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APPENDIX

to the

Testimony Presented to the Commission by Harrison B. Rhodes

on August 15, 1977

Regarding 16 CFR Parts 1304 and 1305

RESPIRABLE FREE-FORM ASBESTOS

Proposal to Ban Certain Patching Compounds and Artificial Emberizing Materials (Embers and Ash)

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August 29, 1977

SUMMARY AND CONCLUSIONS

This report presents and compares all of the known data on asbestos dust exposure levels during commercial and consumer drywall installation operations. The following conclusions regarding consumer usage have been drawn from the data.

1. Consumer exposure during drywall installation can reasonably be expected to be approximated by the range of 0.5-1.5 f/cc* during dust generation operations.

2. The corresponding 8-hour time-weighted average (TWA) exposures are only several tenths of a f/cc.

3. Residual household exposure after drywall installation is less than 0.01 f/cc which falls within the NIOSH description of ambient levels.

* f/cc means asbestos fibers greater than five micrometers in length per cubic centimeter of air.

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ASBESTOS EXPOSURE IN DRYWALL INSTALLATION

INTRODUCTION

This document is the Appendix referred to by Dr. Harrison B. Rhodes in the testimony before the Consumer Products Safety Commission on August 15, 1977, in the matter of a "Proposal to Ban Certain Patching Compounds and Artificial Emberizing Materials (Embers and Ash)." It provides the technical support for Figures I and II that were presented to the Commissioners at that time.

ANALYTICAL METHODS AND LIMITATIONS

All of the exposure data to be presented will be in expressed terms of fibers/cubic centimeter longer than 5 micrometers as measured by the optical phase contrast procedures developed by NIOSH. This is done of necessity because the data were measured in these terms and most of the health data to which the results must be related are expressed in the same manner.

The NIOSH procedure has a number of recognized problems which include:

1. The inability to distinguish asbestos fibers in an unambiguous manner from other non-asbestos particulate matter which meets the criteria for a fiber, i.e., a length greater than 5 micrometers and a length-to-diameter ratio greater than 3.

2. Limitations on sample time due to the presence of other dust in the air which preclude collecting sufficient asbestos on the filter to meet the criteria for reliable counting.

3. A decrease in empirical precision as the airborne concentration to be measured decreases.

All of these problems exist to varying degress in the data to be presented and will be referred to as data from different investigators are compared. It should also be pointed out that in several studies exposures from zero to several tenths of a fiber per cubic centimeter longer than five micrometers were found. Since these levels are in the same range and are compared to ambient background it is relevant to quote NIOSH on ambient levels to provide a proper frame of reference. Thus:

> "Only a few studies of ambient levels have been performed using phase contrast optical microscopy. These studies indicate ambient levels to be generally less than 0.01 fibers >5 µm/cc, with some peak values as high as 0.03 fibers >5µm/cc."[1] (Emphasis added.)

PRESENTATION OF DATA

The data to be presented are contained in five reports:

1. The tests conducted by Rohl et al [2] 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 [3] and cited extensively by the Asbestos Information Association/North America in their response to the petition.

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1. Re-Examination and Update of Information on the Health Effects of Occupational Exposure to Asbestos. U.S. Dept. of H.E.W., December 1976, p. IV-18.

2. Rohl et al, Science, Volume 189, August 15, 1975, p. 552.

3. G.D.C.I. Drywall, January/February 1976.

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 of a consumer installation of a large room including the ceiling.

The results of each investigation will be summarized in this section. Comparisons of the results of the several investigators will be made in the following section, "Discussion of Results".

