FIBRE EMISSIONS WHILE HANDLING FIBROCEMENT AND FRICTION PRODUCTS

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Abstract

There is a general questioning in the world regarding the effect of microfibres that can potentially be released from cutting large quantities of friction products and nonfriable building materials. Convention 162 of the International Labour Organization - *Safety in the use of asbestos* - warned, from the very start of the 1980's, employers, workers and governments of the importance to protect the workers by the use of adequate respiratory protection equipment and by the use of suitable tools. With the appearance, during the last decades, of a great number of fibrous materials on construction, repair, restoration and demolition sites, there is an increase in questioning and the lack of scientific data on this issue is deplored.

The first objective of this study is to evaluate the airborne fibre emissions rates for various fibrocement and friction products to compare the safety of the various techniques of cutting for each of them. The tools used in the laboratory are among those that are generally found on building sites. This research also aims at carrying out a comparison between products containing chrysotile and equivalent products made from other industrial fibres, to evaluate which were most likely to release respirable fibres beyond the recommended threshold limit value.

No less than 107 analyses were carried out at the time of the experiment. The methods of cutting and analysis followed a rigorous protocol in conformity with international standards. The results obtained made it possible to draw the following conclusions:

1) The use of water to reduce the emissions of respirable fibre is a very effective process. Compared against the same product cut with the same tool, saturation makes it possible to reduce the dust contamination by 50 to 90 %. However, the use of an abrasive disc to cut building materials and of a grinding stone for friction products without an aspiration system is not advisable. All these products release important respirable fibre concentrations when not properly cut, in particular in the case of chrysotile containing products. Even with the addition of water, the concentration of respirable fibres released by these tools exceeds the recommended thresholds.

2) The use of manual tools, in all circumstances and whatever the type of fibre containing material used, does not release respirable fibre concentrations beyond the threshold of 1 fibre/cc (on an eight-hour time-weighted average), which is the standard for chrysotile. These tools, which are recommended by the fibrocement manufacturers, regulation agencies and under the terms of the policy of controlled use, are the best for all types of fibrous materials.

3) Except in the case of an abrasive disc without any system of aspiration (a tool which in any event is not recommended for this kind of work), the respirable fibre emissions are of the same order of magnitude, whether the products contain chrysotile or not. Admittedly, the values are lower in the case of certain fibres other than chrysotile, but in all the cases, they remain within range of the recommended levels.

It is not possible to reach a conclusion regarding the relative risk of each product or each tool used in this study. It is necessary to consider other factors, mainly the biopersistance of each type of fibre, to evaluate the risk. It is however advisable to recall that, in spite of their growing presence on the market, the majority of fibres other than chrysotile, alas, are essentially unregulated.

Overall, it is possible to ensure minimal conditions of exposure to airborne respirable fibres for workers required to handle fibrocement products. As long as the basic rules that govern their use are followed, these products do not release respirable fibres beyond the recognized standard proposed by international regulation organizations. The wearing of respiratory protection equipment remains however a recommended precautionary measure.

Sommaire

Il existe un questionnement général dans le monde à l'effet que les produits de friction et les matériaux de construction non friables composés de fibres peuvent potentiellement dégager des microfibres en quantité importante lors de leurs coupes. La Convention 162 de l'Organisation internationale du travail – *Sécurité dans l'utilisation de l'amiante* – mettait en garde, dès le début des années 1980, les employeurs, les travailleurs et les gouvernements de l'importance de protéger les ouvriers par le port d'équipement de protection respiratoire adéquat et par l'utilisation d'outils appropriés. Avec l'apparition au cours des dernières décennies d'un grand nombre de matériaux fibreux sur les chantiers de construction, de réparation, de rénovation et de démolition, le questionnement ne cesse de s'intensifier, et on déplore trop souvent le manque de données scientifiques à cet effet.

L'objectif premier de cette étude est d'évaluer les émissions de fibres aéroportées pour divers produits de fibrociment et de friction pour comparer la sécurité des diverses techniques de découpe pour chaque produit. Les outils utilisés lors des tests en laboratoire sont parmi ceux que l'on retrouve généralement sur les chantiers. Cette recherche vise également à effectuer une comparaison entre produits à base de chrysotile et produits équivalents à base d'autres fibres industrielles pour évaluer lesquels étaient les plus susceptibles de dégager des fibres respirables au-delà du seuil recommandé.

Pas moins de 107 analyses ont été effectuées lors de la découpe des matériaux. Les méthodes de coupe et d'analyse ont suivi un protocole rigoureux conforme aux normes internationales. Les résultats obtenus ont permis de dégager les conclusions suivantes :

1) Le recours à l'eau pour réduire les émissions de fibres respirables est un procédé très efficace. Par rapport à un même produit découpé avec un même outil, la saturation permet de réduire l'empoussièrement de 50 à 90 %. Cependant, l'utilisation d'un disque abrasif pour la coupe de matériaux de construction et d'une meule pour les produits de friction, dépourvus d'un système d'aspiration, n'est pas recommandable. Tous ces produits dégagent d'importantes concentrations de fibres respirables lorsque mal utilisés, en particulier dans le cas des produits contenant du chrysotile. Même avec l'apport d'eau, les concentrations de fibres respirables dégagées par ces outils dépassent les seuils recommandés.

2) L'utilisation d'outils manuels, en toutes circonstances et quels que soient les types de fibres contenus dans les matériaux, ne dégage pas de concentrations de fibres respirables au-delà du seuil de 1 fibre/cc (moyenne pondérée sur 8 heures), ce qui est la norme pour le chrysotile. Ces outils, qui sont ceux recommandés par les fabricants de fibrociments, les organismes de réglementation et en vertu de la politique d'usage contrôlé, sont donc les mieux adaptés pour tous les types de matériaux composés de fibres.

3) Si on exclut la découpe des matériaux de construction au moyen d'un disque abrasif sans système d'aspiration (un outil qui de toute façon n'est pas recommandé pour ce genre de travaux), les émissions de fibres respirables ont tendance à se comporter de façon semblable que les produits contiennent ou non du chrysotile. Certes les valeurs sont plus faibles dans le cas de certaines fibres autres que le chrysotile, mais dans tous les cas, elles demeurent dans la fourchette des niveaux recommandés.

Il n'est pas possible de dégager de conclusions quant au risque relatif pour la sécurité de chaque produit ou de chaque outil utilisé lors de cette étude. Pour ce faire, il faut tenir compte d'autres facteurs, principalement la biopersistance de chaque type de fibre, pour en évaluer le risque. Il convient cependant de rappeler que, malgré leur présence grandissante sur le marché, la plupart des fibres autres que le chrysotile sont hélas peu réglementées.

En somme, il est possible d'assurer des conditions minimales d'exposition aux fibres respirables aéroportées pour les travailleurs appelés à manipuler des produits de fibrociment. Pour autant que les règles de base qui régissent leur utilisation soient respectées, ces produits ne dégagent pas de fibres respirables au-delà de la norme reconnue par les organismes internationaux de réglementation. Le port d'équipement de protection respiratoire demeure cependant une mesure de précaution recommandée.

