PLAINTIFF'S
EXHIBIT
AIA-71

ENGINEERING FEASIBILITY AND ECONOMIC IMPACT STUDY OF A PROPOSED OSHA REGULATION ON OCCUPATIONAL EXPOSURES TO AIRBORNE ASBESTOS IN THE CONSTRUCTION INDUSTRY

INTERIM REPORT

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Prepared for

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1. INTRODUCTION

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor is in the process of developing a standard for exposure to asbestos in the construction and demolition industries. In order to assist the Asbestos Information Association/N.A. (AIA/NA) in the formulation of a response to any proposed construction industry standard for asbestos exposure, Equitable Environmental Health, Inc. (EEH) is conducting this study. The primary concerns of this study are (1) an assessment of current worker exposure to asbestos in the construction industry, (2) the technical feasibility of control strategies, and (3) the economic impact of regulatory requirements on the construction industry.

The development of an adequate data base is the first requirement for addressing these concerns. Chapter 2 of this report represents a compilation of the necessary data, excluding worker exposure. These data were obtained from correspondence and telephone surveys, the published literature, and construction site observations. The manufacturing and construction industries, including demolition, are summarized in terms of products; quantities produced and consumed; the numbers, sizes, and receipts of contractors; the composition and distribution of the labor force by age and trade group; wages of workers; and the seasonality of employment in the industry.

Chapter 4, in its present form, is a model for treatment of worker exposure, feasibility of control, and development of costs for complying with alternative standards. Asbestos fiber count data have been obtained from the open literature, personal communications with industry and governmental agencies, and air sampling surveys performed during this program. Feasibility of control has been based on the literature, construction site visits, and discussions with manufacturers and contractors. The costs of compliance were derived from consideration of an hypothesized work situation or scenario developed from site visits and a survey of contractors and employing data contained in Chapter 2. The origin of information and assumptions relating to specific compliance cost elements, such as medical examinations, industrial hygiene surveys, and respiratory protection, is indicated in the text. Since this section is intended to elicit comment, only one product category, asbestos-cement sheet, is presented in detail.

The Appendixes to this report contain copies of the forms used in correspondence surveys; associations, unions, and governmental agencies contacted; and summary reports of the industrial hygiene surveys performed during this program.

This interim report was intended to provide a compilation of available information and an example of the approach taken for cost assessment. The final report, which will be prepared after the issuance of the proposed construction standard for asbestos by OSHA, will follow the outline shown as the Table of Contents for this report. The NI (not included) designation for chapters indicates material that requires issuance of the standard before completion.

2. CONSTRUCTION AND DEMOLITION INDUSTRY DATA

2.1 METHODOLOGY

2.1.1 Study Design

In preparing a data base that would allow formulation of a response to an asbestos standard for the construction industry, it was necessary to characterize and summarize the asbestos manufacturing and the construction industries. In addition, the interrelationships of these two industries had to be known.

These requirements were divided into three subtasks, with each subtask further subdivided into specific questions. The subtasks are as follows:

1. characterization and summarization of the manufacturing industry
2. characterization and summarization of the construction industry
3. construction industry's consumption of asbestos products
4. installation and application of asbestos construction products
5. worker exposure to asbestos products (i.e., fiber counts).

This information was obtained from published sources, correspondence and telephone surveys, and construction site observations. The procedural details are discussed in Section 2.1.2.1. Essentially, a comprehensive literature search was carried out to identify media sources that would answer the questions under the subtasks as completely and as currently as possible. It was anticipated that particular elements in the study would not be available through published sources, and, therefore, questionnaires were sent to various organizations that might have such data. Questionnaires were sent to asbestos manufacturers, manufacturing associations, trade associations, unions, and government (i.e., federal, state, and local) agencies. Procedural details are provided in Section 2.1.2.2, and copies of the respective questionnaires are contained in Appendix A.

Construction site observations were necessary to provide documentation of actual working situations involving fabrication, assembly, and installation of asbestos products as well as removal of materials and demolition. The details of this segment of the program are provided in Section 2.1.2.3.

It should be noted that the transportation of asbestos and the use of asbestos-containing materials in the maritime industry were excluded from this study because these areas will be the subject of future regulations.

2.1.2 Sources

2.1.2.1 Published Data

Two major sources of published information to be identified were government documents and commercial or private publications. Appropriate sources of information from the government were identified through:

1. Statistical Survey of the United States Government, 1975 (U.S. Office of Management and Budget 1975), which is an excellent guide and reference book on statistical data published by the federal government
2. The American Statistical Index, a monthly indexing and abstracting service produced by a private organization, The Congressional Information Service, Washington, D.C., which is the most authoritative index of statistical information on and/or by the U.S. government

3. The Council of Planning Librarians' (CPL) Exchange Bibliography on construction, housing, and real estate statistics, dated March 1976.

In addition, the Monthly Catalogue of the U.S. Government Printing Office was also searched for information that could support this study.

In identifying sources from the commercial base, the CPL Exchange Bibliography was consulted since it is not limited to government sources and includes all sources providing information relevant to the subject. To identify information from the commercial periodical literature, computerized literature searches were carried out through Lockheed's Information System, DIALOG, and the National Library of Medicine's TOXLINE system. Data bases searched in DIALOG included Compendex, which covers all the significant engineering periodicals; the National Technical Information Service, which covers report information from a multitude of sources including government-generated reports, e.g., National Institute for Occupational Safety and Health (NIOSH), OSHA, the Environmental Protection Agency, etc.; and the Predicasts data bases, which cover business and economic periodical literature, corporate annual reports, government documents, and information generated by Predicasts intelligence. In addition, extensive searching was carried out in the classified catalogues of the University of California at Berkeley libraries and special libraries of the San Francisco Bay area.

2.1.2.2 Correspondence and Telephone Survey

To supplement and update the information derived from published sources, numerous private and public organizations were contacted. In each case, the intent was to obtain current and as yet unpublished information that would serve to supplement or verify data reported in the literature.

Contacts were made with organizations in five basic categories: asbestos manufacturers, manufacturing trade associations, construction trade associations, trade unions, and regulatory agencies (federal, state, and local). Individual organizations within each category were selected to provide input from a broad cross-section of sources knowledgeable in the production, distribution, use, and control of asbestos-containing construction materials. Lists of these contacts were developed from a variety of sources. In the case of manufacturers, these consisted of the current AIA/NA membership roster, attendance rosters from recent AIA/NA conferences, and listings under SIC 3292 in Thomas' Register, Dun & Bradstreet, and Standard & Poors. Trade associations and trade unions of probable relevance to the asbestos products were identified in the 1976 edition of National Trade & Professional Associations of the United States and Canada and Labor Unions. Letters of request for fiber count information were also sent to OSHA, NIOSH, and appropriate health and safety agencies in each of the 50 states, Guam, the District of Columbia, Puerto Rico, the Virgin Islands, and several local jurisdictions.

Surveys were conducted using a combination of telephone calls and written communication with subsequent follow-up as needed. Except for the regulatory agencies that were asked only to provide fiber counts, most organizations received a cover letter that explained the purpose of the survey and one of four questionnaires designed specifically for the study (Appendix A).

The names of the asbestos manufacturing associations, trade associations, trade unions, and public agencies that were contacted are contained in Appendix A. A list of the manufacturers contacted is not included becaude EEH assured them that their participation in the study would be treated in confidence.

2.1.2.3 Construction and Demolition Site Visits/Observations

Visits to construction/demolition and renovation sites were undertaken to provide information in a number of areas, including typical operational procedures and practices for field installations and removals of asbestos-containing materials; man-hours spent in field operations; the numbers of workers involved in operations with asbestos-containing materials relative to the total number of workers on the site; identification of alternative materials; and a qualitative description of the level and frequency of construction worker asbestos exposure. At a number of sites, samples were collected and analyzed for asbestos fiber so that a determination of ceiling and time-weighted average (TWA) exposures could be made.

Site visits were arranged through various organizations including manufacturers, construction contractors, and trade associations. Qualified personnel conducted the visits and, as an aid to providing uniformity of information, completed the site survey report shown in Appendix A. In all, 36 sites were visited during the program. The data obtained during these visits are presented and discussed in Section 4, Exposure to Asbestos.

2.2 DISCUSSION OF DATA

2.2.1 Results

2.2.1.1 Published Data

The published literature contained a thorough documentation of the type of asbestos products manufactured, their quantities, and dollar volume, and the number of workers employed in their manufacture, as well as a good characterization of the construction industry in terms of number of workers, seasonal work variations, special trade groups, contractor size, business volume, and construction activity in general. The literature search was thus fairly straightforward, requiring only that the necessary values be obtained from the pertinent table or graph.

The 1972 Census of Manufactures, Industry Series (U.S. Bureau of the Census 1974a-b, 1975a-b) was the primary source of information concerning the manufacture of asbestos and asbestos-containing products. Some supplemental data were retrieved from publications such as the Annual Survey of Manufactures (U.S. Bureau of the Census 1975c), the Minerals Yearbook (U.S. Bureau of Mines 1973), Mineral Facts and Problems (U.S. Bureau of Mines 1975), and the Predicasts Market Abstracts (1976). From these additional sources, it was possible to estimate manufacturing values for 1974.

Information on the construction industry was also obtained from census data (U.S. Bureau of the Census (1975d-n). Additional construction information was found in the statistical series presented monthly in

Construction Review (U.S. Bureau of Domestic Commerce 1976a-b) and in the latest issues of the Survey of Current Business (U.S. Bureau of Economic Analysis 1976).

The major disadvantage of utilizing this published data arises from the time lag between data collection and publication. This is particularly true for data on the manufacturing industries, for which detailed data are available only as recently as 1972. However, as noted previously, general category totals were available for 1974 and thus it was possible to estimate by interpolation relative changes in values from 1972 to 1974. Additional data gathered from EEH's in-house survey of asbestos manufacturers, associations, and unions provided further support in determining the overall makeup of asbestos manufacturing activities.

Asbestos fiber counts pertaining to the construction industry were obtained from trade journals (Nicholson 1971, Rhodes and Ingalls 1976a), scientific and technical journals (Harries 1968, 1971a-b; Rohl et al. 1975), and other technical publications (Cross et al. 1971; Rhodes and Ingalls 1975, 1976b).

There was a relative paucity of published literature concerning several issues covered in this search. The Minerals Yearbook (U.S. Bureau of Mines 1973) presented some data on the percentage of asbestos products that are consumed by the construction industry. The 1976 Dodge Manual for Building Construction Pricing and Scheduling (McGraw-Hill 1976) and Building Construction Cost Data 1976 (Godfrey 1976) gave a rough indication of which special trade group may install a particular asbestos product and the approximate man-hours required for field installations.

A few articles presented information on products that compete with or can be substituted for asbestos products (Williams 1971, 1973; Industrial Minerals 1975). EEH's site visits and surveys of asbestos manufacturers, associations, and trade unions supplied more thorough information on these subjects.

No substantially useful information was obtained from the published literature concerning procedures for installation of asbestos products, the percentage of the market a particular product commands, the extent to which asbestos materials have been replaced due to OSHA regulations, the number of workers directly exposed to asbestos products, or the degree and frequency of worker exposure in the construction industry. Again, information on these subjects was sought through site visits and correspondence surveys.

2.2.1.2 Correspondence and Telephone Survey

2.2.1.2.1 Manufacturers

A total of 73 companies associated with asbestos materials were contacted during the survey of manufacturers. Results of the survey have been divided into four categories: questionnaire completed, no construction products, refusal to participate, and no response. The results are tabulated below:

Response	Number of Manufacturers
Questionnaire completed	20
No construction products	39
Refusal to participate	5
No response	9
Total	73

Information obtained from the 20 companies that completed the questionnaire is summarized in Table 2-1 and was also used to develop much of the data presented in Section 2.2.2. Of the seven basic subjects covered by the questionnaire, answers were generally responsive and complete in all areas with the exception of fiber counts. Only two manufacturers had such data available from the actual installation or application of their materials at construction sites.

Precise production and sales figures are regarded as privileged information by most companies and were usually made available only with the assurance that this information would be treated confidentially and used only to develop industry-wide data. Even with assurances, five manufacturers refused to participate in the study, and no response was received from several other companies.

Most manufacturers had no difficulty in identifying the trade groups that utilize their products, even when the products were not used exclusively by the construction trades. There was one difficulty, however, which was caused by the propensity of some manufacturers to separate repair and maintenance work from the construction industry. This was particularly evident in the case of companies that manufacture gaskets and fluid sealings. As a result, scant information was obtained on these products than might otherwise be possible with continued probing for clarification. These companies are included in the total of the 39 companies identified as producing "no construction products." A follow-up survey of these manufacturers is planned to further refine information on these asbestos products.

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Table 2-1

Production and Employment for 1975 in the Manufacture of Asbestos Construction Products

Product	Number of Establishments	Number of Employees	Value of Product (million dollars)	Quantity Produced
Asbestos-cement pipe	4	2,595	160.42	377,000 tons
Asbestos-cement sheets (includes prefabricated components)	5	503	28.44	10,923,700 square feet 36,164 tons
Asbestos-cement shingles	3	452	11.00	518,000 squares
Asbestos compounds	7	590	50.98	45,858,150 gallons
Asbestos felts (except flooring felts)	3	1,054	54.81	55,367 tons 819,000 rolls 280,000 squares
Flooring products	4	3,852	149.00	432,562,000 square feet
Other asbestos construction products (includes insulation, paper, textiles, gaskets, etc.)	7	902	11.48	9,523,000 pounds
Total	21[a]	9,888	465.07	x

Source: EEH 1976b.
x = Quantity not determined as manufacturers' data were given in differing units (tons, square feet, gallons, rolls, etc.)
a. Number does not equal summation of figures in column as some companies produce more than one asbestos construction product.

Of the 39 companies that report no participation in the direct manufacture of asbestos building materials, 37 were active in some other phase of the asbestos industry. This group included mines, importers, distributors of raw asbestos fibers, fabricators, and the manufacturers of friction materials, filters, and asbestos/plastics. The two remaining companies had discontinued the use of asbestos in their manufactured products.

2.2.1.2.2 Manufacturing Trade Associations

Responses were received from 7 of the 10 manufacturing trade associations that were contacted. The information available from these sources, however, does not add materially to that available directly from the manufacturers. Beyond confirmation from several associations that their members do or do not produce asbestos-containing construction products, no industry-wide data were available from them.

The seven responses can be grouped into three categories:

1. Two associations were unable to respond to any part of the questionnaire.
2. Three associations verified that none of their members manufactured asbestos-containing construction materials.
3. Two associations confirmed that some of their members produce asbestos-containing construction materials, but the information they could provide was limited to the names of these specific companies.

2.2.1.2.3 Construction Trade Associations

Construction trade associations are almost equally divided between those that have data relating to asbestos usage by their members and those that do not. The amount and type of detail available from the former group vary considerably, however, and are primarily dependent upon the functions each association performs for its membership and its corresponding internal need for information.

Insulation contractors' associations, for example, have been active for several years in the administration of health surveillance programs for insulation workers. Their knowledge of practices and trends within that industry is extensive and current. To varying degrees, other trade associations have had less need to develop information on product usage and worker exposures, and this fact was reflected in the responses they submitted.

