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GEARBOX RELIABILITY

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The Core Preventive and Proactive Maintenance Requirements to achieve Gearbox Reliability

Introduction to Gearbox Reliability

Gear reducers are an integral part of all production processes. They can range from small throwaway units to large, both specialized and standardized units. Gearbox Reliability is a critical factor for those companies who are tasked with reducing plant maintenance and operational costs.

Additionally, they can be very complex in design and can pose a challenge for maintenance staff, as there are many moving interfaces (i.e. gear mesh types, couplings, bearings and sealing mediums) all requiring their own and often different installations, adjustments / setups. Not to mention the very high loads that they can operate under and all of these factors require them to operate at all times with an effective and contamination free lubrication film thickness.

This document intends to summarise the core preventive and proactive maintenance requirements to achieve gearbox reliability with particular emphasis on maintaining an effective and contamination free lubrication film thickness.

Lubrication Film Thickness

Particles in the oil, greater in size than the oil lubrication film thickness, is the main cause of machinery and component wear. This is supported by the fact that a leading bearing company confirms that if the particles in the oil are smaller than the lube film thickness, then the bearing will have an infinite life.

A lubrication film thickness is only a few microns in thickness. Consider it another way, take a strand of human hair and split it twenty times, this is how small the lube thickness really is.

Most people think that **new oil is clean**, **WRONG**, unless it is ordered as a clean lubricant, it is dirty and needs to cleaned before it is put into service.

Of course wear due to contaminates / particles in the oil is one cause of wear, another important point is the fact that the oil in operation does not provide adequate separation of the moving metal components. Or in other words **the oil does not provide an effective lubrication film thickness.** The causes for this can be any number of reasons.

For example:

1. The wrong viscosity oil is being used.
2. The oil levels are running low.
3. The oil has water in it or other fluid contaminants.
4. The oil Is oxidized.
5. The oil has lost its additive pack.

And of course there can be a number of Root Causes for the lubricant to be in any of the conditions listed above.

For example:

- The lubricants were mixed.
- The oil was not topped up.
- The gearbox is operating in moist, damp or wet area.
- The gearbox experienced a running condition or high temperatures.
- The gearbox coupling was misaligned.

Below is a table showing the lubrication conditions that will effect gearbox wear and reliability, along with the ways to detect the condition while in operation or at the repair stage and the rectification actions to prevent the condition from happening again.

Lubrication Condition	Fault Detection	Rectification Needs
Dirty oil in operation	Oil Analysis RCFA on damaged parts	Change the oil Filter the oil in operation Knowledgeable staff on Bearing RCFA
Dirty oil used in top ups	Oil Analysis	Filter the oil before use
Oils were mixed	Oil Analysis RCFA on damaged parts	Effective labeling / identification Defined details / procedures Knowledgeable staff on Bearing RCFA
Wrong oil was used	Oil Analysis	Replace the oil
	RCFA on damaged parts	Defined details / procedures
		Knowledgeable staff on Bearing RCFA
		Consult manufacturer
Oil lost its additive pack or wrong additive pack used.	Oil Analysis RCFA on damaged parts	Replace the oil Knowledgeable staff on Bearing RCFA Consult manufacturer
Water in the oil	Oil Analysis	Fit desiccant breathers
	RCFA on damaged parts	Knowledgeable staff on Bearing RCFA
Not enough oil	High operating temperatures Oil leakage	Fit bulls eyes or sight glasses Defined details / procedures

Table showing the lubrication conditions that will effect gearbox wear and reliability

In order to achieve a good gearbox reliability, maintenance management need to address the Fault Detection Mechanisms and rectification needs as listed above.

These are summarized as:

- A good oil analysis program.
- Staff with good bearing RCFA.
- A regular applied visual inspection program.

- Filter the oil before use
- Filter the oil in operation
- Effective labelling / identification
- Defined details / procedures
- Fit desiccant breathers
- Fit bulls eyes or sight glasses
- Knowledgeable staff on Bearing RCFA
- Consult manufacturer

Now that we know the main activities we need to act to achieve better gearbox reliability, the key is formulating it into a standard part of the maintenance strategy.

