nebulizer was utilized to generate NaCl particles ranging from 10–205.4 nm. The number concentrations for upstream and downstream of tested filters were measured through a set of Condensation Particle Counter (CPC) and an Electrostatic Classifier (EC) containing a long DMA. Consequently, the penetration (the ratio of downstream to upstream concentration) was calculated for the tested range.
Results: The penetrations at Most Penetrating Particle Size (MPPS) range (29.4–39.3 nm) reached 3.06, 3.49, 7.99 and 9.74 % under flows A, B, C and D, respectively; showing an increased penetration by either variations of frequency or PIF; however, the impact of PIF was significantly more important than frequency. It was also shown that the enhancement fraction value for PIF was more than 90 % if path ABD was followed; and more than 70 % if path ACD was pursued.
Conclusions: Penetration can significantly vary by any change in PIF, but slightly by breathing frequency. Thus, enhancement of penetration from low to high respiratory workloads (where PIF and breathing frequency are simultaneously increased) is mostly attributed to the rise of PIF and partially to frequency.

CS-131-05
Particle Statistics Applied to Filter Penetration When Challenged with Nanoparticles

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Objective: Studies have been conducted to determine the penetration (P) curve over a range of particle sizes of respirators or sampling devices. However, when using a polydisperse aerosol, considerable uncertainty exists when determining efficiency with counts made at the tails of the count distribution of the upstream aerosol. Given little guidance on the proper statistics to be applied to enumerate that uncertainty, the purpose of this study was to (1) review the literature for applicable methods for computing a 95% confidence interval about P, and (2) evaluate its use when challenging N95 respirators with nanoparticles.
Methods: Four methods for determining a CI about P were found in the literature. One of these methods was adopted for further analysis. The application of this method was applied hypothetically to establish a guideline for the use of P values. The method was also applied to lab-produced P values in which one type of N95 filtering facepiece respirator (FFR) was challenged with engineered nanoparticles consisting of various metal oxides as well carbon nanotubes, and measured over 103 size channels produced by a scanning mobility particle sizer.
Results: Based on the upper CI computed for each P value over a range of particle sizes, a guideline was established to eliminate P values for which the upper CI is less than 120% of the computed P value. This guideline was then applied to the FFR P data to determine a maximum penetration value. The highest P was measured for the carbon nanotubes (6.5%) and the lowest for silicon dioxide (2%).
Conclusions: The statistical method for computing an upper CI for P allows the use of a guideline for eliminating P values with excessive uncertainty. It is recommended that this method be followed in future filter and sampler penetration studies.

SR-131-06
Pressure Drop, Capture Efficiency and Dust Loading Capacity of Custom Fabricated High Efficiency Particulate Air (HEPA) Filters Before and After Being Cleaned and Reused

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Objective: To examine the possibility of cleaning and reusing industrial filters by determining the pressure drop, capture efficiency, dust loading capability of custom fabricated HEPA filters and comparing the findings with those of the same filters after being cleaned and reused multiple times.
Methods: Four different types of HEPA rated filtration media (2 sizes polypropylene, 1 size glass fiber, 1 size polyester, and 2 sizes teflon) were fabricated in cylindrical shape. Each filter was mounted in the filter compartment of a specially designed exhaust ventilation system and gradually loaded with cadmium contaminated dust emission in 10-

gram increments. The pressure drop was recorded as the filter was gradually loaded up to a total of 100 grams of emission while the airflow speed was kept constant at 3500 ft/min. Each filter media (except glass fiber and polyester) was reused at least 3 times. A used filter was cleaned in dilute (< 4%) nitric acid for 24 hours, rinsed with deionized water and dried under a laboratory hood to gain its original weight. The glass fiber and the polyester filters were used as reference media and were not cleaned or reused. A scale was used to monitor the level of loading and the weight of the filter during drying.
Results: The pressure drop across all filters (new or reused) increased exponentially as the filters were gradually loaded. Baseline pressure drop on new (unused) filters ranged from 0.2 to 0.4 inches of water column (wc) and as the loading continued, the pressure drop approached 0.8 to 1.2 wc. After each cleaning and drying cycle, filter's pressure drop was returned to its original baseline. All filter media, new or reused, performed well with capture efficiencies of 99.97% or higher.
Conclusions: The results suggest that custom fabricated HEPA filters can be cleaned and reused frequently.

SR-131-07
Descriptive Analysis of Industrial Hygiene Air Sampling Data Stored in OSHA's Integrated Management Information System Databank

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Objective: The Integrated Management Information System (IMIS) databank contains measurements taken by inspectors of the Occupational Safety and Health Administration (OSHA) to verify compliance to Permissible Exposure Limits (PEL). This databank represents the biggest source of exposure data in North America and could be used to estimate historical exposure distributions across a wide range of agents and industries. Despite reports published about specific agents (e.g. lead, silica, formaldehyde), little information is known about what data is available in IMIS. This paper presents a detailed descriptive analysis of the content of this databank.
Methods: An IMIS extract containing the results of all PEL compliance evaluations since the start of IMIS was obtained through the Freedom of Information Act. Descriptive statistics related to all variables included in the extract are presented.
Results: The IMIS extract, excluding screening results, contained 851,987 records corresponding to 132,280 inspections, and covering 1,022 Standard Industrial Classification (SIC) codes for the period 1979 to 2012. After removal of noise measurements and other records not related to chemical exposures, a total of 616,858 records remained of which 88% were personal samples representing either time-weighted average (TWA), short term exposure limit (STEL), peak, ceiling or non-detected results. Sixty-six percent of all results corresponded to unprogrammed visits (e.g. complaint, referral) while the remaining were obtained during regularly scheduled inspections. Of the 1,169 different agents present in the database, 55 had greater than 1,000 personal measurements, constituting 84% of all personal samples. Metals (lead, iron oxide, copper, zinc, manganese), solvents (toluene, xylene), and dust/fibers (crystalline quartz, asbestos) were the chemical families with the most personal measurements.
Conclusions: IMIS contains a large number of personal measurements covering important chemical families and industrial sectors over a long period of time, and researchers should consider this databank among potential sources of occupational exposure information.

SR-131-08
Fiber Escape from Asbestos Abatement Enclosures – Quantitative Results

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Objective: The purpose was to investigate airborne fiber levels outside asbestos-containing material (ACM) abatement enclosures and in adjacent clean work areas, during specific tasks. The tasks were physical abatement (e.g. scraping, cutting), removal of

ABSTRACTS

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