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How to Develop an Effective PM Lube Program

Mike Johnson, CMRP, CLS, MLT2, MLA1
AMRRI Principal Consultant
AMRRI. * 3978 E. McEwen Drive * Franklin, Tennessee * 37067
615.771.6030
Mike.Johnson@PrecisionLubrication.com

How to Develop an Effective PM Relubrication Program

"Without a vision, the people will perish". Proverbs 29:18

Understanding the importance of effective machinery lubrication for mill equipment is no more difficult than understanding the importance of blocking and tackling in the game of football. You simply won't win if you don't do it correctly. As in the game of football, there is a fair amount of precise technique that the victorious teams engrain into their personnel. Without precise technique the work of blocking and tackling is more difficult and less effective, and the results are seen in the win-loss record.

Machinery lubrication is an area that begs, but receives little support, for precision. After all, how hard can this be? Oil is oil, grease is grease. Just keep the sumps and the bearings full, and we will be fine.

An effective plant tribology program requires some understanding of physics, mechanical engineering, organic chemistry, analytical methods, and organization management. Fortunately, we have those skills available within most of our maintenance organizations. What we lack, though, is vision, purpose and a clear understanding of the incredible value that is available to us through precision lubrication.

The intent of this presentation is to characterize what is required to develop and execute an effective machinery relubrication program.

Table Stakes

Reliability Centered Focus: Senior operations, engineering and financial management must understand and embrace the concept of asset management for reliability, including understanding the implication of misguided maintenance and operations practices.

Changing a plant culture from a fix and repair to a loss prevention mentality requires unambiguous focus, planning and persistence. While it is nice to see a burst of energy and attention momentarily focused on the right things, it is best to see a conscientious, planned effort to reorder the way the organization thinks about basic practices, such as alignment, balance, housekeeping, contamination control and relubrication.

There will be a lot to tackle once the program begins. The more clearly we have defined the critical and high gain areas, the faster we will be able to show the desired results.

Management Support: Management needs to recognize the pot of gold at the end of the precision lubrication rainbow. A grasp of the benefits of precision at the dynamic interface of the lubricated components would be helpful. That is not to say that senior management needs to understand how to interpret a lubricant viscosity specification or filter beta designation. However, without a clear understanding of the benefit derived

(ROI) from investing time, energy and money in improved practices, it is unlikely that management will continue to support improvements.

Knowledge Development: The concept of a knowledge driven organization actually has merit when applied to machine relubrication practices. Invariably, organizations have poor knowledge of lubrication fundamentals. The practices executed on a daily basis are done by habit and tradition more than from a proper and complete design.

A plant culture is only gradually changed. The change in habit follows a change in thinking that follows education and reinforcement of the right ideas. Certification demonstrates that there are clear expectations of employees involved in practices. Certification also offers credibility and dignity, and hopefully financial opportunity to those employees.

The more the whole organization, including personnel not routinely involved in the practice, understands the fundamentals of product selection and contamination control, the faster the benefits will accrue.

Personnel Choices: The role of lubrication technician is a paradox. In some facilities the role is a coveted holy grail of senior mechanics at the twilight of their careers, and in other facilities it is a human land-fill position for those not capable of functioning in other roles.

The lubrication technician needs to be attentive to detail, oriented toward precision and control, capable of working efficiently and effectively in an unsupervised role, and capable of thinking and learning for him/her self. Any more, computer and working mathematical skills are a near requisite as well.

This is a critical mill role. If you don't believe that to be true, then send all of your lubrication technicians back to other tasks and quit fussing with scheduled relubrication.

Program Development Strategy

So, you are planning to make some changes, and you are wondering where to begin. Planning is a good first step. What do you want your program to look like? How will it be managed? How will continuous improvement be executed? Do you have any experts? Do you expect all of your mechanical supervisors to become experts for their respective areas? Do you even have the role within your organization?

Information Management: Perhaps we should begin with realizing that we have to construct, organize and promote a significant amount of change. That means generating and managing a lot of new details.

For the sake of argument, let's count the details:
Assume that a paper mill had 1,000 assets or drive trains. Some are simple, such as a Goulds 3196 pump: A motor, a coupling and a reservoir. Some, such as a barking drum,

will be more complex, and have many more discrete lubricated component requirements. A typical average would be about 6 components per asset.
Each component will have 5 basic factors to consider, including: speed, size, design type, operating temperature, operating environment, and OEM designation. From this we will calculate a product type, quantity, relubrication frequency, analysis frequency, and contamination control requirements, another 5 factors.