Commercial Applications

Data of Rohl et al

The data presented by the petitioners was that of Rohl, et al which is summarized in the table below:

AIRBORNE ASBESTOS FIBER CONCENTRATIONS
SANDING, DRY-MIXING AND SWEEPING(4)

Operations	Number of samples	Peak fiber concentration (fibers per milliliter)	
		Mean	Range
Pole-sanding (1 to 1.5 m)	10	10.0	1.2 to 19.3
Background (2.5 m), same room	3	8.6	3.5 to 19.8
Background (7.5 m), adjacent room	2	4.8	0.7 to 8.8
Hand-sanding (1 to 1.5 m)	11	5.3	1.3 to 16.9
Background (2.5 m), same room	2	2.3	2.1 to 2.5
Background (4.5 m), adjacent room	2	4.3	1.5 to 7.1
Dry mixing (1 to 1.5 m)	2	47.2	35.4 to 59.0
Background (3 to 6 m), same room	3	5.8	0.5 to 13.1
Background (5 to 10 m), adjacent room	2	2.6	2.1 to 3.1
Sweeping floor (3 to 15 m)			
15 Minutes after sweeping	1	41.4	
35 Minutes after sweeping	1	26.4	

No details are provided on the nature of the operation sampled, i.e., whether it was run as a specific test or as the sampling of a routine commercial installation, the asbestos content of the mud, the number of men sanding in a room, the size of the room or rooms sanded, or the presence or lack of ventilation. There is no way to evaluate the influence of the specific test conditions on the results reported or to determine how they may relate to other commercial operations. The tests also appear to cover a total sanding time of no more than 15 minutes for pole sanding and about the same time for hand sanding. It can be questioned whether this is a representative sample of commercial operations.

Regarding analytical methods, it was stated that the NIOSH procedure was used for optical measurements. The lack of any qualifying statement indicates that all particles which met the length greater than 5 micrometers and

4. A. N. Rohl, A.M. Langer, I.J. Selikoff and W. J. Nicholson, Science, Volume 189, August 15, 1975, p. 552.

L/D ratio greater than 3 were counted without any attempt to correct for non-asbestos particulate as permitted under the "other information" provision in the method. It was also stated that for every fiber visible by light microscopy:

> "... there were from 200 to almost 1000 that could be seen only at electron microscopic magnifications of X25,000."

No procedural details on the electron microscope method are provided nor are data presented on the actual size distribution, or the proportion of particles that were chrysotile and the proportion that were amphibole chips. It will only be noted here that the biological significance of particles that are so short that they can only be seen at magnifications of 25,000X is a very controversial subject at this time and is not directly relevant to the available commercial exposure data.

Data of Rhodes and Ingalls

Subsequent to the work of Rohl just cited, Rhodes and Ingalls[5] conducted a study of asbestos dust levels during sanding at seven locations throughout the United States. This work was done at the invitation of the Gypsum Drywall Contraxtors International who assisted in the selection of jobsites to represent the range of sanding conditions normally encountered in industry. All samples were collected during routine commercial operations and in most cases the man doing the sanding was not aware of the details or purpose of the test. The results for these samples, plus a later test at Denver, CO, by the same investigators, are summarized in the following table. (Note that at one location, Minneapolis, MN, an "asbestos-free" mud was used.)

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5. G.D.C.I. Drywall, January/February 1976.

