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A COMPARISON OF MASS AND FIBRE CONCENTRATIONS OF ASBESTOS DUST IN SHIPYARD INSULATION PROCESSES

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Abstract—Measurements have been made of the mass and fibre concentrations of dust produced during shipyard processes involving asbestos insulating materials. Comparison of the results of measuring total dust, 'respirable' dust and fibre concentration show that gravimetric measurements are not suitable for environmental monitoring in Naval Dockyards. The membrane filter technique for estimating fibre concentration is recommended for that purpose.

THE APPLICATION and removal of insulating materials containing asbestos during shipbuilding and refitting are both associated with potentially hazardous concentrations of asbestos dust. British Naval Dockyards now use a standard method of monitoring asbestos dust which is based on the membrane filter technique described by HOLMES (1965).

The membrane filter method enables asbestos fibres between 5–100 μm long and with length to breadth ratio of at least 3 : 1 to be counted. The sampling techniques involved in this method are relatively simple, and air may be drawn through the membrane filters for long periods using mechanical pumps. Short period samples may be taken with a suitable hand pump. The methods of fixing the deposit, clearing the opaque membrane, and counting the sample require the services of skilled technicians and they are tedious and time-consuming.

Methods for measuring the mass concentration of dust in air are simpler and quicker and are obviously attractive for use in routine monitoring of dust levels. In order to see if mass concentration measurement would be a suitable method for monitoring the dust concentrations associated with asbestos processes in Naval Dockyards, it was decided to compare the results of such measurements with those obtained from membrane filter sampling as part of a survey of asbestos hazards in Devonport Dockyard (HARRIES 1970).

METHODS

Mass concentration

Six Casella type 113A MRE samplers fitted with horizontal elutriators were used for the gravimetric estimations. The elutriators are designed to allow only the 'respirable' fraction of the dust to reach the collecting filters. Three of the samplers were fitted with a by-pass for the elutriator in order to collect dust of all sizes (total dust). This study does not consider the problems caused by the fibrous nature of asbestos dust when using size selective samplers for gravimetric estimations. For the instruments used in this study the 'respirable' fraction of the dust is that defined by the Medical Research Council (HAMILTON and WALTON, 1961). The samples were collected on Whatman 5·5 cm GF/A glass fibre filters and weighed to 0·01 mg.

Fibre concentration

Hunt personal samplers (HUNT and ELLISON, 1963) were used to draw air through 20 mm millipore type GA membrane filters, pore size 0·45 μm held in Gelman aluminium sampling heads. The method of fixing the samples, clearing the membrane, and counting the deposit was that described by HOLMES (1965).

The samplers for total dust, 'respirable' dust, and the membrane filter samplers were placed side by side during different processes involving asbestos insulating materials, and run for the same periods of time.

RESULTS AND DISCUSSION

The dust concentrations associated with the removal of sprayed crocidolite asbestos, the removal of pipe lagging, and the application of pipe lagging are shown in Tables 1, 2 and 3. The relationships between the three dust indices are not sufficiently good for any one of them to be accurately derived from another.

There is some correlation between total and 'respirable' dust in the stripping procedures (Tables 1 and 2), but no such tendency is seen for the application of lagging (Table 3). For the stripping procedures the degree of correlation between total dust and fibre concentration, and between 'respirable' dust and fibre concentration is less than the relationship between total and 'respirable' dust. The gravimetric indices show very little relationship to fibre concentration in the application processes. There are very large variations in all three estimates of dust concentration for each type of process.

The results from the stripping procedures show that for a given respirable mass there are most fibres during the removal of sprayed crocidolite asbestos, less in the brick stowage space and least fibres in the engine and boiler rooms. These differences are probably explained by the nature and amount of the asbestos materials, the different methods of removing them and the size of the compartments.

The data on the application of lagging show much lower dust concentrations than found in the stripping procedures. There appears to be little change in fibre count with mass at these low concentrations, but some very low mass measurements in the engine room samples give a very wide range of fibre count. The consequence of this was to give an apparent negative correlation between mass and number, which is really artificial. The conclusion that may be drawn is that where there is little damage to insulating materials containing relatively small amounts of asbestos, then the fibre concentrations remain low. The stripping processes are much more vigorous, and the materials contain more asbestos, so that the fibre concentrations during these processes are very high.

The speed and simplicity of mass concentration measurement of dust in air, compared with the slow and tedious method of measuring fibre concentration, are two advantages which should be considered when deciding on the appropriate method of monitoring dust exposure of men working with asbestos. ROACH (1965) suggests that weighing 'respirable' dust is, in some instances, the best method of monitoring asbestos dust levels. This is probably true for manufacturing processes in which the asbestos content of the product is known and remains constant, and where the process is either continuous or repetitive. The processes involving asbestos in Naval Dockyards are varied, and the amount of asbestos in the insulating materials also varies, so that gravimetric estimation of dust levels are unlikely to be of much value unless it can be shown that for specified processes there are close correlations between mass and fibre concentrations.

The present study shows that there is some correlation between mass and fibre concentrations in those stripping processes with high dust levels, but that there is no correlation between the dust indices at low concentrations.