Resumen

Existe un cuestionamiento general en el mundo respecto al efecto de las micro fibras que se puedan potencialmente desprender, debido a los recortes de grandes cantidades de los productos de fricción o de los materiales de construcción que no son friables. La Convención 162 de la Organización Internacional del Trabajo –Seguridad en el Uso del Asbesto – previno, desde el principio de los años ochentas a los empleadores, trabajadores y a los gobiernos de la importancia de proteger a los trabajadores del uso adecuado del equipo de protección respiratoria así como del uso seguro de la herramienta adecuada. Por lo que se refiere a la aparición de un gran número de materiales fibrosos en la construcción, durante las últimas décadas, ya sea para la reparación, restauración, y la demolición, existe una duda creciente sobre la falta de información científica respecto a este tema, lo cual es deplorable.

El objetivo principal de este estudio, es la evaluación de grados de emisiones de fibras volátiles de los diversos productos de fibrocemento y de fricción con objeto de comparar la seguridad de las diferentes técnicas de recortes para cada uno de éstos. Las herramientas utilizadas en los laboratorios, son aquellas que generalmente se encuentran en los lugares de construcción. Esta investigación, también se dirige a llevar a cabo una comparación entre los productos que contienen crisotilo y los productos equivalentes que se manufacturan con otras fibras industriales, con el objeto de evaluar cuales son las que más probablemente desprenden fibras por arriba de los valores limítrofes de los parámetros recomendables.

No menos de 107 análisis se llevaron a cabo durante los experimentos. Los métodos de recortes, y los análisis siguieron un protocolo riguroso, conforme a los estándares internacionales. Los resultados que se obtuvieron hicieron posible llegar a las siguientes conclusiones:

1. El uso de agua para reducir las emisiones de las fibras respirables, es un proceso muy efectivo. Haciendo comparaciones del recorte del mismo producto con la misma herramienta, la saturación hace posible reducir la contaminación del polvo de un 50 a un 90 %. Sin embargo, el uso de un disco abrasivo para recortar el producto utilizado en la construcción y la esmeriladora para el recorte de materiales de fricción, sin el uso de un sistema de aspiración, no es recomendable. Todos estos productos despiden cantidades importantes de concentraciones de fibras respirables cuando no se cortan adecuadamente, particularmente en el caso de los productos que contienen crisotilo. Aún con la adición del agua, las concentraciones de fibras respirables emitidas por estas herramientas, exceden los parámetros recomendados.

2. El uso de las herramientas manuales en todos los casos y de cualquier tipo de fibras que contenga el material utilizado no desprenden concentraciones de fibras respirables más allá de los límites de una fibra por centímetro cúbico

(considerando un promedio de 8 horas medidas), que es el estándar para el crisotilo. Este tipo de herramientas son las recomendadas por los fabricantes de fibrocemento y por las agencias de regulación, bajo la política del uso controlado. Estas son las mejores para todo tipo de materiales fibrosos.

3. Con la excepción del caso de un disco abrasivo sin ningún sistema de aspiración (una herramienta que en todo caso no es recomendada para este tipo de trabajo), las emisiones de fibras respirables son del mismo orden de magnitud ya sea para aquellos productos que contienen o no crisotilo. De hecho, los valores son menores en el caso de algunas fibras que no contienen crisotilo sin embargo, en todos los casos estos se encuentran dentro del rango de los parámetros recomendados.

No es posible llegar a la conclusión con respecto al riesgo relativo de cada producto o de cada herramienta utilizada en este estudio. Es necesario considerar otros factores, principalmente el de la biopersistencia de cada tipo de fibra para evaluar el riesgo. Es recomendable, sin embargo, recordar que a pesar del incremento de la presencia en el mercado con mayoría de otras fibras diferentes al crisotilo, desgraciadamente no están esencialmente reguladas.

Sobretodo, es posible asegurar condiciones mínimas de exposición a las fibras volátiles respirables por los trabajadores que necesitan utilizar productos de fibrocemento. Mientras existan los reglamentos básicos que deben regir su uso y estos se atiendan, estos productos no despedirán fibras respirables mas allá de los estándares reconocidos propuesto por las organizaciones que llevan a cabo la reglamentación internacional. El uso de equipo de protección respiratorio sigue siendo, una medida precautoria recomendada.

Краткий обзор

Вопрос, относительно эффекта воздействия микро волокон, которые осыпаются при нарезке больших фрикционных продуктов, а также прочных строительных материалов, занимает одну из лидирующих позиций в мире. В соответствии с Конвенцией №162, изданной Международной Организацией Труда, под названием «*Безопасность использования асбеста»*, с самого начала восьмидесятых годов работодатели, рабочие, представители правительства должны принимать во внимание важность использования средств достаточной респираторной защиты, а также использование соответствующего оборудования в целях защиты работников. В связи с использованием огромного количества волокнистых материалов при строительстве, проведении ремонтных и реставрационных работ, а также работ по сносу зданий за последние десятилетия, возникает ряд вопросов относительно их воздействия, а отсутствие научных данных лишь усугубляют данную проблему.

Первостепенная задача данного исследования заключается в оценке масштаба эмиссии волокон в окружающий воздух для различных типов фиброцемента и фрикционных продуктов в целях сравнения различных способов безопасного нареза для каждого из них. В лабораторных условиях были использованы те же инструменты, что и на строительных площадках. В цели данного исследования также входит проведение сравнения продуктов, содержащих хризотил и эквивалентных продуктов, выработанных из других производственных волокон, чтобы выявить продукты, которые, наверняка, превысят уровень допустимого выброса вдыхаемых волокнистых веществ.

По меньшей мере, 107 анализов было проведено при выполнении данных исследований. Способы нарезки и проведенные анализы, позволили составить точный протокол в соответствии с международными стандартами. Полученные результаты предоставили возможность прийти к следующему заключению:

1) Использование воды в целях сокращения эмиссии вдыхаемых волокон представляется очень эффективным средством. При сравнении процесса нарезки одних и тех же продуктов одинаковыми инструментами, использование воды позволяет сократить содержание пыли от 50% до 90%. Однако, проведение работ без аспирационной системы не рекомендуется, в случае с использованием шлифовального круга при нарезке строительных материалов и шлифовального камня для фрикционных продуктов. Все данные типы продуктов выделяют значительное количество вдыхаемых волокон при неправильной нарезке, особенно в случае с продуктами, содержащими хризотил. Даже при использовании воды, концентрация вдыхаемых волокон, осыпающихся при использовании данных инструментов, превышает рекомендуемый уровень.

2) При использовании ручных инструментов независимо от типа использованных материалов, содержащих волокна, концентрация волокон не превышает допустимого предела 1 волокно/кк (средневзвешенное содержание на восьми часовой период времени), что является стандартом для хризотила. Данные инструменты, рекомендуемые производителями фиброцемента, организациями по стандартизации, и соответствующие условиям контроля над использованием оборудования, представляются лучшими для всех типов волокнистых материалов.

