WHITE PAPER

OIL ANALYSIS ALARMS: Practical Steps to Increase Your Site's Ability to Detect and Manage Abnormal Lubrication Events

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There is a lot of discussion about artificial intelligence (AI), internet of things (IoT) and how these can be applied in all areas of reliability programs, particularly oil analysis. In this technology, many users struggle to understand and trust how alarms are set, maintained, and adapted to meet the changing conditions with lubricated mechanical equipment. All of these intelligence initiatives are ineffective if the data is not trustworthy.

Oil analysis alarms, and the application of them, have been developed and applied by laboratories and entities with large historical databases. As more equipment maintainers move to performing oil analysis onsite with the latest technologies, the alarms provided may not work to determine real faults. It is important to understand the basics of setting up alarms for your onsite program, and what is really needed for your site. And, most importantly — you can do it on your own schedule with the resources at hand.

Figure 1. Onsite Oil Analysis

This article outlines a five-part approach for setting, maintaining, and using meaningful oil analysis parameter alarms. This standardized alarm limit approach within onsite oil analyses is also relevant for AI and IoT processes.

Five Steps to Trustworthy Oil Analysis Alarm Limits

1. Lubrication personnel
2. Onsite advantage
3. Data quality
4. Recommended actions
5. Equipment profiles

Lubrication Personnel

The process of building and maintaining trustworthy oil analysis alarms begins with the lubrication team taking responsibility for oil analysis alarm limits. "Every successful oil analysis program I have observed has passionate technicians performing the work. And almost without exception, each includes some degree of onsite oil analysis." (Troyer, 2001)

The team responsible for setting and maintaining parameter alarm limits appropriate for the operating equipment uses all of the following: pre-loaded alarm limit templates, industry standard limits, statistical limits per ASTM D7720 or a similar approach, and trending limits.

Table 1 provides example target cleanliness levels (TCLs) for setting particle count alarm limits. Particle Count TCLs are usually easy to find for many equipment types in manuals or online OEM support, and a great first step. Note that TCLs are lower for filtered than for unfiltered oils. We see confident maintenance teams make further adjustments to contamination limits, as appropriate, for the operating environment.

ALARM LIMIT SET	TARGET CLEANLINESS (ISO 4406 CODE)
Servo-Controlled Oil	15/13/10
Turbine Bearing Oil	16/14/12
Non-Servo Hydraulic Oil	16/14/12
Paper Machine Oil	18/15/13
Compressor Oil	19/16/13
Gear Oil Pressure	19/16/13
Gear Oil	20/17/14
Pumps	20/17/14

Table 1. Contamination control particle count TCL limits.

Wear parameter alarm limits are straightforward. Onsite analysis software has some guidance based on equipment type to start off with (see Equipment Profiles), or a lubrication technician may set and adjust high limits based on past failure experience and comparing similar operating equipment. Wear alarm limits indicate damage progression. An alert means a vibration technician should be notified. A high alarm warrants prompt investigation.

In an effort to provide some guidance on how to sell alarms for both labs and end users alike, ASTM D7720 was created. ASTM D7720 describes how lubrication technicians statistically evaluate parameter alarm limits. For example, Figure 2 compares copper PPM alarm limits with the most recent 850 sample measurements on an in-service pinion lubricant. "Alarm limit sets may be improved through the advantage afforded by using the cumulative distribution technique for evaluating these settings in nearly all measurement populations, whether normally distributed or skewed by one