AIRBORNE ASBESTOS FIBER CONCENTRATIONS

DURING SANDING OF TAPE-JOINT COMPOUND

Location	Structure	TJC Definition App. Tool	TJC Definition Type	Sanding Definition Tool	Walls	Ceiling	Description	Sample Definition Total Sample Time (Hrs.)	No. Samples	Airborne Asbestos Fiber Concentration (Fibers/cc >5μ) Range	Average
New York City, NY	High rise apt. building. Windows open, light breeze. 13, 14, 15th story. Humid ~750ft.^{2} of floor area per apt.	Hand	General Purpose, Ready-Mix	Pole & Hand	x	x	Finishing touch-up operation by tapers. Scraping, sanding (generally light) & filling. 5 man crew, 1 man/room.	5	5 Personal 1 Area	0.1-0.4 0.2	0.3 0.2
Ft. Lauderdale, FL	Condominium apt. bldg. Windows in and generally closed. Little breeze.	Ames	General Purpose, Ready-Mix	Pole	x	x	Steady sanding by laborer. 10-15 minutes to complete 1 B.R. apt., ~500 ft.^{2} of floor area.	1.5	7 Personal 7 Area	1.3-3.4 0.3-1.5	1.8 0.9
				Hand	x	-	Spot sanding bad areas.	0.5	2 Personal	0.8-1.1	1.0
Hialeah, FL	Condominium apt. bldg. Windows in and generally closed. Little breeze.	Ames	General Purpose, Ready-Mix	Pole	x	-	Steady sanding by laborer. 15-20 minutes to do a 3-5 room apt.	1	2 Personal 1 Area	0.6-1.0 0.6	0.8 0.6
Dallas, TX	Single level residential dwelling. ~2000 ft.^{2} floor area. Windows in and closed.	Ames	General Purpose, Ready-Mix	Pole	x	x	Steady sanding by 2 laborers. 30 minutes to do complete house.	1	4 Personal 1 Area (after)	0.6-1.8 0.1	1.1 0.1
Niagara Falls, NY	Remodeled office. 12'x10'x12' No ventilation.	Hand	General Purpose, Ready-Mix	Hand	x	-	One man, heavy sanding.	0.6	3 Personal	2.3-3.8	2.9
Detroit, MI	Multilevel residential dwelling. ~3000 ft.^{2} of floor area. No ventilation.	Ames	Topping Compound, Dry Mix	Pole	x	x	Steady sanding by laborer. ~4 hours to complete.	4	8 Personal 1 Area	0.6-1.3 0.5	1.0 0.5
Minneapolis, MN	Two-level residential dwelling. ~2300 ft.^{2} of floor area. Moderate ventilation.	Ames	Topping Compound, Dry- Mix Asbestos Free	Pole	x	x	Steady, heavy sanding. 1 man ~4 hours	4	6 Personal 3 Area	0.1-0.4 0.0-0.4	0.2 0.2
Denver, CO	Two-story medical bldg. Two-story hall, many small rooms. Rain, no ventilation.	Hand	Ready-Mix to bury tape. Non-asbestos Ready-Mix Topping.	Pole	x	x	One man, moderate sanding. ~30 mins.	3	3 Personal 2 Area	0.1-0.4 0.2	0.2 0.2

When the large differences between the two studies became apparent, filters from three locations were counted "blind" by two other laboratories. The results shown below demonstrate that the differences were not due to improper counting by the authors of the work.

INTERLABORATORY COMPARISON

ASBESTOS FIBER COUNTS

Sample Source		Airborne Asbestos Fiber Concentration (Fibers/cc longer than 5μm) By UCC	By Lab A	By Lab B
Location I	(Filter #1)	0.4	0.3	0.2
"	(Filter #2)	0.4	0.0	0.2
Location II	(Filter #1)	1.5	1.0	1.6
"	(Filter #2)	1.3	1.0	0.6
Location III	(Filter #1)	0.6	0.0	0.9
"	(Filter #2)	0.4	0.2	0.2

The concentrations just described were obtained during the actual sanding operation. In virtually all cases, even the commercial operators do not sand for a full shift so that the 8-hour time-weighted average will be considerably less than the exposure while dust is being generated. Values for the sanding conditions in the 8-hour time-weighted average in this study are shown in the table below. Note that the highest TWA value obtained was 0.9 f/cc.

SUMMARY OF AIRBORNE ASBESTOS

FIBER CONCENTRATIONS DURING DRYWALL SANDING

Location	Ceiling Exposure (Fibers/cc >5μm)	Exposure Time During Sanding (Hours)	Estimated 8-Hour TWA Exposure (Fibers/cc >5μm)
New York City, NY	0.4	8.0	0.3
Hialeah, FL	1.0	4.0	0.4
Ft. Lauderdale, FL (Hand)	1.1	1.0	0.1
Detroit, MI	1.3	8.0	0.9
Dallas, TX	1.8	0.5	0.1
Ft. Lauderdale, FL (Pole)	3.4	3.3	0.6
Niagara Falls, NY	3.6	0.6	0.2