If our 1000 assets average 6 components that require lubrication, and 5 design factors to consider per lubricated component, leading to 5 scheduling factors, means that this mill has to address how to manage 60,000 pieces of data, of which 30,000 items will be fixed.

A mill can use existing technology (CMMS), purchase new technology (LMS), or use a punch card system (Paper System). There are strengths and weaknesses of each. The CMMS is likely a powerful, but insufficiently detailed program for lubrication detail management. Creating the level of detail that is required can mean adding many thousands of new PM tasks to the existing system. This is generally an unwelcome thought. A paper system is too cumbersome. Too much time would be required to construct and maintain the paper system.

A dedicated lubrication management system (LMS) is a useful consideration. Most are inexpensive, and therefore can be purchased and operated without a great deal of IT time, money and involvement. They are designed to accommodate the 30,000 items efficiently.

Program Definition: Relubrication, Contamination Control, and Oil Analysis:
Traditional programs offered by Big Oil, Inc., log the asset (drive train) to the component level, and then a branded product type at a generalized task frequency. Little consideration is given to lubricant volume, contamination control requirements and oil analysis requirements.

It is logical that Big Oil would not engage in the minutia of detail since this is a 'free' service, and since the warranty extends only to cover the stated manufacturing specifications for the lubricant, not the application of the lubricant. The equipment owner would have heightened interest in precision to assure the right volume, frequency, cleanliness, sample collection effectiveness, and analysis frequency, as all of these factors contribute to asset reliability management.

The mill should select some parameters based on criticality assessment by machine class. For instance, all high pressure servo controlled (CNC) hydraulic systems should receive system modifications (filter selection, design adjustment) according to a similar class of ISO Cleanliness specification (ISO 13/10 for pressures above 3,000 PSI). Critical or expensive to repair gear drives at a given horse power could receive a blanket contaminant control target. Or, drives of a given manufacturer type could receive a unique contamination control target.

Oil analysis must be done according to the same care and concern that the mill applies to process measurements if the mill expects to receive clear and useful information from the effort. Therefore, sample ports should be installed at useful, if not ideal locations for each sump. Management must include these factors into the project scope, with the intent to follow the scoping process with system modifications to accommodate the full program requirements.

Information sources: Where will the input data come from? There are a handful of useful sources. Including:

- Physical inspection. Can we physically inspect the equipment? What are the safety and runtime considerations? Is the equipment geographically accessible (is it in another country or down the street)?
- OEM Guidelines. In lieu of physical observation, is there an equipment file, complete with diagrams, component numbers and specifications and guidelines for consideration? Are the guidelines current, specific and useful or are they vague?
- Industry Association Guidelines. Do the items have generic guidelines produced for the type of component, such as AGMA lubricant specifications?
- Hard Calculations. In lieu of other data sources, and sometimes even with the benefit of those sources, it is necessary to physically measure, chart and calculate the required type, volume and frequency. Calculations used to determine viscosity of the oil and oil in the grease, grease volume and frequency can be found in appendix 1, 2 and 3.
- OEM Technical help. Call the manufacturer and get him involved in solving problems and designing improvements.

The combination of available resources, including plain simple hard work, is generally enough to develop precise and useful program details.

Program Creation

Pre-survey

Step 1. Overview the flow of raw materials into, through and out of the plant, including the main and sub assembly/finishing processes.
Step 2. Overview the flow of materials through each department.
Step 3. Establish a pattern that will be followed for data collection. It is recommended to begin with the energy input and follow the energy through the machine to the final output. If the machine has components separated by significant space, it may be best to survey by drive side to non-drive side.

Survey

Step 4. Record the asset number and general description used by maintenance personnel. If the compressor is known to maintenance personnel as ‘Big John’, then it is probably best to note this in the survey document.
Step 5. For each asset (drive train), document the name of each discrete component in the drive train. If there is a non-lubricated component in use it is best to log this as a non-

lubricated component to avoid questions later on about where something was missed during the survey.
Step 6. Log the name of each surveyed component. The manufacturer's product name and serial or model number often work as a useful component name. Create a separate list of machine components by component type to facilitate decisions during the contamination control and oil analysis exercises.
Step 7. Log the meaningful design parameters that can be collected from observation. The manufacturer name, make, serial, model, shaft orientation, shaft speed, existing filtration, existing automatic lubrication or circulation system design, existing ports for filtration and sample collection fittings, sump capacity, and physical dimensions.
Step 8. Log the environmental factors, including temperature, moisture, abrasive airborne contaminants, obvious loading issues, obvious vibration issues, accessibility, and any safety considerations for relubrication.

