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# Project Summary

# Airborne Asbestos Concentrations During Buffing, Burnishing, and Stripping of Resilient Floor Tile

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**This study was conducted to evaluate airborne asbestos concentrations during low-speed spray-buffing, ultra high-speed burnishing, and wet-stripping of asbestos-containing resilient floor tile under pre-existing and prepared levels of floor care maintenance. Airborne asbestos concentrations were measured before and during each floor-care procedure to determine the magnitude of the increase in airborne asbestos levels during each procedure. Airborne total fiber concentrations were also measured for comparison with the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 0.1 f/cm$^3$, 8-hr. time-weighted average (TWA). Low-speed spray-buffing and wet-stripping were evaluated on pre-existing floor conditions and three levels of prepared floor-care conditions (poor, medium, and good). Ultra high-speed burnishing and wet-stripping were evaluated on two levels of prepared floor-care conditions (poor and good). All of the computed 8-hr. TWA personal sample results were below the OSHA PEL. It is noted that the floor tile in this study was of low asbestos content and in good condition, hence it is conceivable that floor tile with higher percentages of asbestos could result in higher levels of airborne asbestos during routine floor care maintenance activities. TEM analysis showed higher exposures to fibers predominantly less than 5 µm in length, whereas these shorter fibers were not counted by PCM.**

**This study shows that low-speed spray-buffing, ultra high-speed burnishing, and wet-stripping of asbestos-containing resilient floor tile can be sources of airborne asbestos in building air. The results suggest that multiple layers of sealant applied to the floor prior to the application of the floor finish can reduce the release of asbestos fibers during polish removal. The results of this study further support the U.S. EPA Recommended Interim Guidance for Maintenance of Asbestos-Containing Floor Coverings.**

***This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

Three principal types of preventive maintenance are routinely performed on resilient floor tile: spray-buffing, ultra high-speed burnishing, and wet-stripping followed by refinishing. Spray-buffing is the restorative maintenance of a previously polished floor by use of a floor-polishing machine (operating at 175 to 1000 rpm) immediately after the surface has been mist-sprayed with a restorative product whereby the floor is buffed to dryness. Ultra high-speed burnishing is the buffing of a previously polished floor by using a floor polishing machine (operating at greater than 1500 rpm) without using a restorative spray product. Wet-stripping is the removal of the finish from the floor using a chemical floor-polish stripper and a 175 rpm floor machine equipped with an appropriate strip pad. This current study was conducted to evaluate airborne asbestos concentrations during low-speed spray-buffing, ultra high-speed burnishing, and wet-stripping of asbestos-containing resilient floor tile under pre-existing and prepared levels of floor care maintenance.

## Objectives

The objectives of the study were as follows:

- To determine the airborne asbestos concentrations during low-speed spray-buffing of asbestos-containing resilient floor tile in pre-existing floor condition.
- To determine airborne asbestos concentrations during polish removal from asbestos-containing resilient floor tile in pre-existing floor condition.
- To determine and compare the airborne asbestos concentrations during low-speed spray-buffing of asbestos-containing resilient floor tile in poor, medium, and good floor conditions.
- To determine and compare airborne asbestos concentrations during polish removal after low-speed spray-buffing of asbestos-containing resilient floor tile in medium and good conditions using a manual floor machine.
- To determine and compare the airborne asbestos concentrations during ultra high-speed burnishing of asbestos-containing resilient floor tile in poor and good floor conditions.
- To determine and compare the airborne asbestos concentrations during polish removal after ultra high-speed burnishing of asbestos-containing resilient floor tile in poor and good floor conditions using an automated floor machine.
- To determine whether personal breathing zone concentrations during low-speed spray-buffing of floors in pre-existing, poor, medium, and good conditions exceed the OSHA Permissible Exposure Limit (PEL) of 0.1 f/cm$^3$, 8-hr. Time-Weighted Average (TWA).
- To determine whether personal breathing zone concentrations during ultra high-speed burnishing of floors in poor and good conditions exceed the OSHA PEL of 0.1 f/cm$^3$, 8-hr. TWA.
- To determine whether personal breathing zone concentrations during polish removal after low-speed spray-buffing of floors in pre-existing, poor, medium, and good condition exceed the OSHA PEL of 0.1 f/cm$^3$, 8-hr. TWA.
- To determine whether personal breathing zone concentrations during polish removal after ultra high-speed burnishing of floors in poor and good conditions exceed the OSHA PEL of 0.1 f/cm$^3$, 8-hr. TWA.

