Predicting the Performance Efficiency of Membrane Filters in Process Liquids Based on Their Pore-Size Ratings

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Abstract

Because semiconductor microcircuits can be easily damaged by contacting contaminants during manufacture, microporous membrane filters are commonly used to control the purity of process gases and liquids. Such filters remove particles via gravitational settling, electrostatic deposition, impaction, interception, diffusion, and sieving. All of these mechanisms are active in gas filtration, making microporous membranes particularly effective in that application. Indeed, filters with a 0.2-µm rating have been found capable of removing essentially all (>99.9999999%) particles from gases regardless of particle size. This complete retention capability has been verified for 0.05-µm particles — the most penetrating size — and for particles as small as 0.003 µm.

In contrast, the physical chemistry of liquid filtration is very different, and particle capture is often done by sieving alone, which limits filter effectiveness. (Particles are captured by sieving when they are too large to pass through the openings, or pores, in the filter matrix.) The same 0.2-µm-rated filters that remove essentially all particles from gases remove approximately 99% of 0.22-µm particles from liquids when new, and their retention efficiency can decrease with use. However, when sieving is the only operative mechanism, a filter's retention efficiency improves with increasing membrane thickness; e.g., if a membrane initially removes 99% of incoming particles, doubling its thickness will increase retention efficiency to approximately 99.99%

The pore-size ratings of most commercially available liquid filters are determined by bubble-point extrapolation techniques and reflect the membrane's microbial retention efficiency. Because the hard spherical particles that may contaminate semiconductor process fluids are retained at lower efficiencies than suggested by these pore-size ratings, there has been a need for a simple method of predicting filter performance under conditions of actual use. The study reported in this article showed that pore-size ratings based on the bubble point of membranes with a controlled thickness can be used to accurately predict the retention of hard particles under the operating conditions usually found in the industry. It was found that filters typically retain approximately 99% of such particles at the rated pore size. Additionally, hard particles that have a diameter approximately 2.5 times the rated pore size are completely (>99.99999999%) retained.

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