WHITE PAPER

BECKMAN COULTER Life Sciences

Using Pressure to Reduce Bubble Contamination from Particle Count Results

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Abstract

False counts from bubbles can lead to costly downtime and create unnecessary production costs. In an effort to quantify the effect pressure can have on fluid samples containing bubbles, the pressure in the sample chamber of the HIAC 8011+ was increased and showed significant improvements in count data.

Introduction

Particle count data is a critical element to any fluid analysis program. The data obtained from a particle counter can be used to identify maintenance intervals for heavy equipment, indicate the cleanliness level of fuel or the quality of hydraulic fluid used in an aircraft. Because of the potential impact on production uptime, costly physical assets and even human safety, having reliable data is crucial.

How do you ensure quality data given the costly impact poor data can have on your operation? Creating a sample prep SOP specific for your particle counting application (ie collection, agitation, degas, sample) is a critical first step. However, the presence of bubbles in sample fluid is something that nearly all particle counting applications have to contend with. Even if you've taken the time to create a robust sampling protocol, bubbles in your sample fluid will add counts to your data and negate your efforts at getting consistent, reliable data. Research has historically shown that when bubbles are present in sample fluid, the data shows an abnormal distribution of counts across a large number of channels.

Bubbles can be created during the sample prep process when the sample fluid is agitated to get particles into suspension. Bubbles can also be created by the Particle Counter itself. Many instruments "pull" fluid through the wetted path, creating cavitation. This process can create micro bubbles and results in erroneous data.

Historically, use of an ultrasonic bath has been the standard method for removing bubbles from the suspension during the sample prep process. However, differences in fluid viscosity impact the length of time samples need to be introduced to the ultrasonic bath.

Pressure has a similar effect on bubbles in fluid. As pressure increases, bubbles eliminated as the gas is pushed back into solution. In an effort to enhance your sample prep SOP and the time required to get results, the HIAC 8011+ has incorporated a user configurable setting which pressurizes the sample chamber to a desired level and uses that pressure to "push" the sample through the Particle Counter Sensor.

This unique process provides a couple advantages to users. The first is the elimination cavitation by using pressure as the sample delivery mechanism. Secondly, using pressure can reduce sample handling and provides results similar to the traditionally accepted method of using an ultrasonic bath. Once the desired pressure is reached in the sample chamber, sampling automatically begins, according to the sample recipe (SOP) created by the user.

Method

8011+ System Setup	
Recipe Name	Bubble Evaluation
Number of samples / run	3
Sample volume	5ml
Tare	1.8ml
Sample volume	Counts/ml
Reporting Standard	2,3,4,5,7,12,14,21,25
Channel sizes	80 PSI
System Pressure	40 PSI

Prepare a water sample

1. Blow out a new unused sample bottle for 5 seconds with clean dry air.
2. Fill the bottle to the shoulder with water and install into the 8011+
3. Run the "Bubble Evaluation" Recipe
4. Ensure this baseline run is saved to the USB drive

Prepare a "bubble" sample to run at 50 PSI Sample Pressure

5. Ensure this baseline run is saved to the USB drive
6. Prepare one of sample bottles of sample fluid by performing the following:
    a. Handshake for one minute
    b. Immediately install into the 8011+ sample chamber and run the "Bubble Evaluation" recipe
    c. Ensure this bubble run is identified and saved to the USB drive.
    d. Re-shake this sample again for one minute
    e. Degas for 25-35 seconds
    f. Immediately install into the 8011+ sample chamber and run the "Bubble Evaluation" recipe again
    g. Ensure this degassed run is saved to the USB drive.
    h. Repeat procedure for 60, 70 and 80 PSI

Results

Test data showed that as pressure in the sample chamber increased, particle counts decreased across all channel sizes. In samples where an ultrasonic bath was used during sample prep, additional improvement in count data was seen. Specifically, test data showed that use of an ultrasonic bath had a greater impact on count data on smaller channels (2,3,4µm). Comparing the data compiled in Tables 1 and 2, use of an ultrasonic bath had less of an impact on count data at channels > 5µm when compared to the data that used pressure alone. The count difference between these two methods on the larger channel sizes resulted in an average differential of 10% or <10 counts/ml across these channels.