## Site Description

This study was conducted in an unoccupied building located at the decommissioned Chanute Air Force Base (AFB) in Rantoul, IL. The study was conducted in a room which contained approximately 8600 ft$^2$ of open floor space tiled with 9-inch by 9-in. resilient floor tile containing approximately 5% chrysotile asbestos. Representatives of the Chemical Specialties Manufacturers Association (CSMA) and a floor products manufacturer visually inspected the physical condition of the floor. Their inspection focused on the evenness of the floor plane and the physical condition of the tile. They concluded that the floor was acceptable for the proposed study.

## Configuration for Low-speed Spray-buffing and Wet-stripping Experiments

Approximately 6500 ft$^2$ of floor space was isolated as the experimental test area. A containment shell was constructed from 2-in. by 4-in. and 2-in. by 6-in. lumber to provide five equally-dimensioned test rooms, each with approximately 1300 ft$^2$ of floor space and 7-ft ceiling height. The containment shell was then surfaced with 6-mil polyethylene sheeting to provide air-tight walls and ceilings for the five test rooms. The ceiling for each test room consisted of a single layer of polyethylene sheeting. The walls of each test room were surfaced with seven layers of polyethylene sheeting. Four high-efficiency particulate air (HEPA) filtration units were placed in the hallway outside of the five test rooms to ventilate the test rooms and reduce the airborne asbestos concentrations to background levels after each experiment.

## Configuration for Ultra High-Speed Burnishing and Wet-Stripping Experiments

Upon completion of the low-speed spray-buffing and wet-stripping experiments, the test area was reconfigured to accommodate the ultra high-speed burnishing and wet-stripping experiments. The test area was reconfigured to provide a single test room of approximately 6500 ft$^2$ of floor space and 7-ft. ceiling height. The ceiling for the test room consisted of a single layer of polyethylene sheeting. The walls were surfaced with eight layers of polyethylene sheeting. Three HEPA filtration units were placed in the hallway outside of the test room to ventilate the test room and reduce the airborne asbestos concentrations to background levels after each experiment. The units were operated during the preparation phase of each experiment but not during the actual burnishing or wet-stripping experiments. All three HEPA units discharged the air outdoors via 12-in. diameter flexible ducting. Fresh air into the test room was obtained directly from outdoors through windows.

## Experimental Design

### *Low-Speed Spray-Buffing and Wet-Stripping*

#### Pre-existing Conditions

Low-speed spray-buffing was first evaluated on the pre-existing floor-care condition. Pre-existing condition was the condition of the floor as it existed in the room prior to evaluating the prepared floor-care conditions. Pre-existing floor conditions consisted of an undetermined number of coats of a Carnauba-type, buffable polish on the floor tile. Low-speed spray-buffing of the pre-existing floor-care condition was evaluated five times, once in each of the five test rooms. Wet-stripping (including polish and sealant removal) was also evaluated on the pre-existing floor-care condition. Wet-stripping of the pre-existing floor-care condition was evaluated five times, once in each of the five test rooms.

#### Prepared Floor Care Conditions

Low-speed spray-buffing was evaluated on three levels of prepared floor-care conditions: 1) poor floor-care condition, 2) medium floor-care condition, and 3) good floor-care condition. Poor floor-care condition was defined as a floor with one coat of sealant and one coat of polish. Medium floor-care condition was defined as a floor with one coat of sealant and two coats of polish. Good floor-care condition was defined as a floor with two coats of sealant and three coats of polish. Floor-care conditions were defined in consultation with the CSMA and other representatives of floor-care products manufacturers. Each floor-care condition was evaluated five times, once in each of the five test rooms, to yield a total of 15 experiments.

Wet-stripping after low-speed spray-buffing was evaluated on two levels of floor-care conditions (medium and good). This comparison addresses the effectiveness of two coats of sealant versus one coat of sealant to limit the extent of airborne asbestos concentrations during polish removal. Wet-stripping of each of the two floor-care conditions were evaluated five times, once in each of the five test rooms, to yield a total of 10 experiments.

### *Ultra High-Speed Burnishing and Wet-Stripping*

Ultra high-speed burnishing was evaluated on two levels of prepared floor-care conditions: 1) poor floor-care condition, and 2) good floor-care condition. Poor floor-care condition was defined as a floor with two coats of sealant and one coat of polish. Good floor-care condition was defined as a floor with two coats of sealant and four coats of polish. Floor-care conditions were defined in consultation with the CSMA and other representatives of floor-care chemicals manufacturers. Each floor-care condition was evaluated four times to yield a total of eight experiments.

