

Indoor Environment CONNECTIONS™

The Newspaper for the IAQ Industry

www.ieconnections.com

Volume 6, Issue 11 • September 2005

Info Overload: What Do My Particle Counts Mean?



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What is the difference between an orange?

You may be thinking, what kind of question is that? Different than what?

Common sense, and a decent background in the English language, tells us we need to compare the orange to something else to determine any differences.

One of the most common questions I am asked regarding particle counters pertains to the values, or particle counts, the instrument just recorded. I am often asked, "Jim, I just took a sample with my new particle counter. I got 40,000 counts at 0.3 μ (microns). What does this mean? Is that good or bad?"

My typical response to this question is that one set of data, in and of itself, means very little. Kind of like the question I posed earlier regarding the orange. Unless we compare the particle counts to a baseline of previously recorded counts, the new set of data has little value. As we

know, other than the U.S. Environmental Protection Agency's PM_{2.5} and PM₁₀ (mass concentration), there are no standards for particulate levels in the IAQ industry. This is due in part to the nature of airborne particulates, and the many influences that man and nature play in particulate generation and movement.

Particle Counter Terminology

There are different types of particle counters – handheld, portable and remote. For ease of portability, I generally use a handheld instrument during IAQ investigations. When using particle counters, one needs to be aware of certain terms or phrases that are commonly used when describing functions of the instrument, or how the data is viewed and reported. Data are displayed in either Cumulative or Differential mode. When viewing the data in Cumulative mode, the number (counts) associated with each channel size is the number of particles that the instrument counted for that size and greater.

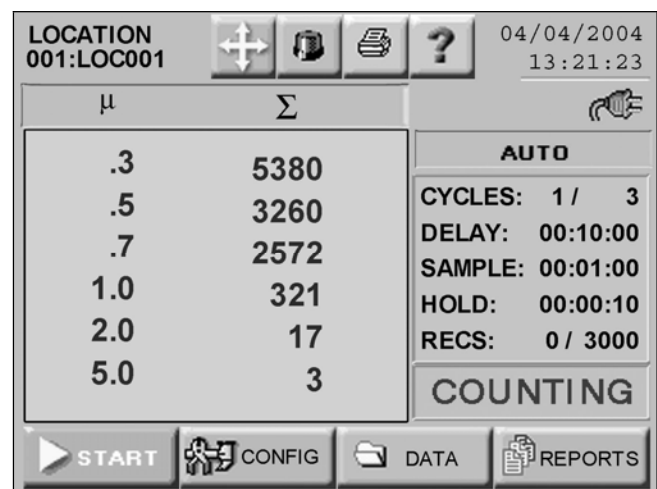


Figure 1

Figure 1 shows that 5,380 particles were 0.3 μ in diameter and greater; 3,260 particles that were 0.5 μ in diameter and greater; 2,572 particles that were 0.7 μ in diameter and greater; and so on.

If the data are being viewed in Differential mode, then the counts associated with each channel size would indicate the number of particles that are at least that micron size in

This article is reprinted from Volume 6, Issue 11 (September 2005)
 of *Indoor Environment Connections* newspaper.

