Oil Filtration

Particulate contamination is the most common problem hindering the reliable operation of equipment and machinery components.

The best mineral or synthetic oil cannot provide proper lubrication if the oil is not clean. Abrasive particles in the oil can damage sensitive machinery components. Therefore, filtering the oil is necessary to remove these particles and prevent premature component wear and equipment failures. Lubricant cleanliness is necessary to provide optimum protection for the reliable operation of machinery components. This provides a brief discussion of appropriate oil filtration guidelines and practices.

Filter basics

- Kidney loop filters
- Single pass filtration
- Choice of filter porosity
- Portable filter carts vs. permanent installations
- Last chance filters

Considerations to maintain ISO cleanliness levels

- Atmospheric air control
- Water contamination
Upgrading Existing Filters

All mechanical equipment comes with some sort of filtration system. The most common filtration system is an oil filter designed to handle the full oil flow and equipped with a bypass valve that opens if the back pressure on the filter gets too high (this prevents catastrophic equipment failure from a lack of lubrication). Replacement filters are frequently selected based on fit and cost. You can improve your oil filtration, and in turn add to your equipment life, by upgrading your replacement filters. At a minimum, you should use the original equipment manufacturer’s suggested recommendation for pore size, beta ratio and flow rate.

However, as you increase the effectiveness of the filter you must ensure that you do not increase the operating pressure and reduce the flow rate, or cause the filter bypass valve to open. Figure 1 shows a typical oil filter.

With applications such as hydraulic systems, gearboxes, compressors, turbines, or any equipment with full-flow filtration systems, using finer particulate filtration can cause electrostatic discharge to occur. Too much flow through a tight filter element can cause internal “rubbing” or shearing of oil molecules. This can create a static electrical charge in the oil itself. When this charge is high enough, it arcs to discharge the electrical energy and creates sparks in the oil. Localized temperatures around the sparks can reach 20,000° Fahrenheit and can cause oil degradation.

Kidney Loop Filters

To reach the goal of improved oil and equipment life, a dedicated filtration system offers more flexibility with filter choices. It needs to be a system that does not affect the oil flow of the lubrication system and does not limit filter possibilities. A kidney loop, or a side stream off-line filtration system, as shown in Figure 2, is a good option. Sometimes there is extra flow available from the system pump, like in diesel engines, so a small amount (approximately 5 percent) can be bled off to go through a filter. In other applications, a dedicated pump needs to go with the filter to completely isolate the new filter system from the installed filter system.

When utilizing kidney loop filters for lubricant storage tank applications, it is important to ensure the system has been designed properly and that the fluid has enough residence time to complete the process. Depending on the system and the cleanliness level of the incoming new product, it can take multiple turns on a tank to meet the required ISO cleanliness code. For some systems, this residence time can be many days.

Single-Pass Filtration

It is common to find systems that have single-pass filtration. In some instances, these systems are severely undersized and not effective at changing or maintaining the ISO cleanliness of the fluid. When designing these systems, it is very important to factor in the flow rate, pressure, surface area of the system, and the viscosity and temperature of the lubricant. When trying to reach a certain ISO cleanliness level, it is much more effective and cost efficient to have the lubricant delivered to your storage tanks at a certain ISO cleanliness level.
**Choice of Filter Porosity**

The selection of a filter needs to be based on the goal that has been set for the required ISO cleanliness level. There are many different suggestions for cleanliness levels based on system criticality and tolerances. These are based on the ISO cleanliness measurement standard ISO4406:99. This is a two- or three-numbered system measuring how many and what size particles are in the oil, expressed as xx/yy.zz. The first number refers to particles above 4 microns; the second above 6 microns; and the third number above 14 microns.

**Other factors that affect filter choice**

- **Viscosity**
  High viscosity gear oil barely flows through a 1 or 3 micron filter. With little or no flow, the filter cannot clean the oil. A 3 micron filter may work for turbine or hydraulic oil that stays hot and flows well (less viscous), but engine and gear oil (more viscous) works better with a 15 micron filter.

- **Additives**
  The additive package in the oil gives the lubricant unique performance features. Sometimes filtration can affect the additives. Most additives are chemicals that are dissolved in the oil and are immune to filtration. However, there are several types of additives that can affect filtration.

  **Solid additives**
  Solid additives are suspended in the oil and are usually less than half a micron in size, but sometimes they can clump and adhere together (especially if water is present) to create larger particles that can be filtered out of the oil. Sticking to a 15 micron-size filter has usually proven to be safe. Very small pore-size filters can remove all the solid additives out of some of these specialized oils.

  **VI improvers**
  These are long chain polymer molecules that are most often used in multi-viscosity oils like engine and transmission oil, and some gear oils. In most cases, they are thoroughly dissolved in the oil and do not pose a target for the filter. There have been rare cases where VI improver has gelled up a filter, usually when the oil is cold and has sat for a long time. The good news is, it is soft and usually oozes through the filter without plugging it. Warming and recirculating the oil can restore balance, but it can be difficult to get these re-dissolved into the oil.

