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489

TESTIMONY REGARDING

16 CFR Parts 1304 and 1305

RESPIRABLE FREE-FORM ASBESTOS

Proposal to Ban Certain Patching

Compounds and Artificial Emberizing

Materials (Embers and Ash)

As Published in the FEDERAL REGISTER,
Vol. 42, No. 146 - Friday, July 29, 1977

Presented by Harrison B. Rhodes
Union Carbide Corporation
Metals Division
Niagara Falls, New York 14302
August 15, 1977

My name is Harrison B. Rhodes and I am speaking on behalf of the Union Carbide Corporation where I hold the position of Technology Manager in the "Calidria" Asbestos Department. My education is in the field of Chemical Engineering where I hold the degree of Dr. of Science from Columbia University. For the past four years my assignment has been in the area of asbestos health and regulatory matters and has also included research on monitoring techniques. I am currently serving the Asbestos Information Association/North America as Chairman of the Standards and Technical Committee.

Union Carbide Corporation has been actively engaged, since 1963, in the mining and milling of asbestos ore at facilities in central California. The asbestos fiber produced is marketed throughout the United States and in many foreign countries. One of the principal applications for this asbestos in this country has been in tape-joint compounds. We do not ourselves manufacture such compounds, however, nor do we manufacture any other asbestos-containing finished products.

As the Commissioners are well aware, there has been a tremendous flood of "paper" generated in relation to the asbestos regulatory matters under consideration here. We believe that several crucial issues have been lost in the flood and would like to take the opportunity today to address these issues, as follows:

1. A look at all of the commercial and consumer exposure data available today including some recent consumer tests and also some OSHA compliance inspection results.
2. An examination of the risk estimation model proposed by Dr. Bayard of the CPSC staff in terms of actual consumer exposure.

3. A discussion of the elimination or reduction of unreasonable risk of injury as required by the statute and the absolute zero risk regulatory approach that is advocated by the petitioners.
4. The direction of your attention to the fact that "asbestos" of one type or another is present throughout the air, water and earth of this planet and the overwhelming consequences of a ban of ubiquitous material such as this without a precise definition of what is banned, a well specified analytical procedure, and some allowable levels other than zero.
5. The presentation of a suggested alternative approach to protect the consumer from unreasonable risk of injury which is more realistic, more workable and more enforceable than the proposed total ban.

It should be emphasized that this discussion will deal directly with, and be presented, in terms of tape-joint compounds. Spackling compounds are similar in composition and use, but are applied in so much smaller amounts that the potential for significant exposure is virtually non-existent. Emberizing kits are outside the field of our expertise and will not be considered.

Gypsum wallboard was developed around 1880-1900. It did not come into wide usage until World War II when the need for houses and other buildings made this quicker, less complex construction method very popular. Usage has grown substantially since that time and drywall construction is now used in a majority of residential construction and in a wide variety of commercial and public buildings. Initially, ordinary plaster was used to embed and cover the tape to make the joint between the boards, but in the mid 40's specially formulated dry mixtures with casein as the binder were introduced. These mixtures typically contained 10-15% asbestos. We have been told that the plaster of that time also contained asbestos.

Ready-mix, i.e., wet compounds or mud were introduced in the mid 50's and were in broad general use by 1960. The asbestos content of muds in general dropped during the 70's to approximately the range of 2-7%. Tape-joint compounds containing asbestos have thus been in widespread use for 30-35 years. Over the first 15 years of this period the main material used was provided dry and contained relatively high levels of asbestos, i.e., 10-15%.

The Commission's consultant, A. T. Kearney, Inc., estimates that today's annual value of shipments of patching compounds is 80 million dollars. At an average price of $4.50 per can. This is equivalent to about 18 million cans. The formulations we have seen cost about 20-30¢ more per can in raw material costs to replace asbestos so that the added burden, just to cover raw materials cost is about 4.5 million dollars annually. This cost, plus any percentage markups used, would be added to the cost of the structure and would carry the normal financing charges over the life of the indebtedness. It should also be noted that about 10,000 tons per year of asbestos with a product value of about one million dollars were used in this application prior to the decline that has resulted from actions of a variety of governmental agencies. We believe that the total of 5.5 million dollars annually presents a reasonably reliable minimum estimate of the direct economic effects of the replacement of asbestos in tape-joint compounds. The added effect of the poor performance of many of the asbestos-free muds has not been considered.

In the assessment of the risk that needs to be related to this cost burden, it is important to have a reliable estimate of the level of consumer exposure. All of the available information on exposure has been assembled and is documented and discussed in detail in an Appendix to this presentation which will be submitted prior to the August 29, 1977, deadline for written comments. Only the key results will be summarized here.

The data presented are contained in five reports:

1. The tests conducted by Rohl et al[1] at one location in New York, NY. This is the data cited by the petitioners.
2. A survey of a variety of sanding conditions made by Rhodes and Ingalls[2] and cited extensively by the Asbestos Information Association/North America in their response to the petition.
3. Data from State and Federal OSHA compliance inspections compiled by Equitable Environmental Health Incorporated as part of a study of asbestos exposure in the construction industry.
4. A report submitted to the CPSC by Union Carbide Corporation on July 14, 1977, covering consumer exposure during a typical spackling and a moderate size drywall installation operation.
5. A study by Union Carbide Corporation which has just been finished on another consumer installation of drywall in a large room including the ceiling.

The results of this survey are summarized in the two figures you are now receiving. Figure 1 shows along the vertical axis, the airborne asbestos concentration, in fibers per cubic centimeter longer than 5 micrometers, that occurred in the breathing zone of the operator <u>during</u> the sanding operation. Usually a number of samples were collected at each location. The dark bar shows the range of concentrations found with the arithmetic average of all samples indicated by the arrow.

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1. Rohl et al, <u>Science</u>, Volume 189, August 15, 1975, p. 552.
2. G.D.C.I. Drywall, January/February 1976.

The data on the left are those of Rohl et al that were cited in support of the petition. These were obtained in one test in New York City. Note that an exposure of 20 fibers/cc for four days was used by Dr. Bayard in his projection of risk to be discussed later.

The next group of results were obtained by the Union Carbide Corporation in a survey of commercial operations in eight different cities. Results range from about 0.2 to 3 fibers/cc. These fiber counts have been spot checked "blind" by two other laboratories. The EEH and OSHA compliance data shown next fall in the same range as those of Union Carbide.

The consumer-use data are shown on the far right. The first case is for extensive spackling and the installation of three panels of drywall. The second is for three walls and the ceiling of a large basement recreation room. This latter mud contained 2.6% asbestos by weight on a dry basis. Exposures in these tests were only 0.2 to 1.0 fibers/cc >5μ, which correspond roughly to the lower end of the range found for commercial use.

Two other operations in tape-joint installation present the possibility of exposure to free-form asbestos fiber, the addition of dry powder product to water and the cleanup after sanding. Data for these operations are shown in Figure 2. Here, in order to get the Rohl et al data on the graph it was necessary to run the scale from zero to sixty instead of zero to twenty as in the previous figure. Otherwise the graph follows the same format and shows a very similar pattern. The Rohl et al data are far higher than the OSHA results and the consumer values are below or in the lower end of the range found for commercial use.

It is very important to understand that all of the concentrations shown occurred during the active pursuit of the particular operation, i.e., sanding, wet-out, or cleanup. These operations generally take place for a moderate portion of the day with concentrations at much lower values for the rest of the 8 hour period. Eight-hour time-weighted average exposures were calculated for the two consumer installations and the highest exposure found was 0.2 fiber/cc >5μ for two days while asbestos-containing dust was being generated.

One of your staff members, Dr. Stephen Bayard, has developed a model[1] to estimate the risk of respiratory cancer from low level exposure to asbestos from taping compounds. This model is patterned on that described in a paper by Enterline and Henderson[2] except that Dr. Bayard has made an assumption that the effect of dose is cumulative. This builds a geometric increase in risk into the model. We question whether there is any basis for this assumption, but do not feel that this is an appropriate place to debate the issue. It is of more interest to use this model, which is heavily biased toward predicting a high risk, with the highest exposure just noted for consumer use, i.e., 0.2 fiber/cc TWA for two days of operation.

Following Dr. Bayard's directions in page 3, Part C, of the reference cited for the highest time-weighted average of 0.2 fibers/cc for two days found for the consumer applications we obtain an annual exposure of 0.004 fibers/cc per day for one year, a mean latent period to tumor of 621 years, and zero deaths of asbestos induced cancer in the 40-year period considered. If the period examined is extended to 100 years, the number of deaths predicted would be 0.000003 which is still far less than a single death. These estimates are probably on the high side due to assumptions used in the model but since an exposure of 0.004 fibers/cc is indistinguishable from background, the values found not unreasonable.

It is also instructive to point out that if we assume an exposure of 5 fibers/cc for two full 8-hour days, which is well above that found in commercial use, the yearly rate becomes 0.1 fiber/cc. This yields a median time to tumor of 212.5 years and an asbestos induced cancer estimate of 0.02 deaths. We question whether these are the unreasonable risks referred to in the statute.

