HASKELL LABORATORY MEDICAL RESEARCH PROJECT MR-1311

Dustiness of Thermal Insulating Materials

Introduction

The study which is reported herein is part of a study initiated by the Thermal Insulation Group of the Engineering Services Division.

Purpose

The purpose of the study was to attempt to devise a means of measuring the comparative dustiness of several competitive insulating materials in relation to the risk of injury to health during their installation, use, removal, and disposal.

The health risk in working with thermal insulating materials consists of the danger of contracting lung disease from excessive inhalation of fine dust, including, in particular, asbestos fibers. The magnitude of the danger is dependent upon (a) the amount of dust inhaled, (b) its particle size, and (c) the composition of the crystalline particles or fibers. Glossy, non-crystalline particles and fibers have not been implicated in producing lung disease.

In this study we attempted to compare the amounts of dust generated from each of the test materials when subjected to mechanical energy in a repeatable, reproducible manner, to examine the relative amounts of coarse and fine particles, (roughly the irrespirable and the respirable) and to examine the crystallinity of the fine dust by x-ray diffraction.

Methods

The tests were carried out at the Engineering Test Center by Engineering Department personnel jointly with Haskell Laboratory personnel. They were done in a small, closed room at the Center in which there was a minimum of air movement.

The thermal insulating materials that were chosen for entry into the comparative series were furnished by the Engineering Service Division. They were in the form of slabs, 2 inches thick. Mechanical energy was applied to the slab by making a series of 18-inch cuts with a circular table saw operating at a fixed speed. The cuts were timed and the times were held constant for all of the materials. The sequence that was followed in making the cuts and in collecting samples of airborne dust is presented in Appendix A.

Sampling Equipment.

Three series of samples of airborne dust were collected simutaneously during the sawing and another three series were collected after the dust had had time to settle out of the air. The first series consisted of a sample collected by drawing air through a millipore membrane filter (0.8 micron pore size) by means of a Unico® Telmatic Air Sampler; a second series was collected by drawing air through a similar filter by means of a small battery operated personal sampler of the type that has been in use in the construction division for the past couple of years. The third series of samples was collected by means of the Unico® 550 Turbinjet High Volume Air Sampler. It pulled the air first through a Model 240 Cyclone Separator. The fine fraction of dust passed through the cyclone and was deposited on Whatman No. 41 filter paper. In Appendix A, the high volume sampler is referred to as Hi-Vol and the millipore filter sampler is referred to as M. F.

Fiber Counts.

The millipore filters from both the Telmatic samplers and the construction division samplers were used for counting fibers according to the method currently in use by the U. S. Public Health Service. This is a count with a 430 x magnification, using phase contrast illumination and counting all fibers greater than 5 microns in length.

Weight Determinations.

The cyclone separators were each weighed before and after dust collection and the difference was recorded as the weight of coarse dust. Each of the Whatman filter papers was weighed before and after collection and the difference was recorded as fine dust.

X-Ray Diffraction.

The filter papers on which had been deposited the fine dust were submitted to the Chemical Physics Department, Carnegie-Mellon University, for identification of the minerals by means of x-ray diffraction.

Statement of Results

Fiber Counts.

The results of fiber counts are presented in Table 1. In this table the designation C after the Roman numeral identification of each material refers to the sample collected by the use of the construction division sampling equipment. The fiber counts that were obtained from the millipore filter used with the Telmatic sampler during sawing are presented in Figure 1. Figure 2 gives the results obtained from the millipore filter samples collected with the Telmatic sampler after settling. Figures 3 and 4 present graphically the counts obtained from the millipore filter samples collected by use of the construction division sampling equipment during sawing and after settling respectively.

Weight Determinations.

In Table 2 are presented the results of the weighings of the cyclone separators and the filter papers with the calculated ratio of the coarse to the fine fractions. The ratios are plotted graphically in Figure 5 and Figure 6 representing the ratios during sawing and after settling respectively.

It will be noted that air volumes were not equal for all of the samples collected. It was satisfactory to calculate ratios of coarse to fine fractions with the weights that were actually obtained, but in order to make a meaningful comparison of the quantity of the fine dust generated by the sawing per unit volume of air, it became necessary to adjust the weights of the fine fractions to an equal air volume for all samples. The results are given in Tables 3 and 4 and they are plotted graphically in Figures 7 and 8.

Results of X-Ray Diffraction Analysis.

The fine fractions of dust that were deposited on Whatman 41 filter paper after passage thru the cyclone separator were submitted for analysis by means of the Debye-Scherrer technique. The results are presented in Appendix B.

It will be noted that with each material the composition as seen by x-ray diffraction remains the same for the fraction collected during sawing and that collected after settling. This rules out any selective settling of components of the mixture on a scale sufficient to influence the health effects of inhaled particles before and after settling.

The finding with respect to Unibestos is clear-cut. It consists of amosite asbestos.

In the group represented by Calsilite SS, Super-Caltemp, and Thermasil; and in the group consisting of Kaylo 20, the report states a possibility of the presence of either amosite or crocidolite. This question should be settled by reference to the suppliers because crocidolite would be less desirable from the health standpoint. There are reports of disease having occurred from relatively brief exposures in contrast to the slowly developing effects from long exposure in the case of the other asbestos forms.