In total, 20 construction trade associations were contacted with the following results:

1. Four associations did not respond to EEH inquiries despite repeated follow-up contacts.
2. One association declined to participate in the study.
3. Eight associations indicated a willingness to cooperate, but simply had no data relevant to the study.
4. The remaining seven associations responded to the questionnaire. The information they provided was particularly useful in identifying asbestos-containing construction products and alternate products used by the various trades, numbers of contractors,

numbers of employees, and, to a lesser degree, dollar volume of sales. All of the information obtained from these associations has been combined with corresponding data from other sources for presentation in Section 2.2.2.

2.2.1.2.4 Construction Trade Unions

The effort to obtain information from construction trade unions was largely nonproductive. Of the nine international unions contacted, only one responded with specific answers to the EEH questionnaire.* Even in this case, the answers were not based upon verifiable data, but instead. represented the best estimate of the union's director of safety.

With this one exception, the responses from the unions fell into three categories:

1. One union refused to participate in an industry-sponsored study, apparently in the belief that the interests of its membership

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* Construction Trade: Carpenters:

1. SIC codes 1742, 1752, 1761, 1771.
2. Asbestos products utilized: siding, wallboard, spackling compounds, roofing materials, vinyl-asbestos floor tile, acoustical materials.
3. Union membership is 800,000. Of this number, 600,000 are in construction work. A carpenter can expect to work approximately 9 months a year. The most significant decline in available work is during the winter.

4 and 5. Although précise information is not available, the union believes that all carpenters are at times exposed directly or indirectly to asbestos.

6. It is also believed that most carpenters who achieve journeyman status remain in the trade until retirement. Those who change to another occupation usually do so during the first 5 years.

would be best served by assuming an "adversary" relationship vis-a-vis industry on questions of worker health.

2. Five unions had simply not developed for their own internal purposes the types of data that were requested. While these unions indicated a willingness to cooperate, they had little or no relevant information. One respondent suggested that the survey was in a sense premature, as construction trade unions are only beginning to accumulate information of this kind. Another union official, who is currently serving on the Construction Safety Advisory Committee to the Secretary of Labor--a committee that is considering problems related to asbestos usage in the construction industry--made the same point.

3. The two remaining unions neither provided information nor refused to do so. Although they were contacted repeatedly, a definite response was never received.

2.2.1.2.5 Regulatory Agencies

Fiber counts taken during the manufacture or use of asbestos-containing products were received from nine of the agencies contacted. (These data are incorporated in Section 4.) Useful data included the operation being performed, the asbestos product, and duration of the sample. The counts were given in fibers per cubic centimeter greater than 5 micrometers in length with a length-width ratio of 3:1. Unless the fiber counts were given as a time-weighted average (TWA), it was assumed that the fiber counts denoted peak exposures.

In addition to the nine agencies that provided data, the OSHA office in Washington, D.C., was another source of fiber count data. The office of Management Data Systems, Division of Program and Systems Analysis, produces a national listing of site inspections performed by OSHA offices. A compilation of site inspections of asbestos exposures between June 1972 and July 1976 included approximately 1,000 listings. The listing for each inspection gave the area office performing the sampling, name of establishment, inspection date, trade group SIC codes from 1967, and a qualitative result (e.g., at or within the standard, 1.1 to 2.1 times the standard, etc.). From the SIC code, over 50 site inspections were identified with the construction industry. Under the Freedom of Information Act requests were made to 33 area offices for more complete information. OSHA responses were placed in the "Responded, No Data" category if they involved a site inspection for which only the asbestos content of the sample was determined, if the product sampled contained no asbestos but another fibrous material (i.e., fiberglass), or if the noted fiber counts were measured by someone other than the OSHA agency. The results of responses to this OSHA survey were as follows:

Response	Number
Supplied fiber count data	21
Responded, no data	6
Incomplete data	2
No response	4
Total No. OSHA offices contacted	33

The fiber count data received from the various state OSHA offices has been tabulated in Section 4 by asbestos product and operation.

2.2.1.3 Site Visits/Observations

A summary of the asbestos products observed at construction sites, the operations being performed, and a statement regarding the conduct of a fiber count survey is contained in Table 2-2. Site observations and fiber count data are incorporated in the appropriate subsection of Section 4. The information obtained was invaluable in terms of putting into proper perspective the operations performed with asbestos-containing materials as well as the conditions existing at various kinds of construction sites.

2.2.2 Subtasks

2.2.2.1 Manufacturing of Construction/Asbestos Products

In identifying types of manufactured products that contain asbestos (Table 2-3), this study relied upon the 1972 Census of Manufactures (U.S. Bureau of the Census 1974a-b, 1975a-b), the Standard Industrial Classification (SIC) Manual (1972), EEH's in-house survey of manufacturers (1976b), and published articles on the history and uses of asbestos (Brodeur 1968). Table 2-3 presents those groups of manufactured goods that include asbestos-containing products. Although the bulk of asbestos products are covered by SIC group 3292 (asbestos products), there are several other groups of manufactured goods that include asbestos-containing products (e.g., paper, building paper, paints, adhesives and sealants, asphalt coatings, plastics, gaskets, etc.). Not all products within these groups contain asbestos

Table 2-2

Summary of Site Visit Observations

Asbestos-Containing Materials	No. of Sites	Operations	Fiber Count Surveys
Asbestos-cement sheet	5	Sawing Installation	3
Asbestos-cement pipe	7	Sawing Filing Installation	1
Roofing felt; asphalt-cement	6	Rolling; cutting Tear-off	1
Vinyl asbestos tile and sheet flooring	3	Installation, sanding, tear-off	3
Shingles	4	Cutting, punching Installation	1
Drilling fluids	7	Addition of fibers	7
Drywall taping compound	2	Application of tape Finishing Sanding	1
Friable asbestos insulation	2	Removal prior to demolition	2
Pipeline felt	1	Wrapping, cutting	0
Coatings	1	Mixing, spraying	1

Table 2-3

Asbestos and Asbestos-containing Products (by SIC)
Used in Construction and Non-Construction Industries

SIC	Product
2621	Paper, except building paper
2661	Building paper and board
26611	Insulating board
26612	Construction paper
2851	Paints, varnishes, lacquers, enamels, and allied products
2891	Adhesives and sealants
2951	Paving mixtures and blocks
2952	Asphalt felts and coatings
3079	Miscellaneous plastics products
3292	Asbestos products
32922	Asbestos friction materials
32924	Asbestos-cement shingles and clapboard
32925	Asphalt floor tile
32926	Vinyl asbestos floor tile
32927	Textiles, insulation, other asbestos and asbestos-containing products
32927 11	Yarn, cord, thread
32927 21	Cloth
32927 31	Other asbestos textiles
32927 35	Pipe insulation
32927 37	Other insulation
32927 41	Asbestos-cement flat sheets and wallboard
32927 51	Asbestos-cement corrugated sheets
32927 73	Asbestos-cement pipe, conduit, ducts
32927 75	Asbestos-cement pressure pipe
32927 81	Asbestos felts--roofing
32927 85	Asbestos felts--other
32927 98	Other asbestos and asbestos-cement products
3293	Gaskets, packing and sealing devices
32932	Gaskets and gasketing
32933	Packing and sealing devices

Note: With the exception of SIC group 3292 products (asbestos products), not all products of a group contain asbestos (e.g., not all gaskets contain asbestos). All SIC groups listed here were identified as including one or more products that do contain asbestos.

(i.e., SIC group 2891 is listed in Table 2-3 because some adhesives and sealants contain asbestos fibers).

Table 2-4 lists in greater detail those asbestos products utilized by the construction industry. This information was gathered from EEH's in-house survey of asbestos manufacturers (1976b). Numbers in parentheses following a product or group of products refer to the SIC group or numbers in which that product will be found.

Table 2-5 is a tabulation of several characteristics of the asbestos product manufacturing industry. For each product listed, the number of establishments producing this product, the number of employees, and more specifically, the number of production workers involved in its manufacture, the quantity produced, and the dollar value of that production are presented. All information in this table is taken from the 1972 Census of Manufactures (U.S. Bureau of the Census 1974a).

A major limitation of these census data is the inability to separate construction from nonconstruction products. For example, asbestos textiles, friction products, insulation, and other asbestos and asbestos-cement products (SIC 32927) are grouped together. Separate figures for number of establishments, employees, and production workers are not given for each product included in this grouping. Few friction products find their way into the construction industry, whereas most insulation and asbestos-cement products are consumed by the construction industry. In addition, SIC group 3292, while including most asbestos products, excludes some asbestos-containing products (such as asbestos-containing compounds) that are widely used in the construction industry. Hence, these data, as presented in the

Table 2-4

Asbestos Products Used in the Construction Industry

Asbestos-cement pipe
- pressure pipe (32927 75)
  - water
  - sewer
- pipe, conduit, ducts (32927 73)
  - electrical
  - sewer
  - telephone
  - transmission
  - water
  - well casing

Asbestos-cement sheets (32927 41 and 32927 51 and 32927 98)
- acoustic ceiling panels
- corrugated sheets
- custom molded wall panels
- extruded panels
- flat sheets
- insulated sandwich panels
- laminated panels
- millboard
- prefabricated housing components
- prefabricated sheets
- roof decking
- roof tiles
- roofing
- siding
- structural sheets
- window sills

Asbestos-cement shingles and clapboard (32924)
- siding shingles
- roofing shingles
- clapboard

Asbestos-containing compounds
- caulking putties
- drilling fluid additives
- emulsions
- fireproof coatings
- foundation coatings
- joint compounds
- mastics

Asbestos-containing compounds (Cont.)
- paints
- plastic cements
- restaurants
- roof adhesives
- roof cements
- roof coatings
- sealing compounds
- spackles
- weather coatings

Asbestos felts
- roofing felts (32927 81)
  - base felts
  - base sheets
  - cap sheets
  - flashing sheets
  - other felts (32927 85)
    - flooring substrate
  - pipeline felts

Asbestos insulation
- pipe insulation (32927 35)
- other insulation (32927 37)

Asbestos paper

Asbestos textiles
- cloth (32927 21)
- rope (32927 31)
- tape (32927 31)

Asphalt floor tile (32925 11)

Miscellaneous asbestos products
- expansion joints
- gasket sheets (32932)

Vinyl-asbestos floor tile (32926)

Table 2-5

Employment and Production for 1972 in the Manufacture of Asbestos Products

SIC	Product	*No. Estab-lish-ments	*Total No. Employees	Produc-tion Workers	Quantity Produced	Dollar Value
3292	Asbestos products, total	142	21,000	16,600	--	$742,600,000
32922	Asbestos friction materials	23	7,900	6,300	--	209,500,000
32924	Asbestos-cement shingles and clapboard	7	600	500	1,300,000 sqs.	20,800,000
32925 11	Asphalt floor tile	x	x	x	9,800,000 sq. yds.	9,100,000
32926	Vinyl asbestos floor tile	18	4,400	3,400	x	199,300,000
32927	Textiles, insulation and other asbestos-cement products	55	7,700	6,100	--	298,600,000
32927 11	Yarn, cord, thread	x	x	x	17,500,000 lbs.	13,700,000
32927 21	Cloth	x	x	x	11,100,000 lbs.	15,100,000
32927 31	Other asbestos textiles	x	x	x	--	8,400,000
32927 35	Pipe insulation	x	x	x	x	20,700,000
32827 37	Other insulation	x	x	x	x	12,800,000
32927 41	Asbestos-cement flat sheets and wallboard	x	x	x	x	20,700,000
32927 73 32927 75	Asbestos-cement pipe, conduit, ducts, pressure pipe	x	x	x	870,100 short tons	143,300,000
32927 81	Asbestos felts: roofing, asphalt or tar saturated	x	x	x	x	23,200,000
32927 85	Asbestos felts: others	x	x	x	x	13,300,000

Source: U.S. Bureau of the Census. 1974a.

* = Primary product class of establishment.
-- = Does not apply.
x = Not available.

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Table 2-5 (Cont.)

SIC	Product	*No. Estab-lish-ments	*Total No. Employees	*No. Produc-tion Workers	Quantity Produced	Dollar Value
32927 51 32927 98	Corrugated sheets, plus other asbestos and asbestos cement products	x	x	x	x	$ 23,700,000
32927 00	Asbestos textiles and other asbestos and asbestos cement products, n.s.k.	x	x	x	x	3,700,000
32920 00 32920 02	Asbestos products, n.s.k.	x	x	x	x	2,600,000
3293	Gaskets, packing and sealing devices	374	27,700	21,100	--	714,700,000
32932	Gaskets, all types	119	9,500	7,500	--	264,600,000
32932 13	Asbestos, compressed	x	x	x	--	24,500,000
32932 15	Asbestos, beater saturated	x	x	x	--	19,200,000
32932 17	Asbestos gasketing cloth	x	x	x	--	2,400,000
32932 51 32932 45 32932 95	Other non-asbestos gaskets and gasketing	x	x	x	--	209,900,000
32932 00	Gaskets, all types, n.s.k.	x	x	x	--	8,500,000
32933	Packing and sealing devices	101	16,100	12,100	--	403,200,000
32933 21- 32933 51	Rubber, plastic, leather packings and seals	x	x	x	--	$291,300,000
32933 61 32933 69	Other packings and seals	x	x	x	--	44,400,000
32933 71 32933 00	Axial mechanized seals and packing and asbestos insulation, n.s.k.	x	x	x	--	67,500,000
32930 00 32930 02	Gaskets and insulation, n.s.k.	x	x	x	--	46,700,000

n.s.k. - Not specified by kind

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Census of Manufactures (U.S. Bureau of the Census 1974a), do not completely describe that portion of the asbestos product manufacturing industry whose goods are ultimately destined for use in the construction industry.

An in-house survey of manufacturers (EEH 1976b) of those asbestos products utilized by the construction industry was therefore conducted to supply this information in the degree of specificity needed. In addition, this survey supplied more recent information than that available in the census data. A total of 20 manufacturers participated by providing information on employment and production of asbestos products utilized in the construction industry for the year 1975. Results of this survey are presented in Table 2-1.

The major groups of construction products manufactured include pipes, sheets, shingles, compounds, felts, and floor tiles. The table indicates the number of participating companies that produced some amount of the product during 1975. For most products listed, the total quantity produced by all manufacturers could not be determined.

Table 2-6 shows the relative distribution of asbestos products into other (consumer) industries. Figures given in thousands of short tons represent the amount of raw fiber contained in the various products. Note that the construction industry consumes 100 percent of asbestos pipe, sheets, floor tile, and roofing papers, as well as 80 percent of asbestos insulation and 70 percent of asbestos coatings and compounds. A total of 77 percent of asbestos fibers as contained in asbestos products are consumed by the construction industry.

Total United States consumption of asbestos during the past decade

Table 2-6

Distribution of Asbestos Products by Consuming Industry

Product	Consuming Industry[a]: Construction 10^3 short tons	Construction %	Transportation 10^3 short tons	Transportation %	Appliance and Equipment 10^3 short tons	Appliance and Equipment %	Total	Percent of Total
Asbestos-cement pipe and sheet	217	100	0	0	0	0	217	26.8
Vinyl asbestos floor tile	152	100	0	0	0	0	152	18.7
Sheet vinyl flooring	96	100	0	0	0	0	96	11.8
Roofing papers	82	100	0	0	0	0	82	10.1
Gaskets and packing	10	14	25	36	35	50	70	8.6
Friction materials	0	0	60	88	8	12	68	8.4
Insulation, pipe and thermal	40	80	0	0	10	20	50	6.2
Coatings and compounds	23	70	5	15	5	15	33	4.1
Plastics	4	17	11	48	8	35	23	2.8
Electrical insulation	0	0	0	0	10	100	10	1.2
Export and re-export	0	0	4	50	4	50	8	1.0
Miscellaneous	0	0	1	50	1	50	2	0.3
Total	624		106		81		811	100.0
Percent of Total	77		13		10		100	

Source: U.S. Bureau of Mines. 1973. Minerals Yearbook. Vol. 1, page 174, Table 7.
a. Quantities and percent of asbestos fiber consumed as various products.

