Technical Facts

Asbestos Products

# Asbestos-containing Flooring Products

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# FOREWORD

One of the main objectives of the Canadian Asbestos Information Centre is to make available to all interested parties the most factual and up-to-date information possible on all scientific, medical, technical, regulatory or commercial aspects of asbestos.

The Centre's Technical Facts aim to assemble in a single document the various data existing on asbestos products — and often originating from multiple sources — from the technical and technological standpoint as well as that of health and safety. The documents cover a variety of aspects such as manufacturing processes, usage, physical characteristics, performance assessment.

The purpose of these documents is to provide a maximum of facts on asbestos-containing products so as to promote enlightened decisions on the uses of asbestos.

The present document was compiled to answer the many queries received by the Centre, especially from the United States, about asbestos-containing floor coverings. In view of the particular interest manifested in the United States, most of the data referred to in this brochure have been gathered from U.S. sources.

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# INTRODUCTION

This brochure explains the use of asbestos in vinyl-asbestos floor tile and vinyl sheet flooring. The test data gathered in this brochure are aimed at providing update information on the functions and safety of these products.

## Health Concerns in Perspective

Because of the potential health problems associated with occupationally-related exposure to asbestos, there continues to be some question regarding its safe use in modern products. When discussing asbestos health concerns related to asbestos-containing flooring products, it is important to keep several facts in mind.

1. In the manufacture of flooring products containing asbestos fibre, advances in packaging materials for asbestos and adherence to proper work procedures and industrial hygiene practices are meant to prevent potentially hazardous exposures in occupational and related environments.

2. In vinyl sheet flooring, asbestos is only incorporated in the backing felt, where it is encapsulated by the latex binder. No asbestos is used in the wearing surface of sheet flooring and thus traffic wear will not cause release of fibre. Asbestos in vinyl-asbestos tile is mixed throughout the tile, but is encapsulated by the plastic binder. In-use monitoring tests have been performed on floor tile in an effort to evaluate potential fibre release. To our knowledge, all tests have failed to demonstrate any detectable fibre release from heavy pedestrian traffic or floor maintenance operations.

A similar conclusion can be found in a U.S. Navy report on a study of asbestos-containing flooring materials. They reported no reason to be concerned about adverse health effects in using such products.

"Materials which contain asbestos encapsulated in a pliable or malleable organic binder (vinyl-asbestos floor tile or asphalt-asbestos roof tile) are not likely to release asbestos fibres even under the most severe conditions and consequently need not be substituted except when specifically directed." (1)

3. During the removal of asbestos-containing flooring products, adherence to recommended work procedures, published by flooring manufacturers or, in the U.S., by the Resilient Floor Covering Institute, has been shown to prevent hazardous exposures. The recommended procedures stress the importance of not sanding an existing resilient floor covering. However it is considered completely acceptable to buff an existing resilient floor covering.

# SECTION I

# Vinyl Sheet Flooring

## Why Asbestos?

The asbestos fibre in vinyl sheet flooring contributes many valuable characteristics to the finished product. The asbestos/latex backing makes the flooring resistant to rot, which is especially important in high humidity environments or when the flooring is laid in basements or on concrete slab floors. Asbestos also contributes to the dimensional stability of the flooring in these environments. Another advantage of asbestos/latex felt backed flooring resides in its stretch recovery characteristic, resulting in a product that, after installation, retains its shape even as the subfloor expands and contracts with temperature change. Asbestos provides a cost-effective means of building thickness in the flooring, ensuring warmth and comfort together with strength and durability.

Aside from its characteristics in the finished product, asbestos/latex felt plays a key role in facilitating the manufacturing process, permitting the felt to withstand the high temperatures required for the finishing and curing operations and adding the strength needed to endure the rolling and pulling effect of manufacturing machinery.

## Manufacturing

Asbestos/latex backing is produced on a paper machine. Asbestos fibre used in the process is supplied in pulpable paper bags that need not be opened. Mixing is done in a hydropulper with water. Latex is added to the asbestos slurry in a chemical chest before being pumped into the paper machine head box.