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1. Memorandum to Dan Clay dated June 3, 1977.

2. Presented at Pinehurst, NC, March 12, 1976.

Let us now relate this risk to the proposed ban of consumer patching compounds containing respirable, free-form asbestos under Sections 8 and 9 of the Consumer Product Safety Act. To quote Section 8:

"Sec. 8. Whenever the Commission finds that--

(1) a consumer product is being, or will be, distributed in commerce and such consumer product presents an unreasonable risk of injury; and

(2) no feasible consumer product safety standard under this Act would adequately protect the public from the unreasonable risk of injury associated with such product,

the Commission may propose and, in accordance with section 9, promulgate a rule declaring such product a banned hazardous product." (Emphasis added.)

And from Section 9, Paragraph 2 (c):

(2) The Commission shall not promulgate a consumer product safety rule unless it finds (and includes such finding in the rule)--

(A) that the rule (including its effective date) is reasonably necessary to eliminate or reduce an unreasonable risk of injury associated with such product;

(B) that the promulgation of the rule is in the public interest; and

(C) in the case of a rule declaring the product a banned hazardous product, that no feasible consumer product safety standard under this Act would adequately protect the public from the unreasonable risk of injury associated with such product." (Emphasis added.)

Note particularly the repeated use of the words "unreasonable risk" and the requirement to eliminate or reduce unreasonable risk, not to make this risk zero. The Act makes it quite clear that the intent is not the total elimination of all risk but of "unreasonable risk" and it delegates to the Commission the complex and soul-searching problem of deciding what is "reasonable".

The comments of your own staff on the strength of the evidence used to support the ban is well summarized by three short quotations from the record:

> "The petitioners believe that high quantities of asbestos fibers remain in the air after these products are sanded and the fibers substantially increase the risk of mesothelioma and lung cancer." (1)

> "The petitioners have addressed problems which arise from being exposed to asbestos fibers occupationally and environmentally. However, they have not cited any concrete evidence of the hazard which is tied directly to the products for which they seek a ban. It merely cited the fact that these products do contain asbestos fibers and they have cited the fact that asbestos fibers in other situations have been linked to lung disease. We question whether the evidence presented in the petition is sufficient to show that these substances may cause substantial personal injury or substantial illness during or as a proximate result of any customary or reasonably forseeable handling or use." (Emphasis added.)(2)

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(1) CFR, Vol. 42, No. 146 - Friday, July 29, 1977 p. 38790.

(2) Letter of July 11, 1976, from Charles M. Jacobson, BCMI to Francine Shacter, TAD, OSCA.

"The instances of single or short-term exposure to asbestos cited in the petition can be taken as evidence of a possible (but not necessarily probable) cause-effect relationship. However, by themselves, they would not stand up to statistical scrutiny in predicting a correlation between brief exposure to asbestos and the later development of cancer caused by such exposure." (3) (Emphasis added.)

Substantial evidence has been presented here that the commercial use data upon which the petitioners based their allegations is substantially higher than that of all other investigators (including OSHA compliance inspections). It has also been shown that consumer exposures are low, of short duration, and when averaged over a year or more are not distinguishable from ambient background. We know of no evidence that such casual, low exposure represents any hazard so that the question becomes one of a banning action based on the existence of a possible, but not proven risk, which if it exists at all differs only slightly from zero.

You are probably aware, that this question of the regulation of carcinogens is a major issue today before virtually all of the governmental regulatory agencies. The FDA saccharin ban has received wide publicity and OSHA is deeply involved with a proposal for a generic regulation approach to carcinogens and hearings on benzene are now in progress. All of this activity does not help to find answers to our immediate problem, but we are at least in good company.

The problem we face originates in the so-called "one-hit" theory of carcinogenisis. In simplest outline, this theory holds that:

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(3) Briefing Package, February 2, 1977, presented to the Commission by Fracine Shacter.

1. A single molecule of a carcinogen is capable of causing cancer in a particularly susceptible person.
2. If enough people are exposed, the susceptible person (or small number of such persons) will contract cancer.
3. It follows, therefore, that there is no absolutely safe or zero risk level for a carcinogen and such a material should, depending on the statutory authority of the agency involved, be banned, severely restricted, replaced, controlled to the limits of detection, etc.

It is useful to examine this theory in the light of where there is general agreement and where responsible opinions diverge. We believe that virtually all medical authorities would agree:

1. That there is a wide range of dosages for a carcinogen where a dose-response relationship exists. The larger the dose, the greater percentage of these exposed contract cancer and vice versa.
2. In exposed populations, even at substantial exposure levels, large proportions of those exposed do not contract cancer.
3. As the dosage goes down the average time to the appearance of a tumor increases. This principle was illustrated by the extrapolation formula of Enterline and the Bayard modification discussed previously.

The medical disagreement occurs over what happens as the dosage is decreased to very low levels. There is one school of thought, and this is embraced by most of the regulatory agencies, that no completely safe level exists. There are other responsible authorities who contend that a dosage level is reached where the body's defense mechanisms can effectively combat the altered cells and a cancerous growth does not occur. Supporters of this position cite the low level presence of certain metals and hormones that are essential to the human body in trace amounts but at higher levels are carcinogens.

Unfortunately, there is no way to demonstrate the correctness of either view since there is a background level of cancer in both man and experimental animal. As the dosage and the corresponding number of cancers decreases one point of view is that the occasional cancer from the specific agent still occurs but cannot be distinguished from the background while the other is that the added cases do not occur. These views can be partially resolved with the model of Enterline discussed previously, i.e., a very low exposure may cause a cancer but the time to tumor is 150 years for example. With an expected life span of 70 years this, for all practical purposes is a safe threshold exposure, at least until life expectancy approaches 150 years. Since there is no provable scientific answer to this risk question, we are really left with a socio-political rather than a scientific decision to consider.

The fundamental question, then, is whether a total absence of risk approach to regulation is appropriate or more particularly will be acceptable to society. In our lives we undergo a succession of risks, some knowingly and some unknowingly. The American people have always indicated a willingness to take risks as evidenced by such things as the widespread use of the automobile, smoking, alcohol, improper diet, and even the home as it is today. We believe that the zero risk concept, when it begins to impact on jobs and the way of life of a substantial number of people will not be acceptable and will have to be modified to balance risks against benefits in a realistic fashion. This sort of balance rather than regulation by cliche, "its a carcinogen so ban it", should be applied here. The benefits from the continued use of asbestos in tape-joint compounds is substantial and the risk is either zero or so small it cannot be distinguished from zero.

This finishes the risk-benefit discussion and I would like to conclude this presentation by pointing out certain practical aspects of enforcement of the ban as presently proposed in the Federal Register. These questions were discussed at great length, and generally were not solved, at the recent meeting in Gaithersburg, MD, conducted by the National Bureau of Standards. Since several members of your staff were present at this meeting, they will only be indicated briefly.

Since the promulgation of the OSHA asbestos regulations in 1972 there has been a continuing debate on what is asbestos and what is an asbestos fiber. Asbestos, when narrowly defined, in a way that will satisfy the most precise minerologists is ubiquitous in the atmosphere although generally it occurs at very low, but not zero, concentrations. When the definition is broadened to include all amphibole chips which are longer than 5 microns and have a length to diameter ratio greater than 3, you approach a condition aptly described by Dr. Malcom Ross of the U.S. Geological Survey at the NBS meeting just mentioned, of "shutting down the face of the earth". Particles of this type are everywhere and would contaminate any product containing a mineral.

The EPA faced this problem in 1973 in writing emission standards for the spraying of asbestos-containing products and decided to treat it by setting a 1% by weight maximum limit. Their reasoning was as follows:

> "The intent of the 1-percent limit is to ban the use of materials which contain significant quantities of asbestos, but to allow the use of materials which would: (1) Contain trace amounts of asbestos which occur in numerous natural substances, and (2) include very small quantities of asbestos (less than 1 percent) added to enhance the material's effectiveness.[1]"

1. CFR, Volume 38, No. 66 - Friday, April 6, 1977, p. 8821.

In order for any action by the Commission to be workable and enforceable it is absolutely essential that you provide a definition of "asbestos" which states exactly what mineral species and what form of these species are included and specify what particle dimensions constitute an asbestos "fiber". The present definition in the proposal could be applied to the rock that covers much of the surface of the earth. In addition, an analytical procedure and the levels of "impurities" that are acceptable, as measured by this procedure, must be specified. Without the practical definitions the ban is virtually universal and completely unworkable.

To conclude this discussion, I would like to summarize the Union Carbide position and expand on the approach presented in my letter of July 14, 1977, which we believe is a reasonable alternative to the ban proposed by the Commission.

