Contaminant Monitoring Targets Root Causes of Machinery Problems

By James C. Fitch, Diagnetics, Inc.

Proactive maintenance can provide substantial maintenance cost savings by identifying and correcting the root causes of machine deterioration and failure, rather than simply reacting to the symptoms of the problems. The result is significantly extended machine life, reduced scheduled maintenance, and improved efficiency.

A proactive maintenance approach has been particularly successful in reducing or eliminating one of the most serious equipment maintenance problems: contamination of lubricant or hydraulic fluid systems. According to the bearings division of TRW, "contamination is the number one cause of bearing damage that leads to premature removal." Caterpillar states that "dirt and contamination are by far the number one cause of hydraulic system failures." Similarly, J.I. Case states that "systems must be kept clean, spotlessly clean, in order to achieve the productivity they are capable of." Finally, Oklahoma State University reports that when fluid is maintained 10 times cleaner, hydraulic pump life can be extended by 50 times (Fig. 1).

The most common types of contaminant-induced failures in machinery are wear, sticking, seizure, erosion and corrosion. Contaminants can include solid particles, moisture, air, chemicals and other foreign materials.

The rate at which contamination enters a system is typically underestimated, and the effectiveness of filters in removing this contamination is often overstated. According to a study of hydraulic equipment at Oklahoma State University, "it has been demonstrated that apparent ingression rates of 10-100 million particles greater than 10 microns (per minute) characterize field systems (Figure 2)." Filters often have great difficulty removing these high contamination levels since they are subject to frequent changes in temperature, fluid viscosity, pressure, and flow; plus the effects of shock, vibration and fatigue. Other common problems are filter by-pass valves that are stuck open, damaged or missing filter gaskets, and filters that are installed crooked or backwards.

In spite of these obstacles, a number of companies have developed and implemented successful contamination control programs. For example, after Nippon Steel installed a hydraulic contamination control program plant-wide, pump replacement frequencies were reduced by 80% and the cumulative frequency of all failures relating to wear and contamination were reduced by 90% (Figure 3). Kawasaki Steel, implementing a similar program of improved filtration and fluid cleanliness monitoring, achieved a 97% reduction in hydraulic component failures.

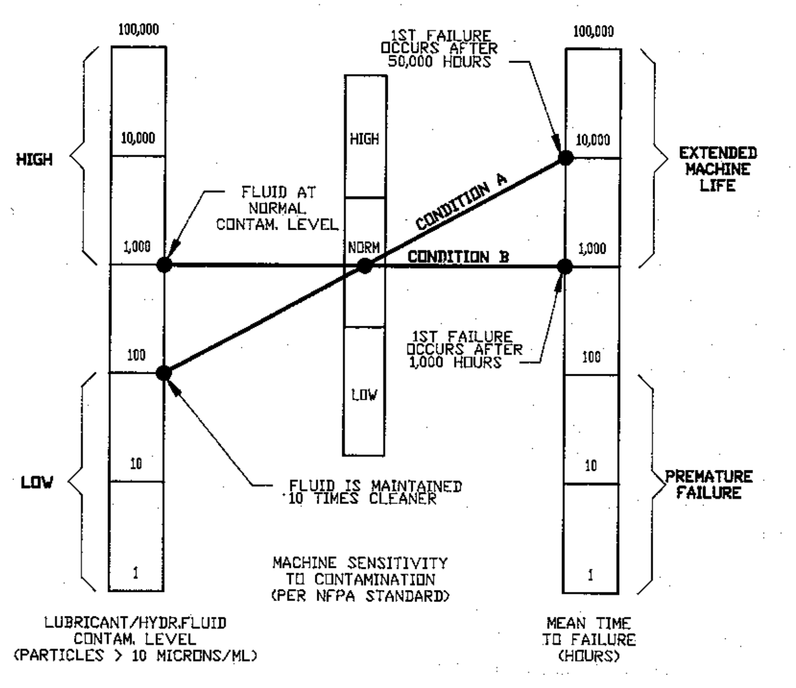
A study by the British Hydromechanics Research Association carefully monitored the field experience of 117 hydraulic machines from eight broad categories: injection molding, machine tools, material handling, mobile/construction, marine, metalworking, test stands and miscellaneous. The results of the three year study showed a dramatic relationship between fluid contamination levels and service life. Improved system cleanliness extended the mean time between failures from 10 to 50 times, depending on the contamination level (Figure 4). A study by the Naval Air Development Center in Warminster, PA performed on hydraulic pumps showed a nearly 400% increase in component life with a 66% improvement in filtration, and a 1300% increase in life with a 93% improvement in filtration.

