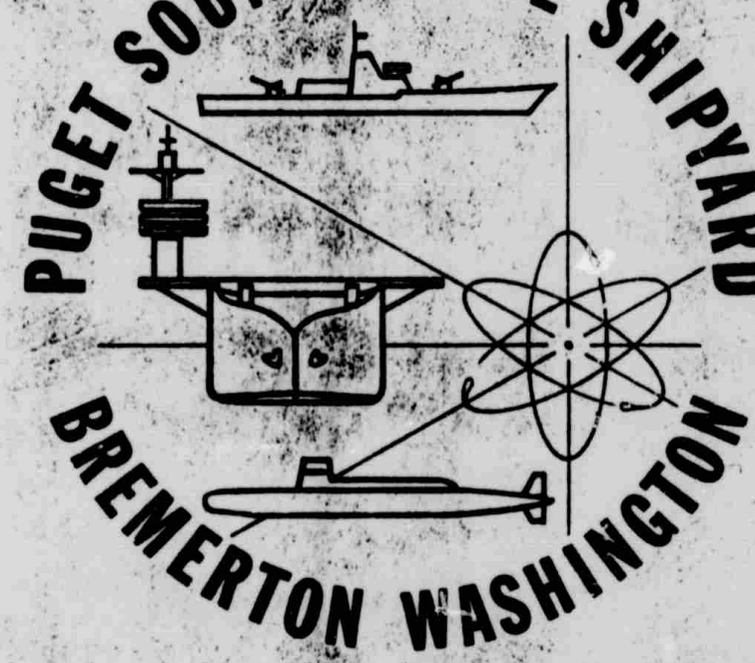
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# ASBESTOS EXPOSURE and CONTROL

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REVIEWED AND APPROVED March 1970

W. F. PETROVIC
Rear Admiral, USN
Commander

## A PREFACE

The complexity of the field of occupational health is ever increasing. In addition to the newer and more exotic health hazards, the older, more prosaic health hazards have a way of suddenly acquiring new dimensions with attendant re-emphasis on evaluation and control. The long-known hazard of asbestosis is one of the latter. Recent publicity has focused attention on the health-endangering proclivities of asbestos, particularly in the pipe covering and insulating trades.

E. W. McBRATNEY, M.D.
Medical Director


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# ASBESTOS EXPOSURE AND CONTROL AT PUGET SOUND NAVAL SHIPYARD

INDUSTRIAL HYGIENE DIVISION
MEDICAL DEPARTMENT
PUGET SOUND NAVAL SHIPYARD

C. A. MANGOLD, R. R. BECKETT, D. J. BESSMER

March 1970


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DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
WASHINGTON, D.C 20390

IN REPLY REFER TO
BUMED-732-SHB:snp
13 October 1969

From: Chief, Bureau of Medicine and Surgery
To: Commander, Puget Sound, Naval Shipyard, Bremerton, Washington 98314

Subj: Asbestos Control Measures at the Puget Sound Naval Shipyard

1. During a recent visit of LCDR S. H. Barboo, MSC, USN of the Industrial Hygiene and Safety Branch of this Bureau, it was favorably noted that the Puget Sound Naval Shipyard is conducting an excellent program for the control of asbestos dust exposures among Shipyard workers.

2. It is requested that approximately twelve large photographs of shop and ship asbestos dust control measures be furnished this Bureau for display purposes. The captioned photographs should be accompanied with a description of the exposure hazard and a narrative method of the control measures.

R. E. Faucett

R. E. Faucett
Assistant Chief for Research
and Military Medical Specialties

DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
WASHINGTON, D.C. 20390

IN REPLY REFER TO
BUMED-732-SHB:snp
10 December 1969

Mr. D. J. Bessmer
Head, Industrial Hygiene Division (Code 730)
Puget Sound Naval Shipyard
Bremerton, Washington 98314

Dear Dan:

I want to send you my special thanks for the eleven photographs of the asbestos control measures. They are now on grand display in our lobby of Building 7 of the Bureau of Medicine and Surgery.

Last week, while on a visit to the Pearl Harbor Naval Shipyard, I discussed your excellent asbestos control program with the Commanding Officer, Captain Barnhardt. I suggested that a member of the Industrial Hygiene Division and a member of the lagging shop visit your shipyard for the purposes of observing shop and shipboard control measures.

In the event that the Navy Industrial Hygiene Association offers papers on various aspects of Navy Industrial Hygiene, I think it would be well that Carl Mangold deliver a paper regarding asbestos control measures at Detroit in 1970.

Again, thanks for the photographs, and advise if I may retain them.

Sincerely,

Sam

S. H. BARBOO
LCDR, MSC, USN
Head, Industrial Hygiene and
Safety Branch

Copy to:
Alex Munton, PoNSY

The opinions expressed in this report are those of the authors and do not necessarily reflect those of the Department of the Navy, the Department of Defense, or any other official agency. Reference to a company or a product name does not imply approval or recommendation of the product to the exclusion of others that may be suitable.

Portions of this report were presented at the annual meeting of the Pacific Northwest Section of the American Industrial Hygiene Association at Richland, Washington on October 3 - 4, 1968.

ABSTRACT

A two and one-half year comparison of chest X-ray findings in the total work force of Puget Sound Naval Shipyard shows that 21% of the Pipe Coverers and Insulators handling asbestos have pulmonary abnormalities compared to 3.5% of the Boilermakers who have some exposure to asbestos and silica, and less than 1% of the Clerical workers with no known exposure to industrial dusts. Pulmonary abnormalities have remained high although evaluation of the asbestos dust exposure of Pipe Coverers and Insulators shows their time weighted exposures are below the current Threshold Limit Value of 5 million particles per cubic foot of air. The Threshold Limit Value may be too high and intermittent peak exposures may play a greater role than suspected. A number of engineering control methods and changes in work practices are suggested to reduce asbestos exposure.


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# PART I

# CLINICAL
# AND
# ENVIRONMENTAL
# FINDINGS


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## A. INTRODUCTION

The relationship between lung disease and exposure to asbestos dust has been known for many years. Numerous authors have described many cases of asbestosis among insulation workers with regular exposure to asbestos or asbestos containing materials(1,2,3).

In 1946, Fleisher(5) found three cases of asbestosis among insulation workers in east coast Navy yards, but since each of the three individuals had worked more than 20 years in the trade and asbestos dust levels were below the Threshold Limit Value, it was concluded that pipe covering was not a hazardous trade. This conclusion was accepted at face value for many years because air samples generally showed asbestos dust counts to be near or below the Threshold Limit Value of 5 mppcf(4), but this study evaluated only ship construction, or asbestos installation which produces less airborne asbestos dust than ripout. During the early 1950's when considerable ship modernization was being done in Naval Shipyards, extensive exposure to dust from ripped out asbestos took place. Marr(6) in 1964, evaluated the asbestos exposure to installation workers during ship overhaul (rip out and installation of asbestos materials), and concluded that shipboard pipe covering and insulating was a hazardous trade. Unfortunately, Marr's dust samples were collected with a Bausch & Lomb counter, and therefore the dust levels are not directly comparable to those used in establishing the Threshold Limit Value.

In general, current literature(7,8,9,10,11) indicates that asbestos dust is hazardous to health; that the Threshold Limit Value of 5 mppcf in air is too high; that the effects of asbestos dust exposure are chronic; and that better controls are necessary.

## B. COMPARATIVE CHEST X-RAY STUDY

A Naval shipyard encompasses a variety of industrial operations and provides a reasonably large population with a multiplicity of exposures for study. Puget Sound Naval Shipyard's occupational health program includes semiannual 14x17 inch chest x-rays on individuals involved in potentially lung-hazardous duties. In addition, a voluntary program of annual 70 mm chest x-rays includes almost all other personnel. Complete medical records are available for all employees. Prompted by Marr's work, in July 1965 a study was initiated to compare the incidence of lung abnormalities among various occupational groups in the Shipyard.

The study covered a two and one-half year period during which statistical analyses were made of all positive x-ray findings likely related to occupational causes. Specific diagnosis and degree of lung damage were not considered. However, the majority of the positive findings were classified by qualified physicians as pulmonary fibrosis. Results of this study are shown in Table I.

It is clear that pipe coverers and insulators and their closely associated work group, the boilermakers, have a significantly higher incidence of pulmonary abnormalities than other trade groups. Specifically, further attention was focused on the pipe coverers and insulators because of their exceptionally high rate of positive chest x-rays.

Table II shows the incidence of positive x-ray findings in pipe coverers and insulators by median age and years employed in the Shipyard. The apparent anomaly of higher median age and higher percent of positive x-ray findings in the 6-10 year employment group is due to a number of workers hired with previous employment and exposure to asbestos. A very high incidence of positive lung findings in pipe coverers and insulators with over 20 years exposure is noted. Balzer reports[13] a 25% incidence of asbestosis in insulators exposed 20 or more years.

The work histories of the 22 men with positive x-ray findings were reviewed to determine the lapsed time between first known exposure to asbestos and first observed x-ray changes. These data are presented in Table III.

It is probable that very short intervals between first exposure and observed chest x-ray findings indicate causes other than an occupational exposure to asbestos. Case number 7 was the only diagnosed case of asbestosis. This was confirmed by chest surgery. He was retired for disability and received compensation at a rate of three fourths pay for the rest of his life.

## C. ENVIRONMENTAL EVALUATIONS

The impinger has been used as a sampling device for asbestos dust at this Shipyard since the early 1940's, although it has some recognized limitations such as low collection efficiency. Accordingly, the midget impinger was chosen for this study so that data collected would be comparable to previous data and also comparable with the current Threshold Limit Value. The Threshold Limit Value was established on data collected by the Standard Procedure for Sampling and Counting Dust, adopted by the 5th annual meeting of the National Conference of Governmental Industrial Hygienists in 1942[14], which specifies impinger collection and light field microscopic counting methods.

The insulation materials described in Table IV are commonly used by most insulators at this Shipyard. The amosite and crysotile asbestos products are similar to those used by employees in other studies[6,12,13].

Airborne asbestos dust samples were collected aboard several ships of various sizes, ranging from destroyers to aircraft carriers, and in the shop complex. The dust sample data represents that dust found in an insulator's breathing zone. The results are summarized in Tables V, VI, and VII together with an estimate of the time spent on each type of operation. This estimate is for extended work periods as workers are assigned specific jobs which may take a few days or several months to complete.

Particle size distributions were determined for 20% of the samples counted. The geometric mean diameter did not exceed 2.3 microns for any sample. Many asbestos fibers were below the resolution limit of the light field microscope[11]. As was expected, the number of fibers in the sample was related to the type of material, fiber content and method of sampling.

Observation of work patterns indicates that most exposures occur during intermittent peak dust levels throughout the day. Figure 1 shows a time-exposure pattern for a typical operation.