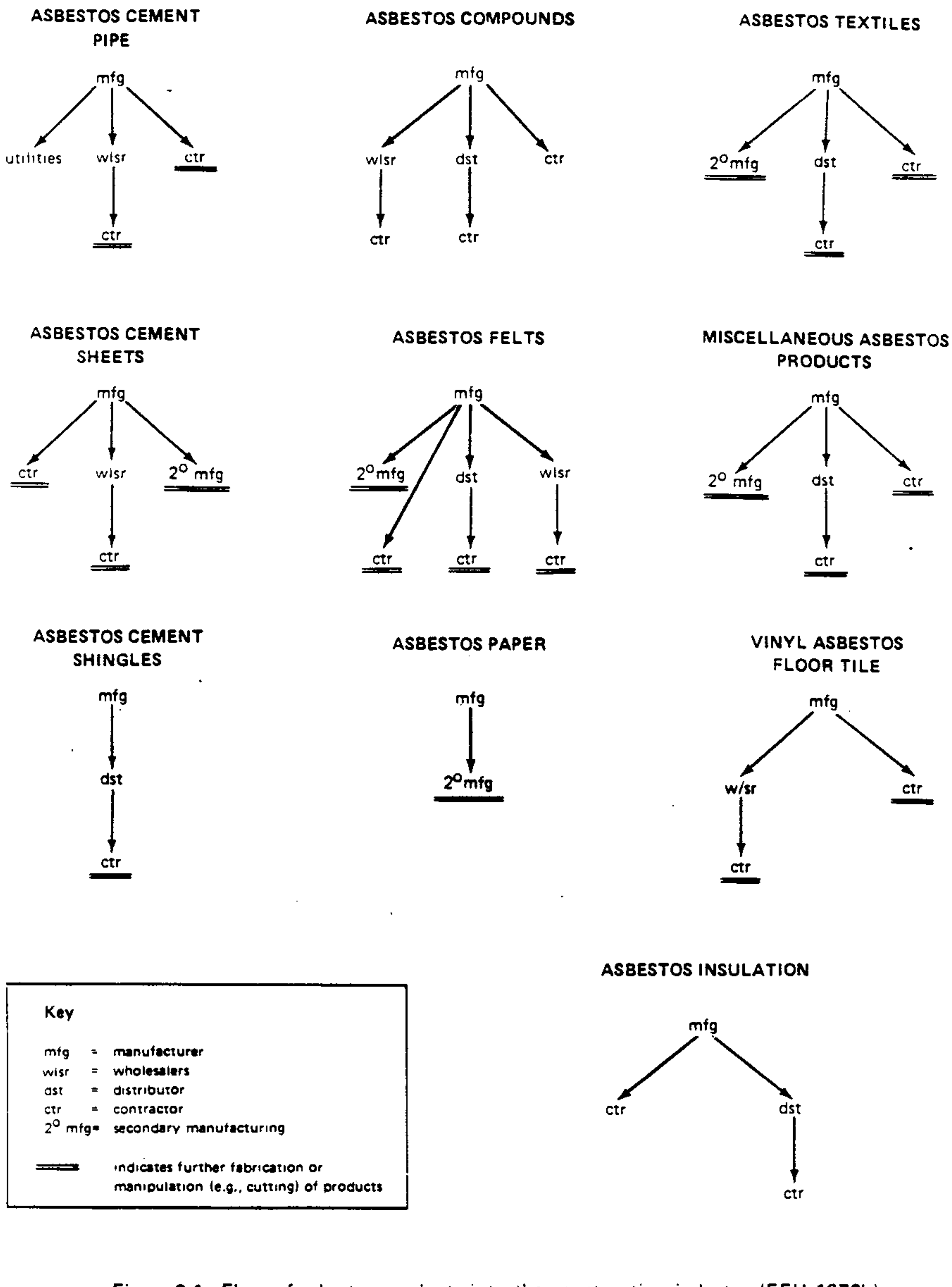

Figure 2-1. Flow of asbestos products into the construction industry (EEH 1976b).

Table 2-8

Exported and Imported Manufactured Asbestos Products, 1972[a]

Imports	Unit	Value
Asbestos yarn, slivers, etc.	4,274,730 lb	$ 3,874,295
Asbestos-cement pipes, tubes, and fittings	35,494,572 lb	1,868,866
Asbestos-cement articles, other	19,907,573 lb	3,252,830
Asbestos articles, other	--	2,326,474
Total		$11,322,465

Exports	Unit	Value
Asbestos-cement shingles and clapboard	20,732,017 lb	$ 2,307,607
Other asbestos-cement fiber-cement articles	19,298,922 lb	2,148,247
Gaskets	523,081 lb	935,421
Packing	4,293,564 lb	6,526,589
Heat or sound insulation	--	1,772,061
Textiles and yarns	17,286,830 lb	4,863,444
Protective clothing	--	320,282
Manufactures other than friction materials	--	4,623,428
Clutch facings and linings for automobile use	1,778,271	1,425,549
Other clutch facings and linings	949,304	482,163
Brake linings for automotive use	6,209,525 lb	4,366,514
Other brake linings	2,782,921 lb	2,286,528
Total		$32,057,833

a. From Asbestos. May 1973. pp. 22-25.

Table 2-9

Exported and Imported Manufactured Asbestos Products, 1974[a]

Imports	Unit	Value
Asbestos yarn, slivers, etc.	7,248,093 lb	$ 7,923,813
Asbestos-cement pipes, tubes, and fittings	14,691,356 lb	1,050,573
Other asbestos-cement articles	54,434,564 lb	6,575,948
Other asbestos articles	--	4,684,986
Total		$20,235,320
Exports		
Asbestos-cement shingles and clapboard	24,690,963 lb	$ 3,347,781
Other asbestos-cement fiber-cement articles	62,550,540 lb	7,715,462
Gaskets	847,961 lb	1,684,712
Packing	5,622,108 lb	10,897,330
Heat or sound insulation	--	4,541,471
Textiles and yarns	18,930,697 lb	8,407,609
Protective clothing	--	556,218
Manufactures other than friction materials	--	10,467,063
Clutch facings and linings for automobile use	1,696,151	1,856,440
Other clutch facings and linings	733,386	647,276
Brake linings for automotive use	8,420,952 lb	6,475,469
Other brake linings	3,427,859 lb	3,661,487
Total		$60,258,318

a. From Asbestos. April 1975. pp. 22-31.

As in 1972, the net exported consisted primarily of friction, packing, and nonspecified categories. In relation to the total amount manufactured, net values applicable to construction product categories are so small that they do not warrant inclusion in the tables.

Although the greatest detail on the manufacturing industry is available only from the 1972 Census of Manufactures, data on major SIC categories are available from the 1974 Annual Survey of Manufactures (U.S. Bureau of the Census 1976b). It is therefore, possible, to extend the 1972 figures to 1974. In addition, identification of secondary asbestos products, i.e., products in which asbestos is a secondary component, such as building paper and board (SIC 2611) and asbestos-backed vinyl floor covering, was carried out and added to the relevant data from Table 2-5 and is presented for 1972 and 1974 in Tables 2-10 and 2-11. The values for asbestos-backed vinyl floor covering were obtained by calculating the quantity of product produced in 1972 and 1974 from the quantity produced in 1973 as identified in a computer search of the Predicasts data base <u>Predicast Market Abstracts</u>. The reference given was Predicast Study T-38, <u>Floor Coverings</u>. The value given was 402 million square feet for felt-backed resilent flooring. Values for 1972 and 1974 were determined by extrapolating from the consumption of plastic in the construction/flooring industry as obtained from <u>Modern Plastics</u> (1974, 1975); the values were 214,000; 202,000; and 156,000 metric tons for 1972, 1973, and 1974, respectively. Once quantities were obtained, the dollar value could be determined by multiplying the unit cost by the total quantity giving total value. Unit costs (Table 2-12) were obtained from <u>Building Construction</u>

Table 2-10

Quantity, Dollar Value, and Cost of Installation for Asbestos-Containing Construction Products Manufactured in 1972

Product	Quantity (000,000 units)	Product Value ($000,000)	Installation Cost ($000,000)	Total Cost ($000,000)
Flooring, tile		$ 455.9		
Plain-backed	1,164.6 sq. ft.	151.3	$192.2	$ 343.5
Adhesive-backed	195.9 sq. ft.[a]	48.0	32.3	80.3
Asphalt	88.2 sq. ft.	9.1	14.5	23.6
Vinyl sheet, asbestos-backed	426.0 sq. ft.	247.5	95.9	343.4
Asbestos-cement pipe	41.1 linear ft.	143.3	65.6	208.9
Roofing		44.0		
Shingles	1.3 squares	20.8	32.5	53.3
Felt	4.46 squares	23.2	10.4 10.0	43.6
(Additional cost for built-up roofing per ply)	3/4 (4.46 squares)			
Asbestos-cement sheets	51.8 sq. ft.	44.4	25.1	69.5
*Insulation				
Pipe	11.2 linear ft.	20.7	17.1	37.8
Other	116.4 sq. ft.	12.8	12.8	25.6
Gaskets, packings, and sealings (selected)		122.1	91.6	213.7
Textiles	39.3 lbs.	37.2	27.9	65.1
Coatings and cements	60.4 gal.	32.2	75.2	107.4
Felts, not specified by kind	2.58	13.4	6.00	19.4
Building paper and board	361.6 sq. ft.	90.4	54.2	144.6
Other[b]	82.9 sq. ft.	22.3	13.4	35.7
Subtotal		1,038.7	776.7	1,815.4
Friction products				
Total				

a. Estimated from Building Construction Cost Data (Godfrey 1974).
b. Includes millboard, prefabricated housing components, felts, textiles, and other asbestos-cement products not specified by kind.
* Indicator of magnitude of future demolition removals.

Table 2-11

Quantity, Dollar Value, and Cost of Installation for Asbestos-Containing Construction Products Manufactured in 1974

Product	Quantity (000,000 units)	Product Value ($000,000)	Installation Cost ($000,000)	Total Cost ($000,000)
Flooring, tile		$ 412.6		
Plain-backed / Adhesive-backed	1,386.9 sq. ft.	227.4	$253.9	$ 481.3
Asphalt	43.2 sq. ft.	5.1	7.8	12.9
Vinyl sheet, asbestos-backed	310.0 sq. ft.	180.1	69.8	249.9
Asbestos-cement pipe	50.0 linear ft.	179.3	89.0	268.3
Roofing				
Shingles	1.15 squares	18.5	30.0	48.5
Felt	5.33 squares	29.2	13.1 / 20.4	62.7
(Additional cost for built-up roofing per ply)	3/4 (5.33 squares)			
Asbestos-cement sheets	61.4 sq. ft.	55.7	38.3	94.0
*Insulation				
Pipe	12.3 linear ft.	26.0[a]	21.07	47.07
Other	167.3 sq. ft.	18.4[a]	18.4	36.8
Gaskets, packings, and sealings (selected)		138.9	114.0	252.9
Textiles	49.3 lbs.[a]	46.7	38.3	85.0
Coatings and cement	100.73 gal.	53.7	125.4	179.1
Felts, not specified by kind	3.07	16.8	7.51	24.31
Building paper and board	421.2 sq. ft.	105.3	63.18	168.48
Other[b]	112 sq. ft.	28.0	16.8	44.8
Subtotal		1,129.1	926.96	2,056.06
Friction Products		274.7		
Total				

a. Estimation based on extrapolation of 1972 data ratio by EEH.
b. Includes millboard, prefabricated housing components, felts, textiles, and other asbestos-cement products not specified by kind.
* Indicator of magnitude of future demolition removals.

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Table 2-12

Unit Value, Installation Cost, and Labor Requirements for Selected Asbests-Containing Construction Products

Product	1972 Unit Value	1972 Installation Cost per Unit	1974 Unit Value	1974 Installation Cost per Unit	Labor Output per Day
Flooring (sq. ft.)	0.245	0.165	0.31	0.18	540 sq. ft.
Asbestos-backed vinyl floor covering (sq. ft.)	0.581	0.225	0.581	0.225	487.5 sq. ft.
Pipe (linear ft.)	3.49	1.6	3.66	1.78	91.3 linear ft.
Shingles (sqs.)	16	25	16	26	4 squares
Roofing Felts (sqs.)	5.20	2.33	5.48	2.45	58 squares
Built up roofing (sqs.)		3.00	--	5.10	28 squares
Asbestos-cement sheets (sq. ft.)	0.857	0.485	0.907	0.623	170.5 sq. ft.
Insulation pipe (linear ft.)	1.85	1.53	2.11	1.71	68.5 linear ft.

$$\frac{\text{Installation Cost}}{\text{Material Cost}} = \text{Ratio Index}$$

Insulation "other"	1	
Coatings and cements	2.33	
Building paper and board	0.6	
"Other"	0.6	
Gaskets, packing, and sealings	0.75	0.82
Textiles	0.75	0.82

that could replace asbestos. This factor was obtained from "Selected Materials Consumed" of the 1972 Census of Manufactures (U.S. Bureau of Cost Data (Godfrey 1973, 1975). Data on building paper and board were obtained by taking the value of SIC 2661 and multiplying it by the percentage of asbestos consumed in that SIC, relative to alternative materials that could replace asbestos. This factor was obtained from "Selected Materials Consumed" in the 1972 Census of Manufactures (U.S. Bureau of the Census 1975a).

Additional data presented in Tables 2-10 and 2-11 include values on quantities produced and installation costs. Data on quantities, when provided, were obtained from census tables. However, for several product categories, either data were not provided or units given were not compatible to EEH's analysis. In these cases, data on product value per unit, e.g., square feet, squares, etc., were derived by averaging data obtained from Building Construction Cost Data for 1972 and 1974 (Godfrey, ed.) and from the Dodge Construction System Costs (McGraw-Hill 1975). Material costs (Table 2-10) per unit could then be divided into total product value providing an estimation of the quantity produced. In certain cases, however, it was not possible to make quantity estimations for product categories due to the non-specific nature of the category, e.g., textiles and gaskets, packings, and sealings. Similarly, in the insulation "other", cements and coatings, and "other" categories, the quantity values represent very rough estimates and these data were not used in calculating installation costs.

Costs of installation were determined by multiplying the unit cost of installation (Table 2-12) from Building Construction Cost Data (Godfrey 1974, 1975) by the total quantity produced, with the exception of insulation "other", coatings, and cements, building paper and board, and the category "other". For these categories, it was more feasible to obtain an index of the cost ratio of installation cost over material cost by averaging material costs versus installation costs from Building Construction Cost Data and the Dodge Construction System Costs for as many items as possible that could be classified into these categories. Thus, if material value is known, the installation value could be calculated. For textiles and gaskets, packings, and sealings, it was impossible to obtain such an index ration with any reliability; therefore, the best alternative was to apply a general ratio to these categories derived from total product value over total installation costs. All unit values can be found in Table 2-12.

