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Short Communication

Development of the KOSHA Proficiency Testing Scheme on Asbestos Analysis in Korea

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ABSTRACT

This commentary presents the regulatory backgrounds and development of the national proficiency testing (PT) scheme on asbestos analysis in the Republic of Korea. Since 2009, under the amended Occupational Safety and Health Act, the survey of asbestos in buildings and clearance test of asbestos removal works have been mandated to be carried out by the laboratories designated by the Ministry of Employment and Labor (MOEL) in the Republic of Korea. To assess the performance of asbestos laboratories, a PT scheme on asbestos analysis was launched by the Korea Occupational Safety and Health Agency (KOSHA) on behalf of the MOEL in 2007. Participating laboratories are evaluated once a year for fiber counting and bulk asbestos analysis by phase contrast microscopy and polarized light microscopy, respectively. Currently, the number of laboratory enrollments is > 200, and the percentage of passed laboratories is > 90. The current status and several significant changes in operation, sample preparations, and statistics of assigning the reference values of the KOSHA PT scheme on asbestos analysis are presented. Critical retrospect based on the experiences of operating the KOSHA PT scheme suggests considerations for developing a new national PT scheme for asbestos analysis.

1. Introduction

Exposure to airborne asbestos is associated with asbestos-related diseases such as asbestosis, mesothelioma, and lung cancer [1]. Because most of asbestos either imported or produced is used for manufacturing building materials, measurements of asbestos concentration in the air and surveys of asbestos in buildings are widely conducted to protect workers from the exposure to airborne asbestos and to manage asbestos in buildings. Exposure to airborne asbestos is measured by pulling air through a filter and then counting fibers using microscopic techniques. The phase contrast microscopy (PCM) is the most widely used technique for counting asbestos fibers in industrial hygiene laboratories. To survey asbestos in buildings, bulk samples are collected from representative portions of suspected asbestos-containing building materials and analyzed by polarized light microscopy (PLM).

Accuracy and precision of asbestos analysis are highly dependent on the proficiency of laboratories because of the nature of asbestos analysis by microscopic techniques. The United States and several European countries, which strictly control asbestos use in building, have operated national proficiency testing (PT) schemes on asbestos analysis to evaluate the performance of laboratories and enhance the accuracy and precision of asbestos analysis [2,3]. Since 2007, the PT scheme on asbestos analysis in the Republic of Korea has been operated by the Korean Occupational Safety and Health Agency (KOSHA) on behalf of the Ministry of Labor and Employment (MOEL) of the Republic of Korea.

This commentary reports regulatory backgrounds, operation, and the current status of the KOSHA PT scheme on asbestos analysis. Critical retrospect and implications regarding the operation of the scheme are presented for improvement in the near future.

2. Launching of the KOSHA PT scheme on asbestos analysis

Until early 2000, concerns on workers' health problems associated with asbestos exposure were limited to mining and manufacturing industries in the Republic of Korea. Since 2003, the MOEL has amended the Occupational Safety and Health (OSH) Act several times to protect construction workers from exposure to asbestos during the renovation or demolition of asbestos-containing

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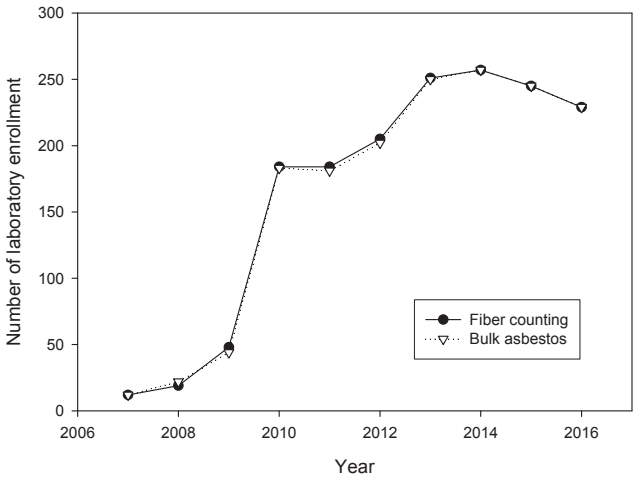

Fig. 1. Trend on the number of laboratory enrollments to the Korea Occupational Safety and Health Agency proficiency analytical testing scheme on asbestos.

buildings. Since 2009, an asbestos survey before the renovation or demolition of buildings and clearance test of asbestos removal works have been mandated, and subsequent use of asbestos and asbestos-containing materials has been totally banned under the amended OSH Act [4]. The MOEL of the Republic of Korea has mandated the survey of asbestos in buildings, and clearance test of asbestos removal work should be carried out by laboratories designated by the MOEL. To control the quality of asbestos survey and clearance test results, laboratories designated by the MOEL should pass the PT scheme on asbestos analysis operated by KOSHA.