Equitable Environmental Health and OSHA Compliance Data

There is another source of exposure data which is particularly relevant, that obtained by OSHA compliance inspectors. The Asbestos Information Association/North America has engaged a contractor, Equitable Environmental Health, Inc. to study asbestos exposure in the construction industry. As part of this project they obtained a fairly substantial body of data from several State and Federal compliance offices. The OSHA results for the sanding operation plus data from a test that was run directly by EEH are summarized in the following table:

AIRBORNE ASBESTOS FIBER CONCENTRATIONS
DURING SANDING OF TAPE-JOINT COMPOUNDS[1]

Location	Structure	TJC Definition: App. Tool	TJC Definition: Type	Sanding Definition: Tool	Sanding Definition: Walls	Sanding Definition: Ceiling	Sanding Definition: Description	Sample Definition: Total Sample Time (Hrs.)	Sample Definition: No. Samples	Airborne Asbestos Fiber Concentration (Fibers/cc >5μ): Range	Airborne Asbestos Fiber Concentration (Fibers/cc >5μ): Average
DATA FROM OSHA COMPLIANCE INSPECTIONS[1]											
A	-	-	Ready-mix	Pole	X	X	Apparently 3 men sanding.	0.5-2	8 Personal 4 Area	1.5-5.0 1.0-10.0	4.3[2] 5.0[2]
F	-	-	-	Pole	-	-	-	0.7	1 Personal	0.1	0.1
H	-	-	-	-	-	-	-	-	9 Personal	0.3-1.5	0.7
I	-	-	-	-	-	-	-	1.2	3 Personal	0.2-0.6	0.4
DATA FROM EQUITABLE ENVIRONMENTAL HEALTH, INC.											
CO	One story annex to existing building.	-	Non-asbestos for tape, finished with asbestos-containing.	Pole	-	X	Heavy sanding. One man on stilts.	0.5	1 Personal 2 Area	0.2 0.1	0.2 0.1
	"	-	Non-asbestos throughout.	Pole	-	X	"	0.5	1 Personal 1 Area	0.1 0.1	0.1 0.1

1. Supplied to Equitable Environmental Health, Inc. as part of a study of asbestos exposure in the construction industry. Specific locations not identified.

2. Includes all particles L/D >3 L>5μ . Estimated by TEM proceeding to be about 50-70% chrysotile plus amphibole. No split on relative amounts is available.

Although sample collection details are limited for the OSHA data, it should be noted that at location A it appears that a three man crew was sanding together and moving from room to room. It was reported that the optical fiber counts included all particles which met the criteria, but a representative sample was analyzed by TEM procedures and the particulates in this size range counted optically were 50-80% chrysotile and tremolite. No breakdown of the relative amounts of the two was available. A figure of 70% was used to correct the data for asbestos content for graphical presentation in Figure 1. It should also be noted that the area sample in this study that showed 10 f/cc was collected directly below the place where a ceiling was being sanded while receiving a heavy stream of dust.

In addition to this sanding data, EEH was able to obtain OSHA results for the wet-out of dry-mix TJC and for a similar material, spray texture paints. Data for cleanup after sanding and texturing operations were also available and are summarized in the following table:

AIRBORNE FIBER CONCENTRATIONS
FROM OSHA COMPLIANCE INSPECTIONS (1)
DURING WET-OUT OF DRY PRODUCT AND CLEANUP
AFTER SPRAYING OR SANDING

Location	Product Identification	Operation	Sample Time (Min.)	Ceiling Concentration Fibers/cc >5μ
B	All purpose TJC	Wet-out	10	5.4
C	Spray Texture(2)	"	10	4.4
E	Spray Texture(2)	"	20	4.9
G	TJC	"	2	4.0
H	TJC (Morter)	"	-	2.7
D	TJC	Sweeping	15	2.7
		"	15	2.5
		"	15	2.0
		"	30	0.9
	TJC	Sweeping and Scraping	15	1.5
		"	15	0.6
		"	15	1.6
H	TJC	Sweeping	-	0.6

1. Supplied to Equitable Environmental Health, Inc. as part of a study of asbestos exposure in the construction industry. Specific locations not identified.