## D. DISCUSSION

Lung changes are the possible effects of many factors which are not shown by our data. For example, knowledge of the smoking status of personnel would be of interest, as would positive diagnoses of the chest x-ray findings. However, we feel that these data show without doubt that we do have a problem with asbestos. The percentage of pipe coverers and insulators having positive x-ray findings are compared to other occupational groups is too outstanding to be without meaning, in spite of other possible contributing factors. Claims for compensation for asbestosis which have been paid after thorough investigation tend to confirm this concept. The data also show, as would be expected, that the number of positive findings increases with age and length of exposure.

The data presented in Tables V, VI, and VII indicate that the controls established at this Shipyard have been adequate to maintain asbestos dust exposures below the Threshold Limit Value, giving consideration to time weighting and asbestos content of materials. In most cases, the exposures have been below the proposed lowered Threshold Limit Value of two million particles per cubic foot of air[16]. In spite of this, pipe coverers and insulators display a high incidence of

pulmonary abnormalties detectable by X-ray even though most cases are not specifically diagnosed as asbestosis, but more often as pulmonary fibrosis, probably because diagnosis of asbestosis in the early stages is difficult.

Figure 1 shows that peak exposures considerably above the Threshold Limit Value frequently occur during the work day of a pipe coverer and insulator. It is reasonable that these peak exposures could be responsible for lung damage, even though the time-weighted exposure is within what has been considered to be safe limits. If the rate of lung clearance is less than the rate of arrival of dust, the rate of accumulation increases[15].

## E. CONCLUSIONS AND SUMMARY

A two and one-half year comparison of the chest X-ray findings of the working population of a Naval shipyard shows that about 21% of all the pipe coverers and insulators have positive X-ray findings compared to 3.5% for the boilermakers and about 1% or less for other occupations with no known asbestos exposure. A very high incidence of positive lung finding in pipe coverers and insulators with over 20 years exposure is evident.

Exposures depend on work habits, asbestos content of materials, type of job, and protection used. Considering time weighting factors and asbestos content of materials, pipe coverers and insulators received exposures below current and proposed Threshold Limit Values for asbestos dust. Peak exposures during the work day often exceeded Threshold Limit Values up to ten times.

The high incidence of pulmonary changes may be explained by:

a. Intermittent peak exposures which are of more importance than formerly recognized, based on the knowledge of lung loading characteristics.

b. Threshold Limit Values which are too high;

c. Methods of assessing exposures may not reflect the true airborne concentration of asbestos dust.

In general, workers handling, sawing, cutting or ripping-out asbestos materials produce considerable amounts of very fine asbestos fibers and particles in their breathing zone. The larger particles fall rapidly, but the tiny unseen particles between 0.1 and 100 microns average diameter remain suspended for hours. Particles of this size range enter the lung easily, and are trapped, where they provoke an

irritating and inflammatory reaction. The disabling pneumonoconiosis, asbestosis, is caused by prolonged exposure to fine asbestos dust. The amount of pulmonary fibrosis is proportional to the amount of dust breathed daily and the years of exposure. Exposure to low concentrations of asbestos dust does not necessarily imply that asbestosis will develop, so that careful control of the environment will reduce the probability of serious pulmonary effects.

The Threshold Limit Value refers to the airborne concentration of asbestos fiber or dust and represents conditions under which workers may be exposed daily without adverse effect, based on an eight-hour day and pathological evidence.

The TLV of 5 million particles per cubic foot of air was proposed in 1938, and adopted in 1942 by the American Conference of Governmental Industrial Hygienists, along with the impinger collection and light field microscopy techniques for evaluation. This value has remained until about 1968, a period of almost 30 years, until epidemiological evidence showed that perhaps the TLV was too high.

The notice of intended changes of the TLV's published in 1969 recommends lowering the allowable airborne concentration to 2 million particles per cubic foot counted by light field microscopy, or 12 fibers greater than 5 microns in length per milliliter of air when counted on filter membranes at 430X phase contrast magnification. Revisions under consideration by the American Conference of Governmental Industrial Hygienists would lower the TLV for asbestos to 5 fibers greater than 5 microns in length, per milliliter of air.

Recent studies compiled by the Bureau of Occupational Health and Safety, U.S. Department of Health, Education and Welfare, suggest that 20% of all deaths of asbestos workers is due to lung cancer, which is 7 times the expected rate in a normal population. Other researchers have suggested that cigarette smoking roughly doubles the risk of cancer in this work group.

The evidence in Part I of this report and the work of other researchers suggests that the Threshold Limit of 5 mppcf is too high, and supports lowering the values.

Lowering the TLV, and reduction of exposures of PC&I workers will require a sustained, detailed program of control. Otherwise, the threat of pulmonary abnormalities and asbestosis will remain high. The success will largely depend on how well the control measures suggested in Part II are applied.

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G. TABLES AND FIGURES


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TABLE I

INCIDENCE OF POSITIVE CHEST X-RAY FINDINGS IN OCCUPATIONAL GROUPS

| Occupational Group | No. of Persons In Group | No. With Pos. X-Ray Findings | Percent Having Pos. X-Ray Findings |
|---|---|---|---|
| Shipfitters | 890 | 6 | 0.7 |
| Sheetmetal Workers | 489 | 6 | 1.2 |
| Forge Workers | 32 | 0 | 0.0 |
| Welders | 998 | 11 | 1.1 |
| Machinists | 536 | 1 | 0.2 |
| Marine Machinists | 490 | 0 | 0.0 |
| Boilermakers | 115 | 4 | 3.5 |
| Electricians | 574 | 0 | 0.0 |
| Pipe Coverers & Insulators | 104 | 22 | 21.2 |
| Pipefitters | 765 | 6 | 0.8 |
| Shipwrights & Joiners | 228 | 0 | 0.0 |
| Electronics Mechanics | 280 | 0 | 0.0 |
| Painters | 263 | 4 | 1.5 |
| Riggers | 664 | 1 | 0.1 |
| Temporary Service Mechanics | 143 | 1 | 0.7 |
| Clerical Workers | 420 | 1 | 0.2 |


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TABLE II

INCIDENCE OF POSITIVE CHEST X-RAY FINDINGS IN PIPECOVERS & INSULATORS
VERSUS
YEARS OF EMPLOYMENT IN SHIPYARD

| Years Employed At Shipyard | Number Of Employees | Median Age | Number With Positive X-Rays | Percent Of Group | Percent Of Total Workers |
|---|---|---|---|---|---|
| 0-5 | 27 | 37 | 2 | 7 | 2 |
| 6-10 | 30 | 47 | 5 | 17 | 5 |
| 11-15 | 12 | 43 | 1 | 8 | 1 |
| 16-20 | 21 | 48 | 4 | 19 | 4 |
| 21-25 | 7 | 51 | 4 | 57 | 4 |
| 25+ | 7 | 56 | 6 | 86 | 6 |

The positive X-ray findings shown in Tables II and III reflect all reported abnormalities, and do not imply diagnosed asbestosis.

TABLE III

WORK HISTORY OF PIPE COVERERS & INSULATORS WITH POSITIVE CHEST X-RAY FINDINGS

| Case No. | Age When Hired | Year Hired | Years PC&I At Other Activity | Years PC&I At Shipyard | Years Total Employment As PC&I | Year Pos. Chest X-Ray First Recorded | Years Between First Exposure and First Positive X-Ray |
|---|---|---|---|---|---|---|---|
| 1 | 22 | 1933 | 0 | 33 | 33 | 1959 | 26 |
| 2 | 22 | 1933 | 0 | 33 | 33 | 1954 | 21 |
| 3 | 18 | 1936 | 0 | 30 | 30 | 1958 | 22 |
| 4 | 27 | 1939 | 0 | 27 | 27 | 1963 | 24 |
| 5 | 26 | 1941 | 0 | 25 | 25 | 1947 | 6 |
| 6 | 39 | 1941 | 0 | 25 | 25 | 1953 | 12 |
| 7 | 31 | 1942 | 8 | 17 | 25 | 1961 | 19 |
| 8 | 30 | 1944 | 2 | 22 | 24 | 1951 | 9 |
| 9 | 25 | 1945 | 0 | 21 | 21 | 1963 | 18 |
| 10 | 28 | 1947 | 0 | 20 | 20 | 1965 | 18 |
| 11 | 19 | 1947 | 0 | 20 | 20 | 1964 | 17 |
| 12 | 36 | 1951 | 2 | 15 | 17 | 1963 | 14 |
| 13 | 38 | 1952 | 0 | 14 | 14 | 1962 | 10 |
| 14 | 45 | 1952 | 2 | 14 | 16 | 1958 | 8 |
| 15 | 35 | 1953 | 5 | 13 | 18 | 1962 | 14 |
| 16 | 49 | 1960 | 3 | 6 | 9 | 1960 | 3 |
| 17 | 38 | 1958 | 2 | 8 | 10 | 1960 | 4 |
| 18 | 54 | 1961 | 6 | 5 | 11 | 1966 | 10 |
| 19 | 31 | 1961 | 0 | 5 | 5 | 1961 | 0 |
| 20 | 57 | 1961 | 10 | 5 | 15 | 1962 | 6 |
| 21 | 47 | 1963 | 0 | 3 | 3 | 1965 | 2 |
| 22 | 22 | 1965 | 0 | 1 | 1 | 1966 | 1 |

TABLE IV

ASBESTOS INSULATION MATERIALS

| | | |
|---|---|---|
| Amosite: | 95% long fiber asbestos | Used on piping, fittings, machinery units and large or irregular surfaces. |
| Magnesia block: | 15% asbestos, 85% magnesium carbonate | Used on tanks, boilers, valves, pipes |
| Asbestos cement: | | Several brands in common use: Usually contains 10-25% asbestos fibers and less than 30% cement. Used as a smooth finish over cloth or metal. |
| Unibestos: | | Fine asbestos fibers mixed with a waterproof adhesive. Used as a pipe insulation, very little installed at present. |
| Asbestos cloth: | | 80-95% crysotile or amosite fibers with cotton. Used for a covering over amosite or magnesia block on valves, piping, tanks and fittings. |

TABLE V

SHIP OVERHAUL

| Material and Operation | Airborne Dust Concentration In Breathing Zone (Million Particles per Cubic Foot) | | Percent of Time Exposed (Average) |
|---|---|---|---|
| | Range | Average | |
| **INSTALLATION** | | | |
| Asbestos cloth; cutting, fitting, glueing, and installing | 2.8-5.7 | 4.3 | 15% |
| Magnesia block; cutting, installing | 3.5-40.5 | 16.7 | 35% |