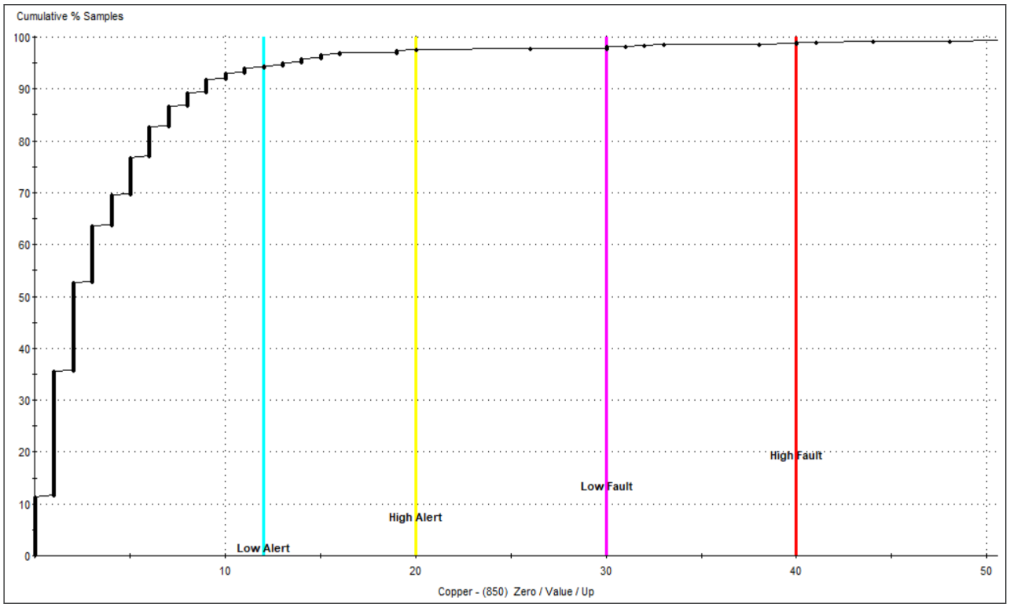

Figure 2. ASTM D7720 cumulative distribution function statistically validates current alarm limits.

Figure 3. Trivector™ graphic for wear, contamination, chemistry alarm status

or more root causes. In one actual case, a serious bearing fault was detected, trended, and corrected, and the corresponding measurement data were compared favorably with the cumulative distribution information." (Garvey, 2013)

Trend-based alarms highlight "hockey stick" changes in historical measurement profiles. Note that immediate resampling and retesting validates repeatability before taking expensive action in response to an abrupt change in trend history. For example, a second sampling and retest contradicted a first sample showing high wear and high contamination. The second oil was acceptable for continued use, avoiding three-day minimum shutdown, and saving an estimated $1,219,100. (Services, 1994)

It is common for an onsite oil sample to report more than forty parameters covering wear, contamination, and chemistry. The technician selects appropriate alarm limits for these parameters. The limits are chosen to flag potential problems with a respective equipment population. Values exceeding these limits reflect abnormal conditions for mechanical wear, system contamination, and lubricant quality. Overall wear, contamination and chemistry status is graphically reported using the Trivector™ shown in Figure 3.

Onsite Advantage

Unplanned repairs and downtime are ten times more expensive than planned repairs and downtime. An advantage for onsite oil analysis compared with offsite laboratory analysis involves collection and storage of valuable predictive maintenance expertise, and nowadays there are more software systems available to capture this knowledge. There is no substitute for practiced firsthand experience, technical understanding, equipment manuals and specifications. Onsite technicians have ready access to databases that receive, accumulate, and report information pertinent to the equipment operating in that facility. This knowledge would otherwise have been lost when individuals change jobs. Today, fluid Intelligence software that drives onsite instruments, connected with ERP systems, or "Data Lake" connectivity provide important details such as the following.

- Lubrication information – lubricants, suppliers, compartments where fluids are stored and where they are used, target cleanliness levels for each storage and in-service fluid compartment
- Oil compartment information – volume, fluid, level, add, drain, flush, fill, desiccant, and observations
- Documented failure and repair history by item and by population – root cause failure analysis (RCFA), failure modes and effects analysis (FMEA), common failure mechanisms, and defect elimination strategy
- Physical characteristics and interactions between machine components – bearings, rollers, journals, gears, couplings, cylinders, rings, shafts, belts, chains, engines, motors, and valves
- Measurement point information – sampling location, method, frequency, analysis parameters and standard test methods for each one
- Equipment operating characteristics – power, speed, primary, standby, operating, not operating, electrical, mechanical, hydraulic
- Equipment criticality classification
- Parameter trend history
- Parameter dataset population for similar equipment under similar conditions
- Alarm limit datasets by equipment population for wear, contamination, and chemistry parameters

Data Quality

High confidence in oil analysis alarms is contingent on data quality. Consistent, repeatable and trendable measurement values are produced by well-trained operators running tests properly using calibrated instruments. Excellent work processes are essential for good data quality. Wrong reference oil selection, poor sampling techniques, incorrect test methods, incomplete records for time-on-oil, and mislabeled bottles all potentially lead to false positive or false negative findings.

Here is some sage advice from technicians who have achieved good data quality needed for successful lubrication programs.