3) За исключением случая со шлифовальным диском, применяемым без использования какой-либо системы аспирации (инструмент, который ни при каких обстоятельствах не рекомендуется для проведения такого рода работ), эмиссия вдыхаемых волокон представляется в той же самой последовательности, независимо от того содержат ли продукты хризотил или нет. Уровень выброса у других типов волокон, помимо хризотила, представляется более низким, однако во всех случаях он не превышает рекомендуемых пределов.

Представляется невозможным, прийти к заключению, относительно риска, возникающего при контакте с каждым продуктом или инструментами, использованными при проведении данного исследования. В целях оценки возможного риска, необходимо принимать во внимание другие факторы, в основном биоперсистенцию каждого типа волокон. Следует принимать во внимание тот факт, что большинство волокнистых продуктов появляющихся на рынке содержат другие волокна помимо хризотила, которые, к сожалению, остаются нерегламентированными.

В общем, и целом, представляется возможным обеспечить минимальный уровень воздействия вдыхаемых волокон в окружающем воздухе на рабочих, в задачи которых входит работа с фиброцементными продуктами. Если следовать основным правилам работы с данными продуктами, уровень выпускаемых вдыхаемых волокон не будет превышать допустимой отметки, указанной международными организациями по стандартизации. Рекомендуемой мерой предосторожности по-прежнему остаётся использование защитных респираторных средств.

With the passing of years, the working methods for the use of potentially dangerous products for human health are refined, and nowadays there are hardly any non-friable products on the market that endanger users and consumers. Nevertheless, safe work practices must be applied to ensure maximum protection.

In the construction field, there is a greater health risk for workers due to the high number of harmful products and working conditions. It is necessary to point out the importance of applying responsible use practices, since it is essential to provide workers with proper training for handling these products and with the applicable warnings.

With regard to the installation of fibrous products, certain myths are frequently conveyed, which have no basis in reality. For example, the opponents to the responsible use of chrysotile have protested many times that while it may be possible to adequately control the exposure of workers to airborne fibres in mines and in manufacturing plants for finished products, this precaution is impossible on a construction site where the workers are not trained to use suitable working methods. Based on this assumption, the manufacturers of products or fibres for replacement of chrysotile claim that their products are safer because they can be handled in complete safety, and thus without risk.

It is to answer these claims that this study was undertaken.

1. Objective

One of the prime objectives of this study is to compare airborne fibre emissions rates for various asbestos-cement products to compare the safety of the various cutting techniques for each product. The tools used for the laboratory tests are those that are generally found on construction, repair, restoration and demolition sites.

Secondly, the study aims at comparing airborne fibre emissions when grinding friction products. Many manufacturers of brakes, for example, do not apply the same safety measures to both chrysotile containing materials and materials without chrysotile.

Lastly, the third objective is to make a comparison between products containing chrysotile and equivalent products containing replacement fibres to evaluate which were most likely to release respirable fibres beyond the recommended threshold limit values.

It should be stressed that this study does not aim to establish whether a material is more durable or of better quality than another or even whether it is safer than another. On the one hand, it aims to measure only the airborne respirable fibre concentrations produced. Other components, silica, lime and other nonfibrous components, potentially harmful to health, were not taken into consideration by microscopic analyses. In addition, this research does not pass judgement on the toxicity of the products studied and that of the fibres they contain. This study is based on the premise that the presence of any airborne respirable fibre should not exceed the standard of one fibre per cubic centimetre of air (on an eight-hour time-weighted average), whatever its nature and its biopersistance. It is the role of the toxicologists and epidemiologists to suggest other permissible exposure according to the relative toxicity of each type of fibre.

2. Methodology

The objective of this study was to evaluate the emissions rates of respirable fibres under normal use and while using methods not recommended for the cutting of fibrocement products. The methodology employed called upon the tools generally used for cutting and installing these products.

2.1 Products

The products tested are available on the market and were not manufactured in the laboratory. Although their composition is not known with precision, since these are industrial secrets, these products were chosen in order to represent the realistic situation for a worker when assigned to cutting, grinding or installing these products on the job.

Table 2.1
Products Tested

Construction material *(fibrocement)*	Friction products
• Corrugated chrysotile-cement sheet	• Drum brake containing chrysotile
• Flat chrysotile-cement sheet	• Brake shoe containing chrysotile
• Chrysotile-cement pressure pipe	• Brake shoe containing wollastonite, acrylic fibres and cellulose
• Corrugated polyvinyl alcohol (PVA)-cement sheet	
• Flat cellulose-cement sheet	
• Corrugated polypropylene-cement sheet	

The various asbestos-cement and friction products were cut or submitted to grinding in a sealed room with controlled ventilation, using controlled and strictly comparable cutting or grinding methods. The tests include both the cutting and grinding methods recommended by the manufacturer and by those of the ILO *Code of Practice*[1] in addition to methods considered hazardous for the health of workers.

1 International Labour Organization (ILO), *Code of practice – Safety in the use of asbestos*, 1984.
International Labour Organization (ILO), *Code of practice – Use of synthetic vitreous fibre insulation wools (glass wool, rock wool, slag wool),* 2000.

2.2 Sealed Room

A sealed room measuring 2.1 x 2.1 x 2.1 meters was built in the *Centre de technologie minérale et de plasturgie inc*. in Thetford Mines (CTMP) to accommodate all the tests. This room was built with a wood frame covered from the inside with polypropylene film. The polypropylene was stapled to the frame and all the joints were made tight using a sealant applied with a caulking gun.

The room was ventilated using a ventilator equipped with a HEPA (High Efficiency Particulate Air) filter. The flow of the ventilator was fixed at one cubic metre/minute with the aim of ensuring six changes of air per hour in the sealed room[2]. An air inlet to the room was provided by means of an opening measuring 30 cm X 30 cm fitted with a filtration septum of tightly woven cotton fibre. The room was equipped with adequate lighting to compensate for the weak external luminosity.

[2] In accordance with the Occupational Heath and Safety Regulation of the Québec Occupational Health and Safety Act (L.R.Q., chap. S-2.1, a. 223).

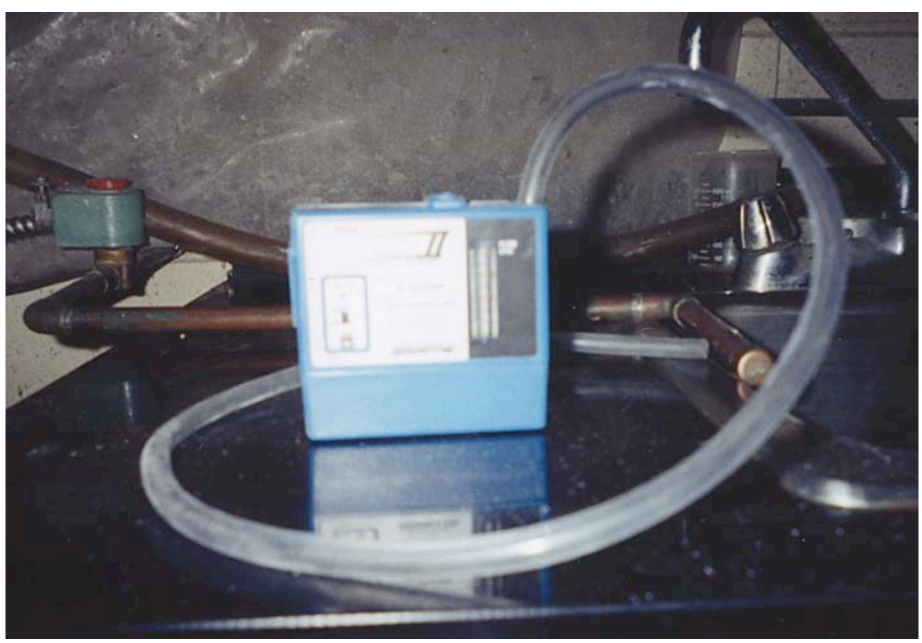
2.3 Technician's Protective Clothing and Respiratory Protection

The technician assigned to carry out the cuts wore disposable Tyvec coveralls. These coveralls had straps at the wrists and the ankles to ensure its sealing, in addition to a cap to cover the head and to form a hermetic seal with the respiratory protector.