2.2.2.2 Construction Industry Characteristics

Total construction employment accounted for approximately 5.2 and 5.4 million persons for 1972 and 1974, respectively, based on the annual tabulations of the current population survey (U.S. Bureau of the Census 1976a).

These figures represent all persons engaged in construction activities, including government, forced-account (i.e., those involved in speculative construction), self-employed, unpaid-family workers, etc. A more manageable, greater detailed data base is the 1972 Census of Construction Industries (U.S. Bureau of the Census 1975d-n) and monthly Construction Review (U.S. Bureau of Domestic Commerce),* which focuses upon the contract construction industry. Contract construction accounts

*Data in Construction Review (U.S. Bureau of Domestic Commerce) are obtained from the U.S. Bureau of Labor Statistics and are compatible with the U.S. BLS Employment and Earnings.

for approximately 70 percent of all construction with population estimates being approximately 4 million in 1972 (quinquinal 1972 Census of Construction Industries) and 3.95 million in 1974 (U.S. Bureau of Labor Statistics 1975).

A general review on the construction industry is available in "Employment and Training Report of the President to the Congress, 1976" (U.S. Department of Labor 1976).

Contract construction is divided into three categories by the federal government: general building contractors, heavy and highway contractors, and special trades contractors. It is this system and sources addressing this system that have primarily been utilized in this study.

In addition, data were also obtained when necessary from the decennial 1970 Census of Population, specifically the subject reports, e.g., Industrial Characteristics, Occupation By Industry (U.S. Bureau of the Census).

From these sources, data have been compiled identifying the major characteristics of the contract construction industry. Table 2-13 is a list of some of the topics for which data were compiled and the years for which data were available.

Data were also gathered for the employment and workforce of oil and gas extractors in SIC 13 and its various subcomponents. Bureau sources used for this compilation were the same as for all other construction SIC's.

Trade groups that utilize asbestos products in the construction industry were first identified according to their SIC code (SIC Manual

Table 2-13

Contract Construction Characteristics

Characteristic	Years Available
Number of proprietors by SIC code	1972
Number of all employees by SIC code	1972/1974 (Selected)
Number of construction workers by SIC code	1972/1974 (Selected)
Seasonal variation of workforce by SIC	1972/1970-1976
Transient characteristics of the construction industry	1970
Average hours worked/week by SIC	1972/1974
Average weeks worked/year by SIC	1970
Average hourly earnings by SIC (Bureau of Labor Statistics and Building Construction Customer Data)	1972/1974
For each SIC, breakdown of number of employees, number of establishments and value paid for materials, components and supplies by $ volume of construction receipts and by employee size of establishment	1972
Payments for materials, components, and supplies for each SIC	1974-extrapolated

1972). The list was prepared from a preliminary investigation of construction products that contain asbestos and a common-sense interpretation of the probable user. This list has been verified and amended by the EEH survey of manufacturers (1976b) and the survey of trade unions (1976d) to include most construction trade groups.

In Table 2-14, the trade groups are identified by the SIC code and number of employees. The U.S. Bureau of the Census in the 1972 Census of Construction Industries (1975) gives both the average number of construction workers and the average number of all employees for each four-digit SIC code. Data for number of workers in subsequent years are given in the monthly publication of the U.S. Bureau of Domestic Commerce, Construction Review, and in the monthly publication of the U.S. Bureau of Labor Statistics, Employment and Earnings. These monthly publications, however, do not detail the data to a complete four-digit code system. As an example, in Table 2-14, the number of carpentering contractors (SIC 1751) is designed for 1972, but they are part of the total for the figures given in the two-digit SIC code 17, all special trade contractors, for 1974.

The data presented in Table 2-14 are for establishments with payroll only. There is limited information on the individual proprietor working in the construction industry during 1972. These people account for approximately 10 percent of the construction work force identified in the 1972 Census although they account for 482,865, or 52 percent of the 920,806 construction work establishments. The majority of this group

Table 2-14

Number of Workers in Trade Groups Identified by SIC Code for 1972 and 1975

SIC	Trade Group	Number of Employees, 1972 [a]		Number of Employees, 1972 (Revision) [b]		Number of Employees, 1974		Number of Employees, 1975 [b]	
		All Employees (average)	Construction Workers (average)	All Employees (average)	Construction Workers (average)	All Employees (average)	Construction Workers (average)	All Employees (average)	Construction Workers (average)
	All contract construction	4,083,465	3,464,203	3,831,000	3,166,000	3,957,000	3,234,000	--	--
15	General building contractors	1,149,520	937,771	1,196,500	980,000	1,225,600	987,100	1,047,900	826,700
152	Residential building construction	--	--	--	--	--	--	--	--
1521 and 1531	Single-family housing construction Operative builders	469,152	365,778	--	--	--	--	--	--
1522	Residential, not elsewhere classified	112,215	94,627	--	--	--	--	--	--
154	Non-residential building construction	--	--	--	--	--	--	--	--
1541	Industrial buildings and warehouses	173,094	144,625	--	--	--	--	--	--
1542	Non-residential construction, not elsewhere classified	395,059	332,741	--	--	--	--	--	--
16	Heavy construction contractors	827,346	709,306	739,100	626,700	778,100	653,900	692,500	572,500
161 / 1611	Highway and street construction / Highway and street construction	278,107	244,292	340,700	297,700	337,400	291,400	296,500	253,000

01-000600

Table 2-14 (Cont.)

SIC	Trade Group	Number of Employees, 1972[a]		Number of Employees, 1972 (Revision)[b]		Number of Employees, 1974		Number of Employees, 1975[b]	
		All Employees (average)	Construction Workers (average)	All Employees (average)	Construction Workers (average)	All Employees (average)	Construction Workers (average)	All Employees (average)	Construction Workers (average)
162	Heavy construction, except highway and street construction	549,239	465,014	398,400	329,000	440,800	362,600	396,000	319,500
1622	Bridge, tunnel, elevated highway construction	53,710	47,366	--	--	--	--	--	--
1623	Water, sewer, pipe line, communication and power line construction	209,318	184,199	--	--	--	--	--	--
1629	Heavy construction, not elsewhere classified	286,211	233,449	--	--	--	--	--	--
17	All special trade contractors	2,106,599	1,817,126	1,895,700	1,559,000	1,953,400	1,593,000	1,716,800	1,362,600
1711	Plumbing, heating (except electric), and air conditioning	456,100	371,113	467,200	368,400	472,000	370,000	413,800	314,300
1721	Painting, paper hanging, and decorating	136,575	125,807	134,600	116,200	139,300	120,900	123,000	105,000
1731	Electrical work	323,748	271,441	324,700	259,300	351,200	281,600	315,900	247,100
174	Masonry, stonework, tile setting, and plastering	366,818	334,820	245,900	220,600	228,300	201,800	189,100	163,600

Table 2-14 (Cont.)

SIC	Trade Group	Number of Employees, 1972[a] All Employees (average)	Number of Employees, 1972[a] Construction Workers (average)	Number of Employees, 1972 (Revision)[b] All Employees (average)	Number of Employees, 1972 (Revision)[b] Construction Workers (average)	Number of Employees, 1974 All Employees (average)	Number of Employees, 1974 Construction Workers (average)	Number of Employees, 1975[b] All Employees (average)	Number of Employees, 1975[b] Construction Workers (average)
1741	Masonry, stonesetting, and other stone work	165,580	165,395	--	--	--	--	--	--
1742	Plastering, drywall, acoustical, and insulation work	170,364	151,825	--	--	--	--	--	--
1743	Terrazzo, tile, marble, and mosaic work	30,874	26,600	--	--	--	--	--	--
175	Carpentering and flooring	168,172	151,866	--	--	--	--	--	--
1751	Carpentering	123,910	115,464	--	--	--	--	--	--
1752	Floor laying and other floor-work, not elsewhere classified	44,262	36,402	--	--	--	--	--	--
1761	Roofing and sheet metal work	158,051	134,189	121,000	99,000	130,300	106,800	119,900	96,500
1771	Concrete work	147,942	135,041	--	--	--	--	--	--
1799	Special trade contractors, not elsewhere classified	101,294	82,899	--	--	--	--	--	--
		4,145,779	3,486,592	3,831,000	3,166,000	3,957,000	3,234,000	3,457,000	2,762,000

a. Source: U.S. Bureau of the Census. 1975n. 1972 Census of Construction Industries. Industry Series, U.S. Summary.
b. Source: U.S. Bureau of Domestic Commerce, Statistical Series. 1976a. Construction Review. Vol. 22, No. 3.
-- = Not given.

is special trade contractors (80 percent); however, there is no further indication as to which trade groups are included in this figure except for plumbers (SIC 1711) and electricians (SIC 1731). The data for characterizing these workers in the construction industry are shown in Table 2-15.

In addition to noting the number of establishments or locations of business, the number of proprietors are given for each SIC code group for the year 1972. Tables 2-16 to 2-31 show that there are, for establishments with employed workers, 272,501 proprietors employing an average of 4,083,465 people. Therefore, the total workforce employed in 1972, including individual proprietors, was 4,827,320. A similar breakdown for individual proprietors is not available for 1974. The population data presented in Table 2-14 represent only those construction establishments with employees in 1974.

Data available for 1972 construction establishments according to the size of business by both employee size and dollar volume (Tables 2-16 to 2-31) are not tabulated for 1974. The only data available for 1974 is a total figure for payments for materials components and supplies for the whole industry (U.S. Bureau of Economic Analysis 1976), which is presented in Table 2-32.

As general building contractors encompass nearly a third of the work force and well over a third of the construction receipts, it is interesting to note that 41 percent of the total construction receipts received by operative and residential contractors (SIC 152 and 153) is

Table 2-15

Selected Characteristics for Proprietors in the Construction Industry With No Employees

SIC Code	Number of Establishments	Number of Proprietors	Total Receipts (1,000's)
15, 16, 17	476,107	471,354	$8,369,423
15	73,329	71,663	3,024,195
16	14,726	14,383	460,355
17	384,343	383,592	4,863,871
1711	35,070	34,782	779,456
1731	25,361	25,224	518,076

Table 2-16

General Building Contractors and Operative Builders (SIC 15)

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										77,916
Total No. Establishments	85,304	24,171	12,747	7,445	2,149	941	214	65	18	133,054
Average No. All Employees	161,062	157,618	169,850	222,568	146,887	136,250	74,127	43,320	37,838	1,149,520
Total Construction Receipts (thousands of dollars)	8,542,458	6,917,294	7,824,138	11,739,475	9,199,512	8,536,636	5,143,407	2,424,092	1,538,282	61,865,294
Payments for Materials, Components, and Supplies (thousands of dollars)	3,030,380	2,363,535	2,297,648	2,961,419	1,975,543	1,810,035	1,050,592	493,934	430,943	16,414,029
Standard Error of Estimates for Average No. Employees (percent)	2	2	2	1	1	1	1	1	1	1

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Table 2-16 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	7,058	13,132	19,342	25,497	30,917	16,297	9,879	6,663	2,319	1,950	133,054
Average No. All Employees	6,708	15,423	37,637	72,106	145,759	134,082	133,776	173,710	120,382	309,937	1,149,520
Total Construction Receipts (thousands of dollars)	37,507	219,044	693,501	1,793,231	4,765,507	5,529,425	6,588,002	9,757,878	7,697,294	24,783,905	61,865,294
Payments for Materials, Components, and Supplies (thousands of dollars)	56,383	88,265	282,388	714,485	1,850,015	1,989,698	2,115,807	2,668,619	1,734,507	4,913,862	16,414,029
Standard Error of Estimates for Average No. Employees (percent)	5	4	3	3	2	2	2	1	1	1	1

Table 2-17

Heavy Construction General Contractors (SIC 16)

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										13,440
Total No. Establishments	12,246	4,667	3,992	3,904	1,681	1,076	269	103	53	27,991
Average No. All Employees	21,641	30,924	55,181	120,572	115,293	161,484	91,245	231,006	(a)	827,346
Total Construction Receipts (thousands of dollars)	759,543	965,276	1,815,765	4,338,610	4,257,418	6,463,227	3,475,272	8,438,898	(a)	30,514,009
Payments for Materials, Components, and Supplies (thousands of dollars)	254,549	320,625	597,642	1,404,390	1,375,775	1,954,636	1,104,969	3,091,108	(a)	10,103,694
Standard Error of Estimates for Average No. Employees (percent)	3	4	3	2	1	1	1	1	--	1

a. Withheld to avoid disclosing figures for individual companies. Data are included in underscored figures in adjoining column.

Table 2-17 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	1,306	2,203	3,838	3,900	5,173	3,609	2,870	2,808	1,150	1,134	27,991
Average No. All Employees	1,337	2,517	6,835	12,755	35,472	46,407	67,484	128,683	105,082	420,774	827,346
Total Construction Receipts (thousands of dollars)	6,836	35,598	137,614	270,707	821,241	1,245,299	1,996,620	4,305,207	3,915,017	17,779,870	30,514,009
Payments for Materials, Components, and Supplies (thousands of dollars)	6,456	12,945	48,846	90,979	259,517	404,077	645,758	1,397,361	1,243,676	5,994,079	10,103,694
Standard Error of Estimates for Average No. Employees (percent)	8	9	6	5	4	3	3	1	1	1	1

Table 2-18

Selected Characteristics of Water, Sewer, and Utility Line Contractors (SIC 1623)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTORS

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										4,360
Total No. Establishments	3,695	1,764	1,527	1,493	530	267	53	20	6	9,355
Average No. All Employees	6,693	11,786	20,979	45,294	35,797	38,943	17,730	13,465	18,631	209,318
Total Construction Receipts (thousand of dollars)	235,908	336,888	656,025	1,458,500	1,132,278	1,188,962	437,924	392,239	328,758	6,227,482
Payments for Materials, Components, and Supplies (thousands of dollars)	80,965	119,480	222,590	503,733	363,368	346,605	127,686	100,926	35,051	1,909,404
Standard Error of Estimates for Average No. Employees (percent)	6	6	4	3	1	1	1	1	1	1

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a. U.S. Bureau of the Census. 1975d. Census of Construction Industries, 1972. Industry Series (SIC 1623), April 1975.

Table 2-18 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999(b)	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	385	625	1,155	1,398	1,893	1,354	1,106	962	291	186	9,355
Average No. Employees	359	666	2,434	4,993	14,081	18,894	28,204	47,964	28,645	63,078	209,318
Total Construction Receipts (thousands of dollars)	2,184	9,972	42,132	99,896	304,615	471,157	782,920	1,485,894	985,749	2,042,963	6,227,482
Payments for Materials, Components, and Supplies (thousands of dollars)	1,037	3,556	15,329	32,712	95,333	152,312	258,515	481,309	308,968	551,333	1,900,404
Standard Error of Estimates for Average No. Employees (percent)	15	14	11	9	5	4	4	1	1	1	1

b. Over 30 percent of the data was estimated.

