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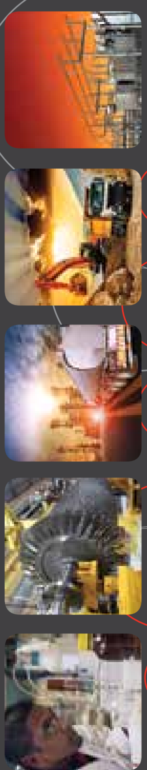

KEEP IT CLEAN

By Steven Lara-Lee Lumley, technical manager for WearCheck

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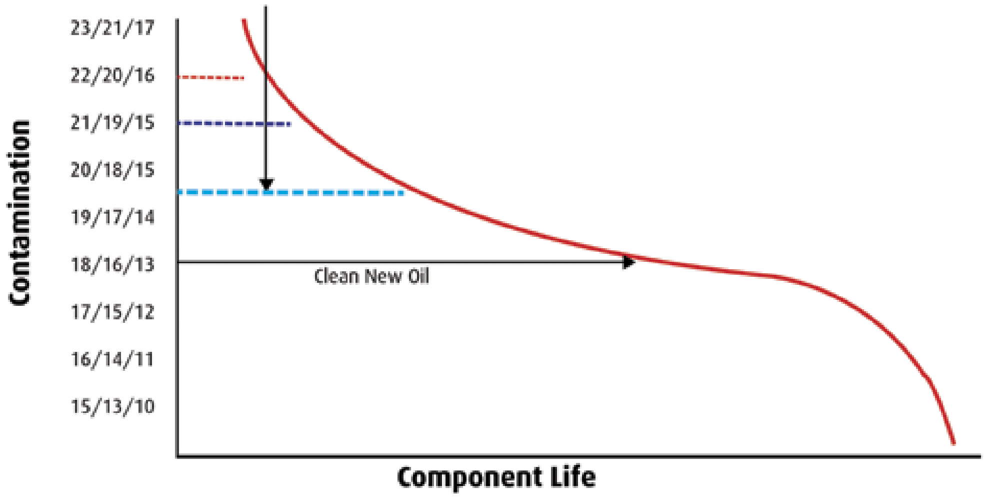
In today's highly competitive global economy, the concept of machine reliability has led many an organisation to make the paradigm shift to proactive maintenance practices that take a holistic approach to asset management and contamination control.

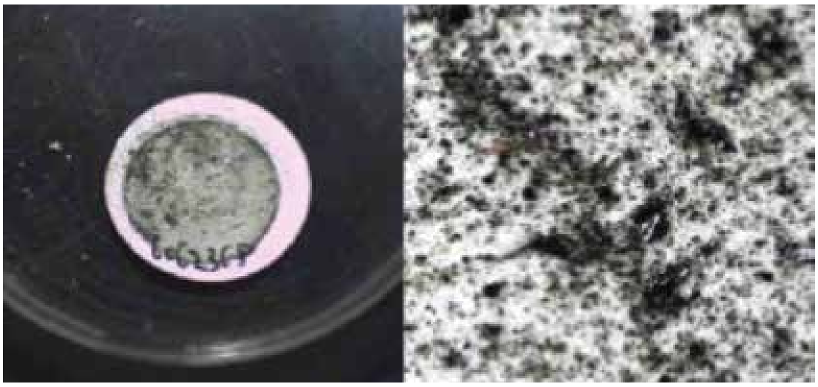
This focus on asset management and contamination control has highlighted the important rôle lubricants play in achieving machine reliability. Lubricants are no longer seen as merely consumables, but rather an integral part of a mechanical system having just as much merit as the componentry they lubricate and protect.

With this emerging proactive maintenance mindset, we no longer count the cost of the oil but rather the cost of lubrication, and with good reason. It is estimated that approximately one percent of a mining operation's maintenance budget is spent purchasing lubricants, but the subsequent effects of poor lubrication practices and contaminated oil can impact as much as 30% of the operation's total maintenance costs annually.

According to a recent study performed by a prominent oil filter manufacturer, 70% of loss of machine life is attributed to metal surface degradation. This surface degradation is largely caused by mechanical wear which, in turn, is predominantly due to particulate contamination. In hydraulic systems this figure is higher, with 83% of all system failures being attributed to particulate ingress. Particulate contamination can irreversibly damage metal surfaces, shorten the service life of equipment and cause unexpected downtime.