Methods Development

Step 9. Arrange the details in a logical order sequence as noted in Table 1, either in a database (spreadsheet) program or using accounting type grid paper.
Step 10. Beginning with the motors, assign the lubricant types and quantities for each component type collected. Many of the system sump capacities can be estimated from tank dimensions, while some sump capacities will be referenced to equipment type or model in the OEM maintenance guidelines. AGMA lubricant type and viscosity references usually appear on the name plate on the gear drive. For bearings, use the formulas noted in Appendix 1-3 to assign a viscosity grade for all bearings and a grade and quantity for grease lubricated bearings.
Step 10. For grease lubricated equipment, use the grease quantity calculations from step 10 to calculate the actual number of shots from the grease gun type in use. Assign the requisite number of shots for each grease point noted during the physical survey.
Step 11. Assign the frequencies for each component noted in the survey. Judgment is necessary to accommodate high volume consumption assets. For grease lubricated bearings use the details from Appendix 6.
Step 12. Note the most efficient linear sequence of steps and order the equipment according to the sequence. This generally requires input from the personnel conducting the tasks.
Step 13. Sort the data by task frequency, and name the routes based on frequency and linear sequence.
Step 14. Develop a document for each drain component noting the component manufacturer, name, model or serial number, safety conditions, steps to relubricate the component, including product type, quantity, frequency, and with pictures note the lubrication application point. Reference Appendix 9 for more details.

Contamination Control

Step 15. Access the list of components by component type from step 6. Based on the contamination control values assigned to the component type, determine the cleanliness requirements or each sump. (Appendices 6-7) Determine if the requirements can be achieved through the use of the existing filtration/fluid conditioning system and make modifications accordingly. If assist filtration is required determine the proper locations

for installation of fluid couplings photograph the equipment and annotate the photos. Note the type and size coupling required.
Step 16. Evaluate the air ventilation mechanism for the sump. Assign a ventilation filter to either install or upgrade as required.
Step 17. Assess the quality of the seals and shields on the sumps if any exist. If deterioration is observed, specify upgrades by type and make. Make note of any reservoirs that require mechanical modifications to enable complete closure.
Step 18. As with the basic requirements, develop contamination control procedures for changing filters, replacing breathers, coupling and operating portable filter units and inspecting for seal degradation.
Step 19. Issue change orders to be executed at an appropriate time.

Oil Analysis
Step 20. Access the list of components by component type from step 6. Assign control levels for all test parameters selected for each type of equipment. The control parameters should reflect failure conditions both rising and falling where appropriate.
Step 21. Make notations of special equipment needs and adjust the parameters accordingly. For example, if a critical system is operating in a very wet (direct water contact) environment, then tighten the moisture check interval.
Step 22. Determine which tests are to be conduct internally and set intervals. Do the same for externally conducted analyses.
Step 23. Review the machine for efficient, effective and low cost locations to install lubricant sample valves and fittings. Photograph the machine, annotate the photos and develop a set of sample port modification and installation guidelines according to the machine types.
Step 24. Issue change orders to be executed at an appropriate time.
Step 25. Integrate the oil sample tasks and intervals into the route and tasks scheduling list that was developed for other routine practices. Execute accordingly.

This paper will not address repetitive scheduling issues.

Development of Procedures
Appendix 9 is an example of a procedure developed around a fluid coupling relubrication requirement. Procedure development was proposed in 3 sections of the detail development task list. While procedures for maintenance work have not been popular in the past, mostly due to lack of understanding of the cost of repeated mistakes and errors, it is certainly a condition that is necessary to achieve 'best practice' quality levels.

Having a detailed procedure will not prevent a mistake from being repeated, but not having a procedure assures that when a change in personnel is required the risk that mistakes will surface is greatly increased.

Training to the procedures
It is best to develop procedures that represent accurate, precise methods, and then train to those procedures. This may not seem warranted but is particularly important if there is an

interest in shifting the work culture from a get-by perspective to a world class perspective.

Ownership and Accountability

Attaining precision is difficult without the benefit of personnel trained and dedicated to a given task. This would not necessarily mean that it is a lifetime sentence, but it is absolutely necessary that relubrication practices have the benefit of consistency and stability.