TABLE VI

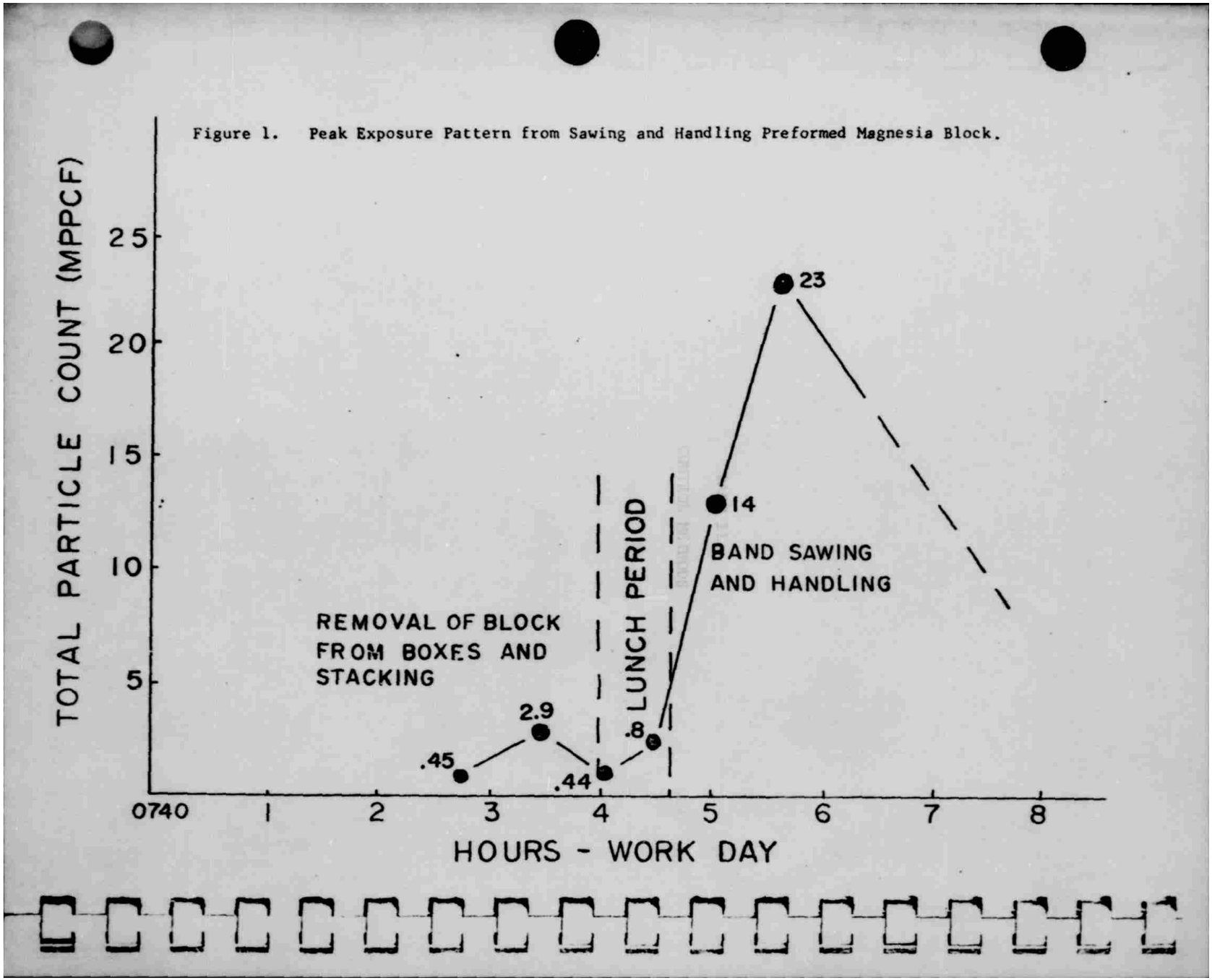
SHOP PREFABRICATION

| Material and Operation | Airborne Dust Concentration In Breathing Zone (Million Particles per Cubic Foot) | | Percent of Time Exposed (Average) |
|---|---|---|---|
| | Range | Average | |
| Magnesia block | 1.1-1.3 | 1.2 (cutting, glueing) | |
| Amosite | 0.4-4.7 | 2.4 (cutting, fitting, applying) | 67% |
| Asbestos cloth | 0.1-4.0 | 0.2 (cutting, fitting, sewing) | |
| Fibrous glass, rubber, cork | -- | - (cutting, fitting) | 33% |

TABLE VII

NEW SHIP CONSTRUCTION

| Material and Operation | Breathing Zone Dust Concentration (mppcf) | | Estimated Average Percent Time Exposed |
|---|---|---|---|
| | Range | Average | |
| Amosite: Installation | 2.6-8.9 | 5.6 | 10% |
| Magnesia block: :Cutting & installing | 2.4-13.3 | 6.1 | 39% |
| Asbestos cloth: Cutting, fitting, glueing | 3.1-4.6 | 3.6 | 20% |
| Asbestos cement: Mixing | 11.5-82.8 | 47.5 | 1% |
| Fibrous glass, rubber, cork: Cutting, fitting, installing | -- | -- | 30% |


Figure 1. Peak Exposure Pattern from Sawing and Handling Preformed Magnesia Block.
TOTAL PARTICLE COUNT (MPPCF)
25
20
15
10
5
23
14
BAND SAWING
AND HANDLING
REMOVAL OF BLOCK
FROM BOXES AND
STACKING
2.9
.8
.45
.44
LUNCH PERIOD
0740
1
2
3
4
5
6
7
8
HOURS - WORK DAY

# PART II

# CONTROL METHODS


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## A. INTRODUCTION

Even though some exposures to asbestos have been reduced over the past 20 years, exposures still appear too high based on results of studies shown in Part I, and leave no doubt that occupational exposures to asbestos materials cause injury.

A four point program was drafted to further reduce exposures.

First, a respirator program was initiated to immediately reduce exposures until other control methods could be developed.

Secondly, the work practices were examined to identify the most hazardous operations and to suggest alternate methods. For example, wetting of amosite materials reduced the airborne asbestos dust production 50 to 60%. The change of work practices gave the greatest promise for the reduction of airborne asbestos dust as an immediate engineering control, with minimum expenditures.

Thirdly, engineering controls which have a far reaching effect, but take longer to initiate are: (1) substitution of materials, (2) new methods, and (3) techniques of ventilation control.

Fourth, an educational program was initiated to help workers understand the potential hazards and the reasons why a change in approach to the control of asbestos was needed. This educational program was based on a survey of pipe coverers and insulators that revealed much misunderstanding regarding asbestos exposure and its effects.

Part II presents some of the methods employed to reduce airborne asbestos exposures. While it is by no means complete, it represents the opinions of the authors that control must follow:

a. Adequate respiratory protection;

b. Change of work practices and handling methods;

c. Engineering controls such as ventilation;

d. An educational program to retrain workers to use less dusty methods;

e. Substitution of less hazardous materials.

The ultimate goal is to reduce the exposure level to a point where workmen are no longer affected.




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B. RESPIRATORS AND PROTECTIVE CLOTHING

Respirators were first issued to pipe coverers and insulators at PSNS early in the 1950's, and were required in 1960. The emphasis waxed and waned until about 1967 when the Industrial Hygiene Division began urging strict compliance based on epidemiological data which showed that asbestos was still a serious occupational health problem.

In January 1968, dust respirators were made mandatory because a survey showed that 76% of the insulators did not use a respirator. About 50% of all insulators did not have a respirator in their possession.

Poor face fit, breathing resistance, and comfort were given as reasons for non-compliance, although enforcement was lax.

A laboratory program was started to find respirators suitable for long periods of wear. Of the tentbest dust respirators commercially available, four were selected that were U.S. Bureau of Mines approved and gave a good face fit, good visibility, and lowest breathing resistance. They were:

a. Mine Safety Appliance Company
MSA Dustfoe 66 (#10-76869)
Cushion Face Piece (#10-41501-N)
Dustfoe 66 Filter (#10-73056)--- Box of 50

b. American Optical Company
R-3030 Respirator with the R-30 "Red Devil" filter
for dusts and mists.
A/O Filter R-30

c. Safeline Respirator #5441
Safeline Filters #5905

d. Acme "Duo-Seal" Dust Respirators #8101-R
Dust Filter (Lambs wool) 8147 EW
Filter Holder 5021-R

Some of the rejected respirators failed the simple tests when used on the job. The respirators now supplied are largely accepted by the workmen and provide effective filtration of at least 90% of the airborne particles and fibers that are of the size most often trapped by the lungs (1 to 100 microns in size).

Even though usage is not 100%, the insulators usually wear the respirators during peak dusty conditions. This, alone, effectively reduces the peak intermittent exposures thought to play a large role in the development of asbestosis.

On 15 August 1969, a Naval Ship Systems Command Notice directed that protective coveralls would be worn by all employees engaged in shipboard rip-out of asbestos which produces high airborne dust levels. The coveralls were to be cleaned before each use in an attempt to limit personal clothing contamination. Coveralls were to be removed before removal of the respirator to limit exposure.

The Industrial Hygiene Division recommended disposable, plastic impregnated, paper coveralls with zippers, costing about $1.00 each, because they were cheap compared to procurement and laundry costs of cotton, twill, or duck coveralls. The plastic finish on the paper coveralls reduces the number of fiber penetrations and disposal of the garment aids dust control. In addition, packing, laundry, transportation, and re-distribution costs are eliminated. When the paper coveralls are taped at the sleeve and pant cuffs, the worker is essentially enclosed, yet the paper garments are permeable to air and do not trap body moisture.



Figure 1. Insulator shown wearing an approved respirator and disposable paper coveralls. The canvas or plastic refuse bag is conveniently located.