On the most commonly used paper machine, the fibre suspension will flow out of the head box onto a traveling wire mesh cloth. Water drains through the wire assisted by table rolls and/or suction boxes. The sheet, with the fibre encapsulated by the latex, then passes through rollers and is dried on a series of steam-heated cylinders. In a final step, the sheet is passed through a stack of calendar rolls to control thickness and smoothness.

The asbestos/latex felt is converted to a finished flooring product in a variety of operations, which may include addition of a foam cushion layer to the felt, followed by rotogravure printing or embossing of a decorative pattern. In the final step a vinyl or urethane coating is applied, which serves as the wearing surface of the flooring.

## Substitutes

Since a vast wealth of knowledge on potential exposures and safe work procedures is available to those manufacturing asbestos/latex vinyl flooring, it is, in a very practical sense, probably safer to use asbestos than many other materials about which little is known.

Among the substitutes developed for asbestos in the backing of vinyl sheet flooring is a composite material based on cellulose and fillers such as calcium carbonate. This product, according to experts in the field, lacks the dimensional stability and rot resistance of the asbestos/latex backing. In addition, the composite material does not have the tensile strength and heat resistance of asbestos that is important in manufacturing.

The evaluation of other substitute materials, such as polyesters and fibrous glass, also tends to show that asbestos still is the most cost-effective material for sheet flooring.

At present, competitive products for asbestos-containing vinyl flooring are carpeting and hardwoods. While the choice of products often is conditioned by price, other factors also are important. Both carpeting and hardwoods normally require greater amounts of maintenance than vinyl sheet flooring and may not be suitable for high-traffic commercial areas. In addition, most carpeting and hardwoods will not provide the same rot protection that is inherent in asbestos.

# SECTION II

# Vinyl-Asbestos Floor Tile

## Why Asbestos?

When used in the manufacture of floor tiles, asbestos fibre imparts abrasion and indentation resistance, as well as reinforcement and dimensional stability. The result is a durable, long-lasting floor tile that is especially suitable for commercial installations where heavy wear can be expected.

The reinforcing characteristic of asbestos in floor tiles is especially important, and is demonstrated by the fact that tiles not manufactured with asbestos have a greater tendency to indent or become brittle and crack. This attribute is important when heavy wear can be expected from pedestrian traffic, mobile equipment or when heavy furniture or appliances will be resting on the flooring.

The tensile strength of asbestos and its ability to withstand high temperatures also are important in the manufacturing process.

## Manufacturing

In the manufacture of vinyl-asbestos floor tiles, unopened bags of asbestos can be fed directly into the mixers since the polyethylene bags will melt at the high temperatures used in the process.

A cohesive mass is formed after being mixed with resin, plasticizers, fillers and pigments. This hot material is fed to a two-roll mill where it is blanketed out to a desired thickness. The slab then is passed through a series of calendar rolls to bring the product to a uniform, finished thickness.

Embossing or pigmenting is done before cutting, while the material still is soft. Cooling usually is accomplished by water sprays, although air cooling is necessary before die cutting in order to minimize shrinkage.

## Substitutes

The search for cost effective substitutes for asbestos in vinyl floor tiles has been difficult. The flooring industry considers that by and large asbestos remains the most efficient, reliable and cost-effective material for this use.

One substitute for asbestos that has been evaluated is a product that uses more limestone in place of the asbestos. Tests, however, show that this mixture lacks the hot strength of asbestos, and also tends to be brittle and more likely to crack.

Fibrous glass also has been evaluated as a substitute. This material tended to cause problems in the manufacturing process, that would necessitate a change in equipment for most floor tile manufacturers. In addition, the mixture was difficult to stabilize thermally under the high temperatures used in manufacturing, often resulting in degradation of the vinyl itself.

When a combination of fibrous glass and ball clay was tested, the end product proved to be brittle and to pose the need for costly changes in the manufacturing process.

Some man-made organic materials, such as polyethylene and polypropylene, also have been evaluated as substitutes for asbestos in vinyl floor tiles. These materials tend to melt or degrade at the high temperatures necessary in the manufacturing process, resulting in quality problems in the final product.