Component Life vs Contamination Level





Solid Particle Ingression

Built in
- Service debris
- Manufacturing debris

Ingested
- Process
- Atmosphere
- Combustion

Generated
- Surface wear
- Oil degradation

When it comes to classifying solid particulate contaminants, they are generally grouped according to the way in which ingression takes place. There are three general types of ingression: built-in, ingested and generated.

Built-in contamination consists of manufacturing or service debris such as machining swarf, weld spatter or drill turnings.

Contamination that enters the machine and lubricant under normal operating conditions from the outside environment is referred to as ingested particle ingress. These could be from process contamination, (coal dust, ore dust, cement etc.), atmospheric contaminants, (airborne dust), or combustion by-products like soot from internal combustion engines.

Finally, generated particle ingress occurs when the mechanical system generates its own particles. This can occur on internal metal surfaces through corrosion, mechanical wear, cavitation, abrasion, etc. The oil itself also has the ability to break down and form particles (sludge, oxidation by-products etc.).

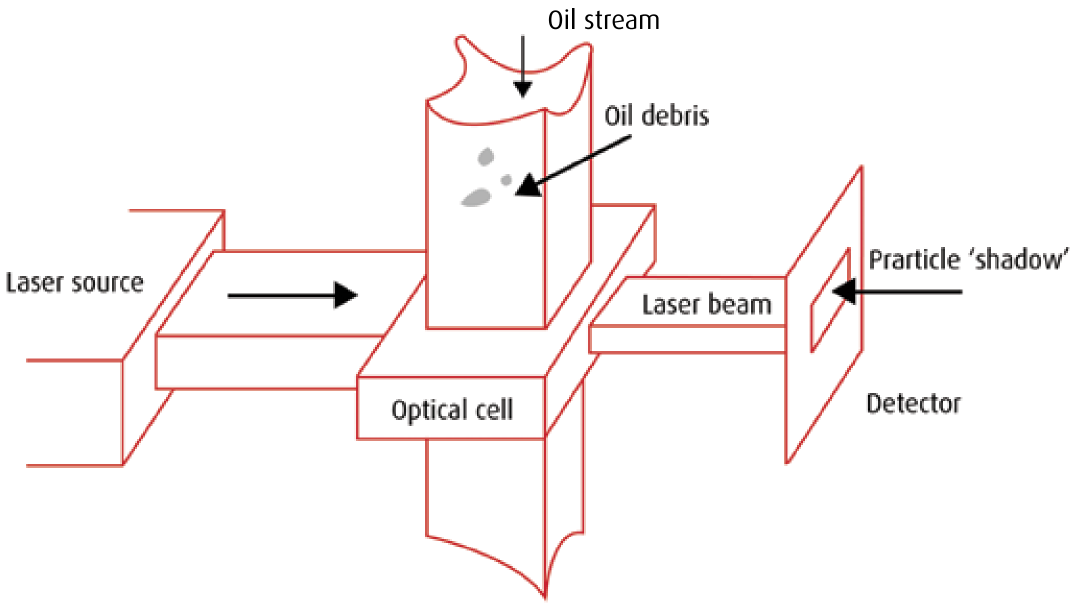
It stands to reason that if there are fewer particles in the oil, there will be less surface degradation and the equipment will last longer. If the equipment lasts longer, it will perform its intended function over a longer period of time and the equipment will be more reliable.

In a nutshell, oil cleanliness is key to equipment reliability and uptime, which is central to productivity.

Now that we have established the importance of oil cleanliness, let us examine how particulate contaminants are measured and quantify the value of their removal.

The cleanliness level of an oil sample can be determined using a number of techniques, but the most common methods used today by commercial oil analysis laboratories measure the amount and size of particles with an optical particle counter. As fluids move past a laser light, particles in the path block the light and create a shadow

Conceptual diagram of optical particle counter



that is measured by a photo sensor. The sensor, which has been calibrated with a special calibrating fluid containing a known number of particles and their sizes, reports the number of particles by size per ml of oil.

The International Organisation for Standardisation (ISO) developed a code system called the ISO cleanliness code which is a global standard for measuring particulate contamination levels in fluids. The cleanliness code is used to quantify particulate contamination levels per millilitre of fluid.

ISO 4406:99 is the current reporting standard for fluid cleanliness. According to this standard, the number of particles per millilitre of oil is counted in size ranges from four micron going up to 100 micron. The total number of particles greater than four, six and 14 micron is then evaluated and assigned range numbers that indicate the cleanliness of the oil as seen in table 1 below.

Note that for every number increase in the ISO code scale, the number of particles per ml of fluid doubles, which has an overall exponential effect.