The technician also wore a full-face type-C respiratory protector, equipped with a portable ventilator fitted with filtered HEPA discharge in conformity with applicable regulations.

2.4 Air Monitoring

The technician carried a personal air sampler set at 3 litres/minute. A fixed sampler set at 0.6 litre/minute was also in operating inside the sealed room for the majority of the tests, for the purpose of controlling the accuracy of personal sampling. The rate of flow of the air samplers was checked after each test. The filtration cassettes of the samplers were also changed after each test. Lastly, the power supply batteries of the samplers and the power supply for the respiratory protector ventilator were recharged at the end of each day.



2.5 Experimental Procedure

2.5.1 Preparation

All interior surfaces of the sealed room were wiped using wet paper towels, and the working space was ventilated for 30 minutes before each test. A polyethylene film carpet was placed on the floor, covering all the available surfaces.

The two air samplers – personal and fixed – were started respectively at flows of 3 and 0.6 litres per minute.

2.5.2 Test Cutting Procedure

The samples were cut without delays between each cut. This practice represents an extreme condition that is seldom met in a work environment. Several cuts were necessary for each test. At the end of each test, the personal sampler was stopped and its filtration cassette placed in a container identified with the number of the test and the number of the sampler. A new cassette was inserted for the following test.

The polyethylene carpet on the floor was then folded to collect all the particles that had settled, and these particles were then placed in a paper envelope identified with the test number, using a fine-haired brush. Thereafter, all the visible particles were aspirated using a Hazvac Model EC-12(G) HEPA aspirator fitted with the narrow slot suction nozzle. The floor carpet was then wiped using wet paper towels, which were then put in plastic bags for disposal.

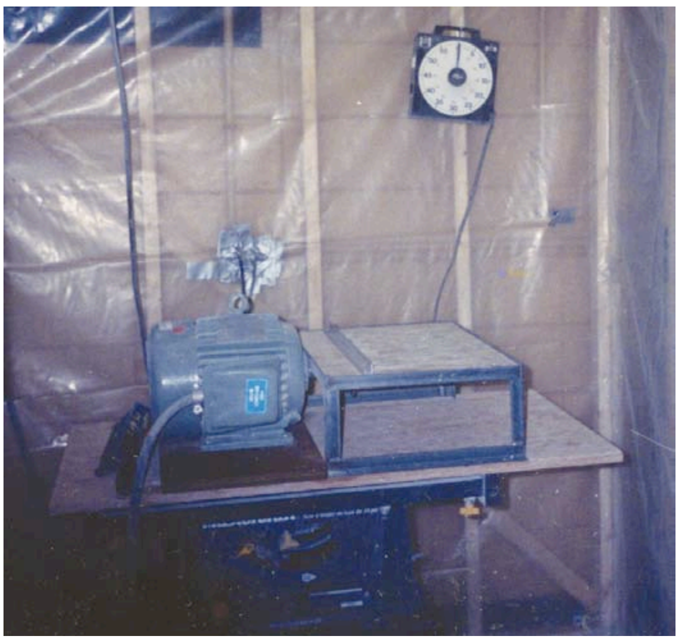
The airtight room was ventilated for twenty minutes following the end of each test. A visual inspection was made before starting the following test. The stages described previously were carried out for each test undertaken. After the last test of each day, the fixed sampler was stopped, and its filtration cassette was placed in a container identified with the date and the number of the sampler. A new cassette was then inserted in the apparatus.

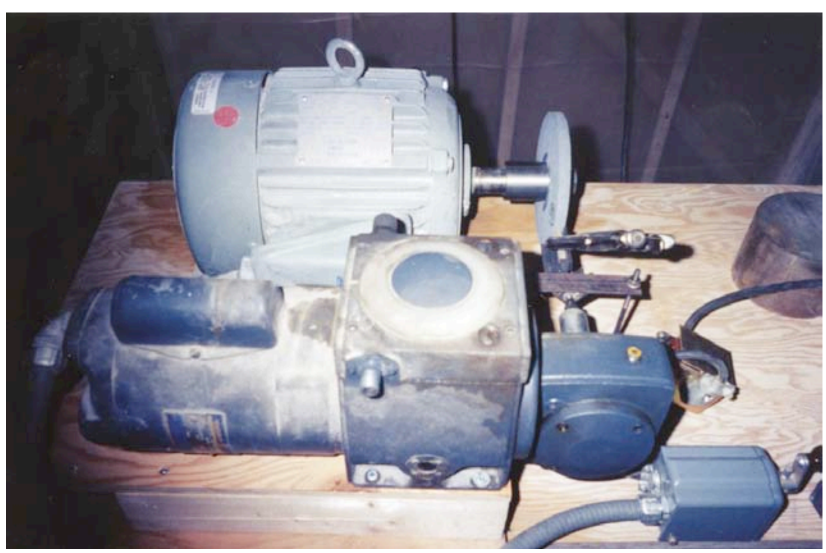
2.6 Tools Used

None of the tools used were equipped with an aspirator system. The majority of the cuts were carried out dry. When the airborne respirable fibre counts were elevated, the tests were repeated by using specimens saturated with water. In this manner, it was possible to estimate the reduction in airborne respirable fibres released when cutting with wetted materials.

Table 2.2
Operations carried out on the products

Building Materials		Friction products
Electrical tools (no vacuum)	*Manual tools*	
• 2 mm thick toothed saw blade, 8 mm spacing between teeth, rotating speed of 250 rpm and diameter of 10 cm. • 2mm thick toothed saw blade, identical to the preceding one, rotating speed of 500 rpm 3.4 mm abrasive disk, rotating speed of 5000 rpm	• Guillotine-type shear • cutting chain (snap cutter) • low speed motorized field lathe	• 13.7 mm thick grinding wheel, no vacuum system, rotating speed of 5000 rpm





2.7 Data Obtained

The respirable fibre emissions produced by the various shaping operations were measured by precision with phase contrast optical microscopy according to the method suggested by the World Health Organization[3]. The WHO method may be relied on evaluate the airborne respirable fibre emission concentrations. This procedure also meets the requirements for a method that enjoys international recognition and which can yield comparable results when used in different laboratories by qualified microscopists. Specifications for the equipment and materials required for the verification of materials, the preparation of test specimens, the fibre counting protocol and the calculation of results are included in the Who method. The fibre counting and calculations were carried out by a specialist recognized by the Institute de recherche Robert-Sauvé en santé et en sécurité du travail du Québec (IRSST).

