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Matching Engine Population Statistics - MEPS

Why and How?

The primary reason for doing engine oil analysis is to monitor the operating condition of oil wetted parts within your engine. Although some engine problems can occur with little warning because the wear metal generation rate is extremely rapid, many problems will reveal themselves through more gradual increases of wear metals coming from the affected components. By analyzing the elemental wear metal type and quantity, good judgments can be made pertaining to the actual part origin and its relative wear. It should be noted that oil analysis only monitors the fine suspended wear metal particles - those less than 10 microns in size. Filter debris analysis monitors the larger wear particles that are trapped by the oil filter and should be regularly combined with oil analysis for best monitoring of all wear metal particle sizes as a part of your comprehensive aircraft engine preventive maintenance program. Visit AvLab's **KnowledgeBox** via http://www.avlab.com to read fact sheet **"Analysis Explanation"** for more information.

Oil analysis or wear metal analysis is really an elemental analysis of the oil. Measurements are made of the amounts of various primary elements like iron, copper, aluminum etc. as contained within the oil sample. These concentration measurements are of small wear metal particles usually less than 8 microns. Each engine component is made from a particular alloy, which is a combination of the elements with exact percentages for each element. These alloy particles are suspended in the oil sample.

All of the sample alloy particles present in an oil sample are measured not individually but at the same time. They are passed through a high energy source all at once, where the particles are destroyed. During the destruction of each alloy particle, which is a mixture of elements, the particle is reduced to its elemental and atomic level. Once each element is at its atomic level, an inner electron is kicked out of its atomic shell, and an outer electron will drop into its place. This causes the emission of very specific wavelengths of light which are unique for each element. An instrument measures all wavelengths of interest within a few minutes for each sample to create an analysis report of "parts per million" for each element.

The challenge is to relate the elemental concentrations of all of the elements measured at once back to the possible alloys involved. Statistics are important because it is too complicated to relate the elemental analysis of thousands of small 8 micron particles, all analyzed at the same time, back to the alloys the particles came from. Fortunately some of the alloys have one or two elements that are major concentrations, copper alloys have lots of copper, iron alloys have lot of iron. but there are several other alloys that have lots of iron or copper too.

The Factors That Affect Results

Oil analysis results are shown in Parts Per Million (PPM) for each element, or how many particles of the specific element metal are found per each million parts of oil. This absolute value is obviously affected by the amount of specific metal generated by engine wear per hour, and the number of hours the engine has been run for this oil sample. Newly built or overhauled engines are expected to have a high amount of wear initially, and this will normally decrease over time after break-in. Of course a six cylinder engine has more moving parts than a four cylinder engine, and thus can be expected to generate more wear metal per hour of operation. Engine size is also a factor for the same reason. Other factors include how many hours has it been since the engine oil was changed, and how much residual wear metal remained suspended within the engine when the old oil was removed.

One can easily understand this last interaction by visualizing the simplified model of a leaky milk jug suspended over a glass of water. The milk jug represents the engine creating wear metal (milk) droplets at a generally constant rate per hour. The glass of water represents the engine oil which gets contaminated over time by the milk droplets and turns cloudy. It is quickly obvious that the amount of dripping time and the amount of time passed since last dumping the glass and refilling with fresh water will determine the cloudiness at any instant. The amount of cloudiness at any instant can be measured in PPM of milk. When you dump the glass of water, you will remove most of the milk, but a residue will always remain, depending on the smoothness of the glass. This residue will determine a starting point PPM. If the glass also held some marbles, thereby increasing the interior surface area, then even more milk residue would remain. Once you consider the numerous oil passages, bearing surfaces, and crannies in your engine, you will quickly realize that a substantial amount of wear metals will remain after the old oil is drained. This affects future PPM measurement, however the effect diminishes with time. But just how much and when?

Displaying the Factors

The 3-D chart below demonstrates these interactions. It was created using Aviation Laboratories extensive database with hundreds of thousands of results from oil analysis samples. Just one engine type with steel cylinders was selected and the average data for ferrous material (iron) plotted, while neglecting extreme high and low values. The Category (X) axis shows total engine hours since overhaul or new at the time the oil sample was taken. The Series (Y) axis shows the number of hours on the oil, e.g. time accrued since the last filter change - not the time since last sample was taken, at the time when this oil sample was taken. The Value (Z) axis displays the measured PPM values. During initial break-in, there are no samples with less than 60 PPM and peaks at 140 PPM. This is expected as the new engine parts wear slightly. After full break-in has been completed, e.g. at approximately 450 hrs, you will note a definite decrease in all PPM measurements. Looking at the oil hours relationship, one quickly sees how the PPM measurements increase as the oil hours increases from 20 to 100 hours, regardless of the other factors, and cause the "peaks" as seen on the chart against the back "wall". This is expected as the longer one keeps the same oil accumulating wear metal, the greater the measured PPM value will be.