ISO 4406:1999 Code Chart

Particles per ml more than:	Particles per ml up to and including:	Scale number:
40 000	80 000	23
20 000	40 000	22
10 000	20 000	21
5 000	10 000	20
2 500	5000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13

ISO 4406 = 20/18/14

Total >4 = 9321
Total >6 = 1753
Total >14 = 86

Table 1

SETTING TARGETS

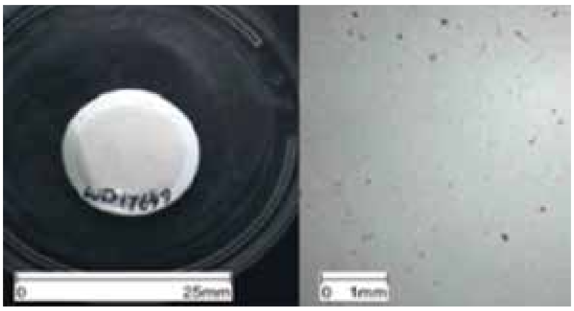
It is important to have a contamination control strategy wherein targets are set, action is taken and results measured.

When selecting target cleanliness codes for lubricating systems it is important to keep in mind the objectives to be achieved. Maximising equipment reliability and safety, minimising repair and replacement costs, satisfying warranty requirements and minimising production downtime are all attainable goals with an effective contamination control strategy.

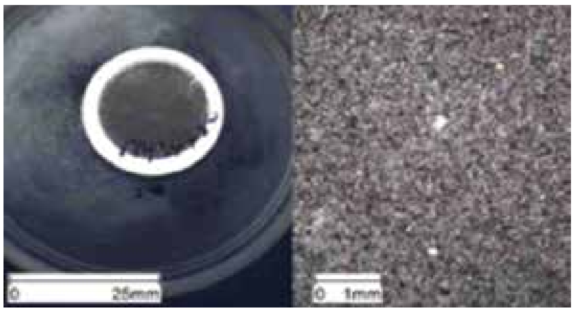
Establishing targets and measuring performance against these benchmark targets allows maintenance professionals to quantify potential savings.

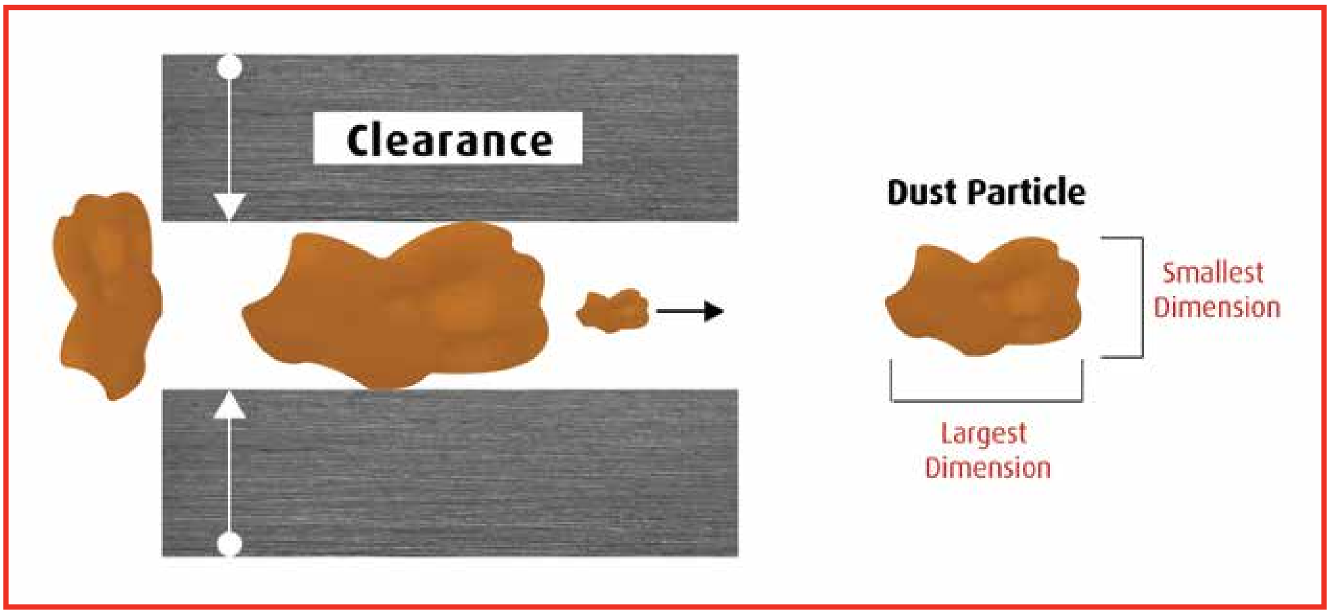
Hydraulic oil sample filtered through a 5 micron membrane

