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PROJECT TITLE: "Dust-Producing Potential of Construction Materials"

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DUST-PRODUCING POTENTIAL OF CONSTRUCTION MATERIALS

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W. Clark Cooper, M.D., and Irving R. Tabershaw, M.D.

Purpose of Study

The purpose of this study was to develop methods for assessing the hazard potential of asbestos-containing construction materials. The methodology was to be developed during a systematic study of four commercial insulation products containing asbestos. The results include the actual concentrations of airborne asbestos fibers found to result from operations typical of the industrial uses of these products.

The necessity frequently arises in industry to predict the potential hazard during comminution of a solid material. In other words, "is the dust produced by sawing, drilling or filing of a solid containing a hazardous component necessarily of the same composition as the parent material?" At first glance, the answer must seem, "Obviously, yes." In reality, however, there are several factors which can result in a different distribution of components. Occupational exposures to potentially hazardous dusts may be affected by the conditions of use of the materials from which the dusts are generated or by the physical characteristics of the material.[1,2]

Occupational exposure of construction craftsmen to airborne asbestos fibers are primarily a result of the comminution of thermal insulation materials during their installation, repair, and removal.[3] Inhalation of asbestos fibers has been shown to cause, or be associated with, an increased

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incidence of fibrotic and neoplastic disease.[4,5] However, at present, ther are no thermally suitable alternatives to asbestos-containing materials for the prevention of heat loss from high-temperature (750°F and higher) pipes and boilers.

There are two major types of asbestos-containing thermal insulation products. One of these is made by binding a mat of amosite asbestos fibers with sodium silicate, either with or without the addition of diatomaceous earth (Product E). The minimum asbestos fiber content of this type is approximately 60%. The other major type is prepared by baking a slurry of calcium silicate and amosite and/or chrysotile asbestos fibers and contains approximately 10-15% asbestos (Products A, C and D).

It has been suggested that exposure of insulation workers to asbestos fibers might be substantially reduced by restricting the use of products which have a high asbestos content. However, the two types of materials differ significantly in their physical properties so that the asbestos concentrations in aerosols generated during the handling of the two types might differ in ways not directly related to the concentrations of asbestos in the parent materials.

The 60% asbestos/sodium silicate insulation has been described as being more readily cut and shaped than the calcium silicate products, requiring the application of less prolonged or intense force for a given shaping operation. There are also significant differences in the two types of asbestos fibers used in the materials, amosite being of greater specific gravity than chrysotile (3.5 vs. 2.5), and having individual fibrils of

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larger diameter than chrysotile (0.1 μm vs. 0.01 μm).

Thus, it would seem that there are theoretical arguments favoring the product with higher asbestos content. The greater ease of fabrication would mean a shorter period of production of the aerosol, and the larger, more dense amosite fibers would tend to fall out of the produced aerosol more rapidly than will chrysotile fibers.

Research Performed

Four thermal insulation products, 9-inch outside diameter and 3-inch inside diameter, containing differing asbestos types and concentrations were tested for respirable dust production under conditions simulating actual usage. These products were purchased "blind"; a reliable third party not connected with the University or any of the manufacturers concerned purchased the products through the normal market channels ordinarily used by him in his purchases of other insulation products. Thus, we entered the market randomly; the products used in this study are a "grab sample" of the products which might be delivered to any user. Product D was the only one of those tested which did not meet the original broad specifications; it was supplied as two 1 1/2-inch layers and not the single layer of the other products. The wholesaler confirmed that Product D is not supplied in a single layer in 3-inch thickness. Therefore, it was used as received since this is the way it would be supplied to insulators in actual practice.

A test chamber (shown in Figures I and II) was constructed measuring 10'4" long by 9'8" high by 10' wide. The total volume was 1,000 cubic feet.

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The room was lined with 0.006" plastic sheeting to facilitate cleaning. Farr Company HF 200 filters were used to filter the supply air and the exhaust. Air exchange rate between test runs was 230 cubic feet per minute.

After each run, and between products, the room was flushed for a period which varied depending on the observed "dustiness" of the room but was a minimum of 20 minutes (about 6 air changes). Before each change of product (or change in process), a background air sample was taken in the "room" position (described below); each sample subsequently taken in that series (or run) was then corrected by having the background concentrations subtracted.

The following operations (described in greater detail below) were performed on each product by an insulation mechanic (journeyman asbestos worker).

I. Simulation of pipe covering, and tear-out of heat stressed pipe covering.

II. Power sawing of the products to simulate on-site fabrication of specific shapes of the material by a bandsaw; and the "scoring" of blocks.

III. Pounding with a simulated hammer to estimate the effects of force-fitting (not performed by the insulation mechanic).

In each of these operations (except the tear-out and pounding), the insulation mechanic was permitted to set his own pace; the specific plan of operations was determined in consultation with him so that practices

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usual to the trade were followed.

The insulation mechanic used a "Whitecap" supplied-air respirator throughout; the asbestos fiber concentrations in the air supplied to him were far below the proposed Threshold Limit Value.

Sampling and Analysis

Air samples were taken by drawing air through Millipore 0.8 μm mean pore size organic membrane filters. Filters of 37 mm diameter were used for the personal breathing zone samples and 47 mm diameter filters for all other samples. Additional samples were taken using Nuclepore membrane filters (0.8 μm mean pore size) for subsequent electron microscope analyses.

During the simulated pipe-covering, tear-out, and handsawing, samples were taken at five locations within the test chamber: 1) in the middle of the chamber, with the open-face filter holder 8 feet above the chamber floor level ("Roof" samples), 2) from a support projecting into the chamber approximately 1 foot from the wall opposite the work bench on which the covering was done, through an open-face filter holder about 6 feet above the floor ("Room" samples); 3) above the work bench (near the wall closest to the bench) with an open-face filter holder ("Bench" samples); 4) in the same location as the Bench samples but with the air drawn through a Wexhlet Horizontal Elutriator (Casella-Wilson) before passage through the in-line filter holder ("Elutriator" samples); 5) in the insulator's breathing zone with disposable Millipore Field Monitors (open face) ("Personal" samples). Sample air flow rates were: Roof, 0.7 cubic feet per minute (cfm); Room, 0.5 cfm; Bench, 0.5 cfm; Elutriator, 50 liters per minute (1.8 cfm); and Personal, 0.11 cfm. See Figures I and II for these locations.

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During the scoring operation, only two sampling locations were utilized (Room and Personal samples) as shown in Figures I and II. The pounding operation was monitored with four samplers, one on the bench above the product being pounded ("Bench top") and three others approximately 5 feet distant from the pounding site, 4 feet above floor level. One of these filter holders was directed upward ("Up"), another directed downward ("Down"), and the other directed horizontally ("Horizontal"). Flow rates here were 1.9 cfm for the Room, 1.0 cfm for the three others. These locations are shown in Figures III and IV.

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FIGURE IV

Plan of enclosure during grinding (side view)
Dimensions are as shown in Fig. II

FIGURE III

Plan of enclosure during grinding (top view)
Dimensions are as shown in Fig. I

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Analysis of the collected samples was directed at obtaining two measures of the relative amount of dust production from the products being tested. All filters (except the 37mm Personal sample filters) were weighed before and after use, each such weighing preceeded by desiccation for two hours to stabilize weights. From this weight data, the gravimetric concentrations of total airborne dust were computed in milligrams per cubic meter (mg/m^3) by dividing the milligrams change in weight by the total cubic meters of air which had passed through the filter. This was the sole analysis applied to the "Bench", "Elutriator", and "Bench top" samples.

The other sample filters were analyzed to determine the concentrations of asbestos fibers in addition to the gravimetric analysis. This analysis was by the standard method for the determination of asbestos fibers collected on membrane filters:[6] a wedge of the weighed, exposed filter was cut from the filter and the wedge (about 1/8 of the total filter) placed on a standard microscope slide on which was placed a drop of a mounting medium which matched the index of refraction of the organic filter. The filter wedge thus "cleared" was examined with phase contrast microscopy at 430X magnification, with the microscopic field of examination limited to the area bounded by a Porton eyepiece reticle (0.0061 mm^2 per field). The asbestos fibers seen in each field were recorded and placed into several length and diameter categories, and the field shifted to another portion of the filter. This process was continued until 100 such fields had been examined, or until 300 fibers had been counted and sized.

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When 300 fibers (or 100 fields) were accumulated from any one sample, the count within the field was completed and the count then terminated for that sample. The concentration of asbestos fibers per liter of air was determined by taking into account the area of the filter surface examined (0.0061 mm^2), the total exposed filter area (960 mm^2), the number of fibers counted, and the flow through the filter in milliliters. This result was expressed as fibers per milliliter (f/ml). The proposed Threshold Limit Value (American Conference of Governmental Industrial Hygienists) is only for those fibers longer than 5 micrometers (μm). Therefore, asbestos fiber concentrations expressed within this report are given for both total asbestos fibers and asbestos fibers longer than 5 μm in the tables of results, but the graphic expression of fibers per ml. is limited to fibers longer than 5 μm.

