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# Feasibility Study On Adopting An In-House Oil Analysis for LEPANTO



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Technical Training

# TABLE OF CONTENTS

# 1. Our Current Problems on Lubrication

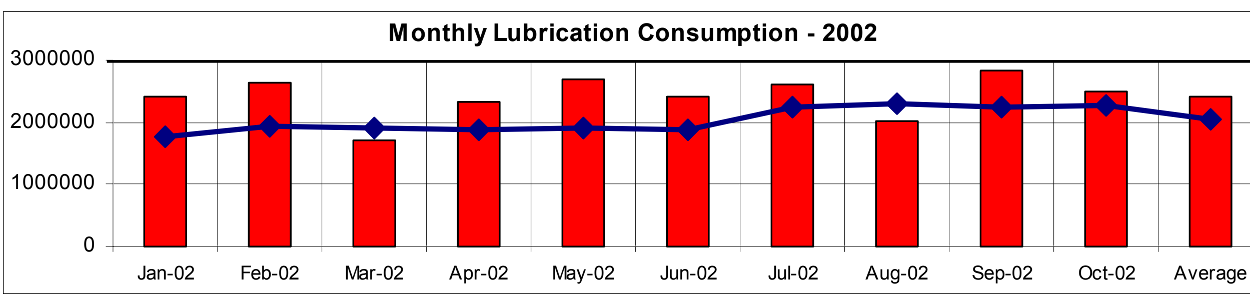
## 1.1 High Cost on Lubricants Consumption

- The current practice on lubrication is that oil change is based on running hours as dictated by our Preventive Maintenance Schedule. Our record shows that the average cost of lubricants purchased from January to October 2002 is around P 2,410,622.00 and from for 2003, January to May 2003 is around P 1,891,045.00. Data for 2003 is much lower than 2002 since there was no operations for the month of February due to strike. The following lubricants being used in our plant is as follows :

**Table 1**

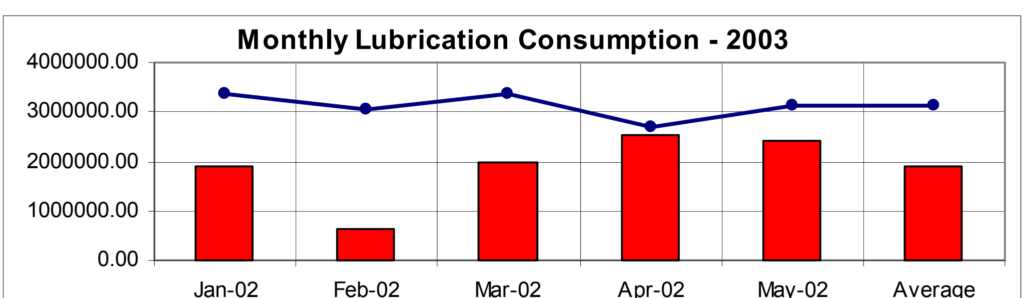
| Lubricants Used | Ave. Monthly Purchase | Ave. Monthly Consumption | Unit Costs | Purchased Costs | Consumed Costs |
|---|---|---|---|---|---|
| For Hydraulic Oil (Tellus T-68) | 24,000 ltrs | 15,283 ltrs | P 57.14 / ltr | P 1,371,360.00 | P 873,270.62 |
| For Transmission (Rimulla X-30) | 24,000 ltrs | 20,872 ltrs | P 52.19 / ltr | P 1,252,560.00 | P1,089,309.68 |
| For Engine Oil (15W-40) | 12,000 ltrs | 2,316.86 ltrs | P 52.84 / ltr | P 634,080.00 | P 122,422.88 |
| For Drilling Oil (Torcula 150) | 12,000 ltrs | 6,915.86 ltrs | P 49.14 / ltr | P 589,680.00 | P 339,845.22 |
| **Total** | **72,000 ltrs** | **45,387.72 ltrs** | **P 211.31 / ltr** | **P 3,847,680.00** | **P 2,424,848.40** |

- Table 2 and Table 3 shows data on the amount of lubricants purchased for the year 2002 and 2003




| Oil | Jan-02 | Feb-02 | Mar-02 | Apr-02 | May-02 | Jun-02 | Jul-02 | Aug-02 | Sep-02 | Oct-02 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Budget | 1772699 | 1941023 | 1913377 | 1884749 | 1914516 | 1885096 | 2231800 | 2287480 | 2240900 | 2272500 | 2034414 |
| Actual | 2404711 | 2623993 | 1724099 | 2326374 | 2687116 | 2397975 | 2598589 | 2012717 | 2834798 | 2495849 | 2410622 |

**Table 2**




| Oil | Jan-02 | Feb-02 | Mar-02 | Apr-02 | May-02 | Average |
|---|---|---|---|---|---|---|
| Budget | 3363260.00 | 3068465.00 | 3348656.00 | 2696941.00 | 3129066.00 | 3121277.60 |
| Actual | 1883994.75 | 635125.43 | 1967703.66 | 2534535.89 | 2433867.53 | 1891045.45 |

**Table 3**

Our current practice on oil drain or change oil is that it is performed based on the following frequencies :

- Change oil for Hydraulic systems is performed every 1000 hrs
- Change oil for Engine is performed every 125 hrs
- Change oil for Transmission is performed every 1000 hrs

## 1.2 Spare Parts That Fail Due To Lubrication

- Not only is the cost of lubrication high but also the cost of spare parts that fail due to contamination. Table 4 below shows a partial list of data on spare parts that fail due to lubrication problems. A failure constitutes a downtime by the equipment which will halt or delay operations, not mentioning the losses incurred on manpower, overhead and other expenses.