Additionally, while mills shift back and for the between centralized to decentralized work scheduling for relubrication, it is impossible for an effective strategy to be set if the work is decentralized. If decentralization works best for a given mill then at least there should be a dispensation to allow for centralized strategy, goals, measurement, data management and incremental support.

Continuous Improvement

Lubrication tasks change with fluctuating demand on equipment, new equipment installation, and relative to the age of the equipment. Additionally, as the reliability centered focus sheds new light on systems that are falling into functional failure then lubrication, and various other tasks, should be adjusted to meet the demand.

Continuous improvement is not a program. It is mindset. It is a benefit of hiring the right personnel to perform a job and providing the organization structure to enable exceptional results.

Final remarks

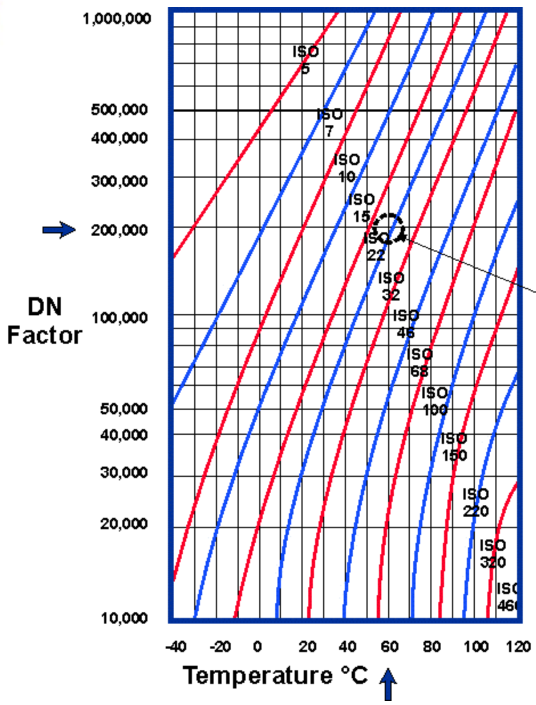
Precise and highly useful machinery lubrication requires visible, vocal support from senior management. It is likely that significant education and training will be required, particularly for those individuals that are intimately involved in the development of the details.

Program development could occur in number of ways. This 25 step sequence is intended to serve as a catalog and a guideline for this process. The process certainly should include as much detail as is reasonable to develop, including contamination control and oil analysis methods and procedures development. It is likely that change orders will be executed and some money will be spent, both capital and expense dollars, in order to achieve the desired platform for effectiveness. Senior management needs to support these changes in spirit and in truth (with the pocketbook).

Appendix 1

Viscosity Selection

Rolling Bearing Lubrication - Viscosity Selection



Viscosity Selection Example:

Speed (n) = 10,000 rpm
Bore Diameter (Di) = 15 mm
Outside Diameter (Do) = 25 mm
Operating Temperature = 60°C

$$\text{DN Factor} = \frac{n(Di + Do)}{2}$$

$$= \frac{10{,}000\,(15+25)}{2} = 200{,}000$$

Viscosity Required: ISO VG 22

SKF Recommended ISO Viscosity Grades		
Bearing operating temperature °C (°F)	Ball and cylindrical roller bearings	Other roller bearings
70 (158)	VG46	VG68
80 (176)	VG68	VG100
90 (194)	VG100	VG150

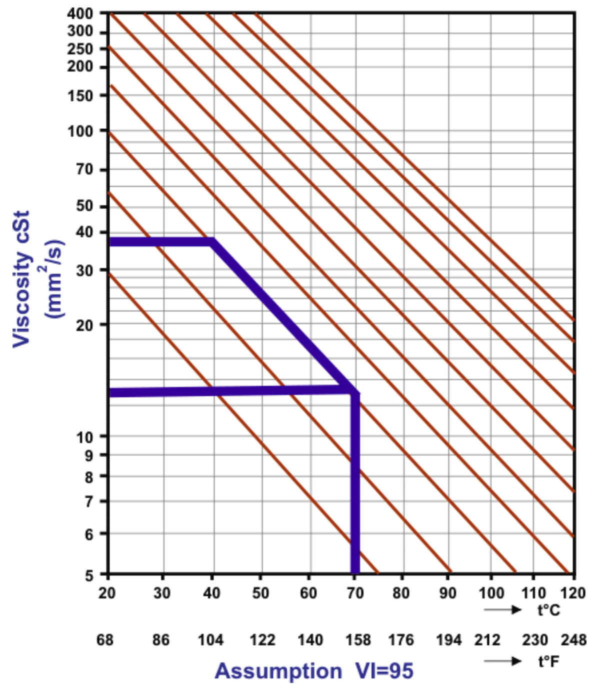
G2113 Ref: ExxonMobil

Appendix 2

Converting Required Operating Temperature Viscosity to ISO Viscosity Grades

Example:

- Rolling element bearing
- Required viscosity at operating temperature = 13 cSt
- Operating temperature = 70°C
- Required ISO VG = 46



1090 Ref: Bloch

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Appendix 3

Grease Volume - Rolling Element Bearings

Overlubricating rolling element bearings causes churning and generates excess heat, especially on higher speed applications.