Specific Operations

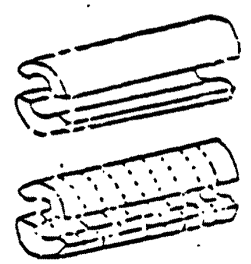
I. Pipe-covering.

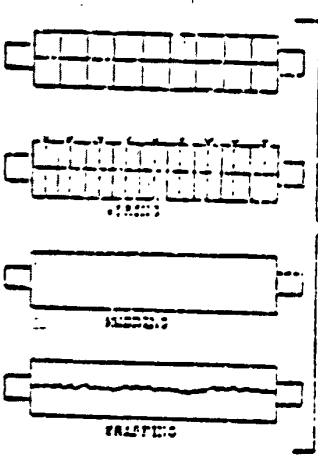
Three "runs" were made on each product during the simulation of pipe covering. For each of these runs, two 36-inch long half-round sections of insulation were cut into 18 separate pieces by cutting across at 4" intervals, the major axis of the 36-inch long sections. These 4" sections were then wired in place around a 48-inch long piece of 3" I.D. cast-iron pipe so that the final covering of the pipe extended for approximately 35" (with about 1 inch lost because of saw blade width). The wired insulation was "mudded" with a mix which was constant throughout the series of tests, and the mudded surface wrapped with medium-weight canvas,

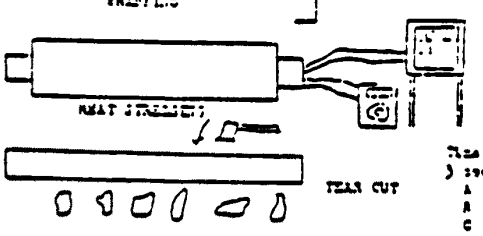
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FIGURE V
Pipe Covering and Treatment







	Room time required (for 1 full round section)	Air samples per treatment (1 full sections)
PIPE SECTION	A 6.2 min. B 9.0 min. C 14.1 min. D 6.1 min.	30
APPLICATION	A 6.2 min. B 9.0 min. C 14.1 min. D 15.8 min.	15
HEAT STRESSED	24 hrs.	
TEAR CUT	Time for all 3 sections A 2.5 min. B 4.0 min. C 2.0 min. D 3.0 min.	9

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Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from All Pipe Covering Operations: Product A

Table 1.

Pipe Covering Results Product A - 1

Operation	Samples									
	Personal		Roof			Room			Bench	Floor/Floor
	f/ml	f/ml(0.5)	f/ml	f/ml(0.5)	mg/m³	f/ml	f/ml(0.5)	mg/m³	mg/m³	mg/m³
Handsawing	27.264	26.057	9.376	8.159	29.234	10.241	8.899	6.099	19.894	1.616
	27.711	26.967	23.269	22.963	6.169	15.577	14.191	6.341	6.937	6.567
	56.385	49.374	9.119	8.108	6.683	2.256	2.102	6.311	10.655	0.356
	31.811	27.551	13.431	13.041	2.779	9.196	8.295	0.239	1.516	0.479
	32.010	27.965	15.751	14.911	1.359	5.227	5.139	0.195	4.264	1.364
	26.948	25.249	21.249	23.916	4.395	13.659	15.991	5.253	43.259	1.517
Mean	33.556	29.361	17.667	16.241	9.915	9.751	9.061	3.555	16.591	2.174
Standard Deviation	11.364	9.699	8.939	8.771	8.927	5.383	10.318	3.699	21.719	1.121
Application	15.334	16.435	19.872	18.615	10.911	6.771	7.139	7.679	1.282	1.292
	13.759	12.293	15.829	15.512	5.566	3.916	12.675	2.562	1.601	1.167
	18.615	15.956	21.991	20.699	6.691	9.656	9.666	3.619	11.993	1.278
Mean	15.903	14.927	19.564	18.275	7.389	6.781	8.744	3.953	1.640	1.912
Standard Deviation	2.493	1.961	2.655	2.593	2.663	4.649	6.159	0.556	8.611	1.196
Tearout	43.231	47.641	20.951	23.258	19.376	3.781	7.647	9.556	73.836	3.960

Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from All Pipe Covering Operations: Product B

Table 2.

Pipe Covering Results Product B - 2

Operation	Samples									
	Personal		Roof			Room			Bench	Floor/Floor
	f/ml	f/ml(0.5)	f/ml	f/ml(0.5)	mg/m³	f/ml	f/ml(0.5)	mg/m³	mg/m³	mg/m³
Handsawing	162.335	121.744	110.199	97.809	9.794	63.033	52.957	20.193	4.277	1.733
	192.521	156.477	149.567	139.415	13.319	169.792	135.493	17.632	15.269	1.659
	215.899	179.759	62.269	56.639	1.809	75.276	21.959	2.976	16.592	4.297
	291.287	249.529	223.634	217.962	17.939	189.631	185.746	15.121	36.907	13.932
	268.473	202.719	154.753	142.278	26.931	101.697	99.682	2.945	19.529	3.324
	293.445	243.674	142.964	92.676	-------	109.919	97.925	16.351	9.912	21.028
Mean	239.506	193.649	137.064	127.796	13.965	104.561	82.127	10.696	17.651	7.829
Standard Deviation	59.223	57.675	55.647	56.966	8.427	61.150	57.510	8.111	11.175	8.690
Application	57.135	69.789	36.847	30.352	10.190	25.951	19.897	8.159	3.136	1.292
	124.325	109.142	98.795	96.689	10.776	32.899	27.971	9.841	5.993	2.329
	158.149	133.341	99.617	64.791	13.679	39.868	35.327	8.644	7.679	3.261
Mean	113.597	97.411	62.753	47.196	11.677	32.906	27.731	8.881	5.603	2.294
Standard Deviation	51.647	43.865	7.476	8.533	1.766	7.076	7.723	0.820	0.910	1.457
Tearout	282.021	248.335	71.477	69.121	19.154	137.966	133.166	27.289	55.311	3.711

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Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from All Pipe Covering Operations: Product C

Table 1

Pipe Covering Results Product C

Operation	Samples										
	Personal		Roof			Floor			Dust	Fiberglass	
	f/ml	f/ml (>5)	f/ml	f/ml (>5)	mg/m³	f/ml	f/ml (>5)	mg/m³	mg/m³	mg/m³	
Handsawing	5.693	5.614	1.892	1.779	0.529	0.692	0.931	0.219	3.615	0.295	
	12.519	11.261	6.851	6.463	1.056	6.596	5.889	1.642	6.305	2.426	
	11.189	10.569	2.094	1.911	11.891	2.596	2.295	3.615	1.996	0.343	
	11.599	11.023	1.561	1.279	1.693	1.129	1.019	2.918	10.535	1.609	
	4.384	4.443	4.083	3.978	10.131	3.999	3.895	6.246	4.268	33.311	
Mean	10.574	9.811	3.796	3.644	7.051	3.418	3.398	4.367	3.356	6.797	
Standard Deviation	2.819	2.691	1.193	1.151	3.999	2.918	1.674	2.077	3.731	11.660	
Application	5.525	4.339	1.913	1.773	1.446	1.529	1.263	2.331	1.441	0.863	
	5.922	4.932	1.532	1.219	1.871	2.396	1.819	3.612	1.195	1.434	
	7.937	6.755	2.599	2.144	17.529	5.196	4.999	5.619	1.869	1.419	
Mean	6.329	5.172	1.841	1.514	6.948	2.707	2.527	3.854	1.502	1.239	
Standard Deviation	1.134	0.976	1.872	1.907	7.985	2.712	2.353	1.088	2.473	0.401	
Tearout	13.393	12.526	8.893	8.328	4.337	5.343	4.925	6.593	33.334	1.265	

Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from All Pipe Covering Operations: Product D

