Estimation of Work Rate in Workplaces Using Breathing Pattern Data

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Investigating worker's breathing patterns in various workplaces is essential information when estimating performances of respirators in actual work conditions, because worker's breathing donning a respirator is affected by various factors. As shown in technical reports published by ISO RPD working group, metabolic work rate which is expressed in unit of watt (W) per body surface area (m^2) is considered as the factor which has a huge effect on amount of worker's breathing.

Recently, we have been collecting and analyzing workers' breathing patterns at various workplaces in Japan using the developed breath sampling device including a dust respirator which employed the sampling method that monitored the difference in pressure inside the facepiece for measuring breathing pattern. While it has generated valuable breathing data, this effort did not allow us to directly determine the metabolic work rates based on the breathing data such as minute volumes (MV), tidal volumes (VT) and breath frequencies (F) obtained from collected breathing patterns, because calculating metabolic work rate needs to measure such oxygen uptake by expired gas analysis. To solve this issue, we conducted a test in which human subjects carrying a portable metabolic measurement system performed graded stepping exercise at five step heights. Based on the results, along with the use of the information on breathing data and physique data, we established an equation that enabled us to assess work rates from respiratory information. This equation was applied to the worker cohorts from three factories whose breathing data had been collected while at work activity.

As a result, the metabolic work rate of workers with an average minute volume ranging from 20 to 30 L/min was classified under either moderate or heavy, while the one with an average minute volume of over 30 L/min was classified under heavy and very heavy work rate class. Moreover, analysis of the relationship between work rates and minute volumes conducted for all data revealed that the range of minute volumes tends to be lower than that for standard man with a body surface area of $1.8m^2$ described in the ISO technical report. This is because, more than half of worker's body surface areas are smaller than 1.8 m^2. This tendency implies that body size affects the amount of minute volume. Workers were selected without regard to their body size when the breathing data sampling was conducted in actual workplaces, suggesting that minute volumes of Asian workers while at work activities may lower than those described in ISO technical reports.