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Instrument Model: HANDHELD 3016 Instrument Serial #: 030502002 Downloaded On: 7/28/2005 07:07:02 Particle Data: Cumulative Data Duration: 7/27/2005 15:41:40 to 7/27/2005 16:15:51												
Timestamp	Location (Number)	Location (Name)	0.3 micron (Counts)	0.5 micron (Counts)	1.0 micron (Counts)	3.0 micron (Counts)	5.0 micron (Counts)	10.0 micron (Counts)	Sample Time (s)	Sample Volume (ft ³)	Temperature (F)	Relative Humidity (%)
7/27/2005 15:41:40	1	Outside	131146	13060	2402	473	226	39	60	0.1	85.4	26.2
7/27/2005 15:42:50	1	Outside	123257	11922	2121	418	210	34	60	0.1	87.9	24.4
7/27/2005 15:43:59	1	Outside	118974	12235	2345	419	191	31	60	0.1	90.3	24.3
Average			124459.0	12405.7	2289.3	436.7	209.0	34.7	60.0	0.1	87.9	24.9
7/27/2005 15:46:09	2	Jim's desk	75845	6450	725	62	16	6	60	0.1	79.6	32.6
7/27/2005 15:47:21	2	Jim's desk	75218	6357	693	43	12	1	60	0.1	78.6	34.2
7/27/2005 15:48:30	2	Jim's desk	74486	6321	684	37	12	3	60	0.1	77.1	36.7
Average			75183.0	6376.0	700.7	47.3	13.3	3.3	60.0	0.1	78.4	34.5
7/27/2005 15:57:57	3	Sensor Lab	24070	1804	185	19	11	7	60	0.1	72.7	42.0
7/27/2005 15:59:06	3	Sensor Lab	23360	1780	193	23	11	8	60	0.1	72.7	41.5
7/27/2005 16:00:15	3	Sensor Lab	23671	1755	199	18	9	5	60	0.1	71.8	41.6
Average			23700.3	1779.7	192.3	20.0	10.3	6.7	60.0	0.1	72.4	41.7
7/27/2005 16:01:38	4	Men's Room	59276	5103	768	121	61	21	60	0.1	72.7	43.7
7/27/2005 16:02:46	4	Men's Room	57975	4905	745	123	66	23	60	0.1	72.7	46.1
7/27/2005 16:03:54	4	Men's Room	57351	4761	687	113	58	22	60	0.1	71.8	44.6
Average			58200.7	4923.0	733.3	119.0	61.7	22.0	60.0	0.1	72.4	44.8
7/27/2005 16:05:38	5	Manufacturing Area	48253	3995	533	73	36	8	60	0.1	73.7	41.8
7/27/2005 16:06:43	5	Manufacturing Area	47519	4086	531	72	37	17	60	0.1	73.2	41.3
7/27/2005 16:07:48	5	Manufacturing Area	48864	4394	647	96	55	24	60	0.1	74.2	40.8
Average			48212.0	4158.3	570.3	80.3	42.7	18.3	60.0	0.1	73.7	41.3
7/27/2005 16:09:16	5	Lunch Room	52291	4419	595	68	38	10	60	0.1	74.7	40.1
7/27/2005 16:10:21	5	Lunch Room	52795	4473	671	123	61	27	60	0.1	75.2	38.5
7/27/2005 16:11:26	5	Lunch Room	51272	4454	593	82	44	22	60	0.1	76.2	38.2
Average			52119.3	4448.7	619.7	91.0	47.7	19.7	60.0	0.1	75.3	38.9
7/27/2005 16:13:41	7	Sensor Lab Flow Hood	1984	157	13	1	0	0	60	0.1	75.2	42.0
7/27/2005 16:14:46	7	Sensor Lab Flow Hood	1965	138	10	0	0	0	60	0.1	75.2	42.3
7/27/2005 16:15:51	7	Sensor Lab Flow Hood	1735	130	14	1	1	0	60	0.1	74.7	41.8
Average			1894.7	141.7	12.3	0.7	0.3	0.0	60.0	0.1	75.0	42.0

Table 1

diameter, up to, but not including the next size. Using the data above (if sampled in Differential mode), we would see that there are 5,380 particles that are between 0.3 μ and 0.499 μ ; 3,260 particles that are between 0.5 μ and 0.699 μ ; 2,572 particles that are between 0.7 μ and 0.999 μ , etc.

Data format is also an important idea to understand. Some handheld particle counters display the data as either raw (actual number of particles counted for the time or volume being sampled) or normalized (generally used when certifying or verifying cleanroom classifications). Regardless of the sample time or volume, the count results are displayed in particles per cubic foot or cubic meter. If a one-minute sample is taken (0.1 cubic feet per minute), the counts are multiplied by 10 to give the results in particles per cubic foot; this is done to meet the cleanroom standards requirement of particles per cubic foot (Federal Standard 209e) or particles per cubic meter (ISO 14644-1). (These standards are explained in further detail later in this article.)

Most particle counters allow you to select a sample time or volume for each sample. Handheld particle counters are generally set to sample 0.1 CFM. I would suggest that you sample for at least one minute; this ensures that you test enough air to give a representative idea of what is happening in the area being sampled. Often, I will take three samples at each location and use the average of the three counts.