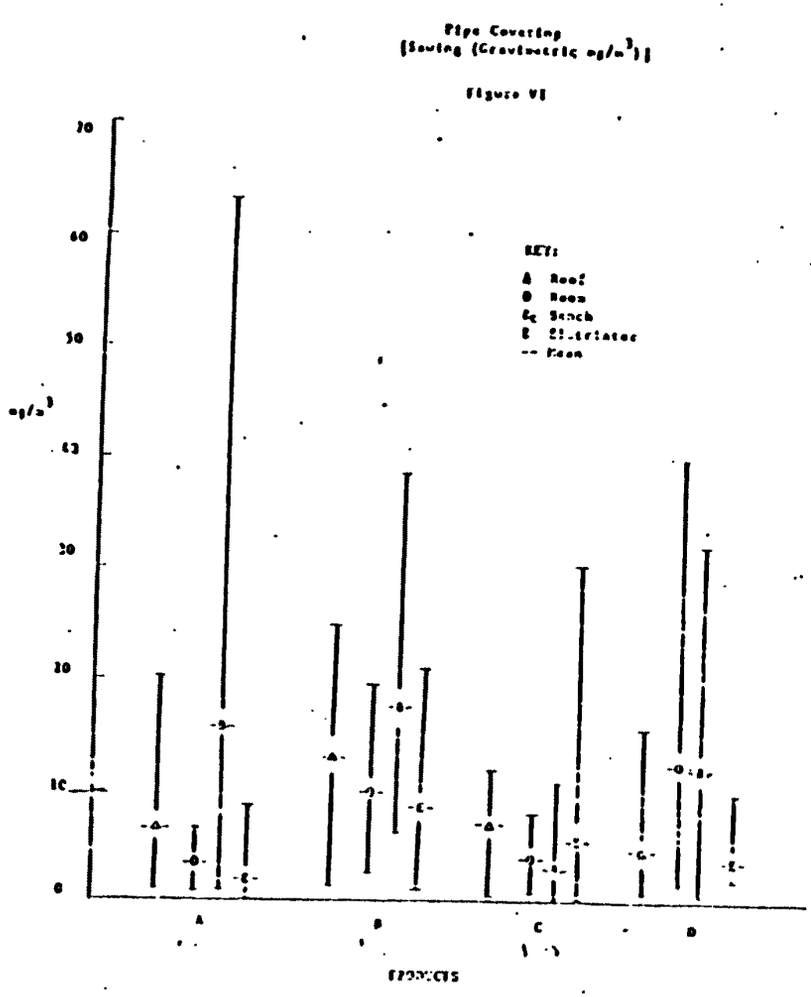
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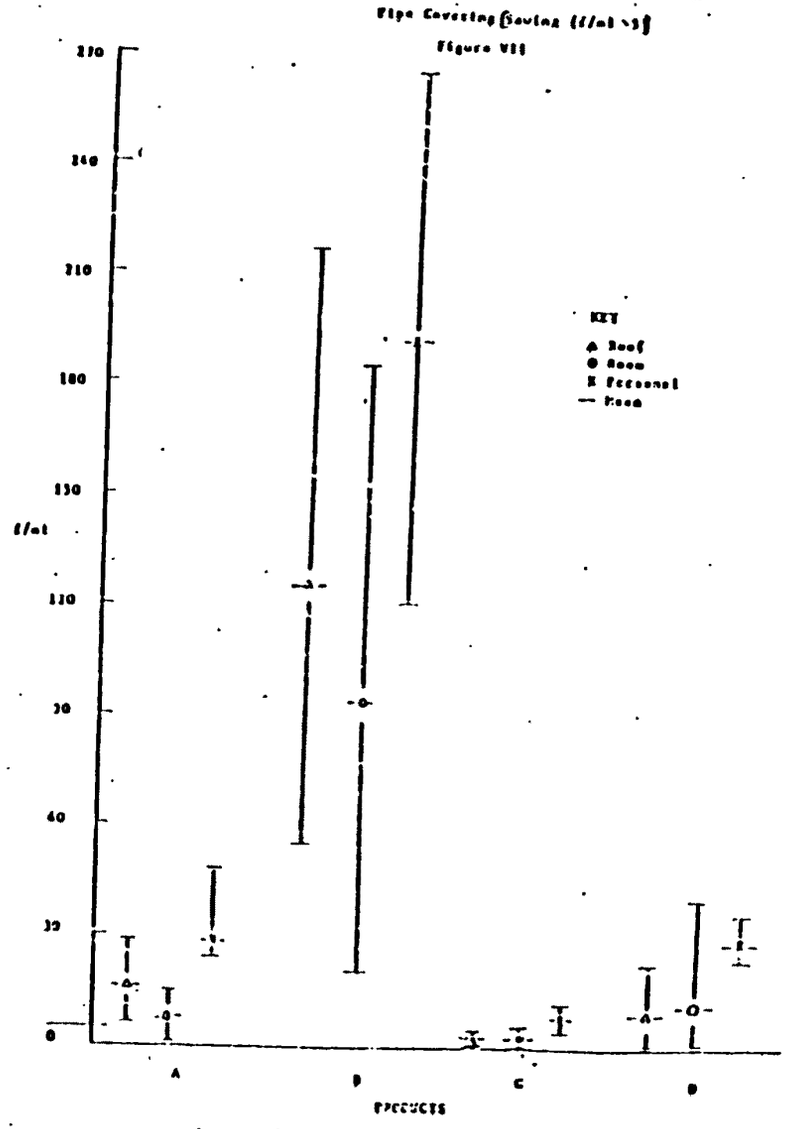
Pipe Covering Results Product D

Operation	Samples									
	Personal		Roof			Floor			Dust	Fiberglass
	f/ml	f/ml (>5)	f/ml	f/ml (>5)	mg/m³	f/ml	f/ml (>5)	mg/m³	mg/m³	mg/m³
Handsawing	28.056	27.299	1.868	1.771	0.178	5.332	4.993	7.066	9.743	6.943
	31.019	26.288	25.254	23.651	3.276	6.296	18.636	6.299	7.189	2.519
	39.356	29.328	3.359	3.191	15.697	10.116	9.281	6.959	10.535	0.191
	27.525	26.149	13.359	13.139	3.251	14.022	13.653	68.271	13.599	5.677
	34.338	32.581	2.592	2.474	1.992	8.596	8.199	13.455	1.379	4.253
	61.359	36.979	12.206	10.638	3.831	4.836	3.639	10.539	32.221	6.153
Mean	37.111	29.187	9.859	9.155	4.541	8.530	8.935	15.726	12.351	3.241
Standard Deviation	9.162	4.878	9.859	8.636	5.367	5.352	5.937	24.895	10.585	2.853
Application	39.287	19.991	39.526	39.662	11.155	7.587	23.696	7.332	7.329	3.267
	25.576	25.963	26.399	25.122	21.725	11.121	10.356	21.219	6.924	2.973
	23.179	22.215	19.179	18.574	15.251	18.899	17.541	14.856	5.662	5.536
Mean	29.013	22.393	28.367	27.721	16.378	12.536	17.197	11.335	5.971	3.925
Standard Deviation	8.294	3.563	7.641	7.979	5.446	5.677	6.531	3.761	1.431	1.691
Tearout	48.262	45.858	41.881	38.696	24.463	12.316	31.766	9.693	35.334	1.762

