Extended ISO Class 1 for Nanoparticle Measurements

Cleanroom standards have been developed since the 1970's when clean manufacturing was utilized for aerospace and electronics. The first standards (Fed-Std 209e) only measured particles down to the 1 and 5 um size since technology did not allow the measurement of particles smaller than this. As technology has improved (and the need for control of smaller particles has developed), smaller and smaller particle measurement and control have continued. Subsequently, ISO took over the specifications for cleanliness control, and the first edition of ISO 14644 was released in 1999 to replace Fed-Std 209e, which had been used for many years. The second edition of 14644-1 was released in 2015 with many revisions to the 1st edition.

ISO 14644-1:2015 defines specification limits for cleanrooms as seen below in Table 1.

Table 1 – ISO Classes of Air Cleanliness by Particle Concentration

ISO Class Number (N)	Maximum Allowable Concentration (Particles/m^3) for Particles Equal To and Greater Than the Considered Sizes					
	0.1 µm	0.2 µm	0.3 µm	0.5 µm	1 µm	5 µm
1	10					
2	100	24	10			
3	1,000	237	102	35		
4	10,000	2,370	1,020	352	83	
5	100,000	23,700	10,200	3,520	832	
6	1,000,000	237,000	102,000	35,200	8,320	293
7				352,000	83,200	2,930
8				3,520,000	832,000	29,300
9				35,200,000	8,320,000	293,000

As shown in Table 1 and the scope of 14644-1:2015, the current specification only allows the measurement of particles down to 0.1 µm.

As additional parts of ISO 14644 have been developed, the need for a document that addresses particles smaller than 0.1 µm was found. As a result, a draft version of ISO 14644:12 was released, including specification limits for nanoparticles. The limits defined in Table 2 below were mathematical extrapolations from the values in Table 1 based on particle size.

Table 2 – Proposed ISO Classes for Air Cleanliness by Nanoscale Particle Concentration					
Proposed Classification	Maximum Allowable Concentration (Particles/m^3) for Particles Equal To and Greater Than the Considered Sizes				
	0.001 µm (1 nm)	0.005 µm (5 nm)	0.01 µm (10 nm)	0.05 µm (50 nm)	0.1 µm (100 nm)
1	145,000	5,080	1,200		10
2	1,450,000	50,800	12,000	423	100
3	14,500,000	508,000	120,000	4,230	1,000
4	145,000,000	5,080,000	1,200,000	42,300	10,000
5		50,800,000	12,000,000	423,000	100,000
6				4,230,000	1,000,000

However, when the full standard was released in 2018, the specification limits were removed; but the need to characterize nanoparticles has not gone away.

Simco-Ion manufactures many ionizer systems that do not generate particulates in the 0.1 – 5 µm range. But through testing with a condensation particle counter (CPC), we have found that many particulate bursts of "nanoparticle" sizes (0.01 – 0.09 µm) are occurring with some corona-based ionization systems. By optimizing several key ionization systems, Simco-Ion has manufactured excellent ionization systems that do not produce these particle bursts.

To quantify these measurements, Simco-Ion utilizes an in-house standard that extrapolates ISO 14644-1 down to 0.01 micron (10 nm) particles, measured with a condensation particle counter (CPC). We define this as "**Extended" ISO Class 1.**"

If we choose the "extrapolated ISO class 1" value for 10 nm (0.01 µm) particles, which is 1200 particles/m^3, and convert this to particles/ft^3, the number becomes 34 particles/ft^3. From this calculation, Simco-Ion has chosen to use this definition of "Extended ISO Class 1 Limit" for the number of particles ≥10 nm as 34.0 particles/ft^3

Simco-Ion is the only ionization supplier that develops and qualifies product cleanliness at cumulative counts ≥10 nm particle size – and publishes cleanliness data collected with a condensation particle counter.

Nanoparticle Measurement Examples

The figure below (Figure 1) shows long-term data collected with a condensation particle counter from a Modulated Pulse Aerobar. The horizontal axis represents time (5-months of data). The vertical axis is a log of the number of particles detected per cubic foot of air. Each red dot represents the average cumulative counts greater than or equal to 10nm (or 0.01 micrometers).