2. Spray texture compounds are generally similar in composition to dry-mix tape-joint compounds with texturing material added.

Consumer Applications

Union Carbide Corporation - Spackling and Drywall Replacement

On July 14, 1977, Union Carbide Corporation submitted a report to the Consumer Product Safety Commission covering asbestos exposures in a home during spackling and the installation of about 12 feet of drywall by a consumer. Since a copy of the report is available to the commission only the key points need to be included here. To quote from the Summary and Conclusions:

> "Residual asbestos exposure in a two-story residential structure that resulted from two prior consumer uses of asbestos-containing tape-joint compound was measured. Asbestos exposure during and after a consumer spackling and drywall renovation job was also measured. This job consisted of extensive spackling in one room and removal and replacement of approximately three 4' x 8' panels of drywall.

Samples were collected on Millipore filters and counted by optical phase-contrast microscopy in accordance with the March 30, 1977, edition of the NIOSH-OSHA method (P & CAM 239). The absence of significant numbers of short and/or narrow fibers not visible optically in the samples was verified by scanning electron microscope techniques at magnifications of 1,500X and to a limited extent at 15,000X.

The results showed that residual asbestos exposure was somewhat less than 0.01 fibers/cc >5μ and was not changed appreciably by the present test. It is questionable whether this is really different from the natural background.

The combined spackling and drywall renovation operation tested gave a maximum, one-day time-weighted average operator exposure of about 0.3 fibers/cc longer than 5μ and a maximum ceiling exposure (10 minutes) of 0.5 fibers/cc >5μ. Considering the size of the area renovated, these values are consistent with values of 1 - 4 fibers/cc >5μ that have been reported for commercial sanding operations where entire series of rooms (including the ceilings) are sanded in sequence."

Union Carbide Corporation - Large Room Drywall Installation

Union Carbide Corporation has also conducted a study of asbestos exposure during the installation of drywall by a consumer in a large room. A complete report is included with this presentation to the Commission so only the Summary and Conclusions will be presented here.

"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 pre-calibrated 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 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."

DISCUSSION OF RESULTS

Commercial Operations

The airborne asbestos fiber concentrations obtained in the operator's breathing zone during sanding for all of the references cited are shown graphically in Figure 1. Similarly, the data for the wet-out of dry powder and for cleanup after drywall installation operations are shown in Figure 2.

Examination of Figure 1 shows that the commercial data from the OSHA compliance samples, from EEH, and from Union Carbide generally fall in the same range of several tenths to about four f/cc whereas the data of Rohl et al appear to be substantially different and much higher. As noted previously, the Rohl article does not provide sufficient information to relate the conditions used to those of the other studies but the following points based on extensive experience in this application are offered as a possible explanation:

1. It is well known that short samples give erratic results. This is in large part due to the combined effects of non-uniformities in the airborne concentration being sampled and in the deposition of fibers on the filter. The Rohl data which appear to be 1-1.5 minute samples are an excellent illustration of this, i.e., 10 pole-sanding samples ranged from 1.2 to 19.3 f/cc and 11 hand-sanding samples showed 3.5 to 19.8 f/cc. With this kind of variability it is most useful to look at the mean values of 5.3 and 10 f/cc for hand and pole sanding respectively.

2. There is little doubt that the Rohl data include an unknown fraction of particles which are neither chrysotile nor amphibole. If the 20 to 50% figure found by one of the OSHA laboratories using TEM techniques is applied the mean values decrease to the range of 2.7-5 f/cc for a 50% correction and 4-8 fibers/cc for a 20% reduction. Any remaining differences, which are now not large, could be due to the sanding procedures, and the configuration and ventilation of the rooms where the tests were conducted.