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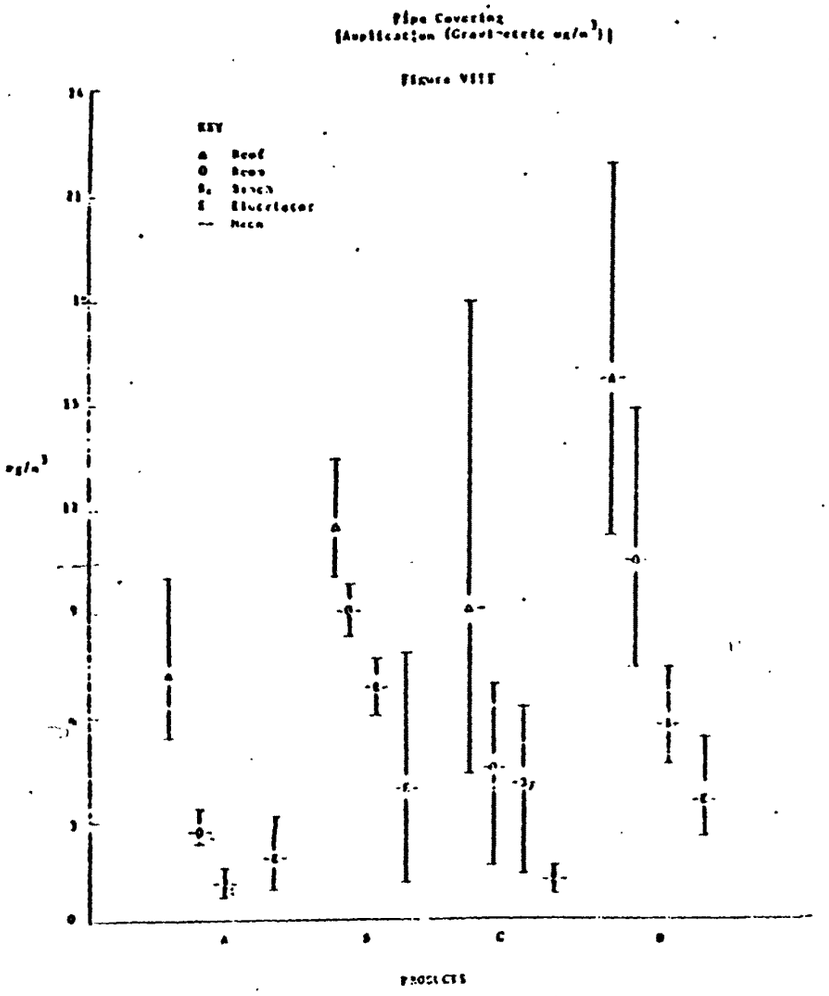
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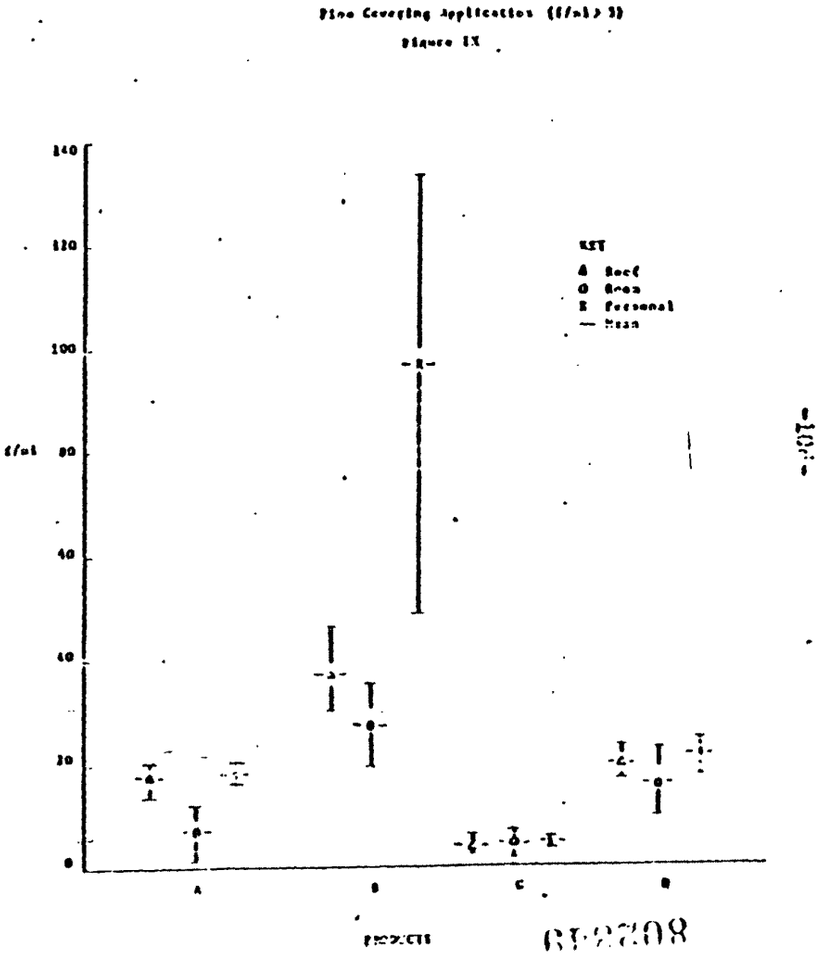




Total Airborne Dust (Gravimetric) and Airborne Asbestos Fiber Concentrations: Handsawing Portion of Pipe Covering

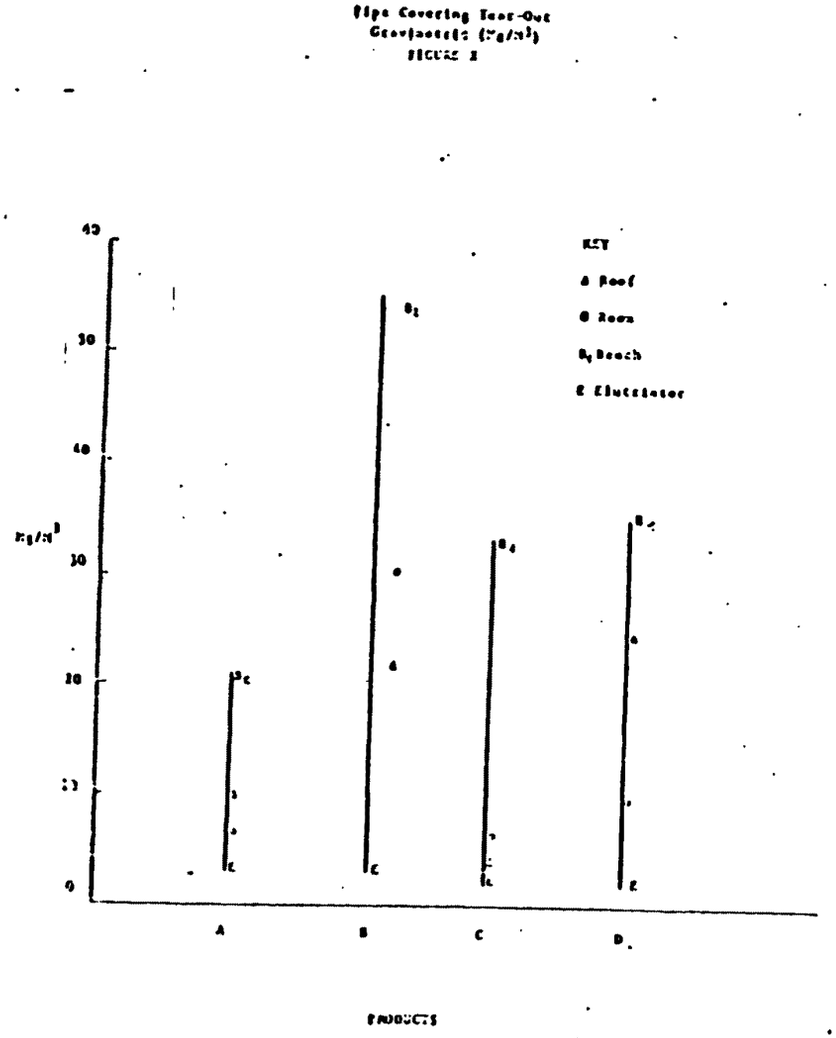
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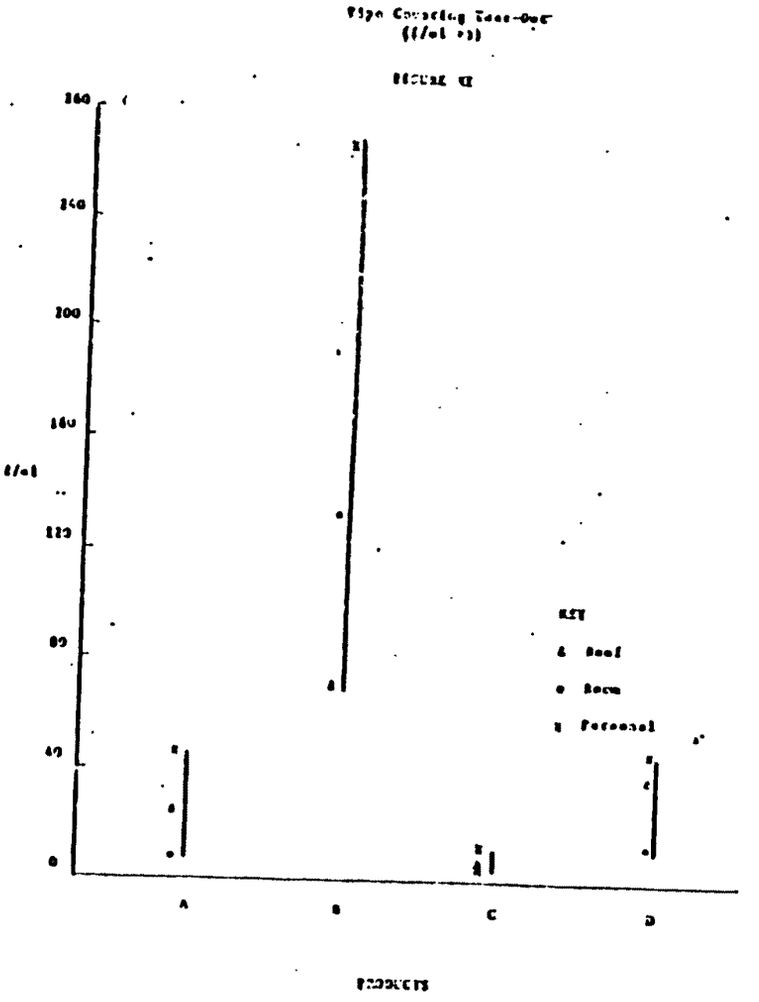




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Total Airborne Dust (Gravimetric) and Airborne Asbestos Fiber Concentrations: Tear-Out Portion of Pipe Covering

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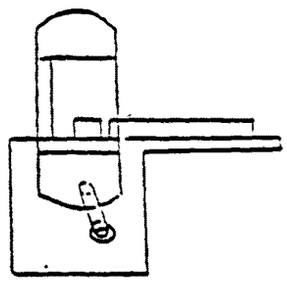
II. Power Sawing (Bandsaw)

Six 3-foot long half-round sections were cut into (approximately) 4-inch long sections (making 9 cuts per 3-foot section), using a Dewalt bandsaw with a 1/2-inch blade with 6-blade points per inch. The linear velocity of the point tips was about 3000 feet per minute. A background sample was taken before each product change. The saw was placed in the center of the room (under the Roof filter holder). Two half-sections were cut, while samples were taken, then the saw shut off and the filters changed. This process was repeated twice more for each product. Figure XII shows a flow chart for this operation.

