassembled as matched for correct assembly.

1. Remove any deflectors, baffles, or coupling guards.
2. Disconnect the high speed and low speed couplings. Disconnect the pump suction and discharge lines.
3. Disconnect any piping, conduit, or wiring that joins the housing sections.
4. Remove any bearing temperature sensor service heads, probes, or other auxiliary instruments that could be damaged by removal of the cover.
5. Remove the cap screws in the upper half of the seals, pump adapter, and thrust bearing housing; if lockwiring is supplied, cut where necessary.
6. Remove pump, pump adapter, seals, and gaskets.
7. Remove all cap screws and nuts on the parting line. Leave studs in place to serve as guides for cover removal.
8. Break the parting line seal by using jacking screws in the jacking screw holes located on each end of the gear unit. Some sharp raps with a rawhide hammer at the corner positions and prying with a large screwdriver may be needed to loosen the parting line joint.
9. Attach a crane or hoist to the lifting provisions in the cover and carefully lift the cover by lifting both ends equally about 1/4 inch (6 mm). Check that bearings remain seated and no



CAUTION:

Do not bump gear assembly with the raised cover.

- conduit or wiring that crosses the parting line is still connected.
10. Check the upper bearing halves to see if they are stuck in the cover. If they are, carefully pry them out or push them out with a rod inserted through the bearing thermometer holes.
11. Carefully lift the cover straight up until it clears the gearing. The cover will need enough clearance above the gear and studs for the cover to be removed.
12. Place the cover on wood blocks so that the machined split line will not be damaged. Take care that internal lubrication lines are not damaged.

6.5 REMOVAL OF PINION, GEAR, AND BEARINGS

Removal of gearing from housing is not required if only bearing or rotating element inspection is needed. Bearings can be removed and replaced by rolling shells out of housing, one bearing at a time (replace the bearing after inspecting it and prior to inspecting other bearings.)

1. Mark the location of each bearing in the housing so that it can be reassembled correctly.
2. One bearing at a time, remove bearing top half. See BEARING INSPECTION for details on assessing bearing condition.)
 - a. Note (and mark if the factory marking has worn off) the exact orientation of the bearing and which face is out so that it will be replaced correctly.
 - b. If necessary, rotate the bearing until its parting line is level with the housing parting line.
 - c. Remove any bearing straps supplied.
 - d. Insert an eye bolt in the top half of the bearing and lift it up.
 - e. If gears are to be removed, *either*
 - remove the top halves of the bearings *or*
 - wire or strap the top and bottom halves of each bearing together to lift shaft and bearings out as a unit.

3. Remove the pinion using a soft sling on each side of the mesh. Place the shaft on a soft material such as wood or rubber or a padded V rack, taking care not to damage the gear teeth.
4. Remove the low speed gear and shaft assembly with a chain inserted through a lifting hole or eyebolts inserted into the gear. Be careful to protect the teeth by placing wood blocks between the chain and the sides of the gear.
5. Place the gear on a soft surface such as wood taking care not to damage the teeth. Block each side to prevent the gear from rolling.
6. See GEAR INSPECTION for an analysis of gear problems.

6.6 OIL SAMPLE COLLECTION

If desired, collect a representative full quart (liter) sample of oil from the sump for later analysis. See PREVENTIVE MAINTENANCE, "Oil Analysis Guidelines," for a discussion of oil quality and contamination.

Gear Inspection

7

7.1 TOOTH CONTACT CHECKING

7.1.1 Introduction

The purpose of this guide is to describe why you should check gear tooth contact, how the actual check is made, and how to interpret the tooth contact check on power transmission gearing with involute double helical teeth and parallel input and output shafts.

7.1.2 Why Check Tooth Contact

Gear teeth must have an even load across the entire face width to minimize stress on the teeth. The contact between gear teeth is line contact; therefore, the alignment between the rotating elements (pinion and gear) is critical. Tooth alignment is controlled by the accuracy of the rotating elements, the housing, and the bearings assembly.



DANGER:

When working near rotating elements, be certain prime mover is turned off and locked out/tagged out.

7.1.3 When to Check Tooth Contact

Tooth contact should be checked on all new installations, after any disassembly of the gear unit, and after any major housing-to-foundation change. It may also be checked as part of routine annual maintenance or when a problem related to alignment is suspected. Contact must be checked on the job foundation to be sure the unit will operate properly.

7.1.4 How to Check Tooth Contact

The contact can be checked two ways.

- **Soft blue:** Apply soft machinist's bluing or transfer bluing to the teeth of one gear and roll that gear by hand through mesh with its mating gear. (The terms "blue" or "bluing" are used for convenience; the dye is available in other colors.) The transfer of the blue from one gear to the other gear is read as the contact.
- **Hard blue:** Paint the gear teeth with hard or layout blue, run the gear unit, and observe the pattern of 'wear-off' of the bluing.

Contact checking may usually be accomplished through the inspection cover port. Occasionally, soft blue checking is done with the housing cover removed, such as during the reassembly process.

7.1.5 Soft Blue Method

The soft blue method is usually performed first. Since the unit is not running, this check does not give true contact. It does give a good indication of what contact will be. If it indicates inadequate contact, you may choose not to start the unit until contact is corrected. If the unit has been disassembled, then a soft blue check before the housing cover is installed may save a tear-down to correct contact. This is especially important if a new set of rotating elements or bearings is installed.

Soft blue is usually applied to three or four teeth on the pinion in two places 180° apart. Clean the teeth thoroughly with solvent, and brush on the blue in a very thin and even layer. With the gear set centered, hold a drag on the gear and roll the pinion through mesh with the gear. Rotation direction is not important, but the contact must be checked on the loaded flank, not the unloaded tooth flank. Observe the blue that transferred from the pinion to the gear. This is the contact pattern.

Cellophane tape can be used to remove this blue pattern from the gear and save it for maintenance records: after the check, firmly place a piece of tape on the gear tooth flank, remove the tape, place it on a clean sheet of white paper, and label it with:

- the date
- name and number of the part the tape was lifted from
- the wing and apex
- which helix (left or right, noting whether wing or apex is leading)

The contact should be checked at three places around the gear (approximately 120° apart;) however, the blue must be reapplied and smoothed on the pinion after each meshing.

7.1.6 Hard Blue Method

Thoroughly clean the area where hard blue is to be applied. The teeth must be absolutely free of oil, or the blue will not adhere properly and large flakes will chip off, making the contact check inaccurate.

Apply the blue to an area three or four teeth wide at four places on the gear and at two on the pinion. Run the unit (usually at full speed.) Running conditions may vary from no load to full load. The best way is to run the unit at very light load (up to 20%) for two hours or so, and then shut it down and check the contact. With higher loads the unit should run a shorter time before checking contact. The trick is to run the unit just long enough to wear the blue off the areas of higher contact stress. High loads can mask poor contact and give a false reading.

7.2 INTERPRETATION OF TOOTH CONTACT

The following is information to be used only for guidance in deciding if tooth contact is adequate. Contact LUFKIN on how to correct poor contact. Assuming properly manufactured parts, minor corrections can be made to the tooth contact by shimming the gear housing. Exactly what contact should be acceptable has to be based on LUFKIN's recommendations and experience.

Remember that tip or root relief modifications are designed to improve load distribution when a unit is operating under load, but they can make the contact appear quite bad under no load, as in a soft blue check. Generally, with a soft blue check you are looking for some blue to transfer, usually in a line that covers at least 80% of the face width. Do not be alarmed by a lack of blue covering the flank of the tooth; flank contact should normally not extend entirely to the tip of the tooth. See Figure 4 for examples of tooth contact patterns. Keep in mind that a soft blue contact will not produce such dark impressions—look for the same pattern in a “sketchy” impression.

The hard blue check can be done from no load to full load, and the results will vary with the load condition. If the unit is run at no load the test will usually appear similar to a soft blue check. More blue will wear off the pinion than the gear due to the higher number of cycles the pinion sees. As the load increases, blue will wear off more of the tooth flank. Look for evidence of even load across as much of the gear tooth, both flank and face width, as possible.