Improvements have been identified in lubrication systems as well. The contamination control program at Nippon Steel included both journal and roller bearings. Over the study's three year period, there was a 50% reduction in replacement bearing purchases plant-wide. Similarly, International Paper Company reported a nearly 90% reduction in bearing failures after six months of improved filtration and contamination control at their Pine Bluff, AK paper mill.

Contamination control should be implemented in three steps: 1) using the Contaminant Life Index, establish the target fluid cleanliness levels for each machine and fluid system; 2) select and install filtration equipment (or upgrade existing filter ratings) and contaminant exclusion methods to achieve target cleanliness levels; 3) monitor fluid cleanliness at regular intervals to verify that targets are being achieved, adjust filtration and contamination control as required to stabilize target cleanliness. A more extensive explanation of each of these steps can be found in the book "Fluid Contamination Control", written by Dr. Ernest C. Fitch, which can be obtained by contacting the author.

It is important to note that a common myth among maintenance people is that the incremental costs of improving system filtration and contamination control exceed the benefits of improved fluid cleanliness and machine performance. While a thorough

Figure 1 - Cleaner hydraulic fluid extends pump life



REFERENCE: FLUID CONTAMINATION CONTROL, BY DR. E.C. FITCH

Non-Conventional Lubricant Base Stocks 1990-2000 - A World Market Study

The lubricant industry worldwide is on the threshold of a new era. Performance requirements will become so demanding by 1995 that lubricant additives will not provide sufficient performance improvements to allow conventional base stocks to meet specifications that will be in place. Synthetics and high viscosity index petroleum base stocks, with additives, will be the only way to meet these advanced lubricant performance requirements.

"Non-Conventional Lubricant Base Stocks, 1990-2000 (A World Market Study)", provides basic technical and market analysis reports for the major non-conventional base stocks with the strongest market growth potential, as well as those that will not be as attractive. Polyalphaolefin (PAO) synthetics, paraffinic high viscosity index (115-125) and very high viscosity index (140-150) non-conventional mineral oil base stocks receive the most attention.

"Lube oil specifications will get tougher, faster, during the current decade," observes Richard Ozimek, president and founder of Ozimek Data Corp. "We can count on technical trends continuing...requiring engines with improved fuel economy and emission control devices which are generating higher engine temperatures. This will require lubricants that are more thermally stable.

"In addition, many OEM's have taken a more active role in specification upgrades and changes; and new specifications are likely to have volatility restrictions and low temperature requirements that will be difficult to meet with conventional base stocks. Further, a trend in Europe and North America to 5W30 engine oils with stringent volatility limits is likely.

"The fast growth for non-conventional base stocks will be propelled primarily by increasingly stringent performance requirements; however, oil supply disruptions and higher crude oil prices could also dramatically increase the rate of substitution."

High viscosity index base stocks can be used to formulate fuel efficient low viscosity engine oils with extended drain capabilities. With synthetic base stocks such as polyalphaolefins, low viscosity fuel efficient engine oils can be formulated for extended service life without compromising performance requirements.

The high viscosity index (HVI) products are not viewed as competitors to the PAO's or very high viscosity index (VHVI) base stocks. They are, however, expected to assume a dominant role in the coming years because they represent the first significant step away from the current industry viscosity index standard of 100. They represent a low cost alternative for satisfying some (but not all) of the future performance requirements for high quality base stocks. They are currently used in formulating low viscosity multigrades with good high temperature/high shear viscosity characteristics. HVI lubricant base stocks are currently used only in Western Europe, with Germany being the major market. Markets in France, Scandanavia, the United Kingdom and other countries are gradually developing, followed by North America, Japan and the rest of the world.

The VHVI base stocks have lower volatility, better low temperature properties, and better thermal stability than the HVI's. They also provide an excellent response when blended with synthetic oxidation inhibitors. A major factor supporting the growth in use is the trend to 5Wx oils, with VHVI's and PAO's competing for the highest quality 5Wx lubricants with the lowest volatility characteristics. VHVI base stocks are also gaining popularity in 10W30 and 10W40 oils for engines with high operating temperatures.

The polyalphaolefins have clearly emerged as the synthetic base stock with the most potential. The base stock is currently in an oversupply position, with production facilities operating at 57% of capacity in 1990; however, even the worst case scenario concludes that this oversupply will disappear by the end of the decade. The fastest growing market for PAO's over the next ten years will be North America.

The establishment of a unified European Community beyond 1992 will expand the European market for high quality lubricants that meet stringent volatility standards. This, in turn, will increase market demand for both VHVI and synthetic base stocks used in high quality lubricants.