Table 2-19

Special Trade Contractors (SIC 17)

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										
Total No. Establishments	168,396	49,728	28,785	16,331	4,053	1,395	239	48	7	268,982
Average No. All Employees	314,563	325,538	386,669	485,293	271,914	200,596	79,797	30,083	12,146	2,106,599
Total Construction Receipts (thousands of dollars)	8,179,059	7,326,585	9,495,468	13,362,993	7,858,355	5,961,940	3,251,752	(a)	295,362	55,731,514
Payments for Materials, Components, and Supplies (thousands of dollars)	2,947,352	2,677,150	3,453,381	4,745,865	2,692,744	1,953,745	1,014,726	(a)	82,016	19,566,979
Standard Error of Estimates for Average No. Employees (percent)	1	1	1	1	1	1	3	1	1	1

a. Withheld to avoid disclosing figures for individual companies. Data are included in underscored figures in adjoining column.

Table 2-19 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	20,764	37,489	53,595	57,920	53,342	22,882	12,915	7,427	1,869	779	268,982
Average No. All Employees	14,059	53,849	119,593	203,233	367,550	314,561	315,483	350,727	180,824	186,720	2,106,599
Total Construction Receipts (thousands of dollars)	108,293	636,524	1,926,306	4,054,242	8,209,804	7,818,700	8,745,418	10,951,538	6,194,402	7,086,287	55,731,514
Payments for Materials, Components, and Supplies (thousands of dollars)	44,916	198,830	619,512	1,405,750	2,958,605	2,860,047	3,157,056	3,902,594	2,107,314	2,312,715	19,566,979
Standard Error of Estimates for Average No. Employees (percent)	3	2	2	2	1	1	1	1	2	1	1

01-020505

Table 2-20

Selected Characteristics of Plumbing, Heating, and Air Conditioning Contractors (SIC 1711)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										30,746
Total No. Contractors	31,500	10,444	6,451	3,666	841	325	61	11	2	53,301
Average No. All Employees	58,469	68,973	86,885	108,507	57,152	45,791	20,647	9,676[b]		456,100
Total Construction Receipts (thousands of dollars)	1,899,055	1,912,100	2,621,773	3,880,446	2,167,557	1,764,758	780,782	294,664[b]		15,321,135
Payments for Materials, Components, and Supplies (thousands of dollars)	860,154	822,973	1,088,589	1,541,136	817,272	617,621	263,362	82,821[b]		6,093,928
Standard Error of Estimates for Average No. Employees (percent)	2	3	2	1	1	1	1	1		1

a. U.S. Bureau of the Census. 1975e. Census of Construction Industries, 1972. Industry Series (SIC 1711), April 1975.
b. Data combined to avoid disclosing figures of individual contractors.

Table 2-20 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	2,895	4,829	8,274	12,066	12,961	5,934	3,339	2,127	592	284	53,301
Average No. All Employees	1,918	5,030	13,243	33,919	75,691	68,600	69,017	83,532	46,215	58,935	456,100
Total Construction Receipts (thousands of dollars)	16,025	84,706	304,000	853,686	1,995,065	2,010,666	2,268,184	3,191,472	1,994,347	2,602,984	15,321,135
Payments for Materials, Components, and Supplies (thousands of dollars)	11,233	37,449	134,046	381,036	886,548	868,880	946,168	1,261,064	713,089	854,415	6,093,928
Standard Error of Estimates for Average No. Employees (percent)	8	6	4	3	3	2	1	1	1	1	1

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Table 2-21

Selected Characteristics of Painting, Paper Hanging, and Decorating (SIC 1721)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										23,828
Total No. Establishments	22,036	4,147	1,736	860	169	58	5	--	--	29,011
Average No. All Employees	39,522	26,507	23,151	25,436	11,238	8,668	2,053	--	--	136,575
Total Construction Receipts (thousands of dollars)	695,298	402,697	381,886	468,157	218,007	163,510	52,746	--	--	2,382,301
Payments for Materials, Components, and Supplies (thousands of dollars)	141,170	80,091	73,422	88,705	42,658	48,468[b]		--	--	474,514
Standard Error of Estimates for Average No. Employees (percent)	3	4	3	2	1	1	1	--	--	1

a. U.S. Bureau of the Census. 1975f. Census of Construction Industries, 1972. Industry Series (SIC 1721), March 1975.
b. Data combined to avoid disclosing figures of individual contractors.

Table 2-21 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000[c]	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	3,853	7,020	7,918	5,335	3,232	952	459	198	38	6	29,011
Average No. All Employees	2,546	10,217	19,617	22,815	27,540	17,872	15,162	13,051	5,718	2,037	136,575
Total Construction Receipts (thousands of dollars)	19,824	117,998	278,608	363,458	483,899	329,033	309,238	288,341	130,797	61,055	2,382,301
Payments for Materials, Components, and Supplies (thousands of dollars)	4,612	23,395	56,537	73,039	96,532	62,768	58,556	57,559	41,516[b]		474,514
Standard Error of Estimates for Average No. Employees (percent)	1	5	4	4	3	2	1	1	1		1

c. Over 30 percent of the data was estimated.

Table 2-22

Selected Characteristics of Electrical Work Contractors (SIC 1731)[(a)]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										17,728
Total No. Establishments	18,732	6,102	4,033	2,566	668	283	56	13	2	32,455
Average No. All Employees	35,096	40,412	54,384	76,204	45,005	42,066	18,823	11,758		323,748
Total Construction Receipts (thousands of dollars)	1,058,944	1,016,729	1,447,180	2,205,755	1,425,771	1,348,340	643,777	302,385		9,448,881
Payments for Materials, Components, and Supplies (thousands of dollars)	445,360	417,384	580,874	849,899	544,567	477,493	201,962	74,353		3,591,892
Standard Error of Estimates for Average No. Employees (percent)	3	3	2	1	1	1	1	1		1

a. U.S. Bureau of the Census. 1975g. Census of Construction Industries, 1972. Industry Series (SIC 1731), April 1975.

Table 2-22 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	1,697	2,591	5,231	8,027	7,365	3,628	2,113	1,269	349	185	32,455
Average No. All Employees	997	2,865	8,806	22,669	46,843	47,109	50,538	59,321	35,645	48,955	323,748
Total Construction Receipts (thousands of dollars)	8,453	43,833	189,588	568,976	1,134,124	1,243,795	1,451,380	1,884,826	1,190,937	1,732,969	9,448,881
Payments for Materials, Components, and Supplies (thousands of dollars)	4,599	19,676	79,889	236,002	468,609	499,609	571,294	720,056	437,219	555,128	3,591,892
Standard Error of Estimates for Average No. Employees (percent)	11	8	5	4	3	2	1	1	1	1	1

Table 2-23

Masonry, Stone Setting, and Other Stonework Special Trade Contractors (SIC 1741)

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										20,444
Total No. Establishments	15,040	4,949	2,311	1,186	300	96	10	4	--	23,896
Average No. All Employees	28,322	31,871	30,653	35,546	20,048	13,474	3,022	2,644	--	165,580
Total Construction Receipts (thousands of dollars)	544,013	486,710	534,073	682,930	410,688	308,378	45,870	63,097	--	3,085,759
Payments for Materials, Components, and Supplies (thousands of dollars)	165,748	144,612	162,433	209,237	128,109	93,849	36,357	(a)	--	940,345
Standard Error of Estimates for Average No. Employees (percent)	3	4	4	3	4	1	1	1	--	2

a. Withheld to avoid disclosing figures for individual companies. Data are included in underscored figures in adjoining column.

Table 2-23 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	2,428	4,718	5,868	4,781	3,604	1,354	707	344	71	21	23,896
Average No. All Employees	1,687	8,349	17,943	22,619	30,923	24,772	22,877	20,830	9,094	6,486	165,580
Total Construction Receipts (thousands of dollars)	12,973	79,992	209,143	334,950	554,421	475,806	484,065	518,348	236,878	179,183	3,085,759
Payments for Materials, Components, and Supplies (thousands of dollars)	(a)	25,583	56,005	95,815	166,039	146,890	150,889	168,610	72,805	57,709	940,345
Standard Error of Estimates for Average No. Employees (percent)	9	6	5	5	4	3	4	2	1	1	2

01-02263

Table 2-24

Selected Characteristics of Plastering, Drywall, and Insulation Contractors (SIC 1742)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										8,836
Total No. Establishments	6,811	2,513	1,847	1,582	473	157	28	2	2	13,415
Average No. All Employees	13,250	16,504	25,328	48,132	31,840	21,865	8,792		4,653[b]	170,364
Total Construction Receipts (thousands of dollars)	358,400	376,945	564,859	1,160,273	765,564	525,909	222,327		110,410[b]	4,084,687
Payments for Materials, Components, and Supplies (thousands of dollars)	112,528	128,751	201,884	403,011	258,403	163,987	62,616		33,958[b]	1,365,138
Standard Error of Estimates for Average No. Employees (percent)	4	5	3	3	3	1	1		1	1

a. U.S Bureau of the Census. 1975h. Census of Construction Industries, 1972. Industry Series (SIC 1742), May 1975.
b. Data combined to avoid disclosing figures of individual contractors.

Table 2-24 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	865	1,416	2,042	2,573	2,891	1,594	1,099	717	172	46	13,415
Average No. All Employees	624	2,178	4,743	9,546	22,207	24,799	32,566	38,566	20,790	14,519	170,364
Total Construction Receipts (thousands of dollars)	3,985	24,745	74,550	180,573	457,413	555,359	744,534	1,031,599	565,730	446,199	4,084,687
Payments for Materials, Components, and Supplies (thousands of dollars)	1,426	6,423	21,615	54,180	150,902	195,990	264,850	351,979	190,216	127,557	1,365,138
Standard Error of Estimates for Average No. Employees (percent)	12	10	8	7	4	3	4	1	1	1	1

Table 2-25

Selected Characteristics of Carpentering Contractors (SIC 1751)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										19,515
Total No. Establishments	17,170	3,787	1,552	736	206	63	10	--	--	23,524
Average No. All Employees	31,560	24,163	20,606	21,935	13,824	8,724	3,098	--	--	123,910
Total Construction Receipts (thousands of dollars)	641,720	391,923	356,773	415,518	267,195	178,536	77,480	--	--	2,329,145
Payments for Materials, Components, and Supplies (thousands of dollars)	192,754	113,068	93,559	107,527	73,303	45,717	23,667	--	--	649,595
Standard Error of Estimates for Average No. Employees (percent)	3	5	5	3	2	1	1	--	--	2

a. U.S. Bureau of the Census. 1975i. Census of Construction Industries, 1972. Industry Series (SIC 1751), May 1975.

Table 2-25 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	2,800	5,005	6,331	4,560	3,250	827	449	240	46	16	23,524
Average No. All Employees	2,017	9,025	16,583	18,428	26,203	15,261	13,433	14,272	4,931	3,757	123,910
Total Construction Receipts (thousands of dollars)	14,217	86,577	224,346	310,840	482,773	281,269	303,093	348,086	147,077	130,867	2,329,145
Payments for Materials, Components, and Supplies (thousands of dollars)	5,092	25,385	38,701	83,267	126,226	69,315	83,197	103,301	53,741	41,370	649,595
Standard Error of Estimates for Average No. Employees (percent)	8	5	5	5	4	2	2	1	1	1	2

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Table 2-26

Selected Characteristics of Floor Laying and Floorwork Contractors, Not Elsewhere Classified (SIC 1752)[(a)]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										6,637
Total No. Establishments	6,634	1,266	745	333	63	11	--	--	--	9,052
Average No. All Employees	10,927	8,371	9,973	9,554	3,862	1,575	--	--	--	44,262
Total Construction Receipts (thousands of dollars)	291,223	197,945	256,950	268,954	120,005	40,769	--	--	--	1,175,846
Payments for Materials, Components, and Supplies (thousands of dollars)	119,994	86,890	110,094	125,985	56,742	17,213	--	--	--	516,918
Standard Error of Estimates for Average No. Employees	5	6	4	1	1	1	--	--	--	2

a. U.S. Bureau of the Census. 1975j. Census of Construction Industries, 1972. Industry Series (SIC 1752), May 1975.

Table 2-26 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	841	1,945	2,087	1,655	1,407	623	313	156	21	4	9,052
Average No. All Employees	528	2,230	3,860	5,709	9,078	7,794	6,528	6,419	1,483	633	44,262
Total Construction Receipts (thousands of dollars)	4,794	34,038	72,913	111,754	219,596	211,094	206,756	220,243	66,668	27,990	1,175,843
Payments for Materials, Components, and Supplies (thousands of dollars)	1,861	10,724	23,689	40,589	96,186	91,111	91,238	113,618	36,468	11,434	516,918
Standard Error of Estimates for Average No. Employees (percent)	14	8	8	8	5	4	.2	1	1	1	2

Table 2-27

Selected Characteristics of Roofing and Sheet Metal Work Contractors (SIC 1761)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										11,[illegible]3
Total No. Establishments	10,968	3,345	2,328	1,452	342	91	7	2	--	18,5[illegible]
Average No. All Employees	21,676	22,237	31,473	43,080	22,903	12,601	4,081[b]		--	158,051
Total Construction Receipts (thousands of dollars)	584,970	483,597	723,169	1,104,777	623,178	337,392	83,160[b]		--	3,940,243
Payments for Materials, Components, and Supplies (thousands of dollars)	220,592	184,826	271,096	412,987	235,827	123,492	15,029[b]		--	1,463,849
Standard Error of Estimates for Average No. Employees (percent)	4	4	3	2	1	1	1		--	1

a. U.S. Bureau of the Census. 1975l. Census of Construction Industries, 1972. Industry Series (SIC 1761), April 1975.
b. Data combined to avoid disclosing figures of individual contractors.

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Table 2-27 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	1,102	2,259	3,406	4,406	3,700	1,790	1,119	604	117	32	18,535
Average No. All Employees	824	3,133	7,649	16,329	27,231	25,956	27,336	31,007	11,402	7,184	158,051
Total Construction Receipts (thousands of dollars)	5,761	36,686	124,536	308,657	581,849	616,049	767,257	892,011	371,029	236,408	3,940,243
Payments for Materials, Components, and Supplies (thousands of dollars)	3,504	14,101	46,571	113,443	216,266	229,557	286,575	338,037	135,624	80,171	1,463,849
Standard Error of Estimates for Average No. Employees (percent)	12	8	6	5	4	3	2	2	1	1	1

Table 2-28

Selected Characteristics of Concrete Work Contractors (SIC 1771)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										12,394
Total No. Establishments	10,069	4,074	2,223	1,045	262	74	19	5	1	17,772
Average No. All Employees	21,346	26,538	29,715	31,348	17,223	10,957	6,068	4,729		147,924
Total Construction Receipts (thousands of dollars)	534,917	577,353	729,263	809,398	455,023	279,394	165,298	99,692		3,650,338
Payments for Materials, Components, and Supplies (thousands of dollars)	203,344	225,296	272,778	309,405	169,797	89,340	89,902[b]			1,359,862
Standard Error of Estimates for Average No. Employees (percent)	4	4	4	3	1	1	1	1		2

a. U.S. Bureau of the Census. 1975k. Census of Construction Industries, 1972. Industry Series (SIC 1771). April 1975.
b. Data combined to avoid disclosing figures of individual contractors.

