The need for proficiency testing in asbestos phase contrast microscopy fibres counting

Gabriel E. Mizan

National Health Laboratory Service, National Institute for Occupational Health
University of Witwatersrand, School of Public Health, South Africa

Corresponding author:
Gabriel E Mizan, National Institute for Occupational Health, PO Box 4788, Johannesburg 2000, South Africa; Fax: + + 27 11 7126405; Ph. ++ 27 11 7126457; E-mail: gaby.mizan@nioh.nhls.ac.za

The current method for the evaluation of asbestos exposure involves passing the potentially contaminated air through a cellulose nitrate membrane filter and counting the fibres collected using phase contrast microscopy (PCM). Although this method is widely utilised, and in many countries also legally prescribed, it has some serious limitations and its precision is amongst the poorest of any occupational hygiene assessment methods. One important reason for this low precision is the large inter- and intra-laboratory variability associated with manual microscopic counting of fibres. Proficiency testing (PT) schemes for asbestos fibre counting allow participating laboratories to compare their counting results with each other and with reference counts assisting them to improve their performance and the quality of their results. This paper will illustrate some of the problems related to PCM counting and will describe the function of PT schemes in addressing these problems.

Key words: asbestos, proficiency testing, phase contrast microscopy, regulated fibre

Introduction

Phase contrast microscopy (PCM) is an internationally accepted method for the evaluation of occupational exposure to asbestos fibres present in breathed air.

Despite the widespread use of this method, which is based on counting fibres under a microscope, it has some inherent limitations which contributes to large variability in counting results from different laboratories. This may impact on the evaluation of workers’ exposure to the fibres and decisions made with regards to the implementation of control measures.

Proficiency testing (PT) schemes for asbestos counting were implemented to achieve better uniformity in counting performed by laboratories and to encourage participating members in the scheme to improve their counting against performance targets.

In 1979 an industry body, the Asbestos International Association (AIA), published the ‘Recommended technical method number 1’ (AIA-RTM1) which was subsequently incorporated into a European Directive on Asbestos in 1983 [European Union, 1983].

A revised method for the sampling and evaluation of asbestos fibres by PCM, MDHS 39/4, was published by the UK Health and Safety Executive (HSE) in 1995 (Health and Safety Executive, 1995).

In an attempt to establish a unified methodology for the evaluation of airborne asbestos fibres in the work environment, the World Health Organisation (WHO) published the ‘Determination of airborne fibre number concentration, a recommended method by phase contrast microscopy’ in 1997 [World Health Organisation, 1997].

The WHO fibre counting rules came into effect in the UK in November 2006. These rules are described in the Health and Safety Guidance 248: ‘Asbestos: The analysts’ guide for sampling, analysis and clearance procedures’ which replaced the MDHS 39/4 [Health and Safety Executive, 2005].

Phase Contrast Microscopy - Principle

The current method for the evaluation of asbestos fibres in air involves the collection of an air sample on a cellulose membrane filter, followed by a count of the fibres in randomly selected areas on the filter using phase contrast microscopy. The count is then adjusted for the total exposed area of the filter and the number of fibres per millilitre of air sampled is then calculated.

The method thus measures the airborne concentration of countable (regulated) fibres, which are defined as particles with length ≥ 5 µm, width ≤ 3 µm and aspect ratio (length:width) of at least 3:1 [World Health Organisation, 1997].

Phase Contrast Microscopy Limitations

Although the PCM method is widely utilised, and is currently the most cost-effective method of fibre evaluation, it has some serious limitations and its precision is amongst the poorest of any occupational hygiene assessment methods [World Health Organisation, 1997]. The main limitations, and source for the variability in counting results, are:
• Although 100 - 200 “fields” or graticule areas are counted on each filter, this represents only a very small portion of the entire filter surface (0.2% - 0.4%, depending on number of fields assessed); this is a source of bias in counting, particularly if the fibres are not uniformly distributed on the filter;
• Fibres having widths below 0.2 µm may not be visible using this method; For the two abovementioned reasons it is clear that the fibres counted represent only a proportion of the fibres present on the filter;
• Subjective differences between microscopists and working environments (e.g. visual acuity, fatigue, ergonomic parameters) will result in different counts; it was found that microscopists generally underestimate (undercount) dense deposits and overestimate low fibre densities; differences in equipment calibration and counting procedures can result in systematic differences in counts produced by different laboratories;
• The presence of dust particles and other fibres on the filter may interfere with the accuracy of results [Health and Safety Executive, 2005].