Wet-stripping after ultra high-speed burnishing were also evaluated on two levels of floor-care condition (poor and good). Each of the two floor-care conditions were evaluated four times to yield a total of eight experiments.

The CSMA and other representatives from the floor-care chemicals industry specified different definitions of poor and good floor-care conditions for the low-speed and ultra high-speed experiments based on the varying nature of the two floor-care procedures. Although this precluded a direct comparison of the results from the low-speed and ultra high-speed experiments, the different definitions of floor-care condition were necessary to conduct a practical evaluation of each floor-care procedure.

## Sampling Strategy

Area air samples were collected before each experiment to establish a baseline airborne asbestos concentration in the test room for comparison with the concentration measured during low-speed spray-buffing, ultra high-speed burnishing or wet-stripping. After the baseline samples were started, the floor of the test room was thoroughly swept with the exhaust of a 1-hp leaf blower. Five baseline area air samples were collected in each test room/area before each experiment. One sample was located in each quadrant of the test room; the fifth sample was located in the center of the test room. Two field blanks (one open and one closed) were also collected during the baseline sampling as a control for filter contamination.

Three personal breathing zone samples were collected on the equipment operator during each experiment for comparison with the baseline samples. Two additional personal samples were also collected on the operator for comparison to the OSHA PEL of 0.1 f/cm$^3$, 8-hr TWA. Three field blanks (one open and one closed 0.45 µm mixed cellulose ester (MCE), one open 0.8 µm MCE) were also collected during each experiment as a control for filter contamination.

## Sampling Methods

The area air samples (baseline and outdoor) were collected on open-face, 25-mm diameter, 0.45-µm pore-size, MCE filters with a 5-µm pore-size cellulose support pad contained in a three-piece cassette. The filter cassettes were positioned approximately 5 ft above the floor with the face of the filter at a 45° angle toward the floor. The filter assembly was attached to an electric-powered (110 VAC) 1/6-hp vacuum pump operating at a flowrate of approximately 9 l/min.

Five personal breathing zone air samples were collected during each experiment on the individual operating the floor machine. Two samples were collected on open-face, 25-mm diameter, 0.8-µm poresize MCE membrane filters and cellulose support pad contained in a three-piece cassette with a 50-mm conductive extension cowl. These two samples were analyzed by phase contrast microscopy (PCM). Three additional personal breathing zone samples were collected on an open-faced, 25-mm-diameter, 0.45 µm pore-size MCE filters with a 5 µm pore-size MCE diffusing filter and a cellulose support pad contained in a 3-piece cassette. These three samples were analyzed by transmission electron microscopy (TEM).

## Analytical Methods

### *Baseline Samples*

The MCE filters were prepared and analyzed in accordance with the nonmandatory TEM method specified in the AHERA Final Rule (October 30, 1987; 52 CFR 4826). In addition to the requirements of the AHERA nonmandatory TEM method, the specific length and width of each structure were measured and recorded. A sufficient number of grid openings were analyzed to ensure a sensitivity (the concentration represented by the finding of a single structure) of no greater than 0.005 asbestos structures per cubic centimeter of air sampled, unless the degree of loading made this impractical. On heavily loaded samples, counting stopped after completing the grid square in which the 100th asbestos structure was found.

### *Personal Breathing Zone Samples*

The two 0.8-µm pore-size MCE filters used to collect the personal breathing zone samples were analyzed by PCM. These samples were prepared and analyzed according to NIOSH Method 7400 (Revision 3, June 5, 1989, National Institute for Occupational Safety and Health Manual of Analytical Methods). The analytical sensitivity was approximately 0.01 fibers/cm$^3$ of air sampled. The three personal breathing zone samples collected on 0.45 µm poresize MCE filters were analyzed by TEM as described above for the baseline samples.

## Statistical Methods

The relative change in airborne asbestos concentration was measured by the ratio of the average concentration during the specific maintenance procedure to the average concentration before the maintenance procedure. These ratios were then compared by taking the natural logarithm and comparing the averages by standard analysis of variance (ANOVA) techniques.

