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# 論　文　要　旨
# Thesis Abstract

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主論文題名　(Title)

Research on the Unified Threshold Criteria of Installed Filter Test in Cleanrooms


内容の要旨　(Abstract)

Currently, ISO 14644 Part 3: 2005 (equivalent to JIS B 9917-3: 2009) have been used as a standard leakage test method of a high-performance air filter installed in a cleanroom. For the leak test, two methods of leakage detection using Aerosol photometer and discrete particle counter (DPC) are presented. Both of test methods are performed by introducing an evenly distributed challenge aerosol at upstream of the filter unit and scanning immediately at the downstream side of the filter gasket, filter frame and filter media but different leakage threshold criteria are used. In the aerosol photometer method, a leak is detected when the downstream concentration measurement is larger than 0.01% of the upstream concentration measurement. Meanwhile, in the DPC method, the leak threshold uses the value obtained by multiplying the MPPS of the test filter with a factor K (usually K=10) as the threshold value. When the scanning probe scanning at the immediate filter downstream, a leak could be detected when particles exceeded the 95% upper confidence limit of the Poisson distribution. When a possible leak is detected, the stationary re-measurement should be performed. In order to set the leakage threshold, users need to know the performance of the installed filters. However, in various cases users will not be known of this information. Therefore, an additional test needs to be done to determine the filter's performance which further creates complexity and adding unnecessary procedure in the process.

This dissertation is a work based on an effort to unify the threshold criteria of installed filter leak test in cleanrooms for both aerosol photometer method and DPC method presented in ISO 14644-3: 2005. The idea is to use the same leakage threshold criterion of aerosol photometer method in the DPC method. First, a comparison based on the difference in measuring unit and leakage evaluation method are done. It was clearly shown that the measuring unit for both instruments provide different platform in the instrument's measurement and DPC always has a more severe leak evaluation. However, we found that this matter could be countered if a different leak evaluation method is being used. Instead of discrete leakage evaluation method that is currently stated in ISO 14644-3: 2005, a cumulative leak evaluation method provides more reliable leak rate for the DPC method. The obtained values are comparable with the aerosol photometer method. Therefore, throughout this dissertation, the cumulative leakage evaluation was tested for its validity towards the possibility of a unified threshold

criterion.

This evaluation method was tested further in the leak rate calculation with the instrument responses considered. There was only slight change observed for DPC as compared to the number of concentration values. However, the leak rate evaluated by aerosol photometer has a relatively big change in comparison to the mass concentration measurement. This is all due to the natural behaviour of the aerosol photometer response in which a different weight is applied for each particle size. As a result, it was found that for a filter having H14 or higher performance in European standard EN 1822-1: 2009, the same leakage evaluation standardized at 0.01% as the photometer method can be applied in the DPC method. On the other hand, similar to results obtained in measuring unit comparison, it was found that it would not be possible to apply the uniform criterion for filters with H13 or lower performance, therefore, it was necessary to establish criteria for each of the filter grade instead. Next, different DPC responses by changing the counting efficiencies in accordance with the limitations provided by the ISO 21501-4: 2018, were modelled to test the reliability of DPC to produce leak rate value below 0.01%. All filter grades were tested, and the result showed that only the filter grade of H13 which some DPCs failed to produce leak rate value below 0.01%. The same threshold as for aerosol photometer can only be used for filter grade equal to H14 or higher, but for filter grade equal to H13 or a looser threshold should be used instead.

The results presented in this dissertation were presented in the working group 3(WG3) consists of Technical Committee (TC) whose representing their respective standard organisations to discuss the revision of the ISO 14644-3: 2005 organised by International Standard Organization (ISO) named ISO/TC209. The Final Draft International Standard (FDIS) consisting the results and findings of this dissertation were proposed and through voting process by the principal members (P-members) carried out in July 2019, with 19 out of 20 votes with 95% acceptance rate (requirement: 66.66%) and 1 negative vote out of 23 votes in the member bodies meeting (requirement: 25%). Then, the FDIS was approved and ISO 14644-3: 2005 was also withdrawn and a new ISO 14644-3: 2019 was established. As a result, a leak detection threshold of 0.01% (same as used in aerosol photometer method) of the upstream challenge aerosol concentration for the H14 filter grade and higher, and a 0.1% threshold of the upstream challenge aerosol concentration for the H13 and lower were established in the new ISO 14644-3: 2019.