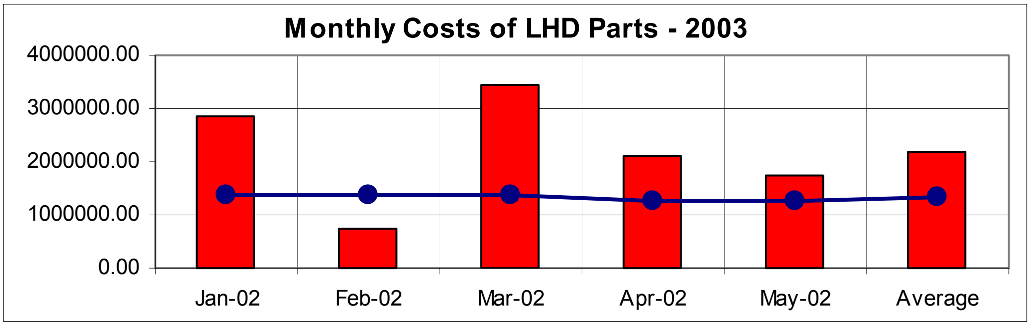
| Item No. | Description | Part Number | Qty | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| MTOR-042 | Motor, Hydraulic | 391012-7 | 1 | 15701.30 | 15701.30 |
| MTOR-043 | Motor, Hydrostatic | 300-38811759 | 3 | 188687.40 | 566062.20 |
| MTOR-045 | Motor, Wagner | MV22-4012 563881 | 2 | 157750.55 | 315501.10 |
| MTOR-045 | Motor, Wagner | MV22-4012 563881 | 1 | 139428.87 | 139428.87 |
| MTOR-061 | Motor | 367,586 | 1 | 21217.61 | 21217.61 |
| MTOR-066 | Motor, Hydrostatic | 64123057 | 1 | 186277.00 | 186277.00 |
| MTOR-095 | Motor, Hydraulic Reel | 65531010 | 1 | 24915.73 | 24915.73 |
| PUMP-097 | Pump | 66555691 | 1 | 156287.78 | 156287.78 |
| PUMP-098 | Pump, Charge | 403343 | 1 | 31216.42 | 31216.42 |
| PUMP-104 | Pump, Hydraulic | 900-3083169 680316 | 3 | 42507.10 | 127521.30 |
| PUMP-104 | Pump, Hydraulic | 900-3083169 680316 | 4 | 31672.70 | 126690.80 |
| PUMP-104 | Pump, Hydraulic | 900-3083169 680316 | 1 | 31216.42 | 31216.42 |
| PUMP-104 | Pump, Hydraulic | 900-3083169 680316 | 1 | 32468.78 | 32468.78 |
| PUMP-105 | Pump,Hydrostatic | 900-3092582 | 6 | 198554.67 | 1191328.02 |
| PUMP-105 | Pump,Hydrostatic | 900-3092582 | 1 | 189733.75 | 189733.75 |
| PUMP-105 | Pump,Hydrostatic | 900-3092582 | 1 | 217678.57 | 217678.57 |
| PUMP-110 | Pump,Wagner | MV21-2072 567418 | 2 | 117700.27 | 235400.54 |
| PUMP-110 | Pump,Wagner | MV21-2072 567418 | 2 | 117396.85 | 234793.70 |
| PUMP-110 | Pump,Wagner | MV21-2072 567418 | 1 | 149264.51 | 149264.51 |
| PUMP-112 | Pump, Assembly | 347915 | 1 | 64776.40 | 64776.40 |
| PUMP-115 | Pump, Hydrostatic Assy | 24VDC 6655755 | 1 | 347042.70 | 347042.70 |
| PUMP-120 | Pump Assembly | 371077 | 1 | 40229.96 | 40229.96 |
| **TOTAL** | | | **37.00** | **2,501,725.34** | **4,444,753.46** |

**Table 4**

- We estimate that around 40 to 60% of P 2,183,554.00 for LHD parts w/c average around P 873,422.00 (at 40%) fails due to lubrication problems and that the major cause of failures of spare parts attributed to lubrication is due to contamination.

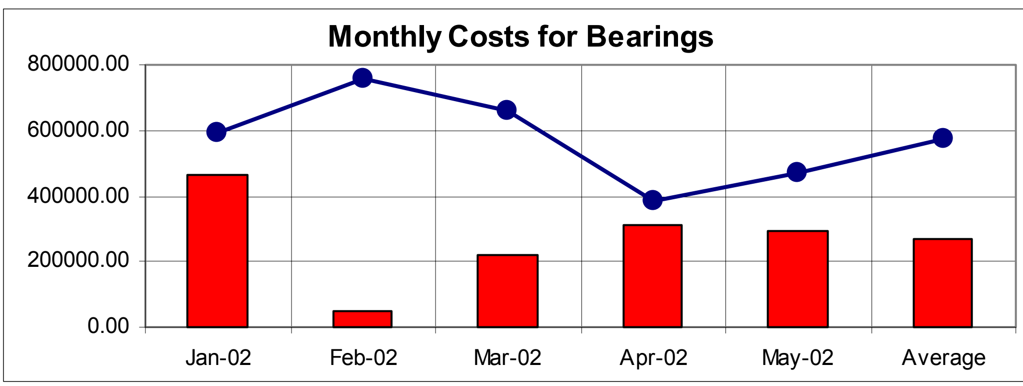
- Contamination is also the reason for oil degradation, hence, the need to change oil on a time-dominated frequency is essential. More contamination means more failures and frequent change oil, therefore it is important to analyze oil on the amount of contaminants as well as what elements are present and not by the frequency of changing oil itself. By knowing this information, maintenance can strategize measures to improve fluid cleanliness and lengthen its drain interval. If oil can be maintained clean, then there is no reason to change it and there is no reason for the parts to fail prematurely, the rate of wear would therefore decrease.

• Table's 5 and 6 indicate the cost of spares that was utilized




| LHD | Jan-02 | Feb-02 | Mar-02 | Apr-02 | May-02 | Average |
|---|---|---|---|---|---|---|
| Budget | 1356085.00 | 1359824.00 | 1355267.00 | 1257652.00 | 1271590.00 | 1320083.60 |
| Actual | 2857484.71 | 737080.54 | 3445189.15 | 2129186.93 | 1748827.47 | 2183553.76 |

**Table 5**




| Bearings | Jan-02 | Feb-02 | Mar-02 | Apr-02 | May-02 | Average |
|---|---|---|---|---|---|---|
| Budget | 593763.00 | 756849.00 | 662425.00 | 383825.00 | 470148.00 | 573402.00 |
| Actual | 464427.14 | 48122.44 | 219843.67 | 310512.46 | 292350.20 | 267051.18 |

**Table 6**

## 1.3 Problem with Oil Leaks

• Another problem that must be address on lubrication is system leaks on hydraulics, transmissions and engines. If there is leaks then there is ingression or entry of dust, dirt and moisture into the system, excessive leaks needs to be address, the more leak there is, the more contaminants that will be present. Below is a table that indicates how much cost is lost due to leaks

| Rate of Leak | Monthly Rate | | | Yearly Rate | | |
|---|---|---|---|---|---|---|
| | Total | Amount ($) | Amount (P) | Total | Amount ($) | Amount (P) |
| **1 drop / 5 sec** | 6.6 gal | $26.40 | **1,399.20** | 80 gal | $320.40 | **16,981.20** |
| **1 drop / sec** | 34 gal | $136.00 | **7,208.00** | 409 gal | $1,637.00 | **86,761.00** |
| **3 drops / sec** | 113 gal | $452.00 | **23,956.00** | 1243 gal | $4,972.00 | **263,516.00** |
| **Steady Flow** | 720 gal | $2,880.00 | **152,640.00** | 8640 gal | $34,560.00 | **1,831,680.00** |