## Quality Assurance

During the study, sample chain-of-custody procedures were an integral part of both the sampling and analytical activities and were followed for all air and bulk samples collected. The field custody procedures documented each sample from the time of its collection until its receipt by the analytical laboratory. Internal laboratory records then documented the custody of the sample through its final disposition. Specific quality assurance procedures outlined in the AHERA rule were used to ensure the precision of the collection and analysis of air samples, including filter lot blanks, open and closed field blanks, and repeated sample analyses.

## Results and Discussion

### *Low-Speed Spray-Buffing and Wet-Stripping Experiments*

#### Pre-existing Floor Conditions

##### *TEM Concentrations*

Low-speed spray-buffing and wet-stripping were first evaluated on the pre-existing floor-care condition. Pre-existing condition was the condition of the floor as it existed in the room prior to evaluating the prepared floor care conditions.

Results of the one-factor ANOVA indicate that the specific maintenance procedure had a statistically significant effect on airborne asbestos concentrations measured during the procedure (p=0.0128). Specifically, larger increases in airborne asbestos concentrations were observed during wet-stripping than during spray-buffing. The estimated airborne asbestos concentrations during spray-buffing and wet-stripping as a proportion of the respective baseline concentrations were calculated along with the corresponding 95% confidence interval. The average airborne asbestos concentration measured during low-speed spray-buffing was approximately 11 times greater than the average baseline concentration. The 95% confidence interval for this proportion is (2.6, 47). The lower 95% confidence limit is greater than 1, which indicates this is a statistically significant increase. The average airborne asbestos concentration measured during wet-stripping was approximately 186 times greater than baseline concentrations. The 95% confidence interval for this proportion is (44, 788). The lower 95% confidence limit is greater than 1, which indicates this is a statistically significant increase.

### *PCM Concentrations*

Two personal breathing zone samples were collected during each experiment and analyzed by PCM. None of the individual PCM concentrations exceeded the OSHA PEL of 0.1 f/cm$^3$. The highest individual PCM concentration (0.023 f/cm$^3$) was measured during wet-stripping. The 8-hr TWA concentrations associated with the measured levels were calculated by assuming zero exposure beyond that which was measured during the experiment. The 8-hr TWA concentrations ranged from 0.001 to 0.003 f/cm$^3$ during low-speed spray-buffing and from 0.0003 to 0.003 f/cm$^3$ during wet-stripping of floors in pre-existing condition. None of the 8-hr TWA concentrations exceeded the OSHA PEL of 0.1 f/cm$^3$.

Although the results of the personal breathing zone samples analyzed by PCM were all below the OSHA PEL, considerably higher exposures were shown by the personal breathing zone samples analyzed by TEM. Two primary reasons explain why the TEM concentrations were considerably higher than the PCM concentrations. First, PCM cannot detect fibers thinner than 0.25 µm in width. Second, the PCM method used in this study (i.e., NIOSH 7400) does not count fibers shorter than 5 µm in length. Over 99% of the asbestos structures measured during low-speed spray-buffing and wet-stripping of floors in pre-existing condition were shorter than 5 µm in length and would therefore not be counted by the PCM method.

Caution should be exercised in extrapolating the PCM measurements collected during this study to conditions at other sites. These tile were of low asbestos content and in good condition, and no other asbestos exposure activity was assumed.

## Prepared Floor Conditions

### *TEM Concentrations*

Figure 1 illustrates the overall average (geometric mean) concentrations measured before and during low-speed spray-buffing and wet-stripping on floors in prepared floor conditions. Although the mean relative increase in airborne asbestos concentrations during low-speed spray-buffing tended to decrease as the floor care condition improved (i.e., poor condition resulted in a larger relative increase than medium, and medium condition showed a larger relative increase than good), the differences between the three levels of floor care were not statistically significant (p=0.1149). Overall, the average airborne asbestos concentration during low-speed spray-buffing was approximately 2.6 times higher than the average baseline concentration. This increase was statistically significant (p=0.0017). A 95% confidence interval for the mean airborne asbestos concentration during spray-buffing as a proportion of the baseline concentration showed that the overall mean airborne asbestos con-