It is important to note that the World Health Organization recommends that workers' exposure to respirable chrysotile fibres should not exceed one fibre per cubic centimetre of air (1 f/cc)[4]. The ILO and several governmental bodies responsible for occupational health and safety suggest that this standard also applies to the majority of natural and synthetic fibres.

No less than 107 analyses were carried out while cutting materials. Out of this number, 48 were personal and 44 fixed samples. In order to validate the reliability of measurements, 15 "blank" filtration membranes were analyzed. Of the 92 fixed samples and personal samples that were used for the analyses, three were overloaded with particles, making reading impossible. The overloaded fields are not necessarily representative of a heavy exposure to fibres, because other materials present in the cut products (for example, cement, silica and lime) can be put in suspension in sufficient quantity to make the readings impossible. Thus there remained only 89 usable tests for study purposes, which is evidently sufficient to provide a realistic portrait of the situation.

Since the personal sample results do not differ appreciably from the fixed sample results – the first giving an average exposure of 0.15 f/cc higher than for the fixed samples for counts lower than 3 f/cc – for purposes of analysing the data, only the personal sampler results (47 results) were retained. Only one fixed sampler result was retained for which there were not reliable personal sampler results.

The 48 air sampler results retained for analysis are thus identified as follows:

- 7 for the cutting of chrysotile-cement sheets,
- 17 for the cutting of chrysotile-cement pipes,
- 18 for the cutting of non-chrysotile fibrocement products,
- 4 for chrysotile friction products,
- 2 for non-chrysotile friction products.

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3 World Health Organization (WHO), *Determination of airborne fibre number concentrations. A recommended method, by phase-contrast optical microscopy (membrane filter method)*, Geneva, 1997, 61 pages.

4 One cubic centimetre (cc or cm^3) is equivalent to one fibre per millilitre (ml).

3. Results

Table 3.1 suggests that the use of the manual tools, whatever the product and the type of fibre of which it is composed, releases very low airborne respirable fibre concentrations. The emissions are, in the worst case, half of the 1 fibre/cc (weighted average over 8 hours) standard exposure suggested by the WHO in the case of chrysotile. The important variations observed in the sampling of respirable airborne fibre emissions produced by the shaping of products by means of power tools imply a need for prudence and judgment in the analysis of the data in order to come to significant conclusions.

Table 3.1
Results by tool and by product

(dry cut only)		Emissions (f/cc)					
		Products with chrysotile			Products without chrysotile		
Tools		Min	Max	Avr	Min	Max	Avr
Electric	Abrasive disc	1.40	25.60	12.60	< 0.1	0.80	0.50
(without	Grindstone	0.23	46.70	17.86	0.23	26.00	13.12
vacuum	Saw @ 250 rpm	0.40	1.90	0.92	0.20	0.50	0.35
system)	Saw@ 500rpm	0.40	3.50[5]	0.80[4]	0.20	0.60	0.29
Manual	Cutting chain	0.08	0.19	0.14	N.A.	N.A.	N.A.
	Shear	0.48	0.50	0.49	0.27	0.30	0.29
	Field lathe	0.01	0.01	0.01	N.A.	N.A.	N.A.

Table 3.2 shows, in fact, it is essentially the tools, much more than the materials, that contribute to respirable airborne concentrations that are higher in terms of fibres per cubic centimetre. Thus, the use of an abrasive disc (without aspiration) almost always gives results approaching or higher than the WHO standard, especially in the case of materials containing chrysotile fibres. Therefore, this practice should not be used for cutting fibrous materials. The same reasoning applies to the use of a grinding wheel without an aspiration system for debarbing (removal of whiskers and shards) from friction materials, when a heavy abrasion of the product is necessary. Whatever the fibres used for the manufacture of these friction products, the resulting emissions produced by heavy grinding may be too high to ensure the adequate protection of the workers.

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5 A measurement of 3.50 f/cc with personal sampling was obtained while cutting a chrysotile-cement pipe, whereas fixed measurement showed a concentration under the limit of detection. The personal measurement appears definitely too high to us for unknown reasons, which is not unusual in this type of study. For statistical purposes, we retained this value to illustrate the maximum exposure, but put it aside for the calculation of the average concentration.

Table 3.2
Average results presented by product and by tool (f/cc)
(electric tools only - dry cut, without air aspiration system)

Product	Abrasive disk	Saw at 250 rpm	Saw at 500 rpm	Grind – light abrasion	Grind – heavy abrasion
Chrysotile-cement corrugated sheet	6.15	0.40	0.40	n.a.	n.a.
Polypropylene/C corrugated sheet	0.30	0.45	0.25	n.a.	n.a.
PVA/C corrugated sheet	0.80	0.50	0.60	n.a.	n.a.
Chrysotile-cement flat sheet	1.40	1.00	0.60	n.a.	n.a.
Cellulose/C flat sheet	0.70	0.30	0.25	n.a.	n.a.
Chrysotile-cement pipe	25.60	0.40	0.40	n.a.	n.a.
Chrysotile-cement pressure pipe	14.90	1.40	1.80	n.a.	n.a.
Friction product w/chrysotile	n.a.	n.a.	n.a.	0.27	35.45
Friction product without chrysotile	n.a.	n.a.	n.a.	0.23	26.00
Average	**6.55**	**0.66**	**0.53**	**0.25**	**32.30**

n.a: not applicable

Regarding the use of saws, except for chrysotile-cement pressure pipes, no values exceed the allowed limit of one fibre per cubic centimetre. In the case of these pipes, the material is very thick and requires a long period of cut, which explains the high airborne respirable fibre level caused by the use of a saw. Moreover, these are the materials that contain the greatest proportion of chrysotile fibres, almost 40 % of the total content. These products, although old[6], can be found nowadays in old buildings where it is necessary to carry out cutting work. Although this extreme situation has relatively few chances to be frequently met, it was considered for the purpose of this study because it is representative of the extreme cases liable to occur. Tests with pipes that contain, as is the case normally, less than 15 % of chrysotile, would have definitely given lower results. In any case, with the tools recommended by the occupational health and safety organizations and recognized under the terms of the controlled use policy, we did not observe emissions higher than the permissible exposure limits.

Tests with water-saturated materials showed clearly that the products, once saturated, liberate much fewer respirable fibres than when they are dry. The average airborne fibre concentration measured after wetting of materials is, at most, less than half of that with the same dry material. We conclude that this practice would make it possible to use high-speed power saws for all types of materials. It should however be noted that the use of the abrasive disc, even with a wet product, still does not make it possible to meet the safety requirement.

6 Chrysotile-cement products manufactured since the beginning of the 1980's contain rarely more than 15% of fibre, generally between 8 and 12%.