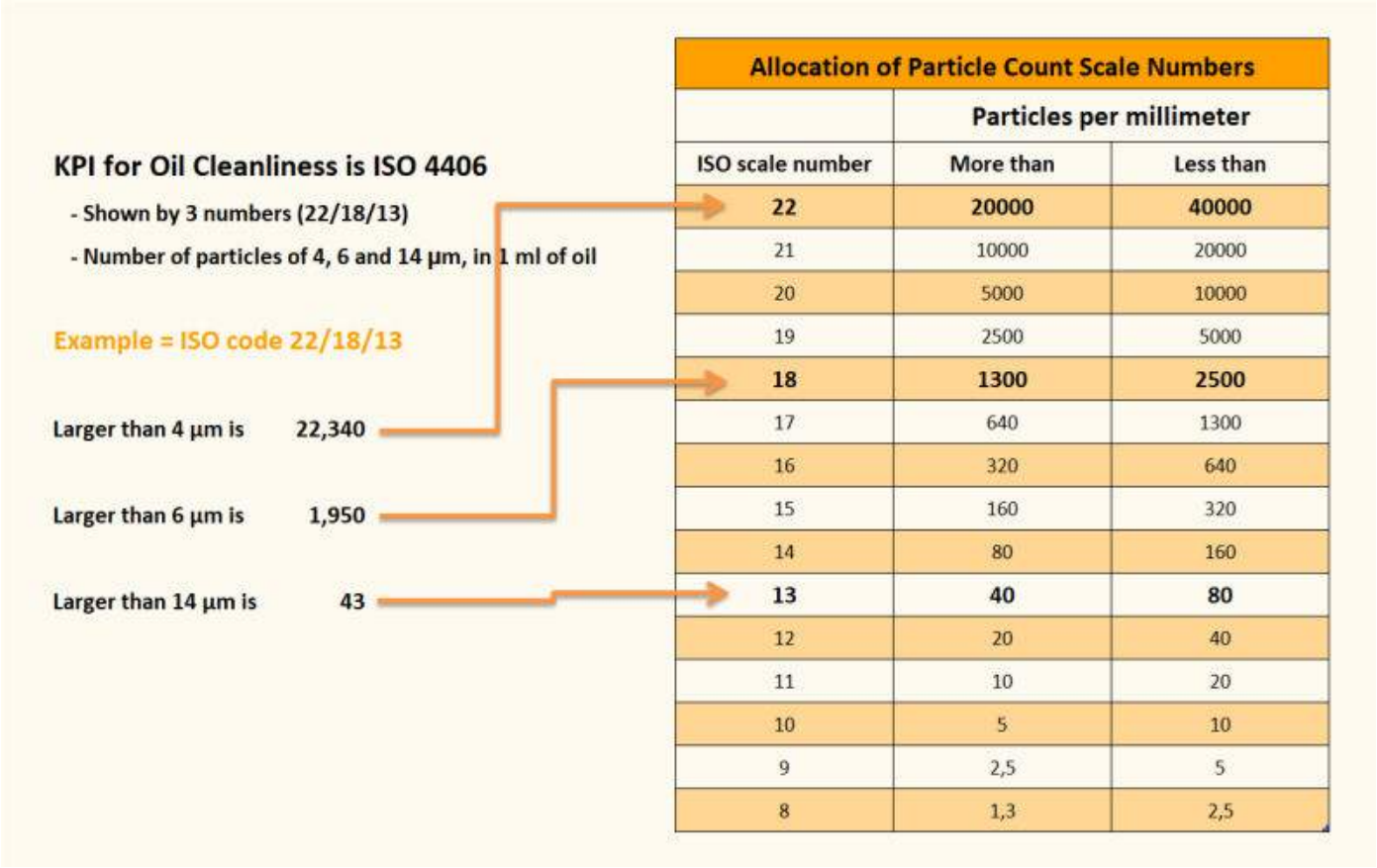
For any strategy to be successful over the long term two considerations are important.

1. That the activity needs to be considered as a process and not a project, A project has a start and a finish, whereas a process is ongoing and thereby can be considered as being Proactive in achieving the results.

2. To ensure we know where we are going and what we want to achieve targets representing success when achieved need to be established. For lubrication to work in a reliable manner i.e. lubrication reliability targets are standards of ISO 4406.

ISO 4406 is a method for coding the level of contamination by solid particles, as spelled out by the International Organization for Standardization, which is more affectionately known by its acronym.

Refer to the graphic below.



Allocation of Particle Count Scale Numbers		
	Particles per millimeter	
ISO scale number	More than	Less than
22	**20000**	**40000**
21	10000	20000
20	5000	10000
19	2500	5000
18	**1300**	**2500**
17	640	1300
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

Table: Allocation of particle count scale numbers

Depending on the criticality of the gearbox an ISO 4406 standard needs to be created. For standard gearboxes at target level of 18/15/11 is generally acceptable.

Of course any strategy will cost money to implement and continue, however this should not be considered as a cost, but more referred to an investment to achieve greater productivity returns. There are many documented cases of the payback achieved from lowering and keeping low the contamination levels in the oil. By lowering a code from 22/18/13 to 16/12/8, the meantime between failures can increase by a factor 4 - 5 times.

Implementing a Lubrication Reliability Strategy has many steps and if any one, of some, of the steps are missed or a wrong step is taken, then achieving the desired results can be become difficult. However, there is a “Checkmark” question that can be asked continually throughout the process that will guide one in making the right decision and that is referring to the 6 Lubrication Rights.

Will this action ensure that we get:

- the ***Right Lube*** ……..
- in the ***Right Machine*** ……
- at the ***Right Time*** …….
- in the ***Right Quantity*** …….
- in the ***Right Way*** …….
- in the ***Right Condition*** ……. (and kept in the **right condition** ?????)

If the answer is YES…,
Great!
The action is correct.
If not… the action needs reconsideration.

The following are the main steps for consideration in a Gearbox Lubrication Reliability Strategy.

1. Management Software.
2. Clean Storage area.
3. Identification and labelling.
4. Clean dispensing system.
5. On site filtering system.
6. Oil analysis program.
7. Desiccant air breathers fitted.
8. Inspection points.
9. Competent staff.