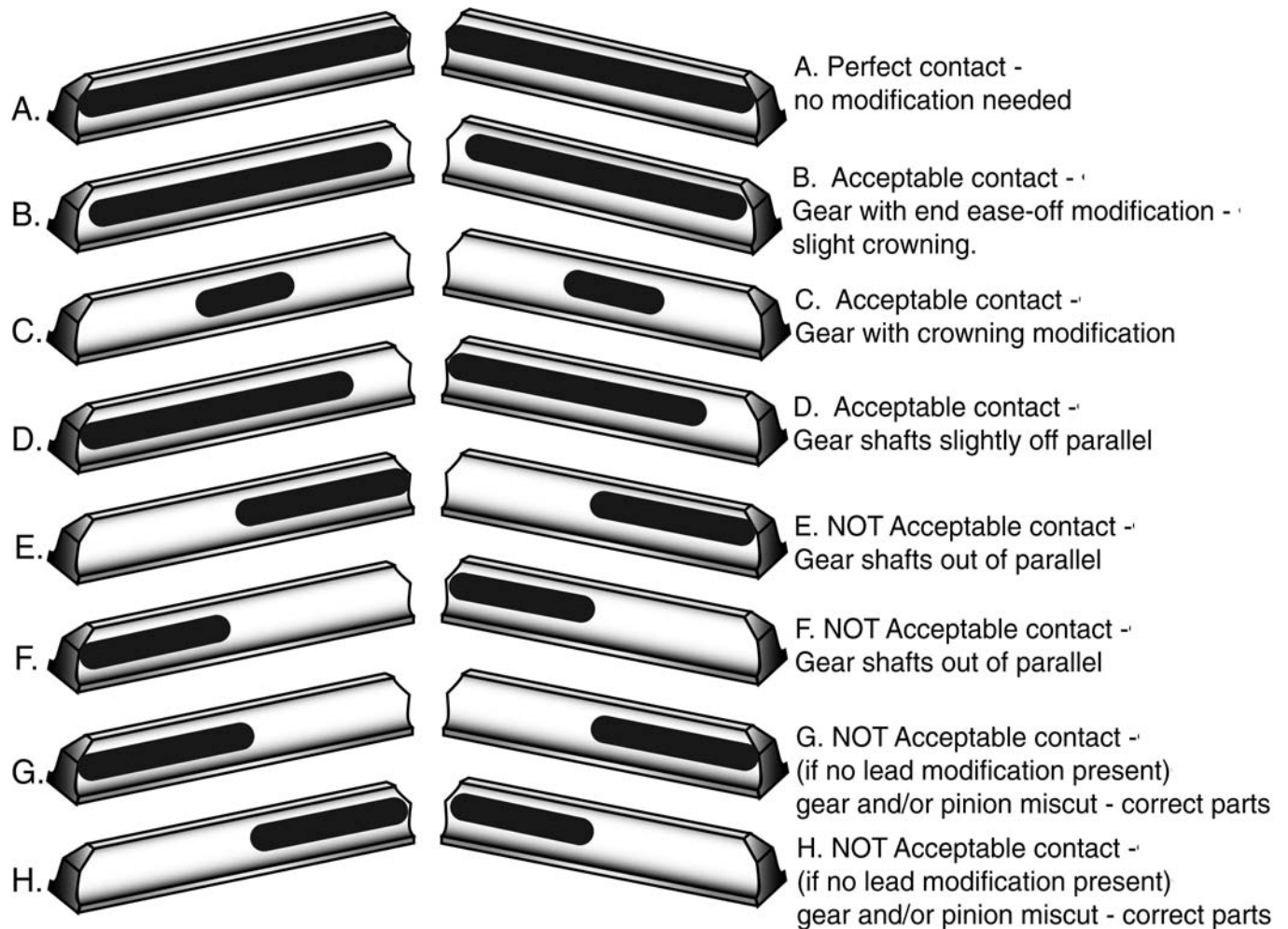


Figure 4 Tooth Contact Patterns

7.3 GEAR CONDITION ASSESSMENT

During the initial operating period of a set of gears, minor tooth imperfections will be smoothed out, and the working surfaces will polish out under normal operating conditions; however, the life of a gear set may be seriously shortened by the following problems:

- poor coupling alignment
- dirty lube oil
- insufficient lubrication
- poor tooth contact
- overloading the teeth.

In assessing gear wear, **observe carefully and document** the condition of the tooth surface and the operating conditions. It is recommended that before a questionable gear set is considered inoperative, periodic examinations be made with photographs or carbon impressions to determine whether or not the observed condition is progressive.

7.3.1 Types of Gear Wear or Failure

Listed below are several common types of gear wear or failure, extracted from *Appearance of Gear Teeth—Terminology of Wear and Failure*, ANSI/AGMA 1010-E95 (revision of ANSI/AGMA 110.04), Dec. 1995 with the permission of the publisher, The American Gear Manufacturers Association, 1550 King Street, Suite 201, Alexandria, Virginia 22314. Additional information with photographs and illustrations may be found in this bulletin.

Abrasion – Type of wear: Removal or displacement of material due to the presence of hard particles suspended in the lubricant or embedded in the flanks of the mating teeth (includes *scoring*).

Bending fatigue– Progressive failure through crack initiation, propagation, and fracture.

Contact fatigue– Cracks and the detachment of material fragments from the gear tooth surface caused by contact stress (includes *pitting*, *spalling* and *subcase fatigue*.)

Corrosion– Type of wear: Chemical or electrochemical reaction between the surface of a gear and its environment.

Cracks– Splits caused by bending fatigue, mechanical stress, thermal stress, material flaws, or improper processing.

Erosion– Type of wear: Loss of material from surface because of relative motion of a high velocity fluid.

Fracture– A fatigue failure caused by tooth overloading resulting in gear tooth or portion of tooth breaking off (includes *tooth shear*.)

Plastic deformation– Deformation caused by stress exceeding the yield strength of the material (including *indentation*, *cold flow*, *hot flow*, *rolling*, *tooth hammer*, *rippling*, *ridging*, *burring*, *root fillet yielding*, or *tip-to-root interference*.)

Scuffing– Severe adhesion that causes transfer of metal from one tooth surface to another due to welding and tearing.

Wear– Change to a gear tooth surface involving the removal or displacement of material, caused by mechanical, chemical, or electrical action (includes *adhesion*, *abrasion*, *polishing*, *corrosion*, *fretting corrosion*, *scaling*, *cavitation*, *erosion*, *electrical discharge*, and *rippling*.)

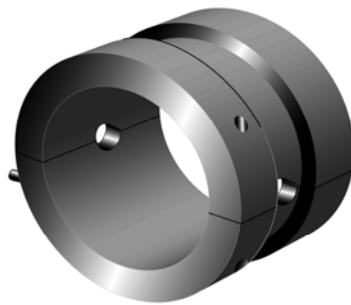
7.3.2 Definition of Gear Failure

It should be understood that the above mentioned types of wear do not necessarily constitute complete failure, for failure is a matter of degree or rate of progression.

Bearing Inspection 8

8.1 BEARING TYPE

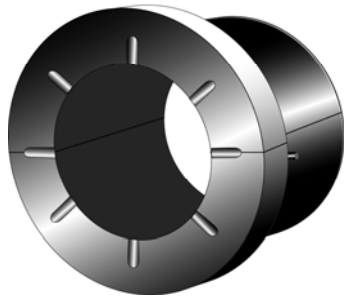
LUFKIN's standard journal bearings for N-type gear units are split, steel-backed, babbitt-lined bearings, shown in Figure 5A.



A. Standard journal bearing.



B. Pressure dam bearing.



C. Flat face thrust bearing with radial grooves.

Figure 5 Std N Unit Bearings.



CAUTION:

Pressure dam bearings must be positioned correctly to prevent damage to equipment.

When speeds or loads warrant, pressure dam bearings may be used (Figure 5B.).

The dam bearing is designed for a particular direction of rotation; therefore, care should be taken at assembly to assure correct rotation. The pressure dam grooves are positioned on the unloaded side of the bearing journal as shown in Figure 6. To axially locate the gear train and to take any nominal thrust created by external loads, LUFKIN normally uses a flat face thrust bearing with radial grooves (Figure 5C.), located on the low speed shaft. The N unit thrust areas are sized so that the maximum continuous thrust pressure on the flat face bearing is 75psi (525kPa).

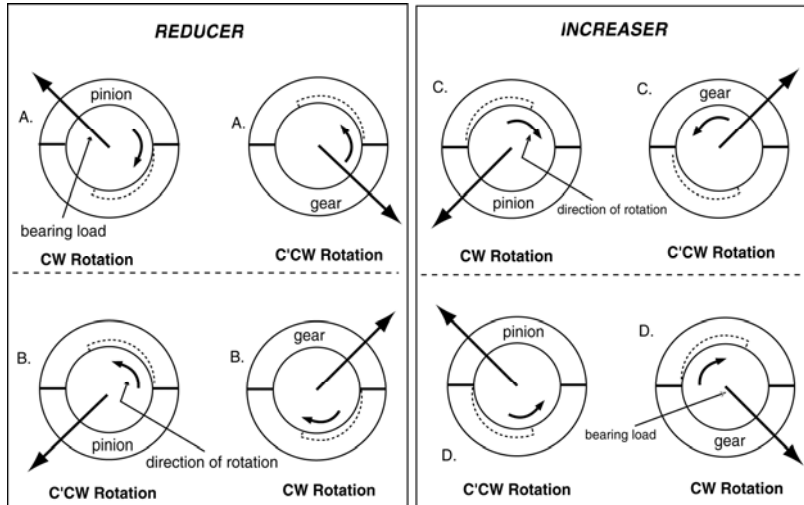


Figure 6 Pressure dam location.

8.2 BEARING CONDITION ASSESSMENT

When the unit is disassembled, the bearings and journal should be carefully inspected for uneven wear or damage. If required, manually polish journals using belt type crocus cloth to remove any high spots.

Bearing surfaces should be thoroughly inspected for:

- correct clearance
- high spots
- flaking of babbit
- scoring
- wiping

8.2.1 Bearing Clearance

The journal bearings used in LUFKIN gears must have clearance between the journal and the bearing. The amount of clearance necessary depends on the oil viscosity, the journal speed and the bearing loading. Each of these parameters is considered in calculating clearance that will provide hydrodynamic lubrication, as well as sufficient oil flow for cooling.

Design clearance on the bearings is indicated on the Installation Plan.