The commercial wet-out and cleanup data in Figure 2 show even wider differences between the Rohl study and the OSHA compliance data. There is insufficient information to even suggest the reason for such differences, but it is believed that the OSHA data from a total of 8 locations can be taken as the most representative of regular commercial use.

It can be concluded from the data presented that operator airborne asbestos exposure during regular commercial drywall operations varies widely but generally falls within the range of several tenths to about four f/cc. Since the dust generating operations normally occupy only a moderate portion of the working day, the corresponding 8-hour time-weighted average exposures will generally be less than 1 f/cc and usually substantially less than this figure.

Consumer Operations

The data for the two consumer installations given on the Figures shows that the large, full-room job gave higher levels than the replacement of one wall. In both cases the exposures during the dust generating operations fell in the lower end of the commercial range, i.e., several tenths to less than 1.5 f/cc.

There was an apparent misunderstanding at the hearing of the description of the counting procedure which we used to obtain these results. It should be reiterated and emphasized that:

1. The procedure used conforms to the NIOSH requirements.

2. It is biased to provide a high count for both chrysotile and amphibole while not including such things as fiberglass, mica chips, clay particles, and similar materials which occur in varying amounts in many industrial samples. All doubts about the identity of any particle found are resolved in favor of including it as asbestos.

3. All concentrations reported on the Figures or in the discussion were based on the total of chrysotile plus amphibole, not chrysotile alone.

As a further check twelve of the samples, five from the small job and 7 from the large, were submitted to two independent laboratories for "blind" counting checks. The results are summarized below:

Sample Designation	Airborne Fiber Concentration (Fiber/cc >5μ) Count by UCC(1)	Count by NGC	Count by McCrone
M-22	0.5	0.6	0.2
M-24	0.2	0.06	0.1
M-26	0.2	0.4	1.0
M-30	0.3	0.4	1.2
N-79	0.1	0.08	0.3
B-10	0.02	0.004	0.003
B-14	1.3	0.5	0.2
B-18	0.8	0.4	0.4
N-10	1.2	1.1	0.5
N-75	0.7	0.4	0.8
N-76	0.9	0.7	0.7
P-60	0.9	0.5	0.2

(1) Total of chrysotile and possible amphibole.

The highest count found for any of the samples is still 1.3 f/cc. There is some notable scatter but considering the low asbestos level and the extremely difficult nature of the samples, the general agreement is reasonably good. It should be pointed out that UCC had the high reading on seven samples, McCrone in four, and NGC in one. UCC was also second high on three other samples. Since the overall conclusions are directed towards the highest numbers found in either test they are not affected by the variability shown.

All of the counts so far discussed were ceiling exposures that occurred during the dust generating operations. It is necessary to estimate 8-hour time-weighted average exposures in order to relate to health data. There was some question raised at the hearing as to whether the proper procedure was used for this calculation.

In OSHA compliance activities when a man works in an asbestos-containing area for part of a day and in an area where there is no exposure for the remainder of the day, his TWA is calculated to include his entire shift, i.e., the part with no exposure is weighted at zero. This method was used in the small-job consumer study dated July 12, 1977. It should be pointed out, however, that the calculation basis was clearly stated and data were provided to allow calculation for the operator remaining in the house for the rest of the day. Regardless of the approach selected the results do not alter the conclusion that the highest TWA reported was 0.3 f/cc.

CONCLUSIONS

The principle conclusions that can be drawn from the data presented are:

1. Consumer exposure during drywall installation can reasonably be expected to be approximated by the range of 0.5-1.5 f/cc during dust generation operations.

