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Aerosol filtration by fibrous filters—I. theoretical ☆

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Abstract

Current theory of aerosol filtration by fibrous filters is based on the Kuwabara-Happel flow field for the cell model. Previous studies in this area have involved mostly an examination of three main filtration mechanisms: Brownian diffusion, direct interception and inertial impaction, either separately or by combining direct interception with Brownian diffusion or inertial impaction. This report presents the results of an investigation of these three mechanisms used simultaneously, and the development of a computational procedure to predict efficiencies of a fibrous filter for both the continuum and the slip-flow regimes. The theoretical procedure involved (1) the development of a modified Kuwabara-Happel flow field allowing for slip effects, (2) the development of an effective fiber length factor to assess filter nonuniformity and (3) the calculation of single fiber efficiency by using equations of motion of the particles either to solve the convective-diffusion equation or to integrate them for solving the particle trajectory. The solutions for both cases were performed on a digital computer.

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* This paper is based on the Ph.D. Thesis of H. C. Yeh for the partial fulfillment of the requirements for the Ph.D. Degree.

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