The KOSHA PT scheme on asbestos analysis was launched to control the accuracy and precision of analytical results of asbestos analysis and evaluate the performance of laboratories designated by the MOEL in 2007, 2 years prior to the enforcement of the amended OSH Act mandating asbestos surveys and clearance tests. Every year, four samples are sent to each laboratory for fiber counting and bulk asbestos analysis. Laboratories typically have 20 days to analyze the samples and report their results to KOSHA. The performance of each round is evaluated as pass or fail under the approval of the committee of the KOSHA PT scheme. Laboratories are classified as proficient if they pass more than one round within the recent two consecutive rounds for each analytical field. Laboratory enrollments to the KOSHA PT scheme on asbestos analysis have increased dramatically from 12 in 2007 to 257 in 2014 (Fig. 1). In 2016, the number of laboratory enrollments was 229 and expected to be stabilized around 200 in the future. The number of laboratory enrollments to fiber counting and bulk asbestos analysis was nearly the same by years because passing both analytical fields had been required to be designated by the MOEL under the OSH Act of the Republic of Korea.

3. The operation of the KOSHA PT scheme on asbestos analysis

3.1. Fiber counting scheme

The KOSHA PT scheme on fiber counting had several significant changes on its operation (Table 1). From 2007 to 2009, samples permanently mounted on glass slides using filters purchased from the American Industrial Hygiene Association (AIHA) proficiency analytical testing (PAT) program were used in round robins. Currently, filter samples prepared by KOSHA are cased in three-piece cassettes and distributed to participants. Three samples containing chrysotile and one sample containing amosite are distributed to each laboratory in each round. Samples are prepared by filtering aliquots of suspension containing asbestos through 25-mm membrane cellulose ester filters in a laboratory of the KOSHA. The fiber densities of samples are approximately 100–500 f/mm^2. Samples are mounted on microscope slides by the acetone/triacetin method, and then fibers measuring $>$ 5 μm in length with an aspect ratio $>$ 3:1 are counted by PCM in each laboratory. The analytical results of samples are reported to the KOSHA as fiber densities of filters. To assign the reference values (R), the mean of the fiber densities reported by all the participants after winsorization of outliers was used during 2007–2009. After 2009, the means of the fiber densities derived from the analytical results of several experienced counters were assigned as the reference value of each batch. The acceptable range of counting is from 0.4R to 1.6R. Each laboratory was evaluated to pass the round when fiber densities of more than three out of four samples were within the acceptable ranges.

The percentage of passed laboratories for each round showed significant changes during 2007–2010 (Fig. 2). The reason for the changes in the early stage of the KOSHA PT scheme could be explained by both the change in the operation methods and abrupt increase in inexperienced new laboratory participations.

4. Bulk asbestos scheme

To prepare samples for the bulk asbestos scheme, KOSHA has operated a repository comprising about 100 asbestos-containing and non-asbestos-containing materials collected from buildings or facilities in the Republic of Korea. Except in 2010, samples of the scheme have been prepared from fragments or powders of materials selected from the repository (Table 2). In 2010, samples purchased from the AIHA's PAT program and the Research Triangle Institute International (Research Triangle Park, NC, US) were used temporarily. Four samples with or without asbestos are distributed to each laboratory in each round. Laboratories are required to analyze samples by PLM and report the presence of asbestos and types and contents of asbestos if detected. The reference values are derived from the analytical results of KOSHA using 400 point-counting by PLM following the matrix reduction of the milled

Table 1
Summary of the operation of the Korea Occupational Safety and Health Agency proficiency analytical testing scheme on fiber counting

Period	Samples		Criteria of performance	
	Type of asbestos (No. of samples distributed)	Type of preparation	Reference value	Acceptable range
2007	Chrysotile (4)	Dimethylformamide/euparal	Mean fiber density of all laboratories	0.4R–1.6R
2008	Amosite (4)			
2009	Chrysotile (3) Amosite (1)			
2010–2016	Chrysotile (3) Amosite (1)	Acetone/triacetin	Mean fiber density of several counters	

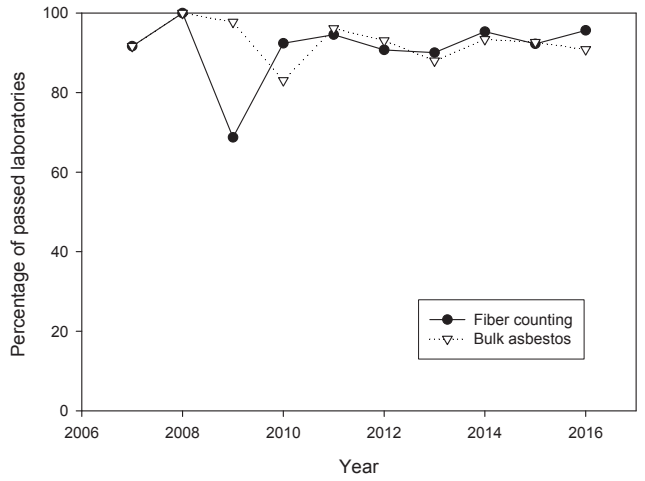

Fig. 2. Trend on the percentage of passed laboratories for each round of the Korea Occupational Safety and Health Agency proficiency analytical testing scheme on asbestos.

