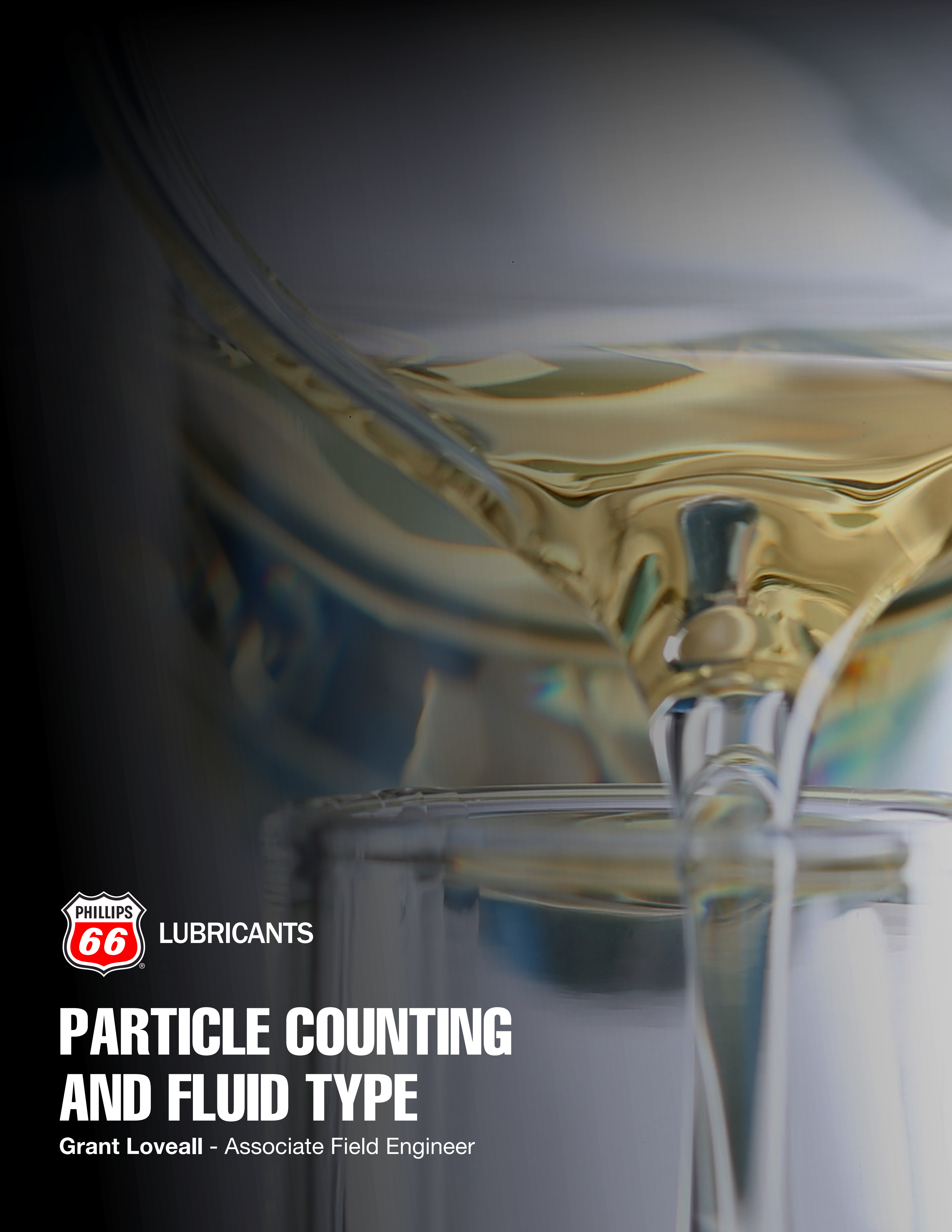

PHILLIPS 66 LUBRICANTS

PARTICLE COUNTING AND FLUID TYPE

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The main function of particle counting today in the lubricants industry is to identify hard particles in the lubricant that can lead to wear in a system. These hard particles can enter a system through a variety of ways including from the external environment, the system itself, and possibly from contaminants in the lubricant. In order to eliminate one mode of entry into lubricated systems there has been a push in the industry towards lubricants which are required to meet a specified cleanliness level depending on the application. While the cleanliness level is nearly always presented according to the ISO 4406 rating standard, there are several different methods by which the particles are counted. Unfortunately, depending on fluid type and sample preparation, particle count results can vary significantly. Understanding the reasons why and tailoring the cleanliness analysis program to the type of fluids being tested is integral to fluid monitoring.