TABLE 1. DUST CONCENTRATIONS DURING REMOVAL OF SPRAYED CROCIDOLITE ASBESTOS

	Gravimetric samples mg/m^3		Fibres per cm/^{3}
	Total dust	Respirable dust	
	24·1	6·0	192
	17·8	7·2	160
	1·2	0·5	23
	22·1	8·2	213
	27·4	20·2	493
	10·1	2·9	117
	2·9	1·7	93
	27·7	13·2	371
	17·6	9·0	484
	21·7	3·3	58
	1·7	0·8	43
	23·9	3·3	61
	2·0	1·4	54
	9·7	3·0	210
	1·0	0·5	177
	1·2	0·5	57
	12·5	5·1	120
	37·4	18·4	311
	6·9	4·3	296
	15·5	6·8	412
	24·1	16·4	375
	23·0	15·7	384
	10·1	3·7	110
	45·4	23·9	343
	13·3	10·8	360
	49·7	20·1	366
Mean concentration	17·3	7·96	226·27
Standard deviation	13·08	6·98	146·08

Correlation coefficients; Total vs. fibres/cm^3 $r = 0·57$. Respirable vs. fibres/cm^3 $r = 0·778$. Total vs. respirable $r = 0·875$.

TABLE 2. DUST CONCENTRATIONS DURING REMOVAL OF PIPE LAGGING

Location	Gravimetric samples mg/m³ Total dust	Respirable dust	Fibres per cm³
Boiler rooms	7·60	3·21	24·7
	6·19	3·26	56·9
	13·54	3·13	68·0
	7·61	2·14	41·9
	46·69	16·21	152·2
	24·66	9·72	123·0
	4·14	1·85	66·5
	11·73	1·38	50·7
	9·80	3·61	186·4
	17·32	3·95	135·0
	5·06	2·17	61·5
	4·45	1·71	26·3
Mean concentration	13·23	4·36	82·76
Standard deviation	11·62	4·14	50·64
Engine rooms	0·61	0·35	25·0
	21·00	2·40	115·0
	9·58	0·81	7·0
	2·98	0·67	27·0
	1·96	1·37	84·0
Mean concentration	7·23	1·12	51·6
Standard deviation	7·54	0·72	40·9
Brick stowage space	38·59	25·57	309·0
	35·49	15·03	225·6
	35·66	14·34	337·1
	233·30	85·50	895·6
	264·30	100·00	331·0
Mean concentration	121·5	48·1	419·7
Standard deviation	104·4	36·97	241·3
All compartments			
Mean concentration	36·47	13·56	152·25
Standard deviation	68·53	25·93	190·26

Correlation coefficients; Total vs. fibre/cm³ $r = 0·789$. Respirable vs. fibres/cm³ $r = 0·797$
Total vs. respirable $r = 0·993$.

TABLE 3. DUST CONCENTRATIONS DURING THE APPLICATION OF PIPE LAGGING

Location	Gravimetric samples mg/m³ Total dust	Respirable dust	Fibres per cm³
	7·59	1·90	5·00
	2·83	0·95	9·00
	16·70	3·78	13·00
	10·67	3·20	11·00
	45·75	1·10	55·00
Boiler	8·37	3·45	4·00
rooms	10·94	4·19	41·00
	4·25	0·63	6·00
	4·05	4·78	12·00
	7·56	2·15	9·00
	0·52	0·26	0·13
	0·72	0·26	0·18
Mean concentration	9·99	2·22	13·77
Standard deviation	11·67	1·54	16·08
	2·76	1·02	3·00
	1·64	0·96	0·80
	2·42	1·11	0·80
	2·34	1·50	0·30
	8·50	0·62	0·10
	2·80	0·30	16·00
	15·54	0·39	0·10
	1·69	0·55	10·90
Engine	0·75	0·36	0·90
rooms	0·39	0·26	40·00
	0·45	0·39	9·00
	0·58	0·38	4·00
	1·59	0·38	29·00
	2·80	1·29	1·00
	4·87	1·06	2·00
	3·88	2·68	0·10
	4·79	1·07	0·10
Mean concentration	3·39	0·84	6·95
Standard deviation	3·62	0·59	11·14
	11·49	1·04	6·00
	26·62	2·32	6·70
	1·91	0·54	2·70
	3·52	0·64	2·90
	10·14	0·60	15·10
Accumulator	4·83	0·99	7·19
compartment	5·82	1·10	11·18
	2·25	0·53	6·40
	3·29	1·40	18·70
	1·86	0·65	0·10
	2·18	0·65	1·57
	1·19	0·52	2·30
Mean concentration	6·26	0·92	6·74
Standard deviation	6·91	0·50	5·44
	All compartments		
Mean concentration	6·17	1·27	8·88
Standard deviation	8·17	1·14	12·06

Correlation coefficients; Total vs. fibre/cm³ $r = 0{\cdot}507$. Respirable vs. fibres/cm³ $r =$ [illegible] Total vs. respirable $r = 0{\cdot}289$.

For practical purposes the processes associated with high dust concentrations are known, the workers are protected, and others are excluded from the work area, so that dust monitoring in Naval Dockyards is now concentrated on evaluating the safety of places adjoining the asbestos work area, or in places where little dust is thought to be produced. Gravimetric sampling is not a suitable method for this, and the measurement of choice remains the more difficult membrane filter method of estimating fibre concentration.

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