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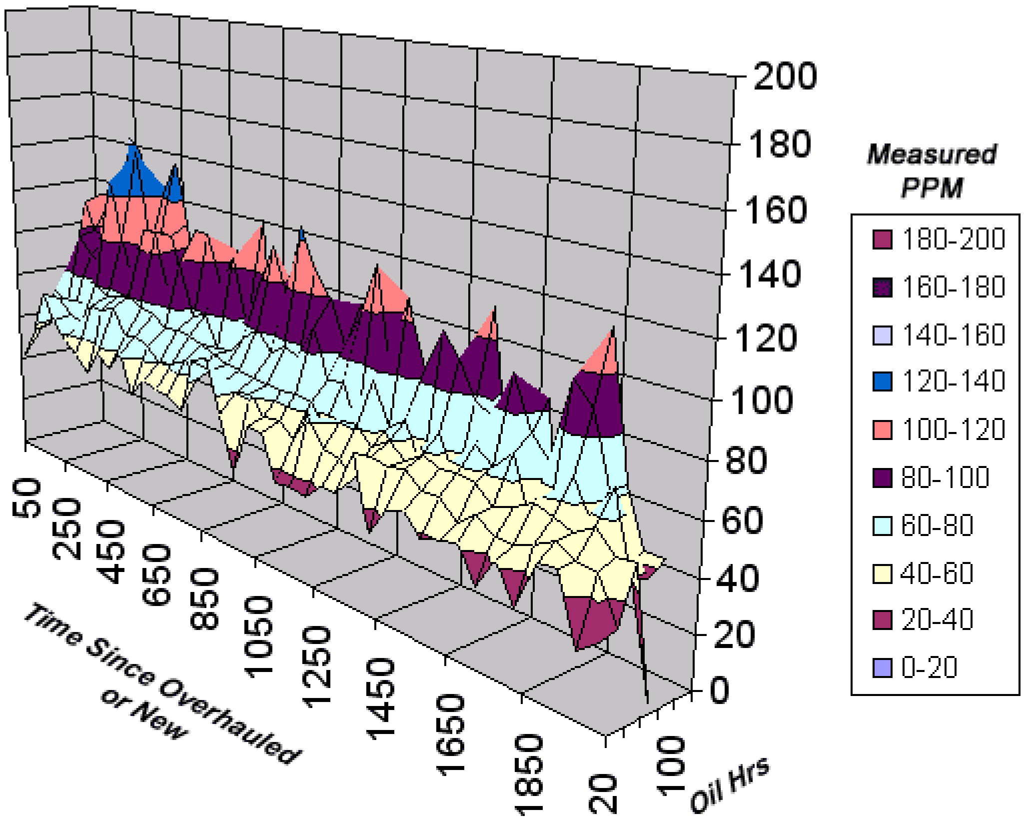

Since the longer one keeps the same oil accumulating wear metal, the higher the PPM measurement will be, it suggests that "PPM/Hr" may be an effective method of monitoring oil sample measurements. Indeed the figure below displays simple PPM/Hr vs. Oil Hours for all the previous oil analysis samples. A classic "hockey stick" curve is seen, becoming nearly asymptotic at the upper end where oil has been left in the engine around 100 hours. This affect can be mitigated by simply controlling the comparison population.

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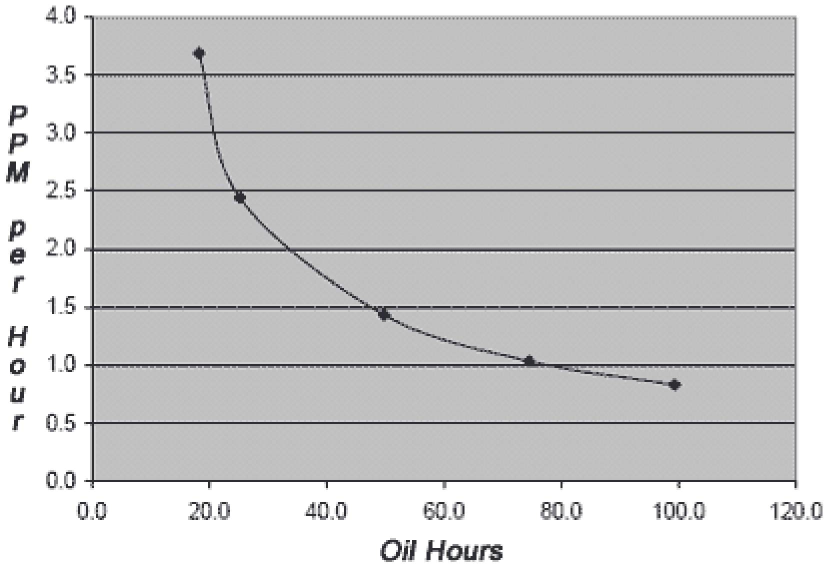

Conclusion

The bottom line is that for proper evaluation of oil sample analysis results, one can not simply look at the measured PPM value and make any valid judgment at all. The engine model, cylinder type, time since overhaul (or new), and oil hours must be factored in. Nor can "average" values be used as purported by other oil analysis companies. Your specific factors must be used and compared to a sufficiently large sample size, historical population of same engine model, same cylinder type, similar time since overhaul, and similar oil hours. These selected historical samples will uniquely determine the data points for each engine oil sample that will properly determine if your engine oil sample analysis values are abnormal or any cause for concern.

Aviation Laboratories is unique in providing this specialized analysis for you and gives easy to read, color-coded results. In addition, your engine oil sample is also checked for abnormal changes from previous trends. Any sudden change for any wear metal is also color coded and provides the only truly comprehensive and accurate results in the industry. See www.avlab.com/explain for instructions how to interpret your own oil sample analysis results.

Acknowledgement:

Contributing author, Rob Duncan of ***Airbase1 (www.airbase1.com)***