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78 WORKPLACE PROTECTION FACTOR STUDY FOR AIRBORNE ASBESTOS Gosselink, D.W., Wilmes, D.P. and Mullins, H.E., 3M Company, 3M Center, Bldg. 230-BS-06, St. Paul, MN 55144

Determination of overall performance of three 3M disposable respirators and one elastomeric dual cartridge respirator with high efficiency and dust/mist filters is reported. The workplace selected for this study was a small manufacture of brake shoes for trucks.

The workers which passed the saccharin qualitative fit test were trained and fitted with test respirators. Participants did not wear products which did not pass the manufacturers' fit protocol. The workers were observed at all times during the sample collection period to help ensure sample validity.

All samples were analyzed for asbestos fiber by Clayton Environmental Consultants using counting rule "A" of the NIOSH method 7400 or scanning electron microscopy. The samples were collected on 25 mm Nuclepore cellulose ester filters with a pore size of 0.8 um, housed in closed-face field cassette holders equipped with half-inch extenders.

Results show that all the tested respirators reliably provided a protection factor in excess of OSHA guidelines for half-mask respirators.

# AMERICAN INDUSTRIAL HYGIENE CONFERENCE



**PROTECTION  
FOR ALL**

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Abstracts

**WORKPLACE PROTECTION FACTOR STUDY**  
**AIRBORNE ASBESTOS**

**SLIDE**

Good morning. My name is Don Gosselink of 3M Company. Today I wish to report the results of a workplace protection factor study performed by 3M, using several 3M respirators in an industrial operation involving use of asbestos. The test was performed by the personnel listed.

**SLIDE**

The goal of this study was to determine workplace protection factors achievable when respirator users are properly fitted and trained, and the respirators are consistently worn by the users. This goal was not completely accomplished, as I will discuss in a few minutes.

The site chosen was a brake shoe manufacturing operation in the Southeastern United States. The composition of the brake shoes being produced was somewhat variable, but included the listed materials. **SLIDE** The process steps included:

1. Compounding and mixing the powder-form raw materials,
2. Weighing the blended components into charges,
3. Thermally preforming the components,

4. Molding the preforms into the brake shoes by a thermal process,
5. Grinding the contact surface of the shoes, and
6. Drilling holes through the shoes and the metal backing for mounting to the vehicle.

These operations were performed by approximately 15 workers, 12 of which participated in the test.

#### SLIDE

The salient features of the test protocol followed involved these steps. Prior to starting the test on the first day, the purpose of the test was explained to the production workers and their supervision. The workers were given fitting instructions following the printed instructions on the boxes of product. The workers were then qualitative fit tested using the 3M recommended saccharin QLFT to determine which of the products provided adequate fit for each worker. None of the workers wore any of the respirators unless they passed the saccharin QLFT. They were asked to wear each of the respirators for which they were qualified but were not forced to do so. They were asked to remain clean shaven for the duration of the test, which they did for the most part.

During the actual test, the subjects fitted their own respirators. The pumps, tubing, cassettes, etc. were installed and removed by the 3M test supervisors. The test subjects were also observed by a test supervisor during the sampling period. Any individual test

was terminated if the respirator seal was broken either accidentally or deliberately. The workers were very busy and largely ignored the test supervisors after the first few tests.

**SLIDE**

The respirators tested are shown here. The 8710, the 9910, and the 9920 are disposable respirators. The EASI-AIR<sup>TM</sup> is a reusable rubber facepiece respirator, and was tested both with dust/mist and with high efficiency cartridges. The Airhat<sup>TM</sup> is powered air purifying respirator. We used units with high efficiency filters.

The next few slides review what I have presented so far.

**SLIDE**

This is a picture of the 8710 respirator probed to sample between the nose/mouth area of the user.

**SLIDE**

This is the 9910 respirator probed in the same fashion.

**SLIDE**

This is the 9920 respirator. It was necessary to probe this respirator off-center because of the exhalation valve. While probe location can cause variability in results, as has been shown by 3M and others, this location is felt to be the best compromise on this valved product.

**SLIDE**

This is the EASI-AIR™ halfmask respirator. It was tested with both D/M and HEPA cartridges as I mentioned before.

**SLIDE**

This is the AIRHAT™ powered air purifying respirator.

**SLIDE**

This is a picture of the probe used in each respirator. It was designed by Dr. Ben Liu at the University of Minnesota. Note the tapered sampling inlet designed to minimize particle losses.

**SLIDE**

I mentioned that the test subjects were given saccharin qualitative fit tests on the first day to determine which products were able to provide adequate fit to the individual worker. For those of you who may be unfamiliar with this QLFT, the first step is to determine whether the test subject can detect the taste of saccharin in a hood-type enclosure without a respirator.

