LNF Particle Count – How Low Can You Go?

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Contamination control is an important aspect of oil condition monitoring for fluid power applications, and it's important to be able to reliably report clean oil cleanliness levels - especially for larger particles. Large abrasive contamination will naturally occur in fewer quantities than the smaller particles in any ingress contamination distribution. At very low cleanliness levels (ISO Codes 9, 10 and 11), repeatability of the measurement becomes a cause of concern with applications such as service labs, engine test cell operators, filter manufacturers and power generation plants where ultra fine filtration has been installed. These customers want to know how our LNF product line performs at these super clean levels. A recent applications project to support a diesel engine development team considering an LNF for their test cell, demonstrated the capability of the LNF at low particulate contamination levels.

Large abrasive contamination will naturally occur in fewer quantities than the smaller particles in any ingress contamination distribution. At very low cleanliness levels, this begins to be a problem with LNF imaging systems that have poor repeatability data. This is primarily due to statistical sampling accuracy that is inherent with any direct imaging device and has nothing to do with the calibration or detection capability of the instrument. The larger particles in a distribution are often the most critical because they are often the sign of a more serious problem manifesting itself. In heavily filtered industrial systems, it is highly probable that large particles are from machine wear rather than ingress of external contamination such as sand or dirt. Table 1 shows how the ISO class table is constructed for these lower ranges using the Renard series. It is clear from this table how the Renard series translated to a cleanliness code can actually be misleading to the end user, and the raw particle count data itself should not be totally ignored. An increase in just a single particle can move you from one ISO class to the next in just the same way as a 400 % increase in particles could do the same!

The basic rule of thumb is for every ISO code increase, the "possible" number of particles has doubled. The simplicity of this coding system does allow for easier tracking of cleanliness targets than trending raw particle count numbers alone. It does however have its limitations. Differences of +/- 1 ISO code level are not significant and more often than not are an artifact of how close the count is to the cut off level between sizes. They have nothing to do with an increase in the actual contamination level in the system.

The industrial accepted standard for instrument ISO code accuracy is often defined in terms of +/- ½ ISO code (when the particle counts are centered within a code range) and +/- a single ISO code across the entire cleanliness classification system. For example, if your average range of results is 7.5 p/ml, then the deviation should be within 5 to 10 particles. This is what is meant as + - ½ ISO code accuracy.

MORE THAN (P/ML)	UP TO AND INCLUDING (P/ML)	ISO CODE
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9

Table 1: ISO code table, Low levels Class 9 to 13

At really low contamination levels, this is purely a statistical accuracy problem that can be rectified by increasing the sample volume at the expense of more analysis time. A series of transmission fluid samples provided by the Engine OEM were tested on an LNF, each sample measured repeatedly. The sample volume, running at 2.0 ml (1.5 minutes) and 4.0 ml (3.0 minutes) respectively increase statistical accuracy because there were so few particles present. The results of this test are shown in Table 2.

The data in Table 2 shows that a + - ½ ISO code accuracy can be achieved at the class

10 and 9 levels by doubling the sample volume via the analysis time from 1.0 ml to 2.0 ml and subsequently from 2.0 ml to 4.0 ml respectively.

Table 3 summarizes how the LaserNet Fines volumes should be adjusted based on a typical cleanliness application and its associated ISO code. The required sample volumes will vary from 0.3 ml to 4.0 ml depending on the criticality of the asset and the associated cleanest ISO code class.

A more detailed application note and white paper on this work will be released shortly. In summary, it shows that the LNF products are extremely versatile for all types of applications where contamination control is an issue, and is an ideal tool for customers who need to have reliable, repeatable data.

	PARTICLES / ml (2.0 ml SAMPLE VOLUME ~ 1.5 MINUTES)											
Measurement #	1	2	3	4	5	6	7	8	9	Average	Stdev	RSD %
Sample 1	9.79	6.29	7.79	9.79	6.29	5.79	9.79	6.979	6.29	7.62	1.71	22.49
ISO Code	10	10	10	10	10	10	10	10	10	ISO 10		
Sample 2	5.35	3.35	2.85	5.35	3.35	2.35	5.85	3.35	3.35	3.91	1.26	32.29
ISO Code	10	9	9	10	9	8	10	9	9	ISO 9		
	PARTICLES / ml (4.0 ml SAMPLE VOLUME ~ 3.0 MINUTES)											
Sample 3	8.75	5.25	7.25	6.75	8.25	8	9.25	5.25	8.75	7.50	1.49	19.86
ISO Code	10	10	10	10	10	10	10	10	10	ISO 10		
Sample 4	4.19	2.69	3.94	2.69	3.69	4.69	4.94	2.94	3.94	3.75	0.83	22.08
ISO Code	9	9	9	9	9	9	9	9	9	ISO 9		

Table 2: ISO code statistical accuracy at 2.0 and 4.0 ml sample volumes

ISO Code	Application	Components	Sensitivity	Recommended LaserNet Fines Sampling volume (ml)
23/21/17	Low pressure systems , large clearances	Ram Pumps	Low	0.3
20/18/15	Typical cleanliness of new hydraulic oil from manufacturer low pressure heavy industrial systems. Long life not critical	Flow control valves cylinders	Average	0.5
19/17/14	General machinery, medium pressure and capacity Mobile systems	Gear pumps motors	Important	0.5
18/16/13	Fuel Charter cleanliness standard: filling staon nozzle General machine requirements	Valve and piston pumps pressure control valves	Very important	1.0
17/15/12	Highly sophiscated systems and hydrostactic transmissions	Proportional valves	Critical	0.5
16/14/11 (10)	High performance servo and high pressure long life systems. Critical roller bearings and test stands	Industrial servo valves	Critical	2.0
15/13/09	Silt sensive control systems: high reliability laboratory and/or aerospace	High performance servo valves	Super critical	4.0

Table 3: Recommended sampling volume based on application to achieve ½ ISO code repeatability.

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