1. The products under consideration have been in widespread use for about 35 years and we know of no evidence that any consumer has ever been harmed by them. No "unreasonable risk" to the consumer has been demonstrated by the petitioners or by the staff.
2. Consumer exposure data have been presented which show that the exposures are both low and brief and when averaged over a year are not distinguishable from the general background. The risk from such exposure, if indeed any risk does exist, is extremely small and is based on the extrapolation of an unproven and unproveable theory.
3. We question whether it is appropriate and whether the Act gives the Commission the authority to ban a product on the basis of a hypothetical or theoretical risk or on the basis of an absolute zero risk requirement.

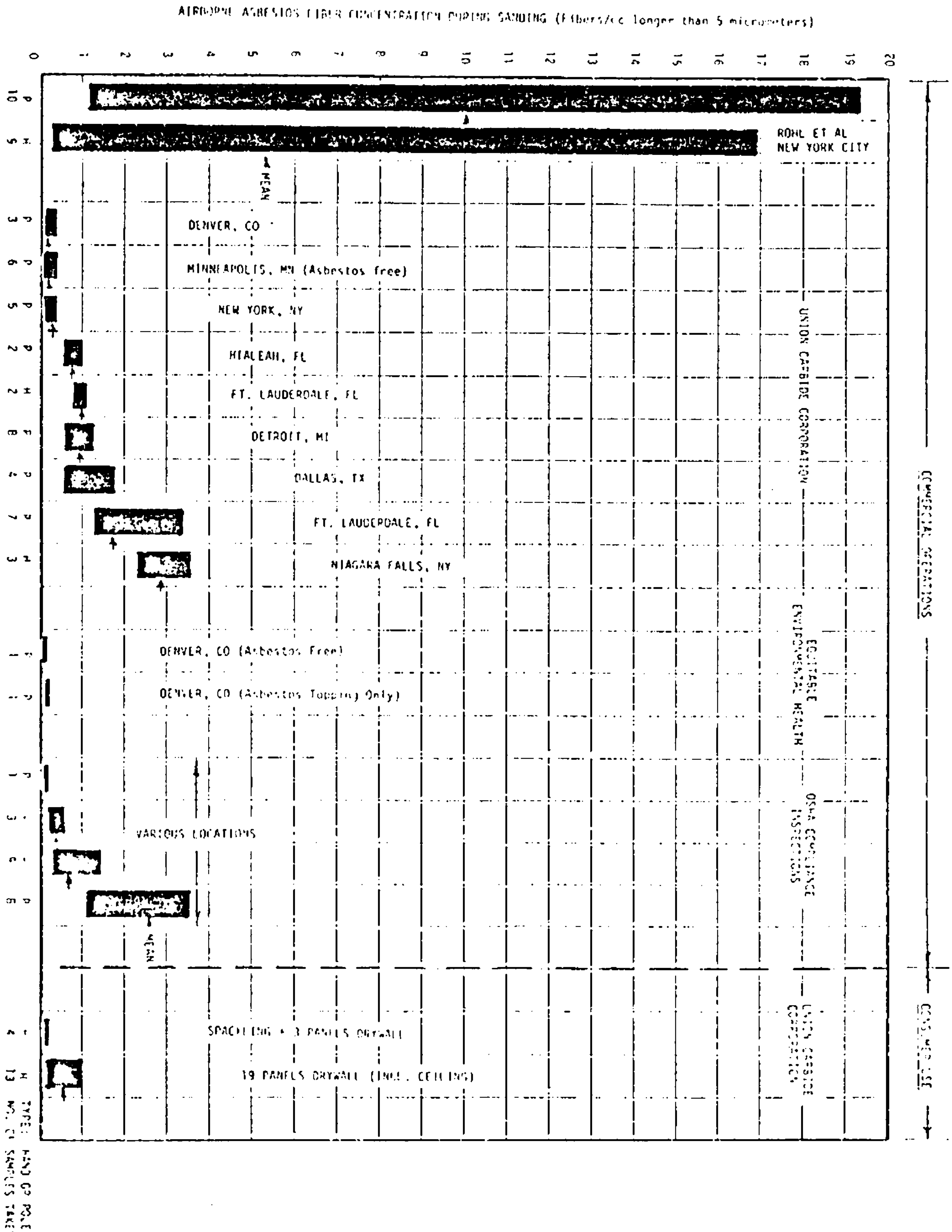
4. We do not agree that a reasonable product safety standard cannot be promulgated to protect the public adequately from any unreasonable risk and recommend the following approach:

    a. Limit the amount of asbestos that can be used in spackling and taping compounds to two percent by weight in the dry formulation. This is sufficient to gain the benefits of the use of asbestos and serves to limit the potential for exposure. It differs from the 1% of total formulation including water suggested previously in that it more closely defines the content in the final product in the form that it is sanded. It is also at a level where analysis is more reasonable.

    b. Require a warning label including proper work procedures on all compounds under the jurisdiction of the commission whether packaged for direct consumer or commercial use in consumer contact. This turns to good advantage the widespread public awareness of the possible potential hazards of asbestos to encourage that the product be treated according to directions and not abused. It also gives the user a choice.

Thank you very much for this opportunity to speak to the Commission. I will be glad to answer any questions you may have or to provide any additional information we have available.

AIRBORNE ASBESTOS CONCENTRATIONS IN OPERATOR BREATHING ZONE DURING SANDING OF TAPE-JOINT COMPOUND



[illegible] ZONE

DURING WET-OUT OF DRY MATERIALS

AND

CLEANUP AFTER SANDING

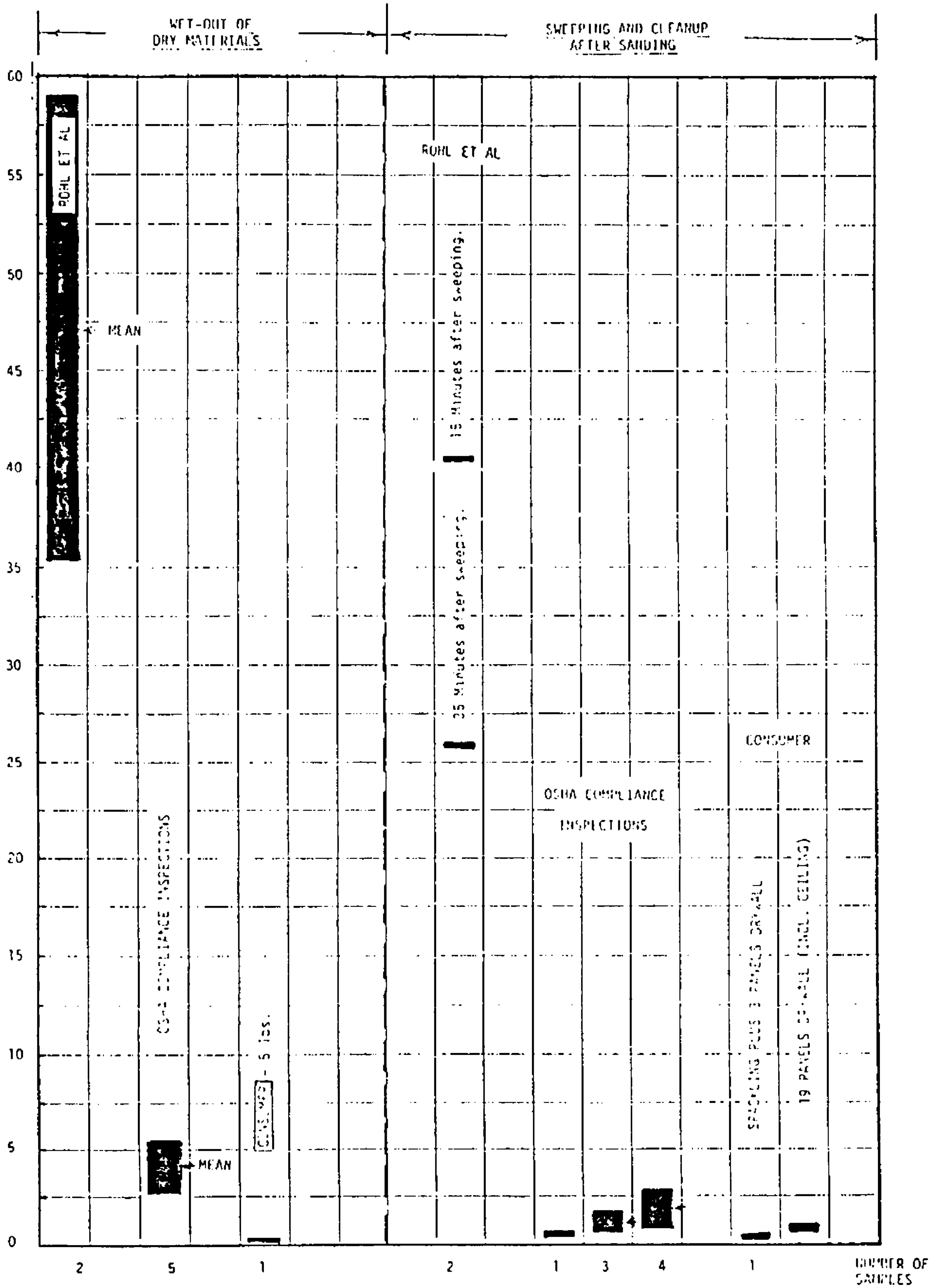


FIGURE 2

Union Carbide has mined asbestos ore and operated an ore benefication plant in California since 1963. We market asbestos fibers for industrial applications, but we do not make any products from asbestos.