Table 3.3
Effect of water saturation on respirable airborne emissions

Product	Tool	Value - dry	Value - wet
7 mm chrysotile-cement corrugated sheet	Saw – 500 rpm	0.40 f/cc	0.20 f/cc
5 mm cellulose-cement flat sheet	Abrasive disk	n.a.	0.30 f/cc
185 mm chrysotile-cement pipe	Saw – 500 rpm	0.40 f/cc	0.16 f/cc
185 mm chrysotile-cement pipe	Abrasive disk	25.60 f/cc	7.60 f/cc
170 mm chrysotile-cement pressure pipe	Abrasive disk	14.70 f/cc	8.80 f/cc

4. Conclusions

The data presented in the preceding sections make it possible to draw the following conclusions:

1. The use of manual tools, in all circumstances and whatever the types of fibre-containing cement products, does not release respirable fibre concentrations beyond the threshold of 1 fibre/cc (on an eight-hour time-weighted average), which is the standard for chrysotile. These tools, which are recommended by the fibrocement manufacturers, regulation agencies and under the terms of the policy of controlled use, are the best for all types of fibre-containing rigid materials.

2. The use of water to reduce the respirable fibre emissions is a very effective process. Compared to the same product cut with the same tool, saturation makes it possible to reduce the respirable airborne fibre concentration from 50 to 90 %. However, the use of an abrasive disc for the cutting of building materials and of a grinding wheel for the friction products without an aspiration system is not advisable. All these products release important respirable fibre concentrations when not properly cut. Even with the addition of water, the respirable fibre concentrations released by these tools may exceed the WHO recommended threshold.

3. Except in the case of an abrasive disc without an aspiration system (a tool which in any event is not recommended for this kind of work), the respirable fibre emissions are of the same order of magnitude, whether the products contain chrysotile or not. Admittedly, the values are lower in the case of certain fibres other than chrysotile, but in all cases, they remain in the range of recommended levels. Regarding other industrial fibres, the lack of toxicological and epidemiologic data does not enable us to vouch for their safety.

Safe procedures for shaping fibre-containing rigid products require appropriate methods, whatever the type of material in question. This is why since the beginning of the 1980's, manufacturers warn users to strictly respect this requirement. The results of this study confirm the basis upon which the appropriate policies and working methods – in particular with regard to the tools used – which ensure that the airborne fibre concentrations in work environments will be always below international standards.

It is not possible to draw conclusions as to the relative health risk of each product or each tool used at the time of this study. To do this, it would be necessary to take into account other factors, mainly the biopersistance of each type of fibre, to evaluate their risk. It is however advisable to recall that, in spite of their growing presence on the market, the majority of industrial fibres, other than chrysotile, are seldom regulated and studies of their harmlessness are definitely insufficient. In the light of these facts and those revealed by some studies in progress on the toxicity of industrial fibres, it becomes pressing that the national and international regulatory organizations consider the establishment of maximum standards of exposure for all respirable fibres. Only through new, additional, and exhaustive studies will we be able to determine the safety of the workers and the people exposed to these fibres.

Overall, it is possible to ensure minimal exposure conditions to airborne respirable fibres for workers required to handle fibrocement products. As long as the basic rules that govern their use are complied with, these products do not release excessive concentrations of airborne respirable fibres. The wearing of respiratory protectors remains, in our opinion, at all times a suitable protection measure.

Appendices

Appendix 1

Sample composition

Sample number	Material	Composition (%)			Number of tests
		Chrysotile	Other fibres	Other	
3	7 mm corrugated sheet	25-30	1-5	65-75	8
4	4 mm flat sheet	20-25	Traces	75-80	6
6	Drum brake lining	30-35	Traces	65-70	4
7	4 mm PVA corrugated sheet		20-30	70-80	6
8	5 mm cellulose flat sheet		30-40	60-70	8
9	8 mm cellulose flat sheet		30-35	65-70	6
10	6 mm polypropylene corrugated sheet		25-35	65-75	13
11	Brake pad	15-20	2-10	70-85	4
12	Brake pad		10-25	75-90	4
14	185 mm pipe	30-35	Traces	65-70	10
15	170 mm pressure pipe	35-40	Traces	60-65	14
20	4 mm PVA flat sheet		20-30	70-80	2
33	100 mm c/c pipe	Not specified	Not specified		2
35	6 mm c/c flat sheet	Not specified	Not specified		2

Appendix 2
Tests compositions
2.1 Electrical tools

Test number	Sample used	Tool	Speed (rpm)	Dust volume generated (ml/minute)	Time (minutes)
7	3	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	5,3	30,7
8	3	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	5,3	30,7
9	3	Abrasive disk	5000	7,7	21,3
10	4	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	2,8	59,3
11	4	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	2,8	59,3
12	4	Abrasive disk	5000	4,0	41,2
14	6	Grind	5000	1,6	20
15	7	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	3,2	50,9
16	7	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	3,2	50,9
17	7	Abrasive disk	5000	3,8	41,2
18	8	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	3,7	44,5
19	8	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	3,7	44,5
20	8	Abrasive disk	5000	5,3	30,9
21	9	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	5,7	28,7
22	9	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	5,7	28,7
23	9	Abrasive disk	5000	8,2	19,9
24	10	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	4,6	35,6
25	10	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	4,6	35,6
26	10	Abrasive disk	5000	6,6	24,7
27	10	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	4,6	35,6
28	10	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	4,6	35,6
29	10	Abrasive disk	5000	6,6	24,7
30	11	Grindstone	5000	1,6	20
31	12	Grindstone	5000	1,6	20
32	14	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	4,6	35,6
33	14	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	4,6	35,6
34	14	Abrasive disk	5000	18,8	8,7
35	15	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	8,0	20,4
36	15	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	8,0	20,4
37	15	Abrasive disk	5000	12,4	13,2
38	15	Saw (Width : 2 mm - Teeth spacing : 8 mm)	250	11,3	14,5
39	15	Saw (Width : 2 mm - Teeth spacing : 8 mm)	500	11,3	14,5
40	15	Abrasive disk	5000	16,3	10,1
41	6	Grindstone	500	0,02	20,0
42	11	Grindstone	500	0,02	20,0
43	12	Grindstone	500	0,02	20,0
44	3	Saw (Width : 2 mm - Teeth spacing : 8 mm) – wet material	500	5,3	30,7
45	14	Saw (Width : 2 mm - Teeth spacing : 8 mm) – wet material	250	8,0	35,6
46	14	Abrasive disk – wet material	5000	18,8	8,7
47	15	Abrasive disk – wet material	5000	16,3	10,1
48	8	Abrasive disk – wet material	5000	2,7	30,9

2.2 Manual Tools

Test number	Sample(s) used	Tool	Work done
49	20	Manual shear	4 cuttings to obtain 4 28 x 305 mm pieces. Air sampling at 0.6 litre per minute.
50	21	Manual shear	11 cuttings to obtain 7 25 x 300 mm pieces and 4 30 x 300 mm pieces. Air sampling at 0,6 litre per minute.
51	35	Manual shear	12 cuttings to obtain 12 25 x 305 mm pieces. Air sampling at 0.6 litre per minute.
52	35	Manual Shear	288 cuttings to obtain 25 x 305 mm pieces. Air sampling at 0.6 litre per minute.
53	22 32 33 34	Snap cutter	As many possible cuttings on the selected samples. . Air sampling at 0.6 litre per minute.
54	15	Snap cutter	As many possible cuttings on the selected samples. . Air sampling at 0.6 litre per minute.
55	22 32 33 34	Field lathe	As many possible cuttings on the selected samples. . Air sampling at 0.6 litre per minute.