Table 2-28 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	952	1,953	3,668	4,139	4,031	1,575	880	419	114	41	17,772
Average No. All Employees	650	3,118	9,697	17,028	29,668	22,149	21,211	20,520	11,916	11,967	147,924
Total Construction Receipts (thousands of dollars)	5,134	32,266	134,936	292,670	629,980	546,749	603,132	635,496	372,389	397,586	3,650,338
Payments for Materials, Components, and Supplies (thousands of dollars)	2,079	11,526	48,227	106,910	233,375	207,517	232,731	246,891	136,053	134,553	1,359,862
Standard Error of Estimates for Average No. Employees (percent)	14	8	6	5	4	4	4	2	1	1	2

Table 2-29

Selected Characteristics of Special Trade Contractors, Not Elsewhere Classified (SIC 1799)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										9,253
Total No. Establishments	10,037	2,708	1,700	768	156	39	11	1	--	15,420
Average No. All Employees	17,154	17,696	22,704	22,570	10,590	6,174	4,406[b]		--	101,294
Total Construction Receipts (thousands of dollars)	470,752	414,784	531,855	541,052	275,002	135,952	70,895[b]		--	2,440,265
Payments for Materials, Components, and Supplies (thousand of dollars)	156,505	146,533	196,514	178,787	122,039[b]		14,794[b]		--	815,172
Standard Error of Estimates for Average No. Employees (percent)	4	5	4	4	1	1	1	1	--	1

a. U.S. Bureau of the Census. 1975m. Census of Construction Industries, 1972. Industry Series (SIC 1799), 1975
b. Data combined to avoid disclosing figures of individual contractors.

Table 2-29 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	1,663	2,419	2,697	3,305	3,044	1,264	651	288	70	19	15,420
Average No. All Employees	940	3,327	5,707	11,982	21,428	17,156	15,314	13,313	12,127(b)		101,294
Total Construction Receipts (thousands of dollars)	8,538	39,401	95,860	230,275	477,902	426,045	421,878	395,637	344,729(b)		2,440,265
Payments for Materials, Components, and Supplies (thousands of dollars)	15,492(b)		29,911	76,608	165,123	152,994	150,588	121,915	102,541(b)		815,172
Standard Error of Estimates for Average No. Employees (percent)	10	8	6	6	4	4	4	3	1		2

Table 2-30

Selected Characteristics of Wrecking and Demolition Work Contractors (SIC 1795)[a]

A. AVERAGE EMPLOYMENT SIZE OF CONTRACTOR

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										559
Total No. Establishments	530	215	171	86	21	4	--	--	--	1,027
Average No. All Employees	931	1,404	2,355	2,423	1,351	603	--	--	--	9,067
Total Construction Receipts (thousands of dollars)	31,791	31,350	47,028	59,874	36,153	13,216	--	--	--	219,412
Payments for Materials, Components, and Supplies (thousands of dollars)	3,203	4,146	6,029	5,470	3,327	2,314	--	--	--	24,489
Standard Error of Estimates for Average No. Employees (percent)	12	12	10	3	1	1	--	--	--	4

a. U.S. Bureau of the Census. 1975p. Census of Construction Industries, 1972. Industry Series (SIC 1795).

Table 2-30 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	91	133	117	153	312	106	72	34	9	--	1,027
Average No. All Employees	58	174	356	598	2,294	1,301	1,832	1,505	949	--	9,067
Total Construction Receipts (thousands of dollars)	439	2,024	4,101	11,169	49,383	33,713	47,219	44,643	26,721	--	219,412
Payments for Materials, Components, and Supplies (thousands of dollars)	64	331	778	1,277	5,654	4,195	4,168	4,347	3,675	--	24,489
Standard Error of Estimates for Average No. Employees (percent)	29	19	35	18	11	5	3	1	1	--	4

Table 2-31

Total Construction Industries (SIC 15, 16, 17)

A. *AVERAGE EMPLOYMENT SIZE OF CONTRACTOR*

Selected Characteristics	1-4 Employees	5-9 Employees	10-19 Employees	20-49 Employees	50-99 Employees	100-249 Employees	250-499 Employees	500-999 Employees	1,000+ Employees	Total
Total No. Proprietors										272,501
Total No. Establishments	265,946	78,566	45,524	27,680	7,883	3,412	722	216	78	430,027
Average No. All Employees	497,266	514,080	611,700	828,433	534,094	498,330	245,169	354,393	(a)	4,083,465
Total Construction Receipts (thousands of dollars)	17,481,060	15,209,155	19,135,371	29,441,078	21,315,285	20,961,803	24,567,065	(a)	(a)	148,110,817
Payments for Materials, Components, and Supplies (thousands of dollars)	6,232,281	5,361,310	6,348,671	9,111,674	6,044,062	5,718,416	7,268,288	(a)	(a)	46,084,702
Standard Error of Estimates for Average No. Employees (percent)	1	1	1	1	1	1	1	--	--	1

a. Withheld to avoid disclosing figures for individual companies. Data are included in underscored figures in adjoining column.

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Table 2-31 (Cont.)

B. TOTAL CONSTRUCTION RECEIPTS OF CONTRACTOR

Selected Characteristics	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $999,999	$1,000,000 to $2,499,999	$2,500,000 to $4,999,999	$5,000,000+	Total
Total No. Establishments	29,128	52,824	76,775	87,317	89,432	42,788	25,664	16,898	5,338	3,863	430,027
Average No. All Employees	22,104	71,789	164,065	288,094	548,781	495,050	516,743	653,120	406,288	917,431	4,083,465
Total Construction Receipts (thousands of dollars)	152,636	891,166	2,757,421	6,118,180	13,796,552	14,593,424	17,330,040	25,014,623	17,806,713	49,650,062	148,110,817
Payments for Materials, Components, and Supplies (thousands of dollars)	107,755	300,040	950,386	2,211,214	5,068,137	5,253,822	5,918,621	7,968,574	5,085,497	13,220,656	46,084,702
Standard Error of Estimates for Average No. Employees (percent)	3	2	2	2	1	1	1	1	1	1	1

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Table 2-32

Comparison of Asbestos-Containing Product Costs to Total Material Costs, by SIC

SIC Code	Construction Industries	1972 Average Number of Employees: All Employees	1972 Average Number of Employees: Construction Workers	Value of Materials, Components, and Supplies (thousands of dollars): 1972	Value of Materials, Components, and Supplies (thousands of dollars): 1974	Value of Asbestos Products (thousands of dollars): 1972	Value of Asbestos Products (thousands of dollars): 1974	Ratio of Materials $ Value to Materials, Components, and Supplies $ Value (%): 1972	Ratio of Materials $ Value to Materials, Components, and Supplies $ Value (%): 1974
15	General Building Contractors and Operatives	1,149,520	937,771	$16,414,029	$19,948,602	$611,600	$616,100	7	5
152	Residential Building Construction			9,313,442	11,318,985				
1521	General Contractors, Single Family Homes								
1531	Operative Builders	469,152	365,778	7,723,579	9,386,763				
1522	General Contractors, Residential Buildings	112,215	94,627	1,589,863	1,932,222				
154	General Contractors, Nonresidential Buildings			17,204,281	20,909,026	155,700	203,500	1	1
1541	Industrial Buildings and Warehouses	173,094	144,625	2,213,309	2,699,920				
1542	Nonresidential Buildings, not elsewhere classified	395,059	332,741	4,887,278	5,939,697				
16	Heavy Construction General Contractors	827,346	709,306	10,103,694	12,279,409				
161	Highway and Street Construction								
1611	Highway and Street Construction	278,107	244,292	3,468,714	4,215,662				
162	Heavy Construction Excluding highway and street								
1622	Bridge, Tunnel and Elevated highway Construction	53,710	47,366	858,892	1,043,844	--	--	--	--
1623	Water, Sewer and Utility Lines	209,318	184,199	1,900,404	2,309,634	323,300	390,000	17	17
1629	Heavy Construction, not elsewhere classified	286,211	233,449	3,875,684	4,710,268	402,800	493,000	10	10
17	Special Trade Contractors	2,106,599	1,817,126	19,566,979	23,780,504	--	--	--	--
1711	Plumbing, Heating and Air Conditioning	456,100	371,113	6,093,928	7,406,186	323,300	390,900	5	5
1721	Painting, Paper Hanging and Decorating	136,575	125,807	474,514	576,695	--	--	--	--
1731	Electrical Work	323,748	271,441	3,591,892	4,365,365	172,100	204,000	5	5
174	Masonry, Plastering and Tile Setting								
1741	Masonry, Stone Setting and Other Stonework	165,580	156,395	940,345	1,142,838	22,300	28,000	2	2
1742	Plastering, Drywall and Insulation Work	170,364	151,825	1,365,138	1,659,105	79,500	102,100	5	6
1743	Terrazzo, Tile, Marble and Mosaic Work	30,874	26,600	279,118	339,308	--	--	--	--
175	Carpentering and Flooring								
1751	Carpentering	123,910	115,464	649,595	789,478	133,400	175,500	21	22
1752	Floorlaying and Other Floorwork, not elsewhere classified	44,262	36,402	516,918	628,230	455,900	412,600	88	66
1761	Roofing and Sheetmetal Work	158,051	134,189	1,463,849	1,779,072	170,600	201,500	12	12
1771	Concrete Work	147,924	135,041	1,359,862	1,652,693	--	--	--	--
1799	Special Trade Contractors, not elsewhere classified	101,294	82,899	815,172	990,710	12,800	18,400	2	2
15, 16 17	Total Contract Construction	4,083,465	3,464,203	46,084,702	56,008,516	934,900	1,007,000	2	2

subcontracted and that nonresidential contractors (SIC 154) subcontract 51 percent of their work (U.S. Bureau of the Census 1975n).

Characterization of oil and gas drilling contractors (SIC 13) has been tabulated separately from the building and other nonbuilding construction trades. Data on average hours worked, average weeks worked per year, and average hourly earnings were obtained from a more current source and consequently the population figures do not correspond to the data obtained from the 1972 Census of Mineral Industries (U.S. Bureau of the Census 1974c). These two sources and corresponding data are both represented in Table 2-33.

Seasonal variation is a commonly noted characteristics of construction employment. Workers will typically have three or four periods of unemployment per year. The effect of this variable work force is estimated to be responsible for two-thirds of enemployment insurance claims in contract construction (Gordon et al. 1973).

Seasonal variation of construction workers employed in the United States for the selected SIC codes listed in Table 2-14 is illustrated in Figures 2-2 through 2-9 for the period of January 1970 through June 1976. The data presented, however, are limited by the aggregation of four-digit SIC code classifications into the three-digit classifications.

Employment levels for the period from 1970 to 1976 are shown for general building contractors (SIC 15) and all heavy construction contractors (SIC 16) in Figures 2-2 and 2-3, respectively.

Figure 2-4 gives the monthly variation for all special trade contractors, which is the only indicator of seasonal employment for the subcontracted and that nonresidential contractors (SIC 154) subcontract 51 percent of their work (U.S. Bureau of the Census 1975n).

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Table 2-33

Characteristics of Oil and Gas Drilling Contractors

SIC Code	Trade Group	All Employees (thousands)	Production Workers Number (thousands)	Production Workers Man-hours (000,000)	Production Workers Operating with Drilling Number	Production Workers Operating with Drilling Man-hours	Drilling or Rig-Building Man-hours
13	Oil and gas extraction	240.6	154.2	318.7			
1311	Crude petrol and natural gas	116.1	51.9	101.8	39.0[a]	78	4.9
1321	Natural gas	10.7	8.9	18.2			
138	Oil and gas field services	113.3	93.4	198.7			
1381	Drilling oil and gas wells	45.2	40.1	84.3	33.7[b]	69.1	67.3
1382	Oil and gas exploration services	9.8	7.8	18.0			0.5
1389	Oil and gas field services not elsewhere classified	58.2	45.5	96.4			2.2

Source: U.S. Bureau of the Census, 1974c. 1972 Census of Mineral Industries.
a. This value represents operations that occur while drilling.
b. This value represents exclusive drilling.

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1381	Drilling oil and gas wells	45.2	40.1	84.3	33.7(b)	69.1	67.3
1382	Oil and gas exploration services	9.8	7.8	18.0			0.5
1389	Oil and gas field services not elsewhere classified	58.2	45.5	96.4			2.2

Source: U.S. Bureau of the Census, 1974c. 1972 Census of Mineral Industries.
a. This value represents operations that occur while drilling.
b. This value represents exclusive drilling.

Table 2-33 (Cont.)

SIC Code	Trade Group	Employees(c) 1972	Employees(c) 1974	Workers(c) 1972	Workers(c) 1974	Average Hourly Earnings(c) 1972	Average Hourly Earnings(c) 1974	Hours(c) 1972	Hours(c) 1974	Weeks Worked 1970(d)	Weeks Worked 1970(e)
13	Oil and gas extraction	261.9	291.9	173.7	196.8	3.97	4.82	42.8	44.6	50.6	49.0
131, 2	Petrol and gas fields	137.8	143.7	70.7	72.0	4.46	5.33	40.9	42.0	50.6	49.0
138	Oil and gas fields services	124.1	148.2	103.0	124.8	3.65	4.55	44.2	46.1	50.6	49.0

c. U.S. Bureau of Labor Statistics. Employment and Earnings, 1973, 1975.
d. U.S. Bureau of the Census 1973a. Subject Reports. Industrial Characteristics.
e. U.S. Bureau of the Census 1973b. Subject Reports. Occupational Characteristics.

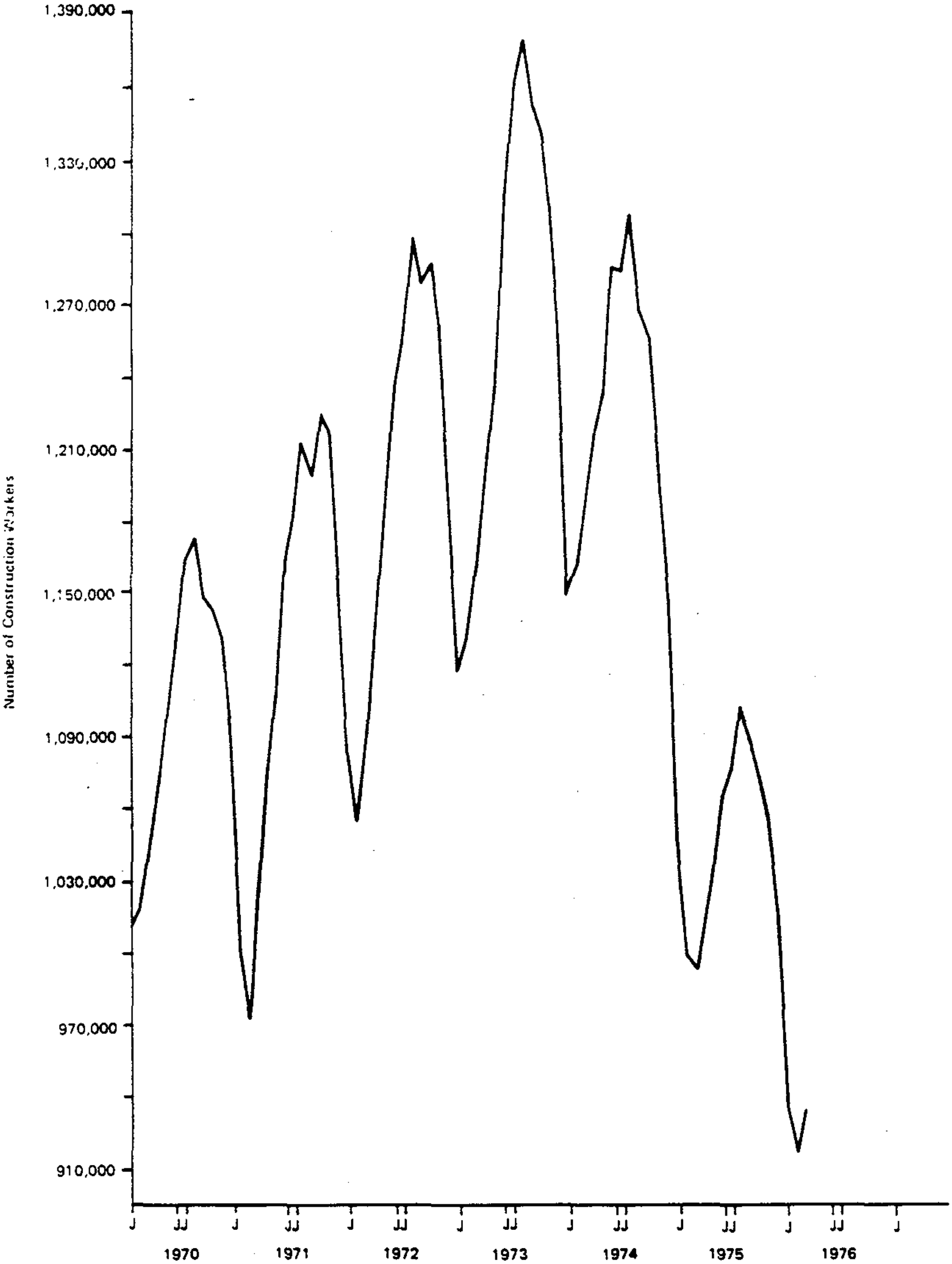

Figure 2-2. Number of construction workers employed in the United States by general building contractors (SIC 15) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

