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ARTICLE

LaserNet Fines® Q230 Technology

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The LNF Q230 offers a patent-pending, completely unique, coordinated analysis of particulate via imaging and magnetic sensing. This capability enables this device to do things that none before it have done. We can characterize BOTH the image of a 20-micron or larger particle AND determine if the particle is magnetic. We can bin the size and compare both the image-based and magnetic particle analysis. The Q230 thus provides a strong measure of the nature of the debris – is the debris primarily magnetic (e.g., machine wear) or not (e.g., contamination via sand ingress)? In that sense, the Q230 provides a first-layer elemental analysis unmatched in any instrument. Beyond these features, the Q230 examines smaller and dissolved particulate via a highly sensitive magnetometer, which provides an overall ppm reading of this particulate in addition to the large particles. With two distinct magnetic sensors onboard the Q230, we can reveal information never possible until now, with quantitative debris analysis for 0-100 micron particles. By integrating

this magnetic analysis into the existing Q2xx series enclosure and streamlining the process with the magnetic sensing devices in normal imaging cell flow path, we are able to acquire this additional information with processing times of 15 seconds, completely invisible to the operator.

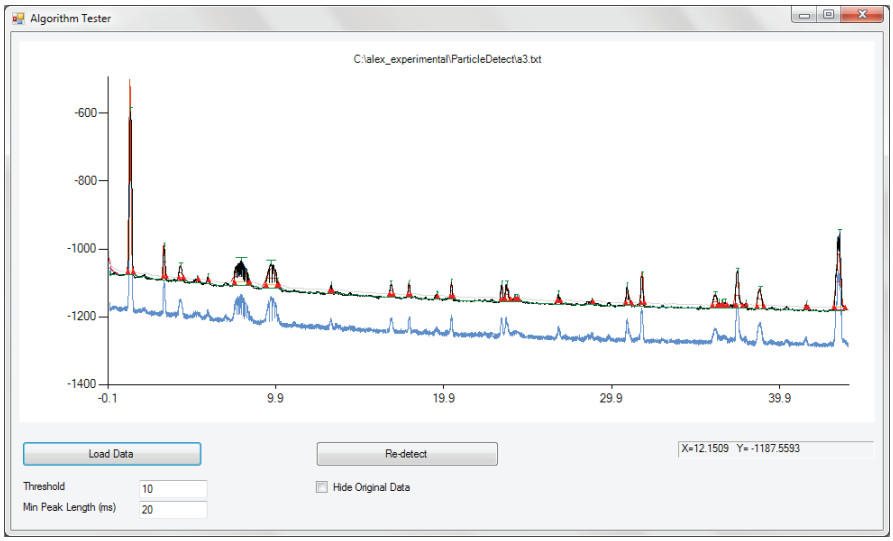


Figure 1: Example raw signal of individual magnetic particles passing through the Q230. The peaks in the data indicate that an individual magnetic particle has passed through the device. The red dots indicate the software's determination of the beginning and end of each peak. The hatches on the top of each peak indicate the Q230's determination of the height of each peak using its built-in peak detection algorithm.

Figure 1 shows an example trace where magnetic particulate is present during an analysis. Each peak, representing an individual magnetic particle, is identified and quantified via a peak detection algorithm embedded in the Q230. The red dots indicate the beginning and end of an identified magnetic particle peak. At a peak threshold of approximately 10 counts and a 20 micron spherical magnetic particle having a signature of 30 counts above the baseline we can clearly see individual magnetic particles all the way down to 20 microns in diameter. During the manufacturing process, the response of each Q230 unit is calibrated to ensure that it provides an accurate and highly sensitive magnetic particle determination of individual magnetic particles. This is validated before shipment of each unit via test with LNF-545 check

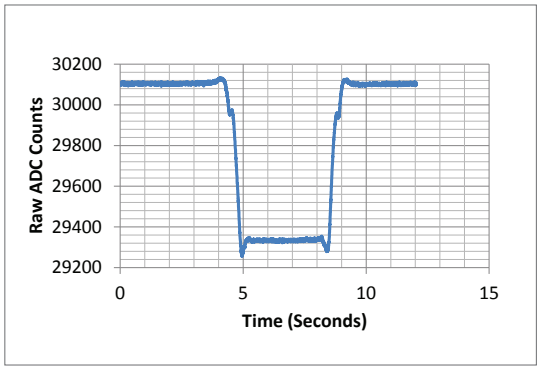
fluid. The fluid contains a near-monodisperse mixture of 42 micron magnetic particles. Each Q230 unit must correctly determine the average magnetic particle size to within +/-5 microns before shipment.

The second magnetic sensor, which determines overall magnetic ppm in the sample being analyzed, is designed to be highly accurate across the range of environmental conditions that can be encountered by the Q230. During manufacture, a calibration is performed to ensure that, under any circumstances, the unit must consistently determine the 0 ppm point to within +/- 7 ppm. An eight hour temperature, solvent, and viscosity sweep is performed to ensure this is the case for each unit. The LNF-545 fluid also contains a homogeneous distribution of nearly dissolved, nanometersized magnetic particles with a calibrated total magnetic content of 100 ppm. The final calibration step for any Q230 involves ensuring that this magnetic content is accurately determined to within +/-10%.

These magnetic signals are determined by comparing the dc signal in the magnetometer, when there is the fluid under test, into the flow line when there is solvent in the flow line. This is illustrated in Figure 2, which shows an example trace of the response of the magnetometer to a magnetic fluid. The 100 ppm sample produces a raw signal of 770 counts, (i.e., the device outputs approximately eight counts per ppm of magnetic material). Due to the extreme accuracy of this magnetometer subsystem, all Q230 units manufactured have essentially this identical sensitivity. With an acceptable instantaneous noise level during manufacture of 20 counts in the magnetometer, an instantaneous noise equivalent of at least 2.5 ppm is validated upon manufacture in each Q230. As the device averages 2500 samples during its five second measurement time, sub-ppm noise levels are standard. Other application notes, which compare the performance of the magnetometer with industry standards, show the technology considerably outperforms any available on the market.

Figure 3 shows repeatability of the magnetometer performance after 20 consecutive runs. A 3 sigma repeatability of 2.5 ppm out of 33 ppm beats the best performing magnetometers in the industry by several folds.

Figure 2: Example magnetometer trace between when the cell contains a 100 ppm magnetic fluid (between approximately 5 - 8.5 seconds) indicated by the dip in the signal and when no magnetic fluid is in the cell. This shows the extreme sensitivity of the device to the presence of magnetic fluid.



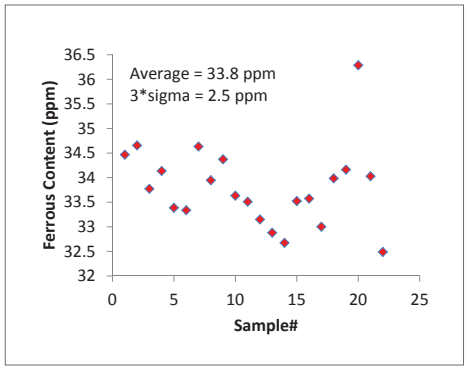


Figure 3: Example of repeatability of 20 consecutive measurements

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