Another substitute for vinyl-asbestos floor tiles is vinyl tile, without asbestos. This product costs considerably more.

Carpeting and hardwoods also can be considered for most of the same uses as vinyl-asbestos floor tiles; however, they may not be as suitable for heavy wear applications. It is generally agreed that vinyl-asbestos tiles will outlast even the best carpeting and hardwoods in heavy commercial usage.

# SECTION III

# Exposure Studies: Sheet Flooring

## Monitoring

In 1979, Stanford Research Institute (SRI) International, in the U.S., undertook a study of sheet vinyl flooring to monitor for asbestos during installation and removal operations. In-use and maintenance tests were not performed since there is no asbestos in the wear layers. (2)

All monitoring and analysis was conducted according to methods prescribed by the U.S. National Institute for Occupational Safety and Health (NIOSH). The NIOSH asbestos monitoring technique has a minimum sensitivity of 0.1 fibre per cubic centimeter. Results are given to hundredths of a fibre per cubic centimeter for illustrative purposes only.

**Installation:** Personal, area and high volume samples were taken during this operation in a private home. Background level samples also were taken prior to and after installation for comparison purposes. The results of this test showed asbestos fibre concentrations ranging from 0.008 to 0.012 fibre/cc, compared with a permissible federal limit of 2.0 fibres/cc. The researchers concluded that the "airborne asbestos concentrations are very low and well below the OSHA allowable limit when recommended procedures are followed." All of the findings were within the ranges normally found in background levels. (Tables 1 through 5).

**Removal:** A variety of removal tests were conducted — unadhered, adhered and partially adhered removal. Personal, area and background air samples were taken, and in all cases, the detectable concentrations of asbestos fibre were well below the recommended OSHA limit. When proper work procedures were followed, the ranges were comparable to natural background levels. (Tables 6 through 8).

## Comparison Testing

SRI International also conducted a study aimed at monitoring asbestos fibre levels during the removal of sheet flooring using different methods — wet versus dry, and different scraping instruments. (3) (The industry recommends wet scraping methods).

Results of this study showed that wet scraping methods resulted in very low concentrations of asbestos fibre well below permissible occupational exposure levels. Dry scraping methods resulted in an increase in the level of airborne asbestos although even these ranges still were at or below permissible limits. They concluded by recommending the wet scraping procedures. (Table 9)

# SECTION IV

# Exposure Studies: Floor Tiles

## Monitoring

A study was undertaken in 1979 by Stanford Research Institute (SRI) International to monitor for asbestos fibres that might be present during conditions of use, maintenance, installation and removal of vinyl-asbestos floor tiles. (4)

All monitoring and analysis was conducted according to methods prescribed by the U.S. National Institute for Occupational Safety and Health (NIOSH). The NIOSH asbestos monitoring technique has a minimum sensitivity of 0.1 fibre per cubic centimeter. Results are given to hundredths of a fibre per cubic centimeter for illustrative purposes only.

**In-Use Test:** The researchers simulated the worst conditions by stripping all wax from vinyl-asbestos floor tiles in an office building, and then monitoring for emission of fibre during heavy pedestrian traffic. Since no detectable traces of asbestos fibre were found during this test, the researchers concluded that the asbestos constituent of floor tiles does not pose a health threat. (See Table 10)

**Maintenance Test:** Monitoring was conducted during maintenance of a vinyl-asbestos floor — damp mopping, floor stripping, etc. No detectable amounts of asbestos fibres were found and the researchers concluded that such operations present no hazard to maintenance workers. (See Table 11)

**Installation Test:** Personal samples of workers and general environment samples were taken during the installation of a vinyl-asbestos floor in a private home. The researchers concluded: "The number of asbestos fibres on the filters was very small, all well below 0.1 fibre/cc. Compared to the OSHA limit of 2.0 fibres/cc, the concentrations measured when recommended work procedures are followed, 0.0046 f/cc to 0.0027 f/cc, are insignificant." (See Tables 12 and 13)