Many particle counters allow you to assign location numbers to your samples. Changing location numbers when you sample in different areas assists in keeping the data in a logical order. Each time you move the particle counter, change the location number. This, combined with a timestamp including the date, will ensure that your data are represented clearly and concisely.

Table 1 shows a sample download of some counts taken in seven different locations around our office. Data were gathered in Cumulative mode, and the counts are in

raw format. Figures for temperature and relative humidity are also included. Three samples were taken at each location, and an average was provided for each set of data. Also, note that the counts taken outside are higher than any of the samples taken indoors.

The counts in Location 7 are extremely low. This area is a laminar flow hood, and is where sensors for our particle counters are manufactured. Also, notice the counts that are 1.0 μ in diameter and greater. Outside, there were an average of 2,289.3 counts at 1.0 μ and greater (which equates to 22,893 counts per cubic foot). If any of the other six locations were to have that many counts, I would have been concerned, as this indicates the possibility of active mold growth. As you can see, none of the other locations were within even 50 percent of this – the closest being the men’s room at 32 percent!

Particle Counters Used in an IAQ Investigation

Now that we are familiar with particle counter terminology, let’s focus on how a particle counter can assist us with our IAQ investigations. As we know, particle counters offer immediate results that define the number of particles present in the sample volume, as well as a size distribution. Each individual IAQ professional can determine his or her own sampling methodology, but each “plan” should contain a few basics.

First and foremost, when sampling in either a residential or business setting, particle counts should be taken outside the building. These readings will be the start of our baseline against which we will be comparing subsequent counts. In an ideal situation, the particle counts outdoors will always be higher than the readings gathered inside. Isn’t that one of the reasons we live in structures – to be protected from the elements? However, in many instances, the level of airborne particulates inside is greater than outdoors. This can be construed as our first indicator that something may be amiss.

Secondly, take samples throughout the structure, paying particular attention to areas of concern from the residents, or where a previous water intrusion is evident. This is establishing your baseline further. My experience indicates that the more samples taken, the more statistically valid your results will be. As we are aware, mold spores are generally between one and 10 μ in diameter. Pay close attention to these channels, as this will be an indicator that mold may be present in the vicinity.

Once an area of concern has been discovered (elevated counts at one micron and greater), additional sampling is in order. By taking multiple counts in various locations, one can start to pinpoint the source of the problem. Traditional sampling methods (Air-O-Cell cassettes, swab sampling, etc.) should be used to determine the types of mold, CFUs, etc.

Comparing Particle Counts to Cleanroom Standards

There are a number of industries outside the IAQ profession that require manufacturing to be done in a clean, controlled environment – commonly called cleanrooms. These are specially designed areas where temperature, humidity, airborne particulates, differential pressure, electrostatic discharge, airborne molecular contamination, and other factors are all closely monitored and controlled. It has been proven that excess particulate matter will have a negative effect on product yield for manufacturers of semiconductors and disk drives. For the pharmaceutical, biotechnology, and medical device-manufacturing industries, the Food and Drug Administration requires that all devices and drugs be produced in a controlled environment.

As alluded to earlier, the two cleanroom standards currently being used in the United States are the Federal Standard 209e and ISO 14644-1. Standard 209e is being replaced by the newer ISO 14644-1 standard, but about 60 percent of our customers are still using it.

In both standards, there are different classifications of cleanrooms denoting the cleanliness level. For Standard 209e, the classifications are Class 1 (the “cleanest” designation), Class 10, Class 100, Class 1,000, Class 10,000 and Class 100,000. For the ISO 14644-1, the classifications are ISO 1 (cleanest), ISO 2, ISO 3, ISO 4, ISO 5, ISO 6, ISO 7, ISO 8 and ISO 9.

For each classification, there is a maximum number of particles allowed at certain sizes per cubic foot (Fed 209e) or cubic meter (ISO 14644). Each standard has a detailed procedure that must be followed to determine the number of sampling locations, how many samples must be taken at each location, and the minimum volume of air that must be sampled at each location. All counts are taken using Cumulative mode, and are reported in either particles per cubic foot or particles per cubic meter. Table 2 shows the associated number of particle counts allowed for each classification.