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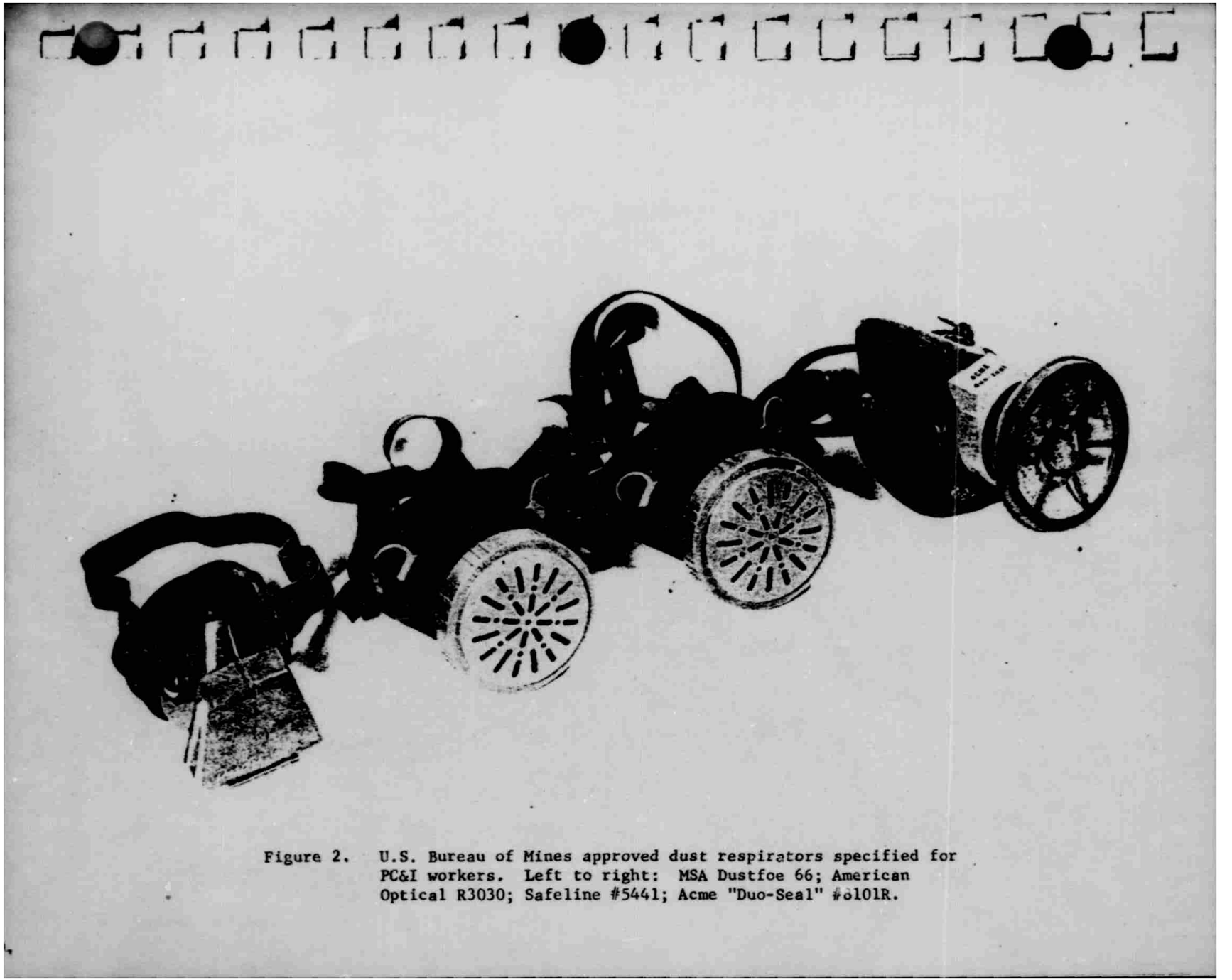


Figure 2. U.S. Bureau of Mines approved dust respirators specified for PC&I workers. Left to right: MSA Dustfoe 66; American Optical R3030; Safeline #5441; Acme "Duo-Seal" #8101R.

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C. VENTILATION CONTROL

The high mobility of asbestos workers aboard ship and the non-uniformity of handling, installation, or rip-out of asbestos material presents unusual ventilation problems. Local exhaust ventilation (most often a 3" or 5" diameter flexible sucker) must be used in conjunction with general ventilation to be effective. The local exhaust ventilation applied to the source of dust production is ideal, but in practice workmen find such ventilation bothersome, do not properly place it, or objects worked on are too large for effective control. General ventilation requires large volumes of air to maintain dust counts at acceptable levels in compartments where asbestos handling is done.

Ideally, the dust should be captured at the source of generation by local exhaust ventilation. General ventilation should remove and prevent build-up of dust escaping the local exhaust ventilation.

There seems to be a practical limit to the local exhaust and general ventilation available to pipe coverers and insulators. During periods of high levels of dust, ventilation techniques customarily used do not adequately keep airborne dust levels in acceptable ranges. Rip-out of old asbestos materials aboard ship is cited as a classic example.

Enclosures around dusty operations have not gained wide acceptance, but hold promise as a good control method for especially dusty asbestos operations. Portable polyethylene enclosures set up around the operations limit the spread of the dust to the rest of the ship's compartments. When such enclosures include local exhaust ventilation, capture of asbestos dust is effective. The enclosures in current use, range from plastic sheet to form one side of a hood and capture debris, to reasonably tight containments as the situation requires.

The photographs display some additional methods of applying ventilation principles to control asbestos dust generated in the work environment.

Figure 3. A portable downdraft table attached to a portable vacuum unit. The major portion of the saw cuttings are captured.


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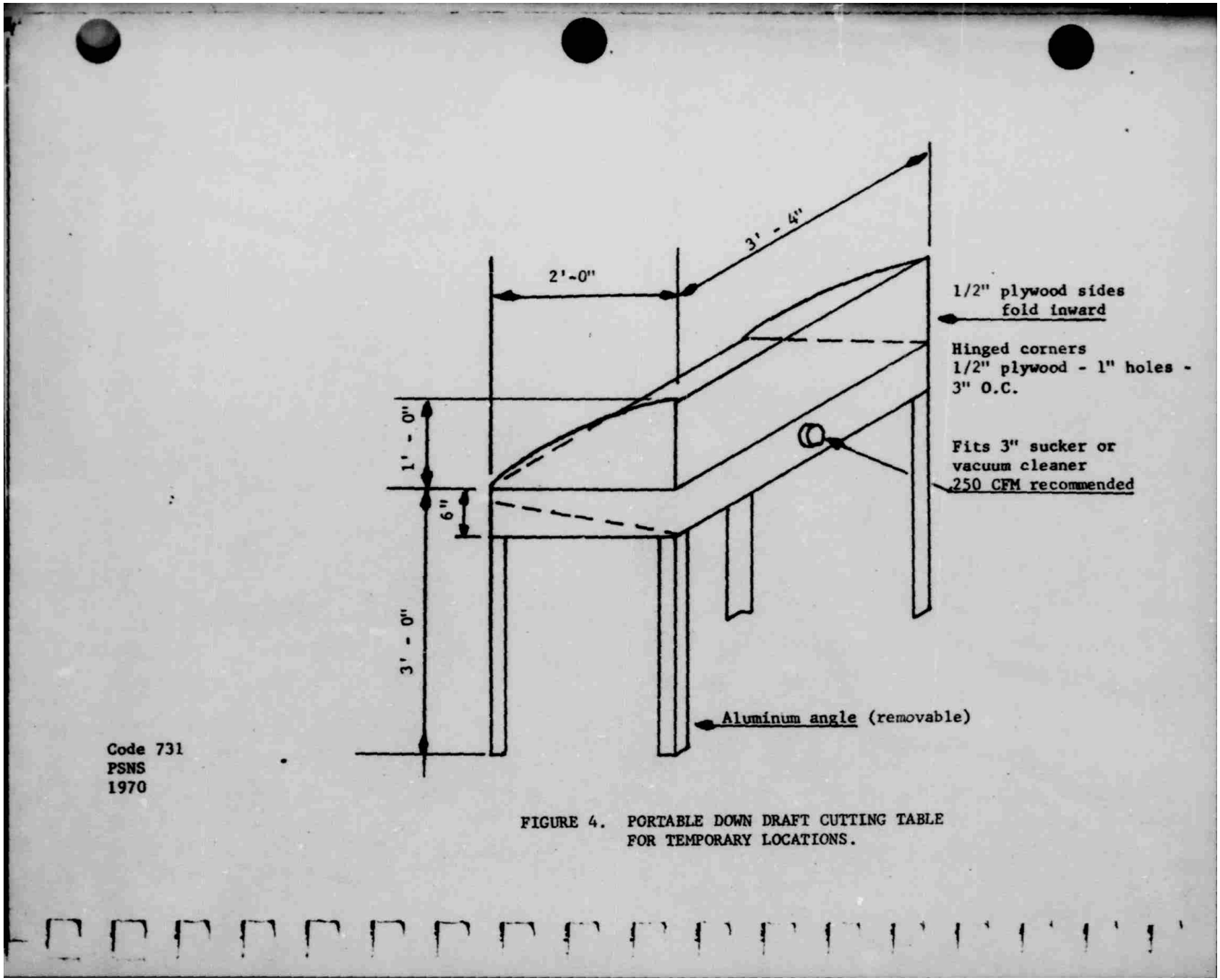



FIGURE 4. PORTABLE DOWN DRAFT CUTTING TABLE FOR TEMPORARY LOCATIONS.

Figure 5. A "Torit" downdraft dust collector for shop use or where large amounts of material are used. This unit is not portable.


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Figure 6. A portable vacuum unit shown sucking up asbestos scraps. This method is preferred to sweeping.

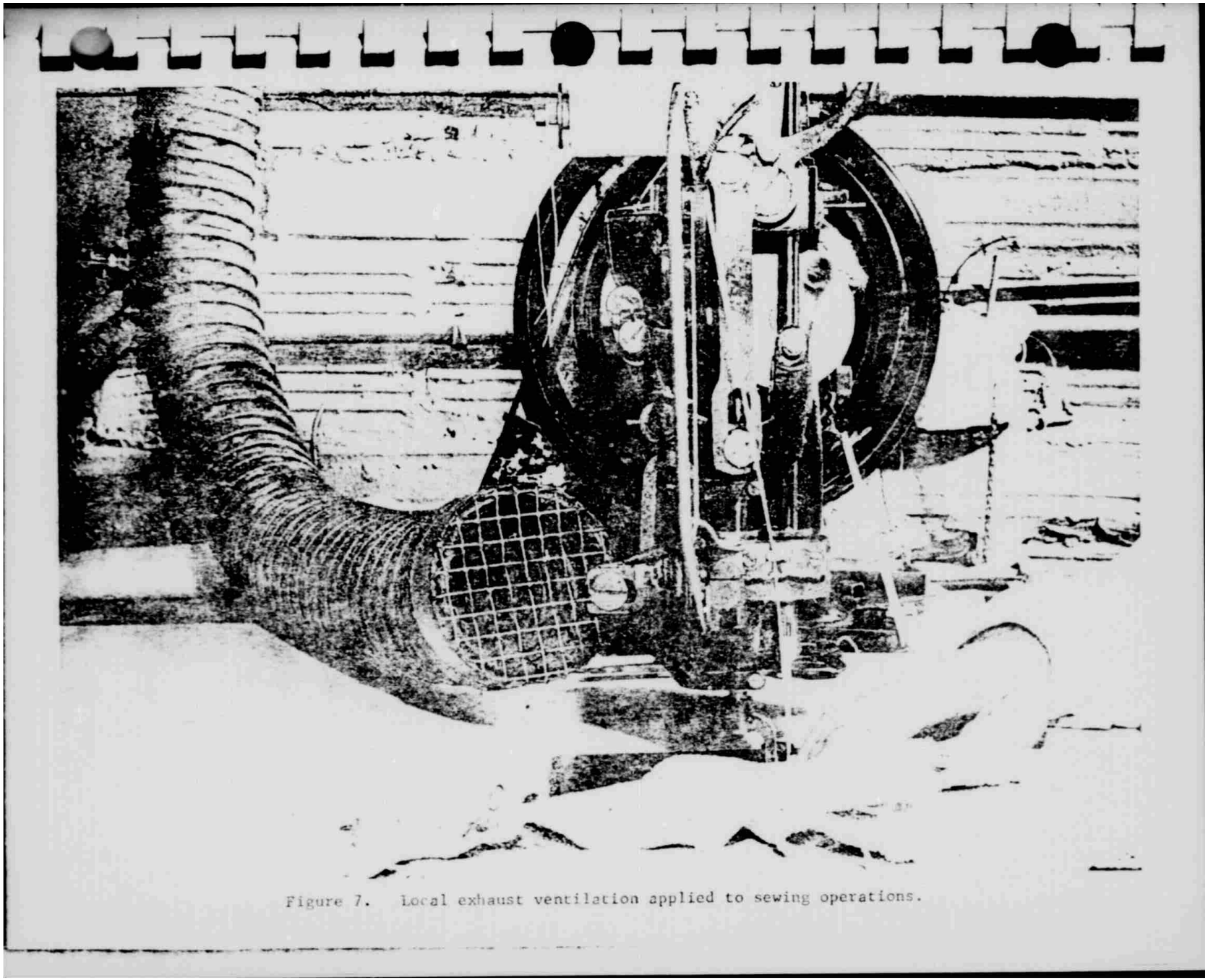


Figure 7. Local exhaust ventilation applied to sewing operations.

