

Cat[®] S·O·SSM Services

Reporting Particle Count by ISO Code



Management Guide

- Two methods of reading particles
- Measuring contamination
- ISO Codes
- ISO 11171:1999



Carolina



CATERPILLAR[®]

Reporting Particle Count by ISO Code

Introduction..... 3
What ISO Means..... 3
Two Methods of Reading Particles 4-5
Measuring Contamination 6-9
Applying ISO Code..... 10
What ISO 11171:1999 Means 11
Working Together With the Same Goal..... 12

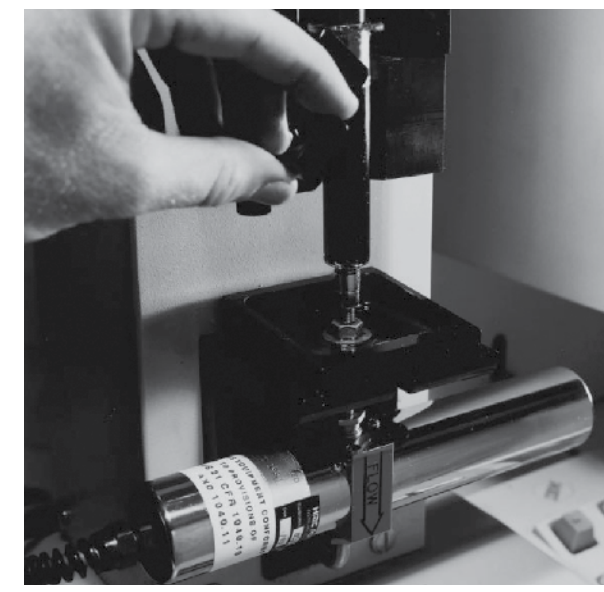
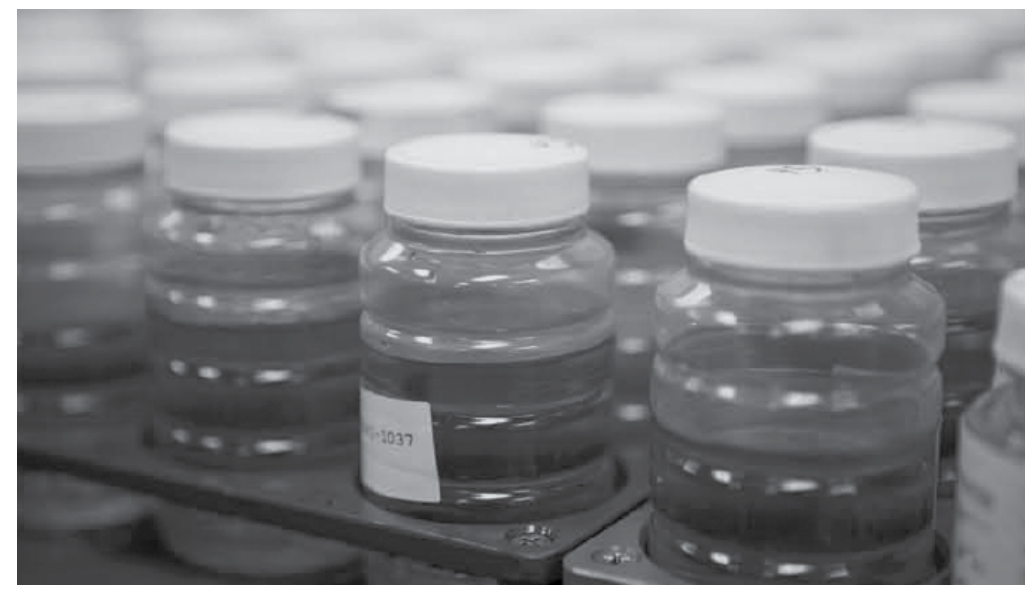
The buildup of wear particles in oil is a key indicator of potential machine problems. Observing the rise in small particles of a specific element can identify specific component wear. Also, tracking the amount and buildup rate of large and small particles over time indicates the severity of system wear. This is why our S-O-SSM program interpreters use two specialized tests: traditional Elemental Analysis that trends the small elemental particles, to tell what might be wearing, and Particle Count that quantifies the buildup of all sized particles whatever their composition, to tell the severity of wear. Elemental Analysis test results are measured in “parts per million,” while Particle Count results are measured in “particle counts per unit volume.” Particle Count results are converted to another useful and efficient way to express findings—the ISO Code.