We have provided medical surveillance for our asbestos plant employees and conducted air monitoring since 1963. Some of our plant areas are currently monitored as often as once per month to ensure that our dust control measures are effective. Safety meetings, posters, and individual consultations are some of the means used to advise employees of the asbestos health hazard. The use of safety equipment is rigidly enforced and employees are constantly reminded of safe procedures and precautions to take to preserve their health. Smoking has always been prohibited in certain plant areas and has been generally discouraged by communicating to employees the apparent connection between an increase in lung cancer and asbestos workers who smoke. Since January 1, 1977, smoking has been prohibited on all plant property. Medical surveillance has included chest X-ray and pulmonary function analysis, and we have recently added sputum cytology to our medical program. Before initiating new rules or programs, we thoroughly discuss them with employees. This facilitates the implementation of changes and demonstrates to our employees why we are making the changes. They can then understand our reasons and cooperate with us in establishing a safe working environment.

Our customer "education" includes mailings and personal contact through meetings, seminars and sales calls. Our salesmen are thoroughly familiar with the asbestos health hazard and are aware of regulatory requirements, safe handling methods, etc. Our bags of asbestos have carried a warning label since 1968, four years before the Federal OSHA standards were promulgated to require this, air monitoring, medical surveillance, and other safety measures. We have provided free air monitoring for our customers for several years. This often provides us with the opportunity to discuss the asbestos hazard and safety precautions with our customer's employees. We have prepared booklets containing information related to specific applications. These booklets contain general information on the asbestos health hazard, regulatory requirements, typical air monitoring results and other pertinent items. We have also prepared information for presentation to technical society meetings or any group who is interested in the asbestos/health story. We have in our files a large number of items which we send to customers, and including all of them with this document would make it very voluminous. The attached list of them is essentially complete and the items are available for immediate mailing, if so desired.

The State of California recently enacted an Occupational Carcinogens Control Act, and asbestos is one of the 16 substances affected by it. The CAL-OSHA Asbestos Standards have been modified to include the provisions of the Act, which also provides for a massive education program. We have worked closely with State personnel to develop standards which are effective and also practical and enforceable. We have participated heavily in the education program, "Preventing On-The-Job-Cancer", by serving on panels and assisting in workshops held at four different California cities in June and July.

Asbestos can be used safely in essentially all of its many applications. The key to safe working and public environments is a thorough knowledge of its potential health hazards and how to handle and use it without creating excessive airborne contamination.

Prepared by John L. Myers, Marketing Manager
Union Carbide Corporation-Metals Division
Niagara Falls, NY - August 29, 1977

INFORMATION AVAILABLE FROM UNION CARBIDE CORPORATION ON THE HEALTH HAZARDS OF ASBESTOS AND HOW TO USE IT SAFELY

Material Safety Data Sheet & Typical Chemical & Spectrographic Analysis of "Calidria" Asbestos
Testimony by George W. Wright, M.D. before U.S. Dept. of Labor, Occupational Safety & Health Hearing on Proposed Occupational Asbestos Standard, March 14-17, 1972
Testimony by J. Corbett McDonald, M.D. - same as above
OSHA Regulations
EPA Regulations
"Airborne Asbestos" National Research Council, 1971
"Airborne Asbestos" - Summary
"Airborne Asbestos" - References
Asbestos Bulletin (Asbestos Information Committee, London - 9/72)
CIBA CEIGY - UK 2/72
QAMA Folder
WHO Report - 10/72
Dust Counting - S. G. Bayer, R. D. Zummalde, T. A. Brown - Feb. 1969 (NIOSH/HEW)
Dust Monitoring Equipment & Costs - 2/19/73
Instructions for Sampling of Airborne Asbestos Fibers
Procedure for Pump Calibration used for Monitoring of Asbestos Dust Emissions
AIA - "Protecting the Asbestos Worker
AIA - "Asbestos and Health"
AIA - "The Asbestos Information Association/North America"
AIA - "Asbestos and Health Questions and Answers"
AIA - "What Asbestos Is: How and Where it Is Used"
AIA - "What Every Employee Should Know About Asbestos" - 2/74
AIA - "Asbestos In the Atmosphere"
AIA - "Asbestos in Water"
AIA - Molding & Fabrication of Asbestos-Containing Plastic Products, Work Practices
Partnership for Prevention - "The Insulation Industry Hygiene Research Program"-4/70
Asbestos - Reprint from National Safety News - 10/73
"Asbestos Health Question Perplexes Experts," C & EN - 12/10/73
Disputes on the Safety of Asbestos - New Scientist 3/7/74
JLM - "Chrysotile Asbestos in Plastics"
Asbestos & Silica Dust in the Drywall Industry. Part 1-Nov./Dec. 1975
Asbestos & Silica Dust in the Drywall Industry. Part 2-Jan./Feb. 1976
Detection of Chrysotile Asbestos in Airborne Dust from Thermosetting Resin Grinding - 1975
"Calidria" Asbestos Pellets - Health and OSHA Information
"Calidria" Asbestos RG-244 - Health and OSHA Information
"Calidria" Asbestos RG-600 - Health and OSHA Information
"Calidria" Asbestos Pellets - JLM, "ASBESTOS" - 10/71

92-385

AIRBORNE ASBESTOS FIBER COUNTS

during

CONSUMER INSTALLATION OF DRYWALL IN A LARGE ROOM

Dates Sampled: August 3-11, 1977
Date Reported: August 29, 1977

Samples Collected By: B. L. Ingalls
Union Carbide Corporation

Samples Analyzed By: B. L. Ingalls & G. J. Spencer
Union Carbide Corporation

Reported By: H. B. Rhodes
Union Carbide Corporation

Union Carbide Corporation
Metals Division
Niagara Falls, New York

SUMMARY AND CONCLUSIONS

Asbestos exposure during and after consumer installation of drywall for the finishing of a 12' x 24' basement recreation room was measured. Nineteen panels of wallboard, each 4' x 8', were required to cover three walls and the ceiling of this room. About 80 pounds of ready-mix taping compound, containing 1.75% by weight asbestos as manufactured and 2.6% by weight when dry, was used.

Personal and area samples were collected throughout the installation, using 0.8μ porosity Millipore filter and precalibrated MSA pumps. The filters were mounted and counted by optical phase contrast microscopy in accordance with the latest, March 30, 1977, draft of the NIOSH method (P&CAM 239).

The maximum ceiling exposure for any of the operators was 1.3 f/cc[1] which occurred during cleanup after sanding. Eight-hour, time-weighted average operator exposures ranged from 0.1 to 0.2 f/cc with an overall average of 0.2 f/cc.

General area exposure levels did not exceed 0.1 f/cc on an 8-hour, time-weighted average basis in the work area (cellar) or 0.02 f/cc in the living room. A general house survey on the day after the job was completed showed that all values were well below 0.01 f/cc and had not been changed appreciably by the present installation. It is questionable whether this is different from the ambient background.

(1) f/cc means asbestos fibers having an L/D ≥ 3, and ≥ 5 micrometers in length, per cubic centimeter of air.

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OBJECTIVES

This study had the following objectives:

1. To measure asbestos exposure during the consumer installation of 19 panels (4' x 8') of drywall.

2. To measure residual household exposure to asbestos after completion of the drywall installation.

TEST LOCATION AND GENERAL PROCEDURE

The tests were run at a one story, wood and brick, single family dwelling located in Lewiston, New York. The house was approximately 20 years old and accommodates ~2000 ft.^{2} of living area. The original construction utilized plaster walls and no known subsequent consumer or professional use of materials capable of releasing substantial quantities of free-form asbestos fiber had occurred.

In this test, studding was installed over three walls (east, south, and west) and the ceiling of a 12' x 24' basement recreation room. Nineteen 4' x 8' panels of 3/8" gypsum board were then fitted and nailed into place. The joints were finished by the following procedure:

1. Compound was hand trowelled over all of the joints and the tape was embedded and covered. The nail holes were filled in at the same time.

2. When the initial taping had dried, a second coat of compound was added and sanded when completely dry.

3. Following the sanding, a finish coat of compound was applied.

4. When completely dry, the finish coat was sanded.

About 1-1/2 cans (62.5 lbs. each) of compound (mud) were used in this installation. The mud was a ready-mix obtained from Florida Rolling Hills, Inc. of Ft. Lauderdale, Florida. It contained 1.75% asbestos by weight as received and dried to 2.6% by weight.