Measurement of bearing clearances may be accomplished while the gear is stopped by lifting the shaft and measuring the distance traveled with a dial indicator or by using feeler gauges, carefully sliding a feeler gauge between the top of the bearing bore and the shaft.

Some wear should be expected, especially on a gear that is stopped and started frequently. The bearing may be considered operational as long as the measured clearance does not exceed the design clearance by more than 0.002" (0.05 mm).

NOTE: If shaft vibration is excessive, this clearance increase may not be acceptable—**contact LUFKIN.**

8.2.2 Bearing Contact and Correction

High speed and low speed bearings should be checked as they are seated for correct bearing contact using Prussian blue dye. This may be done by rolling out one shell at a time for inspection of transfer of blue dye between shaft and journal.

To check the bearing contact, install the loaded half of the bearing in each side of the housing with the journal clean and dry. Check the outside diameter of the bearing with a 0.0015" (0.035 mm) feeler gauge to be sure the lower half is seated in the housing. In the axial direction, apply a very light line of Prussian blue to the journal and rotate the shaft 360° by hand. The journal should show blue transfer for a minimum of 80% of the bearing length.

After bearing contact is satisfactory, it may be possible to improve gear tooth contact by adjusting the shims under the unit (see INSTALLATION, "Alignment" and GEAR INSPECTION, "Interpretation of Tooth Contact".)

Sometimes gear tooth contact may be corrected by scraping and polishing one of the bearings loaded in the bottom section to spread the contact along the face width. If this is necessary, contact LUFKIN.

After correcting bearing and tooth contact and before putting the cover on the gear unit, the bearings should be liberally lubricated with clean oil to provide for initial start-up lubrication.

8.2.3 Bearing High Spots



CAUTION:

All bearing journal polishing must be in a circumferential direction to prevent axial scratches

Location of any high spots in the bearing are indicated by bright spots which should be lightly scraped and polished with fine steel wool or crocus cloth until they blend in with the rest of the bearing.

8.2.4 Flaking of Babbitt



CAUTION:

Do not use sandpaper to polish bearings; damage to equipment may result.

Flaking of babbitt in the load area of the bearing is caused by vibration or shock loading of the bearing material, causing the babbitt to fatigue and break loose from the steel shell. The flakes cause scoring as they pass through the bearing and contaminate the lubricating oil. In the advanced stages of flaking, the load carrying area of the bearing is destroyed and the bearing must be replaced. However, if flaking is caught in the early stages, the bearing may be repaired by scraping and polishing. The cause of vibration or hammering should be corrected before the unit is put back in service.

8.2.5 Scoring

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

8.2.6 Wiping

The melting and wiping away of a spot or area of the babbitt is caused by bearing temperatures rising above the pour point of the babbitt. Abnormal bearing temperatures may be caused by:

- insufficient bearing clearances
- insufficient oil pressure
- excessively high oil temperature in the bearing
- a high spot in the bearing
- extreme bearing loading caused by poor bearing contact
- gear mesh failure

If wiping is localized in a small spot, the bearing may be repaired by scraping and polishing the spot until it blends in with the remainder of the bearing; otherwise, the bearing must be replaced. Before replacing a wiped bearing, determine and correct the cause of the wipe.

8.3 REPLACEMENT BEARINGS

Refer to the Parts List drawing and contact LUFKIN if it is determined that bearings need to be replaced. If new bearings are used, the following precautions should be taken:

1. Remove all nicks and burrs from the housing and bearing shell.
2. Be sure that journals are free of nicks and high spots. These can be removed using a fine hone and polishing with crocus cloth.
3. Obtain the proper bearing contact as described under "Bearing Contact and Correction".
4. After bearings are fitted and lower halves are installed in housing, check the radial clearance using feeler gauge or plastic gauge material. Check endplay by barring the shaft axially.

Reassembly

9

9.1 PREPARATION

NOTE: Any work done on equipment during the warranty period without the written approval of an authorized LUFKIN representative could void the warranty.

NOTE: This procedure assumes that the gear housing is not moved from its foundation/support and that the original shaft alignment was correct.

1. Clean all the interior surfaces of the housing, the housing cover, and all components that will be reused. Parting line surfaces must be clean and smooth; use a spray-on paint and gasket remover fluid and/or carefully scrape the surfaces if necessary. Corroded spots can be cleaned by using a fine emery cloth, rubbing shafts in a rotary or circumferential direction. Do not rub shafts in a length-wise direction as it may cause seal leaks.



CAUTION:

During maintenance of the reduction gear, cleanliness of parts during installation is of utmost importance to assure successful gear operation.

2. Check the bearing shells, the parting line, and the housing bores for any burrs or nicks; remove with a fine file.
3. Put a coat of light oil on all parts to help assembly and to prevent rust during reassembly.

For the discussion that follows, it is assumed that the entire unit must be reassembled.

NOTE: Tighten connectors uniformly: when tightening bolts, studs, or screws on an assembled portion with three or more holes, always partially tighten connectors equally in a “cross” pattern to avoid torquing, binding, or warping the section (for example: 1. top left corner, 2. bottom right corner, 3. top right corner, 4. bottom left corner. Repeat to fully tighten.)

9.2 REASSEMBLY SEQUENCE

Note: Although instructions include using sealer between housing sections, this should actually be done on the final assembly, only after checking tooth contact and ascertaining that the unit is aligned properly.

9.2.1 Bearing, Gear, and Pinion Assembly

1. **Install journal bearings.** Before installing journal bearings, note that pressure dam bearings are match marked and are not interchangeable.



CAUTION:

Correct assembly of pressure dam bearings is required to prevent damage to equipment.

- Install the lower half of the high speed shaft journal bearings (the half with the slot for the roll pin if there is one) in the housing in the position for which they were marked at disassembly, keeping parting lines on bearing and housing even.
- Check with a 0.0015" (0.035 mm) feeler gauge to see that lower halves are seated.
- See Figure 6 to seat pressure dam in correct location.

- Check bearing contact as described in BEARING INSPECTION.



CAUTION:

Do not attempt to install shafts with lower halves of thrust bearing in housing or babbitted thrust faces may be damaged.



CAUTION:

Do not bump gear assembly into housing.

• Rethread any temperature sensor wires from bearing through housing.

2. **Install gear.** Lift the low speed gear with its bearings held in place with wire wrapped around the oil feed groove and carefully place the assembly in its correct location in the gear housing. Check that temperature sensor wires are not pinched.
3. Remove the wire and secure (bolts or bearing straps if supplied—see Parts List for requirements.) Turn bearings in bore if necessary (see Parts List for requirements.)
4. **Install pinion.** Make sure the pinion is level and line it up in mesh with the gear.
5. Carefully set the pinion into its bearings and in mesh with the gear.
6. Set the top of the pinion bearings in place and secure (bolts or bearing straps if supplied—see Parts List for requirements.)

9.2.2 Gear Cover Assembly

1. Lower the cover over the studs carefully to prevent damage to gearing. Leave suspended high enough to reach RTD holes.
2. Thread the temperature sensor wires from the bearings through the top housing if necessary (for safety place wooden blocks between the middle section and the top while threading wires.)



CAUTION:

Do not block oil passages with sealer.



WARNING:

Do not place hands below suspended housing without blocks for protection.

3. Coat the split line with a small bead of sealer, such as LocTite™ No. 549 Plastic Gasket. Circle all studs to assure sealing of oil; avoid feeder groove areas.
4. Seat the cover onto the bottom section and install and torque the tapered dowel pins.
5. Torque all cap screws and studs (see Table 6, “Recommended Tightening Torques.”)
6. Perform a soft blue gear tooth contact check. (See GEAR INSPECTION.)

Table 6. **Recommended Tightening Torques**
(for Grade 5 Bolts & Studs)

Nominal Size		Tightening Torque for BOLTS		Tightening Torque for STUDS	
inches	mm	Ft. Lbs.	N·m	Ft. Lbs.	N·m
1/2	12.7	75	102	87	117
5/8	15.9	150	203	173	234
3/4	19.0	266	360	307	416
1	25.4	644	873	742	1006
1-1/4	28.8	1120	1519	1484	2012
1-1/2	38.1	1949	2643	2582	3501
1 -3/4	44.5	2286	3100	4073	5522

7. If the contact is not acceptable, check for improperly meshed gears, burrs on shafts or housing

bores, or twisted housing. If no satisfactory explanation can be found, contact the LUFKIN Service Department for assistance.

8. Measure to ensure low speed shaft has specified axial movement. (Use a pry bar to move gear from side to side if necessary). Also check that the high speed pinion can float axially.
9. Mount the shaft seals, end plates, pump coupling, adapter, pump, and other auxiliary equipment which may have been disconnected during disassembly.
10. Reconnect any junction box plate and wiring as necessary (see the Wiring Diagram.)
11. Reconnect any instrumentation and lubrication lines necessary (see the Wiring Diagram, Installation Plan, and Lube System Diagram.)
12. Couple unit to driver and driven machines (see INSTALLATION.)
13. Install inspection covers with gaskets and sealer.
14. Align the unit per INSTALLATION, "Alignment" section.
15. Spin the unit slowly with no load, if possible, to verify correct reassembly. Be sure the unit rotates freely and quietly.
16. Confirm proper shaft alignment and tooth contact per INSTALLATION section.
17. Follow the START-UP procedures.