What ISO Means

The International Organization for Standardization is an international standards organization based in Geneva, Switzerland. The “ISO” name is derived from the Greek Isos, which means equal. It is a priority for ISO that countries have equal influence on the standards. The second purpose for the acronym ISO is that it is the same in all languages. ISO is comprised of members from national standards bodies in 100 countries.

The primary ISO goal is to develop uniform technical standards facilitating international exchange of goods and services. In preparing standards, ISO combines the interests of producers, consumers, governments and the scientific community.

Over 2,900 technical bodies involving over 30,000 experts worldwide carry out ISO work. To date, there are over 15,600 published ISO standards.



Two Methods for Reading Particles

The concentration of wear particles in oil is a key indicator of potential component problems. Therefore, oil analysis must be capable of measuring a wide range of wear particles and contaminant particles. Some types of wear produce particles that are extremely small. Other types of wear produce larger particles that can be visually observed in the oil. Likewise, contamination particles come in a variety of sizes. Tiny particles of dust in the air can cause significant damage if the particles enter a lubricated compartment. Dirt from the soil will also cause damage if it is allowed to enter the lubricating oil.

To effectively measure this wide range of particle sizes, S-O-S Services uses two types of tests. The Elemental Analysis test is used to measure the extremely small particles. The Particle Count test is used to measure the larger particles. Trending the concentration and wear rate of large and small particles indicates the severity of system wear.

Elemental Analysis

This test identifies elemental constituents present in the oil and specific elements that comprise wear particles. Results are provided in parts per million or ppm. Over the course of several samples, trending the concentration of various elements can signal potential problems. Classic combinations of elements may identify specific wear sources and other compartment issues.

Elemental Analysis cannot analyze particles larger than 10 microns. These larger particles may also signal abnormal wear and contamination.

Particle Count

Particle Count can quantify the number of particles from approximately 4 microns to 50 microns in size (figure 1), regardless of particle composition. This analysis is measured in particles per milliliter. These results are converted to another useful and efficient way to express findings, the ISO Code.

Dirt, metal and water will all be reported as particles in this analysis since Particle Count does not distinguish particle composition. Particle Count can detect additional signs of abnormal wear that Elemental Analysis cannot detect.

Elemental Analysis and Particle Count Analysis form an efficient partnership in identifying abnormal wear levels and identifying total fluid contamination levels.