1. Management Software

An important key to all successful Lubrication Reliability programmes is the process to ensure that what needs to be done actually gets done. Such a software is not only a work management program, but it is also the data base for all information about the lubrication needs for any given gearbox. CMMS system can do this work, however most CMMS systems do not go down to enough detail for managing the lubrication needs. Such system should also have transparent interfaces for specialised Oil Analysis Programs.

Specialised Lubrication Management software programs available today can be either stand alone (PC Resident) or cloud based and both can be vender specific or vender neutral.

2. Clean Storage Area

A big source of contaminants entering the equipment is from dirty / messy lube storage areas. A well management lube room ensures all lubes are correct identified, filtered before use, the rooms are temperature controlled, plus dust and dirt free. They are generally called contamination control centres. A fundamental staff attitude issue, about the lubrication function resides in what the lube room looks likes. If it is messy and dirty, then the staff think about the activity in the same way – messy and dirty, however if it is clean, well-organised and is managed in a professional way, the staff attitude is then – professional and important.

3. Identification and Labeling

Most plants have more than 3 different lubes in use. i.e. Hydraulic oils, gearbox oils compressors oil, to name just 3 and many have as many as 10 different oils in operation. The biggest dilemma for maintenance staff is to have a clear understanding of what oil goes into what application. For sure a dedicated lube man will have a better understanding of the relevant logistics of what goes into what, but what happens when an application goes down in the middle of the night or when the lube man is away sick or on vacation. The last thing we want is for example a hydraulic oil added to a high load gearbox or a synthetic oil added to a mineral based application.

Most well managed identification systems are colour coded throughout the plant. In the lube room, on the dispensing containers, on the application and on the filtering systems. The labels should also have details about the oil and its viscosity grade. i.e. gearbox oil with a viscosity – ISO 320.

4. Clean Dispensing System

A question: **"Have you ever seen open dispensing jugs or cans and dirty funnels laying around in lube rooms?"**

I am sure the answer is "yes", and these are one of the biggest sources of continents entering the oil. The “Best Practice” for oil dispensing in industry today is the system. Colored lids with various dispensing lid types and sizes and pumping methods.

5. Onsite Filtration

Gearboxes are inherent contamination generators, particularly if they do not have desiccant breathers fitted to them. So we need a system of cleaning up the oil when it becomes dirty. There is an argument that says this can be managed by changing the oil every year, however unless you can guarantee that the gearbox is clinically cleaned after the new oil is added, the new oil will also end up dirty very quickly.

The answer is filtration, driven by Oil Analysis results. The most effective kidney loop systems used in plants today are mobile trolleys, with quick connect couplings fitted to the gearbox. Simply attach the system and run it until the oil is cleaned. Care should also be taken that the same filtering medium is not used for different types of oils and viscosities.

6. Oil Analysis Program

No gearbox reliability or maintenance activity will work unless you can control the quality and specification of the oil in operation. The answer for this control is oil analysis. The OA program will tell you when the oil has a too high contamination level and it need filtering, when the oil is oxidized, has a too high level of water or other contaminant level and needs to be replaced. A good OA program is the gearbox blood test for health management. Efficient OA programs also provide cloud based software for easy program / activity management, including a seamless interface to one's lubrication management program.

7. Desiccant Air Breathers Fitted

Oil levels in gearboxes rise and fall with temperature variations and if they are not protected with air controllers, contaminants like moisture and dust are drawn into the gearbox oil. Desiccant air breathers filter out the airborne contaminants there by only allowing clean and dry air to enter the gearbox.

8. Inspection Points

How do we know in a simply way when the oil levels are low? The answer is sight glasses. However, some glasses get very dirty and it is difficult to see the oil level through them.

An innovation over the last few years have been the development of protruding type sight glasses called BullsEyes, these make it much easier to see the oil levels.

A more recent development of the Bulls Eye are ones with variations to their construction, including Oil Analysis sampling points.

9. Competent Staff

As I have tried to explain in this document, lubrication today is a very technical subject and staff tasked with the function of managing this activity need to be trained as analysts and service technicians. The Best Program for this is one controlled by ICML. (International Council of Machinery Lubrication). These staff also need to understand Oil Analysis and this can be covered in the ICML programmes or from oil laboratories or specialists.

Another very important knowledge that general staff need to be competent in, is recognising . The bearing tells the story of everything that happens in its life time, how it was fitted, how it was lubricated, the condition of the lube it ran it, how hot it became, the external environment the machine ran in and so forth and so forth. The greatest amount of knowledge of what needs to be done to prevent damages for happening again, can be gained from examining bearing wear patents. There are more than 10 different causes for why bearings fail.

Conclusions

By effectively implementing a for operational gearboxes, unexpected failures can be avoided and application lifetimes can be dramatically improved. It is not easy, it is complex and costly, however the uptime rewards outweigh the costs many times over.

What has been highlighted in this document are only the broad details of what is needed in most industries today. It is recommended that companies find a local and competent lubrication consultant or supplier to help them tailor and implement a Lubrication Reliability program, that suits their industry type.

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