Work of Breathing for Respiratory Protective Devices: Method Implementation, Intra-, Inter-Laboratory Variability and Repeatability

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ABSTRACT

As part of development of performance standards, the International Organization for Standardization (ISO) technical committee, ISO/TC 94/SC 15 Respiratory protective devices (RPD), adopted work of breathing (WOB) to evaluate airflow resistance for all designs (classes) of respiratory protective devices. The interests of the National Institute for Occupational Safety and Health's (NIOSH) National Personal Protective Technology Laboratory (NPPTL) are to compare the proposed WOB method and results for current RPD with those for present resistance methods. The objectives here were to assemble a method to meet the ISO SC15 standards, validate operation and conformance, and assess repeatability of WOB measurements for RPD. WOB method implementation and use followed standards ISO 16900-5:2016 and ISO 16900-12:2016. Volume-averaged total work of breathing (WOB_T/V_T where V_T is tidal volume) determined for standard orifices was analyzed for variation and bias. After fabrication and assembly, the method gave preliminary verification orifice results that met ISO requirements and were equivalent to those from other laboratories. Evaluation of additional results from RPD testing showed tidal volume and frequency determined compliance. Appropriate adjustments reduced average absolute bias to 1.7%. Average coefficient of variation for WOB_T/V_T was 2.3%. Over 97% of results obtained during significant use over time met specifications. WOB_T/V_T for as-received air-purifying and supplied-air RPD were repeatable ($p<0.05$). WOB_T/V_T for unsealed half mask air-purifying RPD was an average of 31% lower compared to sealed. When experimental parameters were appropriately adjusted, the ISO WOB method implemented by NIOSH NPPTL consistently provided ISO-compliant verification WOB_T/V_T. Results for appropriately sealed RPD were reproducible.

Keywords: work of breathing; resistance; respirator; respiratory protective device.

Journal of the International Society for Respiratory Protection

Vol. 34, No. 2, 2017