Note : Exchange rate used is $ 1.00 = P 53.00

**Table 7**

### 1.4 Summary

- Here are the current problems we are encountering that must be addressed which contribute to the high cost of oil consumption and frequent failure of spare parts attributed to lubrication
  - Current filtration system (Nominal Rating) cannot trap contaminants in 25 microns or less
  - Presence of moisture in the oil
  - Oxidation of oil which results to gums, acids, varnishes and deposits
  - Contaminants present in oil
  - Problems on improper oil disposal
  - Excessive system oil leaks and spillage
  - Improper oil handling and dispensing procedures, lack of knowledge and its consequences
  - Too much make-up oil added daily to the system specially on hydraulics
  - Inadequate knowledge of maintenance and operations on lubrication
  - Ingression or entry of dirt into the system
  - Metals present in engine oil

## 2. Strategies To Reduce Cost on Lubrication

**1st - Analyze the contaminants present in oil. This is possible through an In-House Oil Analysis Laboratory. Determine what oil test is highly needed and adopt Oil Analysis in three levels**

- Check for oil's Fluid Health and Cleanliness through a particle counter. Set ISO fluid cleanliness standards on every system application
- Check for oil's Physical and Chemical Properties, determine what test is highly relevant
- Check for oil's Wear Metal Debri Analysis to determine what metals are present in engine oil

**2nd - Implement an Awareness Campaign on Oil Contamination Control Program**

- Educate all maintenance and operations on how our current practice highly contribute to contamination
- Improve Oil Handling and Dispensing Methods to reduce or minimize contamination

**3rd - Improve our current filters used**

- Use absolute filter rating to improve fluid cleanliness
- Utilize Offline-Filtration units and Absolute Filters to be used as By-pass for hydraulic and engine oil

**4rth - Remove moisture from the oil**

- Study the application on using desiccant breathers aside from our current air filters
- Utilize the use of Fluid Purifier System which can remove moisture from the system

**5th - Study the feasibility of using synthetic oil instead of mineral oil on selected application or systems that utilized too much make-up oil**

- Provide cost comparison report on the amount of oil added, frequency of oil change & failures

**6th - Address Oil Leaks**

### 2.1 Solution to our current lubrication problems

**Table 8**

| CURRENT PROBLEMS | ANALYSIS TO BE CONDUCTED | SOLUTION |
|---|---|---|
| • Contamination on oil | • Particle Counter | • Use Offline / By-Pass Filtration |
| • Amount of moisture on oil | • Karl Fisher Titration Test | • Use Fluid Purifier System |
| • Too much make-up oil added | • NOACK Volatility Test | • Use Synthetic Oil |
| • Oxidation and Acid on Oil | • Total Acid Number (TAN) | • Keep Oil Clean, remove moisture |
| • Metals present in oil | • Wear Metal Debri Analysis | • By-pass Filtration for engine |

## 2.2 Challenging our current practice on lubrication

Table 9

| OIL TYPE | CURRENT PRACTICE | PHASE 1 : IMPROVE 3x | PHASE 2 : 6x |
|---|---|---|---|
| • Hydraulic Oil | • change every 1000 hrs | • change every 3000 hrs | • 6000 hrs |
| • Engine Oil | • change every 125 hrs | • change every 375 hrs | • 750 hrs |
| • Transmission Oil | • change every 1000 hrs | • change every 3000 hrs | • 6000 hrs |

• The key in extending the drain interval of oil is to shift from running hours to ISO fluid cleanliness rating. Each application must have a designated ISO rating (Refer to appendix 3, page 14) as long as oil achieve it's fluid cleanliness level there is no reason to change the oil.

• To shift from this change process, filters must be change from nominal to absolute in rating. This is possible by adopting Offline or By-pass Filtration and checking the ISO fluid cleanliness of each application with the aid on a particle counter

# 3. Oil Analysis Defined

• When we are examined, our doctor may draw a blood sample and send it to a laboratory. Upon receiving the blood test result, our doctor renders a medical opinion or advisory in which we are free to accept or reject. Like oil inside the equipment can dictate its condition through an oil analysis program. Like blood, oil contains a great deal of information about the envelope in which it circulates

• Oil Analysis is a maintenance management tool that allows users to monitor equipment condition for maximum equipment life, maximum lubricant drain interval length and optimal downtime scheduling

• Oil Analysis saves users significant money by reducing equipment replacement and repairs reducing the volume of lubricant purchased destined for disposal and most of all by reducing downtime

• An oil analysis will aid us in determining the correct frequency of change oil interval as well as determine the amount contaminants present in our oil. By knowing what contaminants present, maintenance have a way of knowing what parts are most likely to fail.

# 4. Benefits of Adopting an In-House Oil Analysis

### a) Prolong the change interval of oil

• An oil analysis also suggests methods to reduce accelerated wear and contamination. Thus, oil becomes a working history of the machine

### b) Reduce consumption of oil

• Oil analysis plays a major role in reducing the maintenance costs & increase the life of machinery.

### c) Reduce contamination in oil

• By knowing what contamination present in oil, study shows ways to reduce particles present in oil

### d) Reduce cost of spare parts

• Studies on the subject of engine wear 92% of the engine's wear comes from particles in the 7 to 40 micron size.

### e) Environment-friendly

• By improving oil contamination it helps to improve the combustion efficiency of engines by monitoring and optimizing fuel system efficiency, thereby decreasing harmful emissions into the atmosphere.

**f) Early detection of problems**

- One major advantage of an oil-analysis program is being able to anticipate problems and schedule repair work to avoid downtime during critical time of use. Studies shows that failures can be predicted 18 months in advance

**g) Evaluating used equipment**

- A complete record of oil analyses performed can prove to be a great tool when selling a piece of used equipment. It shows potential buyers how you have maintained the equipment as well as any adjustments you made to it during its entire life. It also aids us in buying used machines

**h) Establish correct decision making**

- Oil analysis can aid in supporting critical operations and maintenance in making the right decisions

**i) Make sure that the right oil goes into the machine**

- Oil Analysis can detect if the wrong oil had been added to the system by mistake