If crocidolite is absent, the groups containing Calsilite SS, Super-Caltemp, Thermasil, and also Kaylo 10 STS and JM Silicated Thermobestos are about equal with respect to composition: they are all mainly a non-asbestos mineral (tobermorite) and about 10 per cent of an asbestos. Minerals like tobermorite are classed among the "inert" or nuisance particulates with respect to health effects, e.g., Portland Cement.

Kaylo 20 was found to contain a higher asbestos content, and also an unidentified crystalline material.

Comparison of Materials.

Table 5 presents a conditional ranking of the subject materials based strictly upon the numerical results of fiber counts, weights of fine fractions and the ratios of coarse to fine fractions for each material.

This classification, even when combined with the composition data, gives no clear-cut indication of superiority.

It may be reasoned that Kaylo 10 STS and JM Silicated Thermobestos, both of which have low asbestos content, performed remarkably well with respect to numbers of countable fibers and favorable weights of fines and ratios of coarse to fine.

The I&B Material and the Unibestos gave comparatively high fiber counts but were lowest in weight of fines and extremely favorable in ratio of coarse to fine fractions. It should be remembered that the fiber counts were made on whole airborne samples collected on membrane filters without prior size-separation. The I&B Material and Unibestos are apparently high in content of fibers that are countable by optics and by definition, but, when subjected to aerodynamic size separation, the dust cloud from both materials yielded extremely low weight of fines. Unibestos is less desirable on the basis of asbestos content.

Calsilite SS, Super-Caltemp, and Thermasil behaved in a similar range of performance with respect to fiber counts and weights of fine fractions. A strong point in their favor is the low asbestos content (unless it should be crocidolite).

Kaylo 20 is a favorable material with respect to fiber counts and weights of fines. More information should be sought on its asbestos content before passing judgment.

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December 14, 1970

TABLE 1

RESULTS OF FIBER COUNTS

No.	Material	10^6 Fibers $> 5\ \mu$ per Filter	Air Volume (ml)	Fibers $> 5\ \mu$ per ml
I	Unibestos	17.1	14,400	1180
I-C	Unibestos	11.8	10,400	1130
II	Unibestos	4.9	---	---
II-C	Unibestos	6.1	13,000	470
III	Thermasil	2.4	21,600	111
III-C	Thermasil	2.5	10,400	240
IV	Thermasil	2.5	24,000	104
IV-C	Thermasil	1.0	14,000	72
V	Kaylo 10 STS	1.1	22,400	49
V-C	Kaylo 10 STS	1.6	10,400	154
VIII	Kaylo 10 STS	1.0	28,000	36
VIII-C	Kaylo 10 STS	0.71	13,000	55
IX	Kaylo 20	9.5	22,400	424
IX-C	Kaylo 20	5.3	10,400	510
X	Kaylo 20	6.9	28,000	246
X-C	Kaylo 20	3.6	13,000	277
XI	JM Silicated Thermobestos	1.3	22,400	58
XI-C	JM Silicated Thermobestos	0.41	10,400	40
XII	JM Silicated Thermobestos	1.2	28,000	43
XII-C	JM Silicated Thermobestos	0.46	13,000	35
XIII	Calsilite SS	17.5	22,400	780

TABLE 1 (CONT'D)

RESULTS OF FIBER COUNTS (CONT'D)

No.	Material	10^6 Fibers > 5 μ per Filter	Air Volume (ml)	Fibers > 5 μ per ml
XIII-C	Calsilite SS	12.3	10,400	1180
XIV	Calsilite SS*	7.9	28,000	282
XIV-C	Calsilite SS*	3.7	13,000	284
XVII	Super-Caltemp	23.1	22,400	1030
XVII-C	Super-Caltemp	23.3	10,400	2330
XVIII	Super-Caltemp	30.5	28,000	1088
XVIII-C	Super-Caltemp	7.5	13,000	577
XIX	Unibestos	**	22,400	**
XIX-C	Unibestos	61	10,400	5870
XX	Unibestos	77.7	28,000	2780
XX-C	Unibestos	10.7	14,500	740
XXI	Thermasil	34.7	22,400	1550
XXI-C	Thermasil	12.3	10,400	1180
XXII	Thermasil	10.2	28,000	366
XXII-C	Thermasil	4.0	13,000	307
XXIII	Calsilite SS	42.0	22,400	1870
XXIII-C	Calsilite SS	4.4	12,000	367
XXIV	Calsilite SS	11.4	28,000	408
XXIV-C	Calsilite SS	3.7	14,500	255
XXV	I&B Material 1185-31,32,33	44.1	22,400	1960
XXV-C	I&B Material 1185-31,32,33	24.4	10,400	2440

* There was a 4-minute delay in start.