**Removal Test:** Monitoring for asbestos fibres was conducted during the complete removal of a vinyl-asbestos floor in a private home. Both personal and area samples were taken during this operation. Results of the study showed that, "the number of asbestos fibres on the filters was very small, all well below 0.1 fibre/cc. Compared to the OSHA limit of 2.0 fibres/cc, the concentrations measured when recommended work procedures were followed, 0.006 f/cc to 0.015 f/cc, are insignificant." (See Table 14)

## Consumer Union Study

The Consumers Union, in a study of a variety of floor tiles, also conducted tests on vinyl-asbestos floor tiles. Its researchers saw no reason to discontinue the use of vinyl-asbestos floor tiles, concluding:

"The asbestos fibres in tiles that have them are securely bonded into the vinyl. They are not likely to be released — except perhaps by sanding — a practice that should be avoided." (5)

## IRDA Study

The Institut de Recherche et de Développement sur l'Amiante (IRDA), in Sherbrooke, Québec, conducted tests to examine the possible environmental burden which may result from normal handling and from wearing of vinyl-asbestos tile flooring. (6)

Simulation of "normal" work practices for laying vinyl-asbestos tiles showed that this operation results in no detectable exposure to airborne asbestos fibres.

Simulation of heavy misuse by continuous, prolonged sanding yielded an average of 1.2 fibres/cc, counting fibres according to the NIOSH method. (See Table 15)

## SECTION V

## Work Practices

A number of studies have verified the fact that adherence to generally accepted housekeeping practices and recommended work procedures will provide protection from any health risk.

As noted, recommended work procedures for the installation and removal of asbestos-containing floor coverings are available from manufacturers, or the Resilient Floor Covering Institute. (7)

Standards for exposure to asbestos dust and for emissions of asbestos to the atmosphere are available from governmental regulatory agencies or departments. (8)

## CONCLUSION

As noted in this brochure, vinyl sheet flooring backed with asbestos/latex and vinyl-asbestos floor tiles offer special characteristics which make them highly suitable, in comparison with other materials, for use in heavy traffic or commercial areas.

In the manufacturing process of both products, the tensile strength of asbestos and its ability to withstand high temperatures constitute important advantages.

From the health and safety standpoint, a number of studies of both vinyl-asbestos floor tiles and vinyl sheet flooring have shown that, with proper work procedures, the possibility of exposure to asbestos dust in all stages of use, maintenance, installation and removal is not significant and presents no evidence of threat to human health.

When such practices are carried out, modern flooring products are safe to use, and appear to be the most cost-effective materials presently available.

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5. Consumers Report, Self-Stick Floor Tiles, p. 635 (October 1980).

6. DUNNIGAN, J. and LEBEL, J., Institut de Recherche et de Développement sur l'Amiante (IRDA), Measurement of Chrysotile Fibre Emission from Asbestos-Vinyl Tile Laying and Sanding Operations (June 1982).

7. Resilient Floor Covering Institute, Inc., Recommended Work Procedures for Resilient Floor Coverings (1980).

8. In the U.S., references are:

   CRF 29, 1910.1001 — OSHA, Standard for Exposure to Asbestos Dust.

   CFR 40, Title 46, Ch. 1 — EPA, National Emission Standards for Hazardous Air Pollutants — Asbestos and Mercury.

   In Canada,

   Air Pollution Control Directorate, Environmental Protection Service (EPS-3-AP-76-6). Also relevant provincial agencies and departments.


# TABLE 1

## SRI International Test Results
## Sheet Vinyl Flooring — Adhered

**Installation — Site No. 1: Model home kitchen in a new housing development in Northern Virginia**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Outside Air | XX-1 | 660 | 330 | 4.7 | 0.002 | 0.0001 | |
| Area-Bedroom | C-1069 | 876 | 438 | 111.7 | 0.1 | 0.0052 | |
| High-Volume Sample | XX-1 | 782.6 | 78.2 | 99.5 | 0.18 | 0.009 | |
| Head Mechanic | C-1071 | 354 | 177 | 133.7 | 0.31 | 0.0155 | 0.0155 |
| Assist. Mechanic | XX-003 | 350 | 175 | 105.8 | 0.246 | 0.0123 | 0.0123 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that 5% of the total number of fibres were asbestos.