## 5. Case Study On Oil Contamination Control

- Test done by **GM Corporation** shows that 82% of internal wear comes from particle less than 40 microns
- **SKF** states that improper lubrication accounted to 54% of bearing failures
- **Ford** states that 80% of hydraulic system failures can be treated to particulate contamination
- **Cummins** Technical Center indicate that wear can be reduced by 91% using a by-pass filter in combination with a full-flow filter
- **SAE** states that contamination in lubricant of engines, transmissions and hydraulic systems cause 70% of equipment failures
- In a study by the **Canadian National Research Council**, contamination was found out to be the leading cause of wear in a variety of industries investigated. In fact 82% of all wear was found to be particle induced
- **Nippon Steel** reduced bearing failures by 50% through aggressive contamination control
- **International Paper's Pine Bluff Mill** reported a 90% reduction in bearing failures again through aggressive contamination control program
- According to **Caterpillar**, dirt and contamination are the no. 1 cause of hydraulic system failures. J.I. Case states that with regards to hydraulic systems it must be kept clean
- **Alumax** of South Carolina reported a per machine reduction in component replacement cost from $15,000 to $500 per year
- **Kawasaki Steel** implemented a similar contamination control program and achieve an almost unbelievable 97% reduction in hydraulic component failures
- **Oklahoma State University** reports that when a fluid is maintained 10 x cleaner hydraulic pump life can be extended by 50 x
- **Machine Design Magazine** reports that less than 10% of all rolling element bearings reached the fatigue limit since contamination usually causes wear or spalling failure earlier
- **MIT** states that 6 to 7% of gross national product ($ 240 billion) is required just to repair damage caused by mechanical wear which is a result of contamination
- **Bottomline,** is that there is a direct relationship between contamination and the life of the oil as well as the rate of wear of parts, if the oil can be kept clean then there is no need to replace it

## 6. Recommended Instruments needed for Oil Laboratory

### 6.1 Particle Counter

Particle Counter CCS2
Contamination Control System
Vendor : German Hydraulic
Contact : Jimmy Galicia

Price : CCS2 - Euro 14,264.00 / 674,753.5
BSS2 - Euro 3,785.00 / 179,048.1

• Particle count is the procedure recommended by the ISO for establishing fluid cleanliness standards. It measures both metallic and non-metallic particles alike. Of all the contaminant particles, contamination is the most destructive to the oil and machine. The objective of having a particle counter is to control the fluid cleanliness level. Best used for hydraulic and filtered oil

• Particle counter determines the cleanliness classes according to ISO 4406:99 or NAS 1638. This method aims to check the clean-liness by determining the total number of particles in several different size ranges most commonly referred to as particle size distribution

Bottle Sampler

### 6.2 Offline Filtration Unit

Model UFM 42 : Offline Filter
Vendor : German Hydraulic
Contact : Jimmy Galicia

• The unit is compact, self-contained, portable and totally separated from the main system with its own pump and motor. It can operate anytime of the day even when the machine is running or not. It has a sensing mechanism to determine if filter element needs to be changed. Comes in different discharge capacities.

- Improve fluid cleanliness through absolute filtration
- Absolute filtration which can remove particles in 3 microns
- Discharge vary per model in 20 and 40 liters
- Fixed offline or portable depending on its application
- Can be used for stationary and mobile equipment
- Sensing device to indicate if filters needs to be replaced
- Filter element come in different rating 3, 6 10 microns absolute depending upon customers requirements

Price : Euro 1963.806 / P 105,063.60

### 6.3 Fluid Purifier System

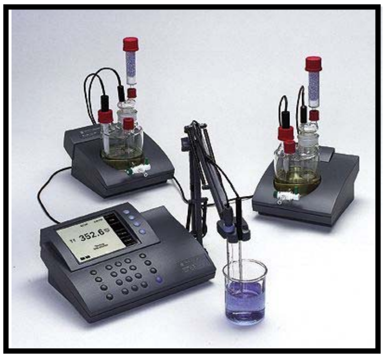
IFPM/IFPS Fluid Purifier Sys.
Vendor : German Hydraulic
Contact : Jimmy Galicia

• Moisture present in oil can be removed through this instrument, this unit can removed around 105 liters of water per day from the system. Moisture inhibits rust and corrosion, when combined with soot it cause acids to accumulate destroying the oil's film and its capability to reduce friction

- Remove free, dissolved and emulsified water from operation fluids
- Can also remove free and dissolved gases
- Remove particle contamination down to 1 micron
- Extend the oil service times and prevent oil ageing
- Improve the reliability and productivity of plants

Price : Euro 25,612.00 / P 1,211,992.00

### 6.4 Karl Fisher Titration Test



**Karl Fischer Reagent Method (ASTM D-1744-64)**

- The standard laboratory test to measure the water content of oil or mineral base fluids. In this method, water reacts quantitatively with the Karl Fischer reagent. This reagent is a mixture of iodine, sulfur dioxide, pyridine, and methanol. When excess iodine exists, electric current can pass between two platinum electrodes or plates. The water in the sample reacts with the iodine. When the water is no longer free to react with iodine, an excess of iodine depolarizes the electrodes, signaling the end of the test.
- From Cole-Palmer

### 6.5 NOACK Volatility Test (ASTM D-5800)

- Volatility is measured by the principal, European test called NOACK, It is the amount of oil lost (the light molecules) over time at a given temperature & pressure. It has a direct impact on high engine temperature oil effectiveness -- especially on viscosity, emissions & oil consumption. Today's oils have a NOACK volatility limit of 22 percent. When an oil suffers from high volatility, and the lighter molecules evaporate, the oil thickens gradually getting out of "spec" and adversely effecting the performance of the lubricant and placing the engine at risk.
- In this test oil is heated for a specified period and the percentage of loss by weight due to boil off is measured.
- The Noack Volatility Test is used to determine evaporation loss of lubricating oils, an issue of particular importance in engine lubrication. Portions of an oil can evaporate under high temperature conditions, potentially altering oil properties such as viscosity. A low Noack score indicates an oil that will maintain its original protective and performance qualities for a longer amount of time. These oils perform better under heat, translating to better engine protection, longer oil life, and improved fuel economy. The Noack Volatility Test has long been a specification test for European motor oils. In 1996, volatility limits tightened to 22% with GF-2 oils' entrance on the market, then were again lowered in 2001 – this time for all grades to 15% (or 13% for European synthetic motor oils) with GF-3 oils' introduction.

### 6.6 Total Acid Number (TAN) ASTM D-664

- Is the measure of both the weak organic and strong inorganic acids present in oil. It is applicable to gearbox, gas engine, gas turbine, synthetic and hydraulic lubes.
- Many people believe that you have to change oil regularly. The only indicator that would tell you that you need to change your oil is TAN (Total Acid Number). If your TAN is greater than 2 then you had been shot and your oil needs to be changed. If TAN is under one , then the oil is in excellent condition unless you have an unusual amount of water in the oil. If your oil has a high amount of particulate don't change it if the TAN number is good, filter it.

