



# CONTAMINATION CONTROL

**SHELL LUBRICANTS**  
TOGETHER ANYTHING IS POSSIBLE



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## AVOIDING THE DAILY GRIND

### HOW TO IDENTIFY AND CONTAIN THE COSTS ASSOCIATED WITH LUBRICANT CONTAMINATION

Contamination can have a dramatic effect on the life and effectiveness of equipment, resulting in increased wear rates and damage, loss of equipment reliability and reduced component efficiency. As equipment continues to become more complex, and manufactured with tighter clearances, system contamination is increasingly important to control maintenance costs and improve equipment reliability.

Lubricant contamination can manifest itself in a number of different ways, but the end result is almost always shorter than expected component life due to wear, corrosion or deposits. These factors can increase operating costs by shortening equipment life and shortening the life of the lubricant. As a result, plant maintenance or machine operators will need to replace more machine components and also change lubricants sooner than otherwise necessary. Consequently, contamination can ultimately lead to increased operating costs of the equipment.

Lubricant contamination can also negatively impact equipment productivity by causing equipment to operate at slower speeds, at reduced efficiency or with higher energy consumption

### THREE COMMON TYPES OF WEAR FROM SOLID CONTAMINATION

System contamination comes in many forms— the worst offenders are solid particles and water, while lesser offenders are sludge, varnish, entrained air, and other fluids like chemicals or fuels. In this paper, we will focus primarily on solid particles. These particles can come from outside the system – such as sand and dirt – or generated inside the system – such as rust, wear metal particles, or metal fines from original manufacturing. Contamination from solid particles can result in three basic types of wear on equipment and components:

- 1. Abrasive wear.** Most particles are larger than the lubricant film thickness. This means that a particle will make contact with metal parts even when the proper lubricant film is present. The hard particle acts as an abrasive, much like sandpaper, and can remove metal from the surface of the component. This abraded metal in turn creates more particles that simply aggravate this condition.
- 2. Fatigue wear.** As with abrasive wear, the force of the load is transferred through the particle and into the metal surface. This force can result in a “micro-dent” on the metal surface of the component. As the component goes through its various cycles of operation, this “micro-dent” goes through loaded and unloaded cycles that can lead to crack formation. Eventually a small piece of metal can break off. This metal loss at the surface is called spalling (also pitting) and ultimately results in component failure as the integrity of the metal surface is destroyed.
- 3. Erosive wear.** Particles impinge on a component’s surface or edge, slowly eroding the material and altering the original machine fit of the component. For example, if abrasive particles are flowing with a liquid, such as hydraulic fluid and they encounter tight orifices, the abrasive particles can remove small amounts of the surrounding metal components. Eventually, this compromises the fit and can result in fluid leakage and a loss of overall operating efficiency.

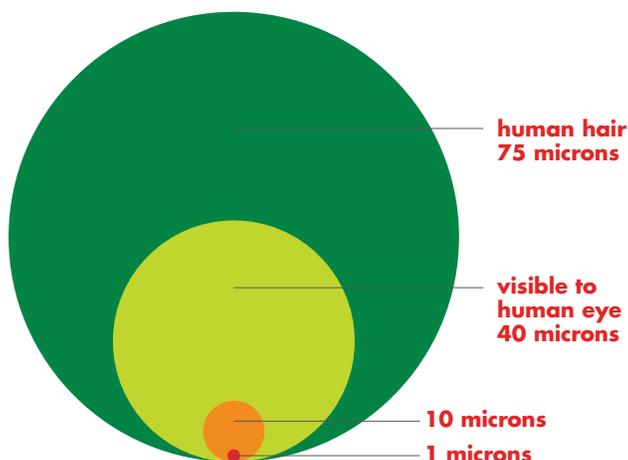
As the number of solid particles increase, the rate of wear mechanisms will increase also. The challenge is to determine how many solid particles exist in a system, and then develop a plan to control the ingress of particles into the system and also the generation of particles by the system.