	Recommended Re-lube Volume as a percent of total volume	
	Roller Bearings	**Ball Bearings**
High Speed	**30%**	**25%**
Medium Speed	**30%**	**30 - 40%**
Slow Speed	**30%**	**40 - 50%**
Very Slow Speed	**30%**	**50 - 80%**

Regrease Volume Formula

Gq = 0.114 DB

Where:
Gq = Grease quantity in ounces
D = Bearing outside diameter in inches
B = Total bearing width in inches (height for thrust bearings)

Notes:

- If uncertain about quantity, add grease slowly until first sign of grease at seal or outlay. Be careful not to rupture seals by applying excessive grease/pressure.
- If too much grease is applied, temperature will rise and remain high.
- When assembling a bearing, coat all surfaces with a thin film of grease.
- Add grease a little at a time to distribute evenly.
- In applications where the bearing is low speed and contamination is a risk the bearing can be packed completely full. Select a grease with high thermal stability.

Ref: Lansdown, SKF

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Appendix 4

Motor Bearing Relubrication Quantity

Motor Bearing Standard Details

NEMA Frame No.	Bearing Bore Unit	AFBMA Bearing No.	DIN 623 Bearing No.	Bearing Bore (mm)	Bearing OD (mm)	Bearing Width (mm)	Dynamic P	Static C	Kinematically Permissible RPM	.114*D*B Gr. Qty Ounces (per USM)
	0		6200	10	30	9	1340	585	32000	0.0
	1		6201	12	32	10	1560	695	30000	0.1
	2		6202	15	35	9	1730	850	26000	0.1
	3		6203	17	40	12	2160	1060	22000	0.1
	4		6204	20	47	14	2900	1500	18000	0.1
	5		6205	25	52	15	3150	1760	17000	0.1
182	6		6206	30	62	16	4400	2550	14000	0.2
184										
	7		6207	35	72	17	5700	3450	24000	0.2
	8		6208	40	80	18	3800	2650	20000	0.3
	9		6209	45	85	19	6950	4550	19000	0.3
324	10		6210	50	90	20	8150	5400	18000	0.3
326										
	11		6211	55	100	21	9800	6550	16000	0.4
	12		6212	60	110	22	11800	8150	14000	0.4
364	3		6213	65	120	23	13400	9300	13000	0.5
365										
404										
405										
	14		6214	70	125	24	14000	10000	12000	0.5
	15		6215	75	130	24	15000	11000	11000	0.5
	16		6216	80	140	26	16300	12000	11000	0.6
	17		6217	85	150	28	18600	14300	10000	0.7
	18		6218	90	160	30	21600	16000	9000	0.8
	19		6219	95	170	32	24500	18300	8500	1.0
	20	100BC02X3	6220	100	180	34	27500	20800	8000	1.1
	21		6221	105	190	36	30000	23600	7500	1.2
	22	110BC02X3	6222	110	200	38	32500	26500	7000	1.3
	24		6224	120	215	40	32500	27500	6700	1.5
	26	130BC02X3	6226	130	230	40	37500	32500	6300	1.6
	28	140BC02X3	6228	140	250	42	40000	37500	6000	1.8
	30		6230	150	270	45	40000	38000	5600	2.1
	32	160BC02X3	6232	160	290	48	45000	45500	5600	2.5
	34	180BC02X3	6234	170	310	52	47500	50000	5300	2.8
	36		6236	180	320	52	51000	55000	4800	2.9
	38		6238	190	340	55	57000	63000	4300	3.3
	40		6240	200	360	58	60000	69500	4000	3.7
			6244	220	400	65				4.6

1383 Ref: NRS: JMJ

Appendix 5

Formula for Calculating Bearing Relubrication Interval is More Accurate

$$T = K \times \left[\left(\frac{14{,}000{,}000}{n \times (d^{0.5})} \right) - 4 \times d \right]$$

Where:

T = Time until next relubrication (hours)

K = Product of all correction factors
Ft x Fc x Fm x Fv x Fp x Fd
(see table)

n = Speed (RPM)

d = Bore diameter (mm)

Grease Interval Correction Factors

Condition	Average Operating Range	Correction Factor
Temperature Ft	Housing below 150°F 150 to 175°F 175 to 200°F Above 200°F	1.0 0.5 0.2 0.1
Contamination Fc	Light, non-abrasive dust Heavy, non-abrasive dust Light, abrasive dust Heavy, abrasive dust	1.0 0.7 0.4 0.2
Moisture Fm	Humidity mostly below 80% Humidity between 80 and 90% Occasional condensation Occasional water on housing	1.0 0.7 0.4 0.1
Vibration Fv	Less than 0.2 ips velocity, peak 0.2 to 0.4 ips Above 0.4	1.0 0.6 0.3
Position Fp	Horizontal bore centerline 45 degree bore centerline Vertical centerline	1.0 0.5 0.3
Bearing Design Fd	Ball Bearings Cylindrical and needle roller bearings Tapered and spherical roller bearings	10 5.0 1.0

1367 *Ref: Luegner, MJ, DT*

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Appendix 6

Life Extension Table

New Cleanliness Level (ISO Code)

Current Machine Cleanliness (ISO Code)	20/17		19/16		18/15		17/14		16/13		15/12		14/11		13/10		12/9		11/8		10/7	
26/23	5	3	7	3.5	9	4	>10	5	>10	6	>10	7.5	>10	9	>10	>10	>10	>10	>10	>10	>10	>10
	4	2.5	4.5	3	6	3.5	6.5	4	7.5	5	8.5	6.5	10	7	>10	9	>10	10	>10	>10	>10	>10
25/22	4	2.5	5	3	7	3.5	9	4	>10	5	>10	6	>10	7	>10	9	>10	>10	>10	>10	>10	>10
	3	2	3.5	2.5	4.5	3	5	3.5	6.5	4	8	5	9	6	10	7.5	>10	9	>10	>10	>10	>10
24/21	3	2	4	2.5	6	3	7	4	9	5	>10	6	>10	7	>10	8	>10	10	>10	>10	>10	>10
	2.5	1.5	3	2	4	2.5	5	3	6.5	4	7.5	5	8.5	6	9.5	7	>10	8	>10	10	>10	>10
23/20	2	1.5	3	2	4	2.5	5	3	7	3.5	9	4	>10	5	>10	6	>10	8	>10	9	>10	>10
	1.7	1.3	2.3	1.5	3	2	3.7	2.5	5	3	6	3.5	7	4	8	5	10	6.5	>10	8.5	>10	10
22/19	1.6	1.3	2	1.6	3	2	4	2.5	5	3	7	3.5	8	4	>10	5	>10	6	>10	7	>10	>10
	1.4	1.1	1.8	1.3	2.3	1.7	3	2	3.5	2.5	4.5	3	5.5	3.5	7	4	8	5	10	5.5	>10	8.5
21/18	1.3	1.2	1.5	1.5	2	1.7	3	2	4	2.5	5	3	7	3.5	9	4	>10	5	>10	7	>10	10
	1.2	1.1	1.5	1.3	1.8	1.4	2.2	1.6	3	2	3.5	2.5	4.5	3	5	3.5	7	4	9	5.5	10	8
20/17			1.3	1.2	1.6	1.5	2	1.7	3	2	4	2.5	5	3	7	4	9	5	>10	7	>10	9
			1.2	1.05	1.5	1.3	1.8	1.4	2.3	1.7	3	2	3.5	2.5	5	3	6	4	8	5.5	10	7
19/16					1.3	1.2	1.6	1.5	2	1.7	3	2	4	2.5	5	3	7	4	9	6	>10	8
					1.2	1.1	1.5	1.3	1.8	1.5	2.2	1.7	3	2	3.5	2.5	5	3.5	7	4.5	9	6
18/15							1.3	1.2	1.6	1.5	2	1.7	3	2	4	2.5	5	3	7	4.5	>10	6
							1.2	1.1	1.5	1.3	1.8	1.5	2.3	1.7	3	2	3.5	2.5	5.5	3.7	8	5
17/14									1.3	1.2	1.6	1.5	2	1.7	3	2	4	2.5	6	3	8	5
									1.2	1.1	1.5	1.3	1.8	1.5	2.3	1.7	3	2	4	2.5	6	3.5
16/13											1.3	1.2	1.6	1.5	2	1.7	3	2	4	3.5	6	4
											1.2	1.1	1.5	1.3	1.8	1.5	2.3	1.8	3.7	3	4.5	3.5
15/12													1.3	1.2	1.6	1.5	2	1.7	3	2	4	2.5
													1.2	1.1	1.5	1.4	1.8	1.5	2.3	1.8	3	2.2
14/11															1.3	1.3	1.6	1.6	2	1.8	3	2
															1.3	1.2	1.6	1.4	1.9	1.5	2.3	1.8
13/10																	1.4	1.2	1.8	1.5	2.5	1.8
																	1.2	1.1	1.6	1.3	2	1.6