DIAMETER OF A HUMAN HAIR
80 MICRONS

TALCUM POWDER
15 MICRONS

1 MICRON

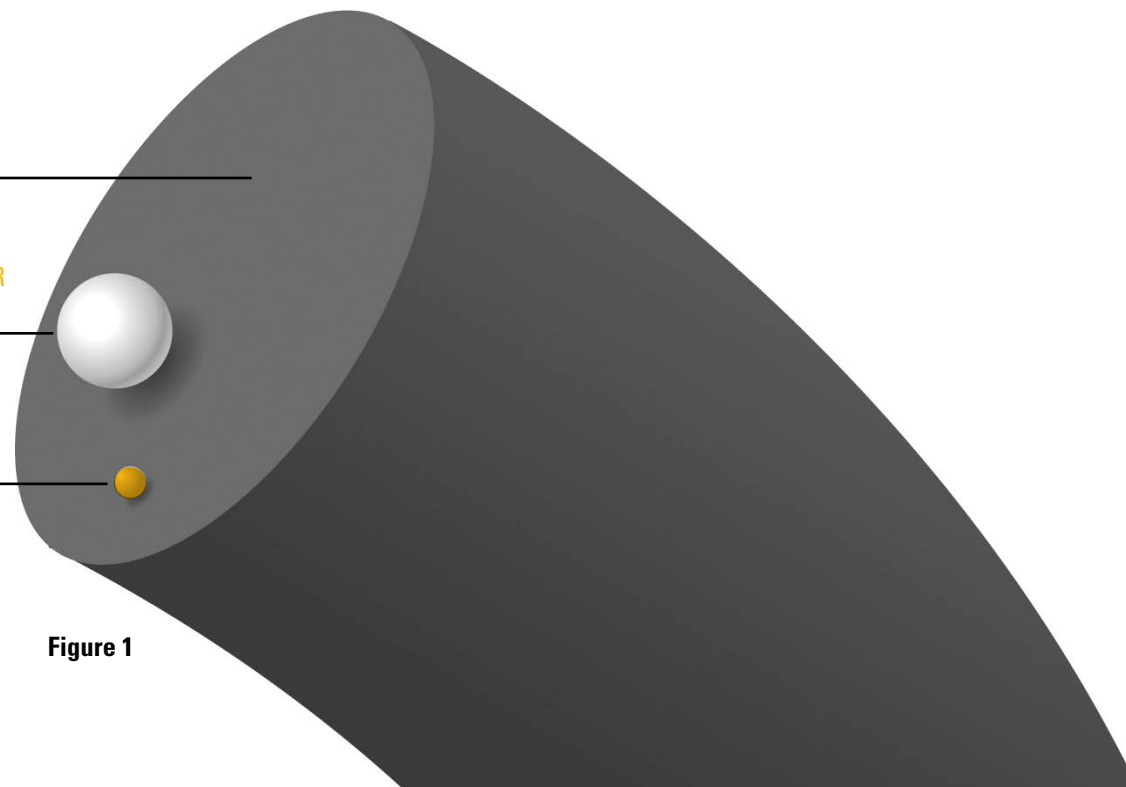
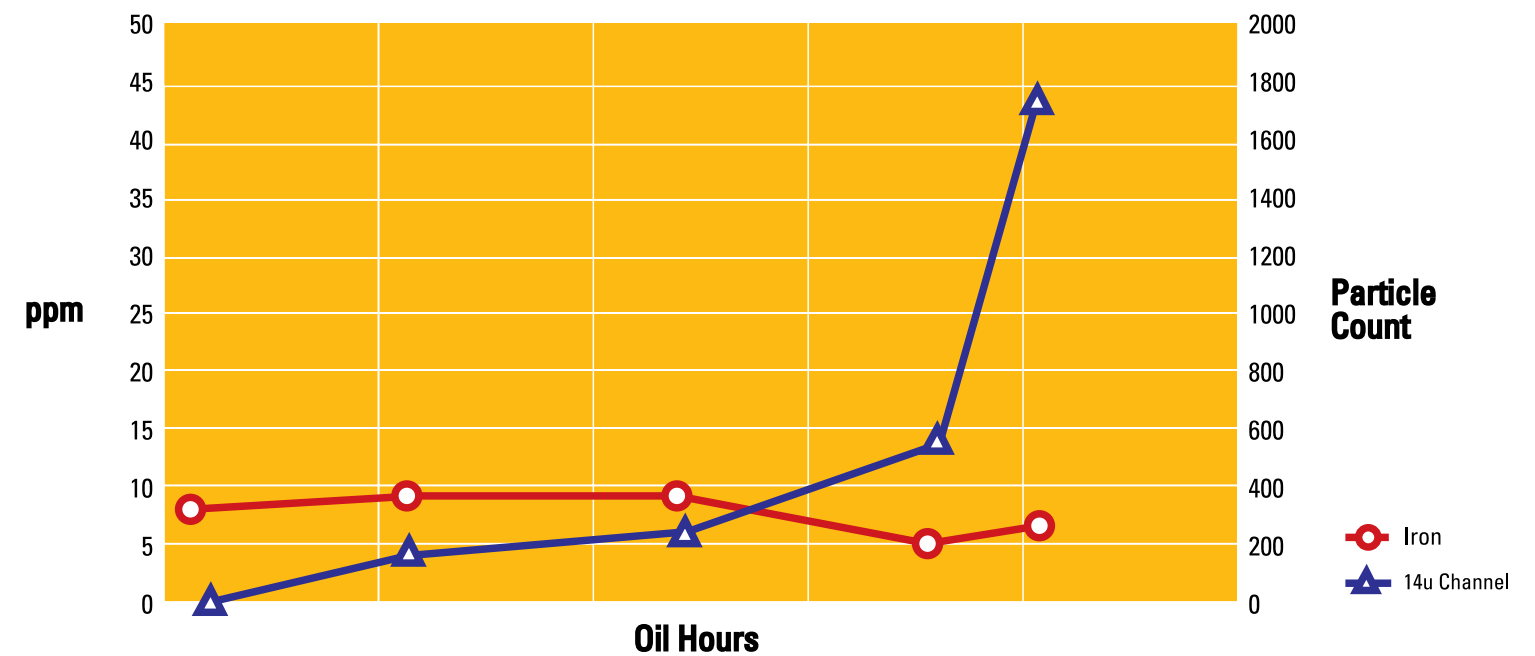