Troubleshooting 10

Table 7 provides troubleshooting tips for high speed gears. For more detailed information, refer to the text following. If the problem cannot be remedied through use of this information, contact LUFKIN.

Table 7. Troubleshooting Tips

Problem	Possible Cause	Remedy
Abnormally High Temperature	<ul style="list-style-type: none"> Housing coated with foreign material, preventing heat dissipation High ambient temperature Lack of oil to bearings and/or mesh (indicated by low oil pressure) 	<ul style="list-style-type: none"> Clean outside of housing Provide adequate ventilation Check lubrication system
Low Oil Pressure	<ul style="list-style-type: none"> Use of lubricant with lower viscosity than required Low lubricant viscosity from high lubricant temperatures Clogged oil filter Pump cavitation Air leak in suction line Incorrect relief valve setting 	<ul style="list-style-type: none"> Use correct viscosity lubricant See "Abnormally High Temperature" Replace filter element Maintain proper oil level in reservoir Check and tighten all pipe fittings Set relief valve correctly
Excessive Vibrations	<ul style="list-style-type: none"> Insufficient foundation rigidity Dynamic instability (critical speed) Unbalanced parts Loose foundation bolting 	<ul style="list-style-type: none"> Reinforce foundation Design to attenuate critical speeds in operating range Determine which parts require balancing and which have been balanced Tighten bolting
Unusual Noise	<ul style="list-style-type: none"> Worn parts Coupling misalignment 	<ul style="list-style-type: none"> Pinpoint noise with mechanic's stethoscope, replace part Realign couplings
Excessive Noise	<ul style="list-style-type: none"> Worn gearing Transmission from other equipment 	<ul style="list-style-type: none"> Replace worn parts Add sound blanket or enclosure
Excessive Foaming	<ul style="list-style-type: none"> Air in oil 	<ul style="list-style-type: none"> Add anti-foaming agent (See caution in text below.)
No Sensor Readings	<ul style="list-style-type: none"> No power Faulty gauge or recording device Failed sensor Lead wire braid rubbed through; wire contacting metal 	<ul style="list-style-type: none"> Check power supply & repair or restore Test gauge or recording equipment Replace sensor Replace lead wire

10.1 ABNORMALLY HIGH TEMPERATURE

- **Oil level too high.** If the oil level in a gear box is so high that the gear runs in the oil, then the resulting churning action will heat the oil. Check the sight gauge while the unit is running. A full gauge may indicate inadequate drainage.
- **Coated housing.** If the gear housing should get coated with a foreign material that will not permit natural heat removal by convection, high temperature may result. To prevent this, the unit should be cleaned periodically.
- **Hot weather.** Obviously, a high ambient temperature will cause abnormally high oil temperature. To prevent this, provide adequate ventilation around the gear.
- **Low oil pressure.** If the oil flow to the bearings and gear mesh is below normal (indicated by below normal oil pressure,) the heat created by friction at the mesh and bearings will cause abnormally high temperatures. To correct this situation, check the lubrication system for proper operation (see OPERATION, “Lubrication.”)

10.2 LOW OIL PRESSURE

- **Use of a lubricant which has a viscosity less than that for which the lube system was designed.** There are several orifices in the lube system which are sized for lubricants with a particular viscosity. A lubricant with less than this normal viscosity will pass through the orifices without building up pressure. This situation can be prevented by using the lubricant designated on the name plate of the gear unit. Abnormally low viscosity may also result from high lubricant temperatures. (See above, “Abnormally High Temperatures.”)
- **Clogged oil filter.** Replacing the filter will allow more oil to flow through it, thus bringing the oil pressure back to normal.
- **Pump cavitation.** Should the oil level in the reservoir get so low that the pump suction line sucks both air and oil, then the oil pressure will drop. This problem may be cured by maintaining proper oil level in the reservoir.
- **Air leak in the suction line to the pump.** This situation is similar to pump cavitation in that air gets in the oil and results in low oil pressure. To remedy this problem, check and tighten all pipe fittings in the suction line.
- **Incorrect relief valve setting.** Adjusting the relief valve setting properly will avoid venting the pump discharge line back to the sump.

10.3 UNUSUAL OR EXCESSIVE NOISE

- **Worn parts.** One common cause of unusual noise is worn parts. If a part wears enough to cause slack in the system, the slack may be heard as a rattle or noise of some sort. A mechanic's stethoscope may be used to pinpoint the worn part which should be replaced.
- **Misalignment.** A coupling that is out of alignment may also cause noisy operation. The misaligned coupling causes misalignment in the gear train which then produces noise or vibrations. The coupling should be immediately realigned before damaging wear occurs.
- **Transmitted sound.** Occasionally other machinery or equipment may be transmitting excessive noise. Enclose one or the other or use a sound blanket.

10.4 EXCESSIVE VIBRATION

- **Soft foundation.** A foundation that is not sufficiently rigid may cause vibration problems. To correct this, reinforce the foundation.
- **Critical speeds.** At certain speeds a rotating shaft will become dynamically unstable and the resulting vibrations and deflections that occur may cause damage to the gear unit. The speeds at which the shaft becomes unstable are called critical speeds. They are a function of the shaft geometry and the type and spacing of the supporting bearings. Contact LUFKIN if such dynamic instability is suspected. See OPERATION, “Customer Check After Start-up” for vibration limits.



CAUTION:

Measure the anti-foaming agent carefully. Too much anti-foam agent will stabilize the foam, destroy the load capacity of the oil, and require a complete oil change.

10.5 FOAMING

Some foam in a gear unit is generally acceptable and inevitable. If the foam exceeds 2 or 3 inches in the sump, LUFKIN recommends adding an anti-foaming agent such as DOW CORNING 200 FLUID™ (1000CS) at approximately 0.075 ml per gallon of oil. If excessive foaming persists, contact LUFKIN.

10.6 NO SENSOR READINGS

Various sensing devices for temperature and vibration are installed to provide warnings that can prevent catastrophic failure. If no readings are being received, before disassembling the unit check for the following:

- **No power.** Check that the power supply to the devices is on.
- **Failed equipment.** Check that the monitoring or recording equipment is functioning.
- **Worn wires.** If the sensor has failed, partial disassembly may be affected to replace the sensor. Visual inspection of lead wire overbraids are necessary to ensure that moving parts are not rubbing through the lead wires and causing shorting out. Replace any worn wires.

Nameplate Data

11

LUFKIN GEARS

MODEL NO.	N1800C	GEAR RATIO	1.8246:1
SERIAL NO.	120920-120931	RATED INPUT	1772 RPM
ORDER NO.	106/204465	RATED OUTPUT	3233 RPM
ITEM NO.		GEAR RATED	4000 HP 2983 KW
ACTUAL K FACTOR	174.77	API SERVICE FACTOR	1.4
SPEC	API 613		
NO. OF TEETH GR/PIN	104 / 57		