**SLIDE**

Then the test subject dons a respirator, the test hood is replaced, and a saccharin solution is again introduced, but at a concentration 100 times that used for the sensitivity check. The test subject goes through normal breathing, deep breathing, side-to-side and up-and-down head movements, talking, and return to normal breathing exercises. If the test subject can detect the

taste of saccharin during any of the exercises the result is logged as a failure and the respirator tested is not assigned to that test subject. Based on substantial testing by 3M and others, subjects who pass the saccharin QLFT achieve QNFT fit factors in excess of 100 the vast majority of the time.

#### SLIDE

The test subjects were trained the first day using these published fitting instructions from the product cartons. A sound on slide presentation was given on the rubber facepiece respirators. During the actual test, only fitting instructions were employed - no further saccharin QLFT testing was done after the initial training phase.

#### SLIDE

This is a picture showing a fully equipped test subject prepared for the workplace sampling.

#### SLIDE

This is a listing of sampling equipment used and the sampling parameters. Sampling time was in the 0.5 - 1 hour range. The sampling rate was approximately 2 Lpm inside the facepiece and 0.5 Lpm for the lapel samples. Closed face cassettes were used for both lapel and inside facepiece sampling. Although I'm not showing the data here, we also took area samples comparing open-and closed-face cassette sampling. We also took area samples comparing 0.5 Lpm and 2.0 Lpm sampling rates. The difference due

to cassette face being open or closed, and different sampling rates were found not to be statistically significant.

#### SLIDE

Asbestos fiber counting was done by Clayton Environmental Services, Inc. using phase contrast method, NIOSH method 7400, set A counting rules.

#### SLIDE

The results are summarized here. The top half shows the individual workplace protection factors found for each product. The lower half shows the statistical summarization of the data in terms of geometric mean, geometric standard deviation, and best estimates of fifth percentile - an estimate of the workplace protection fraction this test population would exceed 95% of the time.

I stated earlier that the objective of this study was to determine what workplace protection factors were achievable using these products when the test subjects were properly fitted and trained, and when the products were worn 100% of the time. I don't feel this objective was fully accomplished. There are several reasons why these workplace protection factors are conservative, but the biggest single reason is that the sensitivity of the phase contrast asbestos fiber counting method is not sufficient to accurately measure inside facepiece asbestos fiber concentration when the respirator fit and filter efficiency are good. In 85% of



the samples collected in this study, the fiber counts inside the respirators were at or below minimum detection limits. In these cases, workplace protection factors were calculated using the minimum detection limit published by Clayton even though it is questionable whether there is any asbestos fiber inside the facepiece at all.

#### SLIDE

Another way of showing this is by plotting fiber challenge concentration versus inside facepiece fiber concentration. Although considerable scatter might be expected, one would expect a general relationship between outside concentration and inside facepiece concentration if true product performance were being measured. We see no such relationship. This has the effect of getting high protection factors only if the external fiber concentration is high.

#### SLIDE

The effect of the limited sensitivity of phase contrast microscopy was also demonstrated by a few samples which were analyzed by both phase contrast and scanning electron microscopy methods. The SEM method has somewhat greater sensitivity than the phase contrast method. This table shows the results when the same samples were counted by the two methods. It can be seen that on external breathing zone samples the calculated fiber concentrations are about 10-fold higher than the same sample counted by phase contrast. At the same time, the inside facepiece samples remain

at or near the detection limit by either counting method. The result is that workplace protection factors calculated for SEM analysis are higher by about a factor of 10.

Another observation made is that regardless of analytical method, no significant difference was seen with the EASI-AIR<sup>TM</sup> respirator whether dust/mist or HEPA cartridges were used. The database on SEM is admittedly very small.

#### SLIDE

In summary, these overall conclusions were reached:

1. All products provided workplace protection factors greater than the assigned protection factor of 10.
2. These workplace protection factors are conservative due to limited sensitivity of phase contrast fiber counting on the inside facepiece samples as I have discussed. Variability in sampling and analytical method also increases conservatism in calculated 5th percentile values.
3. We saw no difference in performance between D/M and HEPA cartridges in the EASI-AIR<sup>TM</sup> respirator.
4. Although the 9920 D/M/F respirator and the Airhat<sup>TM</sup> PAPR HEPA respirator appeared better (and is statistically significant) it is believed that this was caused by the unintentional fact that these products were tested at an overall average higher

ambient asbestos fiber concentration.

**SLIDE**

To again address the objective of this study, it was our intent to determine what workplace protection factors are achievable when users are properly fitted and trained, and the respirators are consistently worn.

I feel we actually have shown very conservative workplace protection factors which indicate these 3M products are capable of reducing asbestos concentration levels in the wearer's breathing zone by a factor greater than their assigned protection factors.