### 6.7 Flash Point Test Instrument ASTM D-92

• Flash Point is the temperature at which oil gives off vapors that can be ignited with flame over the oil. The lower the flash point the greater the tendency for the oil to suffer vaporization loss at high temperature and to burn. Minimum flashpoint must be 400 degree F. The higher the flashpoint the better

**Flash Point Test from Cole-Palmer**
Model EW 59871
Model EW 59871-05
**$ 1740 - $ 1890**

• Flash Point is the lowest temperature at which an ignition source causes the vapors of the specimen (lubricant) to ignite under specific conditions. The flash point temperature corresponds roughly to a vapor pressure of 3 - 5 mm Hg. When a small flame is applied to the oil's surface this vaporous mixture will burn momentarily and then extinguish if the critical temperature has been reach. Continued heating above 50 - 75 deg F above the Flash Point temperature will cause the fire point to be reached

## 7. Ways to Improve Oil Handling and Control Contamination

- Do not use open type containers when adding oil to the sump as this is prone to contamination specially when used on a dusty and humid place such as underground mining. Use dedicated containers for each type of oil to be used, label and properly cover container when not in use
- Use separate dispensing units for each type of oil. Never try to use a single dispensing unit for pumping out all the types of oil in the plant. This technique does not save us money.
- Study the use of desiccant breathers on oil tanks, depots, in order to minimize ingression and entry of moisture. For LHD's current air filters is not sufficient to trap moisture & dirt
- Filter out new oil by using offline filtration (3 to 6 microns absolute) before filling this to the oil tank. The assumption that new oil is clean oil does not hold true. In fact filtered oil is cleaner than new oil that arrived from the supplier (refer to appendix 2 : page 15)
- Provide adequate storage for lubricants with proper labeling and ventilation, do not expose the oil drum containers to rain or sunlight and always cover them when not in use
- Installation of drum racks, proper labeling and possible color coding. When transporting oil from drums, never roll them
- Educate everyone in the plant regarding proper oil handling and dispensing. Create an awareness campaign to people on how oil is contaminated through improper and wrong handling procedures

Bad and wrong practices on lubrication

## 8. Step by Step Procedure On Setting-Up An Oil Analysis Program

Status

OK **Step 1 : Data gathering and documentation**

- How much are we spending in spare parts ?
- How much are we consuming per type ?
- How much oil and lubricant are we consuming
- Specify current problems we have on lubrication

OK **Step 2 : Conduct basic training on Oil Analysis** → Still ongoing

- Provide in house training on basic oil analysis program
- Provide benefits and usefulness of an oil analysis program
- Compare current practice with having an oil analysis program
- Allow participants to appreciate the advantage of oil analysis over current practice

OK **Step 3 : Decide what types of test is highly needed and recommended**

- Decide what types of oil test will be applied to different applications
- What equipment's will be sampled ?
- Provide procedure on how to get sampling from the unit

OK **Step 4 : Source vendor on Oil Analysis laboratory instruments**

- Develop operating cost of the equipment needed
- Decide what test must be done in-house and those that can be done off-site
- Discuss training package with oil analysis vendor

OK **Step 5 : Prepare a management presentation on Oil Analysis**

- Comparing current practice and propose practice on lubrication
- Determine cost needed for the project
- Determine if project is go or no go
- Assign a champion to spearhead the oil analysis

OK **Step 6 : Locate laboratory site and manpower needed**

- Study feasibility and strategic location of the laboratory
- Create a centralized Oil Analysis Laboratory
- Provide detailed job description as well as duties and responsibility of oil analyst

OK **Step 7 : Conduct Project Study and Feasibility Report On Oil Analysis Project**

- Compute for the Rate of Return on Investment and payback period
- Compute for projected savings with an oil analysis project
- Study feasibility and strategic location of the laboratory
- Seek approval of the project

☐ **Step 8 : Procurement of the equipment's needed for the Oil Analysis laboratory**

- Select the best and most qualified vendor
- Purchase the equipment on Oil Analysis

☐ **Step 9 : Installation and Commissioning**

- Hands on training on the equipment with the vendor
- Attend vendors training on the use of oil analysis
- Set meeting with other departments regarding procedures

☐ **Step 10 : Implement an Awareness Campaign on Oil Contamination**

- Conduct brief training on all employees on oil contamination control
- Adopt by-pass and offline filtration to improve contamination levels
- Monitor progress and result specially on reduction of cost on spares and lubrication

## 9. Oil Analysts Qualification and Responsibilities

### Qualifications : Either Internal or External Hiring

- At least 25 - 40 years of age, male or female
- Graduate of any engineering course
- Preferably mechanical or chemical engineering
- Computer literate, knowledge in windows application
- Knowledge in excel, PowerPoint, word application
- Can work with minimum supervision
- Knowledge on oil and lubrication
- Can speak Ilocano
- Excellent communication skills
- Knowledge on heavy equipment an advantage
- Willing to be assigned in Benguet, Mankayan
- With knowledge on lubrication, Oil Analysis and Tribology

### Major Duties and Responsibilities

- Conduct different test on oil analysis as required by maintenance
- Be able to interpret Oil Analysis results and provide recommendations
- Provide oil analysis report and communicate them to maintenance
- Undergo rigid hand on training on different oil analysis instruments & equipment
- Be able to summarize all reports on oil analysis and conduct meeting / feedback with the maintenance people
- Ensure that oil samples are continuously given and provided by the maintenance
- Ensure safekeeping of oil laboratory instruments
- Be able to document success stories and savings generated by Oil Analysis Program
- Spearhead an oil contamination campaign control program
- Responsible for the maintenance of oil analysis instruments and communicate with vendor / supplier regarding equipment's calibration procedures

## 10. Costs of Oil Analysis Test Instruments

| Unit | Qty | Amount | Vendor |
|---|---|---|---|
| • Particle Counter | 1 | P 1,110,000.00 | German Hydraulic |
| • Offline Filtration UMV 40 | 2 | P 274,000.00 | German Hydraulic |
| • Fluid Purifier System | 1 | P 1,576,000.00 | German Hydraulic |
| • Karl Fisher Titration Test | 1 | P 214,000.00 | Philab |
| • Oil Laboratory Tables | 1 | P 60,000.00 | Philab |
| • Microscope | 1 | P 78,000.00 | Philab |
| • 1 set Computer w/ Printer | 1 | P 25,000.00 | for sourcing |
| • Bottles | 1500 | P 3,000.00 | Normalab |
| • Oil Guard By-Pass Filter | 20 | P 223,000.00 | Oil Guard |
| • Air condition | 1 | P 12,000.00 | for sourcing |
| | | **Total - P 3,575,000.00** | |
| **For 2004** | | | |
| • NOACK Volatility Test | 1 | P 209,000.00 (estimate) | for sourcing |
| • Flash Point Analyzer | 1 | P 131,000.00 | Normalab |
| • Total Acid Number Test | 1 | P 209,000.00 (estimate) | Normalab / German Hyd |
| • Soot / Sulfur Analyzer | 1 | P 209,000.00 (estimate) | Normalab / German Hyd |