As seen in Table 1, a significant count difference was realized when pressure was increased from 50 PSI to 80 PSI. Across all channels, counts decreased by an average of 31.7% when an ultrasonic bath was used. Similarly, under worst case scenario conditions where a sample was shaken and introduced directly to the sampler, counts decreased by an average of 27.7% when pressure increased to 80 PSI.

Chamber Pressure and Ultrasonic Bath Count Data					
Size	50 PSI	60 PSI	70 PSI	80 PSI	%improvement in counts
2	920	855	712	730	21%
3	522	479	399	389	25%
4	331	307	253	241	27%
5	147	132	109	96	35%
7	136	123	100	87	36%
12	87	77	60	54	38%
14	5	4	3	3	40%
21	1	2	0	0	100%
25	0	1	0	0	NA

Table 1.

Chamber Pressure Count Data					
Size	50 PSI	60 PSI	70 PSI	80 PSI	%improvement in counts
2	828	865	828	812	2%
3	457	477	453	437	4%
4	294	304	284	273	7%
5	134	130	121	106	21%
7	124	122	110	95	23%
12	86	75	71	60	30%
14	7	5	3	4	43%
21	3	2	1	1	67%
25	1	1	0	0	100%

Table 2.

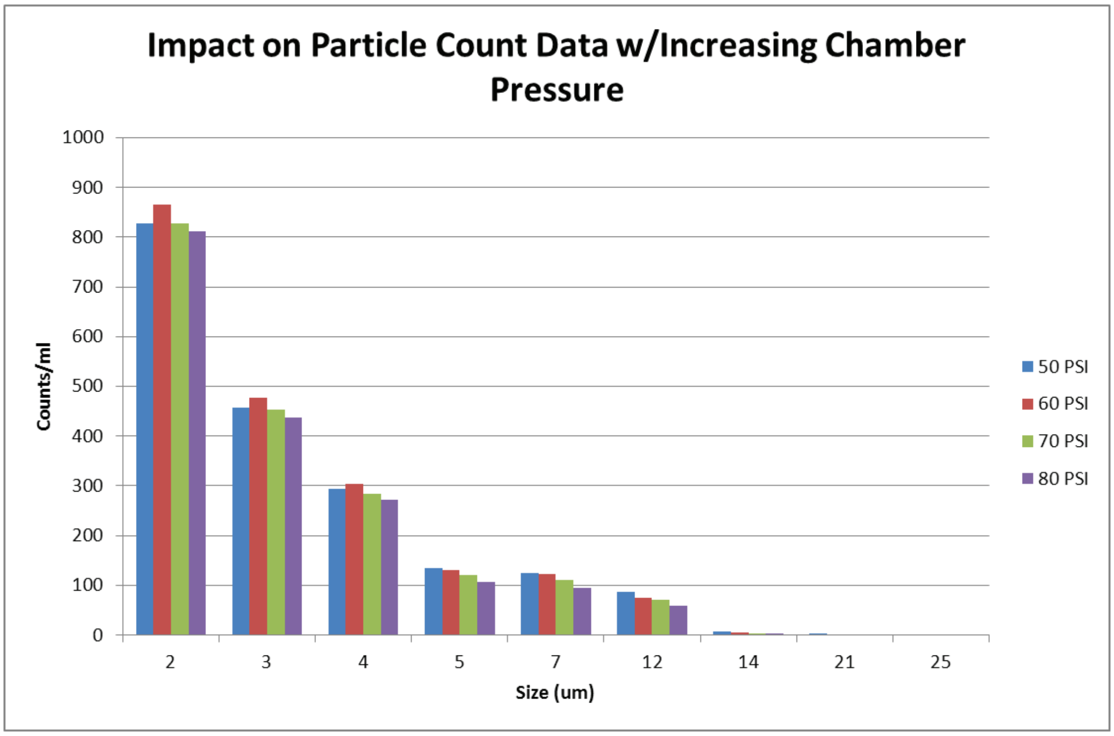

Figure 1.