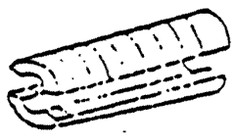
BAND SAWING

FIGURE XII





Mean Time Required (for 1 full section)	Air Samples Per Product
A 3.0 min.	
B 2.8 min.	15
C 2.1 min.	
D 3.3 min.	



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Results (Bandsaw)

Table 5 shows the results for the bandsawing for all products with (again) the results listed as total asbestos fibers per milliliter, fibers (longer than 5 μm) per milliliter, and total particulate milligrams per cubic meter. In Figures XIII and XIV are again shown the graphic representations of results.

Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from Bandsawing: All Products

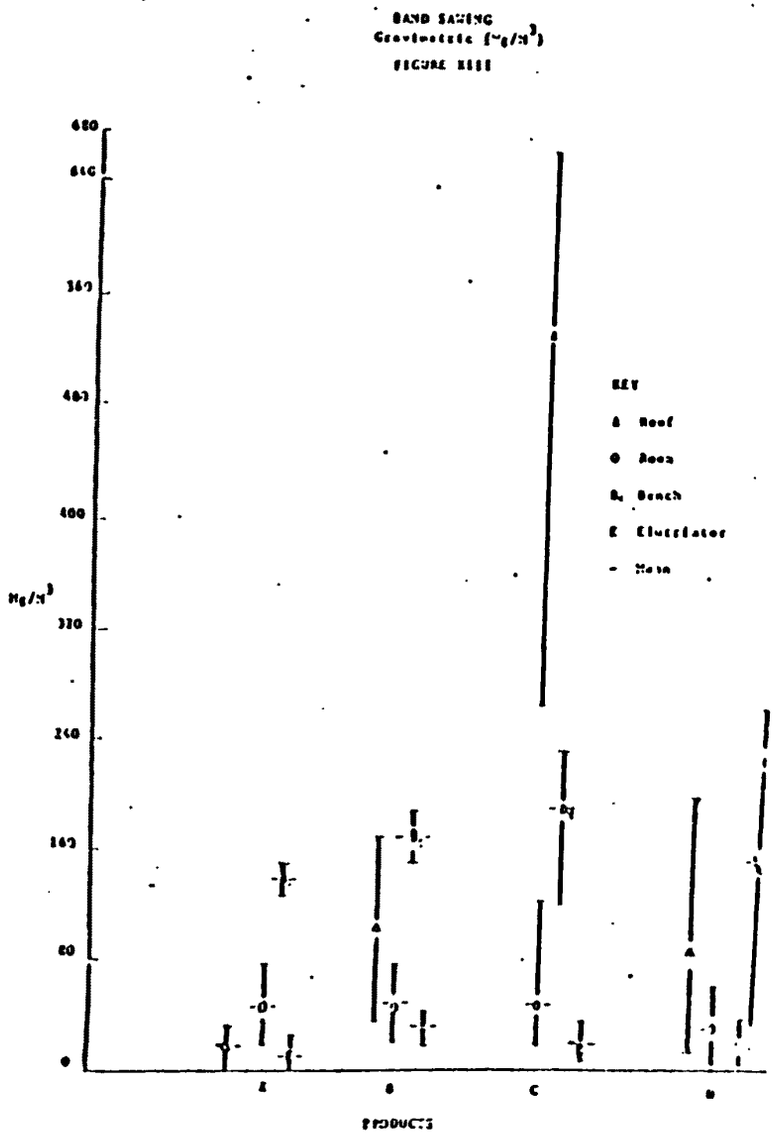
Table 5.

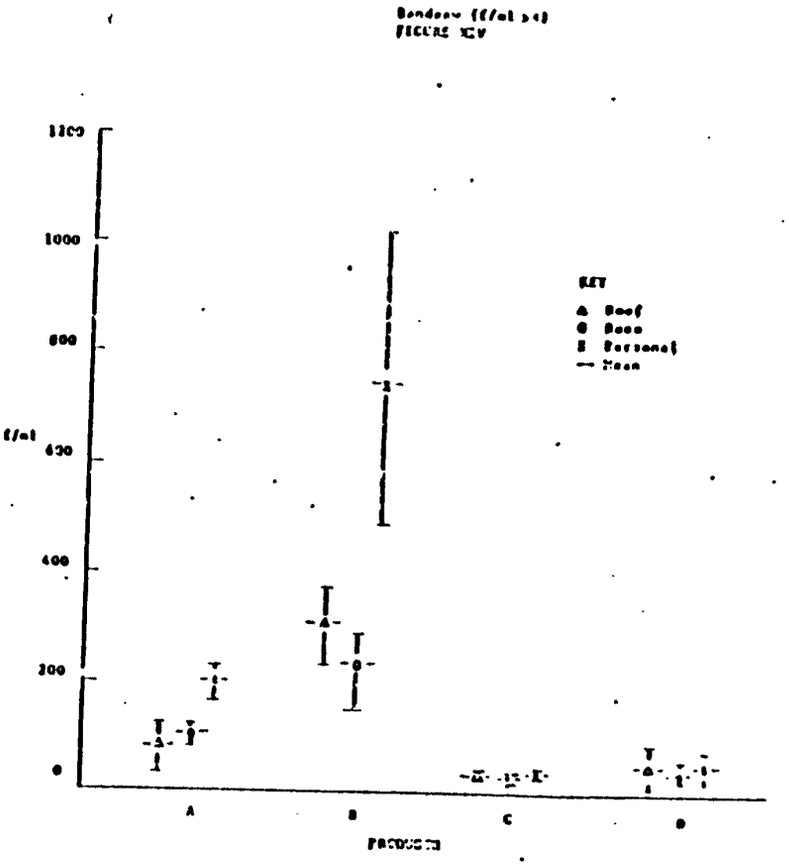
Band Sawing Results

Product	Samples										
	Personal		Fixed			Area			Respirable	Gravimetric
	f/ml	f/ml(>5)	f/ml	f/ml(>5)	mg/m³	f/ml	f/ml(>5)	mg/m³	mg/m³	mg/m³
A	263.777	236.752	6.609	3.999	3.413	135.538	103.271	22.004	144.810	19.461
	225.815	212.091	122.565	112.006	35.295	101.610	99.160	20.377	127.113	6.523
	179.752	170.952	110.873	108.389	31.276	61.371	59.231	17.015	102.096	17.826
Mean	214.781	203.265	80.016	74.998	23.161	101.507	87.887	19.799	124.673	14.603
Standard Deviation	38.312	40.871	66.183	63.255	17.761	8.068	1.006	28.651	3.928	13.567
B	562.875	509.731	265.251	239.762	55.163	134.848	137.796	39.939	126.861	28.243
	1138.225	1029.293	372.230	371.329	108.671	999.598	791.895	35.717	198.135	58.617
	------	------	329.899	115.353	120.928	231.351	269.691	24.899	159.744	34.174
Mean	853.141	774.262	322.460	242.997	161.254	232.599	232.775	33.185	161.580	33.678
Standard Deviation	607.328	574.295	66.247	93.643	67.695	87.652	56.827	23.349	11.623	3.333
C	31.977	69.839	31.906	39.993	544.617	33.391	32.661	29.458	229.260	31.113
	46.228	61.127	29.296	29.953	460.662	29.811	27.295	35.359	229.197	11.722
	69.461	34.699	38.964	40.429	448.571	28.918	26.121	122.295	172.224	20.129
Mean	49.222	41.836	33.359	32.125	536.727	30.227	28.356	75.648	190.591	21.006
Standard Deviation	5.220	5.312	5.061	3.985	232.364	2.428	3.588	47.143	39.223	9.210
D	48.960	41.925	19.364	17.529	16.238	65.299	65.868	6.673	151.531	19.519
	27.625	23.897	17.201	17.979	35.178	22.127	21.918	26.931	95.126	5.097
	81.991	75.181	96.893	93.181	176.179	53.523	51.366	62.150	201.279	19.765
Mean	59.159	53.668	61.486	62.563	81.199	60.316	57.151	31.918	149.312	18.127
Standard Deviation	28.351	26.628	44.189	43.239	99.683	18.232	16.009	27.648	135.334	14.648

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Total Airborne Dust (Gravimetric) and Airborne

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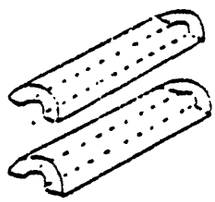
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III. Power Saw[illegible]

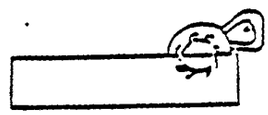
Two 3-foot half-round sections were scored to a depth of 1 1/4 inches, to simulate the scoring of flat blocks of insulation, as is done to facilitate the thermal insulation of large vessels (e.g., boilers) with large radii. Each section of the insulation was scored longitudinally four times while samples were taken; the filters were then changed and the process repeated. As above, a background sample was taken with each change of product, and an additional personal sample was taken during the clean-up process. This was done using a Ram hand circular saw ("Skilsaw" type) with a 7-inch diameter blade with 1 blade point per outside circumference inch. The linear velocity of the point tips was about 3000 feet per minute, as it was for the bandsaw. The flow chart and schematic of this operation are shown in Figure XV.