## 11. By-pass filtration

| | | | |
|---|---|---|---|
|  |  |  |  |
| **FS-2500 Filter**<br>3 microns<br>Absolute | **Oil Guard Filter**<br>1 micron, absolute<br>EP-60 ($ 160.00) | **Gulf Coast Filter**<br>1 micron, absolute<br>Model 0-1 ($ 395.00) | **Filtakleen Filter**<br>1 micron, absolute<br>FV-878-CA-10-EK-11 ($ 449.95) |

### Why By-Pass Filtration?

- Because even the finest full flow oil filtration simply can't do the job completely. Full-Flow filters are installed in-line in an oil circulation system, so they must allow constant oil flow to the engine. Therefore the filtration media has to be relatively coarse and open to provide a rapid oil flow

- But this "free-flow" also compromises the filter's ability to remove the smaller abrasive particles: typical flow-flow filters only remove particles down to 30-40 microns. The problem is that smaller-sized particles, from 5 to 20 microns, are responsible for up to 60% of engine wear. This means a conventional full-flow filter leaves countless wear causing particles in the oil, grinding away at your engine and shortening its life

- The factory spin-on filters on your engines were designed to work in a full-flow environment. As such, these filters, by design can't filter down too fine because the flow of oil to the engine would be restricted too much. As a result the most damaging particles to your engine (the 5 to 20 micron range) are allowed to freely attack all the moving parts in your engine, causing premature failure of your engine. Most By-Pass Filters is designed to take about 10% of the full-flow of your oil in your engine through a very fine filter media that cleans the oil depending upon its micron rating and some by-pass filters also removes water from the oil.

- In the full-flow system, all the oil that is pumped throughout the engine is first passed through the full-flow filter. Since the volume of oil required to lubricate the engine is quite large, 30 to 55 quarts for large diesel engines, the full-flow filter must be very porous so that it will not restrict this large volume of oil. The full-flow filter protects the bearings and all the other moving parts of the engine by removing the larger particles of dirt and wear particles that can damage the precision parts of the engine. Except during start-up, when the engine is cold, or if the full-flow filter becomes clogged. Then a pressure relief valve will open and allow the unfiltered oil to lubricate the engine. The reasoning here is that, "dirty oil is better than no oil."

### Nominal and Absolute Rating of Filters

- The absolute rating of a filter refers to smallest size particle that will be removed during filtration while nominal ratings refer to the average particle size that will remain in the fluid after filtration. A nominal 5 micron filter will trap particles around 5 microns in size. An absolute 5 mic filter will guarantee to trap all particle 5 microns in size & larger. Tests have shown that particles as large as 200 microns can will pass through a nominal rating of 10 micron filter. An absolute rating gives the size of the largest particle that will pass through the filter or screen. This is the size of the largest opening in the filter.

## 12. Oil Analysis Laboratory ROI and Payback Period

| CAPEX | 2003 | 2004 | 2005 | 2006 | 2007 | Total |
|---|---|---|---|---|---|---|
| Capital cost, P(000) | 3575 | 1522 | 556 | 0 | 0 | 5653 |
| Add installation cost | 357 | 152 | 56 | 0 | 0 | 565 |
| **Total Capex** | 3932 | 1675 | 612 | 0 | 0 | 6219 |

| | Reduction in Lubrication and Spare Parts Cost | | | | | |
|---|---|---|---|---|---|---|
| **BENEFITS** | 2003 | 2004 | 2005 | 2006 | 2007 | Total |
| **% of Units Implemented** | 10% | 50% | 80% | 100% | 100% | |
| **1. Change oil, P/a (000)** | | | | | | |
| Hydraulic oil | 105 | 2096 | 3353 | 4192 | 4192 | 13,937 |
| Engine oil | 15 | 294 | 470 | 588 | 588 | 1954 |
| Transmission oil | 131 | 2614 | 4183 | 5229 | 5229 | 17,385 |
| Sub-total | 250 | 5004 | 8006 | 10,008 | 10,008 | 33,277 |
| **2. Make-up oil** | | | | | | |
| Hydraulic oil | 13 | 262 | 419 | 524 | 524 | 1742 |
| Engine oil | 2 | 37 | 59 | 73 | 73 | 244 |
| Transmission oil | 16 | 327 | 523 | 654 | 654 | 2173 |
| Sub-total | 31 | 626 | 1001 | 1251 | 1251 | 4160 |
| **3. Spare** | | | | | | |
| LHD parts | 229 | 4,585 | 7,337 | 9,171 | 9,171 | 30,493 |
| Bearing | 34 | 673 | 1,077 | 1,346 | 1,346 | 4475 |
| Sub-total | 263 | 5258 | 8413 | 10517 | 10517 | 34,969 |
| | | | | | | |
| **COSTS** | | | | | | |
| Labor | 195 | 780 | 780 | 780 | 780 | 3315 |
| Bottles | 7 | 27 | 27 | 27 | 27 | 115 |
| Power | 3 | 10 | 10 | 10 | 10 | 43 |
| Oil-guard Cartridge | 57 | 230 | 230 | 230 | 230 | 975 |
| Off-line Filter Cartridge | 30 | 120 | 120 | 120 | 120 | 510 |
| Sub-total | 292 | 1167 | 1167 | 1167 | 1167 | 4958 |
| **Incremental Income** | 253 | 9,721 | 16,254 | 20,609 | 20,609 | 67,447 |
| | | | | | | |
| **Cashflow** | 2003 | 2004 | 2005 | 2006 | 2007 | |
| Cash outflow, P(000) | -3932 | -1675 | -612 | 0 | 0 | |
| Cash inflow, P(000) | 253 | 9,721 | 16,254 | 20,609 | 20,609 | |
| **Cashflow, P(000)** | -3,679 | 8,047 | 15,642 | 20,609 | 20,609 | |
| Payback, months | | 8 | | | | |

**Table 10**

| Annual Lubrication Cost (Jan. - Oct. 2002 Projected) | | | | | | |
|---|---|---|---|---|---|---|
| | % | Hydraulic | Engine | Transmission | Drilling | Total |
| Spillage/Leaks | 15 | 1,571,888 | 220,361 | 1,960,758 | 611,721 | 4,364,728 |
| Make-up | 25 | 2,619,813 | 367,269 | 3,267,930 | 1,019,535 | 7,274,547 |
| Change Oil | 60 | 6,287,551 | 881,446 | 7,843,032 | 2,446,884 | 17,458,913 |
| Cost per year | 100 | 10,479,252 | 1,469,076 | 13,071,720 | 4,078,140 | 29,098,188 |
| Cost per month | | 873,271 | 122,423 | 1,089,310 | 339,845 | 2,424,849 |