Q. How do you get started with onsite oil analysis?

A. Start with 20 items of critical equipment. Implement excellent oil sampling and testing practices. Expand to 50 and then 100 samples/month. Keep the oil clean, dry, fit for use, and look for evidence of wear debris in the oil. Use the particle counter, ferrous density measurements, and wear particle imaging.

Q. How often do you perform wear debris analysis or particle shape classification?

A. I do it on every sample. If I'm not doing shape classification, I am not looking at machine condition.

Q. How hard is it to recognize different shapes?

A. After you look at some samples with microscope and look at examples in the atlas, then you can tell whether a problem is fretting or fatigue or abrasion.

Q. How do you keep track of oil samples?

A. Accurately labeled oil sample bottles assure that results match machines and lubricant types. An incorrectly labeled sample is WORSE than no sample at all. Route-based oil sampling and analysis keeps data connected with machinery just like route-based vibration analysis does.

Q. What sort of problems are found by lubrication technicians?

A. Common problems include degraded oil, wrong oil, high mechanical wear, water in oil and process contamination. We successfully predicted failure in time to make preparations. We find water in oil, remove it, and verify it has been removed. We detect misapplied oils in several applications. Grease lubricators make notes of visual condition, temperature, and noise when something has changed and report it.

Q. What number of equipment assets are monitored periodically for vibration analysis and what number for in-service oil analysis?

A. A typical plant site collects vibration analysis data from 2000 rotating equipment assets (approximately 20,000 vibration measurement points) and also monitors 150 of those assets using oil analysis.

Q. What is the interval for oil sampling.

A. The scheduled frequency of data collection is set up monthly or quarterly or annually based on criticality. Sample frequencies are self-managed by each area lubrication technician with adjustable intervals as needed (quarterly, monthly, weekly, daily).

Q. What lead times are needed to achieve scheduled maintenance and repairs?

A. Planners and schedulers identify priority and severity for same week, next week or two weeks out. The planner identifies parts, scaffolding, etc., to do each job. Shipping schedule estimates are unreliable, so we do not schedule until parts are in hand. Break-in repairs are planned.

Recommended Actions

An exceeded alarm value may provide a basis for making an observation, but this alone may not be sufficient for making a diagnosis or for recommending an action.

The onsite maintenance team considers oil analysis findings, component maintenance history, visual observations, and information from other sources. Diagnosis and follow up recommendations may request resampling, retesting, further inspection, or other technology testing before taking expensive maintenance actions. Onsite answers enable these followup actions to be taken rapidly, a distinct advantage when investigating a problem. The response time alone is enough to justify onsite testing as a necessity.

For example, a paper machine, wire turning gear oil sample reported high alarms for wear and lubricant oxidation parameters. After inspecting the gearbox, the technician recommended diverting kidney loop oil supply to deliver extreme pressure (EP) gear oil directly to the nips for this turning gear. This recommended action improved torque performance, avoided failure, and the gear has operated normally for 3 years since.

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Equipment Profiles

We mentioned earlier how "starter" oil analysis alarms, particularly for wear elements, are available to build on with site knowledge. These equipment profiles are a great way to manage equipment families as it is easy to assign globally with the latest software. Meaningful alarm limits derived from industry norms are applicable to all types of rotating and reciprocating equipment.

Take some time to ensure you have the right application (e.g., do not alarm a diesel engine with a gearbox profile) as this will likely produce false alarms, which lowers program confidence. Second, if you know the manufacturers' details, do factor them in. To make this point, consider what results would be if a single set of alarm limits were made applicable to an equipment profile combining diesel engines from these two different manufactures: a first manufacturer's alarm limits are Fe = 170 PPM, Cu = 30 PPM, Pb = 11; and a second manufacturer's limits are Fe = 45 PPM, Cu = 15 PPM, Pb = 13. In this situation personnel will not have confidence in alarm limits for the combined "diesel engine" equipment profile.

Conclusion

This five-part standardized approach can improve oil analysis alarm limits for detecting and managing abnormal lubrication events:

- A lubrication technician is responsible for setting and maintaining the site's oil analysis alarm limits.
- An advantage for onsite oil analysis, compared with offsite laboratory analysis, involves availability of predictive maintenance knowledge and experience with operating equipment.
- Consistent, repeatable and trendable measurement values are produced by well-trained operators running tests properly using calibrated instruments.
- The onsite lubrication technician recommendations consider oil analysis findings, component maintenance history, visual observations, and information from other sources.
- Just as work processes are essential for excellent data quality, equipment profile grouping is necessary for meaningful alarm limits.

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