Dustiness of Different High-Temperature Insulation Wools and Refractory Ceramic Fibres

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Recent regulations are encouraging the replacement of older types of man-made mineral fibre by more soluble and, thus, less biopersistent compositions. In order for there to be any health benefits from this policy and to gain maximum benefit from such substitutions, the use of the new materials should not increase exposure. The work reported here was undertaken to investigate the use of new high-temperature glass insulation wools in place of refractory ceramic fibres (RCF). Airborne fibre levels occurring during the manufacture of both RCF and calcium magnesium silicate wools (CMS) were compared using measurements of genuine workplace exposure from a routine monitoring operation on the same plant. Exposures during use were compared in one customer facility where RCF and CMS blankets were used for the same task. Further comparisons were made in a laboratory test of dustiness using a “shaking box test”. For some manufacturing tasks there are only a few workplace samples and there are few opportunities for genuine comparisons with both RCF and CMS in identical uses. However, both materials produced very similar exposure levels during manufacture, use and in the laboratory test. The novel magnesium silicate fibre was significantly dustier in the laboratory test. © 2001 British Occupational Hygiene Society. Published by Elsevier Science Ltd. All rights reserved

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INTRODUCTION

In December 1997 the European Commission published their hazard classification of various glass insulation wools (Directive 97/69/EC). The names used in the scheme adopted are applied to fibres defined, or distinguished from one another, in a way different from that used in any previous classification scheme. For example, most of the “special purpose fibres” in the IARC (IARC, 1988; IPCS, 1988) scheme would be classified as mineral wools under these EU rules. Although the fibres concerned only cause itching, they are classified as irritants, that is, a description previously limited to materials causing skin inflammation or damage. Most importantly, for carcinogen classification the European Union distinguishes between two different types of “fibres with random orientation” (that is, they are wools, not continuous filaments). The two types are distinguished by composition, as follows:

1. Those with an alkaline oxide and alkaline earth oxide (Na₂O + K₂O + CaO + MgO + BaO) content less than, or equal to, 18% by weight. These are called “refractory ceramic fibres and special purpose fibres”, and are classified as category 2 carcinogens.

2. Those with a content of more than 18% of these oxides; these are called “mineral wools”, and are classified as category 3 carcinogens.

There is further provision for the use of appropriate toxicological or biopersistence data in order that some of the second group “mineral wools” may be exonerated from the carcinogen classification. This is not possible for the other fibres.

Alkaline metal oxide and earth alkali oxide content has an effect on the water solubility of glasses and so is itself a determinant of the persistence of inhaled fibres in the lung—so-called biopersistence. By making further exoneration available the directive confirms the benefit of low biopersistence as a determinant of low hazard. This could be due to an effect...
of dissolution on some aspect of surface chemistry reducing some chemical activity. Such an effect could result in a reduction in the hazardous properties of the material itself with each individual fibre being less hazardous, but such a mechanism is speculative. A more important role of low biopersistence is probably in reducing the number of fibres in the lung. For equal exposures, the less biopersistent the fibre the lower the dose; and this will remain true whether the dose is expressed as a peak tissue concentration or as some integral of fibre number over time.

There is an obvious potential for commercial advantage in offering an exonerated fibre for applications previously using fibres now classified as carcinogens. This is especially so when the choice is between an exonerated fibre and a fibre in category 2. The regulations that apply when using category 2 carcinogens are far more onerous. However, where technical requirements allow substitution by a less durable fibre, a genuine reduction in risk requires that the use of such fibres should not result in an increase in exposure. This could negate the advantages of low biopersistence and, perhaps more trivially, would make the workplace less comfortable due to irritation or itching from skin contact.

The purpose of the present study was, therefore, to compare the airborne fibre levels that would be generated by the use of a fibre with reduced biopersistence in some applications previously using refractory ceramic fibres (RCFs). To do this, the dustiness of RCFs was compared to that of the newer fibres using both workplace measurements and in a laboratory test.

METHODS

Materials

RCFs are alumino-silicate glasses used for insulation applications above 1000°C. For some of these applications, various calcium magnesium silicate (CMS) wools are potential substitutes. These contain various proportions of calcium and magnesium, and at the extreme, only one of these elements may be present. While RCFs are classified as category 2, the other fibres used in this study fit the EU mineral wool description and have been exonerated from any carcinogen classification by animal testing.