**Table 11**

# 13. Appendix

Appendix 1 : ISO 4406 :99 Fluid Cleanliness Standard

| ISO 4406 CODE | Number of Particles | |
|---|---|---|
| | From | To |
| 26 | 320,000 | 640,000 |
| 25 | 160,000 | 320,000 |
| 24 | 80,000 | 160,000 |
| 23 | 40,000 | 80,000 |
| 22 | 20,000 | 40,000 |
| 21 | 10,000 | 20,000 |
| 20 | 5,000 | 10,000 |
| 19 | 2,500 | 5,000 |
| 18 | 1,300 | 2,500 |
| 17 | 640 | 1,300 |
| 16 | 320 | 640 |
| 15 | 160 | 320 |
| 14 | 80 | 160 |
| 13 | 40 | 80 |
| 12 | 20 | 40 |
| 11 | 10 | 20 |
| 10 | 5 | 10 |
| 9 | 2.5 | 5 |
| 8 | 1.3 | 2.5 |
| 7 | 0.6 | 1.3 |
| 6 | 0.3 | 0.6 |

**Table 12**

Appendix 2 : Fluid Cleanliness Standard Comparison for New Oil

| **Without By-Pass ISO 22/17** | **Brand New Oil ISO 17/14** | **With By-Pass Filter ISO 13/10** |
|---|---|---|
| > 5 = 29263 ppm | > 5 = 1292 ppm | > 5 = 55 ppm |
| > 15 = 1112 ppm | > 15 = 119 ppm | > 15 = 15 ppm |
| > 25 = 29 ppm | > 25 = 19 ppm | > 25 = 3 ppm |
| > 50 = 0 ppm | > 50 = 5 ppm | > 50 = 0 ppm |
| >100 = 0 ppm | >100 = 0 ppm | >100 = 0 ppm |

**Table 13**

# Appendix

Appendix 3 : Sample Standard Cleanliness Target for System Applications

| MACHINE / COMPONENT | ISO RATING |
|---|---|
| • Roller Bearings | 16/14/12 |
| • Journal Bearings | 17/15/12 |
| • Industrial Gearboxes | 17/15/12 |
| • Mobile Gearboxes | 17/16/13 |
| • Diesel Engines | 17/16/13 |
| • Steam Turbine | 18/15/12 |
| • Paper Machine | 19/16/13 |
| • Servo-Valve | 13/12/10 |
| • Proportional Valve | 14/13/11 |
| • Variable Volume Pump | 15/14/12 |
| • Fixed Piston Pump | 16/15/12 |
| • Vane Pump | 16/15/12 |
| • Gear Pump | 16/15/12 |
| • Ball Bearing | 14/13/11 |
| • Turbine | 17/15/12 |

**Table 13**

Appendix 4 : General Water Concentration Limits

| H20 Concentration | Status | Action |
|---|---|---|
| • 100 - 300 | • Alert | • Check seals, breathers, coolers, etc., for ingression sources, watch the trend |
| • 300 - 800 | • Danger | • Aggressively investigate and correct the source of ingression and implement an effective water removal activities |
| • 800 above | • Extremely Danger | • Immediate action is required to eliminate ingression and effect removal of water to minimize damage to machine and lubricant |

Note : Unit of Water concentration in PPM

**Table 14**

# Appendix

Appendix 5 : Engine Problems Analyzed through Oil Analysis

| Metal Traces | Limit | Engine Problem | What to Check |
|---|---|---|---|
| • Silicon | • 10 - 30 ppm | • Dirt Ingression | • Air intake system<br>• Oil filter plugging<br>• Oil filler cap and breather<br>• Valve cover |
| • Iron (Fe) | • 100 - 200 ppm | • Wear of cylinder liner<br>• Valve and fear train<br>• Oil pump<br>• Rust in the system | • Excessive oil consumption<br>• Abnormal engine noise<br>• Performance problem<br>• Oil pressure<br>• Stuck or broken piston |
| • Chromium (Cr) | • 10 - 30 ppm | • Piston ring wear | • Excessive oil blow-by<br>• Oil consumption / degradation |
| • Copper (Cu) | • 10 - 50 ppm | • Bearing / bushing wear<br>• Radiator corrosion | • Coolant in engine oil<br>• Abnormal noise on operating at stall speed |
| • Lead (Pb) | • 40 - 100 ppm | • Bearing corrosion | • Extended oil change intervals |
| • Aluminum (Al) | • 10 - 30 ppm | • Piston and piston thrust<br>• Bearing wear | • Blow-by gases<br>• Oil consumption<br>• Power loss<br>• Abnormal engine noise |

Table 15

Appendix 6 : Recommended Test for different applications

| Equipment | Spectro-Analysis | Viscosity | FTIR | Particle Count | Karl Fisher | TAN | TBN | Rotrode Filter |
|---|---|---|---|---|---|---|---|---|
| Engines | R | R | R | ---- | R | R | R | A |
| Compressor | R | R | R | A | R | ---- | ---- | R |
| Gearboxes | R | R | R | ---- | ---- | ---- | ---- | R |
| Bearings | R | R | R | A | ---- | ---- | ---- | R |
| Hydraulics | R | R | R | R | A | A | ---- | R |
| Turbines | R | R | R | R | R | R | ---- | R |
| Motor | R | R | R | ---- | ---- | ---- | ---- | R |