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# TABLE 2

## SRI International Test Results
## Sheet Vinyl Flooring — Adhered

**Installation — Site No. 2: Kitchen of a six-year-old home in a suburban Maryland community**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Outside Air | AB-9 | 760 | 380 | 2.5 | 0.0026 | 0 | |
| Outside Air | C-1089 | 766 | 383 | 0 | 0 | 0 | |
| Kitchen Background | XX009 | 748 | 374 | 4.5 | 0.005 | 0 | |
| Mechanic 1 | MWC0620 | 200 | 100 | 0 | 0 | 0 | 0 |
| Mechanic 2 | MWC-1097 | 200 | 100 | 0 | 0 | 0 | 0 |

*Fibres/sq. mm of total filter surface area.
**Analyst estimated that none of the fibres were asbestos.

# TABLE 3

## SRI International Test Results
## Sheet Vinyl Flooring — Adhered

**Installation — Site No. 3: Kitchen of a private home in Woodstown, New Jersey**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | RFCI #1 | 264 | 120 | 0 | 0 | 0 | |
| Background | RFCI #2 | 321 | 169 | 0 | 0 | 0 | |
| Kitchen Area | MWCO 681 | 462 | 231 | 92 | 0.17 | 0.017 | |
| Mechanic JW | MWCO 690 | 104 | 58 | 77 | 0.633 | 0.063 | 0.063 |
| Mechanic JP | MWCO 698 | 120 | 60 | 92 | 0.655 | 0.066 | 0.066 |

Wet bulb temperature — 61°F (16°C); dry bulb temperature — 72°F (22°C).
*Fibres/sq. mm of total filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.
Note:
All measurements with the GCA Respirable Dust Monitor were less than the detection limit (0.1 mg/m$^2$) of the instrument.

## TABLE 4

## SRI International Test Results
## Sheet Vinyl Flooring — Adhered

**Installation — Site No. 4: lower-level foyer of split-level home in Pennsville, New Jersey**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | MWCO 693 | 336 | 168 | 0 | 0 | 0 | |
| Background | MWCO 677 | 675 | 355 | 0 | 0 | 0 | |
| Family Room Area | MWCO 688 | 678 | 357 | 62 | 0.078 | 0.0008 | |
| Steps-Area | RFCI #4 | 650 | 342 | 70 | 0.092 | 0.009 | |
| Mechanic JW | MWCO 674 | 304 | 179 | 197 | 0.554 | 0.055 | 0.055 |
| Mechanic JP | MWCO 679 | 283 | 177 | 25 | 0.075 | 0.008 | 0.008 |

Wet bulb temperature — 63°F (17°); dry bulb temperature — 73°F (23°C).
*Fibres/sq. mm of total filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.
Note:
All measurements with the GCA Respirable Dust Monitor were less than the detection limit (0.1 mg/m$^2$) of the instrument.

## TABLE 5

## SRI International Test Results
## Sheet Vinyl Flooring — Unadhered

**Installation — Site No. 5: Kitchen of private home in Salem, New Jersey**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | MWCO 699 | 327 | 172 | 30 | 0.078 | 0.008 | |
| Background | RFCI #6 | 241 | 127 | 17 | 0.060 | 0.006 | |
| Area-Living Room | MWCO 661 | 238 | 119 | 0 | 0 | 0 | |
| Area-Kitchen | MWCO 697 | 216 | 108 | 100 | 0.395 | 0.040 | |
| Mechanic JP | MWCO 694 | 84 | 44 | 32 | 0.325 | 0.033 | 0.033 |
| Mechanic JW | MWCO 680 | 90 | 45 | 107 | 1.01 | 0.102 | 0.102 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.