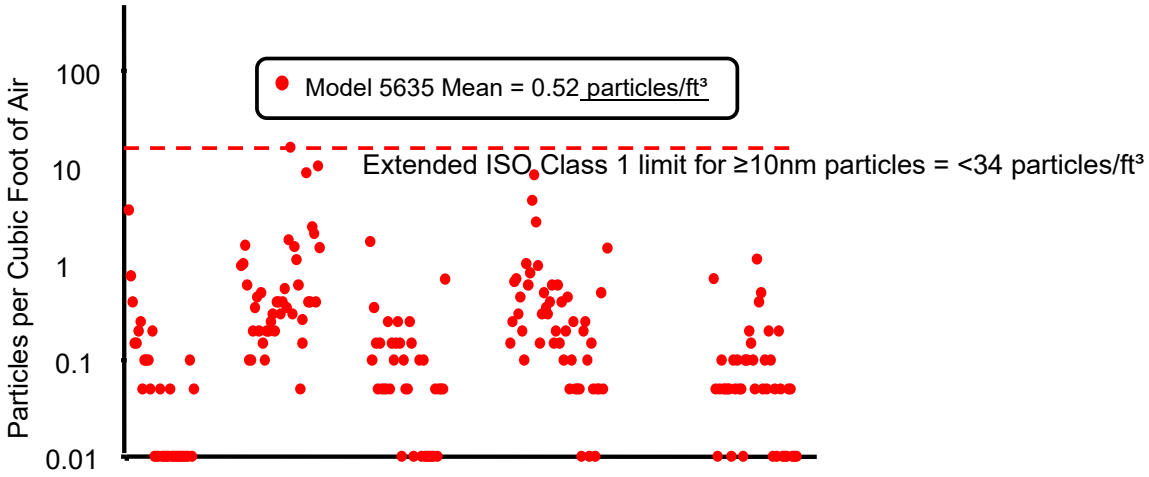
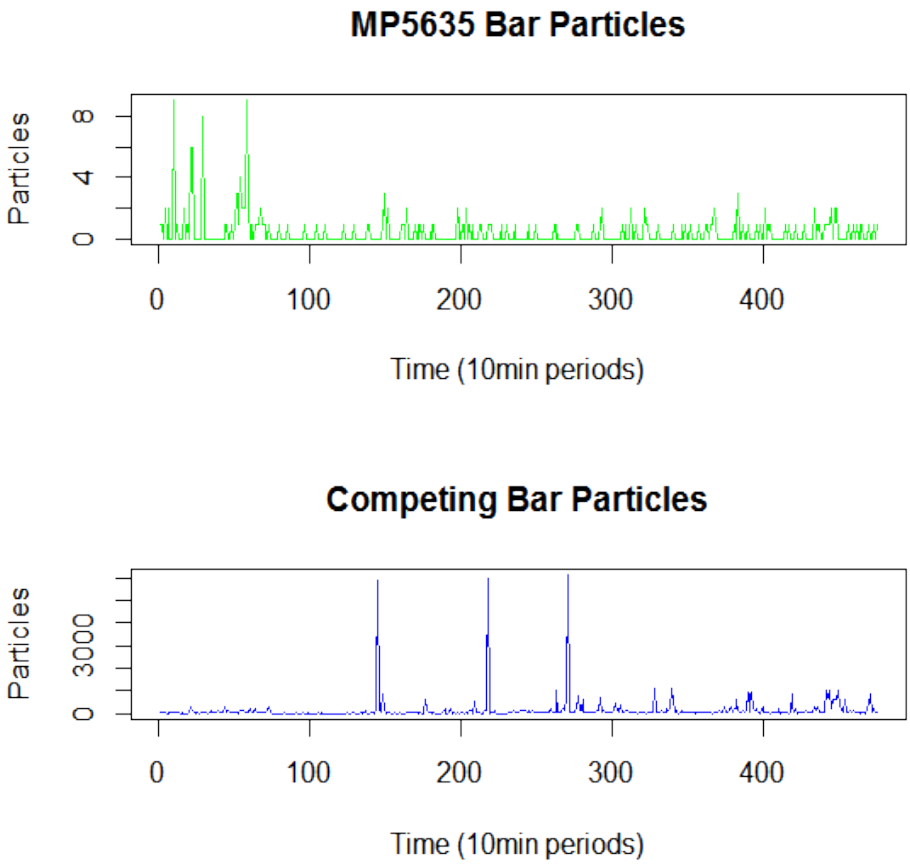


Figure 1 – Long-term nanoparticle count test data from the Model 5635 MP Aerobar

The figure below shows two comparison graphs for the Model 5635 Aerobar versus a competitor's product. It is important to note the scale on the left of the particles detected every 10 minutes.



As can be seen from these graphs, the competitor bar product has bursts of nanoparticles that are not desirable in many critical manufacturing environments.

The purpose of Simco-Ion's "**Extended ISO Class 1**" cleanliness measurement techniques and classification is the highlight the need for ultra-clean ionization technologies that are becoming needed more frequently with the latest semiconductor technology nodes.