Contamination Monitoring in the Hydraulics Industry

Dave Dunham | Beckman Coulter, Inc., 481 California Ave Grants Pass, OR 97526 USA

Abstract

Operators of planes, trains, heavy equipment, and other systems that rely on hydraulics live with the constant battle of scheduling maintenance. The balance of when to change the fluid, filters, or other parts to avoid down time and excessive repair costs versus the cost of maintenance and replacement is delicate. A wrong decision can result in unnecessary maintenance, increasing operating costs; on the other hand, delaying maintenance can result in a catastrophic failure, increasing ownership costs.

Maintaining the Balance

Over 90% of catastrophic failures are the result of abrasive wear that causes the pumps, valves, cylinder rods, differential drive, steering, clutch, or transmission systems to fail. Part of the role oils and hydraulic fluids play is to coat these parts, helping to reduce friction and abrasive wear. Yet these same "protective" oils may be contributing to a catastrophic failure. Over time, the oils themselves are contaminated with particles that can contribute to wear on the machinery. These particles come from a wide variety of sources, including particles left on new machinery or parts by the factory, dirt and dust from the outside environment, wear and tear on the machinery and parts, and even contamination in the oil itself. Over time particles from all these sources build up in the oil, and eventually can cause temporary or permanent equipment failure.

These particles can cause many types of failures:

1. The particles can clog small orifices that control critical hydrostatic balances, causing a catastrophic failure.
2. Particle contamination can also cause moving parts to completely lock.
3. The particles themselves may cause additional wear and tear on the machinery and parts, creating more particles that contaminate the oil.
4. Each of these problems can cost thousands of dollars in damage if not prevented.

One way to reduce the particle contamination level in the oil is through the use of filters. The filter is placed before the critical part to prevent the particles from reaching the part, damaging it. Unfortunately, over time the filters become clogged, and prevent the oil itself from reaching the part. Additionally, the filters can develop holes, allowing the particles through to the part they are intended to protect.

Monitoring the Contamination Level

For many years operators have been trying to develop a balanced maintenance schedule by using a regular oil analysis program. One of the most common methods of analyzing the oil is spectroscopy. Several types of spectroscopy are used, including atomic absorption, ICP, and infrared.

Using spectroscopy, analysts can analyze the composition of the oil; however, only limited information regarding particle contamination can be determined. For instance, spectroscopy can only analyze very small particles; the upper limit ranges from 5 to 15 µm. While it is important to know the composition of the oil, these small particles are usually not the cause of equipment failures; larger particles are often responsible for these failures.

Measuring Critical Particles

In the 1960's laboratories began using particle counters to monitor particle contamination levels in hydraulic fluids and oils. Recent changes in particle counting technology, especially the introduction of portable particle counters, have increased the use of particle counters throughout the industry.

Particle counters are typically used to measure particles from 1 µm to 100 µm in size, so the number of the critical larger particles is known. Therefore, the particle count information gathered using particle counting complements the contamination information gathered using spectroscopy.

Understanding Particle Counting

The basic particle counting system is composed of three parts: the sampler, the sensor, and the counter. Additional equipment, such as a software package, is often added to make the system more efficient and useful. The sampler's primary purpose is to assure the sensor receives a constant, even flow of sample. Many samplers have additional features that allow the analyst to regulate the flow, such as a vacuum regulator or pressure regulator.

The sensor measures the particles in the oil received from the sampler. A light extinction sensor is commonly used to test oils. As the sample moves through the flow cell it passes through an area that is illuminated by a constant-intensity light from a laser diode. The intensity of the light is monitored by a photodetector on the opposite side of the flow cell. The intensity of the light when no oil is passing through the flow cell is the base line for subsequent measurements. As particles in the oil pass through the light beam, they block part of the light, preventing it from reaching the photodetector. The photodetector converts the decrease in light intensity to an electrical signal and transfers the electrical signal to the counter. The counter, in turn, converts this signal into a particle size. A software package can be used to store, manipulate, and view the data.

ISO 4406 Table Number of Particles per mL		
More Than	Up to and including	ISO Code
80,000	1,60,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2500	5,000	19
1300	2500	18
640	1300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1

Using Particle Counting in the Hydraulics Industry

To gain a complete understanding of the condition of the oil, and the parts and machinery themselves, it is vital that the oil be regularly monitored and the results recorded. Over time, these results can be trended, and used to create effective maintenance schedules. These schedules can help reduce unnecessary maintenance expense and, more importantly, costly downtime. Particle counters can also be used to check the efficiency of the filters and schedule filter changes.

In addition to aiding maintenance scheduling, particle monitoring can identify a sudden increase in the number of particles in a sample. This sudden increase can indicate an imminent failure that might be avoided by unscheduled maintenance. In the long run, performing this maintenance before the failure occurs will save thousands of dollars in repair costs and unscheduled downtime on the equipment.

Interpreting Particle Counting Results

For many years particle counters have been used to monitor contamination levels in hydraulic fluids in military aircraft. Because of this, many standards have been developed to judge test results. One of the most commonly used standards is ISO 4406. This standard looks at the particle count data from the 4 µm, 6 µm and 14 µm channels and assigns a three digit cleanliness code. This code quickly tells users if their fluid is in spec or if there is a potential issue in their process.

HIAC Particle Counters

Beckman Coulter manufactures HIAC particle counters for use in testing hydraulic fluids, oils, fuels, organics, glycols, and water. The systems described below were developed for specific aspects of the fluid power industry. In addition to these systems, HIAC offers a complete line of sensors, samplers, and particle counters for all applications.

8011+

The 8011+ was designed to analyze samples of hydraulic fluids, solvents, and aqueous solutions in a laboratory setting. This versatile system has many uses, including monitoring particle contamination levels in mobile and industrial hydraulic systems, measuring roll-off cleanliness of equipment, and testing cleanliness of parts cleaning systems.

HIAC 8011+

PODS+

The was PODS initially designed for field based fluid power applications, but the new HIAC PODS+ has been redesigned to accommodate fuels, glycols, organics, and water based fluids. The PODS+ enables users to get particle count data onsite without the hassle of sending samples to a lab. The instrument is fully battery powered and can sample fluids from 1 - 425cSt without dilution. The PODS+ is remarkably fast, providing user's particle count data in less than 60 seconds. Additionally, the flow path of the instrument cleans in seconds, enabling users to quickly test multiple fluids without the concern of sample to sample carry over.

HIAC PODS+

ROC

The HIAC ROC is a small, robust online particle counter that instantly provides liquid particle counting results. It can fit to any application and can sample a wide range of oil-based products with 2-424 cSt range. Particle count data is available on highly visual local display which can provide data in ISO, NAS and SAE codes as well as alarms and status information. The benefit to the ROC is the real-time liquid particle counting contamination and condition information provided to the user, which in-turn allows for quicker decision-making.

HIAC ROC

Author

Dave Dunham | Beckman Coulter, Inc.,
481 California Ave Grants Pass, OR 97526 USA

Dave Dunham is a Global Marketing Manager for Beckman Coulter Life Sciences. In this role he manages the HIAC portfolio of liquid particle counters and has helped drive the development of both the HIAC 8011+, PODS+, and the HIAC ROC. Dave is also a member of the ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants. He has a B.S. in Microbiology from Oregon State University and an MBA from Marylhurst University.

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