Automated particle counters (APCs) are far and away the most common particle counting instruments in use today to monitor fluid cleanliness. These instruments flow a sample between a light source (often a laser) and a sensor. Anything that obstructs the light source and scatters the light from reaching the sensor will be counted as a particle, and the size of the shadow on the sensor is used to calculate the size of each particle. Water droplets, air bubbles, dispersed additives, along with contaminant particles will all obstruct the light from reaching the sensor and as a result be counted as particles. Direct imaging integrated testers, like LaserNet Fines, can recognize large air bubbles and water droplets and filter them out of the cleanliness results. However, they are still susceptible to count small bubbles and water droplets (<20 microns) as well as dispersed additives in much the same way that traditional particle counters are. The preferred way to mitigate this is sample preparation. Samples that contain dispersed additives or water can be diluted with certain solvents to dissolve the additives as well as mask the presence of water, while air bubbles can be removed by degassing the sample either by vacuum or sonic bath. A less common form of particle counting is the patch test, which eliminates false positives due to water and air bubbles and greatly mitigates false positives due to additives. In this method, the sample is diluted with a solvent, filtered through a patch, and a trained technician counts the particles under microscope and assigns a cleanliness code. While this method provides more accurate particle counts than the APCs listed above, it is also more labor intensive and expensive.

In order to illustrate the difference in particle counts provided by each method and the effect of fluid type, two drastically different unused products were examined. Each product was degassed and analyzed by LaserNet Fines, by APC with the sample diluted with solvent to eliminate false positives due to water and additives, and a patch test. The results are described in the table below.

Particle Count Method	Megaflow® AW 46	PowerTran® Fluid
LaserNet Fines	16 / 14 / 11	23 / 22 / 18
APC with Solvent Dilution	17 / 15 / 12	17 / 16 / 15
Patch Test	15 / 14 / 11	15 / 14 / 11

Before diving into these results, it is important to understand the design differences in the two products. Megaflow AW 46 is a lightly additized fluid that does not contain silicon-based anti-foam additives, whereas PowerTran Fluid is highly additized and does contain them. These additives are dispersed, not solubilized in the lubricant and as a result can be counted as particles by APCs. Another key design difference is how the two fluids handle water. Megaflow AW 46 is designed to separate from water, whereas PowerTran Fluid is designed with dispersants to hold on to and suspend the water in the fluid. This suspended water can also be counted as particles by APCs. The water content was 40 ppm for the Megaflow sample and 446 ppm for the PowerTran sample. With this information, we can revisit the cleanliness results above.

The sample of Megaflow AW 46 has consistent particle count results across all three methods with only slight variations, whereas the particle counts for the sample of PowerTran Fluid vary significantly depending on the method used. The LaserNet Fines instrument interprets the antifoam additives in the PowerTran sample as particles, and while it can filter out water droplets greater than 20 microns in size, it will count all water droplets smaller than 20 microns as particles. When the samples ran through the APC were diluted with a solvent to help solubilize the antifoam additives and mask the water droplets, this had little effect on the Megaflow® sample because it does not contain a significant amount of either, but the PowerTran® sample contains both insoluble additives and water and as a result the particle counts are reduced greatly. The patch test, least susceptible of the three methods to false positives from additives and water, provides the cleanest results for both fluids, however the results were only appreciably different for the PowerTran sample.

IN CONCLUSION

Knowing the type of fluid to be analyzed is crucial to deciding on the particle counting method to be used. Light industrial products like Megaflow AW, which do not contain large amounts of insoluble additives or hold water, can have the cleanliness measured accurately regardless of method if steps such as degassing are taken to remove air bubbles from the sample. Heavily additized products like PowerTran, which contain large quantities of dispersed additives and hold water in suspension, are more sensitive to the particle counting method performed and require sample dilution with a solvent or a patch test to accurately measure the cleanliness of the fluid.

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