The drywall finishing was done by a couple whose previous experience with drywall had been limited to the patching of a single seam in a prior residence. They received intermittent instruction over a period of about 1-1/2 hours at the start of the taping from another consumer with limited experience, and completed the job on their own. The work was done in a manner that was considered to be reasonably representative of "middle-of-the-road" consumer use. All joints were sanded to give a good smooth finish. No specific precautions were taken to avoid dust during sanding and cleanup but deliberate efforts to create airborne dust were also not made.

The installation divided naturally into five steps and both area and personal air samples were collected to monitor any significant generation of airborne asbestos fiber as follows:

1. The completion of the studding, the hanging of drywall panels, and start of taping.

2. Completion of the taping and application of the second coat of compound. (No samples taken.)

3. First sanding, cleanup and application of the finish coat of compound.

4. Second sanding and cleanup.

5. Residual exposure after completion of installation.

SAMPLE COLLECTION AND FIBER COUNTING PROCEDURES

The latest draft of the NIOSH sample collection and counting procedure, P and CAM #239, dated March 30, 1977, was used as the general basis for this test. Samples were collected on Millipore filters of 0.8µ porosity using M.S.A. pumps precalibrated at 2 liters per minute.

The counting procedure specified in this draft differs significantly from earlier editions in that:

1. Substantial changes have been made in the selection rule covering which fibers encountered by the reticle are to be included in the count. This largely eliminates systematic bias due to fiber size distribution.

2. The total coefficient of variation is expressed as a function of the total number of fibers counted instead of a single value applicable to all situations. A minimum total count of ten fibers is also required.

These are clearly substantial improvements but the method still has some serious shortcomings particularly when applied to situations where airborne fiber concentrations are low and/or where non-asbestos particulate material is present.(1) Both of these situations exist in the present study and certain refinements in the procedure have been necessary in order to present the results in the most understandable and meaningful fashion. It should be emphasized that these are additions to the procedure and are not in conflict with it.

The legal basis for refinements to be described is found in the following quotation from P & CAM 239:

"3. Interferences

In an atmosphere known to contain asbestos, all particulates with a length to diameter ratio of 3 to 1 or greater, and a length greater than 5µ should, in the absence of other information, be considered as asbestos fibers and counted as such." (emphasis added.)

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(1) See for example, "A Report on the Fiber Content of Eighty Industrial Talc Samples Obtained from, and Using the Procedures of, the Occupational Safety and Health Administration. NBS, May 1977." This report is one of the principle reasons for an international confernece on the problem sponsored by NBS and scheduled for July 18-20, 1977.

The approach here emphasizes the development and use of "other information" to obtain the most intelligent assessment of what is seen through the microscope. In this connection it is important to realize that optical fiber counting is not an exact science but an art. It requires a unique blend of talent, training, and concentration. An experienced counter develops both an "eye" and a counting rhythm, which permit him to recognize "fibers," decide which fibers are of the appropriate type and dimensions to be counted, and to move rapidly from field-to-field so the counts do not take an inordinate amount of time. The objective is to provide the experienced operator with a set of ground rules to judge between the various types of fiber and put them in certain classes.

Under phase-contrast illumination, chrysotile asbestos has some very distinctive characteristics. It is typically dark appearing, composed of random-sized bundles and flexible hair-like threads with curvature. When chrysotile fibers are short, however, i.e., 5-10μ, they often appear as perfectly straight, dark rod-like particles.

Fibers of amphibole asbestos are usually larger in diameter than chrysotile and more rigid and rod-like in appearance. They can, however, break down into very fine needle-like material. With the exception of crocidolite, the amphiboles also can contain prismatic crystals which usually have the appearance of chips. The amphiboles normally refract light differently than chrysotile under phase contrast and appear brighter. As particle size decreases, however, light refraction and contrast are diminished and the particle will appear darker and less definitive. At this size it cannot be distinguished from chrysotile fibers of similar dimensions.

In addition to the three kinds of "fiber" just described, i.e., chrysotile, amphibole fibers and chips and material that looks like the amphiboles, particles are frequently encountered that meet the NIOSH fiber definition of $L/D > 3$, $L > 5\mu$, but are obviously not asbestos in any form. These include such things as fiberglass "poles," some clay and mica particles, organic fibers, and linear agglomerates of nonfibrous material.

On the basis of the optical characteristics discussed tempered with broad operator experience with a wide variety of known particulate materials, fiber counts at this laboratory are made and reported in the categories described below. Material which is obviously not asbestos is not counted even though it meets the $L/D \geq 3$, $L > 5\mu$ criteria.

1. Chrysotile asbestos - Any fiber having an $L/D \geq 3$ and a length $\geq 5\mu$ that is, in the operator's judgment, chrysotile. In the event of doubt, any fiber having the proper dimensions and dark appearance will be included as chrysotile. On this basis, the short, dark amphibole fibers, where present, would be reported as chrysotile.

2. Possible amphibole - Any fiber of the appropriate dimensions that is not judged to be chrysotile and is not obviously material other than asbestos. This would include all amphiboles and materials similar in appearance.

In this approach, all doubts are resolved in favor of including particles as chrysotile or amphibole so it is biased to give a high count for all possible "asbestos" particles without masking results by including particulate that is neither asbestos nor fibrous. It is backed by counter experience gained in approximately 250 on-site sample collections and the counting of over 1500 filters. A photo library and a reference sample collection of a wide variety of known materials which contain amphibole or amphibole-like materials are maintained. It falls within the "other information" allowed in the NIOSH procedure.

The other counting problem encountered relates to the very low airborne asbestos concentrations found in most of the samples. The NIOSH procedure sets an optimum fiber density on the filter of 50 to 100 fibers per 100 viewing fields and states a minimum density of 10 fibers/100 fields. Within these limits the method is claimed to be applicable to a concentration range of 0.1 to 60 fibers/cc with a total coefficient of variation of 0.24 - 0.36.

The validity of these claims, particularly with regard to accuracy, is a subject of considerable controversy at this time. The discussion of this question is well beyond the scope of this study. For the present work, sample times were adjusted, within the limits set by the nature of the operation, to deposit the proper density of fiber on the filter. Where this was not possible, additional fields were counted in increments of 100 fields, until the minimum of 10 fibers was achieved or a minimum of 500 fields were counted. Separate results for chrysotile and possible amphibole are reported at values rounded to the nearest significant figure. Fibers/100 fields and the total number of fields counted are also shown in all cases to provide more complete information.

PRESENTATION AND DISCUSSION OF RESULTS

A detailed listing of all samples taken including location, operation tested, collection time, and counting results is provided in Table I. In this section these airborne fiber counts will be related to the corresponding drywall installation step. The ceiling and eight-hour, time-weighted average exposures for the consumers involved are described.

Completion of Studding, Hanging Drywall, and Start of Taping (8/3/77, 8/4/77, 8/5/77)

Figures 1(b)(c) and 2 show various stages in the hanging of the 19 sheets of gypsum board. Seven of the 19 sheets used in the ceiling and four of the sheets used in the walls required cutting and trimming in varying amounts to achieve proper fit. Figires 3(a), (b), and (c) continue the job through the application of the tape and the second coat of compound over both the tape and the nail heads.

Area air samples were collected on 8/3/77 in the living room (see Figure 1(a) and the cellar (see Figures 1(b) and 1(c)) prior to the use of the mud. Personal samples were then collected on both operators during the start of the taping. An area and a personal sample were collected in the cellar on the following day (8/4/77) while a single operator completed the first installation of compound. No samples were taken on 8/5/77 when the second coat of compound was applied.

The fiber count results are summarized in Table I and include samples N-73, N-52, B-3, J-2, N-53, and N-70. The upstairs area sample showed a concentration of 0.004 f/cc prior to the use of the compound. The highest value found in the working area was 0.3 f/cc for Operator #1 during taping.

Both operators were in the area about 11-1/2 hours on 8/3/77 but time-weighted average (TWA) exposures have been based on 8 hours (480 minutes) in accordance with NIOSH procedures as follows:

Operator #1

$$TWA = \frac{(607)(0.08) + (87)(0.28)}{480} = 0.15 \text{ f/cc}$$

Operator #2

$$TWA = \frac{(607)(0.08) + (84)(0.108)}{480} = 0.12 \text{ f/cc}$$

The completion of the initial taping on 8/4/77 took Operator #2 a little over four hours. At that point he left the house. Both the personal and area samples during this step were 0.02 f/cc so that his actual TWA exposure would be:

$$TWA = \frac{(0.02)(252)}{480} = 0.01 \text{ f/cc}$$

If he had elected to remain the rest of the day in the work area in the cellar, his TWA would not have exceeded 0.02 f/cc.

No samples were taken while the second coat of compound was applied on 8/5/77. The completed job is shown in Figure 3(d). Note that the joints are covered with compound for a width of a foot or more.