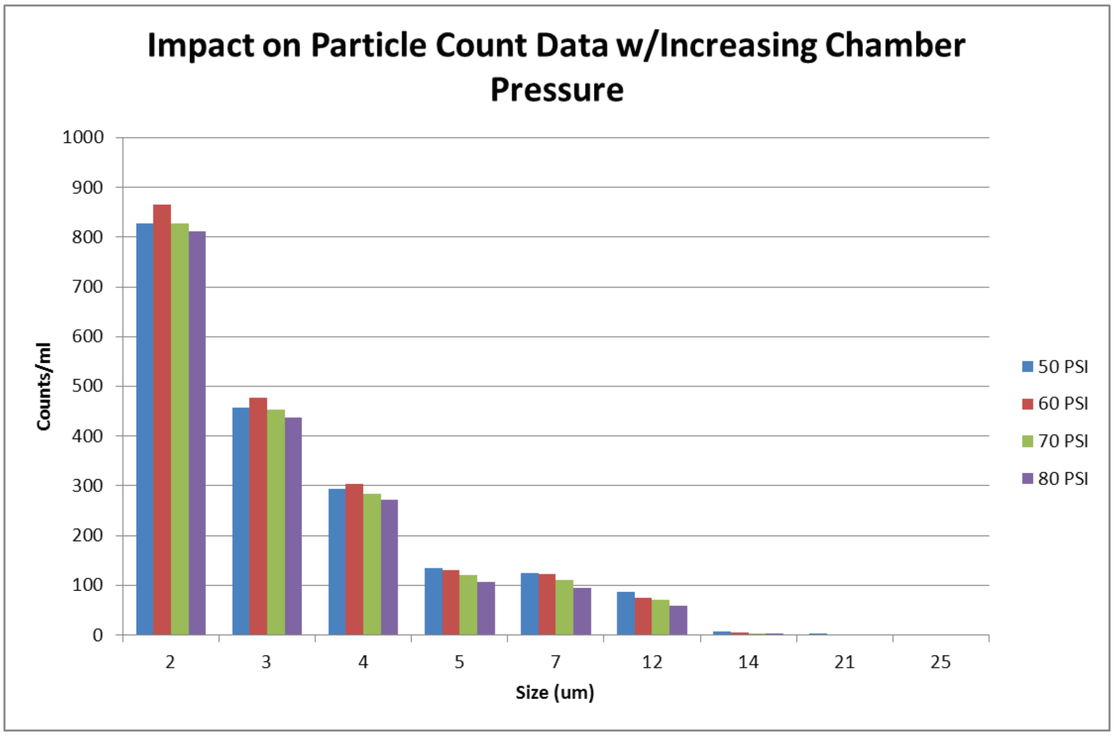

Figure 2.

Conclusion

One of the goals during the design process of the HIAC 8011+ was to provide reliable data to users regardless of the condition of the sample. This led to the need for the design team to develop a method for eliminating bubbles entrained in sample fluid. Micro-bubbles commonly appear in samples following agitation and can greatly impact count data. The need to mitigate the effects of bubbles drove the design team to create an instrument that allowed for configurable pressure levels in the sample chamber. While it is commonly accepted that pressure removes entrained air from liquids, we wanted to quantify the improvement seen over a wide set of pressures.

The HIAC 8011+ has a configurable pressure setting that allows users to set the chamber pressure up to 90 PSI. Utilizing this feature allowed for us to demonstrate that, for the samples under test, an increase in pressure resulted in a decrease in counts. The largest improvement in counts was seen in the larger sized channels; however, in the data set that required use of an ultrasonic bath, counts were reduced by up to 40%. Further, data indicates the even under worst case scenario conditions where a sample is agitated then placed directly into the sample chamber, significant improvements in count data are still seen.

False counts can create downtime and drive unnecessary production costs. It is critical that the data generated is truly representative of the sample fluid itself. While the data presented in this paper is limited in scope, the same method could be used on additional fluids to determine the impact pressure has on bubble elimination. The ability for users to dial-in the optimum pressure for a particular fluid increases the precision of the data and reduces the potential for costly downtime.

About the author

Dave Dunham is a Global Marketing Manager for Beckman Coulter Life Sciences. In this role he manages the HIAC portfolio of liquid particle counters and has helped drive the development of both the HIAC 8011+ and the HIAC ROC. Dave is also a member of the ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants. He has a B.S. in Microbiology from Oregon State University and an MBA from Marylhurst University.

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