## TABLE 6

## SRI International Test Results
## Sheet Vinyl Flooring — Unadhered

**Complete Removal — Site No. 5: Kitchen of private home in Salem, New Jersey**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | MWCO 699 | 327 | 172 | 30 | 0.078 | 0.008 | |
| Background | RFCI #6 | 241 | 127 | 17 | 0.060 | 0.006 | |
| Area-Living Room | MWCO 661 | 238 | 119 | 0 | 0 | 0 | |
| Area-Kitchen | MWCO 697 | 216 | 108 | 100 | 0.395 | 0.040 | |
| Mechanic JW | RFCI #7 | 144 | 76 | 17 | 0.100 | 0.010 | 0.010 |
| Mechanic JP | MWCO 689 | 148 | 74 | 12 | 0.069 | 0.007 | 0.007 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.

## TABLE 7

## SRI International Test Results
## Sheet Vinyl Flooring — Adhered

**Complete Removal — Site No. 4: lower-level foyer of split-level home in Pennsville, New Jersey**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | MWCO 693 | 336 | 168 | 0 | 0 | 0 | |
| Background | MWCO 677 | 675 | 355 | 0 | 0 | 0 | |
| Area-Family Room | MWCO 688 | 678 | 357 | 62 | 0.078 | 0.008 | |
| Area-Steps | RFCI #4 | 650 | 342 | 70 | 0.092 | 0.009 | |
| Mechanic JW | MWCO 696 | 206 | 121 | 97 | 0.402 | 0.040 | 0.040 |
| Mechanic JP | MWCO 691 | 197 | 123 | 85 | 0.368 | 0.037 | 0.037 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.

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# TABLE 8

## SRI International Test Results
## Sheet Vinyl Flooring — Adhered

**Partial Removal — Site No. 3: Kitchen of a private home in Woodstown, New Jersey**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | RFCI #1 | 264 | 120 | 0 | 0 | 0 | |
| Background | RFCI #2 | 321 | 169 | 0 | 0 | 0 | |
| Area-Kitchen | MWCO 681 | 462 | 231 | 92 | 0.170 | 0.017 | |
| Mechanic JW | RFCI #3 | 88 | 44 | 42 | 0.408 | 0.041 | 0.041 |
| Mechanic JP | MWCO 678 | 112 | 62 | 25 | 0.190 | 0.019 | 0.019 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.

# TABLE 9

## SRI International Test Restults
## Sheet Vinyl Flooring — Unadhered

**Comparison Testing**
**Complete Removal — Site: Kitchen of six-year-old home in a suburban Maryland community**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| **Background Samples** | | | | | | | |
| Outside | AB-9 | 760 | 380 | 0 | 0 | 0 | |
| Outside | C-1089 | 766 | 383 | 0 | 0 | 0 | |
| Kitchen | XX009 | 748 | 374 | 0 | 0 | 0 | |
| **Wear Layer Removal** | | | | | | | |
| Mechanic 1 | AB-12 | 150 | 75 | 39 | 0.218 | 0.1637 | 0.1637 |
| Mechanic 2 | AB-2 | 140 | 70 | 14 | 0.0844 | 0.0844 | 0.0844 |
| **Wet Scrape** | | | | | | | |
| Mechanic 1 | AB-14 | 110 | 55 | 96 | 0.4837 | 0.4093 | 0.4093 |
| **Dry Scrape** | | | | | | | |
| Mechanic 1 | AB-13 | 126 | 63 | 327 | 2.168 | 2.0248 | 2.0248 |
| Mechanic 1 | AB-11 | 80 | 40 | 96 | 1.0035 | 0.8279 | 0.8279 |
| Mechanic 2 | AB-10 | 126 | 63 | 191 | 1.2669 | 1.1207 | 1.1207 |
| Mechanic 2 | AB-15 | 90 | 45 | 121 | 1.1259 | 1.0583 | 1.0583 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that about 90% of the fibres were asbestos.