## QUANTIFYING CONTAMINATION

### DETERMINING THE LEVEL OF SOLID CONTAMINATION IN A LUBRICANT

It must be understood that the size of solid particles that do the most damage to component surfaces are smaller than the human eye can see. For example, the most damaging particles in hydraulic systems and roller bearings are in the one to 10-micron range. To give perspective, an average human hair is about 75 microns and the smallest "spec" a typical human can see is 40 microns. This means that a lubricating fluid may appear bright and clear, yet contain an extremely high level of particles that can damage the equipment.

#### HOW SMALL CAN A CONTAMINANT BE TO DAMAGE YOUR SYSTEM?



The contaminants most likely to damage your system are in the **1 - 10 micron** range.

The actual level of solid contaminants has to be identified in the lubricant. The International Standards Organization (ISO) has developed a process for quantifying contamination by "counting" the number of particles in a milliliter of a fluid. The ISO 4406 cleanliness standard classifies particles by three different sizes: > 4 micron, > 6 micron and > 14 microns. The ISO 4406 standard assigns a numerical code based on the quantity of particles in each size range. For instance, a fluid of 22/20/18 has more particles in each range than a fluid that tests at 21/19/17. The important thing to remember is that an increase in ISO code by one number represents a DOUBLING of contamination level. For example, an oil with a 22/20/18 rating would on average have twice as many particles sized four microns and larger compared to a rating of 21/20/18.

Cleanliness targets must be set for each type of equipment based on the type of components that make up that equipment – e.g. servo valves, vane pumps, bearings, etc. Most OEMs have established cleanliness targets that will maximize the life and performance of their components. That means for any particular piece of equipment, the cleanliness requirements must be chosen to protect the most sensitive component. The cleanliness targets for hydraulic systems are stringent, due to the various valves, seals, pumps and actuators that are used. Other mechanical systems that contain different types of components, such as bearings, gears or slides may have slightly larger clearances than what is recommended for hydraulics.

### SYSTEM LIFE AND CONTAMINATION

Various industrial organizations have studied the rate at which lubricant contamination affects equipment. It has been determined that in hydraulic systems, up to 60 percent of premature failures are caused by contamination of some type. In bearing failures caused by contamination, particulates account for 20 percent of failures, while water contamination causes almost 70 percent. Not surprisingly, as cleanliness declines, system life is shortened.

### MANAGING CONTAMINATION

The target cleanliness levels of each system that will be monitored must be established. This can be done by using OEM cleanliness requirements or industry standards set for hydraulics, gears, bearings and circulating systems.

Once cleanliness targets are established, the actual cleanliness levels of the fluids in the system have to be measured. This can be accomplished by taking a sample of oil from the system. Special care must be taken when obtaining the sample to ensure that contaminants are not introduced from the sampling process itself. As mentioned earlier, since most contaminants cannot be seen with the naked eye, it is not always apparent when a bad sampling technique has introduced contaminants. The proper method for taking oil samples is detailed and will not be explained here. Naturally, if the sample is contaminated when collected, the cleanliness of the test sample will not be indicative of the contamination in the system.

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## WHAT ARE THE SOURCES OF SOLID CONTAMINATION INTO A LUBRICANT?

Once the cleanliness of the lubricant in the system is determined by oil analysis, the real work begins to identify and remove the source of contamination. There are many possible sources of contaminants, and some of the most common are:

- Original equipment manufacturers. Debris from the manufacturing process that has not been properly cleaned can remain in the system when in use. There may also be residual chemicals, solvents, metal working fluids or rust proofing materials in the system that can negatively affect operation if left in the system.
- Topping off. Simply adding lubricants can contaminate a reservoir if the pump, hose and nozzle being used aren't clean. If a "transfer container" is used that is not properly covered or stored to prevent dirt and dust contamination, this too can be a source of contamination. Every piece of transfer equipment must be maintained with proper fitting caps, lids, seals and covers. Topping off with dirty or poorly maintained transfer equipment simply introduces unnecessary contaminants.
- Lubricant tanks. Many lubricant storage tanks have "goose-neck" piping to allow the tank to breathe, but unfortunately do not always keep out contamination. The use of desiccant-filtration breather systems can greatly reduce contaminants entering storage tanks. The desiccant breathers remove water vapor from the air entering the tank as well as large particulates. Fill caps and reservoir lids that are left open can expose tanks to dirt and moisture. Storage tanks should be viewed as an extension of the production equipment itself – whatever contaminant is in a storage tank can eventually reach the equipment.
- Lubricant distributors and supply. Lubricant contamination can occur at every stage of delivery, storage, handling and filling into the equipment. Consistent procedures can be adopted to control contamination of the lubricant at each and every step along the way. Work with distributors who are routinely audited by their lubricant suppliers, such as through the Distributor Product Quality Assurance (DPQA) program.
- Maintenance. Storage areas for tools and parts should be kept clear of potential contaminants. For example, if parts are stored in an open-air shop, particles in the air may settle on parts or tools that will be used to maintain the equipment.
- Human error. Carelessness and neglect are frequent causes of contamination. While lubricants may be changed according to the maintenance schedule, the process must be done with the proper care, using uncontaminated equipment and following the proper procedures to avoid contamination.



## WHAT CAN BE DONE TO REDUCE CONTAMINATION?

Companies looking to minimize contamination should examine their operations to identify areas in which contamination may occur, such as the receiving and storage of fluids. Keeping tanks completely sealed and using desiccant breathers is an "easy win" that can be done when improving your program. Filtering the fluids as they are transferred into tanks and equipment will help to remove particles during the exchange and is a good second step. Additionally, the rest of this section shares some additional tips.

Drum storage is always a concern. Drums stored outside are most vulnerable to contamination ingress. Drums are not airtight, but are designed to "breathe" as the temperature changes and the fluids expand and contract. This "breathing" can draw contaminants into the drum. Storing drums inside a building or under a covered area is preferred. Regardless of where a drum is stored, drum covers should be properly secured to prevent accumulation of dirt and moisture on top of the drum. When a pump or hose is used on the drum, all surfaces should be kept clean and a tight seal should be maintained around between the drum bung and the transfer equipment.

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Whenever a lubricant is transferred from one tank or container to another container or reservoir, there is a potential for contamination. Companies should adopt processes that maintain cleanliness of the fluids during fill and transfer. Fill areas should be free of water and debris, and pumps and hoses should be clean. Tools such as grease guns should be cleaned before and after each use to ensure no dirt collects in the nozzle. Filters and breathers must be stored and maintained properly. Every tank, drum, transfer pump, hose, valve and container is a source for potential contamination and must have a "keep clean" process to control contamination.

Remember, the particles that do the most damage to equipment and components are smaller than the human eye can see. Solid particles of all sizes are everywhere in the environment and will easily enter the system unless intentional handling practices are adopted to keep them out!

Avoiding contamination is easier and cheaper than removing it once it has occurred. Some companies may start purchasing more expensive filters to help control contamination, without first eliminating the "low hanging" fruit of removing the contamination sources in the first place.

Keeping systems free of contamination is not just technical; it is also behavioral. Companies should adopt a culture that emphasizes proper maintenance and cleanliness procedures. The entire organization should embrace contamination control as a strategic decision and recognize the benefits of achieving targets. Proper training for staff is essential. This is not a one-time fix but must be part of a continuous improvement (and continuous training) mindset. The changes must be supported from the highest levels of the organization.

## THE COST OF CONTAMINATION

The impact of contamination is increasing because of advancing equipment technology that incorporates greater energy efficiency, increased power density, higher pressures, and tighter tolerances. All these advances make the equipment more sensitive to contamination than ever before.

As a result, the costs associated with contamination are rising, which can, in turn, increase overall operating costs. The best way to avoid contamination costs is to ensure that contaminants do not enter the systems in the first place. This requires an investment in training and the adoption of best practices, as well as a focus on lubricant cleanliness in every step of the lubricants journey from storage to transfer and finally into the equipment. The most critical tool in fighting contamination is human behavior. Companies should improve staff awareness, adopt anti-contamination procedures and engage workers in the entire process.

FROM INCREASING COMPONENT  
LIFE TO ENHANCING THE LIFE OF  
YOUR BUSINESS.

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