AGMA LUBRICANT NUMBER

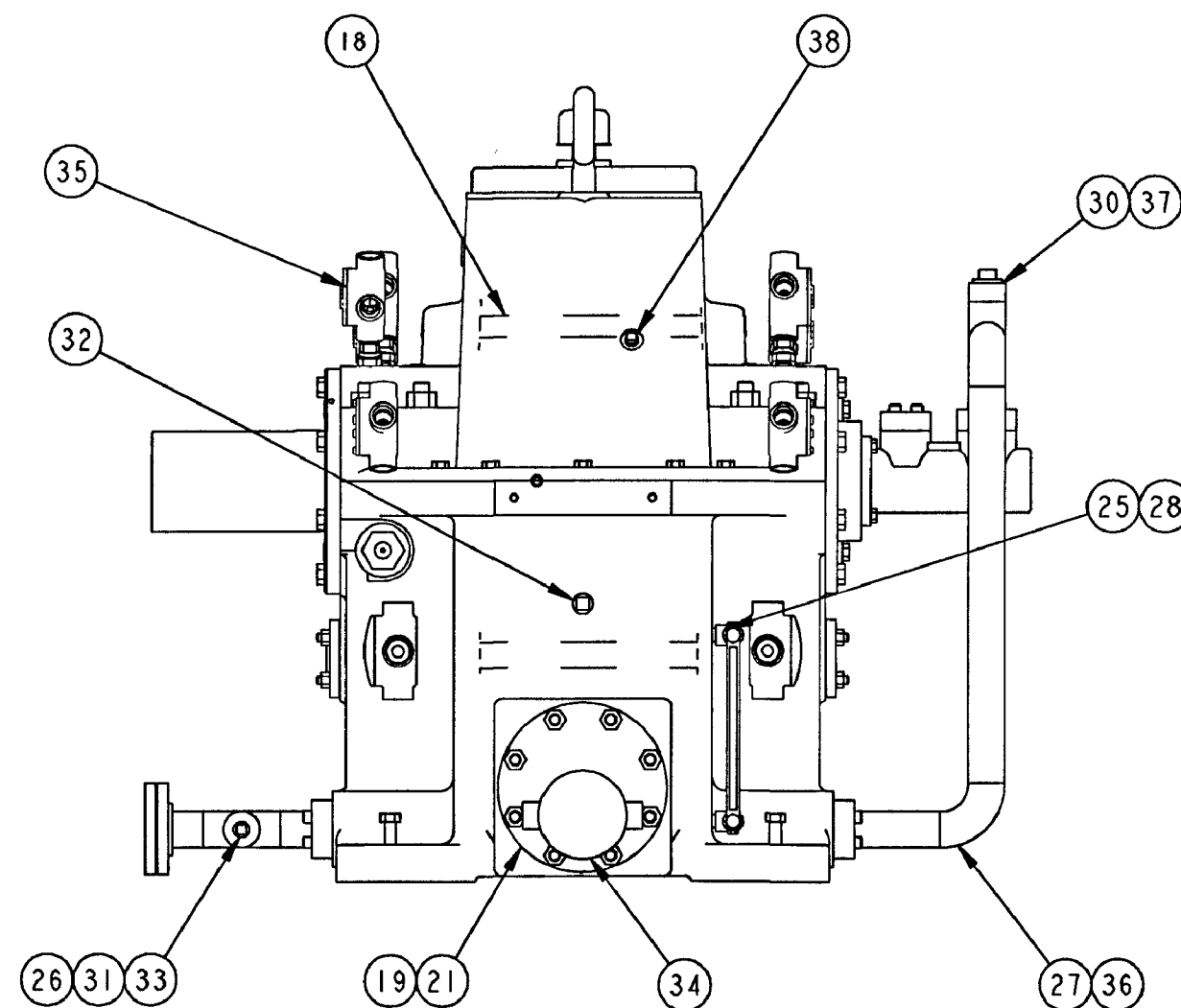
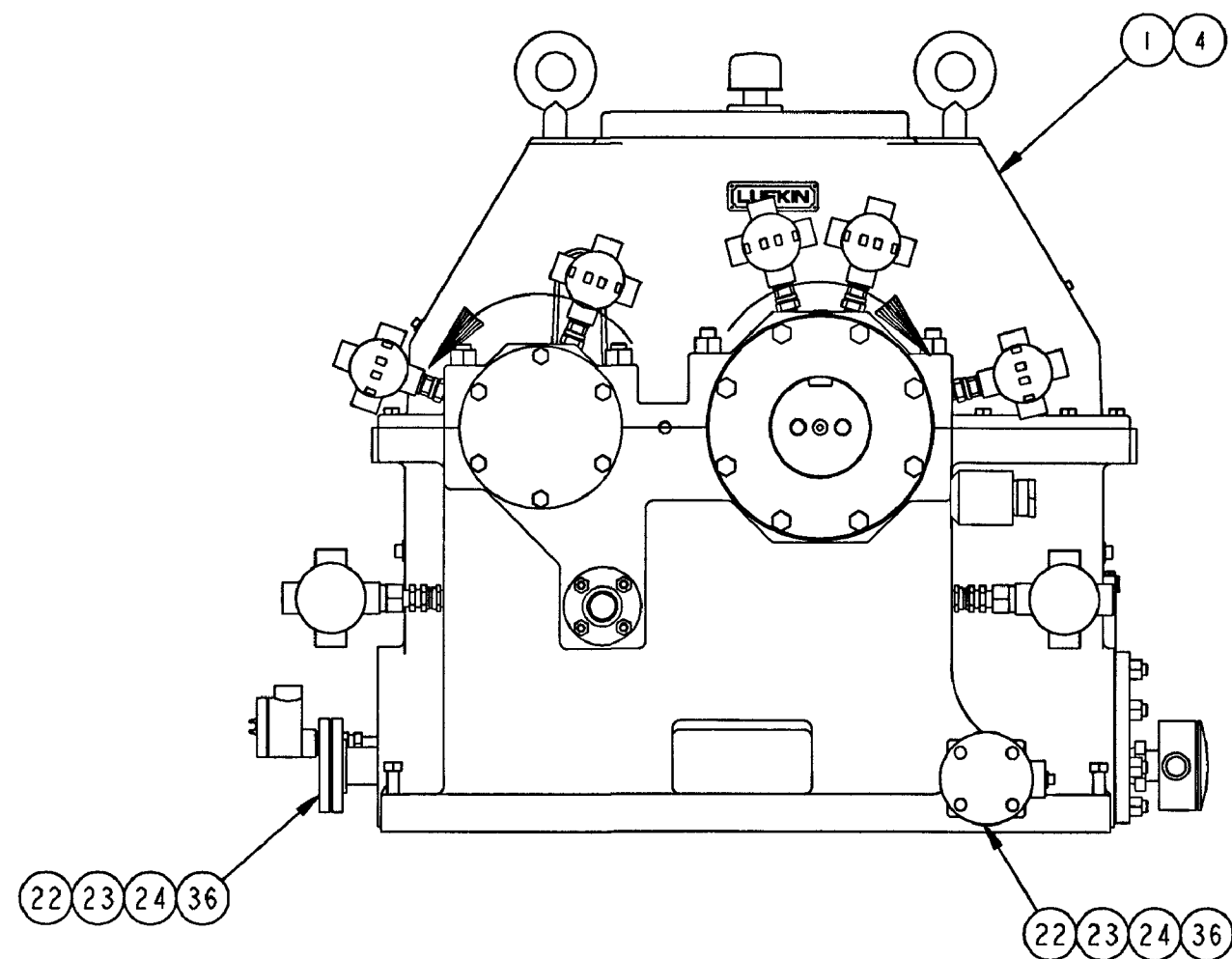
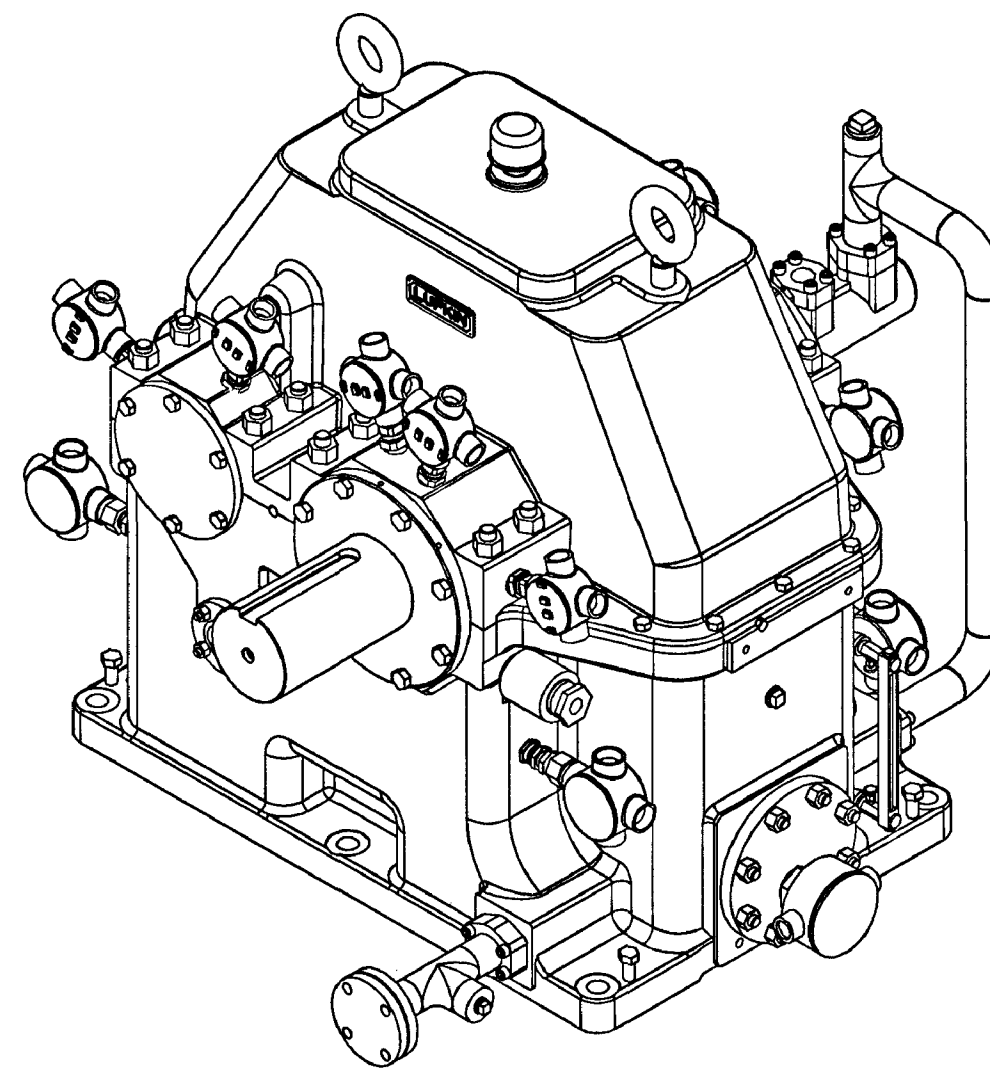
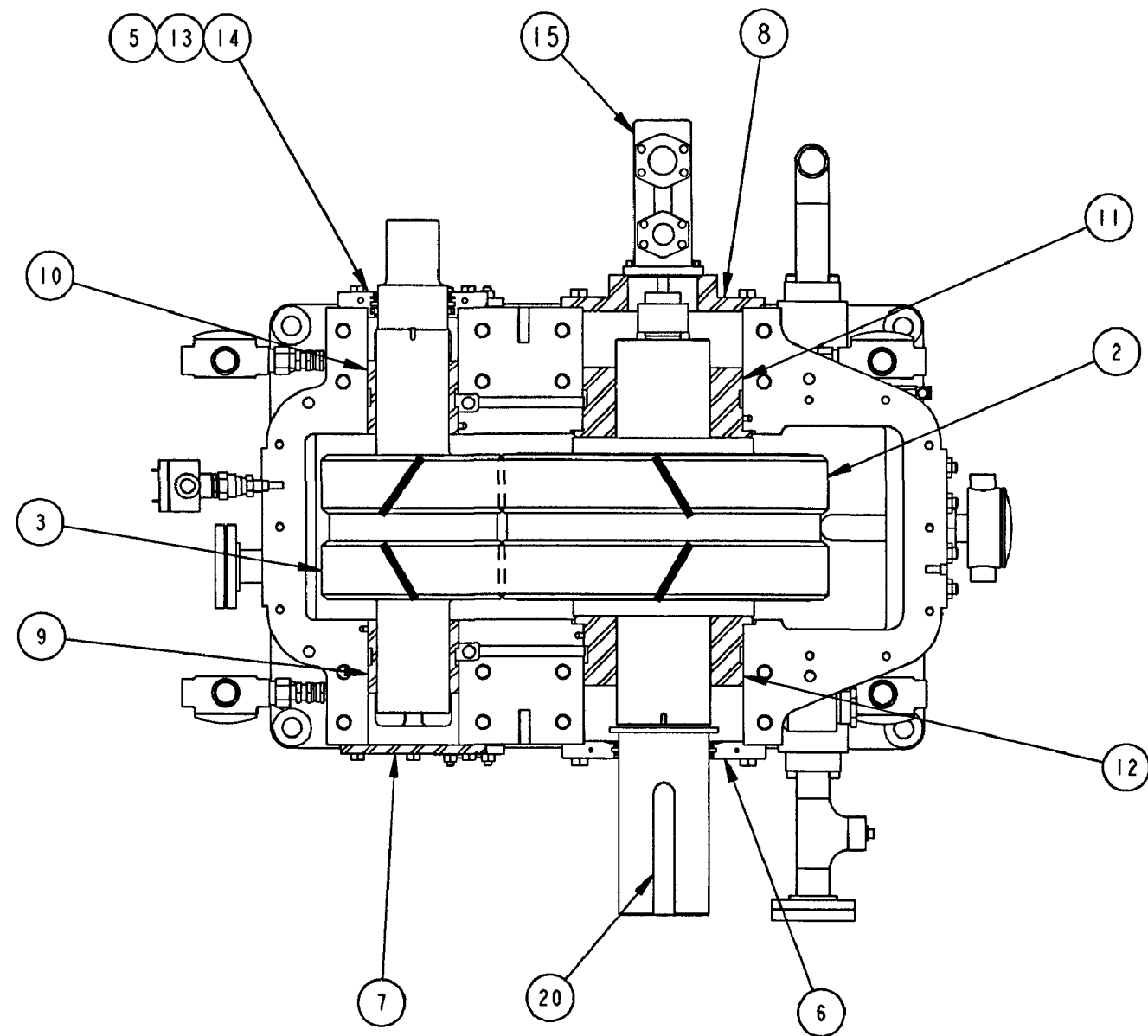
USE **Lt. Turbine** (136-165 SSU at 100 °F)