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# TABLE 10

## SRI International Test Results
## Vinyl-Asbestos Floor Tiles

### In-Use — Site No. 2: Office building in Alexandria, Virginia

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc |
|---|---|---|---|---|---|---|
| **Background samples** | | | | | | |
| Air Vent | C-1066 | 588 | 294 | 4.7 | 0.0067 | 0 |
| Hallway | XX005 | 556 | 278 | 4.7 | 0.007 | 0 |
| Copy Centre | XJB | 590 | 295 | 0 | 0 | 0 |
| Outside | XX102 | 616 | 308 | 0 | 0 | 0 |
| Outside | XX031 | 834 | 417 | 0 | 0 | 0 |
| Outside | XX006 | 840 | 420 | 0 | 0 | 0 |
| Copy Centre | | | | | | |
| 1 ft high | XX015 | 594 | 297 | 2.5 | 0.0035 | 0 |
| 3 ft high | XX008 | 594 | 297 | 0 | 0 | 0 |
| 5 ft high | XX016 | 594 | 297 | 0 | 0 | 0 |
| Snack Shop | C-1051 | 284 | 142 | 0 | 0 | 0 |
| **In-use samples** | | | | | | |
| Copy Centre — Table | | | | | | |
| 1 ft high | XX027 | 838 | 419 | 4.4 | 0.0044 | 0 |
| 3 ft high | XX030 | 838 | 419 | 0 | 0 | 0 |
| 5 ft high | XX011 | 838 | 419 | 11.1 | 0.011 | 0 |
| Copy Centre — Middle Room | | | | | | |
| 1 ft high | C 1078 | 822 | 411 | 2.3 | 0.0023 | 0 |
| 3 ft high | C 1096 | 822 | 411 | 4.5 | 0.0046 | 0 |
| 5 ft high | C 1083 | 822 | 411 | 4.6 | 0.0047 | 0 |
| Snack Shop | | | | | | |
| Bookcase — 1 ft | XX017 | 260 | 130 | 0 | 0 | 0 |
| Bookcase — 3 ft | XX022 | 260 | 130 | 0 | 0 | 0 |
| Bookcase — 5 ft | XX002 | 260 | 130 | 2.5 | 0.0079 | 0 |
| Storage Door — 1 ft | XX023 | 266 | 133 | 4.5 | 0.0618 | 0 |
| Storage Door — 3 ft | XX019 | 266 | 133 | 2.4 | 0.0088 | 0 |
| Storage Door — 5 ft | XX029 | 266 | 133 | 0 | 0 | 0 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that none of the fibres were asbestos.

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# TABLE 11

## SRI International Test Results
## Vinyl-Asbestos Floor Tiles

### Maintenance — Site No. 2: Office building in Alexandria, Virginia

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc |
|---|---|---|---|---|---|---|
| **Background samples** | | | | | | |
| Air Vent | C1066 | 588 | 294 | 4.7 | 0.0067 | 0 |
| Hallway | XX005 | 556 | 278 | 4.7 | 0.007 | 0 |
| Copy Centre | XJB | 590 | 295 | 0 | 0 | 0 |
| Outside | XX102 | 616 | 308 | 0 | 0 | 0 |
| Outside | XX031 | 834 | 417 | 0 | 0 | 0 |
| Outside | XX006 | 840 | 420 | 0 | 0 | 0 |
| Snack Shop | C1051 | 284 | 142 | 0 | 0 | 0 |
| **Maintenance samples** | | | | | | |
| Mopping-Copy Centre | XX026 | 30 | 15 | 4.9 | 0.1351 | 0 |
| Buffing-Copy Centre | XX001 | 30 | 15 | 4.3 | 0.1210 | 0 |
| Mopping-Snack Shop | XX000 | 42 | 21 | 9.8 | 0.1949 | 0 |
| Buffing-Snack Shop | XX025 | 42 | 21 | 0 | 0 | 0 |
| Buffing-Copy Centre | KGB-1 | 22 | 11 | 2.4 | 0.0921 | 0 |
| Buffing-Copy Centre | XX | 60 | 30 | 0 | 0 | 0 |
| High Volume Sample (Mopping) | QTH-1 | 537 | 54 | 4.9 | 0.0075 | 0 |
| Floor Area | XX-014 | 30 | 15 | 2.5 | 0.682 | 0 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that none of the fibres were asbestos.