The market study is available only on a subscription basis. For further information on subscription terms, prices, scope, contents and techniques, contact Ozimek Data Corp., 92 Mendota Ave., Rye, NY 10580; (914) 967-8420.

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economic evaluation of all possible contamination control programs is beyond the scope of this article, it is our experience that only high contaminant ingression systems may not provide an immediate return on investment and payback within a two year period. In fact, Nippon Steel reported a reduction in oil consumption of 83%, and Pall Corporation reports that by improving fluid cleanliness, oil change intervals can be increased by as much as 100%. Additional savings can be achieved by routine monitoring of fluid contaminant levels in order to schedule filter changes at the optimum time.

Since machine contaminant levels can be very dynamic (a variance of two or three orders of magnitude over a period of a few days is not unusual), routine fluid monitoring is an integral part of an effective contamination control program. Monitoring can be accomplished by extracting fluid samples for analysis on-site or at an independent lab. Independent lab analysis does not require an investment in analytical equipment; however, results are not immediately available. An on-site lab can make results more readily available, although there is still a delay between the sample time and the analysis, and there is the added cost of the analytical equipment.

More recently a third option has become available, the use of a portable contaminant monitor that is battery operated and plugs into a diagnostic port (the port is permanently installed in the hydraulic or lubricant system pipin). One system, the Digital ContamAlert consists of a sensor attached by cable to a hand-held computer. During a test, the unit is placed momentarily on the special diagnostic port, a small sample of fluid under pressure passes into the sensor, and after a minute or two the particle count is displayed on the computer screen. Particle count data can be stored in the computer, tagged to machine ID, the date and user comments. Later the data can be printed out with a portable printer, or it can be downloaded to a PC.

The use of a portable monitor provides immediate information on system contamination levels, identifying which systems are within guidelines and which need attention. This can significantly reduce the time required to respond to a developing problem, since work orders can be created within minutes of taking a reading. In some cases contaminant monitoring can also provide an early warning of a developing machine problem before other predictive maintenance techniques such as vibration analysis, wear particle analysis or spectrographic oil analysis. This is particularly true for hydraulic systems.

For more information on contamination monitoring and control systems contact Diagnetics, Inc., 5410 S. 94th E. Ave., Tulsa, OK 74145-8109; (918) 664-7722.

Figure 2 - Hydraulic particle Contamination Ingression

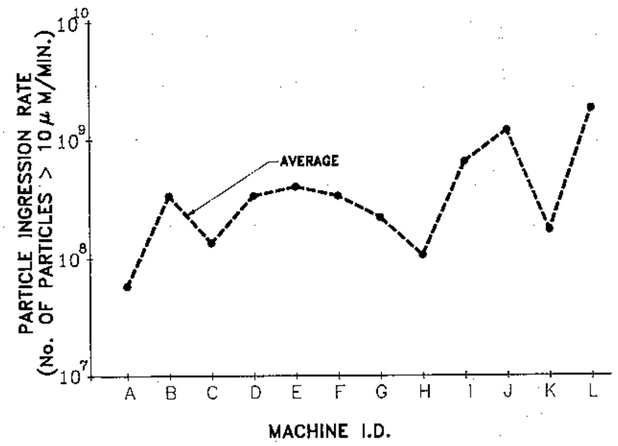

Figure 3 - Nippon Steel Hydraulic Failure Savings with Contamination Control

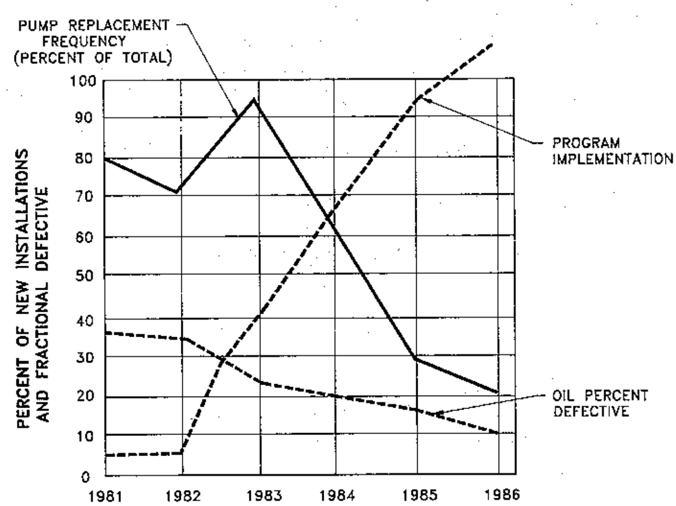

Figure 4 - Machine Cleanliness vs. Hours Between Breakdowns