USE **ISO VG 32** (28.8-35.2 cST at 40 °C)



LUFKIN
INDUSTRIES, INC.
LUFKIN, TEXAS





*** S/N 120920 THRU 120931

LUFKIN GEARS

MODEL NO.	N1800C	GEAR RATIO	1.825 : 1
SERIAL NO.	***	RATED INPUT	1772 RPM
ORDER NO.	106/204465	RATED OUTPUT	3233 RPM
ITEM NO.		GEAR RATED	4000 HP
ACTUAL K FACTOR	174.77	API SERVICE FACTOR	1.4
UNIT RATED AND BUILT PER:			
SPEC. API 613 5TH EDITION			
NO OF TEETH	GR/PIV	104 / 57	
LUBRICANT AGMA NO.	LTO	OIL SUMP CAPACITY	35 GALS
VISCOSITY SSU @ 100°F	150 SSU	ISO GRADE	ISO VG 32

LUFKIN INDUSTRIES, INC.
LUFKIN, TEXAS - USA



LUFKIN INDUSTRIES, INC.
Lufkin, Texas

(Model No.) - (Serial No.)

N1800C-120931

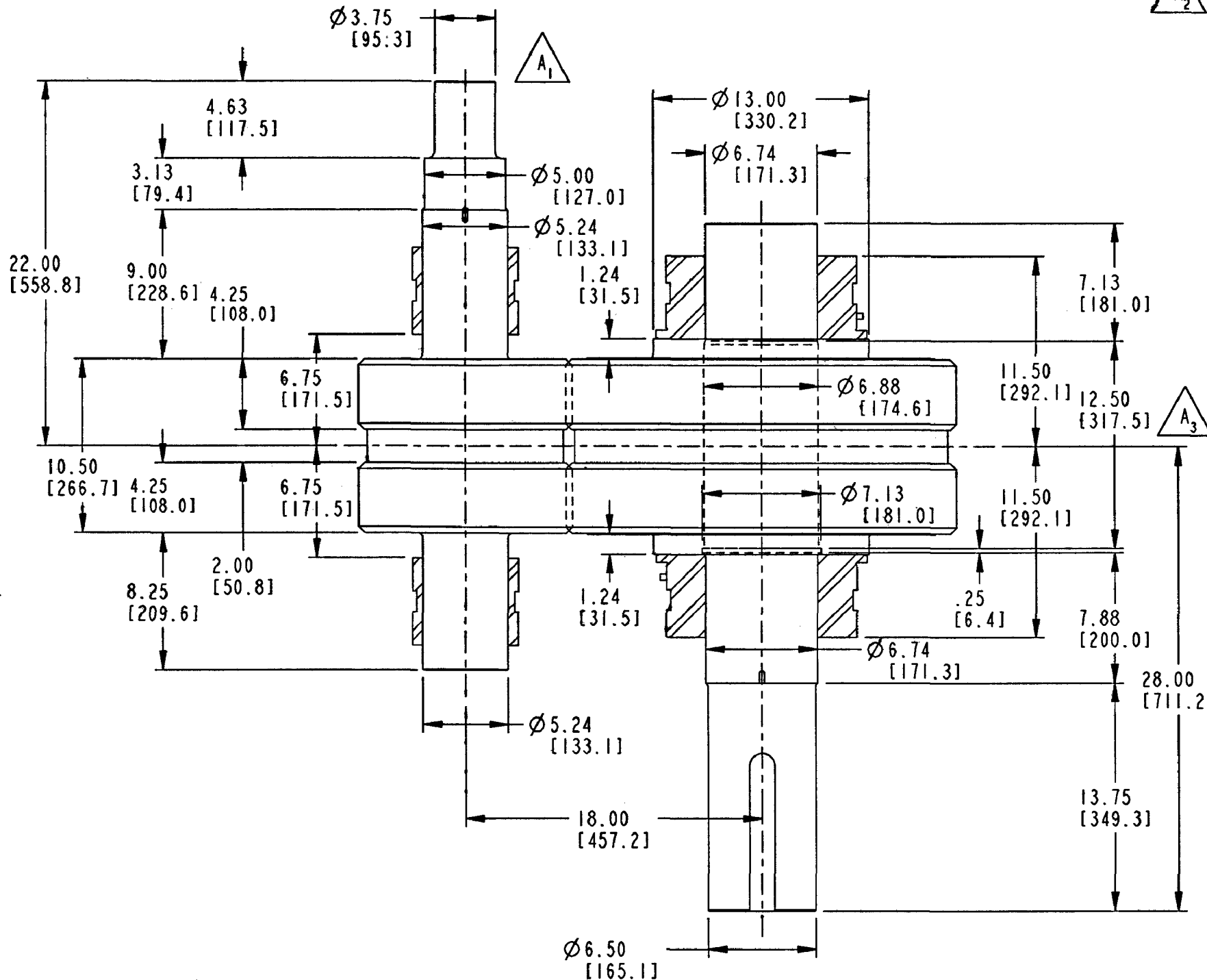
CUSTOMER: YORK PROCESS SYSTEMS
 P/O. NO.: P308908 DATED: 10-27-08
 NO. OF UNITS: 12 ARRANGEMENT: L-R ROTATION, HS: CW
 PRIME MOVER: ELECTRIC MOTOR
 DRIVEN EQUIPMENT: YORK M555BA CENTRIFUGAL COMPRESSOR
 INSTALLATION PLAN: SK22137-8 MASS ELASTIC: SK14738-2
 ASSEMBLY DRAWING: WIRING DIAGRAM: SK18208-4
 LOCATION OF INSTALLATION: IAG/SAND RIDGE ENERGY - CENTURY PLANT
 REFERENCES TO DOCUMENTS AND DRAWINGS IMPLY THE LATEST REVISION UNLESS INDICATED

LUFKIN	DATE
PREP. BY: GRD	3-18-09
CHECKED BY: <i>[Signature]</i>	3-27-09
CERTIFIED BY: <i>[Signature]</i>	3-27-09
ENGINEERING RELEASE:	

Parts List No.

