



Figure 1. Hand-Sawing of Prefabricated Asbestos Block Aboard Ship

Aboard ship the most common procedure was wiring contoured asbestos block to pipes. Prefabricated sections were tailored to fit bends by handsaw and knife (Fig. 1). The blocks were smoothed with cement containing 15 per cent asbestos and 85 per cent magnesia, and covered with asbestos cloth. Asbestos in fibrous form was stuffed into jackets and sewn around small pipes. Ventilation was provided by portable blowers on deck, but they were not always used.

Shop work included layout, cutting, sewing, asbestos cement mixing and fabrication of pads. In 1963, a ventilation exhaust trunk was installed over the four benches. Band-saw cutting, cement mixing and pattern cutting were dustier procedures but required less than 5 per cent of man-hours, and involved intermittent work by only a few men. Pattern cutting was done in a separate room by one man who wore a respirator.

The insulating materials were largely determined by United States Navy specifications. Amosite was

called for most frequently because of its low thermal conductivity, light weight and strength. Chrysotile was used to a lesser extent, and crocidolite was never used. Fiberglass, cotton, calcium silicate, magnesia, hair felt and other materials were also employed, either alone or mixed with asbestos.

AEROMETRIC ANALYSIS

Dust concentrations were determined in 1945 and again in 1965 and 1966, to coincide with these studies. The same konimeter was used according to the method of Kotze.⁵ All dust particles in a high-power field were counted for the total dust count. Particles with a length-to-diameter ratio greater than 3 were called fibers. Both dust and fiber concentrations were expressed in millions of particles per cubic foot of air (mppcf). Simultaneous total dust counts were made with a midjet impinger in 1965 according to the Public Health Service method.⁶

All counts were made at the worker's breathing level at all the usual sites during usual operating conditions. A time-weighted average dust exposure was calculated by multiplying the mean dust concentration at various sites by the average percentage of time spent by the workers at these sites. This was expressed in mppcf-years.

Results of dust counts with the midjet impinger — the instrument used in setting the threshold limit value of 5 mppcf — averaged 5.2 mppcf (Table 1). Konimeter counts, as always, were higher: in areas where over 98 per cent of the man-hours were spent the overall range was from 8.2 to 61.7 mppcf (Table 1). A weighted average, which considered the amount of time spent in these locations, as well as the number of samples taken during the three periods in 1945, 1965 and 1966, was 32.7 mppcf.

POPULATION STUDIES

There were 101 pipe coverers employed at the

Table 1 Dust Concentrations in Million Particles per Cubic Foot.

A. MIDJET IMPINGER (1965)*		AVERAGE CONCENTRATION (MPPCF)			
LOCATION					
Cutting room		5.7			
Sewing & fabrication bench		3.0			
Band-saw cutting		10.0			
Mixing mud		0.8			
Aboard ship (various)		7.2			
Weighted average		5.2			
B. KONIMETER		CONCENTRATIONS (MPPCF)		% FIBER	
LOCATION	YR	NO. OF SAMPLES	CONCENTRATIONS (MPPCF)		
Sewing & fabrication	1945	2	10.6-12.3	11.4	0.5-0.8
	1965	12	14.2-30.2	23.4	0.1-2.7
	1966	10	12.9-32.8	23.1	0.1-3.8
Aboard ship	1945	15	25.3-89.0	49.2	0.2-2.4
	1965	12	8.2-61.7	21.4	0.1-0.7
	1966	10	18.5-35.7	25.9	0.1-0.7

*Instrument used in setting threshold limit value of 5 mppcf.

**Simultaneous counts with Konimeter equaled 24.4 mppcf.

Yard in November, 1965. One hundred and one controls were selected from the 486 shipfitters and pipefitters employed at the time of the survey. To match them for age and duration of employment, cards with this information only were inspected in sequence, and the first worker whose age was within one year of a pipe coverer was selected provided he had spent approximately the same time at the Yard. All pipe coverers participated, but seven of the selected controls refused, leaving 94 individuals.

METHODS

Questionnaire

A questionnaire on respiratory symptoms⁷ was administered by one observer. It was adapted from that previously given extensive trials by Fletcher and others.⁸⁻¹⁰

Past History

The company medical records of all workers were examined for symptoms, signs and diagnostic impressions presumably related to cardiorespiratory disease.

Physical Examination

Physical examination was made by one physician with particular attention to breath sounds in each of eight locations. In 1966, tape recordings were made. Adventitious sounds were defined according to the nomenclature of Chamberlain.¹¹ To evaluate clubbing, a tracing of all fingers was made in the frontal and lateral projection. The hyponychial angle of the right index finger was measured according to Regan et al.,¹² and an angle of 196° or greater was considered indicative of clubbing.

Spirometry

Maximal forced expirations were recorded with a Stead-Wells spirometer, and peak flow with a Wright Peak Flow Meter. The order of tests was randomized. Five recordings were made, and the average of the last three was used to calculate the forced vital capacity (FVC), the volume expired in the first second (FEV₁) and the peak flow (PF). Methods of calibration and analysis were previously described¹³; normal predicted values derived from a population study of a New England town were used.¹⁴

Roentgenologic Examination

Posteroanterior and lateral views were examined independently by three radiologists after identification had been masked and the films had been randomly interspersed. Results were coded as follows: 1, no abnormality; 2, abnormality not consistent with asbestosis; 3, questionably consistent with asbestosis; 4, consistent with slight asbestosis; 5, consistent with moderately advanced asbestosis;

and 6, consistent with advanced asbestosis.* The reported results represent the combined readings of the three observers.

Prevalence of Other Disease

The prevalence of tuberculosis was assessed from the roentgenograms, skin testing and sputum culture. The criteria of Fletcher and Tinker¹⁶ were used to calculate the prevalence of nonspecific chronic obstructive lung disease. Simple and complex bronchitis was defined according to Reid et al.¹⁷

RESULTS

Description of the Populations

The control group, matched for age and duration of employment, was similar to the exposed group in color, height, weight, marital status and location of residence (Table 2). The majority of both groups had spent their lives in the general vicinity of the shipyard town. All were blue-collar workers who received hourly wages. The pipe coverers had been employed at the Yard for an average of 17.4 years, and the controls for 17.1 years.

With shipbuilding for defense, the work force varies with national crises. When not working at the Yard, members of both groups most commonly engaged in fishing, lumbering and general outdoor construction work. Cumulative years in dusty occupations other than pipe covering did not differ in the two groups. One pipe coverer had been a sandhog for five years, and one control had spent five years shoveling gravel. There were no exposures to material likely to cause pneumoconiosis in less than five years of exposure.

Respiratory Questionnaire

The significant differences in positive responses appear in Table 2. Smoking habits were similar: according to our classification,¹⁸ two thirds of both groups were "present smokers" (Table 2).

Physical Examination

Dry, crackling rales with a "close-to-the-ear" sound (cellophane rales) were a most striking finding in some pipe coverers. They could be clearly identified over background noise in the tape recordings, whereas occasional fine rales could not be distinguished. Such rales not only were significantly more common in the pipe coverers (Table 2) but also were heard more often in multiple sites. For example, they occurred in three or more sites in seven pipe coverers but never in the controls.

*Four years after these interpretations were made, a modification of the International Scheme for Classification of the Radiographic Appearance of Pneumoconioses was proposed that was believed to be suitable for interpretation of asbestosis.¹⁵ Our classification corresponds approximately as follows: "1", 0/0; "3", 0/1; "4", 1/0, 1/1 and 1/2; "5", 2/1, 2/2 and 2/3; and "6", 3/2, 3/3 and 3/4.