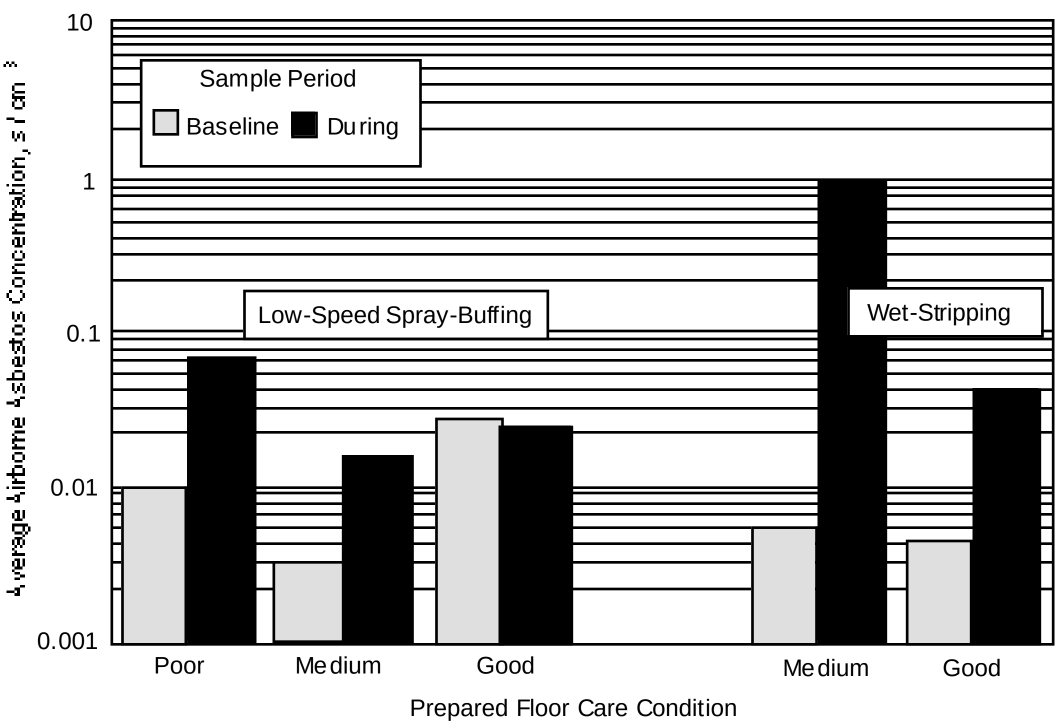


***Figure 1.*** *Average airborne asbestos concentrations during low-speed spraying of floors in prepared conditions.*

centration was between 1.3 and 5 times greater during buffing than before buffing.

Significantly larger increases in airborne asbestos concentrations were observed during wet-stripping of floors in medium condition than on floors in good condition (p=0.0029). The relative increase in airborne asbestos concentrations (i.e., compared to baseline measurements) was approximately 14 times greater, on average, during wet-stripping of floors in medium condition than during wet-stripping of floors in good condition.

The estimated airborne asbestos concentrations during wet stripping of floors in medium and good condition as a proportion of the respective baseline concentrations were calculated along with the corresponding 95% confidence interval. The average airborne asbestos concentration measured during wet-stripping of floors in medium condition was approximately 108 times greater than the average baseline concentration. The 95% confidence interval for this proportion is (33, 335). The lower 95% confidence limit is greater than 1, which indicates this is a statistically significant increase. The average airborne asbestos concentration measured during wet-stripping of floors in good condition was approximately 8 times greater than the average baseline concentration. The 95% confidence interval for this proportion is (2.5, 25). The lower 95% confidence limit for this proportion is greater than 1, which indicates this is a statistically significant increase. The stripping solution used on these floors was designed to remove only the polish from the floor, leaving the layer(s) of sealant on the floor. Therefore, although significant increases in airborne asbestos concentrations were observed during wet-stripping of floors in both medium and good condition, the extra layer of sealant on floors in good condition appears to significantly decrease the airborne asbestos levels.

Overall, significantly larger increases (p=0.0001) in airborne asbestos concentrations were observed during wet-stripping than during low-speed spray-buffing (this comparison was restricted to floors in medium and good condition since wet-stripping was not evaluated on floors in poor condition). The relative increase in airborne asbestos concentrations was approximately 18 times greater, on average, during wet-stripping than during low-speed spray-buffing.