Table 16

Where : R - Require Test
A - Advisable, provides extra details

Appendix 7 : Comparing Multi-grade Oil Properties

Table 17

| BRAND (SAE 20W-50) | VI | Flash | Pour | % Ash | % Zinc |
|---|---|---|---|---|---|
| AMSOIL | 136 | 482 | -38 | < 0.50 | --- |
| Castrol GTX | 122 | 440 | -15 | 0.85 | 0.12 |
| Exxon High Perfmance | 119 | 419 | -13 | 0.70 | 0.11 |
| Havoline Formula 3 | 125 | 465 | 30 | 1.00 | --- |
| Kendall GT-1 | 129 | 390 | -25 | 1.00 | 0.16 |
| Pennzoil GT Performance | 120 | 460 | -10 | 0.90 | --- |
| Quaker State Dix | 155 | 430 | -25 | 0.90 | --- |
| Red Line | 150 | 503 | -49 | --- | --- |
| Shell Truck Guard | 130 | 450 | -15 | 1.00 | 0.15 |
| Spectro Golden 4 | 174 | 440 | -35 | --- | 0.15 |
| Spectro Golden M.G. | 174 | 440 | -35 | --- | 0.13 |
| Unocal | 121 | 432 | -11 | 0.74 | 0.12 |
| Valvoline All Climate | 125 | 430 | -10 | 1.00 | 0.11 |
| Valvoline Turbo | 140 | 440 | -10 | 0.99 | 0.13 |
| Valvoline Race | 140 | 425 | -10 | 1.20 | 0.2 |
| Valvoline Synthetic | 146 | 465 | -40 | <1.50 | 0.12 |
| **BRAND (SAE 20W-40)** | **VI** | **Flash** | **Pour** | **% Ash** | **% Zinc** |
| Castrol Multi-Grade | 110 | 440 | -15 | 0.85 | 0.12 |
| Quaker State Dix | 121 | 415 | -15 | 0.90 | --- |
| **BRAND (SAE 15W-50)** | **VI** | **Flash** | **Pour** | **% Ash** | **% Zinc** |
| Chevron | 204 | 415 | -18 | 0.96 | 0.11 |
| Mobile 1 | 170 | 470 | -55 | --- | --- |
| Mystic JTS | 144 | 420 | -20 | 1.70 | 0.15 |
| Red Line | 152 | 503 | -49 | --- | --- |
| **BRAND (SAE 5W-50)** | **VI** | **Flash** | **Pour** | **% Ash** | **% Zinc** |
| Castrol Syntec | 180 | 437 | -45 | 1.20 | 0.1 |
| Quaker State Sunquest | 173 | 457 | -76 | --- | --- |
| Pennzoil Performax | 176 | --- | -69 | --- | --- |
| **BRAND (SAE 5W-40)** | **VI** | **Flash** | **Pour** | **% Ash** | **% Zinc** |
| Havoline | 170 | 450 | -40 | 1.40 | --- |
| **BRAND (SAE 15W-40)** | **VI** | **Flash** | **Pour** | **% Ash** | **% Zinc** |
| AMSOIL | 135 | 460 | -38 | <0.50 | --- |
| Castrol | 134 | 415 | -15 | 1.30 | 0.14 |
| Chevron Delo 400 | 136 | 421 | -27 | 1 | --- |
| Exxsn XD3 | --- | 417 | -11 | 0.9 | 0.14 |
| Exxon XD3 Extra | 135 | 399 | -11 | 0.95 | 0.13 |
| Kendall GT-1 | 135 | 410 | -25 | 1 | 0.16 |
| Mystic JT8 | 142 | 440 | -20 | 1.7 | 0.15 |
| Red Line | 149 | 495 | -40 | --- | --- |
| Shell Rotella w/ XLA | 146 | 410 | -25 | 1 | 0.13 |
| Valvoline all fleet | 140 | --- | -10 | 1 | 0.15 |
| Valvoline Turbo | 140 | 420 | -10 | 0.99 | 0.13 |
| **BRAND (SAE 5W-30)** | **VI** | **Flash** | **Pour** | **% Ash** | **% Zinc** |
| AMSOIL | 168 | 480 | -76 | <0.50 | --- |
| Castrol GTX | 156 | 400 | -35 | 0.8 | 0.12 |
| Chevron Supreme | 202 | 354 | -46 | 0.96 | 0.11 |
| Chevron Supreme Synthetic | 165 | 446 | -72 | 1.1 | 0.12 |
| Exxon Superflow HP | 148 | 392 | -22 | 0.7 | 0.11 |
| Havoline Formula 3 | 158 | 420 | -40 | 1 | --- |

Appendix 8 : Guidelines for determining, achieving and maintenance Target Cleanliness Levels with High Performance Filtration (Beta Ration > 200)

| Most Sensitive System Components | Low Pressure | | Medium Pressure | | High Pressure | |
|---|---|---|---|---|---|---|
| | 140 Bar | | 140 - 210 Bar | | 210 Bar - up | |
| | ISO Target Levels | Micron Rating | ISO Target Levels | Micron Rating | ISO Target Levels | Micron Rating |
| **PUMPS** | | | | | | |
| Fixed External Gears | 21/17/14 | 25 | 20/16/14 | 10 | 20/16/14 | 10 |
| Vane Pump | 21/17/14 | 25 | 20/16/14 | 10 | 19/16/13 | 6 |
| Fixed Piston | 20/16/14 | 10 | 19/16/13 | 6 | 19/15/12 | 3 |
| Variable Piston | 19/16/13 | 6 | 19/15/12 | 3 | 18/14/12 | 3 |
| **VALVES** | | | | | | |
| Check Valves | 21/17/14 | 25 | 20/16/14 | 10 | 20/16/14 | 10 |
| Directional (Solenoid) | 21/17/14 | 25 | 20/16/14 | 10 | 20/16/14 | 10 |
| Standard Flow Control | 21/17/14 | 25 | 20/16/14 | 10 | 20/16/14 | 10 |
| Cartridge Valve | 20/16/14 | 10 | 19/16/13 | 6 | 19/15/12 | 3 |
| Proportional Valve | 19/15/12 | 3 | 18/14/12 | 3 | 17/13/11 | 3 |
| Servo Valve | 18/14/12 | 3 | 17/13/11 | 3 | 16/12/10 | 3 |
| **ACTUATORS** | | | | | | |
| Cylinders, Vane Motors | 22/18/15 | 25 | 20/17/14 | 16 | 19/16/13 | 6 |
| Gear Motors | 22/18/15 | 25 | 20/17/14 | 16 | 19/16/13 | 6 |
| Piston Motors | 20/16/14 | 10 | 19/16/13 | 6 | 19/15/12 | 3 |
| Swash Plate Motors | 20/16/14 | 10 | 19/16/13 | 6 | 19/15/12 | 3 |
| Hydrostatic Drives | 19/15/12 | 3 | 18/14/12 | 3 | 17/13/11 | 3 |
| **LUBRICATING OILS** | | | | | | |
| Paper Machine Oils | 21/16/13 | 3 | n.a. | n.a. | n.a. | n.a. |
| Steam Turbin Oils | 20/15/12 | 3 | n.a. | n.a. | n.a. | n.a. |
| Diesel Engines | 19/16/13 | 3 | n.a. | n.a. | n.a. | n.a. |
| Mobile Gear Box | 19/16/13 | 3 | n.a. | n.a. | n.a. | n.a. |
| Industrial Gear Box | 19/15/12 | 3 | n.a. | n.a. | n.a. | n.a. |
| Journal Bearings | 19/15/12 | 3 | n.a. | n.a. | n.a. | n.a. |
| Roller Bearings | 18/14/12 | 3 | n.a. | n.a. | n.a. | n.a. |
| Ball Gearings | 17/13/11 | 3 | n.a. | n.a. | n.a. | n.a. |

- Severe conditions may include high flow surges, pressure spikes, frequent cold starts, extremely heavy duty use or the presence of water
- Two or more systems filters of the recommended rating may be required to achieve and maintain the desired Target Cleanliness Level (ISO 4406 : 99)