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## TABLE 12

## SRI International Test Results
## Vinyl-Asbestos Floor Tiles

**Installation — Site No. 3: Private home in Newark, Delaware**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | RFCI #8 | 587 | 326 | 0 | 0 | 0 | |
| Background | MWCO 700 | 594 | 297 | 10 | 0.014 | 0.001 | |
| Area-Breezeway | MWCO 692 | 537 | 316 | 70 | 0.0111 | 0.0011 | |
| Area-Laundry | MWCO 686 | 739 | 389 | 140 | 0.161 | 0.016 | |
| Area-Powder Room | MWCO 685 | 725 | 372 | 75 | 0.088 | 0.009 | |
| Mechanic JS | MWCO 682 | 464 | 232 | 145 | 0.267 | 0.027 | 0.027 |
| Mechanic TD | MWCO 684 | 418 | 220 | 40 | 0.081 | 0.008 | 0.008 |

*Fibres/sq. mm of total filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.

## TABLE 13

## SRI International Test Results
## Vinyl-Asbestos Floor Tiles

**Installation — Site No. 1: Model home in new housing development in Northern Virginia**

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Indoor Background | C1069 | 876 | 438 | 111.7 | 0.104 | 0.0052 | |
| Outdoors | XX-1 | 660 | 330 | 4.7 | 0.003 | 0.003 | |
| High-Volume Sample | XX11 | 1710 | 90 | 38.1 | 0.28 | 0.0014 | |
| Head Mechanic | C102 | 228 | 114 | 27 | 0.092 | 0.0046 | 0.0046 |
| Assistant Mechanic | C1062 | 226 | 113 | 52.3 | 0.184 | 0.0092 | 0.0092 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that about 5% of the fibres were asbestos except for filter XX-1.

## TABLE 14

## SRI International Test Results
## Vinyl-Asbestos Floor Tiles

### Complete Removal — Site No. 3: Private home in Newark, Delaware

| Description | Filter No. | Air Vol. (Liters) | Time (Min.) | Fibres/ Sq. mm* | Total Fibres/cc | Asbestos** Fibres/cc | 8-Hr. TWA |
|---|---|---|---|---|---|---|---|
| Background | RFCI #8 | 587 | 326 | 0 | 0 | 0 | |
| Background | MWCO 700 | 594 | 297 | 10 | 0.014 | 0.001 | |
| Area-Breezeway | MWCO 692 | 537 | 316 | 70 | 0.111 | 0.011 | |
| Area-Laundry Room | MWCO 686 | 739 | 389 | 140 | 0.161 | 0.016 | |
| Area-Powder Room | MWCO 685 | 725 | 372 | 75 | 0.088 | 0.009 | |
| Mechanic JS | MWCO 662 | 246 | 123 | 18 | 0.062 | 0.006 | 0.006 |
| Mechanic TD | MWCO 687 | 255 | 134 | 44 | 0.147 | 0.015 | 0.015 |

*Fibres/sq. mm of filter surface area.
**Analyst estimated that 10% of the fibres were asbestos.

## TABLE 15

## IRDA Test Results

### Fibre Concentration Resulting from Various Handling Operations of Vinyl-Asbestos Tiles

| | Operations | | | | | |
|---|---|---|---|---|---|---|
| **Sampling Data** | **Tile Laying** | | **Tile Laying; Sanding; Vacuuming; Installation of Second Layer** | | **Continuous Sanding** | |
| **Duration** | 30 min. | | 40 min. | | 23 min. | |
| **Flow Rate** | 2 liters/min. | | 2 liters/min. | | 2 liters/min. | |
| **Fibre concentration (f/cc > 5)** | **Samplers** | | **Samplers** | | **Samplers** | |
| | **Fixed** | **Personal** | **Fixed** | **Personal** | **Fixed** | **Personal** |
| | B.D.L. | B.D.L. | 0.53 | 0.45 | 1.15 | 1.23 |
| | — | — | 0.51 | 0.56 | 1.12 | 1.30 |
| **Average** | — | | 0.52 | 0.48 | 1.14 | 1.27 |
| | **B.D.L.** | | **0.5** | | **1.2** | |

B.D.L.: Below detectable limit of 0.06 f/cc

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