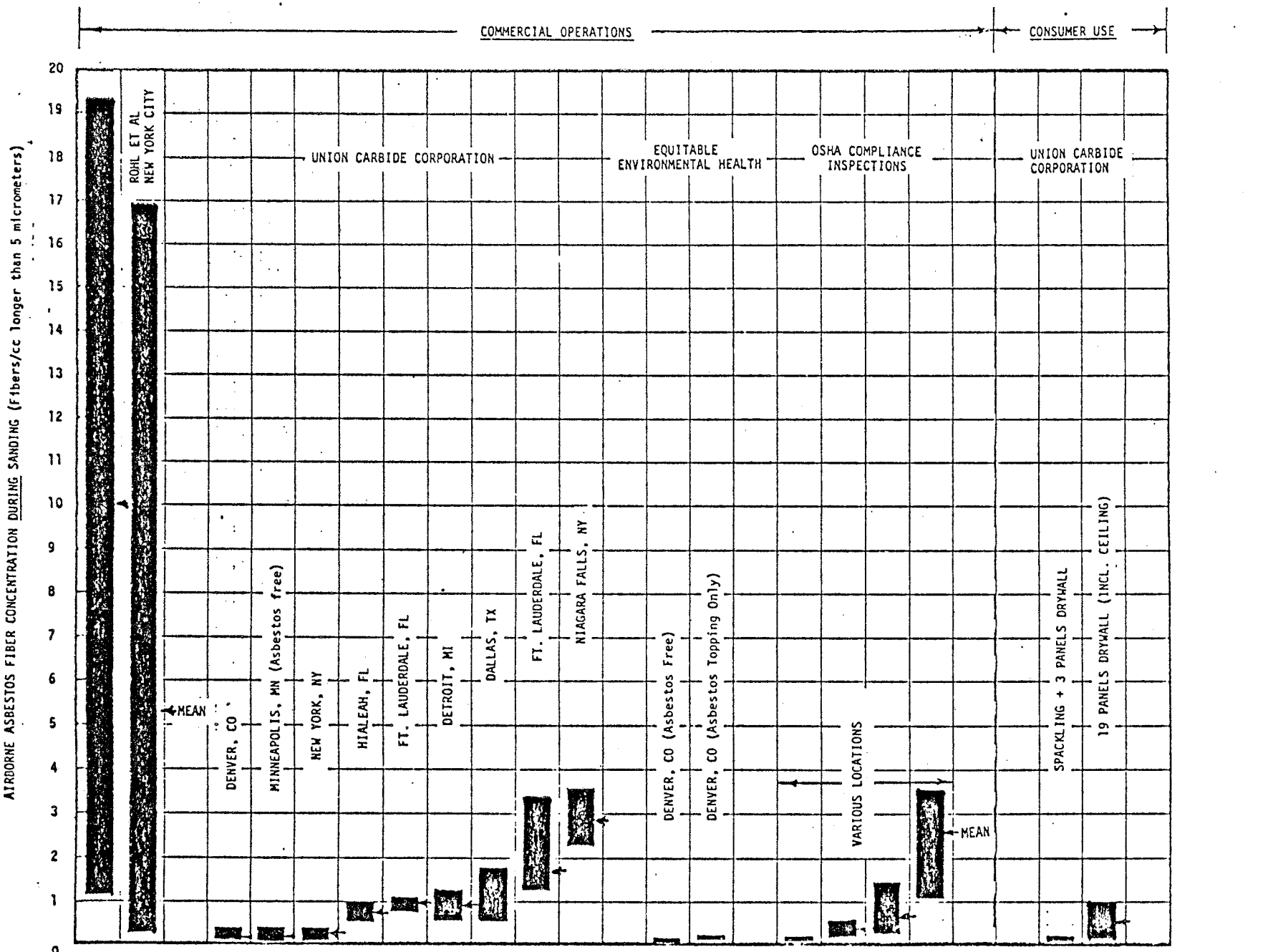
2. The corresponding 8-hour time-weighted average exposures are only several tenths of a f/cc.

3. Residual household exposure after drywall installation is less than 0.01 f/cc which falls within the NIOSH description of ambient levels.