Proficiency Testing Schemes
Inter-laboratory proficiency testing (PT) schemes are designed and operated to assure laboratories performance in specified areas of testing, measurement and calibration. They are often used by accreditation bodies as part of laboratories assessment process [The International Laboratory Accreditation Cooperation, 2007]. Asbestos PT schemes were established to overcome some of the PCM method limitations mentioned above which results in large variability between counting laboratories. The aims of the asbestos PT schemes therefore include: a) to continuously monitor and compare laboratories’ performances against each other and against established reference counts and b) to motivate counting laboratories to improve their own fibre counting performance and quality assurance standards.

Against the background of increasing control of airborne fibres, a number of PT schemes were set up in the 1980s. Two of these schemes were introduced in Europe by the Institute of Occupational Medicine (IOM) of the UK, namely the Regular Inter-laboratory Counting Exchanges (RICE), which was developed by the IOM on behalf of the UK Health and Safety Executive; and the Asbestos Fibre Regular Informal Counting Arrangement (AFRICA). RICE, now managed directly by the UK Health and Safety Laboratory (HSL), is the largest scheme and has about 200 members, mostly located in the UK and it forms part of the formal national quality assurance system in that country. AFRICA, discussed in further detail below, was designed to provide links between voluntary participating laboratories in different countries [Brown and Jones, 2001]. Similar schemes were established in other parts of the world, for example the Industrial Hygiene Proficiency Analytical Testing (IHPAT) programme operated by the American Industrial Hygiene Association (AIHA). In any PT scheme, each participant is regularly sent a set of samples to analyse (AFRICA scheme has two rounds per year, each round comprises of eight samples, RICE currently has two or three rounds). The schemes compare the participants’ measurements with the assigned values (or reference count) for each sample. The measurement and assigned values are expressed in terms of fibre density (fibres / mm²). The reference count may be a consensus of the participants’ results, a count from expert laboratories or even one produced by an image analyser. The assessment of laboratory’s performance is done by comparing the lab’s results with pre-defined performance bands on either side of the reference counts (see graph). The limits of the bands are calculated as functions of the fibre density. A laboratory achieving at least 75% of its results in performance band A is awarded a rating 1 for “good” performance. On the other hand more than 25% of results in band C is considered unsatisfactory and given a rating of 3. Intermediate performance is rated 2 and still described as “satisfactory” [Brown and Jones, 2001].

Figure 2: Asbestos counting proficiency testing scheme - performance bands [Institute of Occupational Medicine, 2010]

The AFRICA Scheme
The AFRICA scheme was established in 1984. It was organised by the IOM, with financial support until 1991 from the UK Health and Safety Executive (HSE). Since 1992, the operation of the scheme has been funded by membership fees of the participating laboratories. To date, over 100 different laboratories from countries across the world have taken part in the scheme and over 450 samples were used. At present, 33 participants from 17 different countries are registered with members including government laboratories, research institutions, asbestos inspection authorities and producers [Institute of Occupational Medicine, 2011]. The samples used in the scheme originate from a variety of sources of airborne asbestos. Initially, most samples were from asbestos product manufacturing plants but since 1995 approximately half of the samples in each round came from asbestos removal operations.

Industry samples typically contain chrysotile fibres while asbestos removal samples often contain amosite fibres. The asbestos removal samples generally have lower fibre densities than the industry samples. It is important that each batch of samples in a particular round contains a range of fibre densities and types [Brown and Jones, 2001].

Figure 3: AFRICA scheme - performance ratings, 1984 - 2010 [Institute of Occupational Medicine, 2011]
Results
Using the performance ratings as a guide it is possible to demonstrate that a laboratory’s performance generally improves after it begins to participate in the scheme (Figure 3). In the most recent round of AFRICA (Round 44) 83% of participants achieved the ‘1’ rating indicating good performance. This is compared to 55% achieving rating ‘1’ in the first round of the scheme (Institute of Occupational Medicine, 2011).

References