Table 2
Summary of the operation of the Korea Occupational Safety and Health Agency proficiency analytical testing scheme on bulk asbestos

Period	Samples	Criteria of performance
2007–2009	Materials collected from construction sites in Korea	Analytical results of a reference laboratory
2010	AIHA BAPAT samples and RTI reference samples	Reference values of BAPAT and RTI samples
2011–2016	Materials collected from construction sites in Korea	Analytical results of a reference laboratory (KOSHA)

AIHA, American Industrial Hygiene Association; BAPAT, bulk asbestos proficiency analytical testing; KOSHA, Korea Occupational Safety and Health Agency; RTI, Research Triangle Institute International.

samples. Laboratories get penalties by the types of analytical errors compared with the reference values. Each laboratory is evaluated as passing the round when the sum of the penalties obtained from four samples is <100. The percentage of the passed laboratories for each round has been about 90% since 2010.

5. Critical retrospect

The data generated by a PT scheme are a valuable source to understand the analytical performance of the participating laboratory group. At the initial stage, several significant changes on the operation of the KOSHA PT scheme on asbestos have been introduced to improve the effectiveness of the scheme. Maintaining consistency is required in the operation of the PT scheme not only for effective evaluation of analytical trends but also for the improvement of precision and accuracy of the participating laboratories.

The ISO/IEC 17043, the international standard of The International Organization for Standardization (ISO) specifies general requirements for the competence of providers of PT schemes and the development and operation of PT schemes [5]. PT scheme is an essential component of the accreditation program on the quality assurance of testing laboratories under ISO/IEC 17025 [6]. In the Republic of Korea, the PT scheme provider and the PT scheme should be accredited by the Korean Laboratory Accreditation Scheme (KOLAS) to be competent under the ISO/IEC 17043. The KOSHA PT scheme on asbestos is operated by following most of the specifications of ISO/IEC 17043 but has not yet been accredited by the KOLAS. Therefore, to be accredited for the asbestos analysis on ISO/IEC 17025 in the Republic of Korea, laboratories should participate in an additional scheme accredited on the ISO/IEC 17043. Currently, there is no such accredited scheme on asbestos analysis in the Republic of Korea. As a national PT scheme on asbestos supported by the MOEL of the Republic of Korea, the KOSHA PT scheme on asbestos analysis needs to be accredited by the KOLAS on the provider of PT scheme for assuring its reliability.

To achieve the aim of operating a PT scheme, statistical validity and consistency of the reference value should be assured. The criteria used for determining the reference values of the fiber counting scheme have been a matter of debate in the KOSHA PT scheme on fiber counting. The mean of the values reported by all the laboratories passing the previous round after the winsorization had been used for the reference value during 2007–2009; however, the validity of the reference values was questioned due to an abrupt increase in new inexperienced laboratory enrollments to the scheme. In 2010, a change was introduced to data for the reference values by switching counts of all the laboratories to several experienced counters selected by the committee of the KOSHA PT scheme. However, currently, this change needs to be reversed because of the decrease in inexperienced laboratory enrollments in recent years. When a country tightens the regulations on asbestos control and subsequent abrupt increase in inexperienced laboratory enrollments to the national PT scheme is expected, reasonable criteria for determining reference value should be carefully considered at the early stage.

Webber et al [7] reported that using asbestos-containing bulk samples synthesized in the laboratory from known masses helps improve the precision and accuracy of quantitative analytical results. The KOSHA PT scheme on bulk asbestos analysis has been used to prepare samples only using real world materials collected from buildings and facilities in the Republic of Korea. The PT scheme samples having the reference values can be used for the purpose of samples for internal quality control testing after each round. Therefore, introducing asbestos-containing bulk samples synthesized in the laboratory from known masses to the bulk asbestos scheme is worth considering to help more effective quality control of laboratories.

Introducing effective and reliable national PT scheme on asbestos analysis needs to be considered when a country legislates to prevent environmental exposure and workers' exposure from the airborne asbestos. This commentary reports regulatory backgrounds and the development of the KOSHA PT scheme on asbestos analysis. Critical retrospect on the experiences of operating the KOSHA PT scheme suggests considerations for developing a national PT scheme on asbestos analysis to tightening enforcement on asbestos.

Conflicts of interest

No potential conflicts of interest relevant to this article were reported.

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