



## ***S2.4.1 - Using Particle Counting to Measure Test Dust Concentrations Suspended in Fluid***

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Laboratory testing for filter capacity utilizes gravimetric measurements to determine the mass of test dust not retained in the filter element during multipass testing. Obtaining high-quality gravimetric results is challenging. It requires robust test methodology, consistent operator processes, and time. However, since multipass testing uses standardized Arizona test dust according to ISO 12103-1, it's reasonable to consider measuring gravimetric level based on the number and size of test dust particles suspended in the test fluid. Using particle counting to determine the mass of test dust suspended in a fluid can be done by assuming all particles are spherical, calculating the total volume of test dust per unit volume of test fluid, and using the density of test dust to calculate the total mass of test dust. This returns a concentration just like traditional gravimetric based on ISO 4405, with a mass of dust per unit volume of fluid. Of course, the dust particles are not truly spherical but preliminary data has shown measured concentrations can be comparable to traditional gravimetric and may be more consistent. Advantages of using particle counting instead of

traditional gravimetric include more flexibility in sampled volume, decreased test time, and likely decreased variation between operators. Obtaining consistent results from automatic particle counters often presents many challenges. Measuring a sample with one type of particle counter vs another may return different results. Using the counts to determine the mass of test dust adds an additional factor requiring the counts to be both accurate and consistent. Most automatic particle counters also require dilution for lube oil samples. All particle concentrations presented here are measured using a Lasernet Fines Q230 (LNF) instrument developed by Spectro Scientific. This instrument is advertised as an automated wear debris analyzer but also has the capability to output cumulative particle counts from 4-100 micron. This instrument can analyze most new and used diesel engine oils without dilution. Standard multipass testing according to ISO 4548-12 suggests the use of aircraft hydraulic oils which should be transparent with a red dye. However, this work is not specifically following ISO 4548-12 and all samples presented are 15w40 diesel engine oil with no dilution. In all samples presented here, ISO Medium Test Dust (MTD) was used. The LNF measurement range of 4-100 micron works well for the particle size distribution of MTD. To date, this concept has only been tried using MTD, but it should also work with other test dust distributions, provided the particle counter has a resolution in the proper size ranges. The main reason for developing this concept stems from observing large variation in gravimetric measurements during capacity tests in 15w40 lube oil. When gravimetric were returning inconsistent results, the idea for using the LNF to measure particle concentration and convert to test dust concentration was developed. It takes less than 15 minutes to analyze a sample on the LNF and obtain results for comparison with gravimetric. While still in the vetting process, using the LNF to determine MTD gravimetric levels has shown great potential to become an effective alternative to traditional gravimetric measurements.

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Caleb Wilson's background is in Mechanical Engineering and he has been working within Cummins Inc. for the last 9 years. He was introduced to the filtration world as a co-op with Cummins Filtration where he performed various lube filter tests and spent a decent amount of time with particle counting in lube oil. After graduation, he was a diesel engine performance engineer for Cummins Power Systems and transferred to working in Cummins Filtration for the last 3 years. In his current role, he focuses on developing new lube oil filtration technologies and test methods.

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