### *PCM Concentrations*

Two personal breathing zone samples were collected during each experiment and analyzed by PCM. None of the individual PCM concentrations exceeded the OSHA PEL of 0.1 f/cm$^3$. The highest individual PCM concentration (0.032 f/cm$^3$) was measured during low-speed spray-buffing. The 8-hr TWA concentrations associated with the measured levels were calculated by assuming zero exposure beyond that which was measured during the experiment. The 8-hr TWA concentrations ranged from 0.0003 to 0.006 f/cm$^3$ during low-speed spray-buffing and from 0.0003 to 0.002 f/cm$^3$ during wet-stripping. None of the 8-hr TWA concentrations exceeded the OSHA PEL of 0.1 f/cm$^3$. It is noted, however, that these tile were of low asbestos content and in good condition, and that no other asbestos exposure activity was assumed. TEM analysis showed higher exposures to structures predominantly less than 5 µm in length. Over 99% of the asbestos structures measured during low-speed spray-buffing and wet-stripping of floors in pre-existing condition were shorter than 5 µm in length and would not be counted by the PCM method. Therefore, caution should be exercised in extrapolating the PCM measurements collected during this study to conditions at other sites.

## ***Ultra High-Speed Burnishing and Wet-Stripping Experiments***

### TEM Concentrations

Figure 2 illustrates the average airborne asbestos concentrations measured before and during high-speed burnishing and stripping. Results of the two-factor ANOVA indicate that neither the maintenance procedure (p=0.2491) nor the floor condition (p=0.7396) had a statistically significant effect on the relative increase in airborne asbestos concentrations measured during the maintenance procedure. That is, similar increases in airborne asbestos concentrations were seen during ultra high-speed burnishing and wet-stripping of floors in both poor and good condition. No floor condition or maintenance procedure resulted in significantly higher or lower increases in mean airborne asbestos concentration.

The estimated airborne asbestos concentrations during ultra high-speed burnishing and wet-stripping as proportions of the respective baseline concentrations were calculated along with the corresponding 95% confidence interval. When averaged over floor care condition (good, poor), the mean airborne asbestos concentration during ultra high-speed burnishing was approximately 14 times greater than the mean baseline concentration. The 95% confidence interval for this proportion is (7.6, 26). The lower confidence limit is greater than 1, which indicates this is a statistically significant increase. Similarly, when averaged over floor care condition, the mean airborne asbestos concentration during wet-stripping was approximately 9 times greater than the mean baseline concentration. This increase is also statistically significant.

The estimated airborne asbestos concentrations during procedures on floors in poor and in good condition as proportions of the respective baseline concentrations were calculated along with the corresponding 95% confidence interval. When averaged over floor care procedure (ultra high-speed burnishing, wet-stripping), the mean airborne asbestos concentration during procedures on floors in poor condition was approximately 12 times greater than the mean baseline concentration. The 95% confidence interval for this proportion is (6.4, 22). The lower confidence limit is greater than 1, which indicates this is a statistically significant increase. Similarly, when averaged over floor care procedure, the mean airborne asbestos concentration during procedures on floors in good condition was approximately 10 times greater than the mean baseline concentration. This increase is also statistically significant.

Overall, ultra high-speed burnishing and wet-stripping resulted in an 11-fold increase, on average, in airborne asbestos concentration. A 95% confidence interval for the overall average concentration during ultra high-speed burnishing and wet-stripping expressed as a proportion of the average baseline concentration is (7.1, 17.2). The lower confidence limit is greater than 1, which indicates the increase is statistically significant.

### *PCM Concentrations*

The ultra high-speed burnishing operation produced a fine, pale yellow, powdery dust from the wax and/or sealant. PCM concentrations measured during ultra high-speed burnishing were significantly higher than those measured during stripping. The elevated concentrations measured during ultra high-speed burnishing were due primarily to the white dust generated during the process. The fine dust particles (pulverized wax/sealant) that measured greater than 5 µm in length and had a length-to-width aspect ratio of 3:1 were counted as fibers (NIOSH Method 7400, A Counting Rules). The corresponding TEM concentrations show that the PCM concentrations do not reflect an accurate indication of the airborne asbestos concentrations.

The 8-hr TWA concentrations were calculated by assuming zero exposure beyond that which was measured during the experiment. Although none of the 8-hr

