A Novel High Protection Exhalation Valve for Respirators

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The major goal of this work was to design and validate a new exhalation valve for better protecting workers against air contaminants in the workplace. A dynamic leakage test apparatus, composed of a piston-cylinder breathing simulator, an aerosol chamber, and a particle counter, was used to measure the leakage rate of exhalation valves operated under cyclic flow. The same exhalation valves were also tested using a static leakage test meter currently employed by certifying bodies. For the dynamic leakage test, a constant output nebulizer was used to generate aerosol particles around 0.03 micron. A condensation particle counter was used to measure the aerosol number concentrations inside and outside the respirator. Filter foams of different porosity and other types of flow straighteners, such as honeycomb, were placed in between the valve membrane and valve cover in order to reduce the mixing between the clean exhaled air and the dirty outside air after the end of an exhalation cycle. The aerosol penetration through the exhalation valve into the respirator cavity correlated well with the leakage rate measured by the static leakage test meter. The addition of filter foams in exhalation valves caused slightly higher air resistance during exhalation. This air resistance increased with increasing foam thickness and porosity number (pore per inch). In return for this air resistance increase, however, the aerosol penetration decreased considerably due to the retention of the clean exhaled air right outside the valve membrane, and the aerosol deposition on the filter foam during inhalation. Static leakage testing can only reveal the fit of the valve membrane to the valve seat. Dynamic leakage testing is necessary for evaluating the total performance of exhalation valves in real-life situations. The insertion of a piece of filter foam between the valve membrane and valve cover significantly increases the protection efficiency of the exhalation valve.