Figure 1

The chart below shows the results from the Elemental Analysis of iron and the results from a Particle Count test. The iron results are in ppm. The Particle Count results are shown for particles larger than 14 microns. Observe how the iron results remain relatively constant, while the particle counts show an increasing trend. This type of analysis could indicate a wear problem that only creates larger particles.

Figure 2

CATERPILLAR POWERSHIFT TRANSMISSION



Particle Count has been used for many years by the fluid power industry to monitor debris levels in close-tolerance hydraulic systems. The ability to warn of severe wear across a wide range of materials and micron sizes makes it a useful tool in trending wear debris levels in most equipment compartments, especially hydraulics.

Measuring Contamination

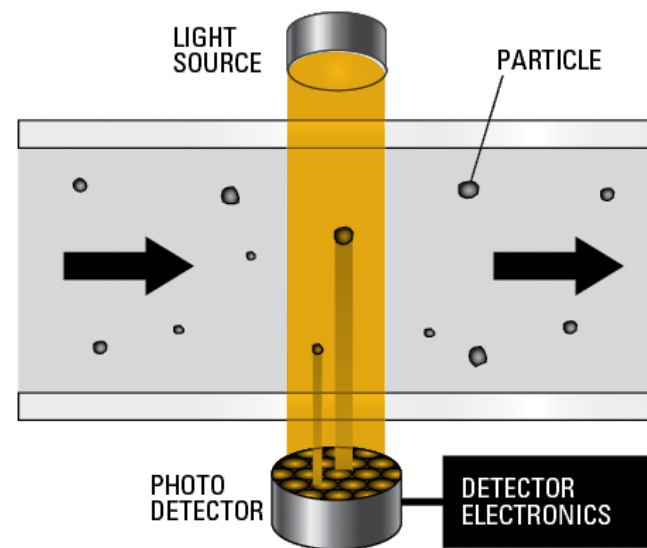
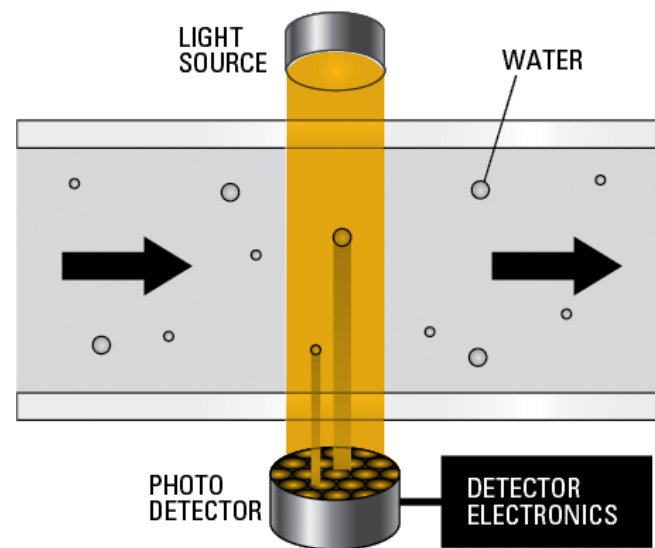
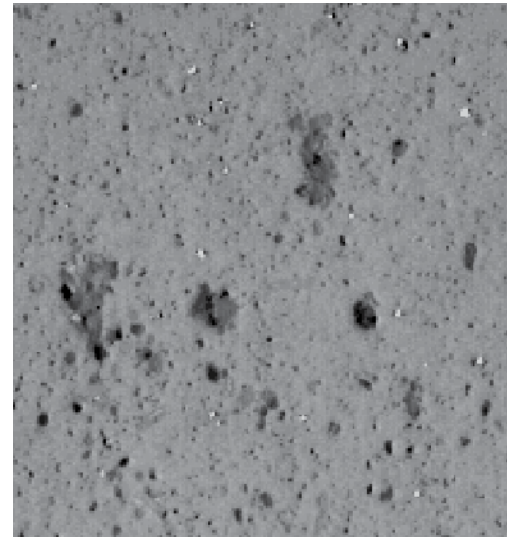
Particle Counting Techniques