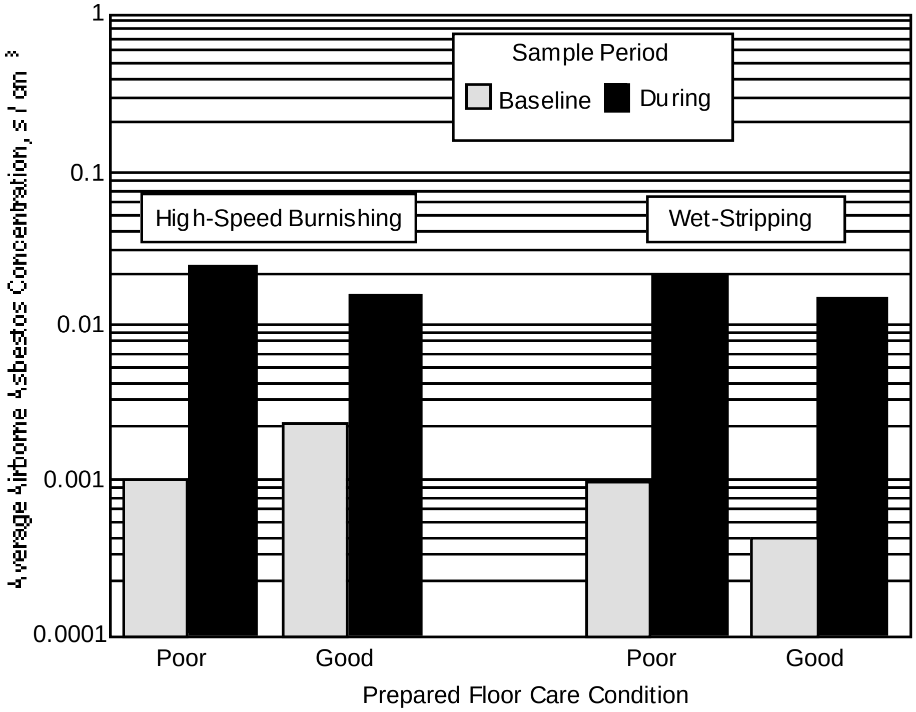


***Figure 2.*** *Average airborne asbestos concentrations measured before and during ultra high-speed burnishing and wet-stripping of floors in prepared conditions.*

TWA concentrations measured during wet-stripping (after ultra high-speed burnishing) exceeded the OSHA PEL of 0.1 f/cm$^3$ for total fibers, all of the 8-hr TWA concentrations measured during ultra high-speed burnishing exceeded the OSHA PEL. These exceedances, however, were due to the excess nonasbestos-containing particulate generated during the burnishing process and not to elevated airborne asbestos particles.

## Conclusions

The following are the principal conclusions reached during this study:

1) Larger increases in airborne asbestos concentrations were observed during wet-stripping than during low-speed spray-buffing of floors in pre-existing condition. The average airborne asbestos concentration measured during low-speed spray-buffing was approximately 11 times greater than the average baseline concentration. The average airborne asbestos concentration measured during wet-stripping was approximately 186 times greater than the respective average baseline concentration. In both cases, the increases in airborne asbestos concentrations were statistically significant.

2) The average airborne asbestos concentration measured during low-speed spray-buffing of floors in the three levels of prepared floor-care conditions (poor, medium, and good) was approximately 2.6 times higher than the average baseline concentration. This increase was statistically significant.

3) The level of prepared floor care did not significantly affect the airborne asbestos concentrations measured during low-speed spray-buffing. Although the average increase in airborne asbestos concentrations tended to decrease as the level of floor care improved, the differences due to the three levels of floor care were not statistically significant.

4) Wet-stripping of floors in medium and good condition (after low-speed spray-buffing) resulted in statistically significant increases in airborne asbestos concentrations. The average airborne asbestos concentration measured during wet-stripping of floors in medium condition was approximately 108 times higher than the average baseline concentration, whereas the average airborne asbestos concentration measured during wet-stripping of floors in good condition was approximately 8.0 times higher than the average baseline concentration. The increase was statistically significant for both floor-care conditions.

5) A second layer of sealant appears to significantly decrease airborne asbestos levels during wet-stripping (after low-speed spray buffing). Larger increases in airborne asbestos concentrations were observed during wet-stripping of floors in medium condition than on floors in good condition. The average increase (relative to baseline measurements) in airborne asbestos concentration during wet-stripping of floors in medium condi-

tion was approximately 14 times greater than during wet-stripping of floors in good condition. This difference was statistically significant.

6) Overall, larger increases in airborne asbestos concentrations were observed during wet-stripping than during low-speed spray-buffing. The average increase (relative to baseline measurements) in airborne asbestos concentration during wet-stripping was approximately 18 times greater than during low-speed spray-buffing. This difference was statistically significant.