Often, we can compare the particle counts we gather to these standards. If we were to use just particle counts, then my desk would meet the classification of a Class 100,000 cleanroom as there were 63,760 counts at 0.5 μ and greater. (An average of 6,376 counts for 0.1 CFM is multiplied by 10 to demonstrate 63,760 particles per cubic foot.) This type of comparison can be done for your customers as another way of explaining particulate levels.

Assessment, Cleaning & Restoration of HVAC Systems

Another common use of handheld particle counters pertains to the National Air Duct Cleaners Association’s ACR 2005 standard. Chapter 2, on particle-profiling

This article is reprinted from Volume 6, Issue 11 (September 2005)
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Federal Standard 209e and ISO 14644-1 Clean Room Standards

ISO Class	FED 209e	0.1 micron		0.2 micron		0.3 micron		0.5 micron		1.0 micron		5.0 micron	
		(M ³)	(FT ³)	(M ³)	(FT ³)	(M ³)	(FT ³)	(M ³)	(FT ³)	(M ³)	(FT ³)	(M ³)	(FT ³)
1		10		2									
2		100		24		10		4					
3	1	1,000	35	237	7.5	102	3	35	1	8			
4	10	10,000	350	2,370	75	1,020	30	352	10	83			
5	100	100,000		23,700	750	10,200	300	3,520	100	832		29	
6	1,000	1,000,000		237,000		102,000		35,200	1,000	8,320		293	
7	10,000							352,000	10,000	83,200		2,930	70
8	100,000							3,520,000	100,000	832,000		29,300	700
9								35,200,000		8,320,000		293,000	

To convert particles per cubic foot (ft3) to particles per cubic meter (m3) the count value needs to be multiplied by 35.31
 1,000 liters equals 1 cubic meter
 35 cubic feet equals 1 cubic meter
 28.3 liters equals 1 cubic foot
 2.83 liters equals 0.1 cubic foot and 0.00283 cubic meters

Table 2

procedures, details how the use of a particle counter can assist in ascertaining the levels of respirable and countable particles in the HVAC system. This value can then be compared to the expected particle removal efficiency of the air filters in use. NADCA states that the results obtained from this procedure are then used to “determine if certain sources of contamination are likely originating from within the HVAC system, and are subsequently contributing these undesired agents or particles to the indoor ambient air.”

Some duct-cleaning companies are also using handheld particle counters to ensure proper cleaning of the HVAC ducts have been performed. Particle counts are taken throughout the ductwork prior to cleaning. Cleaning is performed, and the same locations are again sampled. Obviously, we hope the particle counts are substantially lower after this process. I have assisted in this type of sampling in the past, and was pleasantly surprised at the difference in particulate levels after cleaning. In one section of the ductwork, an 80 percent decrease in particulate levels was observed.

Particle Counts vs. Traditional Sampling Methods

I am often asked if there is a correlation between particle counts and data gathered by the more traditional sampling methods. To my knowledge, no one has performed this type of testing and published their findings. However, many of the IAQ professionals that I work with are convinced that there is indeed a correlation.

Within the past couple of months, I have initiated a program within the industry to compare particle counter data with lab results. When gathering samples for lab work, particle counts are taken in the same location and for the same time duration. Data are being logged and compared to the results provided by the labs. Upon completion of testing, I will report our findings to the industry.

Conclusion

Throughout this article, I have used some form of the word “compare” many times. As we have seen, when using a particle counter in your investigation, we need to first establish a baseline and then compare subsequent readings to this baseline. Whether comparing particle counts to a baseline or to another industry’s existing standard, the data gathered can be of great assistance in determining sources of airborne particulates.

Jim Akey is responsible for inside sales with the state-of-the-art manufacturing facility of Lighthouse Worldwide Solutions, a recognized leader in the design and manufacturing of aerosol particle counters. Akey holds a bachelor’s degree in business and has 20 years experience within the electronics and scientific instrumentation fields. He has participated in numerous IAQ investigations. A presenter at the National Air Duct Cleaners Association’s technical seminars, he is an active member of the Indoor Air Quality Association. Akey can be reached by e-mail at jakey@golighthouse.com or by phone at (541) 770-5905.

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