Any valid measuring system must give consistent results and be calibrated to conform to industry reporting standards. Consistent results enable interpreters to identify wear trends in consecutive samples and enable compartment cleanliness targets to be set and monitored.

The most direct method for measuring the larger particles is with an optical microscope. With this method, a measured amount of oil is passed through a fine piece of filtration media that traps the particles. A technician then counts and measures the size of each particle on the filter media. The counting and sizing of the particles is done through a calibrated microscope. This optical microscope technique is very time consuming and expensive.

Optical particle counters were developed to reduce the expense and time required for particle counting.

Optical Particle Counters are used in the S-O-S program. The instrument shines a laser through the sample. A detector then counts the number and size of shadows created by particles in the oil. Any object in the oil that creates a shadow will be counted as a particle. Water droplets, entrained air and some oil additives will cause shadows. When water, air and additives are measured by a particle counter, it is called interference. It is not possible for the optical particle counter to distinguish the difference between shadows caused by debris and shadows caused by interference. Therefore, careful sample preparation and screening is required for best results.



Sample Preparations

The following guidelines may be used when preparing a sample for testing with an optical particle counter.

Water

Samples that contain more than 0.5% water contamination should not be tested on an optical particle counter. Water contamination at this level is more of a problem for the fluid system than debris in the oil.

Entrained Air

Entrained air or air bubbles will create shadows during the analysis and will be counted as particles by the particle counter. Bottle samples can be vacuumed or sonicated to remove the air bubbles before analysis.

Oil Additives

This problem is most prominent with new oils. Once the oil has been placed into service for a few hours, additive interference is reduced. The problem is also not the same for all new oils. The amount and type of additives in the oil affect the severity of additive interference. High quality engine oils contain the highest levels of additives. Hydraulic oil contains fewer additives than engine oil and gear oil has the least amount of additives.

For in service engine oils, Particle Count analysis is not performed. Soot formation and the associated darkening of the sample make optical particle counting impossible for this type of oil sample. All other compartments are analyzed for particles.



Understanding Particle Count Results

Particle Count is reported in the number and size (in microns) of particles in a volume of fluid. Particle Counting instruments are calibrated to recognize different sizes of particles. Particle Count results are divided into size ranges or "channels," each based on a specific size of particle. Figure 3 shows a typical array of such channels and particle counts per milliliter of sample results.

particle count for each channel includes all of the particles in all of the larger channels as well.

By trending this information over a series of samples, changes in the concentration of particles in each channel can be used to spot abnormal wear. Elemental Analysis of the same samples can often identify the makeup of the smaller particles involved and point to probable wear sources.

As with all S-O-S tests, proper sampling technique is important. Trending of data depends on repeatable performance of sampling technique and using the same sampling locations. For more information on correct sampling techniques ask us about AERV5514 "S-O-S Services Sampling Techniques" and PEGJ0047 "How to Take a Good Oil Sample."

Figure 3

Channels (In microns)	4	6	10	14	18	21	38	50
Particle Count	26650	9108	4016	1750	740	467	50	16

Particle Count data is reported as a number of particles greater than a certain size. Figure 3 shows this sample contains 26650 particles larger than 4 microns, 9108 particles larger than 6 microns, 1750 particles larger than 14 microns. The



Converting Particle Counts to ISO Codes

ISO Codes are a simple way to quantify particulate matter by size. These codes were established by ISO and are the most widely used method of reporting particle count results.

Under the ISO Code system (see Figure 4) 28 code numbers are set up, each representing a given range of particles per milliliter. The lowest number of particles per milliliter of sample is 0.01 and the highest number of particles per milliliter of sample is 2,500,000. Smaller code numbers correlate to smaller numbers of particles. Please note that the size of each code range is double the number of the preceding range.