ISO 4406 = 17/16/13



ISO 4406 = 27/25/80

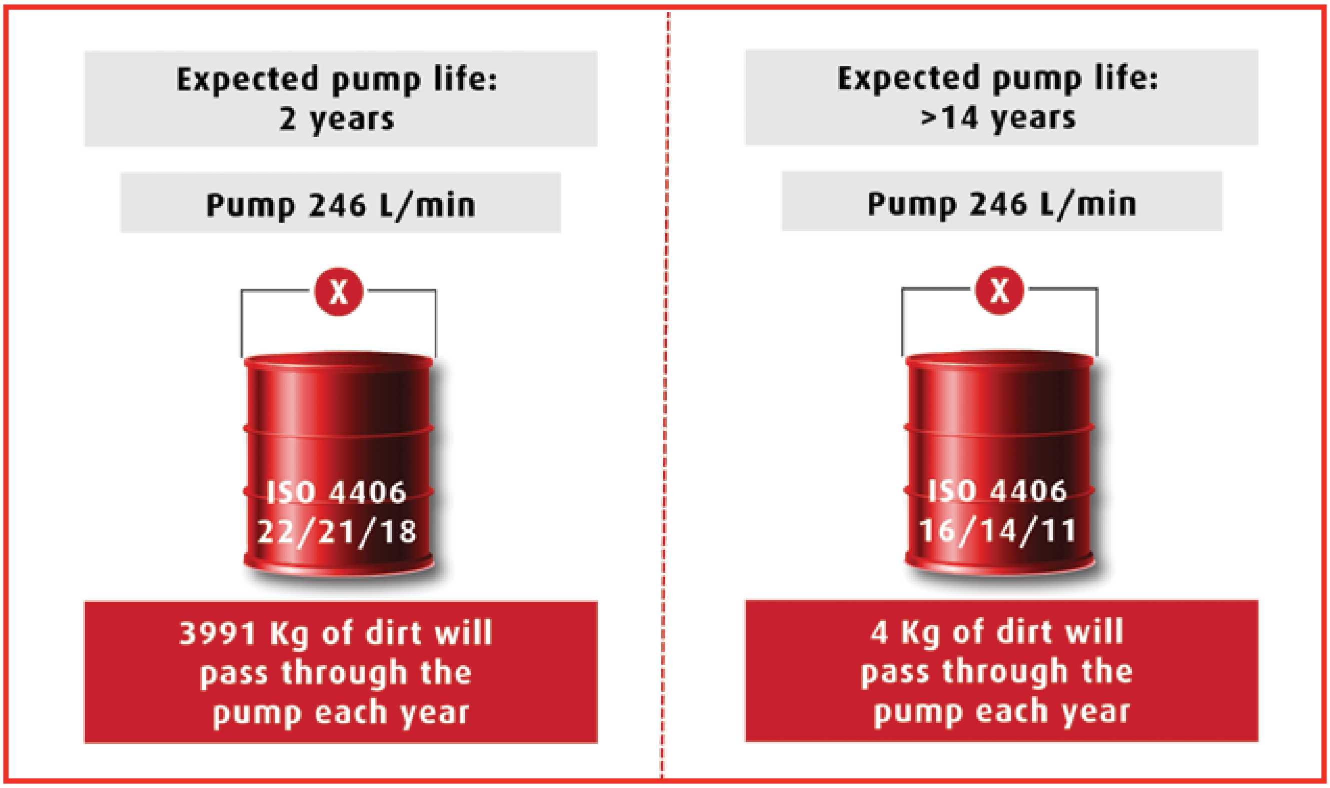




When selecting target cleanliness levels for lubricating systems it is important to keep in mind that it is particles of approximately the same size as the machine clearances that have the greatest destructive potential. Particles the size of, or slightly larger than, the oil film thickness enter the contact zone and damage metal surfaces.

Generally speaking, the smaller the clearances between a component's metal surfaces, the tighter the cleanliness requirements will be. For instance, servo valves in hydraulic systems are more vulnerable to contamination-related failures than low-speed gearboxes, therefore the hydraulic systems will require stricter (lower) oil cleanliness targets.