** Reported too dense to count.

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TABLE 1 (CONT'D)

RESULTS OF FIBER COUNTS (CONT'D)

No.	Material	10^6 Fibers > 5 µ per Filter	Air Volume (ml)	Fibers > 5 µ per ml
XXVI	I&B Material 1185-31,32,33	10.9	28,000	390
XXVI-C	I&B Material 1185-31,32,33	6.8	13,000	523

TABLE 2

SIZE SEPARATED SAMPLES

(Unico Cyclone - Whatman 41 Paper)

	During Sawing				After Settling			
		Wt.Coarse gm	Wt.Fines gm	Ratio Coarse/Fine		Wt.Coarse gm	Wt.Fines gm	Ratio Coarse/Fine
Unibestos	XIX	0.0890	0.0484	1.8388	XX	0.0426	0.0186	2.2903
Thermasil	XXI	.0432	.0773	.5589	XXII	.0196	.0309	.6343
Kaylo 10 STS	V	.0548	0.0993	0.5519	VIII	0.0438	0.0274	1.5985
Kaylo 20	IX	.0211	.0388	.5438	X	.0056	.0003 (1)	18.66 (1)
JM Silicated Thermobestos	XI	.0922	.0701	1.315	XII	.0468	.0367	1.275
Calsilite SS	XIII	.0444	.1235	.3595	XIV	.0135	.0282	0.4787
	XXIII	.0490	.0930	.5269	XXIV	.0151	.0476	0.3172
Super-Caltemp	XVII	.0449	.1103	.4021	XVIII	.0134	.0459	.2919
I&B Material	XXV	.0872	.0142	6.1408	XXVI	.0161	.0024	6.7083

(1) Apparently anomalous.

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TABLE 3

DUST WEIGHTS, SIZE SEPARATED SAMPLES

(Unico Cyclone - Whatman 41 Paper)

Adjustment of weights of fine fractions for equal air volumes.

A. During Sawing

Average air volume for all samples: 70.9 ft^3

Material	Sample No.	Air Vol. (ft^3)	Wt. Fines (gm)	Equivalent Wt. Fines
Kaylo 10 STS	V	71.36	0.0993	0.0986
Kaylo 20	IX	78.72	.0388	0.0350
JM Silicated Thermobestos	XI	69.28	.0701	.0716
Calsilite SS	XIII	61.60	.1235	.1420
Super-Caltemp	XVII	67.28	.1103	.1160
Unibestos	XIX	79.20	.0484	.0433
Thermasil	XXI	67.28	.0773	.0814
Calsilite SS	XXIII	64.16	.0930	.1025
I&B Material	XXV	79.20	.0142	.0127

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TABLE 4

DUST WEIGHTS, SIZE SEPARATED SAMPLES

(Unico Cyclone - Whatman 41 Paper)

Adjustment of weights of fine fractions for equal air volumes.

B. After Settling

Average air volume for all samples: 98 ft^3

Material	Sample No.	Air Vol. (ft^3)	Wt. Fines (gm)	Equivalent Wt. Fines (gm)
Kaylo 10 STS	VIII	98.5	0.0274	0.02725
Kaylo 20	X	99	0.0003*	
JM Silicated Thermobestos	XII	96.5	.0367	.0372
Calsilite SS	XIV	99	.0282	.0279
Super-Caltemp	XVIII	99	.0459	.0454
Unibestos	XX	99	.0186	.0184
Thermasil	XXII	95.4	.0309	.0137
Calsilite SS	XXIV	96.5	.0476	.0483
I&B Material 1185-31,32,33	XXVI	99	.0024	.0024

* Apparently anomalous. Not to be plotted.

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TABLE 5

CONDITIONAL RANKING OF MATERIALS

	Fiber Counts Telmatic Sampler		Fiber Counts Construction Sampler		Weights Fine Fractions		Ratios of Weights Coarse to Fine	
	During Sawing	After Settling	During Sawing	After Settling	During Sawing	After Settling	During Sawing	After Settling
BEST	Kaylo 10 STS	Kaylo 10 STS	JM Sil. Thermo.	JM Sil. Thermo.	I&B Material	I&B Material	I&B Material	I&B Material
	JM Sil. Thermo.	JM Sil. Thermo.	Kaylo 10 STS	Kaylo 10 STS	Kaylo 20	Uni-bestos	Uni-bestos	Uni-bestos
	Kaylo 20	Kaylo 20	Calsilite SS	Calsilite SS	Uni-bestos		JM Sil. Thermo.	
	Calsilite SS	Calsilite SS	Kaylo 20	Kaylo 20	JM Sil. Thermo.	Kaylo 10 STS	Therma-sil	Kaylo 10 STS
	Super-Caltemp	Therma-sil	Therma-sil	Therma-sil	Therma-sil	Therma-sil	Kalo 10 STS	JM Sil. Thermo.
	Therma-sil	I&B Material	Super-Caltemp	I&B Material	Kaylo 10 STS	JM Sil. Thermo.	Kaylo 20	Therma-sil
WORST	I&B Material	Super-Caltemp	I&B Material	Super-Caltemp	Super-Caltemp	Super-Caltemp	Calsilite SS	Calsilite SS
	Uni-bestos	Uni-bestos	Uni-bestos	Uni-bestos	Calcilite SS	Calcilite SS	Super-Caltemp	Super-Caltemp