First Sanding, Cleanup, and Application of Finish Coat of Compound, 8/6/77

After the second coat of compound was dry, the joints and the covered nail heads were hand sanded smooth using 150 grit paper mounted on a sanding block. This operation is shown in Figure 4(a), (b), and (c). After completion of sanding, the dust on the floor was swept into piles with a broom and transferred with a dust pan to a bag and deposited with the trash. The sweeping is shown in Figure 4(d). A finish coat of compound was then applied to all joints and nail heads.

Personal samples were collected in the breathing zone of both operators during the sanding and subsequent cleanup. Separate area samples were also obtained during sanding and during cleanup. Area samples were obtained in both rooms (cellar and first floor living room) for the remainder of the day during the installation of the finishing coat of compound.

Relevant samples here are N-76, N-89, B-14, N-94, B-18, N-75, N-71, B-30, B-31, and B-10 (Table I). Personal exposures during sanding ranged from 0.5 to 0.9 f/cc and were 0.7 and 1.3 f/cc for operators 2 and 3, respectively, during cleanup. The cellar area samples showed 0.2 f/cc during sanding, 0.7 f/cc during cleanup, and dropped to an average of 0.03 f/cc over the remainder of the day. The living room sample was 0.013 f/cc during the application of the compound.

Operator #2 was present in the house for about 5-1/2 hours. On this basis his actual 8-hour TWA exposure would be:

$$TWA = \frac{(44)(0.9) + (28)(0.52) + (12)(1.3) + (237)(0.033)}{480} = 0.162 \text{ f/cc}$$

If it is assumed he remained in the cellar at an exposure of 0.033 f/cc for the remainder of the day, the TWA would be 0.172 while the remainder of the day in the living room at 0.013 f/cc would yield 0.166 f/cc. It is realistic to round all these values to 0.2 f/cc.

In this same sequence, Operator #3 had 415 minutes accounted for and was largely in the upstairs area or out of the house for the 65 minutes needed to complete 8 hours. Using the 0.013 f/cc level found for the living room, a TWA of 0.19 f/cc results (round to 0.2 f/cc).

Second (Final) Sanding and Cleanup (8/10/77)

After the finish coat of compound was completely dry, it was sanded in the same manner as just described. This operation is shown in Figure 5 and the corresponding cleanup is shown in Figure 6. The large amount of dust generated is clearly evident. This cleanup differs from the previous one in that after the dust had been swept into piles, it was taken up with a shop vacuum cleaner instead of a dust pan.

The 17 samples relevant to this operation are too numerous to list individually but appear in Table I [SECOND SANDING AND CLEANUP (8/10/77)]. Personal samples during sanding ranged from 0.2 to 0.9 f/cc and a level of 1.2 f/cc was found during cleanup. This latter value is not significantly different from the 1.3 f/cc found in the previous cleanup.

The area samples in the cellar ranged from 0.1 to 0.5 f/cc during sanding and cleanup and dropped to an average of 0.04 f/cc for the remainder of the day. The living room showed a level of 0.02 f/cc throughout the entire day.

Operator #2 was present for about two hours during this operation. On this basis, his actual 8-hour TWA exposure would be 0.16 f/cc. If it is assumed he remained in the cellar or in the living room for the remainder of the day, his TWA's would be 0.19 and 0.17 f/cc, respectively. These all round off to 0.2 f/cc.

Operator #3 had 382 minutes of personal sampling accounted for and was in the general area of the living room for the remainder of the 8 hours. A TWA of 0.17 (round to 0.2) results.

Residual Exposure After Completion of Installation (8/11/77)

On the day following the completion of the drywall installation, the first floor rooms adjacent to the cellar entrance were cleaned with a household vacuum cleaner. A personal sample was obtained on the operator during the cleaning and area samples were taken for the remainder of the day in the living room, kitchen, stairwell to the cellar, and in the completed recreation room. The results are listed in Table I as samples A-72, A-76, Z-4, A-70, and P-56.

The results ranged from 0.001 to 0.006 f/cc and averaged 0.003 f/cc. Within the limitations of the method, this is not different from the value of 0.004 f/cc for sample B-73. It is also in the range of the general background exposure and the household is not being subjected to continued high exposure to asbestos as a result of this consumer drywall installation.

Summary of Results During Drywall Installation

The ceiling and eight-hour TWA values so far described for the operators during the various steps in the installation are summarized below. The corresponding TWA values for the cellar and the living room are also shown.

	8/3/77 Completion of Studding, Hanging Drywall Start Taping		8/4/77 Completion of Tape Installation		8/5/77 Second Coat of Compound	8/6/77 First Sanding, Cleanup Finish Coat of Compound		8/10/77 Sanding of Finish Coat Cleanup		8/11/77 House Cleanup After Installation	
	Ceiling(1)	TWA(1)	Ceiling	TWA	-	Ceiling	TWA	Ceiling	TWA	Ceiling	TWA
Personal					No Samples Taken						
Operator #1	0.3	0.2	-	-		-	-	-	-	-	-
Operator #2	0.1	0.1	0.02	0.01-0.02		1.3	0.2	0.9	0.2	-	-
Operator #3	-	-	-	-		0.7	0.2	1.2	0.2	0.004	0.001
Area											
Cellar (Work Area)	-	0.08	-	0.02		-	0.1	-	0.1	-	0.004
Living Room	-	0.004	-	-		-	0.01	-	0.02	-	0.006

(1) All results expressed as fibers/cc ≥5μ.

The highest ceiling exposure for any of the operators was 1.3 f/cc which occurred during cleanup. For the three days when asbestos-containing dust generating operations were in progress, the TWA's for the operators involved ranged from 0.1 to 0.2 f/cc and averaged 0.2 f/cc. The sanding and cleanup operations with two people working took 2-3 hours

The area TWA's in the cellar where the work was being done ranged from 0.08 to 0.1 f/cc during operations but was measured at 0.004 f/cc for the day after the installation was completed. The living room showed the highest value of only 0.02 f/cc during sanding but recorded only 0.004 f/cc before and 0.006 f/cc after the project. It is clear that there was no significant contamination of the rest of the house during the operation nor any residual contamination after it was completed.

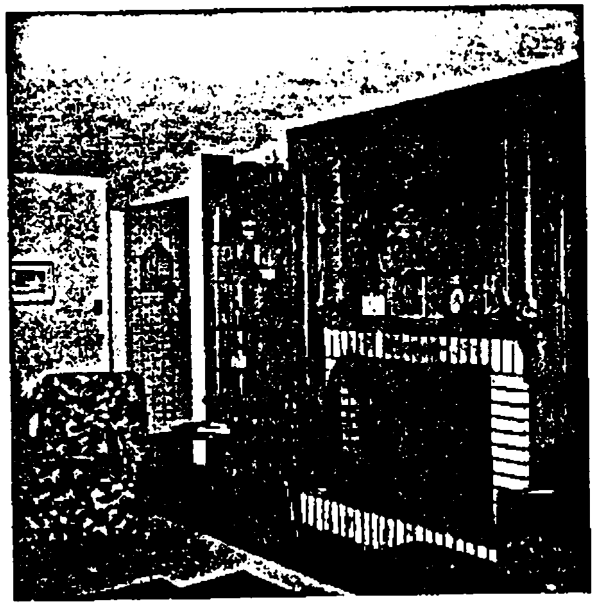
CONCLUSIONS

The data, as obtained and reported herein, support the following conclusions:

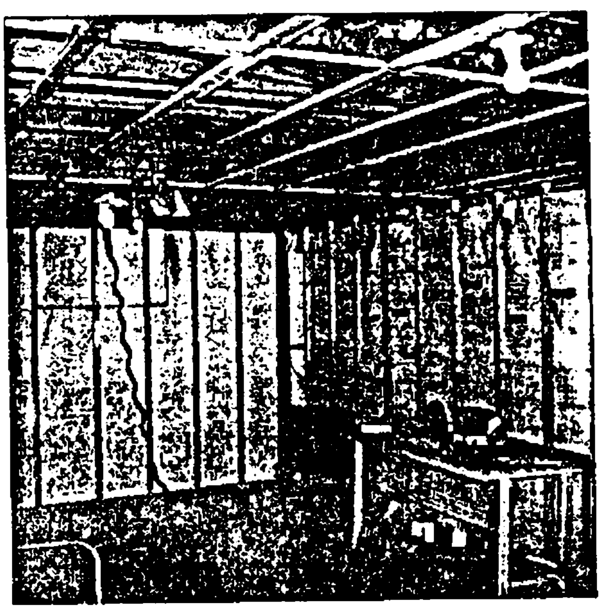
1. Consumer installation of full-room drywall panelling with tape-joint compound containing approximately 2.5% asbestos (dry weight) gives asbestos exposures substantially less than both the present OSHA standard of 10 f/cc ceiling and 2 f/cc for an eight-hour, time-weighted average and the proposed standard of 5 f/cc ceiling and 0.5 fibers TWA. These standards are designed to protect the worker for daily exposure for an entire working lifetime.

2. Household exposures after the installation were substantially below 0.01 f/cc and had not been changed appreciably by the present activities. It is questionable whether this is different from natural background.