Hydraulics and Diesel Engines | Rolling Element Bearings | Journal Bearings and Turbo Machinery | Gear Boxes and Other

LET

How Low Should Moisture Limits (Targets) be Set?

1. Good

Target Dryness Table

Machine or Fluid Description	Reliability Penalty Factors 1	2	3	4	5	6	7	8	9	10
Steam Turbine - Bearing Oil	2000	1500	1000	750	500	400	300	200	100	50
Steam Turbine - EHC Fluid	2000	1500	1250	1000	750	600	500	400	325	250
Mobile Hydraulics - Mineral Oil	10,000	5000	3000	2000	1000	750	500	400	300	200
Diesel Engine Oil	20,000	10,000	5000	3000	2000	1000	500	400	300	200
Air Compressor Lube - Mineral Oil	4000	3500	3000	2000	1000	500	400	300	200	100
Industrial Gearbox	3000	2000	1500	1250	1000	750	600	500	400	300
Transmission/Differential	10,000	5000	3000	2000	1000	750	500	400	300	200
Paper Machine Oil	4000	3500	3000	2000	1000	500	400	300	200	100
Motor or Pump Bearing Oil	2000	1500	1000	750	500	400	300	200	100	50
Industrial Hydraulics - Mineral Oil	4000	3500	3000	2000	1000	500	400	300	200	100
Phosphate Ester Hydraulic Fluid	2000	1500	1250	1000	750	600	500	400	325	250
Diesters or Polyol Esters	3000	2000	1500	1250	1000	750	600	500	400	300

10,000 ppm = 1%

Example: **The target dryness level for an air compressor lube having a reliability factor of 5 is 1000 ppm.**

2. Better As low as reasonably achievable (ALARA)

3. Best Below the saturation point at operating temperatures

Never Let It Rest.

L766

NORIA

Appendix 8

Life Extension Table – Moisture

New Moisture Level (ppm)

Current Moisture Level (ppm)	10,000		5,000		2,500		1,000		500		250		100		50	
	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal	Rolling Element	Journal
50,000	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5	16.2	4.3	26.2	5.5	37.8	6.7
25,000	1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9	11.2	3.5	18.2	4.6	26.2	5.5
10,000			1.4	1.2	2.0	1.5	3.3	1.9	4.8	2.3	6.9	2.8	11.2	3.5	16.2	4.3
5,000					1.4	1.2	2.3	1.6	3.3	1.9	4.8	2.3	7.8	2.9	11.2	3.5
2,500							1.6	1.3	2.3	1.6	3.3	1.9	5.4	2.4	7.8	2.9
1,000									1.4	1.2	2.0	1.5	3.3	1.9	4.8	2.3
500											1.4	1.2	2.3	1.6	3.3	1.9
250													1.5	1.3	2.3	1.6
100															1.4	1.2

 LETM Ref: SKF, OSU, DT, UVLM

Appendix 9
Fluidrive ECU type Fluid Coupling Re-grease Procedure:
Size 320HFN20 (1015G20 Hub)
Size 1480HFD20 (1030G20 Hub)