D. SUBSTITUTION OF MATERIALS

One of the most direct methods of reducing asbestos dust exposure is the substitution of less hazardous materials.

Fiberglass products have been applied where asbestos materials have traditionally been used for insulation aboard ship. Fiberglass dusts are not presently known to produce an adverse physiological response in the lung. A magnesium or calcium carbonate rigid block material containing only 15% asbestos fibers is used for much of the piping. Only minimum exposure occurs unless the block material is sawed, broken, or ripped off.

Substitution is limited only by technical requirements, such as temperature range, and the willingness to change the design or specifications. Identifying, testing and applying new insulation materials takes considerable time. Therefore, changes in application and substitution are likely to appear gradually as technological advances occur.

For example, "Ceramic Foam," a new rigid insulation material, has been introduced by Dow Chemical Company in 1969. Ceramic foam is an entirely inorganic, closed cell, vitreous material that is incombustible and resistant to chemical attack. The material has a density of 8 lbs. per cu. ft.; heavier than plastic foams but having greater structural strength for piping, tanks, vessels, low temperature storage and block foam building insulation. The temperature range is from cryogenic to more than 1400°F., and is impervious to moisture.

In May 1968, the PSNS Pipe Shop requested planning and design branches to substitute other insulation material for asbestos products as a measure to reduce airborne asbestos dust exposure to tradesmen.

The Naval Supply Systems Command prohibited the use of asbestos materials for carton packing in 1969.

Such measures of substitution will eventually reduce the overall exposure to workmen.



Figure 8. Substitution of fiberglass insulation for amosite (95% asbestos) substantially reduces asbestos exposures. Compare with Figure 9.

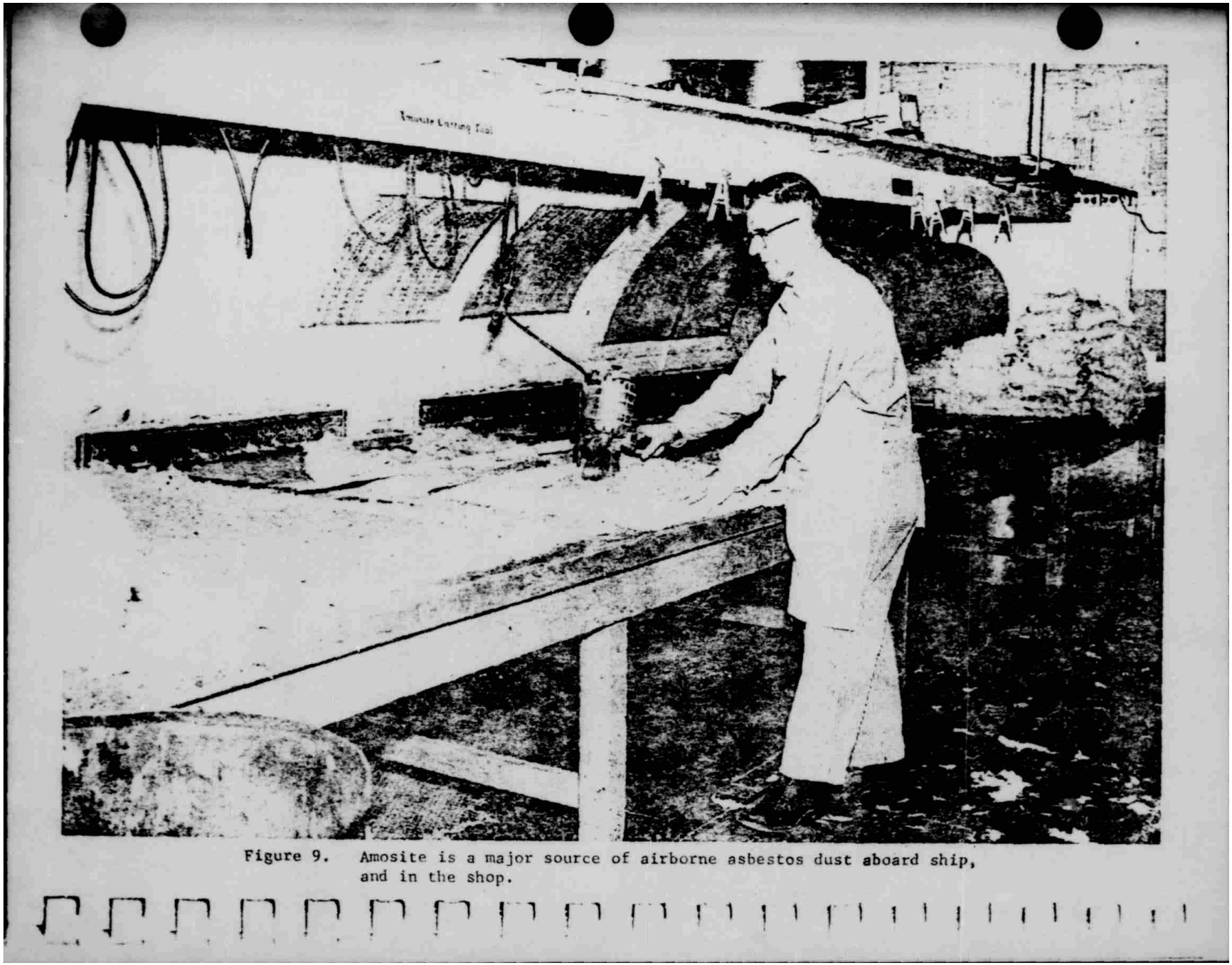


Figure 9. Amosite is a major source of airborne asbestos dust aboard ship, and in the shop.

## E. CHANGE OF WORK PRACTICES

Until asbestos substitutes are in full use, the most significant reductions in airborne asbestos dust can be accomplished by changes in work practices. The worker often applies the materials in a manner that leads to high concentrations of dust in the breathing zone regardless of ventilation supplied, location, or packaging. For example, one worker may carefully pre-wet the materials while another will not, yet pre-wetting is known to reduce airborne asbestos dust production from 50 to 60%. Such changes in work practices will largely depend on the identification of dusty processes, and development of new work methods. Education and training will allow the worker to accept a realistic role in his own health protection. For management, a careful review will show that asbestos dust reduction practices provide better control at little or no extra cost.

The change of work practices can be divided into several categories, each containing methods that do not require large expenditures, extensive engineering, or special ventilation technique.

(1) Pre-fabrication in shops and on the job site.

(a) Materials are removed from containers under ventilated conditions because this source produces much fine dust. Pre-wetting by dipping or spraying reduces dust levels.

(b) Dust collection systems are attached to power saws to capture dust at the point of generation.

(c) All machines or process tables have waste container systems to prevent the material from falling on the floor. Otherwise foot traffic would keep the dust dispersed for long periods.

(d) Wetting down asbestos material of any type reduces airborne dust production. If the materials are to be used later, a plastic bag will retain the moisture and contain any dust.

(e) Pre-fabrication of asbestos materials in the shop is done under adequately ventilated conditions. Such pre-fabrication in the shop saves time aboard ship, and reduces cutting by workers on the job. Pre-cut sections are packaged and identified in the shop and delivered directly to the job site. All of the pieces are kept together, breakage is reduced, and dust is contained.

(f) The modular assembly of piping and insulation under ventilated conditions holds promise because of the time saved, minimizing ship assembly time and uncontrolled exposures.




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(g) For small applications, asbestos cements are placed in a plastic bag, water is added, and the mixture is then kneaded. Often the correct amount of asbestos cement can be sent in the mixing bag to the work site from the shop along with the materials to be applied. Asbestos cements produce high levels of asbestos dust when handled dry.

(2) Installation.

(a) Unpacking, handling, and applying asbestos materials aboard ship contribute significantly to overall exposures. Pre-wetting, pre-packaging, and careful handling does reduce breathing zone exposure. Throwing asbestos materials contributes significantly to airborne dusts, a practice largely accepted.

(b) Hand sawing, cutting, and jacket stripping are performed under ventilated conditions but not all dust is captured. Respirators should be worn by the exposed individual, because hand sawing or breaking, produces excessively high dust levels throughout small compartments.

(c) Portable dust collectors or exhaust blowers are used to collect asbestos dust at their source and exhaust them outside the ship. Exhausting into adjoining spaces is avoided.

(d) Asbestos cloth with a built-in or re-wettable adhesive is used to reduce airborne dusts. Plain asbestos cloth produces relatively high levels of airborne fibers when ripped or handled vigorously.

(3) Application of Cements.

(a) Most asbestos cement products are mixed at dockside and delivered to the work site aboard ship. Some cements which harden rapidly on addition of water are mixed at the site.

(b) The bags of cement are emptied without shaking to reduce dusts.

(c) When the bag is emptied, the material is dropped the shortest distance to avoid dispersion of asbestos dust.

(d) Empty bags are placed in containers, wet down, then removed from the ship.

(e) Mixing areas are selected. Ventilated mixing stations at dock side, open air mixing, or adequate local exhaust ventilation are required to keep large scale asbestos cement mixing from producing excessive airborne dusts.




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(f) U.S. Bureau of Mines approved respirators are worn by personnel mixing asbestos cements.

(g) Surfaces scraped clear of old asbestos cement are pre-wet. Wetting the tools also aids in dust reduction.

4. Removal ("Rip-out")

a. Ships under overhaul have large amounts of asbestos material removed. The removal produces high airborne concentrations of dust in ships' compartments for weeks at a time. The pipe coverers and insulators attempt to isolate the area with curtains, portable partitions, or enclosure of the work area to provide capture of the dust by ventilation, and prevent spreading of dust to adjacent work areas.

b. When rip-out produces high dust levels, PC&I personnel wear coveralls and respirators. Other trades usually have no protection and are excluded from the work area.

c. Materials are sawed into sections for removal instead of ripping with a bar. Removal in this manner produces less rubble. A cast-cutter such as used by the medical profession produces excellent results and little dust.

d. Plastic drop cloths are suspended beneath work areas to catch falling scraps and debris that produces dust.

e. Asbestos scrap is collected in bins, and wet down prior to removal.

f. In inaccessible places, asbestos materials are placed in plastic bags. Burlap bags are no longer used because the fine dust sifts from the bags when they are moved.

g. Exhaust ventilation is provided at the source of rip-out. General exhaust ventilation is provided to the compartment to prevent accumulation of asbestos dust in air.