AIRBORNE ASBESTOS CONCENTRATIONS

IN OPERATOR BREATHING ZONE

DURING SANDING OF TAPE-JOINT COMPOUND



FIGURE

IN OPERATOR BREATHING ZONE

DURING WET-OUT OF DRY MATERIALS

AND

CLEANUP AFTER SANDING

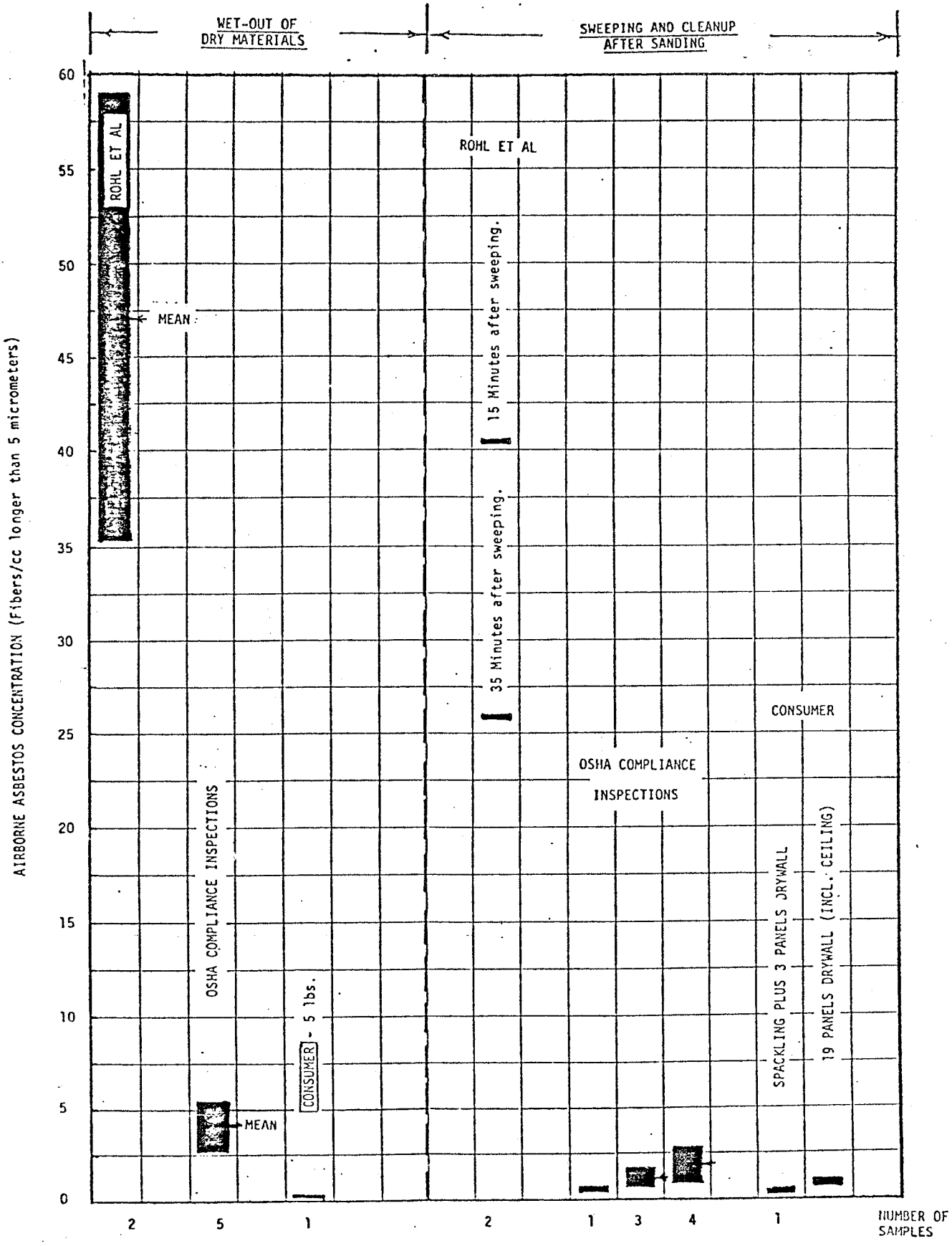


FIGURE 2