Appendix 3
Filter membranes report analysis
3.1 With chrysotile-cement sheet and pipes

Test number	Sample	Volume (l)	Monitoring		Results		Remarks
			Number of fields	Number of fibres	Density (f/ mm^2)	Concentration (f > 5 _m/ml)	
JL-05-59	7-3-Pers.	18,10	100	14,5	18,5	0,4	Less precise because of low density
JL-05-60	7-3-Fix	18,26	100	11,5	14,6	0,3	Less precise because of low density
JL-05-61	8-3-Pers.	17,95	100	16,0	20,4	0,4	Less precise because of low density
JL-05-62	8-3-Fix	18,41	100	11,5	14,6	0,3	Less precise because of low density
JL-05-63	9-3-Pers.	12,66	65	104,0	203,8	6,2	V.C. = 12%
JL-05-64	9-3-Fix	12,66	65	103,0	201,9	6,1	V.C. = 12%
JL-05-67	Blank # 1	--	100	0,5	0,6	--	0,005 f/field
JL-05-68	Blank # 2	--	100	1,5	1,9	--	0,015 f/field
JL-05-114	10-4-pers.	34,71	100	67,5	86,0	1,0	V.C. = 14%
JL-05-115	10-4-Fix	34,71	100	49,5	63,1	0,7	V.C. = 14%
JL-05-116	11-4-pers.	34,71	100	45,5	58,0	0,6	V.C. = 14%
JL-05-117	11-4-Fix	34,71	100	35,0	44,6	0,5	V.C. = 14%
JL-05-118	12-4-pers.	24,48	100	67,5	86,0	1,4	V.C. = 14%
JL-05-119	12-4-Fix	24,48	100	46,5	59,2	0,9	V.C. = 14%
JL-05-146	32-14-pers.	21,00	100	15,5	19,7	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-147	32-14-Fix	21,00	100	14,5	18,5	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-148	33-14-pers.	21,09	100	19,5	24,8	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-149	33-14-Fix	21,09	100	17,5	22,3	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-150	35-15A-pers.	12,02	100	23,0	29,3	0,9	Unknown precision because density is< 25 f/mm^2
JL-05-151	35-15A-Fix	12,02	100	16,5	21,0	0,7	Unknown precision because density is< 25 f/mm^2
JL-05-152	36-15A-pers.	8,51	100	32,0	40,8	1,8	V.C. = 14%
JL-05-153	36-15A-Fix	8,51	100	31,0	39,5	1,8	V.C. = 14%
JL-05-154	38-15B-pers.	8,51	100	33,0	42,0	1,9	V.C. = 14%
JL-05-155	38-15B-Fix	8,51	100	28,5	36,3	1,6	V.C. = 14%
JL-05-156	Blank # 1	--	100	0,0	0,0	--	0,000 f/field
JL-05-157	Blank # 2	--	100	1,0	1,3	--	0,010 f/field
JL-05-158	Blank # 3	--	100	0,5	0,6	--	0,005 f/field
JL-05-159	Blank # 4	--	100	0,0	0,0	--	0,000 f/field
JL-05-160	Blank # 5	--	100	1,0	1,3	--	0,010 f/field

3.1 With chrysotile-cement sheet and pipes
(continued)

Test number	Sample	Volume (l)	Monitoring		Results		Remarks
			Number of fields	Number of fibres	Density (f/ mm^2)	Concentration (f > 5 m/ml)	
JL-05-187	34-14-pers.	5,14	50	133,5	340,1	25,6	V.C. = 12 %
JL-05-188	34-14-fix	5,23	50	125,5	319,7	23,7	V.C. = 12 %
JL-05-189	37-15A-pers.	7,72	50	115,0	293,0	14,7	V.C. = 12 %
JL-05-190	37-15A-fix	7,79	50	107,5	273,9	13,6	V.C. = 12 %
JL-05-191	40-15B-pers.	5,98	55	101,0	233,9	15,1	V.C. = 12 %
JL-05-192	40-15B-fix	5,98	60	100,5	213,4	13,8	V.C. = 12 %
JL-05-193	Blank # 1	--	100	1,5	1,9	--	0,015 f/field
JL-05-194	Blank # 2	--	100	0,5	0,6	--	0,005 f/field
JL-05-248	39-15B-pers.	8,62	100	60,5	77,1	3,5	V.C. = 14%
JL-05-249	39-15B-fix	8,62	100	5,5	7,0	0,32	Below analytical method detection level
JL-05-250	Blank # 1	--	100	0,5	0,6	--	0,005 f/field
JL-05-339	44-3-pers.	18,10	100	9,5	12,1	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-340	44-3-fix	18,41	100	9,0	11,5	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-341	45-14-pers.	18,67	100	6,0	7,6	0,16	Below analytical method detection level
JL-05-342	45-14-fix	18,05	100	7,0	8,9	0,19	Below analytical method detection level
JL-05-343	46-14-pers.	5,27	100	81,5	103,8	7,6	V.C. = 12 %
JL-05-344	46-14-fix	5,27	100	68,0	86,6	6,3	V.C. = 14 %
JL-05-345	47-15B-pers.	5,98	100	107,0	136,3	8,8	V.C. = 12 %
JL-05-346	47-15B-fix	6,08	100	105,5	134,4	8,5	V.C. = 12 %
JL-05-349	Blank # 1	--	100	2,0	2,5	--	0,020 f/field
JL-05-350	Blank # 2	--	100	0,0	0,0	--	0,000 f/field
JL-05-484	51-35-pers.	8,83	100	9,0	11,5	0,5	Unknown precision because density is< 25 f/mm^2
JL-05-485	52-35-pers.	398,87	30	117	496,8	0,48	V.C. = 12%
JL-05-486	49-50-51-52-fix	35,39	100	9,5	12,1	0,13	Unknown precision because density is< 25 f/mm^2
JL-05-487	Blank # 1	--	100	0,5	0,6	--	0,005 f/field
JL-05-515	53-pers.	918,93	75	108,5	184,3	0,077	V.C. = 12%
JL-05-516	54-pers.	74,98	100	29,5	37,6	0,19	V.C. = 14%
JL-05-518	Blank # 1	--	100	1,0	1,3	--	0,010 f/field
JL-05-608	55-33-pers.	1476,09	**	**	**	**	** : Overcharged with particles - impossible to analyse
JL-05-609	55-33-fix	236,25	100	7,0	8,9	0,01	Resample with greater air volume.
JL-05-610	Blank # 1	--	100	0,5	0,6	--	0,005 f/field