[illegible]

[illegible] IV



Time required for both sections	Air samples per product
A 2.5 min.	
B 2.2 min.	
C 2.1 min.	6
D 1.5 min.	





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Results (Scoring)

Table 6 shows the scoring results, Figures XVI and XVII their graphical representation.

Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from Scoring: All Products

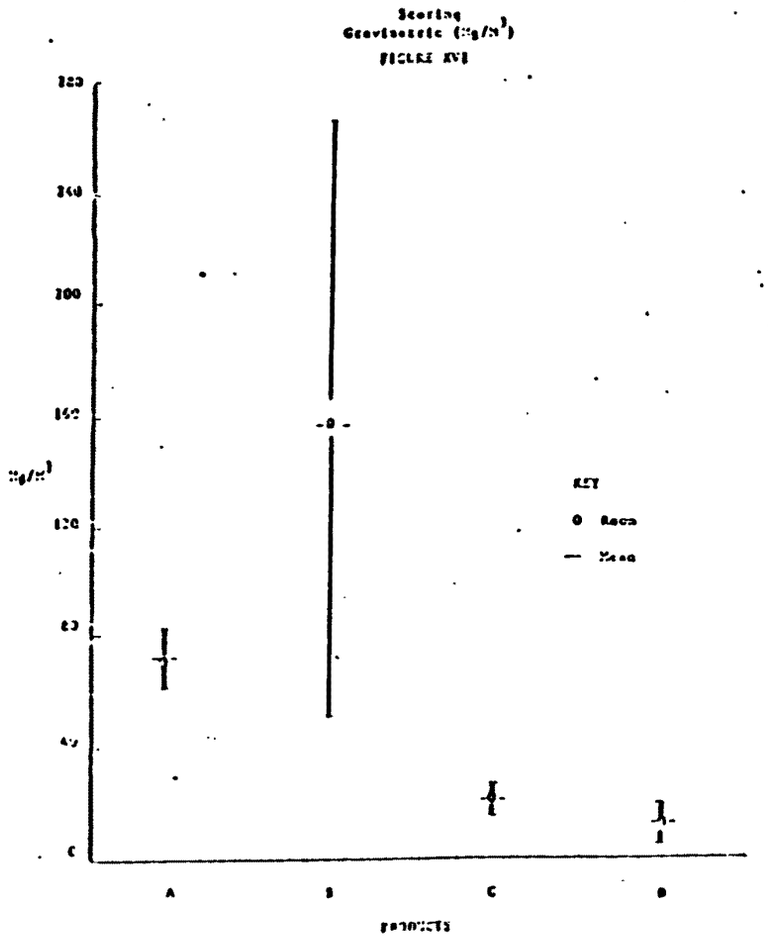
Table 6.

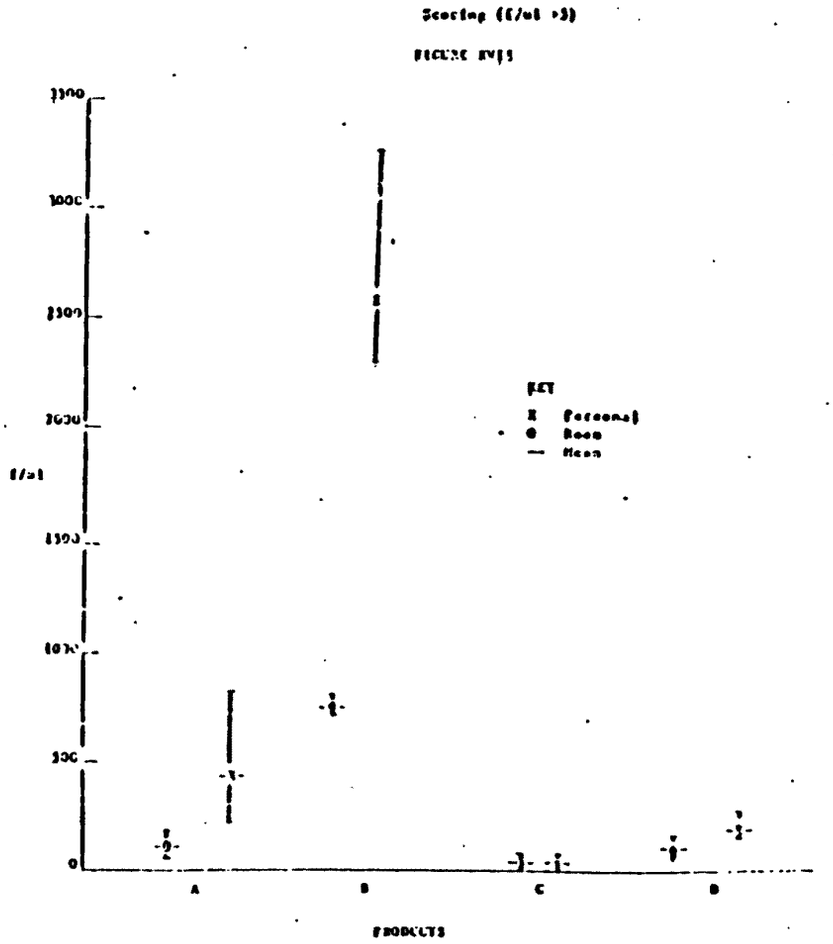
Scoring Results

Product	Scoring				
	Personal		Area		
	f/ml	f/ml(*)	f/ml	f/ml(**)	mg/m³
A	266.861 869.319 373.696 -11.643	231.822 826.799 316.058 276.626	201.760 44.317	191.757 41.611	83.656 61.[illegible]
Mean	489.733	412.276	123.038	[illegible]	[illegible]
Standard Deviation	266.832	243.386	97.177	92.119	36.267
B	2885.442 2747.998 2465.766 2568.609	2561.928 2225.928 2367.968 2262.135	744.638 845.131	722.167 801.220	52 391 263.282
Mean	2666.704	2529.740	794.885	761.694	158.837
Standard Deviation	416.198	444.835	49.714	59.919	151.[illegible]
C	52.608 67.230 59.789 35.839	50.283 61.593 66.[illegible] [illegible]	17.352 27.996	16.011 24.324	10.398 9[illegible]
Mean	53.111	62.624	22.781	21.149	12.282
Standard Deviation	13.504	14.777	7.353	7.295	5[illegible]
D	206.943 179.981 [illegible] 250.244	177.311 165.615 171.777 228.[illegible]	58.823 87.969	62.[illegible] 85.[illegible]	19.693 [illegible]
Mean	201.[illegible]	185.701	73.996	73.[illegible]	12.[illegible]
Standard Deviation	31.852	29.131	21.887	16.144	9.403

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Total Airborne Dust (Gravimetric) and Airborne Asbestos Fiber Concentrations: Scoring

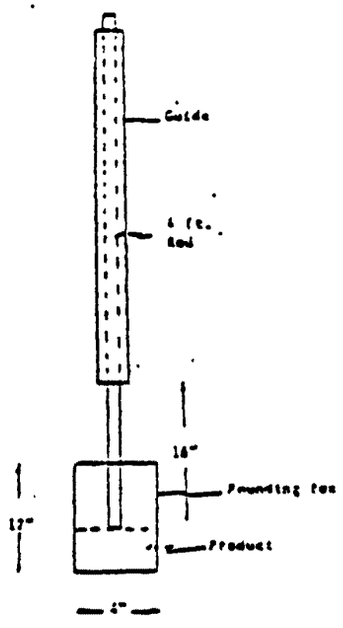
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IV. Pounding

A 4-inch section of insulation (recovered from the Bandsawing) was placed in a 4-inch wide by 9 1/2-inch long by 12-inch deep (internal dimensions) box, and a 4-foot long section of 1/2-inch (I.D.) iron pipe (weight 4 lb. 2 oz.) dropped through a guide section of 3-inch pipe a distance of 16 inches onto the rounded outer surface of the pipe covering. This drop was repeated 50 times, and then the pumps started and 5-minute air samples taken. The process was repeated twice more, using the same piece of pipe covering throughout for each product. As usual, background samples were taken with each product change. Figure XVIII shows this experimental arrangement; the locations of the air samples are shown in Figures III and IV, p. 6a.