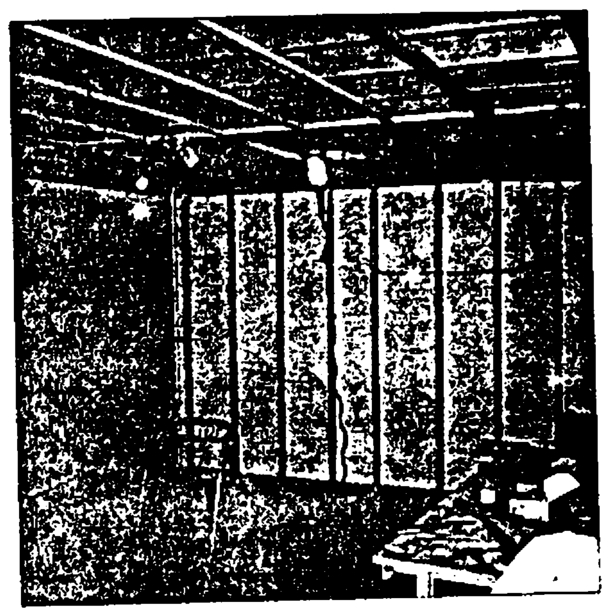
SAMPLE LOCATIONS - PRIOR TO DRYWALL INSTALLATION



1 (a) First Floor Living Room - Monitor
Located over Fireplace mantle



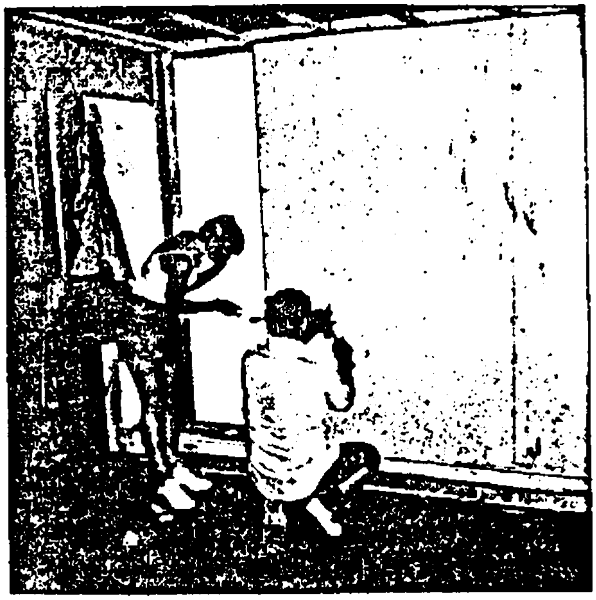
1 (b) Cellar Recreation Room with with studding in place. South and East walls



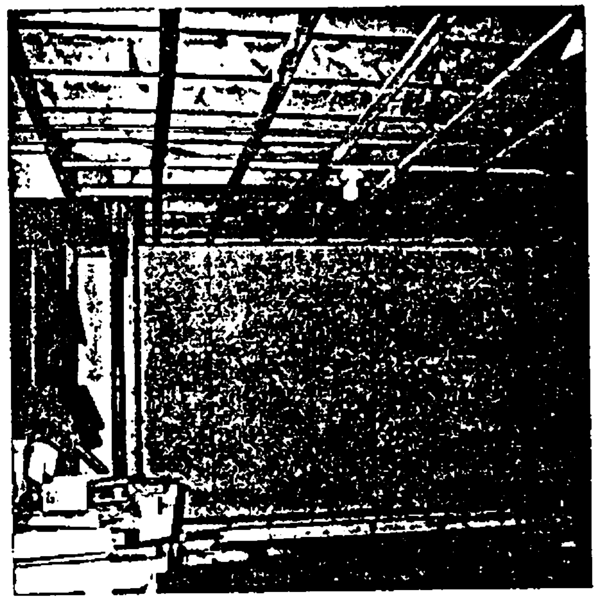
1 (c) Cellar Recreation Room with studding in place. North and East walls

FIGURE 1

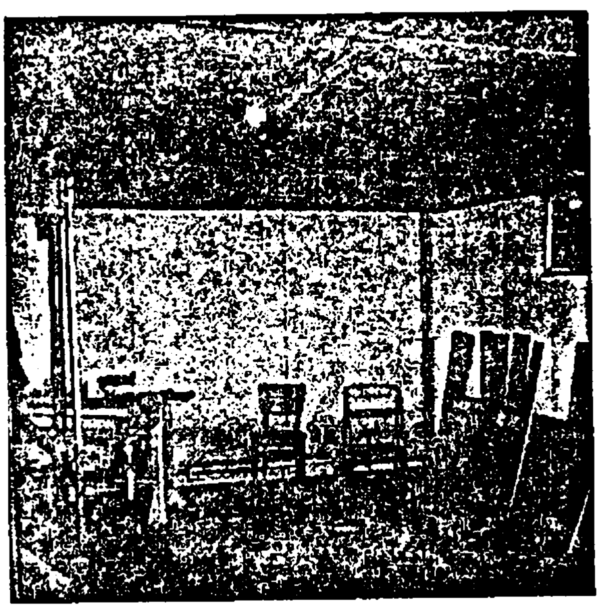
INSTALLATION OF DRYWALL PANELING



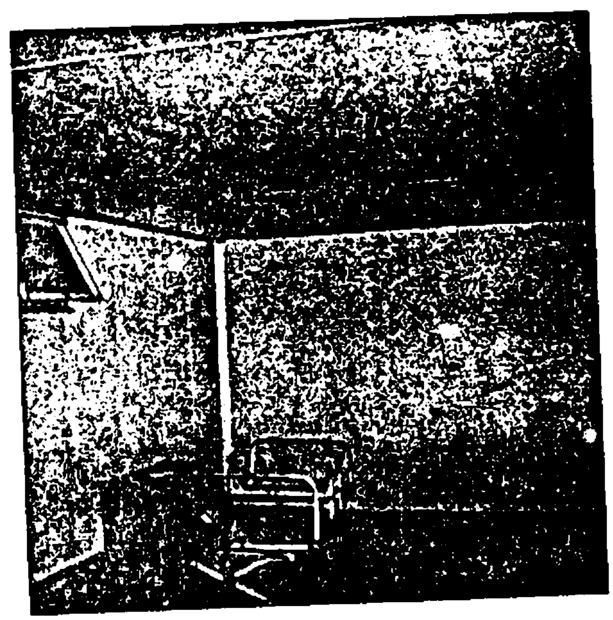
2 (a) Nailing Drywall to studding



2 (b) West wall of cellar



2 (c) West wall and ceiling



2 (d) East wall and ceiling

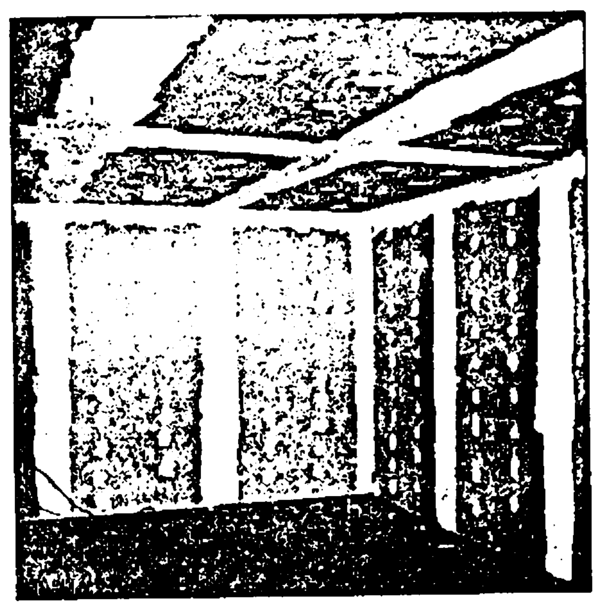
FIGURE 2

APPLICATION OF TAPE & JOINT COMPOUND

3 (a) Covering nail holes with tape joint compound

3 (b) Applying tape & joint compound between drywall seams

3 (c) Applying tape & joint compound to ceiling drywall



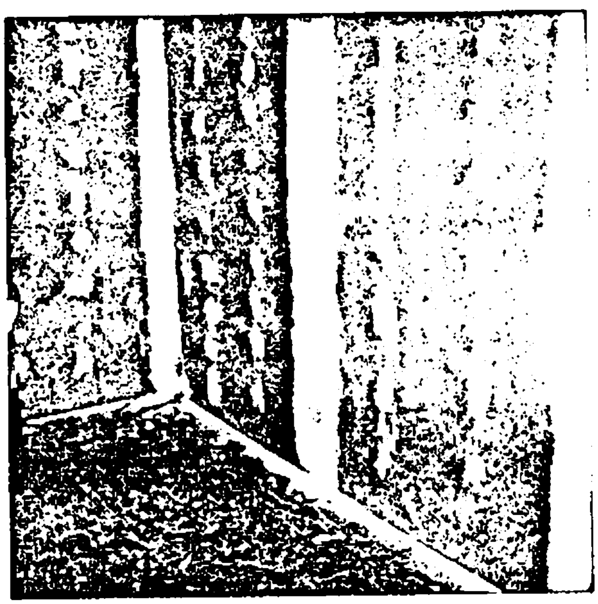
3 (d) After taping and second application of tape joint compound

FIGURE 3

FIRST HAND-SANDING OF TAPE-JOINT COMPOUND

4 (a) Sanding wall tape-joints

4 (b) Sanding ceiling tape-joints



4 (c) Dust accumulation after initial sanding

4 (d) Sweeping after first sanding.

