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VALUE WORLDWIDE

Importance of Fluid Cleanliness

ISO Cleanliness Codes

International Organization for Standardization (ISO) has developed a code system called ISO Cleanliness codes, a universal standard for measuring and reporting particulate contamination levels in fluids. ISO 4406:99 is the newest and most commonly used cleanliness code. It is assigned on the basis of the number of particles per unit volume greater than 4, 6 and 14 microns. The numbers are given in this specific order for consistency in comparison. Each code represents a range of solid particles present in a lubricant.

ISO CODE **18/16/13**

# of Particles ≥ 4 microns / ← 18
# of Particles ≥ 6 microns / ← 16
# of Particles ≥ 14 Microns ← 13

Note: *If the 4 micron particle count is not significant it will be replaced by an *. i.e. */16/13*

What are ISO Cleanliness Codes?

First, particle count analysis is conducted on a representative sample of the fluid in a system. The particle count test provides the quantity and micron size of the various solid contaminants in the fluid. The actual particle count and subsequent ISO Cleanliness Code are compared to the target code for the system. If the actual cleanliness level of a system is worse than the desired target, corrective action is recommended.

Different mechanical systems have distinct levels of cleanliness that are required for optimum life and minimum component wear. Contaminants in a system accelerate wear, reduce efficiency, increase operating costs and can cause significant downtime.

Typically, new fluids are not clean fluids. Bulk lubricants from blending plants can range from 19/17/15 to 17/14/13, while sealed drum lubricants can have cleanliness codes as high as 22/21/19. In contrast, highly filtered fluids may have a code of 16/14/11 or lower.

More Than (p/ml)	Up To and Including (p/ml)	ISO Code
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	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

ISO Cleanliness Codes for Rating Lubricant Cleanliness

Importance of Code Compliance

High ISO Cleanliness codes indicate high levels of particulate contamination in the oil, which increase wear and shorten the lives of both machinery and lubricants. However, if a company maintains a sophisticated and effective contamination control program, the codes can be used to achieve increased efficiency and reduced downtime.

The codes are also used as a basis for comparison, to understand how equipment performs under specific cleanliness levels. Maintenance personnel typically use the codes to evaluate the need for various levels of contamination protection.

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ISO Cleanliness codes themselves do not differ for various components. There are no set standards outside a handful of original equipment manufacturer recommendations, the table below provides a fluid cleanliness guide for hydraulic systems.

Operating Pressure →	< 1,500 psi	1,500 - 2,500 psi	> 2,500 psi
Servo Valve	16/14/12	15/13/11	14/12/10
Proportional Valve	17/15/12	16/14/12	15/13/11
Variable Volume Pump	17/16/13	17/15/12	16/14/12
Cartridge Valve	18/1614	17/16/13	17/15/12
Fixed Piston Pump	18/16/14	17/16/13	17/15/12
Vane Pump	19/17/14	18/16/14	17/16/13
Pressure / Flow Control Valve	19/17/14	18/16/14	17/16/13
Solenoid Valve	19/17/14	18/16/14	18/16/14
Gear Pump	19/17/14	18/16/14	18/16/14

Note: Adjust to cleaner levels for duty cycle severity, machine criticality, fluid type (water base) and safety concerns.

Typical Cleanliness Recommendations

Generally, the tighter the tolerance on the component's metal-to-metal surfaces, the tighter the cleanliness code. For instance, servo valves on hydraulic systems are more susceptible to contamination-related failures than low-speed gearboxes. Therefore, the hydraulic reservoir fluid will require a lower ISO code (cleaner fluid) than the gearbox. This knowledge allows maintenance departments to focus on preventing failures instead of treating them, and prompts them to employ enhanced tactics to keep contamination out of the hydraulic reservoir.

Contamination Prevention and Removal

There are numerous methods available to meet the appropriate cleanliness codes, which vary according to equipment and environment. The main objective is to stop contamination from initial entry, because studies show that it is approximately ten times more cost-efficient to prevent contamination than it is to remove it once it is present in a system. Specific solutions include quality breathers, hydraulic sleeves and improved storage and handling of fluids.

Several technologies exist for the removal of solid contaminants from a lubrication system. The most widely used method is filtration, followed by centrifuge and electrostatic technologies.

It is also important to institute a contamination control program for the establishment and monitoring of appropriate target cleanliness codes for machinery, storage and dispensing of lubricants, periodic cleaning of reservoir tanks and storage vessels, and installation of breathers to reduce ingression of contaminants. Oil analysis can be used for tracking trends to determine the value of various preventive maintenance efforts.

Some of the major lubricant manufacturers and distributors offer programs to help control fluid contamination and maximize lubricant investment values. Desiccant breathers reduce airborne particulate and water contamination, which are leading causes of lubricant-related equipment failure. Contact your local equipment supplier and oil distributor for more information about establishing contamination control/reliability program.

Industry Utilization of ISO Cleanliness Codes

Industry as a whole is beginning to implement solutions to achieve compliance with ISO Cleanliness codes. Manufacturers of machinery are establishing target cleanliness codes for systems and are also providing extended warranty considerations for end-users who maintain long-term system hygiene as part of their reliability programs.