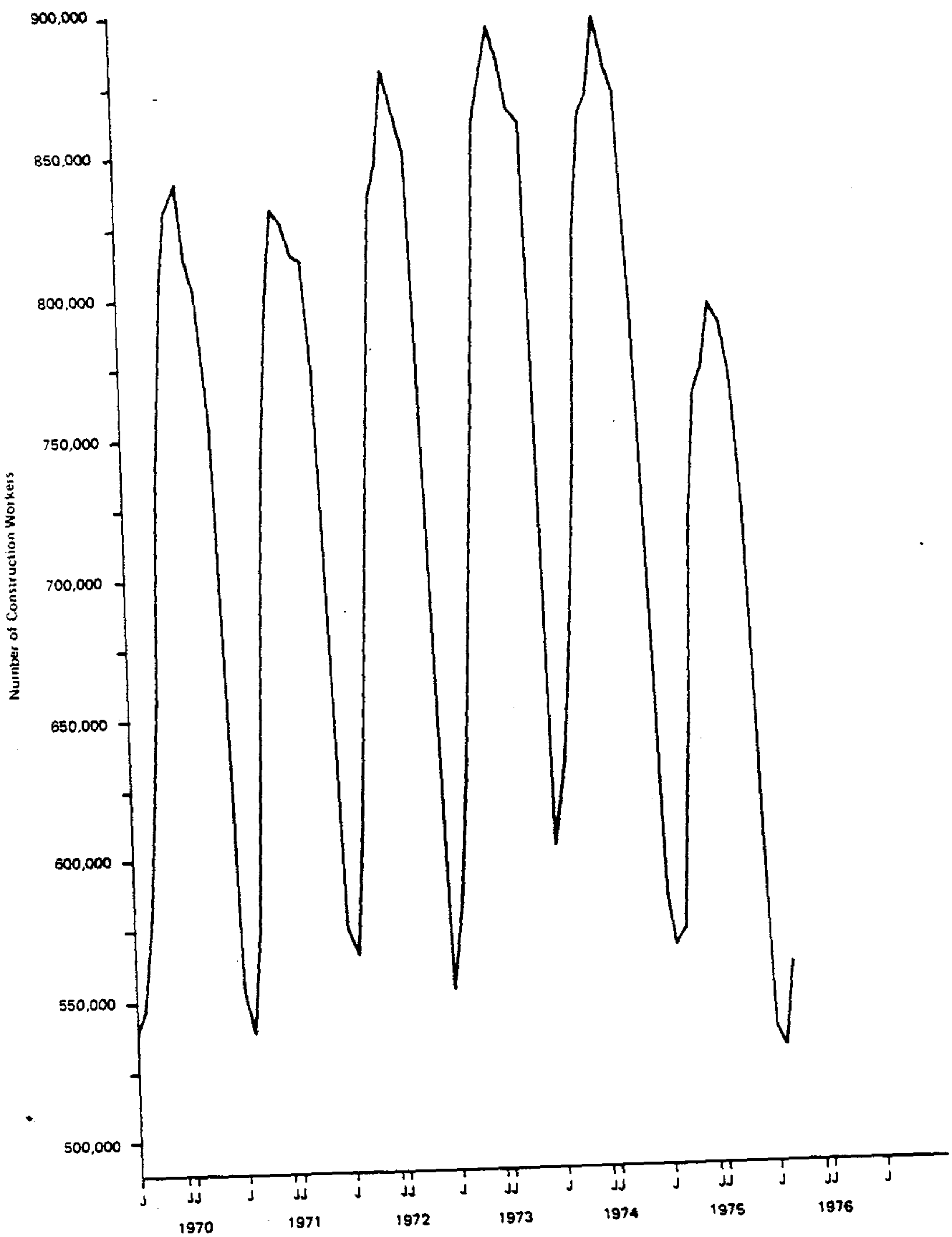

Figure 2-3. Number of construction workers employed in the United Stated by all heavy construction contractors (SIC 16) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

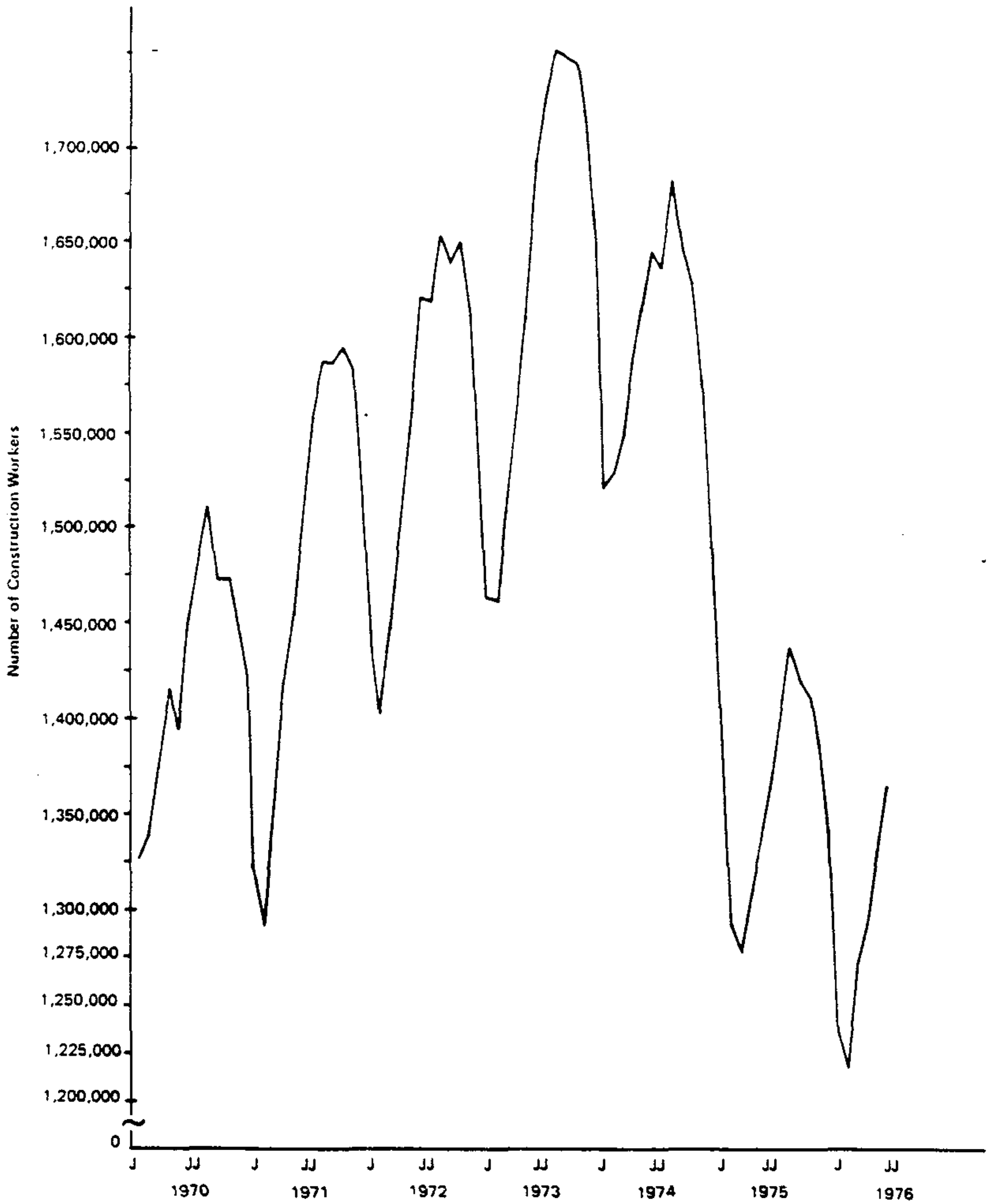

Figure 2-4. Number of construction workers employed in the United States by all special trade contractors (SIC code 17) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

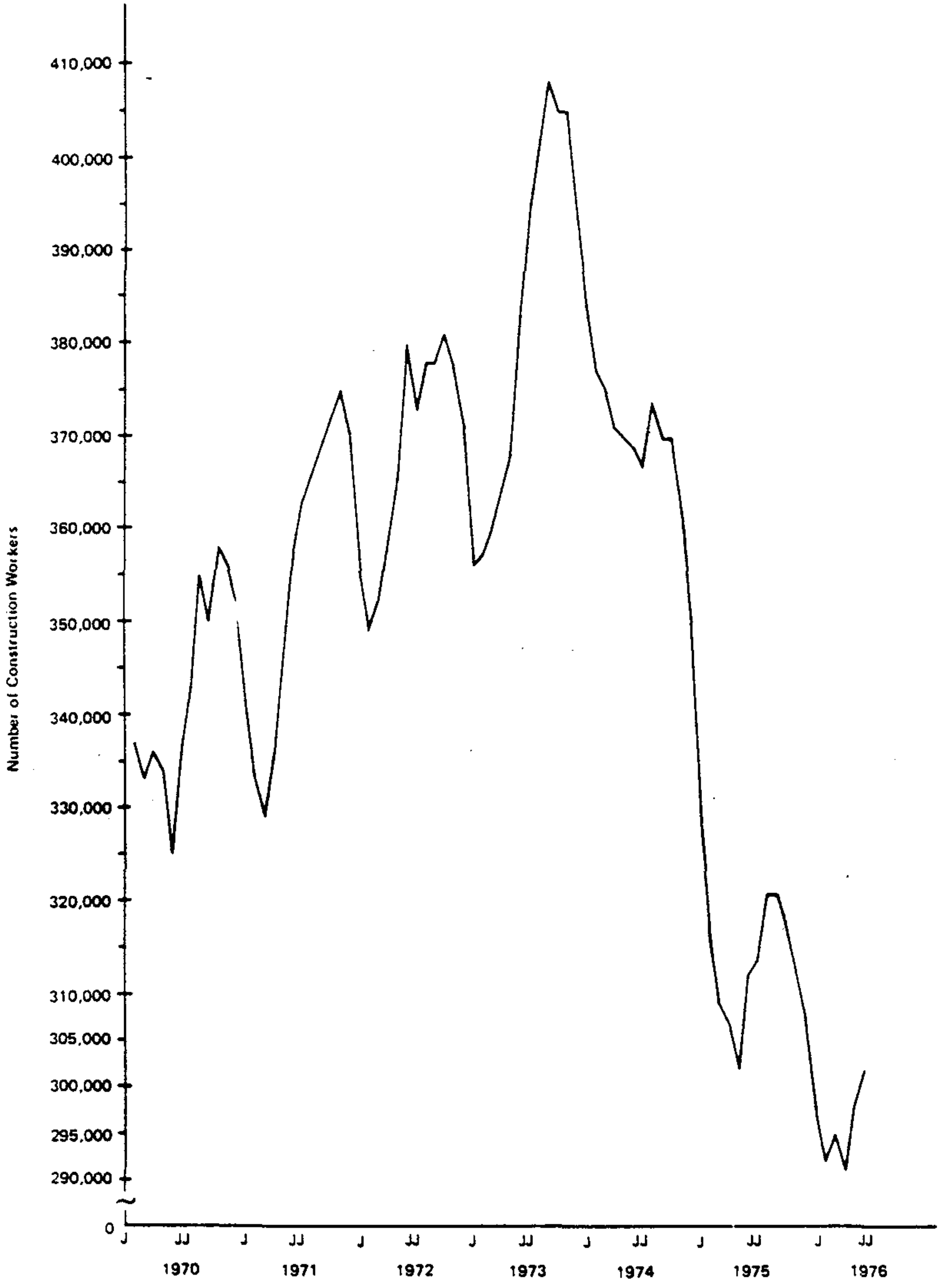

Figure 2-5. Number of construction workers in the United States by plumbing, heating, and air conditioning contractors (SIC code 171) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

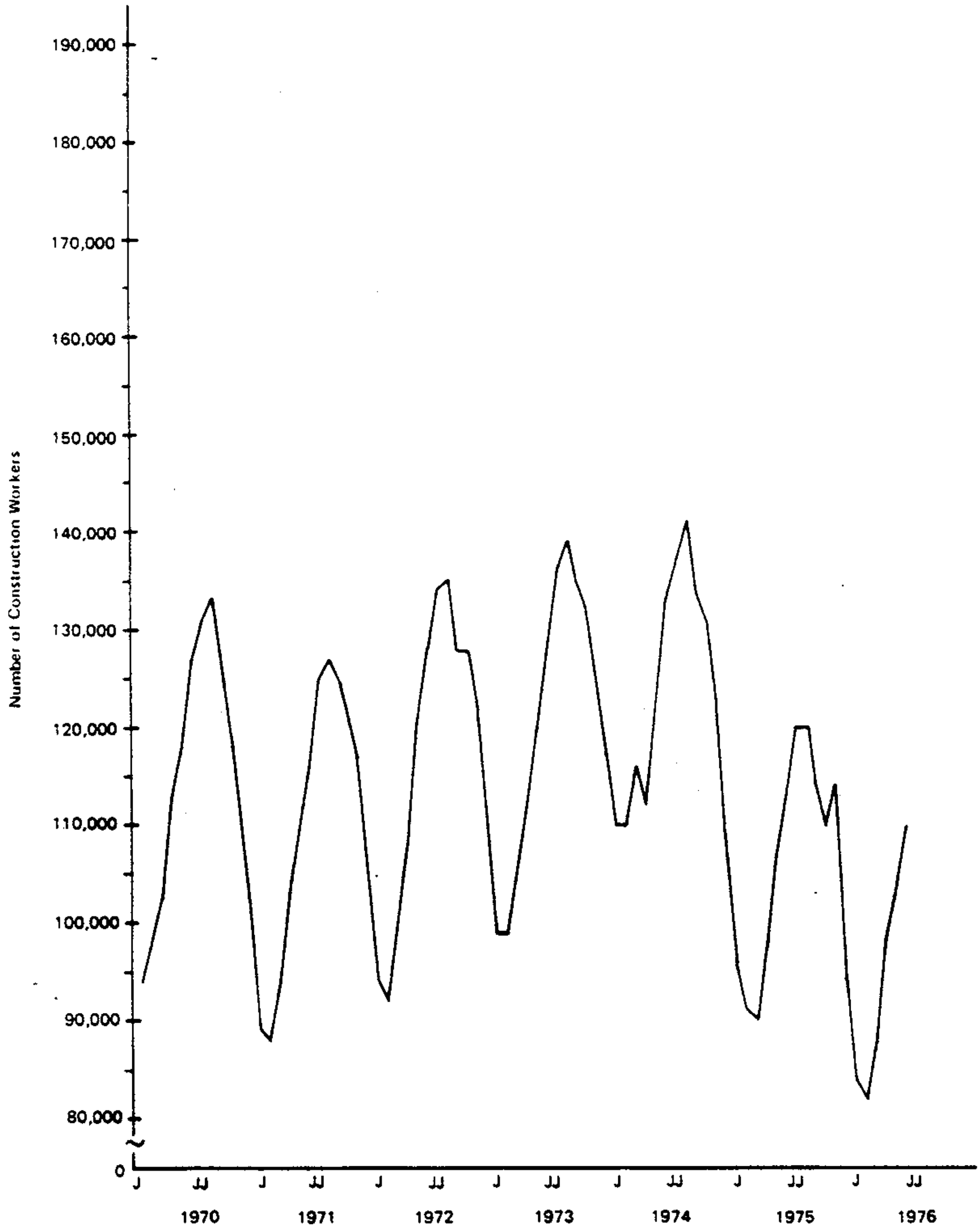

Figure 2-6. Number of construction workers employed in the United States by painting, paperhanging, and decorating contractors (SIC code 172) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