5. Housekeeping for Shop and Ship

a. Periodic cleaning of work area, especially at the end of each shift, contributes greatly to dust reduction. The longer materials lie the more widespread they become, producing considerable airborne dust.

b. Foot traffic produces considerable dust from fallen asbestos scrap, shavings, or debris. The simple procedure of placing cutting or work stations away from general foot traffic significantly reduces dust.




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c. Surplus materials are picked up and placed in cartons or plastic bags.

d. Industrial vacuum cleaners are excellent to remove settled asbestos dust and other material around cutting benches. They provide some ventilation when attached to ventilated cutting tables when other sources of ventilation are not available.

e. The use of brooms, fox-tail brushes or rags is discouraged for clean-up of asbestos dust, because of the high dust levels produced. Such fine dust once re-dispersed remains suspended in air for many hours.

f. Scrap materials are placed in disposable plastic bags. At the end of the shift the bags are taped shut and removed from the work location as refuse.

g. Large pieces of scrap materials are placed in containers and wet down to reduce dust.




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Figure 10. Asbestos refuse collected in polyvinyl plastic bags are sealed and removed from the ship. This reduces a major source of asbestos dust and simplifies clean-up.


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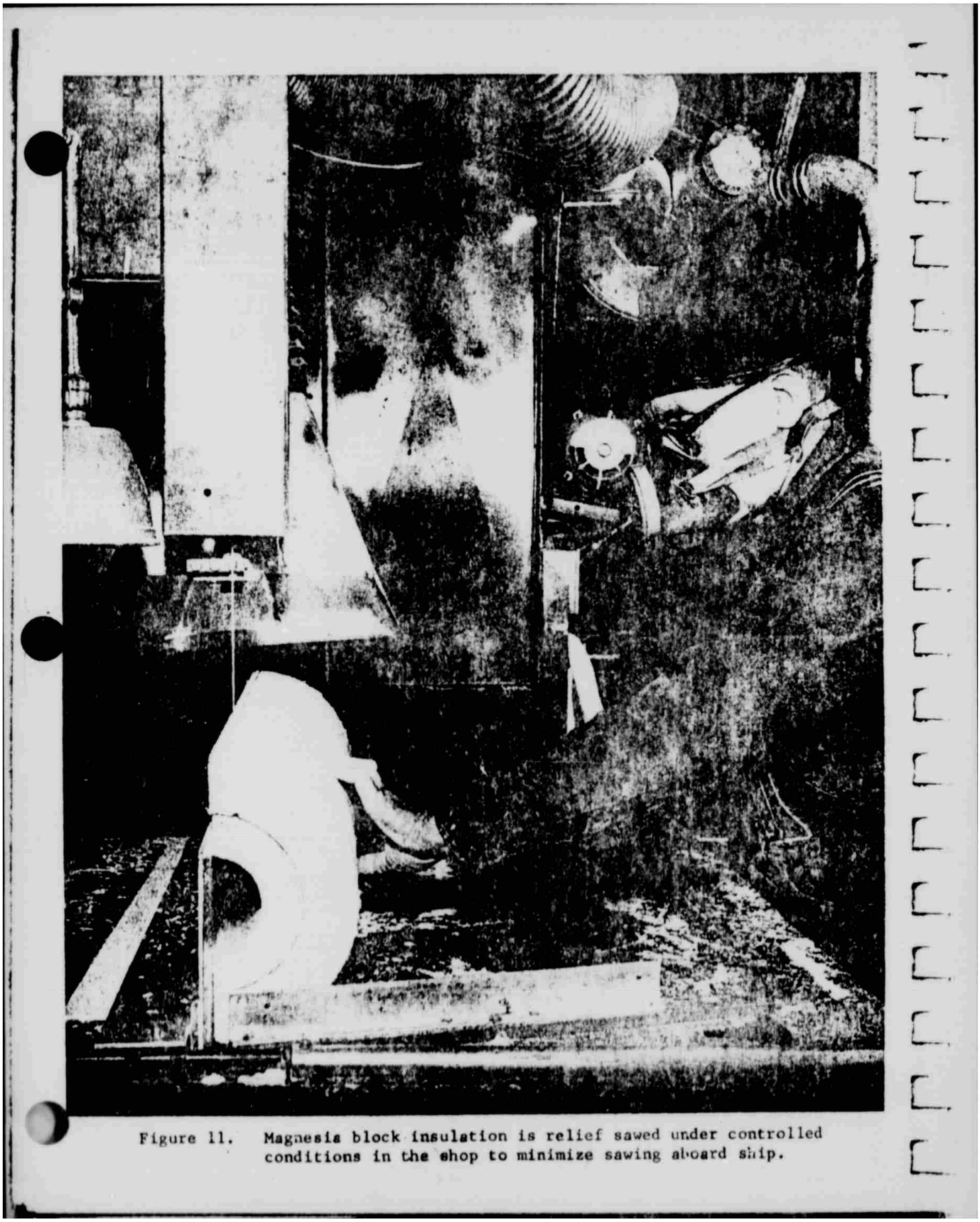


Figure 11. Magnesia block insulation is relief sawed under controlled conditions in the shop to minimize sawing aboard ship.


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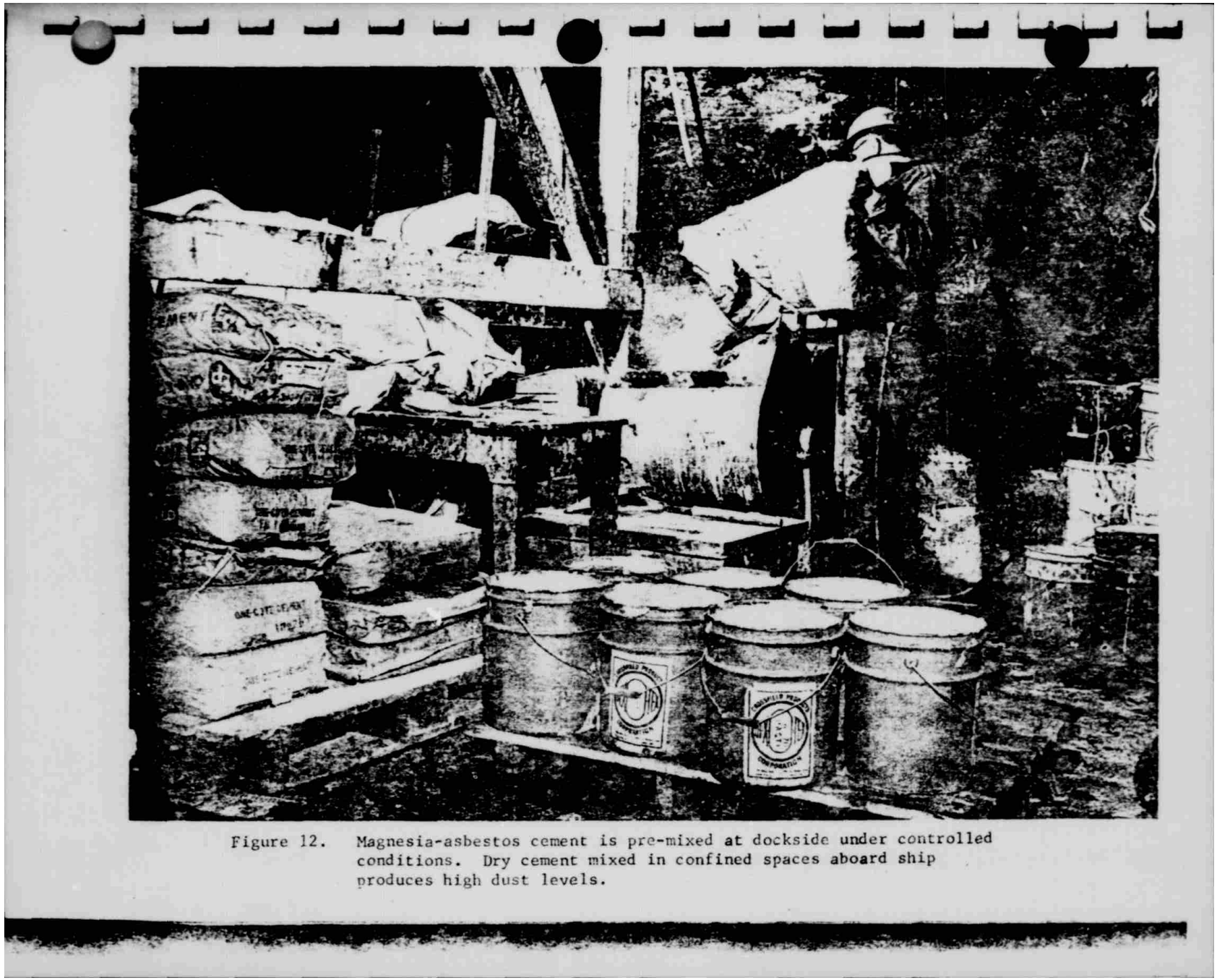


Figure 12. Magnesia-asbestos cement is pre-mixed at dockside under controlled conditions. Dry cement mixed in confined spaces aboard ship produces high dust levels.



Figure 13. Sealing magnesia block in plastic bags reduces airborne dust during handling and reduces breakage.


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Figure 14. Plastic or canvas drop cloths prevent debris from falling to lower levels aboard ship, and facilitate clean-up.


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F. EDUCATIONAL

A sustained, detailed educational program appears essential to continue an asbestos dust control program. A survey revealed asbestos workers did not fully understand the hazards of asbestos, nor had they received formal training explaining the medical and environmental controls. In June, 1969, lectures and demonstrations were given to win their acceptance, allay fears, and carefully explain proposed changes of work practices, and the effects of breathing asbestos dust.

Many doubted that the proposed changes would be helpful, or resented some of the inconveniences, such as respirators.

The lecture series explained improved methods for minimizing exposure of insulation workers, and encouraged them to recommend methods of their own through the U.S. Navy Beneficial Suggestion program.

Also, the lectures explained the medical aspects, tests, the meaning of chest X-rays, and methods of environmental testing. The scientific reasoning for control rules, or equipment use, was carefully explained to insure intelligent application.

The results were excellent; most of the workers began applying changes in work methods that reduced exposures. The Beneficial Suggestion program provided several excellent changes, and identified a number of problem areas worthy of environmental control.

Most of all, the attitude of the workers changed to one of interest and cooperation. No adverse reaction or worker-employer difficulties developed as a result of the presentation of all the facts regarding the health and environment of pipe coverers and insulators.

The authors believe that the change of work practices, which relies largely on the individual worker, could not have been accomplished without the educational program.

Training programs should be sustained because workers forget, new methods develop, and worker feed-back of problems and ideas is important.