To illustrate this concept, let's consider a fluid being pumped at 246l/min that has an ISO cleanliness code of 22/21/18. In one year, 3991kg of dirt would pass through this pumping system. That is almost four tons of dirt and approximately the kerb weight of two Toyota Fortuna SUV's combined! How long do you think a pump would last in that environment? If the fluid is cleaned to a cleanliness level of 16/14/11, only 4kg of dirt would pass through the pump in one year.



A reduction in the cleanliness rating by six codes resulted in a 1000-fold decrease in particulate contamination. From this example, we can clearly see that even small changes in the ISO cleanliness rating results in a large change in particulate contaminants.

Table 2 below illustrates the potential life extension factor of a hydraulic system based on improving the oil's cleanliness level from the initial to the target cleanliness codes.

From the grid, it can be seen that by reaching and maintaining the example machine's new cleanliness target level of 18/16/13 from the current 22/20/17 level, a life extension factor of three-fold can be realised.

Component life can be increased by improving lubricant cleanliness.

		Target Cleanliness					
		22/20/17	21/19/16	20/18/15	19/17/14	18/16/13	17/15/12
Current Cleanliness	28/26/23	5	7	9	10	>10	>10
	27/25/22	4	5	7	9	>10	>10
	26/24/21	3	4	6	7	9	>10
	25/23/20	2	3	4	5	7	9
	24/22/19	1.6	2	3	4	5	7
	23/21/18	1.3	1.5	2	3	4	5
	22/20/17		1.3	1.6	2	3	4
	21/19/16			1.3	1.6	2	3
	20/18/15				1.3	1.6	2
	19/17/14					1.3	1.6
	18/16/13						1.3

Table 2 – Life expectancy table (Source: Noria Corporation)

Expanding upon the life expectancy factors from Table 2, one can further illustrate the potential savings associated with a sound contamination control strategy by developing a value model that takes equipment replacement cost and expected life into consideration.

Table 3 on page six provides an estimated annual value based on a contamination control programme wherein oil cleanliness targets are set and the associated value calculated for each component at a mining site. The component life extension factors are derived from the life expectancy table (Table 2). The value calculation does not consider an increase or decrease in profits associated with contamination control that may positively or negatively impact production.

For the purpose of this theoretical model, certain assumptions have been included in the calculations. The model is intended to simply illustrate the value associated with maintaining appropriate oil cleanliness.

Assumptions in this model include:

- Wear within the component is assumed to be linear over time.
- It is assumed that the equipment life expectancy is based on normal operating conditions.
- The estimated component life is based on an assumed and constant cleanliness value of 21/19/16.
- Correct maintenance practices are applied to the equipment.

When all is said and done, clean oil reduces the lifetime operating expense of equipment. This, in turn, maximises the lifetime usefulness of the equipment and ultimately produces a greater return on investment. In the final analysis, if you want to see the green you've got to keep it clean.

Protecting your lubricants – and, ultimately, your equipment – from the harmful effects of contamination and lubricant degradation begins with a sound contamination control strategy that takes a cradle to grave approach, incorporating best practice lubricant storage, dispensing and filtration practices.

Description	Equipment type	Estimate replacement cost ZAR	OEM expected life in months	Initial cost per year	Target ISO 4406 cleanliness code	Previous ISO 4406 cleanliness code	Current ISO 4406 cleanliness code	Expected life factor	Current equipment age in months	Current annualised cost per year	Annualised life extension savings ZAR
Left conveyor	Gearbox	R 355,700	60	R 71,140	18/16/13	19/17/14	18/16/13	1.3	12	R 57,371	R 13,769
Right conveyor	Gearbox	R 355,700	60	R 71,140	18/16/13	25/23/20	20/18/15	4	6	R 19,227	R 51,913
Primary crusher	Gearbox	R 948,500	240	R 47,425	18/16/13	21/19/16	19/17/14	1.6	176	R 40,884	R 6,541
Primary system	Hydraulic	R 296,400	96	R 37,050	17/15/12	21/19/16	17/15/12	3	17	R 14,114	R 22,936
										Total value	**R 95,159**

Table 3 – Estimated annual value based on a contamination control programme

To this end, WearCheck has established a hydrocarbon and F.L.A.C (Fuels, Lubricants, Air and Coolants) management programme which is designed to assist plant owners to increase machine reliability, extend oil drain intervals and reduce maintenance and operating costs. To find out more about how WearCheck can help your organisation, and make the paradigm shift to proactive asset management, please contact us.

Copies of previous Technical Bulletins can be accessed on WearCheck's web site: www.wearcheck.co.za

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