REV.	DESCRIPTION OF CHANGE	CHGD BY DATE

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	TEETH	PITCH DIA	GROOVE DIA	MATERIAL	BHN	WR ²	WT
HS PINION	57	12.745 [323.72]	12.073 [306.65]	4340H	363	7854 IN ² LBS [2.2984 KG*M ²]	509 LBS [230.9 KG]
LSP GEAR	104	23.255 [590.68]	22.583 [573.61]	4340H	341	84903 IN ² LBS [24.8460 KG*M ²]	1207 LBS [547.5 KG]
LSP SHAFT	- - -	- - -	- - -	4145 MOD.	285	2340 IN ² LBS [0.6848 KG*M ²]	415 LBS [188.2 KG]
LSP ASSY	- - -	- - -	- - -	- - -	- - -	87243 IN ² LBS [25.5308 KG*M ²]	1622 LBS [735.7 KG]

	BEARING BORE	BEARING LENGTH	PROJECTED AREA
HIGH SPEED	5.250 [133.35 MM]	5.250 [133.35 MM]	27.563 IN ² [17782.22 MM ²]
LOW SPEED	6.750 [171.45 MM]	4.750 [120.65 MM]	32.063 IN ² [20685.44 MM ²]

WR² REFERRED TO LSP SHAFT = 113389 IN² LBS [33.1822 KG*M²]
 PRESSURE ANGLE = 20° NORMAL NDP= 5 MODULE=5.08 HELIX ANGLE = 26° 33' 46.23''

NOTE:
 VALUES USED FOR CALCULATIONS ARE
 DENSITY = .283 LBS/IN³ [7833.4 KG/M³]
 SHEARING MODULUS OF ELASTICITY = 11.8 X 10⁶ LBS/IN² [81.4 X 10³ MPa]
 DIMENSIONAL INTERPRETATION = INCHES [MILLIMETERS] UNLESS NOTED OTHERWISE.

SHAFT STIFFNESS:
 HS PINION: 28.6 X 10⁶ IN LBS/RAD [3.23 X 10⁶ N M/RAD] FROM MESH CENTERLINE TO 1/3 PENETRATION INTO COUPLING FIT.
 LSP SHAFT: 86.4 X 10⁶ IN LBS/RAD [9.76 X 10⁶ N M/RAD] FROM 1/3 PENETRATION INTO LSP GEAR TO END OF SHAFT.

CUSTOMER MARKINGS
 YORK PROCESS SYSTEMS P.O. NO.: P308988
 YORK PROCESS SYSTEMS S.O. NO.: 294100

SKI4571-2

REV.	DESCRIPTION OF CHANGE	CHGD BY DATE
A ₄	1) 3.75 DIA. PINION CYL. EXT. WAS 3.00 HYDR. EXT. 2) UPDATED PINION WT AND WR ² . 3) UPDATED WR ² REFERRED TO LSP SHAFT. 4) UPDATED HS PINION STIFFNESS.	GRD/mvl 2-24-09

ENGR. CODE NO.	THIS DRAWING AND ALL INFORMATION THEREON IS CONFIDENTIAL AND IS THE PROPERTY OF LUFKIN INDUSTRIES, INC. IT SHALL BE USED ONLY AS AUTHORIZED BY LUFKIN INDUSTRIES, INC. AND IS SUBJECT TO RETURN ON DEMAND.	MATERIAL SPECIFICATIONS
	REFERENCES TO DOCUMENTS AND DRAWINGS IMPLY THE LATEST REVISION UNLESS INDICATED OTHERWISE	
	PERTAINS TO / ALSO USED ON	
PARTS LIST	NI800C-120931	
I/P	SK22137-8	
SALES ORDER	106/204465	
	SUPERSEDED BY:	

DIAGRAM, MASS ELASTIC
 NI800C, SPEED INCREASER
 L-R UNIT, RATIO 1.825 : 1

DWN GRD CHK RFE APP JWL N/C-CAM READY

DATE 12-17-08 SCALE 0.125

RELEASED FROM DESIGN ENGINEERING:

LUFKIN INDUSTRIES, INC.
 LUFKIN, TEXAS

SKI4738-2 A

TEMPERATURE MONITORING

ORDER ELECTRICAL AREA CLASSIFICATION	NEC	CLASS 1, DIV 2, GROUP D
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ITEM	DESCRIPTION	PART NO.	DETAILS
SENSOR TYPE	DUPLEX RTD'S 4 EMBEDDED	E7086923 E7086923	PROBE STYLE, DUAL ELEMENT (DUPLEX) RTD'S, 3 WIRE, PLATINUM DIN CALIBRATION, 100Ω AT 100°C ±0.12% AT 0°C (0.00385 Ω/Ω/°C) 1 PER HS RADIAL BEARING (2 TOTAL) EMB MINCO # S14405PD3S36B0 1 PER LS RADIAL BEARING (2 TOTAL) EMB MINCO # S14405PD3S36B0
CONDUIT	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
CONDUIT FITTINGS	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
HOUSING EXIT FITTINGS	OIL SEAL		1 PER HOUSING EXIT, UP TO 4 EXITS PER FITTING
SERVICE HEADS	4		APPLETON, 1" GRT100-A COPPER FREE ALUMINIUM
SERVICE HEAD CONNECTIONS	TERMINAL STRIPS		8 TERMINALS PER HEAD PHOENIX UK2.5N
JUNCTION BOX	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
TAGS	STAINLESS STEEL		USE CUSTOMER TAG NUMBERS

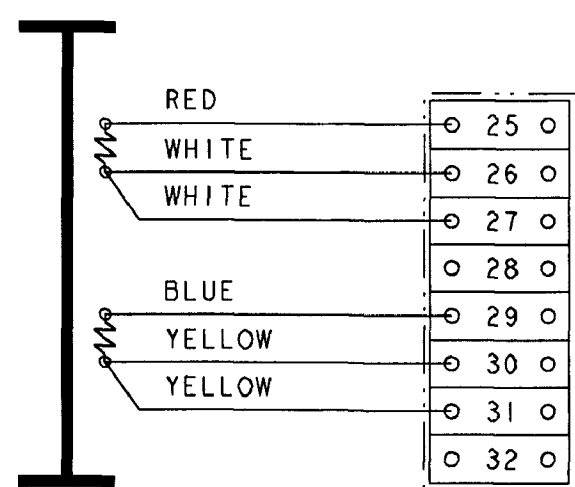
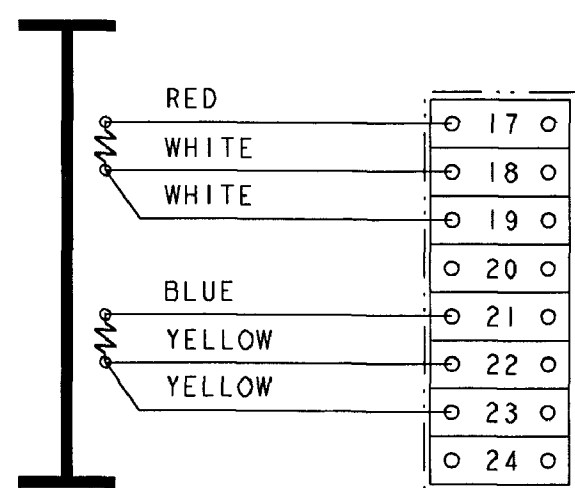
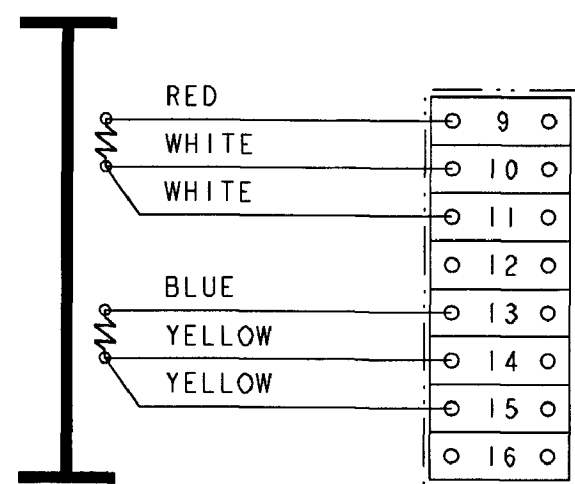
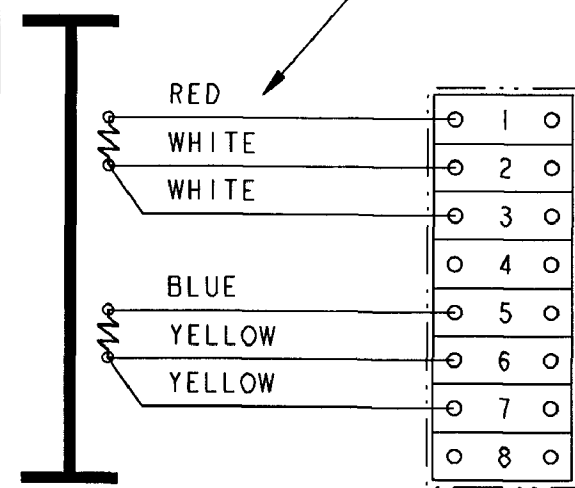
C₂