In addition, end-use customers are becoming more educated about contamination control and as a result, are creating buy-in from upper management to employ solutions that optimize reliability. Companies are implementing programs to measure their system cleanliness and provide tools for removing contaminants. They can also utilize life extension tables to illustrate potential benefits in reducing system contamination from high to low levels, along with capturing the economic value of these solutions.

Moving to Proactive Maintenance

It can be difficult to convince maintenance staff of the importance of complying with and relying on the value of ISO Cleanliness codes. Due to the recent economy, maintenance departments are usually squeezed for time and money. Also, because contaminants are microscopic and invisible to the eye, most planners are unaware of the harm these unseen contaminants can cause to system reliability. Therefore, new tactics can often be seen as burdensome and inconvenient.

However, with recent emphasis on education and training, more maintenance personnel are learning about the problems associated with contamination. Once appreciative of the benefits that improved cleanliness offers, most maintenance departments are eager to travel the road to less downtime and improved reliability and profitability. Nevertheless, the transition can sometimes be tough, because while the maintenance department must deal with typical issues such as rebuilds, outages and frequent oil changes, it must simultaneously execute new measures that require extra time. Plus, depending on the equipment and environment, it is possible that benefits may not be seen for an extended period of time. Consequently, this paradigm shift requires a great deal of discipline and commitment from the maintenance staff.

Cases from the Field

There are many cases where compliance with a higher standard of cleanliness has significantly improved operations at industrial facilities. For instance, a leading national independent petroleum refiner instituted an all-inclusive contamination control program. The petroleum refiner has significantly reduced lubricant spending along with upgrading its products to Group II and synthetics. They have experienced fewer maintenance failures over the last three years, along with significantly reducing lubricant purchases.

A major Midwest power plant realized a lubricants cost savings of 53 percent over a five-year period through better housekeeping measures and improved filtration, which included the use of desiccant breathers. After several months of practicing these improved processes, oil analysis reports showed a substantial decrease in silicon levels. The ISO level set for new oil supplied was 18/17/14. When the first in-service sample was taken, readings were 15/14/12, indicating that the oil was cleaner than when it came in the door. By consistently maintaining levels below code, the plant has achieved a four-fold extension of lubricant life. The same oil has been in service since October 2002 and based on sampling trends and sustainable cleanliness codes, plant technicians are expecting to extend its life to as much as five to seven years.

Several years ago, a major wheel hub manufacturing facility in the Midwest found its maintenance department was primarily focused on repairing a large number of pump, valve and cylinder failures. Particulate testing found contamination levels in most systems were significantly higher than established targets. The company implemented a preventive maintenance service program, which involved analysis, reservoir cleaning, fluid reclamation, filtration upgrades and system flushing. The results were staggering: In the first year, the plant reduced component usage and failures and unscheduled downtime by 60 percent, allowing maintenance staff to concentrate on proactive maintenance activities versus reactive. This resulted in bottom-line savings of $450,000.

These case studies help underline the huge savings and increased efficiency that industrial facilities can achieve through reliability-based maintenance programs that effectively monitor system cleanliness and remove contaminants. By implementing these programs, combined with the effective utilization of ISO Cleanliness codes as part of an efficient contamination control plan, increased efficiency and reduced downtime can be achieved. This means significant benefits for a company's bottom line and enduring success in today's highly competitive global economy.

Relative Sizes of Particles

Substance	Micron	Inches
Grain of table salt	100	.0039
Human hair	70	.0027
Lower limit visibility	40	.0016
Milled flour	25	.0010
Red blood cells	8	.0003
Bacteria	2	.0001

Not all Filters are created equal

Filter ratings are an often misunderstood area of contamination control. Often a filter will be described by its nominal rating, a nominal rating is an arbitrary micrometer value given to the filter by the manufacture. Theses ratings have little to no value. Test have shown that particles as large as 200 microns will pass through a nominally rated 10-micron filter.

Another common rating for filters is the absolute rating. An absolute rating gives the size of the largest particle that will pass through the filter. Essentially, this is the size of the largest opening in the filter although no standardized test method to determine its value exists. Still, absolute ratings are better for representing the effectiveness of a filter over nominal ratings.

The best and most commonly used rating in industry is the beta rating. The beta rating comes from the Multipass Method for Evaluating Filtration Performance of a Fine Filter Element (ISO 16889:1999).

To test a filter, particle counters accurately measure the size and quantity of upstream particles per known volume of fluid, as well as the size and quantity of particles downstream of the filter. The ratio is defined as the particle count upstream divided by the particle count downstream at the rated particle size. Using the beta ratio, a five-micron filter with a beta 10 rating, will have on average 10 particles larger than five microns upstream of the filter for every one particle five microns or greater down stream.

A filters beta ratio does not give any indication of its dirt-holding capacity, the total amount of contaminant that can be trapped by the filter throughout its life, nor does it account for its stability of performance over time.

Generally most absolute filters have multiple layers of filtering media and beta ratings greater than 200, while most nominal filters are Resin-Impregnated cellulose or single layer filtering media with low beta ratings.

Note: *Information from NORIA Corporation and various industry trade publications.*

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