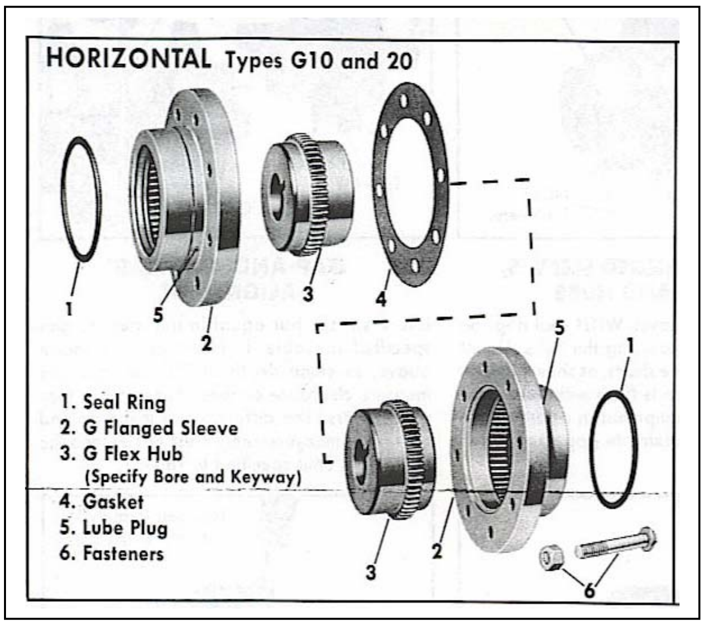
Oil VOLUME: For Oil Top-up Requirements, See: 'Coupling. Fluid (Falk) HFN.G10.G20.Top-up Procedure. PDF'

Gear Hub Lubricant Type:
Size 320HFN20 (1015G20 Hub)
For 1015G20, Grease volume is 0.16 lbs or 12 oz. (1 tube)

Size 1480HFD20 (1030G20 Hub)
For 1030G20, Grease volume is 0.8 lbs or 12 oz. (1 tube)

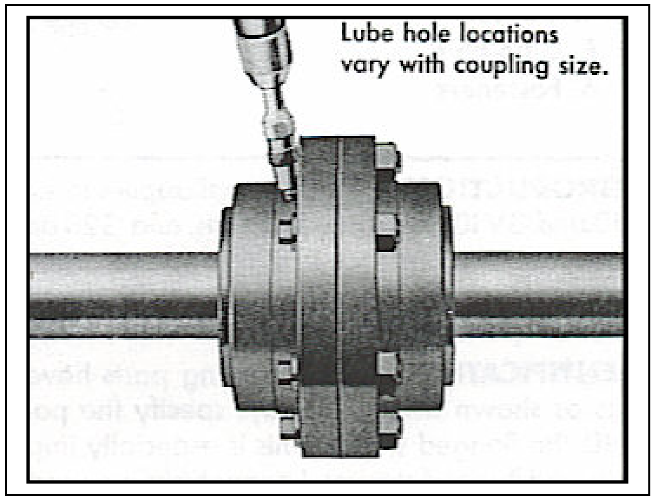
0°F to 200°F	**FALK LTG**	**NLGI #1**	**Hi Vis Mineral**

<u>Re-lubricate / Fill Procedure for G Type Couplings:</u>



1. Care should be taken to follow appropriate safety and hazardous energy procedures.
2. Stop the system and ensure it is locked out according to the plant safety requirements.
3. Remove Covers and coupling guards.
4. Remove plugs on each side of the hub as noted by Item 5, and insert a grease fitting into one of the two holes.
5. Take the grease gun in hand and stroke it one or more times until clean fresh grease has discharged from the hose end of the gun. Wipe the purge grease off the hose end (nozzle) with a clean cloth.
6. Press the grease gun hose end connection onto grease fitting. Apply grease slowly to the coupling.
7. Stop pumping the grease when grease purges from other hole. Replace the plug on the relief port.

8. If multiple relief ports exist, purge grease into the fitting until grease has discharged from each port. Once the correct amount of grease has been applied, remove the grease gun and zerk from the coupling. Replace the port into the hub.



9. Repeat the procedure on the other side of the coupling.

10. If an excessive amount of grease has emerged from the purge hole, use a shop rag to wipe off the discharge.

11. The amount of grease for each type of coupling is noted at the top of this procedure.

Appendix 1

Arrangement of Survey Details.

Eq. ID	Sub-Assembly	Product	Method of Application	Volume in Ounces	Shots from Grease Gun	Gallons of Oil	Number of Points	PM cycle (mo.)	PM Function	Test Slate	PM Procedure
P-462	**Pellet Vibratory Feeder/Screener No. 1**										
	Motor	RB 2	Pressure Gun	0.28	5		2	12	Relubricate Motor		Lube Procedures\Bearings Motor Drive. PDF
	V Belt	N/A							None		
	Shaft Pulley	EP 2	Pressure Gun	0.5985	11		1	1	Relubricate Bearing		Lube Procedures\Bearings Pillow block Procedure. PDF
	Shaft Pulley	EP 2	Pressure Gun	0.5985	11		1	1	Relubricate Bearing		Lube Procedures\Bearings Pillow block Procedure. PDF