FIGURE XVIII



Plan of Pounding Foot
And Rod Arrangement

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Results (Pounding)

Table 7 gives the results from this experiment, as do Fig
and XX.

Airborne Asbestos Fiber Concentrations and Total Airborn
Dust (Gravimetric) Concentrations from Pounding: All Produ

Table 7.

Pounding Results

Product	Samples			
	Leachate	Ca. 8mm Horizontal		
	mg/m³	mg/m³	f/ml	f/ml(>5)
A		1.050	2.106	2.[illegible]
		1.883	7.[illegible]	7.[illegible]
		2.354	6.267	6.[illegible]
		1.686	7.141	10.391
		2.349	9.869	2.[illegible]
		36.925	4.956	5.[illegible]
	2.650	------	2.416	3.[illegible]
	6.617	1.662	9.731	10.132
	2.650	3.054	5.415	5.[illegible]
Mean	3.972	5.407	5.415	5.[illegible]
Standard Deviation	1.020	11.677	2.470	3.[illegible]
B		------	60.840	67.615
		0.295	29.640	31.647
		1.001	35.617	37.647
		0.662	67.253	69.[illegible]
		0.643	26.[illegible]	28.717
		2.[illegible]	25.[illegible]	27.617
	2.320	0.295	64.836	69.635
	2.320	2.615	32.819	36.255
	10.708	------	31.[illegible]	35.[illegible]
Mean	3.369	1.[illegible]	3.[illegible]	12.[illegible]
Standard Deviation	1.731	3.[illegible]	4.[illegible]	4.[illegible]
C		0.298	0.825	1.[illegible]
		2.298	1.[illegible]	2.[illegible]
		0.656	1.276	1.612
		4.635	2.627	2.[illegible]
		0.220	1.952	2.164
		1.626	2.366	2.629
	4.283	1.626	1.141	1.581
	1.285	0.953	1.557	1.[illegible]
	4.497	0.953	1.[illegible]	1.[illegible]
Mean	1.355	1.[illegible]	1.[illegible]	1.[illegible]
Standard Deviation	1.794	1.624	0.581	0.529
D		0.157	3.[illegible]	3.[illegible]
		5.811	2.216	2.168
		6.871	3.[illegible]	3.[illegible]
		5.106	4.510	6.[illegible]
		4.832	2.673	2.663
		7.564	3.[illegible]	3.744
	3.641	6.518	5.229	5.634
	1.371	6.144	2.[illegible]	2.[illegible]
	0.643	0.334	3.[illegible]	3.[illegible]
Mean	1.952	4.[illegible]	3.[illegible]	3.[illegible]
Standard Deviation	1.535	2.721	1.627	1.180

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Results (Pounding)

Table 7 gives the results from this experiment, as do Figures XIX and XX.

Airborne Asbestos Fiber Concentrations and Total Airborne Dust (Gravimetric) Concentrations from Pounding: All Products.

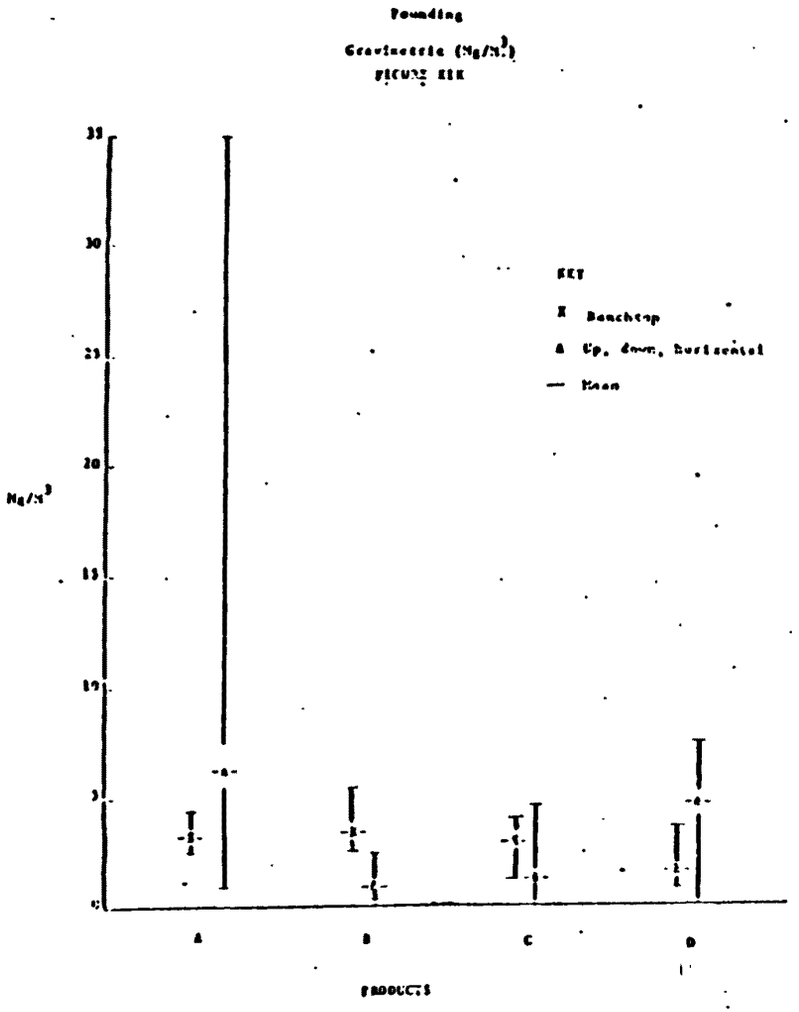
Table 7.