A follow-up educational program is warranted to convince PC&I workers not to smoke. The risk of lung cancer among asbestos workers who smoke is nearly 2:1 compared to PC&I workers who do not smoke.




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## G. SUMMARY

The control of asbestos materials and the dust produced required a 5 point program to reduce exposures to acceptable levels.

The evidence of excessive pulmonary abnormalities among pipe coverers and insulators implied that overexposures were still occurring even though the Threshold Limit Value of 5 million particles per cubic foot asbestos dust in air had been applied for the last 20 years.

Proposed reductions in the 1970 Threshold Limit Value for asbestos dust to 2 million particles per cubic foot means that more effective control measures must be applied. The respirators and change of work practices provided an immediate solution, but substitution of less hazardous materials, and engineering controls, such as improved ventilation methods, must ultimately be applied. They hold greater promise for direct material control and engineered applications which eliminate human decision related to asbestos dust on the job.

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# ASBESTOS EXPOSURE AND CONTROL AT PUGET SOUND NAVAL SHIPYARD

INDUSTRIAL HYGIENE DIVISION
MEDICAL DEPARTMENT
PUGET SOUND NAVAL SHIPYARD

C. A. MANGOLD, R. R. BECKETT, D. J. BESSNER

March 1970

INSTITUTE OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH MONTREAL CANADA

ABSTRACT

A two and one-half year comparison of chest X-ray findings in the total work force of Puget Sound Naval Shipyard shows that 21% of the Pipe Coverers and Insulators handling asbestos have pulmonary abnormalities compared to 3.5% of the Boilermakers who have some exposure to asbestos and silica, and less than 1% of the Clerical workers with no known exposure to industrial dusts. Pulmonary abnormalities have remained high although evaluation of the asbestos dust exposure of Pipe Coverers and Insulators shows their time weighted exposures are below the current Threshold Limit Value of 5 million particles per cubic foot of air. The Threshold Limit Value may be too high and intermittent peak exposures may play a greater role than suspected. A number of engineering control methods and changes in work practices are suggested to reduce asbestos exposure.


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B2013
JAEA 3795

ENVIRONMENTAL RESEARCH 11, 248–260 (1976)

# Asbestos Exposure Control at Puget Sound Naval Shipyard[1]

ROGER R. BECKETT

*Industrial Hygiene Division, Naval Regional Medical Center, Puget Sound Naval Shipyard, Bremerton, Washington 98314*

## INTRODUCTION

Puget Sound Naval Shipyard is a U. S. Navy owned and operated shipbuilding and repair facility located at Bremerton, Washington. Employment varies between 8000 and 10,000 workers. Of this group, 40–120 persons work as pipe coverers and insulators, using in varying degrees, asbestos products as well as other insulating materials. Even though many of the traditional exposures have been eliminated or substantially reduced the continuing use of asbestos materials and the "rip-out" of existing material requires that exposures to personnel be controlled.

A four-point program for exposure control was drafted in 1967 and has remained in effect.

*First*, a respirator program was initiated to immediately reduce exposures until other control methods could be developed.

*Second*, the work practices were examined to identify the most hazardous operations and to suggest alternate methods. For example, wetting of amosite materials reduced the airborne asbestos dust production 50 to 60%. The change of work practices gave the greatest promise for the reduction of airborne asbestos dust as an immediate engineering control, with minimum production expenditures.

*Third*, engineering controls which have a far reaching effect, but take longer to initiate, were begun: (1) substitution of materials, (2) new methods, and (3) techniques of ventilation control.

*Fourth*, an educational program was initiated to help workers understand the potential hazards and the reasons why a change in approach to the control of asbestos was needed. This educational program was based on a survey of pipe coverers and insulators that revealed much misunderstanding regarding asbestos exposure and its effects.

This report presents some of the methods employed to reduce airborne asbestos exposures. While it is by no means complete, it covers the major points in a control program:

a. adequate respiratory protection;
b. change in work practices and handling methods;
c. engineering controls such as ventilation;
d. an educational program to retrain workers to use less hazardous methods;

[1] Reference to a company or a product name does not imply approval or recommendation of the product to the exclusion of others that may be suitable.



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e. substitution of less hazardous materials;
f. a monitoring program.

The ultimate goal is to reduce the exposure level to a point where workmen are no longer adversely affected.

## RESPIRATORS AND PROTECTIVE CLOTHING

In January 1968, dust respirators were made mandatory because a survey showed that 76% of the insulators did not use a respirator. About 50% of all insulators did not have a respirator in their possession. Poor face fit, breathing resistance, and comfort were given as reasons for noncompliance, although enforcement was lax.

A laboratory program was started to find respirators suitable for long periods of wear. Of the ten best dust respirators commercially available, four were selected that were U.S. Bureau of Mines approved and gave a good face fit, good visibility, and lowest breathing resistance. They were (see Fig. 1):

a. Mine Safety Appliance Company
MSA Dustfoe 66 (76869)
with Cushion Face Piece
Dustfoe 66 Filter (457485—box of 50 USBM Schedule 21B)
(Use Kit 457755 to convert USBM Schedule 21A respirators to USBM Schedule 21B);

b. American Optical Company
R-3030 Respirator with the R-30 "Red Devil" filter
for dusts and mists.
A/O Filter R-30;

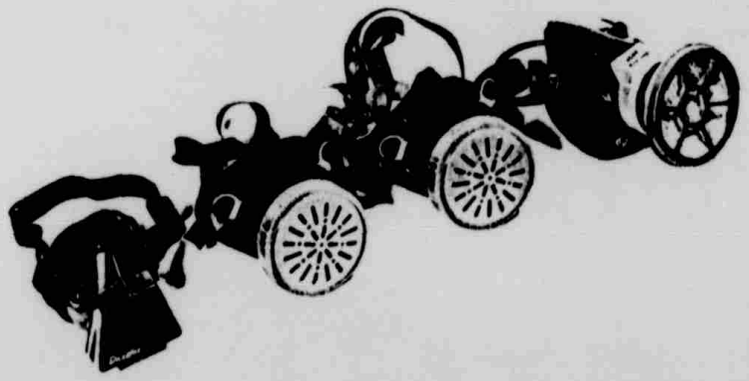


FIG. 1. U. S. Bureau of Mines approved dust respirators specified for PG&E workers. Left to right: MSA Dustfoe 66; American Optical R3030; Safeline #5441; Acme "Duo-Seal" #8101R.

c. Safeline Respirator #5441
Safeline Filters #5905;
d. Acme "Duo-Seal" Dust Respirators #8101-R
Dust Filter (Lambswool) 8147 EW
Filter Holder 5021-R.

In 1971, the shipyard cooperated with the Minnesota Mining & Manufacturing (3M) in evaluating the #8710 3M disposable respirator. This respirator now has been approved on a BuMines schedule and is used by over 50% of the asbestos workers at this shipyard.

Several types of air-fed respirators and full hoods have been tried and are used when high dust levels are occasionally encountered.

In 1969, a Naval Ship Systems Command Notice directed that protective coveralls would be worn by all employees engaged in shipboard "rip-out" of asbestos which produces high airborne dust levels. The coveralls were to be cleaned before each use in an attempt to limit personal clothing contamination. Coveralls were to be removed *before* removal of the respirator to limit exposure.

The Industrial Hygiene Division recommended disposable, plastic impregnated,



FIG. 2. Insulator shown wearing an approved respirator and disposable paper coveralls. The canvas or plastic refuse bag is conveniently located.

paper coveralls with zippers, costing about $1.00 each, (Fig. 2) because they were cheap compared to procurement and laundry costs of cotton, twill, or duck coveralls. The plastic finish on the paper coveralls reduces the number of fiber penetrations, and disposal of the garment aids dust control. In addition, packing, laundry, transportation, and redistribution costs are eliminated. When the paper coveralls are taped at the sleeve and pant cuffs, the worker is essentially enclosed, yet the paper garments are permeable to air and do not trap body moisture. Several manufacturers have suitable garments available.

## VENTILATION CONTROLS

The high mobility of asbestos workers aboard ship and the nonuniformity of handling, installation, or "rip-out" of asbestos material presents unusual ventilation problems. Local exhaust ventilation (most often a 3 or 5 in. diameter flexible sucker) must be used in conjunction with general ventilation to be effective. Local exhaust ventilation applied to the source of dust production may be ideal, but in practice, workmen find such ventilation bothersome, do not properly place it, or objects worked on are too large for effective control. General ventilation requires large volumes of air to maintain dust counts at acceptable levels in compartments where asbestos handling is done.

Enclosures around dusty operations have not gained wide acceptance, but hold promise as a good control method for especially dusty asbestos operations such as "rip-out." Portable polyethylene enclosures set up around an operation limit the spread of the dust to the rest of the ship's compartments. When such enclosures

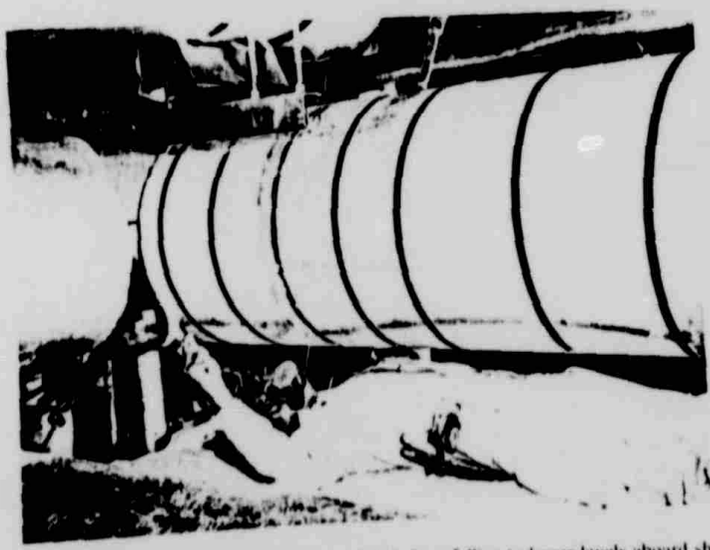


FIG. 3. Plastic or canvas drop cloths prevent debris from falling to lower levels aboard ship, and facilitates cleanup.

include local exhaust ventilation, capture of asbestos dust is effective. The enclosures in current use range from plastic sheet to form one side of a hood and capture debris, to reasonably tight containments as the situation requires.

The photographs (Figs. 3–10) display some additional methods of applying ventilation principles to control asbestos dust generated in the work environment.

## MATERIAL SUBSTITUTION

One of the most direct methods of reducing asbestos dust exposure is the substitution of less hazardous materials. Fiberglas products have been applied where asbestos materials have traditionally been used for insulation aboard ship. Fiberglas dusts are not presently known to produce a significant adverse physiological response in the lung. A magnesium or calcium carbonate rigid-block material containing only 15% asbestos fibers is used for much of the piping. Only minimum exposure occurs unless the block material is sawed, broken, or ripped off. This type of product is now available without asbestos.