FIGURE 4

SANDING OF FINISH COAT

5 (a) Sanding ceiling joints

5 (b) Sanding wall and ceiling joints

5 (c) Sanding wall joints

FIGURE 5

CLEANUP AFTER FINAL SANDINGS

6 (a) Dust accumulation after final sanding

6 (b) Sweeping after final sanding

6 (c) Vacuuming after initial sweeping with broom

FIGURE 6

TABLE I

SUMMARY OF AIRBORNE FIBER CONCENTRATIONS
(GYPSUM DRYWALL INSTALLATION)

Sample No.	Date	Time On	Time Off	Duration	Description of Operation	No. of Fields Counted	No. of Filter Sections Used	Airborne Fiber Concentrations: Chrysotile Fibers/100 Fields	Chrysotile Fibers/cc >5µ	Possible Chrysotile Fibers/100 Fields	Possible Chrysotile Fibers/cc
COMPLETION OF [illegible] (8/3/77)											
N-73	8/3/77	8:30A	[illegible]	609	Area - Before finishing compound. Located in living room 1st floor ~6' above floor on mantel of fireplace.	500	5	3	0.004	0	0
N-52	8/3	8:20A	6:22P	607	Area - Before handling of asbestos. Located in construction area ~6' above floor on north wall ~ center of room.	100	1	63.5	0.08	0	0
B-3	8/3	7:43P	9:10P	87	Personal (Operator #1) Taping joints with ready mix	100	1	25.5	0.2	10.5	0.08
J-2	8/3	7:46P	9:1[illegible]	85	Personal (Operator #2) Taping joints with ready mix.	100	1	16	0.1	1	0.008
COMPLETION OF INSTALLATION AND COVERING OF TAPE (8/4/77)											
N-53	8/4	9:30A	[illegible]	252	Personal (Operator #2) Taping joints with ready mix	200	2	7.25	0.02	0	0
N-70	8/4	9:35A	1:43P	253	Area - During taping. Located ~6' above floor area near center of north cellar wall.	200	1	5.5	0.02	0	0
APPLICATION OF SECOND COAT OF COMPOUND (8/5/77)											
..... No air samples taken.											
FIRST SANDING CLEANUP AND APPLICATION OF FINISH COAT OF COMPOUND (8/6/77)											
N-76	8/6	10:00A	10:44A	44	Personal (Operator #2) Hand sanding. Tape joint compound	100	1	53.5	0.8	6.5	0.1
N-89	8/6	11:00A	11:28A	28	Personal (Operator #2). Hand sanding. Tape joint compound	100	1	21.5	0.5	1	0.02
B-14	8/6	11:58A	12:10P	12	Personal (Operator #2). Sweep up after first sanding	100	1	17.5	1.0	4.5	0.3
N-94	8/8	10:01A	10:47A	46	Personal (Operator #3). Hand sanding. Tape joint compound	100	1	43	0.7	2.5	0.04
B-18	8/6	10:55A	11:29A	34	Personal (Operator #3) Hand sanding Tape joint compound	100	1	35	0.7	5	0.1
N-75	8/6	11:57A	12:11A	14	Personal (Operator #3) Sweeping up after first sanding.	100	1	15	0.7	0	0
N-71	8/6	9:59A	11:23P	84	Area. During first sanding of tape joint compound. Located ~6' above floor near center of north wall (cellar).	100	1	25.5	0.2	0	0
B-30	8/6	11:57A	12:12P	15	Area - During sweep up after first sanding Located ~6' above floor near center of north wall cellar.	100	1	14.5	0.7	0	0
B-31	8/6	12:39P	4:46P	237	Area. After sanding and sweep up. During final application of tape joint. Located near center of north wall (cellar).	100	1	10	0.03	1	0.003
B-10	8/6	12:23P	4:39P	256	Area. After sanding and sweep up. During final application of tape joint compound. Located first floor upstairs living room on mantle of fireplace.	300	3	8.5	0.01	2	0.003

TABLE I (Continued)

[illegible]

[illegible] SANDING [illegible]

Sample No.	Date	Air Sample Time On	Air Sample Time Off	Minutes	Description of Operation	[illegible] Sampled	No. of Filter [illegible]	Airborne Fiber Concentration [illegible]	[illegible]	[illegible]	[illegible]
B-17	8/10/77	9:27A	10:01A	34	Personal - Operator #1. Sanding [illegible]	100	1	22.5	0.5	2	0.04
N-36	8/10	10:0[illegible]A	10:2[illegible]	26	Personal - Operator #2. Sanding	100	1	13.5	0.4	0	0
P-60	8/10	10:2[illegible]	[illegible]	17	Personal - Operator #1. Sanding (ceiling).	100	1	23	0.5	1	0.04
N-4	8/10	10:[illegible]A	11:05A	21	Personal - Operator #2. Sanding (cellar).	100	1	20.5	0.7	0	0
N-7	8/10	11:1[illegible]A	11:4[illegible]A	25	Personal - Operator #2. Sanding (ceiling).	100	1	22.5	0.6	0	0
B-8	8/10	9:2[illegible]A	10:0[illegible]A	35	Personal - Operator #3. Sanding	200	1	8	0.2	0	0
B-20	8/10	10:01A	10:[illegible]A	20	Personal - Operator #3. Sanding	200	1	8.75	0.2	0.5	0.01
P-65	8/10	10:31A	11:12A	41	Personal - Operator #3. Sanding	100	1	23	0.3	0	0
N-8	8/10	11:1[illegible]A	11:[illegible]A	20	Personal - Operator #3. Sanding	100	1	23	0.5	0	0
N-10	8/10	11:52A	12:13P	21	Personal - Operator #3. [illegible] after sanding.	100	1	35.5	1.2	0.5	0.02
A-75	8/10	12:47P	4:33P	226	Personal - Operator #3. After final [illegible] and cleanup. [illegible] including [illegible] of work clothes used during [illegible] and sanding.	300	1	17	0.05	0	0
N-85	8/10	9:2[illegible]A	12:1[illegible]P	17[illegible]	Area. During [illegible] sanding and cleanup. [illegible] first floor living room ~6' above floor [illegible] of fireplace.	[illegible]	3	11	0.02	0	0
N-55	8/10	9:27A	10:15A	48	Area. During [illegible] sanding of [illegible]. Located [illegible] floor near center of [illegible] wall cellar.	200	2	9.75	0.1	0.5	0.007
A-74	8/10	10:17A	11:4[illegible]A	9[illegible]	Area. During [illegible] of [illegible]. Located [illegible] above floor near center of [illegible] wall cellar.	100	1	29	0.2	2	0.02
N-6	8/10	11:52A	12:14P	22	Area. During [illegible] and vacuum [illegible]. Located ~6' above floor [illegible] wall.	100	1	15.5	0.5	0	0
A-77	8/10	12:10P	5:49P	339	Area. After final sanding and cleanup. Located first floor living room ~6' above floor [illegible] of fireplace.	100	1	10.5	0.02	0	0
A-71	8/10	12:17P	5:59P	342	Area. After final sanding and cleanup. Located ~6' above floor in north wall of cellar.	100	1	10	0.04	0	0

RESIDUAL EXPOSURE AFTER COMPLETION OF [illegible] (8/11/77)

Sample No.	Date	Air Sample Time On	Air Sample Time Off	Minutes	Description of Operation	[illegible] Sampled	No. of Filter [illegible]	Airborne Fiber Concentration [illegible]	[illegible]	[illegible]	[illegible]
A-72	8/11/77	8:53A	9:10A	17	Personal (Operator #3). [illegible] first floor living room, kitchen and [illegible] after final sanding and cleanup.	500	4	0.1	0.001	0	0
A-76	8/11	9:12A	5:00P	468	Area. Day following completion of work in basement. Located in kitchen [illegible] above floor.	500	3	0.3	0.001	0	0
Z-4	8/11	9:13A	5:00P	467	Area. Day following completion of work in basement. Located on mantle of fireplace ~6' above floor.	500	4	3.7	0.006	0	0
A-70	8/11	8:45P	5:01P	496	Area. Day following completion of work in basement. Located in stairway of cellar ~7' above cellar floor.	500	3	1.0	0.001	0	0
P-56	8/11	8:12P	5:01P	499	Area. Day following completion of work in basement. [illegible] north wall of [illegible]	500	4	2.6	0.004	0	0