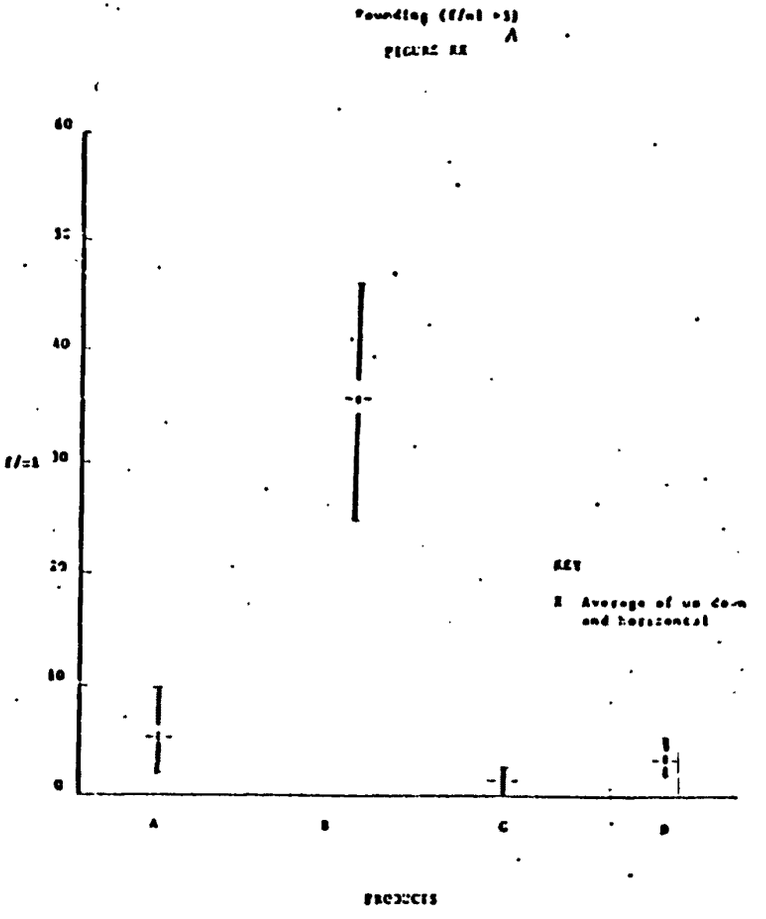
Pounding Results

Product	Samples			
	Gravimetric	Gr. 3mm. Impingement		
	mg/m³	mg/m³	f/ml	f/million
A		1.080	2.104	2.614
		1.883	7.[illegible]	7.987
		2.354	6.267	6.[illegible]
		1.406	2.141	10.[illegible]
		2.349	9.269	2.893
		34.925	6.[illegible]	3.[illegible]
	2.656	———	2.[illegible]	3.[illegible]
	4.617	1.442	9.[illegible]	10.152
	2.650	3.054	5.[illegible]	[illegible]
Mean	3.[illegible]	4.[illegible]	[illegible]	[illegible]
Standard Deviation	1.020	11.677	2.[illegible]	3.[illegible]
B		———	60.[illegible]	67.[illegible]
		0.[illegible]	29.[illegible]	31.[illegible]
		1.[illegible]	35.[illegible]	37.[illegible]
		0.443	67.[illegible]	69.[illegible]
		0.443	26.[illegible]	28.[illegible]
		2.[illegible]	25.[illegible]	27.[illegible]
	9.579	0.[illegible]	64.[illegible]	69.[illegible]
	2.570	1.615	32.[illegible]	36.[illegible]
	10.[illegible]	———	[illegible]	[illegible]
Mean	3.[illegible]	1.[illegible]	[illegible]	[illegible]
Standard Deviation	[illegible]	3.[illegible]	[illegible]	[illegible]
C		0.[illegible]	0.[illegible]	1.[illegible]
		2.[illegible]	1.[illegible]	2.[illegible]
		0.[illegible]	1.[illegible]	1.[illegible]
		4.[illegible]	2.[illegible]	2.[illegible]
		0.[illegible]	1.[illegible]	2.[illegible]
		1.[illegible]	2.[illegible]	2.[illegible]
	4.283	1.[illegible]	1.[illegible]	1.[illegible]
	1.[illegible]	0.[illegible]	1.[illegible]	1.[illegible]
	4.[illegible]	0.[illegible]	1.[illegible]	1.[illegible]
Mean	3.[illegible]	1.[illegible]	[illegible]	[illegible]
Standard Deviation	1.[illegible]	1.[illegible]	0.[illegible]	0.[illegible]
B		0.[illegible]	3.[illegible]	3.[illegible]
		5.[illegible]	2.[illegible]	2.[illegible]
		6.[illegible]	3.[illegible]	3.[illegible]
		5.[illegible]	4.[illegible]	4.[illegible]
		6.[illegible]	2.[illegible]	2.[illegible]
		7.[illegible]	2.[illegible]	2.[illegible]
	3.[illegible]	6.[illegible]	3.[illegible]	5.[illegible]
	1.[illegible]	6.[illegible]	2.[illegible]	2.[illegible]
	0.[illegible]	0.[illegible]	3.[illegible]	3.[illegible]
Mean	3.[illegible]	[illegible]	[illegible]	[illegible]
Standard Deviation	1.[illegible]	2.[illegible]	1.[illegible]	1.180

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Total Airborne Dust (Gravimetric) and Airborne Asbestos Fiber Concentrations: Pounding

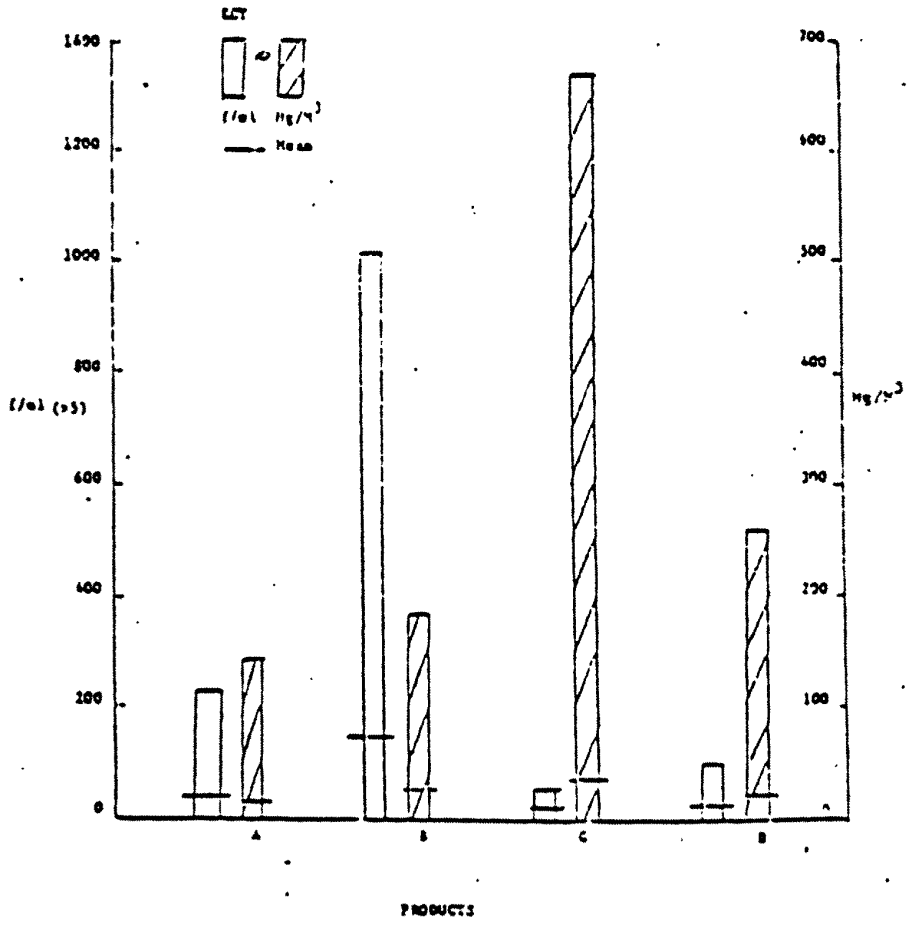
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f Res ts

...ear from the foregoing results that Product B produces ...ly more airborne asbestos fibers from similar manipulations of the other products. This is shown by Figure XXI, where ...s and means of all results (except those from the scoring) have ...cumulated.

Accumulated Ranges and Means
for all samples (except scoring)

FIGURE XXI



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One question which has not yet been answered is: "What are the sizes of the airborne asbestos fibers produced from these products?" Answer to this question is provided by an examination of the diameters of the asbestos fibers counted on the Personal filter samples for all products, (for the hand-sawing portion of the pipe-covering operation) in Table 8.

Table 8

Asbestos Fiber Diameters from Personal Samples

Product	50% less than (geometric mean)	90% less than	geometric standard deviation
A	1.45 µm	2.8 µm	1.66
B	1.7 µm	3.0 µm	1.59
C	1.6 µm	3.0 µm	1.60
D	1.6 µm	2.9 µm	1.56

Another concern which arises from an examination of the data is with the total gravimetric concentrations of airborne particulate matter which were measured. In many cases, these were orders of magnitude above the proposed Threshold Limit Value of 10 mg/m^3 for inert dusts. This indicates that, even if these products contained no asbestos, their use in enclosed spaces similar to our test chamber would produce concentrations of airborne dust which would be unacceptable. Analysis of the "respirability" of these dust concentrations (from the comparison of the Elutriator samples with other samples) is proceeding and will be the subject of future publications.

It must be understood at this point that the results of this study are

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subject to several qualifications. Perhaps the most important of these is that exposures of workers in the actual application and manipulation these materials would often be different than those found here. Higher concentrations would be postulated if several men were working within an enclosed space, or if the available space was more confined. More likel actual concentrations (as we have measured in many diverse job situation would be lower due to slower pace of the work, natural ventilation, or greater space available for dilution.

Another qualification is that the Pounding and Scoring operations performed here are not strictly comparable to actual trade practices. T pounding operation was (in essence) a destructive test; most application would not be accompanied by repetitive blows concentrated on a small are of the surface of a product. However, (desnite the fact that this is considered a poor trade practice) some insulators will not consider an installation complete on a large vessel until they have thoroughly pound the applied insulation material, raising clouds of visible dust.

Scoring is ordinarily done to facilitate "bending" of flat blocks of insulation to fit a curved surface. Product D is not supplied in fla blocks, and it is therefore unlikely that scoring will be done to this product. But mechanization is proceeding in this trade (as in others) and the use of power saws of various sorts is becoming more common for tasks which have traditionally been done by hand.

A third important qualification affecting the application of the results found here is due to our sampling method. None of the data are

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to be able (within reasonable bounds of certainty) to predict airborne asbestos fiber production from given operations on specific products. This prediction would arise from consideration of such factors as density, relative strength of the bonds between the asbestos fibers and the matrix, resistance to specific kinds of applied forces, and others.

From a practical point of view, it is clear that none of these products should be used without industrial hygiene control. Any cutting operation should be accompanied by controls on the dust arising from that operation, preferably controls (such as local exhaust ventilation) which would prevent the dissemination of dust into the breathing zone of the workman doing the cutting, or the breathing zones of those working near him. Where this cannot be done, personal respiratory protection is a poor (but necessary) second choice.

Conclusions

1. A method by which construction materials can be tested for their potential for airborne dust generation has been developed.

2. Four insulation materials containing asbestos have been tested using the method; the material containing the highest percentage of asbestos produced the highest concentrations of airborne asbestos fibers under conditions of the test.

3. Measurement of the total airborne dust concentration is a "poor" indicator of the airborne asbestos fiber concentration.

4. Comminution (by hand or mechanical methods) of any of these products within confined spaces may result in airborne asbestos fiber

Tebbens, Balzer, Cooper and Tabershaw, Dust-Producing Potential of Construction Materials (1970) Published by AsbestosClaims.Law
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concentrations orders of magnitude greater than the proposed ceiling value of the Threshold Limit Value.

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