For example, in figure 4, ISO Code 10 has a range of 5 particles while ISO Code 11 has a range of 10 particles. Each one-step increase in ISO Code (i.e. going from 11 to 12), for the same channel, indicates the particle concentration is double the particle concentration of the preceding code.

ISO/Range Code	Min particles /ml	Max particles /ml < or equal to
1	0	0.02
2	0.02	0.04
3	0.04	0.08
4	0.08	0.15
5	0.15	0.3
6	0.3	0.6
7	0.6	1.3
8	1.3	2.5
9	2.5	5
10	5	10
11	10	20
12	20	40
13	40	80
14	80	160
15	160	320
16	320	640
17	640	1,300
18	1,300	2,500
19	2,500	5,000
20	5,000	10,000
21	10,000	20,000
22	20,000	40,000
23	40,000	80,000
24	80,000	160,000
25	160,000	320,000
26	320,000	640,000
27	640,000	1,300,000
28	1,300,000	2,500,000

Figure 4

Applying the ISO Codes

The governing ISO standard (ISO4406:1999) establishes a three-factor code (X/Y/Z) to express fluid cleanliness. The X factor represents the number of particles larger than 4 microns. The Y factor represents the number of particles larger than 6 microns and Z factor indicates the number of particle larger than 14 microns. S-O-S Services reports the Y and Z codes to keep consistency with older data.

X = number of particles larger than (>) 4 microns
Y = number of particles larger than (>) 6 microns
Z = number of particles larger than (>) 14 microns

} Cat utilizes these channels

For the example in Figure 5, test results where the particles /1 mL sample in the 6 micron channel are 9108, the associated ISO Code is 20. For the example test results where the particle/1mL sample in the 14 micron channel is 1750, the associated ISO Code is 18. The ISO Cleanliness Code is 20/18.

Figure 5.

Channels (In microns)	4	6	10	14	18	21	38	50
Particle Count	26650	9108	4016	1750	740	467	50	16

Method of Reporting	Report Display
ISO4406 X/Y/Z	22/20/18
Y/Z Reports	20/18

Another example is shown in Figure 6

Figure 6.

Channels (in microns)	4	6	10	14	18	21	38	50
Particle Count	45439	4626	664	233	100	53	8	4

Method of Reporting	Report Display
ISO4406 X/Y/Z	23/19/15
Y/Z Reports	19/15

The >6 micron size was selected because the smaller channel indicates particles that can cause silting in the fluid or are close to clearance sizes in various components. This size particle is also identified with Elemental Analysis. The >14 micron size can indicate the presence of rapidly increasing larger wear particles.

An ISO Code is an instant identifier summarizing oil particle count information in two numbers. As the trend changes between samples, particle count can be a first indication of abnormal wear. These indications are signals to review channel readings and other S-O-S tests for potential wear and potential causes of wear. Elemental Analysis can be especially useful when viewed with the Particle Count information.

What ISO 11171:1999 Means

Newer technologies revealed limitations in the test dust used to calibrate particle counters. ISO 11171:1999 discusses proper calibration of optical particle counters with standards that are more consistent. The end result is a more consistent analysis. S-O-S Reports will look slightly different, since the new standard specifies different ISO Code Channels. While the channels may look different, the ISO Codes still indicate the same cleanliness levels as before.



Working together with the same goal

ISO Codes are the international language of reporting particle count results. These codes provide easy-to-read signals of changing contamination levels and enhance the information from Elemental Analysis. This standard language provides a unique code for particle concentrations.

Particle Count and Elemental Analysis work together to alert you of potential abnormal wear. The S-O-S program of tests is designed to find abnormal wear and then identify possible causes of the wear. The S-O-S program is one element of a condition monitoring philosophy that you can put into place with your equipment to monitor the impact of your maintenance program. The S-O-S program combined with regular inspections, analysis of your equipment's site conditions, electronic data, and service history will enable you to evaluate your equipment's health. You can perform a maintenance program on your own, or you can enlist the assistance of your Caterpillar® Dealer to perform any level of preventive maintenance that will keep your equipment running at peak performance.

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