Background. NanoSafe, Inc. developed a testing program to independently evaluate the generation and containment of a controlled nanoaerosol inside a Labconco XPert® Nano™ System. The purpose of the evaluation was to compare nanoparticulate levels generated inside the enclosure via a specialized ejector to particulate levels around the enclosure's sash opening and ultra low penetration air (ULPA) filtration exhaust. Test methods integrated aerosolization and characterization strategies described in recent peer-reviewed studies and one existing test method developed for fume hoods.

Test Enclosure. According to Labconco product literature (www.labconco.com), the XPert® Nano™ System provides user protection by keeping hazardous powders and particulates contained during procedures such as nanoparticle manipulation and dry powder chemical handling. The patented containment enhancing design features maintain user protection by drawing room air into the front of the enclosure, sweeping the cabinet interior, pulling the air to the back through the patented baffle, and filtering the air through a 99.999% bag-in/bag-out ULPA filter before returning the clean air to the laboratory. The all stainless steel interior (sides, worksurface, removable baffle and removable airfoil) is designed for easy wipe down and cleaning procedures. An optional built-in ionizer neutralizes static charge on interior surfaces by emitting ions into the airstream, which helps reduce weighing errors and attraction of particles to the enclosure surfaces.

Testing. To evaluate performance of the XPert® Nano™ System with aerosolized engineered nanoparticles, a series of tests were designed to generate precisely controlled nanoaerosol inside the enclosure and subsequently measure particle size and concentration at various locations inside the enclosure, around the sash opening and at the unit's ultra low penetration air (ULPA) exhaust.

Studies were adapted from ASHRAE 110-1995 and involved traverse-testing of the sash opening and ULPA exhaust during aerosolization of a precisely controlled aerosol of SiO_2 nanoparticles with a geometric mean diameter of 23±1.4 nm. Generation of the SiO_2 nanoparticle aerosols was accomplished using an approach adapted from Ostraat et al. (2008). The overall testing approach was based on Section 7.11 of ASHRAE 110-1995 ("Method of Testing Performance of Laboratory Fume Hoods") with some modifications (e.g., SiO_2 nanoparticles used in place of tracer gas, tests performed in clean room).

The concentration of the test aerosol delivered to the ejector was measured with a TSI Model 3022A Condensation Particle Counter (CPC). The CPC measured the concentration of particles greater than 7 nm and operated with a sampling rate of 1.5 Lpm. A TSI diluter Model 3302A was used to reduce the aerosol concentration in the CPC sample stream to be on-scale of the CPC. The diluter was operated at an 80:1 dilution ratio. The reported challenge particle concentrations have been corrected for this dilution ratio.

The size distribution of the challenge aerosol was measured with a TSI Scanning Mobility Particle Sizer (SMPS). The SMPS used a long DMA (TSI model 3081) and TSI model 3022A CPC. The SMPS was operated with 15 Lpm sheath air, 1.5 Lpm aerosol flow, 240 second upscan, 15 second downscan on a 6 minute repeat cycle. The scans covered the particle diameter range from approximately 7 to 224 nm.

The TSI 3022A CPC (without diluter) was used to perform the traverse measurements. The traverses were performed with a hand held probe connected to a flexible sample line connected to the inlet of the CPC. The CPC sampling rate was 1.5 Lpm. Each traverse began and ended with a high efficiency filter attached to the probe to bring the CPC concentration to zero. Measurements were taken with the ejector positioned at three different locations inside the enclosure. After completing the enclosure traverses for each of the three ejector locations, the ejector was moved to the center position and the CPC probe placed in the ULPA exhaust duct. A 2-minute sample was taken.

Results Summary. The size distribution of the SiO_2 nanoparticle challenge aerosol was measured at the start and end of the traverse measurements. The mean particle diameter was approximately 23 nm with a geometric standard deviation of 1.4. The front mounted pressure gauge read approximately 0.32 inches H_2O throughout the test series.

Inside the enclosure, particle concentrations were mostly in the 50,000 – 100,000 particles per cm^3 range at the mid and top heights. Along the bottom, the concentrations were significantly lower, ranging from about 10 to 1,000 particles per cm^3. With the traverse measurements around the sash opening showing an average maximum of about 1 particle per cm^3, containment could conservatively be expressed as approximately 99.99% ($100x\ (1 - 1\ cm^{-3} / 10{,}000\ cm^{-3})$). Determining containment in this manner was not the intent of the measurements nor is part of the ASHRAE tracer gas test. However, it does help put the results in perspective.

Based on results from the "5x full traverse" tests, the average maximum particle concentration measured during traverse-testing of the sash-opening during aerosol challenge was 1.83 / cm^3. For the entire test series, the maximum test value observed around the sash-opening was 3.82 / cm^3, but this value was found to likely be an anomaly attributable to external air penetration into one corner of the cleanroom (similar spikes were observed at this location during background sampling).

Sampling in the ULPA exhaust flow showed essentially zero particles. For both the aerosol and background measurements, the two-minute sample counted either 0 or 1 particle maximum. For the two minute ULPA exhaust samples, 1 particle represents a concentration of 0.002 / cm^3. Within the sensitivity of the test, the results indicate no leakage of particles greater than 7 nm diameter past or through the ULPA filter. This does not mean that particles of less than 7 nm penetrated the ULPA filter, only that 7 nm was the minimum particle size that could be quantified accurately using our instrumentation.

Limitations. This test addressed one aspect of enclosure containment. Specifically, modified ASHRAE 110 part 7.11 procedures were used to traverse the periphery of the test enclosure for outward leakage of the nanoparticle test aerosol under static operating conditions (i.e., no human activity in or around the enclosure other than the amount needed to perform the traverse itself). The ability of the enclosure, and fume hoods in general, to contain contaminants could be reduced by human activity in the enclosure and near the enclosure opening.

References

ASHRAE 110-1995: Method of Testing Performance of Laboratory Fume Hoods

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