7) None of the individual airborne total fiber concentrations (determined by PCM) measured during low-speed spray-buffing and wet-stripping of floors in pre-existing or prepared conditions exceeded the OSHA PEL of 0.1 f/cm$^3$. The 8-hr TWA concentrations, calculated by assuming zero exposure beyond that which was measured during the experiment, were also below the OSHA PEL. Although all of the computed 8-hr TWA personal sample results for the conditions of this study were below the OSHA PEL, it is noted that these tile were of low asbestos content and in good condition, and that no other asbestos exposure activity was assumed. TEM analysis showed higher exposures to fibers predominantly less than 5 µm in length, whereas these shorter fibers were not counted by PCM. Caution should be exercised in extrapolating the PCM measurements collected during this study to conditions at other sites.

8) When averaged over floor-care condition (poor and good), a 14-fold increase in airborne asbestos concentration was observed during ultra high-speed burnishing, whereas a 9-fold increase was observed during wet stripping. The difference between the increase in airborne asbestos concentrations measured during ultra high-speed burnishing and that measured during wet-stripping was not statistically significant.

9) When averaged over the maintenance procedure (ultra high-speed burnishing and wet-stripping), a 12-fold increase in airborne asbestos concentration was observed during procedures on floors in poor condition, whereas a 10-fold increase was observed during procedures on floors in good condition. The difference between the increase in airborne asbestos concentrations measured on floors in poor condition and those on floors in good condition was not statistically significant.

10) Overall, ultra high-speed burnishing and wet-stripping resulted in an 11-fold increase, on average, in airborne asbestos concentration. This increase was statistically significant.

11) None of the individual airborne total fiber concentrations (determined by PCM) measured during wet-stripping (after ultra high-speed burnishing) of floors in prepared condition exceeded the OSHA PEL of 0.1 f/cm$^3$. The 8-hr TWA concentrations based on these measured levels and sample durations also did not exceed the OSHA PEL.

12) All of the individual airborne total fiber concentrations (determined by PCM) measured during ultra high-speed burnishing of floors in prepared condition exceeded the OSHA PEL of 0.1 f/cm$^3$. The 8-hr TWA concentrations based on these measured levels and sample durations (assuming zero concentration beyond that which was measured during the experiment) would also exceed the OSHA PEL. These exceedances, however, were due to the nonasbestos-containing particulate generated during the ultra high-speed burnishing process and not to elevated airborne asbestos particles.

13) This study was conducted on resilient floor tile containing a relatively low percentage of asbestos. That is, the vinyl floor tile contained 3 to 5% chrysotile asbestos, whereas vinyl floor tile generally contains 3 to 25% asbestos. Hence, it is conceivable that floor tile with a higher percentage of asbestos could result in higher levels of airborne asbestos during routine floor-care maintenance activities. The results of this study should be interpreted accordingly.

## Recommendations

1) Floor-care treatments systems that include the use of a sealant over which the wax or finish coats are applied should be used on asbestos-containing resilient floor tile. Two or more layers of sealant should be applied as a base coat. The use of multiple layers of sealant on asbestos-containing floor tile can significantly lessen airborne asbestos concentrations during the mechanical removal of the wax or finish from the floor.

2) Two or more layers of wax or finish should also be applied to asbestos-containing resilient floor tile. Although to a lesser extent, multiple layers of floor finish may also provide additional protection against asbestos release during low-speed spray-buffing and ultra high-speed burnishing of asbestos-containing resilient floor tile.

3) The results of this study further support the original U.S. EPA Recommended Interim Guidance for Maintenance of Asbestos-Containing Floor Coverings issued on January 25, 1990. Machine stripping of asbestos-containing resilient floor tile should be conducted only when necessary. Wet-stripping of floors tends to result in higher increases in airborne asbestos concentrations than routine buffing procedures. Floors should be kept adequately wet during stripping. The floor machine should be equipped with the least abrasive pad possible to strip the wax or finish coat from asbestos-containing floor tile.

4) Workers responsible for the maintenance of asbestos-containing floor tile should be trained on the proper use of the floor machines used for low-speed spray-buffing, ultra high-speed burnishing, and wet-stripping, the appropriate buffing and stripping pads, and the selected floor-care treatment system. Workers should also be informed of and follow appropriate operations and maintenance (O&M) work practices and procedures for the maintenance of asbestos-containing resilient floor

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*The complete report, entitled "Airborne Asbestos Concentrations During Buffing, Burnishing, and Stripping of Resilient Floor Tile," (Order No. PB95-260212; Cost: $27.00, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
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