3.2 With chrysotile free sheets

Test number	Sample	Volume (l)	Monitoring		Results		Remarks
			Number of fields	Number of fibres	Density (f/ mm^2)	Concentration (f > 5 _m/ml)	
JL-05-120	15-7-pers.	30,13	100	31,5	40,1	0,5	V.C. = 14%
JL-05-121	15-7-fix	30,13	100	25,5	32,5	0,4	V.C. = 14%
JL-05-122	16-7-pers.	30,00	100	34,0	43,3	0,6	V.C. = 14%
JL-05-123	16-7-fix	30,00	100	22,0	28,0	0,4	V.C. = 14%
JL-05-124	17-7-pers.	24,18	100	39,0	49,7	0,8	V.C. = 14%
JL-05-125	17-7-fix	24,18	100	27,0	34,4	0,5	V.C. = 14%
JL-05-126	18-8-pers.	26,26	100	10,5	13,4	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-127	18-8-fix	26,26	100	8,5	10,8	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-128	19-8-pers.	26,14	100	11,5	14,6	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-129	19-8-fix	26,14	100	9,5	12,1	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-130	20-8-pers.	18,20	100	**	**	**	** : Overcharged with particles - impossible to analyse
JL-05-131	20-8-fix	18,20	100	**	**	**	** : Overcharged with particles - impossible to analyse
JL-05-132	21-9-pers.	16,86	100	12,5	15,9	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-133	21-9-fix	16,86	100	8,5	10,8	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-134	22-9-pers.	16,79	100	12,0	15,3	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-135	22-9-fix	16,79	100	9,0	11,5	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-136	23-9-pers.	11,84	100	16,5	21,0	0,7	Unknown precision because density is< 25 f/mm^2
JL-05-137	23-9-fix	11,84	100	13,5	17,2	0,5	Unknown precision because density is< 25 f/mm^2
JL-05-138	24-10A-pers.	20,92	100	22,0	28,0	0,5	V.C. = 14%
JL-05-139	24-10A-fix	20,92	100	15,5	19,7	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-140	25-10A-pers.	21,09	100	11,0	14,0	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-141	25-10A-fix	21,09	100	10,0	12,7	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-142	27-10B-pers.	21,09	100	18,5	23,6	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-143	27-10B-fix	21,09	100	13,0	16,6	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-144	28-10B-pers.	21,09	100	11,5	14,6	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-145	28-10B-fix	21,09	100	8,5	10,8	0,2	Unknown precision because density is< 25 f/mm^2

3.2 With chrysotile free sheets
(continued)

Test number	Sample	Volume (l)	Monitoring: Number of fields	Monitoring: Number of fibres	Results: Density (f/ mm^2)	Results: Concentration (f > 5 _m/ml)	Remarks
JL-05-156	Blank # 1	--	100	0,0	0,0	--	0,000 f/field
JL-05-157	Blank # 2	--	100	1,0	1,3	--	0,010 f/field
JL-05-158	Blank # 3	--	100	0,5	0,6	--	0,005 f/field
JL-05-159	Blank # 4	--	100	0,0	0,0	--	0,000 f/field
JL-05-160	Blank # 5	--	100	1,0	1,3	--	0,010 f/field
JL-05-244	26-10A-pers.	14,81	100	17,0	21,7	0,6	Unknown precision because density is< 25 f/mm^2
JL-05-245	26-10A-fix	14,69	100	15,5	19,7	0,5	Unknown precision because density is< 25 f/mm^2
JL-05-246	29-10B-pers.	14,56	100	12,5	15,9	0,4	Unknown precision because density is< 25 f/mm^2
JL-05-247	29-10B-fix	14,81	100	10,5	13,4	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-250	Blank # 1	--	100	0,5	0,6	--	0,005 f/field
JL-05-347	48-8-pers.	18,21	100	11,5	14,6	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-348	48-8-fix	18,21	100	8,5	10,8	0,2	Unknown precision because density is< 25 f/mm^2
JL-05-349	Blank # 1	--	100	2,0	2,5	--	0,020 f/field
JL-05-350	Blank # 2	--	100	0,0	0,0	--	0,000 f/field
JL-05-482	49-20-pers.	4,28	100	2,5	3,2	0,27	Below analytical method detection level
JL-05-483	50-20-pers.	12,00	100	8,5	10,8	0,3	Unknown precision because density is< 25 f/mm^2
JL-05-486	49-50-51-52-fix	35,39	100	9,5	12,1	0,13	Unknown precision because density is< 25 f/mm^2
JL-05-487	Blank # 1	--	100	0,5	0,6	--	0,005 f/field
JL-05-515	53-pers.	918,93	75	108,5	184,3	0,077	V.C. = 12%
JL-05-516	54-pers.	74,98	100	29,5	37,6	0,19	V.C. = 14%
JL-05-517	29-10B-fix	157,65	100	7,5	9,6	BDL	Below analytical method detection level
JL-05-518	Blank # 1	--	100	1,0	1,3	--	0,010 f/field

3.3 With chrysotile friction products

Test number	Sample	Volume (l)	Monitoring		Results		Remarks
			Number of fields	Number of fibres	Density (f/ mm²)	Concentration (f > 5 _m/ml)	
JL-05-65	14-6-Pers.	11,80	20	116,0	738,9	24,2	V.C. = 12%
JL-05-66	14-6-Fix	11,80	20	114,0	726,1	23,8	V.C. = 12%
JL-05-183	30-11-pers.	5,90	20	111,5	710,2	46,7	V.C. = 12 %
JL-05-184	30-11-fix	6,00	20	105,5	672,0	43,5	V.C. = 12 %
JL-05-333	41-6-pers.	12,00	100	7,5	9,6	0,31	Below analytical method detection level
JL-05-334	41-6-fix	12,20	100	7,5	9,6	0,31	Below analytical method detection level
JL-05-335	42-11-pers.	12,00	100	6,5	8,3	0,27	Below analytical method detection level
JL-05-336	42-11-fix	12,10	100	5,5	7,0	0,23	Below analytical method detection level

3.4 With chrysotile free friction products

Test number	Sample	Volume (l)	Monitoring		Results		Remarks
			Number of fields	Number of fibres	Density (f/ mm²)	Concentration (f > 5 _m/ml)	
JL-05-185	31-12-pers.	5,95	35	109,5	398,5	26,0	V.C. = 12 %
JL-05-186	31-12-fix	5,95	40	106,0	337,6	22,0	V.C. = 12 %
JL-05-193	Blank # 1	--	100	1,5	1,9	--	0,015 f/field
JL-05-194	Blank # 2	--	100	0,5	0,6	--	0,005 f/field
JL-05-337	43-12-pers.	12,00	100	5,0	6,4	0,21	Below analytical method detection level
JL-05-338	43-12-fix	12,10	100	5,5	7,0	0,23	Below analytical method detection level
JL-05-349	Blank # 1	--	100	2,0	2,5	--	0,020 f/field
JL-05-350	Blank # 2	--	100	0,0	0,0	--	0,000 f/field

Notes : The effective filtration surface is 389 mm^2.
V.C.: Intra-laboratory variation coefficient. The interlaboratory variation coefficient is 12% at > 100 f/mm^2.
The mounting was carried out according to IRSST 243-1 method.
Field surface for all samples is 0,00785 mm^2.
Below analytical method detection level: data provided for information purposes.