CUSTOMER TAG NO.	LUFKIN ID NO.	LOCATION
TE-#25A	TE1	HS DE RADIAL RTD
TE-#25B		
TE-#24A	TE2	HS NDE RADIAL RTD
TE-#24B		
TE-#22A	TE3	LSP DE RADIAL RTD
TE-#22B		
TE-#23A	TE4	LSP NDE RADIAL RTD
TE-#23B		

MARK RTD LEAD WITH HEAT SHRINK LABEL USING CUSTOMER TAG NO. IF NOT AVAILABLE USE LUFKIN ID NUMBER

B₁

NOTE:
RED LEAD IS "A" ELEMENT
BLUE LEAD IS "B" ELEMENT



SERVICE ENTRANCE CONDUIT HEAD

C₁

A

CUSTOMER TAG NOTES:

FOR S/N 120920: * = 1231A
FOR S/N 120921: * = 1231B
FOR S/N 120922: * = 1231C
FOR S/N 120923: * = 1231D
FOR S/N 120924: * = 1231E
FOR S/N 120925: * = 1231F

FOR S/N 120926: * = 1331A
FOR S/N 120927: * = 1331B
FOR S/N 120928: * = 1331C
FOR S/N 120929: * = 1331D
FOR S/N 120930: * = 1331E
FOR S/N 120931: * = 1331F

EXAMPLE: TE1 FOR SN 120920
WOULD HAVE CUSTOMER TAG #
TE-1231A25A

CUSTOMER MARKINGS

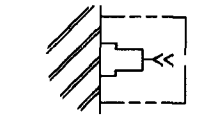
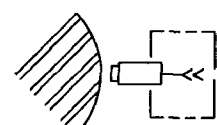
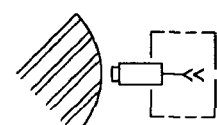
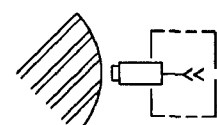
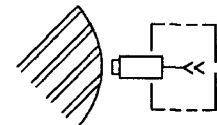
YORK PROCESS SYSTEMS P.O. NO.: P308988
YORK PROCESS SYSTEMS S.O. NO.: 294100

REV.	DESCRIPTION OF CHANGE	CHGD BY DATE
A	CHANGED FROM DUAL DUPLEX TO SINGLE DUPLEX RTDS ON RADIAL.	PID-RH 02-26-09
B ₂	1) ADDED RTD LEAD COLOR NOTE. 2) REMOVED "A" FROM END OF A3 CUSTOMER TAG.	PID-RH 03-27-09
C ₂	1) REMOVED SUMP RTD AND RELATED PARTS. 2) CHANGED CUSTOMER TAG NUMBERS.	PID-RH 06-16-09

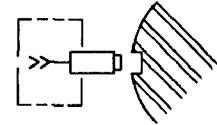
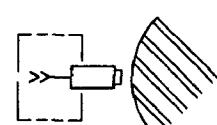
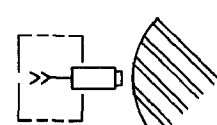
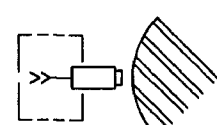
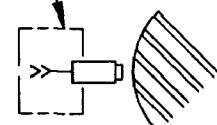
ENGR. CODE NO.	DIAGRAM, WIRING - MOD T10/W0, MOD V6/W0
THIS DRAWING AND ALL INFORMATION THEREON IS CONFIDENTIAL AND IS THE PROPERTY OF LUFKIN INDUSTRIES, INC. IT SHALL BE USED ONLY AS AUTHORIZED BY LUFKIN INDUSTRIES, INC. AND IS SUBJECT TO RETURN ON DEMAND.	8 RAD V/P, 1 K/P, 1 ACCLRM
REFERENCES TO DOCUMENTS AND DRAWINGS IMPLY THE LATEST REVISION UNLESS INDICATED OTHERWISE	4 DUPLEX EMB RTDS
PERTAINS TO / ALSO USED ON	DWN_PID-RH_CHK_RFE_APP_JWL
S/O 106/204465	DATE 12-18-08 SCALE - - -
	RELEASED FROM DESIGN ENGINEERING:
	LUFKIN INDUSTRIES, INC. LUFKIN, TEXAS
	SK18208-4
SUPERSEDED BY:	SHEET 1 OF 2

C₂

CUSTOMER TAG NO.	LUFKIN ID NO.	LOCATION
XE-*X3	VX1	HS DE HORIZ. V/P
XE-*Y3	VY1	HS DE VERT. V/P
XE-*X1	VX4	LSP NDE HORIZ. V/P
XE-*Y1	VY4	LSP NDE VERT. V/P
XE-*S0	A3	LSP DE ACCLRM



SERVICE ENTRANCE CONDUIT HEAD



LOCATION	LUFKIN ID NO.	CUSTOMER TAG NO.
HS NDE HORIZ. V/P	VX2	XE-*X2
HS NDE VERT. V/P	VY2	XE-*Y2
LSP DE HORIZ. V/P	VX3	XE-*X0
LSP DE VERT. V/P	VY3	XE-*Y0
LSP DE K/P	KP3	XE-*K0

B₂

VIBRATION MONITORING

ORDER ELECTRICAL AREA CLASSIFICATION	NEC	CLASS 1, DIV 2, GROUP D
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ITEM	DESCRIPTION	PART NO.	DETAILS
VIBRATION PROBE TYPE	BENTLY NEVADA 3300XL 8MM PROBE (QTY 9)	E7082882	0.5 M LEAD LENGTH BENTLY NEVADA MODEL 330105-02-12-05-02-05 2 X-Y RADIAL PROBES PER HS SHAFT END (4 TOTAL) 2 X-Y RADIAL PROBES PER LSP SHAFT END (4 TOTAL) 1 LSP KEYPHASOR PROBE
VIBRATION PROBE EXTENSION CABLE	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
VIBRATION PROBE PROXIMITOR	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
VIBRATION PROBE SERVICE HEADS	ONE PER EACH RADIAL AND AXIAL PROBE		APPLETON, 1" GRT100-A COPPER FREE ALUMINIUM
ACCELEROMETER	BENTLY NEVADA (QTY 1)	E7087499	BENTLY NEVADA MODEL 330400-01-05
ACCELEROMETER EXT. CABLE	NONE		
ACCELEROMETER HOUSING	ADAPTER AND ATEX REDUCER	20547700 E7093449	ACCELEROMETER HERMETICALLY SEALED. HOUSED IN STAINLESS STEEL ADAPTER AND ACCESS PROVIDED BY DUAL RATED REDUCER
ACCELEROMETER CONNECTION	NONE		
CONDUIT	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
CONDUIT FITTINGS	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
JUNCTION BOX	NONE		TO BE SUPPLIED AND INSTALLED BY OTHERS
BREATHER/DRAIN	NONE		
LOW POINT DRAINS	NONE		
TAGS	STAINLESS STEEL		USE CUSTOMER TAG NUMBERS

CUSTOMER TAG NOTES:

FOR S/N 120920: * = 1231A
 FOR S/N 120921: * = 1231B
 FOR S/N 120922: * = 1231C
 FOR S/N 120923: * = 1231D
 FOR S/N 120924: * = 1231E
 FOR S/N 120925: * = 1231F

FOR S/N 120926: * = 1331A
 FOR S/N 120927: * = 1331B
 FOR S/N 120928: * = 1331C
 FOR S/N 120929: * = 1331D
 FOR S/N 120930: * = 1331E
 FOR S/N 120931: * = 1331F

EXAMPLE: VX1 FOR SN 120920
 WOULD HAVE CUSTOMER TAG #
 XE-1231AX3

REV.	DESCRIPTION OF CHANGE	CHGD. BY DATE
A	CHANGED FROM DUAL DUPLEX TO SINGLE DUPLEX RTDS ON RADIAL.	PID-RH 02-26-09
B ₂	1) ADDED RTD LEAD COLOR NOTE. 2) REMOVED "A" FROM END OF "A3" CUSTOMER TAG.	PID-RH 03-27-09
C ₂	1) REMOVED SUMP RTD AND RELATED PARTS. 2) CHANGED CUSTOMER TAG NUMBERS.	PID-RH 06-16-09

ENGR. CODE NO.	THIS DRAWING AND ALL INFORMATION THEREON IS CONFIDENTIAL AND IS THE PROPERTY OF LUFKIN INDUSTRIES, INC. IT SHALL BE USED ONLY AS AUTHORIZED BY LUFKIN INDUSTRIES, INC. AND IS SUBJECT TO RETURN ON DEMAND.	MATERIAL SPECIFICATIONS	DIAGRAM, WIRING - MOD T10/W0, MOD V6/W0 8 RAD V/P, 1 K/P, 1 ACCLRM 4 DUPLEX EMB RTDS
REFERENCES TO DOCUMENTS AND DRAWINGS IMPLY THE LATEST REVISION UNLESS INDICATED OTHERWISE	PERTAINS TO / ALSO USED ON		DWN PID-RH CHK RFE APP JWL DATE 12-18-08 SCALE - - -
	S/O 106/204465		N/C-CAM READY
			RELEASED FROM DESIGN ENGINEERING:
			LUFKIN INDUSTRIES, INC. LUFKIN, TEXAS
			SK18208-4
			SHEET 2 OF 2