  **Foam inhibitors**
  These are surfactants designed to break foam bubbles before foam gets very far. While they are liquid, they are not dissolved in the oil, and some kinds (like silicon) adsorb or attach to the surface of the filter media. The smaller the filter size rating, the more surface area it has, and the silicon antifoam can be adsorbed on the surface and can be lost.

  Silicon foam inhibitors are used in many oil formulations. There are some applications where lack of foam is critical to the oil’s performance, and removing the foam inhibitor can cause a problem. For instance, modern diesel engines with HEUI fuel systems use the engine oil as a hydraulic medium to power the injectors. Bubbles in the oil can cause rough engine running or stalling. To be safe with engine oil, a lower limit of 15 micron filters is recommended. The other safe option may be centrifugal filtration, depending on product formulation, which takes out particles but doesn’t affect the foam inhibitors.
Portable Filter Carts vs. Permanent Installations

Portable filter carts, as shown in Figure 3, are great for cleaning up temporary problems and cleaning while transferring oil into equipment. This approach is less capital-intensive than installing a dedicated filtration system on each reservoir. Contamination control programs have successfully used roving filter carts that are rotated between pieces of equipment. However, some other considerations favor dedicated filtration permanently installed on each system:

- A single cart cannot be used everywhere at once.
- Labor time can be considerable to constantly move, hook up, and disconnect portable filter carts when the up-front cost of dedicated versus portable systems is calculated.
- Permanently installed filters often get more attention than a portable cart in a closet. An obvious filter with an obvious change indicator on each machine promotes contamination awareness and usually gets changed.

For bulk lubricant storage at shop facilities, installing permanent “last chance” filters on the inlet side of lubricant storage tanks, as well just prior to the dispensing reels, can be effective in maintaining fluid cleanliness levels. Figure 4 shows a last chance filter system. For this type of application, it is important to work with your lubricant supplier on setting ISO cleanliness standards on the delivered product. This process is effective with field mobile lube truck applications.

Atmospheric Air Control

The majority of lubrication systems breathe whether during operation or during routine maintenance. Typically, these breather openings can be one of the primary sources of dirt and moisture contamination in fluids. It is important to control the cleanliness of air flow in all operating systems, bulk storage tanks and package containers. There are a variety of methods, including standard air breathers, combined desiccant breathers, which manage air and moisture, as well as positive pressure systems. It is important to install and size the proper breather to ensure it can handle air flow requirements as well be efficient in removing the contaminants. Figure 5 shows a typical air breather.

Figure 3: A portable filter cart

Figure 4: Last chance filter system

Figure 5: Air breather
Water Contamination

Water is the second most harmful contaminant behind particulate contamination. Water can be present as free water, emulsified water or dissolved water. Figure 6 shows water interacting with oil.

Water can cause rust on equipment and degradation of the lubricant. Always store oil drums under a roof so that water on top of the drums cannot be sucked in through the bungs or introduced when opening the containers. Desiccant breathers are also good at keeping out dirt and moisture. If water does enter into the oil, there are a few options to consider:

- **Gravity** – Settled free water at the bottom of a calm tank can be drained off by opening the drain valve at the bottom.
- **Absorbent filters** – Absorbent filter elements can be used in place of your normal filters to absorb free water. At most, they can hold only about a quart of water, so removing constant water contamination this way is not a practical approach.
- **Vacuum dehydration** – This is a special machine that heats the oil and separates water from oil through a vacuum and drying process. These remove free, dissolved and most emulsified water from oil but they can be expensive machines and it may be best to rent one or use a service that provides one. A vacuum dehydration machine is pictured in Figure 7.
- **Dry air** – This is a new approach using super-dry air in contact with the oil to evaporate free, dissolved and most emulsified water. This new approach has shown to be quite effective. It works very well to constantly remove small amounts of water from circulating oil.

Filtering

When setting up a program to ensure specific ISO cleanliness levels for new fill lubricants, it is more cost efficient and effective to maintain an ISO cleanliness level from your new lubricant bulk storage facility to the point of dispense, as compared to designing a system to clean product. Typically, this reduces capital expenditure as well as the labor cost to maintain a lubricant cleaning system. Work with your lubricant supplier to set an ISO cleanliness standard for new bulk product delivered to your facility. A best practice is to ensure the lubricant manufacturer, as well as the lubricant supplier, provides a certification on ISO cleanliness levels for each delivery and batch blend. It is always recommended to include your lubricant supplier when considering oil filtration practices to ensure your goals can be met, as well ensure the integrity of the lubricant is not compromised.

In summary, lubricant contamination can lead to shorter equipment life. Good filtration practices lengthen equipment life. Lubricant cleanliness is very important and is necessary to provide optimum protection for the reliable operation of your equipment. Always follow OEM recommendations for servicing your lubricants.

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