Workplace fibrous dust levels

The opportunity to compare dust levels during the use of fibrous insulation at a customer’s factory was provided by an oven producer willing to evaluate the possibility of replacing RCF by CMS. Sampling conditions were organised so that, as far as possible, identical tasks were carried out with RCF and CMS wools and all conditions remained unchanged. In particular, the type of oven and production rate were kept constant. The insulation material—a needled blanket—had the same shape and density for both RCF and CMS. The same workers performed the same tasks during both evaluations in order to reduce the influence of individual handling practices on dust concentration; such an effect is often observed in routine occupational hygiene surveys. Measurements were carried out at approximately the same time of the day and were of a similar duration during the same shift on two consecutive days. The products used in this comparison are described in Table 1.

Measurements were also made during fibre production on manufacturing lines that produced both RCF and CMS, albeit at different times. These measurements were a part of the industry’s quality assured sampling and measurement system (the “CARE Programme”). Thus they were not targeted specifically at this study but collected using the sampling strategy independently devised to ensure fully statistically valid dust measurements at plants manufacturing RCFs and CMS fibres (Burley et al., 1997).

Intrinsic dustiness of fibre blankets

Dustiness was estimated using a method based on the shaking “dust box” described in Dodgson et al. (1987). The basic design was modified and the actual equipment and methods used are described in Class et al. (1996). Briefly, ten regularly distributed samples (about 30 g each) were taken from a band, 54 by 90 cm, removed from the central part of different CMS and RCF fibre blanket rolls (total dimension 60 by 710 cm). The samples were shaken at about 3.3 Hz in a mesh cage, contained in an electrically conductive 70 cm cube PVC box (called here the “shaking box”). Airborne fibres generated were kept in suspension using a fan with a flowrate of about 50–100 m³ h⁻¹. This method simulates extreme handling conditions, and samples were weighed before and after testing; the results were discarded if the test sample had lost more than 3% of its weight during testing. The products tested are described in Table 2. Samples 2, 3, and 6 were all calcium magnesium silicate samples differing in the proportion of calcia to magnesia and in the total content of these two oxides.

During testing, the airborne fibre concentration generated in the box was measured by drawing known volumes of air through a membrane filter contained in the chamber by means of a sampling pump located outside the box.

Fibre counts

Both workplace and shaking box airborne fibre concentrations were measured by counting and sizing fibres on the filters using the phase-contrast optical microscope WHO/EURO method (WHO, 1997). The fibre-counting laboratory was a member of the WHO/EURO Reference Scheme (Crawford et al., 1987).
**RESULTS**

**Occupational hygiene survey results**

Table 3 gives the airborne fibre concentrations during operations using CMS and RCF in both oven assembly and during manufacture.

**Shaking box test results**

After rejection of three values, one each from fibres 2, 5 and 7, due to excessive loss of sample, the results are presented in Fig. 1. All the blankets used were 25 mm thick. Two of the fibre types (CMS and CMS with some zirconia) were available at densities of both 96 and 128 kg m\(^{-3}\). The other types were only available at 128 kg m\(^{-3}\). All the values obtained have been plotted so as to avoid making assumptions about the distribution of the values. It can be seen that fibre 7 released significantly more fibres than all the other fibre types.

**DISCUSSION**

Data collected during production and installation of CMS showed that the airborne fibre concentrations occurring during the use of these products were not different from those occurring when producing or using RCF. Again in laboratory scale dustiness testing, both products behave similarly [sample 1 (RCF) and sample 2 (CMS) both having a density of 128 kg m\(^{-3}\)].
m$^{-3}$ and a thickness of 25 mm]. This is perhaps to be expected since dustiness depends on fibre fragility and the coherence, or friability, of the insulation product as a whole. To be physically suitable for any application these properties cannot be allowed to vary over a wide range.

The data obtained during these tests does appear entirely consistent with the view that the shaking test method can be used to reflect the behaviour of products in the workplace, at least when comparing products with one another. However, the airborne dust concentrations measured in the shaking box test can only provide comparative values; these would need extensive calibration against standard fibres used in standardised tasks before they could be used to predict airborne fibre concentrations in the workplace.

For two fibre types, dustiness was measured at two densities. Fibre types 2 and 3, as well as 4 and 5, do suggest an inverse relationship, but further studies are needed in this area. However, the greatest differences in this study were between different products. The magnesium silicate fibre (sample 7) is much dustier than any of the calcium magnesium silicate or RCF blankets, even with the same density and thickness samples; conversely blanket sample 6, the most recently commercialised composition of calcium magnesium silicate, was less dusty than the other blankets tested.

We recommend that attention to exposure should be included in any decision process aimed at replacing one material with another, whatever the hazard classification.

REFERENCES