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70.

DROPLET DEPOSITION IN INDUSTRIAL DUCT BENDS. T. Peters, D. Leith, University of North Carolina, Chapel Hill, NC.

A study of droplet deposition in industrial duct bends is presented. Factors investigated were: (1) flow Reynolds number [Re = 203,000, 368,000]; (2) particle Reynolds number [$10 \leq Re_p\infty \leq 200$]; (3) particle Stokes number [$0.08 \leq Stk \leq 16$]; (4) bend angle [θ = 45°, 90°, 180°]; (5) bend curvature ratio [$1.7 \leq R_0 \leq 12$]; (6) orientation [horizontal-to-horizontal and horizontal-to-vertical]; and (7) construction technique [smooth, gored, segmented]. Measured deposition was compared with models developed for bends in small diameter sampling lines ($Re < 20{,}000$; $Re_p\infty < 13$).

Whereas deposition measured in this work generally agreed with that estimated with models for particles smaller than 30 µm ($Stk < 0.7$), it was significantly lower than that estimated for larger particles. As the flow around larger particles became increasingly turbulent, the models progressively under-represented drag forces and over-estimated deposition. For particles larger than 20 µm, deposition was slightly greater in the horizontal-to-horizontal orientation than that in the horizontal-to-vertical orientation due to gravitational settling. Penetration was not a multiplicative function of bend angle as theory predicts due to the developing nature of turbulent flow in bends. Deposition in a smooth bend was similar to that in a gored bend; however, a tight radius segmented bend ($R_0 = 1.7$) exhibited much lower deposition. For more gradual bends ($3 \leq R_0 \leq 12$), curvature ratio had negligible effect on deposition.

A new model was constructed to explain these results and is applicable to a broad range of industrial situations. Using this model, engineers can optimize ventilation systems to better protect workers—increased protection from harmful contaminants, reduction of duct fires, and/or reduced explosion risks—at reduced operating costs and/or less-frequent system maintenance intervals. Moreover, this model will enable health officials to evaluate bioterrorist threats, such as deposition of anthrax in ducts.

71.

INDOOR AIR PURIFICATION BY IONIC EMISSION. S. Grinshpun, B. Lee, M. Yermakov, University of Cincinnati, Cincinnati, OH.

Among various techniques that reduce the indoor concentration of respirable particles, ionic emitters have been increasingly used in office, industrial, and residential environments. Some ionization-type air cleaners incorporate corona effect to the airborne particles that make the unipolarly charged particles repel and migrate toward the indoor surfaces. In this study, five ionic air purifiers were evaluated in a 25-m^3 nonoccupied, unventilated room. The study was conducted with the particles of typical virus and bacteria sizes (aerodynamic diameter = 0.04 to 2 µm). The particle concentration and size distribution were measured as a function of time with the electrical low pressure impactor that has a real-time measurement capability. The aerosol concentration decay occurring due to the ionic emission was compared to the natural decay. It was found that the ion flow in the tested air environment increased the electric charge of aerosol particles by one to two orders of magnitude, depending on the particle size. The operation of the unipolar ion emitter producing about 10^6 e^-/cm^3 reduced the aerosol concentration by a factor of 5 in 15 minutes and by a factor ranging from 15 to 30 in 30 minutes. The ionic air purification efficiency was found to be primarily dependent on the ion emission rate and the indoor air volume.

72.

AEROSOL GENERATION BY BLOWER MOTORS AS A BIAS IN ASSESSING AEROSOL PENETRATION INTO CABIN FILTRATION SYSTEMS. W. Heitbrink, S. Collingwood, University of Iowa, Iowa City, IA.

Cabin filtration systems use blower motors to pressurize a vehicle's cab with clean, filtered air and to recirculate air through the heater and air conditioner evaporator cores. These systems reduce operator exposure to aerosols, such as pesticides, respirable crystalline silica, and bioaerosols, by a factor of 10–50. To evaluate compliance with product performance specifications, optical particle counters are used to measure size-dependant aerosol concentration inside and outside the cab. The ratio of inside to outside concentration is termed penetration. Blower motors use stationary carbon brushes to transmit electricity to a rotating armature, creating dust. Emissions from four blowers used in agricultural vehicles were measured in a test chamber. The blower motors were operated at 12 and 13.5 volts direct current. A vacuum cleaner moved 76 m^3/hr of air through HEPA filters, the test chamber, and into a 5-cm diameter pipe. An optical particle counter drew air through an isokinetic sampling probe and measured the size-dependent particle concentrations from 0.3 to 15 µm. The blower motor aerosol concentrations were between 200 and 1800 particles per liter. Aerosol penetration into three stationary agricultural vehicles were measured at low concentrations (outside in the winter) and high concentrations (inside repair shops with burning incense sticks). The data was analyzed to estimate the concentration of cab-generated aerosol. In the 0.3–1 µm range, estimated blower motor aerosol concentration and the measured concentration in the cab during low concentration testing were approximately the same. For two used vehicles, other sources of aerosol generation were present for particles larger than 1 µm. For an unused vehicle, the in-cab aerosol concentration during low concentration testing and the estimated concentration of blower motor aerosol were similar over the particle size range 0.3–4 µm. Aerosol generated by the blower motor and other sources affect penetration measured with optical particle counters.

73.

SEARCH FOR THE OPTIMAL PLEAT COUNT FROM THE PERSPECTIVE OF FILTER QUALITY. C. Chen, T. Hsiao, National Taiwan University, Taipei, Taiwan, Republic of China; C. Chen, S. Huang, Institute of Occupational Safety and Health, Taipei, Taiwan, Republic of China.

Pleated filter panels have been used in a variety of industrial sectors. The present optimization of pleat filter design is based on minimizing the pressure drop at a certain approaching velocity. However, the filtration efficiency, an equally important indicator, is rarely being contemplated together with the air resistance in the optimization process.

In this work, filter quality, instead of pressure drop, is used as the optimization criterion. Dioctylphthalate was used as the test agent to challenge fibrous polypropylene filters. The filter media were dipped in isopropyl alcohol to remove possible electrostatic charges. Nine customarily made filter holders were fabricated to hold just one pleat of filter with different spacing, simulating different pleat count range from 0.25 to 5.0 pleat/cm. The approaching velocity was fixed at 100 cm/sec. A scanning mobility particle sizer was used to measure the aerosol number concentrations and size distributions upstream and downstream of the pleated filter. The pressure drop across the filter media was monitored by using an inclined manometer.

The results showed that filter quality curve (as a function of pleat count) is almost independent of aerosol size. For submicrometer-sized particles, aerosol penetration decreased with increasing pleat count because more filtering materials were available for aerosol deposition. For micrometer-sized particles, aerosol penetration decreased with decreasing pleat count due to higher inertial impaction. For the filter tested in the present study, the optimal pleat count for filter quality was always slightly higher than that for pressure drop. For example, the optimal pleat count was 1.88 pleat/cm from the standpoint of pressure drop, but to have the highest filter quality, the pleat count needs to increase to 2.23 pleat/cm.

74.

EFFECTS OF FACIAL FEATURES ON VELOCITY FIELD FOR INHALING MANNEQUINS. T. Anthony, M. Flynn, University of North Carolina, Chapel Hill, NC.

CFD and numerical investigations of particle inhalability and contaminant exposure have used simple geometrical surrogates for a breathing human form, but the effect of elimi-