Substitution is limited only by technical requirements, such as temperature



FIG. 4. Asbestos refuse collected in polyvinyl plastic bags is sealed and removed from the ship. This reduces a major source of asbestos dust and simplifies cleanup.


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FIG. 5. A portable downdraft table attached to a portable vacuum unit. The major portion of the saw cuttings is captured.

range, and the willingness to change the design or specifications. Identifying, testing, and applying new insulation materials takes considerable time. Therefore, changes in application and substitution are appearing gradually as technological advances occur. For example, "Ceramic Foam," a new rigid insulation material, was introduced by Dow Chemical Company in 1969. Ceramic foam is an entirely inorganic, closed cell, vitreous material that is incombustible, impervious to moisture, and resistant to chemical attack. The material has a density of 8 pcf; heavier than plastic foams but having greater structural strength for piping, tanks, vessels, low temperature storage, and block foam building insulation. The temperature range is from cryogenic to more than 1400° F. Synthetic rubber foams have also received wide acceptance. Such measures of substitution will eventually reduce the overall exposure to workmen.

## WORK PRACTICE CHANGES

Until asbestos substitutes are in full use, the most significant reductions in airborne asbestos dust can be accomplished by changes in work practices. The worker often applies the material in a manner that leads to high concentrations of dust in the breathing zone regardless of ventilation supplied, location, or packaging. For example, one worker may carefully pre-wet the materials while another will not; yet prewetting is known to reduce airborne asbestos dust production from 50 to 60%. Such changes in work practices will largely depend on the identification of dusty processes, and development of new work methods. Education and training will allow the worker to accept a realistic role in his own health



FIG. 6. Sealing magnesia sectional in plastic bags reduces airborne dust during handling and reduces breakage.

protection. For management, a careful review will show that asbestos dust reduction practices provide good control at little or no extra cost.

The change in work practices can be divided into several categories, each containing methods that do not require large expenditures, extensive engineering, or special ventilation technique.

*Prefabrication in Shops and on the Job Site*

(a) Materials are removed from containers under ventilated conditions because this process produces much fine dust. Prewetting by dipping or spraying reduces dust levels.

(b) Dust-collection systems are attached to power saws to capture dust at the point of generation.

(c) All machines or process tables have waste container systems to prevent the material from falling on the floor. Otherwise, foot traffic would keep the dust dispersed for long periods.

(d) Wetting down asbestos material of any type reduces airborne dust production. If the materials are to be used later, a plastic bag will retain the moisture and contain any dust (Fig. 7).

(e) Prefabrication of asbestos materials in the shop is done under adequately ventilated conditions. Such prefabrication in the shop saves time aboard ship, and


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FIG. 7. Finished sections are dipped in water and placed in plastic bags for shipment to the work site.

reduces cutting by workers on the job. Precut sections are packaged and identified in the shop and delivered directly to the job site. All of the pieces are kept together, breakage is reduced, and dust is contained (Fig. 8).

(f) The modular assembly of piping and insulation under ventilated conditions holds promise because of the savings in ship assembly time and controlling exposures.

(g) For small applications, asbestos cements are placed in a plastic bag, water is added, and the mixture is then kneaded. Often the correct amount of asbestos cement can be sent in the mixing bag to the work site from the shop along with the materials to be applied. Asbestos cements produce high levels of asbestos dust when handled dry (Fig. 10).

*Installation*

(a) Unpacking, handling, and applying asbestos materials aboard ship contribute significantly to overall exposures. Prewetting, prepackaging, and careful handling does reduce breathing zone exposure.

(b) Hand sawing, cutting, and jacket stripping are performed under ventilated conditions, but not all dust is captured. Respirators should be worn by the exposed individual, because hand sawing or breaking produces excessively high dust levels throughout small compartments.


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FIG. 8. Magnesia sectional insulation is relief sawed under controlled conditions in the shop to minimize sawing aboard ship.

(c) Portable dust collectors or exhaust blowers are used to collect asbestos dust at the source and exhaust them outside the ship (Fig. 5). Exhausting into adjoining spaces is avoided.

(d) Asbestos cloth with a built-in or rewettable adhesive is used to reduce airborne dusts. Plain asbestos cloth produces relatively high levels of airborne fibers when ripped or handled vigorously. Nonasbestos containing insulation materials are becoming more available.

*Application of Cements*

(a) Most asbestos cement products are mixed at dockside or in the shop and delivered to the work site aboard ship. Some cements which harden rapidly on addition of water are mixed at the site.

(b) The bags of cement are emptied without shaking to reduce dusts.

(c) When the bag is emptied, the material is dropped the shortest distance to avoid excessive dispersion of asbestos dust.

(d) Empty bags are placed in containers and wetted prior to disposal.

(e) Mixing areas are selected. Enclosed and ventilated mixing stations are


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FIG. 9. Cement mixing station allows positive control of asbestos dust. Cement "mud" is shipped to use point, thus reducing exposures in many locations.

required to keep large-scale asbestos cement mixing from producing excessive airborne dust (Fig. 9).

(f) U. S. Bureau of Mines approved respirators are worn by personnel mixing asbestos cements.

(g) Surfaces scraped clear of old asbestos cement are prewetted. Wetting the tools also aids in dust reduction.

*Removal ("Rip-out")*

(a) Ships under overhaul usually have large amounts of asbestos material removed. This removal may produce high airborne concentrations of dust in ships' compartments for weeks at a time. Pipe coverers and insulators attempt to isolate the area with curtains, portable partitions, or enclosure of the work area to provide capture of the dust by ventilation, and prevent spreading of dust to adjacent work areas.

(b) When "rip-out" produces high dust levels, pipe coverers and insulators must wear coveralls and respirators. Other trades usually have no protection and are excluded from the work area.

(c) Materials are sawed into sections for removal instead of ripping with a bar. Removal in this manner produces less rubble. A cast-cutter such as used by the medical profession produces excellent results.


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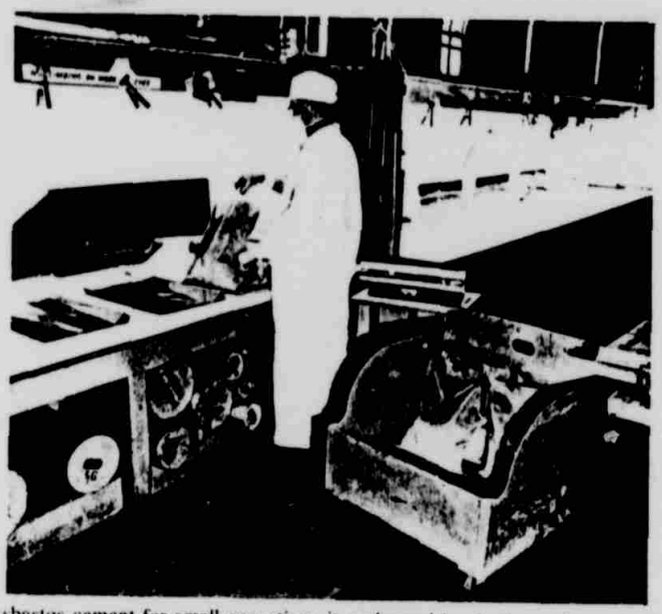


FIG. 10. Asbestos cement for small operations is prebagged in plastic, under controlled environmental conditions. Water is added at the job site.

(d) Plastic drop cloths are suspended beneath work areas to catch falling scraps and debris that produce dust (Fig. 3).

(e) Asbestos scrap is collected in bins and wetted prior to removal.

(f) In inaccessible places, asbestos scraps are collected in plastic bags. Burlap bags are no longer used because the fine dust sifts from the bags when they are moved (Fig. 4).

(g) Local exhaust ventilation is provided at the source of "rip-out." General exhaust ventilation is provided to the compartment to prevent accumulation of asbestos dust in air.

*Housekeeping for Shop and Ship*

(a) Periodic cleaning of work areas, especially at the end of each shift, contributes greatly to dust reduction. The longer materials lie the more widespread they become, producing considerable airborne dust.

(b) Foot traffic produces considerable dust from fallen asbestos scrap, shavings, or debris. The simple procedure of placing cutting or work stations away from general foot traffic significantly reduces dust.

(c) Industrial vacuum cleaners are excellent to remove settled asbestos dust and other material around cutting benches. They provide some ventilation when attached to ventilated cutting tables when other sources of ventilation are not available. It must be determined if the vacuum cleaner has an effective filter.

(d) The use of brooms, fox-tail brushes, or rags is discouraged for clean-up of


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asbestos dust, because of the high dust levels produced. Such fine dust once redispersed remains suspended in air for many hours.

(e) Scrap materials are placed in disposable plastic bags. At the end of the shift, the bags are taped shut and removed from the work location as refuse.

(f) Large pieces of scrap materials are placed in containers and wet down to reduce dust.

## EDUCATIONAL EFFORTS

A sustained, detailed educational program appears essential to continue an asbestos dust control program. A survey revealed asbestos workers did not fully understand the hazards of asbestos, nor had they received formal training explaining the medical and environmental controls. In June 1969, lectures and demonstrations were given to win their acceptance, allay fears, and carefully explain proposed changes in work practices and the effects of breathing asbestos dust.

Many doubted that the proposed changes would be helpful and resented some of the inconveniences, such as respirators. The lecture series explained improved methods for minimizing exposure of insulation workers, and encouraged them to recommend methods of their own. Also, the lectures explained the medical aspects, tests, the meaning of chest X rays, and methods of environmental testing. The scientific reasoning for control rules, or equipment use, was carefully explained to insure intelligent application.

The results were excellent; most of the workers began applying changes in work methods that reduced exposures. The suggestion program proposed several excellent changes, and identified a number of problem areas worthy of environmental control. Most of all, the attitude of the workers changed to one of interest and cooperation. No adverse reaction or worker–employer difficulties developed as a result of the presentation of all the facts regarding the health and environment of pipe coverers and insulators.

Training programs should be sustained because workers forget, new methods develop, and worker feedback of problems and ideas is important.

## MONITORING PROGRAM

Sampling and counting asbestos dust in the workers environment has been conducted at Puget Sound Naval Shipyard on a regularly scheduled basis since the early 1960s. The requirements of this program are largely technical in nature and are accomplished by the Industrial Hygiene Division.

Present requirements for sampling are outlined by the Occupational Safety and Health Administration, U.S. Department of Labor (*Federal Register* 37, 202, October 18, 1972) and fiber counting procedures as published in the National Institute for Occupational Safety and Health, U.S. Department of Health, Education and Welfare, *Criteria for a recommended standard on occupational exposure to asbestos*.

## SUMMARY

The control of asbestos materials and the dust produced requires a comprehensive program and unending efforts to reduce personnel exposures to acceptable

levels. Reductions in allowable exposure levels to two fibers (not longer than 5 $\mu$m) per cubic centimeter of air, scheduled to be effective by July 1, 1976, will require that more effective control measures be applied. The respirators and change in work practices provide an immediate solution, but substitution of less hazardous materials and engineering controls, such as improved ventilation methods, must ultimately be applied.


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