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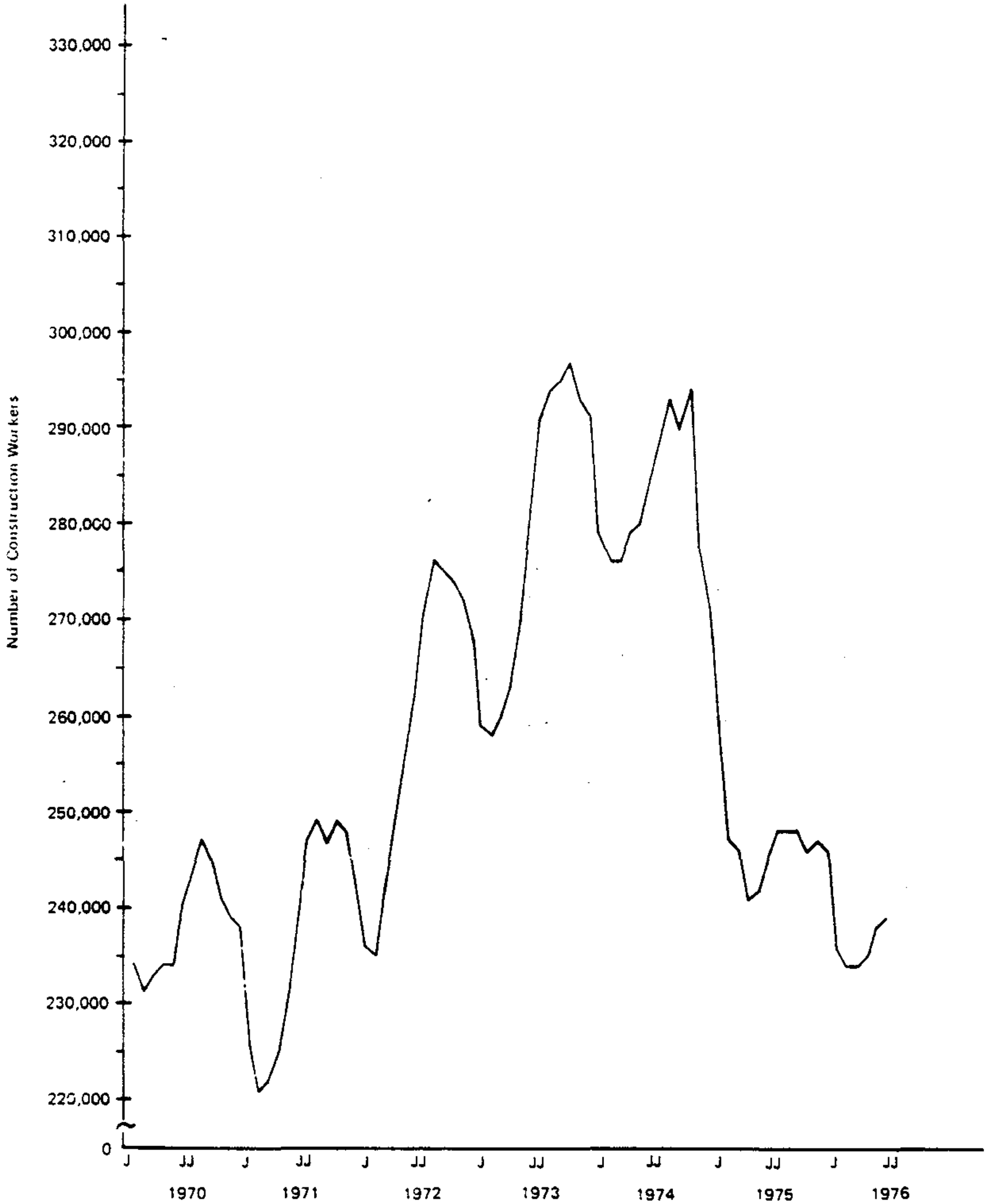

Figure 2-7. Number of construction workers employed in the United States by electrical work contractors (SIC code 173) by month, 1970-1976 (U.S. Bureau of Dome:tic Commerce 1976a,b).

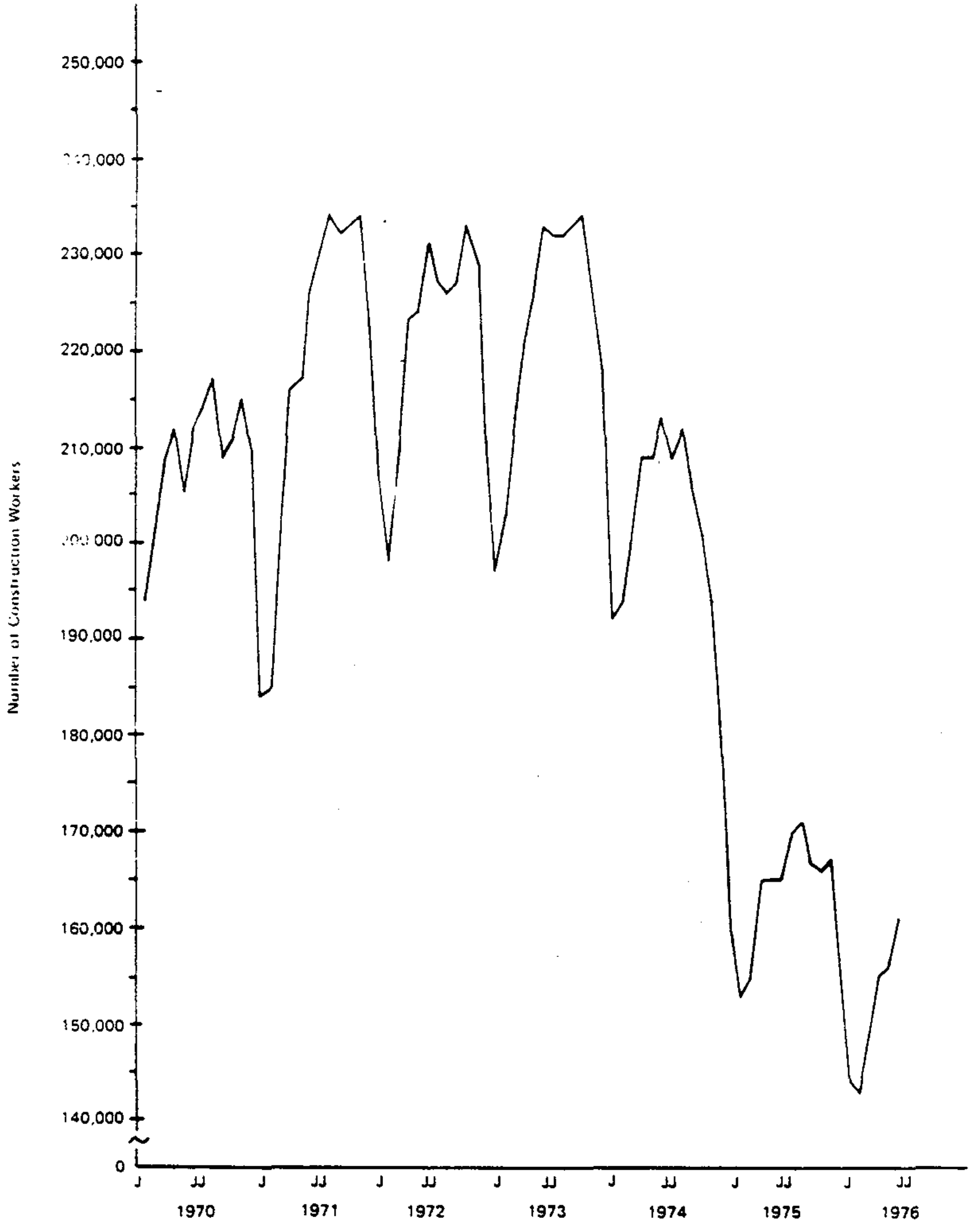

Figure 2-8. Number of construction workers employed in the United States by masonry, plastering, stone, and tile work contractors (SIC code 174) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

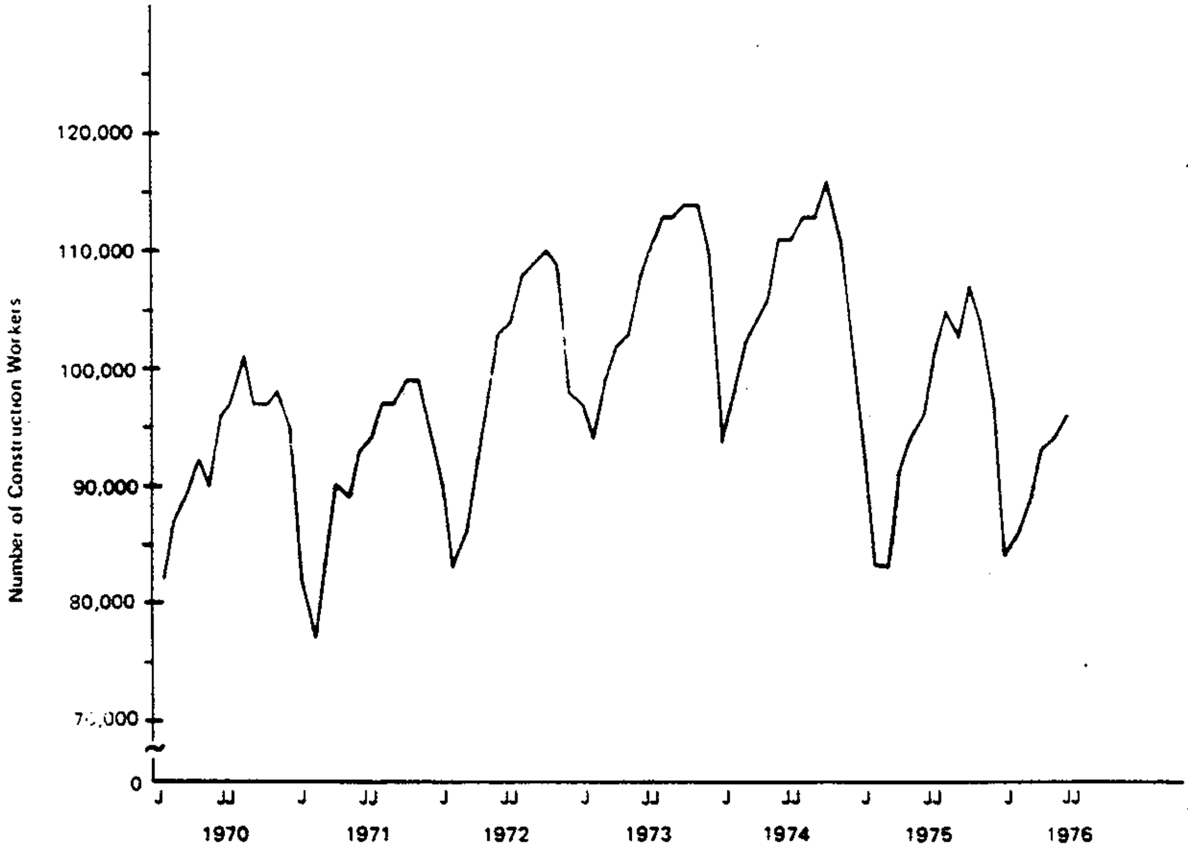

Figure 2-9. Number of construction workers employed in the United States by roofing and sheet metal work contractors (SIC code 176) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

1970 to 1976 period for construction workers in carpentry, floor work, and concrete work.

Plastering, drywall, acoustical, and insulation workers represented in Figure 2-8 account for only 33 percent of the data presented, with setting and other stone workers (SIC code 1741) accounting for 57 percent and terrazzo, tile, marble, and mosaic workers (SIC code 1743). making up the remaining 10 percent (U.S. Bureau of the Census 1975h).

The seasonal variations--presented in Figure 2-5 for plumbing, heating, and air conditioning; Figure 2-6 for painting, paperhanging, and decorating; Figure 2-7 for electrical workers; and Figure 2-9 for roofing and sheet metal workers--are not affected by the aggregation to a three-digit classification.

The seasonal variation of all construction workers in 1972 is summarized for establishments with payroll in Table 2-34. March was chosen as representative of the month of lowest employment and August as the highest. The data were tabulated for the <u>1972 Census of Construction Industries</u> (U.S. Bureau of the Census 1975n) and therefore similar tabulation is not made for 1974. The data presented in Figures 2-2 through 2-9 are the best representation for the seasonality of the construction workforce in 1974.

In addition to monthly variation of construction workers employed within the various trades, it is of interest to determine the flow of workers into and out of the construction industry. Table 2-35 tabulates the percentage of workers who, for a 5-year period (1965-1970), remained in the same industry (construction) and same trade or occupation. The less skilled workers (laborers) were least likely to remain in the con-

1970 to 1976 period for construction workers in carpentry, floor work, and concrete work.

Plastering, drywall, acoustical, and insulation workers represented in Figure 2-8 account for only 33 percent of the data presented, with setting and other stone workers (SIC code 1741) accounting for 57 percent and terrazzo, tile, marble, and mosaic workers (SIC code 1743). making up the remaining 10 percent (U.S. Bureau of the Census 1975h).

The seasonal variations--presented in Figure 2-5 for plumbing, heating, and air conditioning; Figure 2-6 for painting, paperhanging, and decorating; Figure 2-7 for electrical workers; and Figure 2-9 for roofing and sheet metal workers--are not affected by the aggregation to a three-digit classification.

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Table 2-34

Seasonal Variation of Construction Worker Employment by Industry, 1972

SIC Code	Trade Group	Total Employed March	Total Employed August	Percent Change
15	General Building Contractors and Operatives	823,261	1,021,295	19.4
16	Heavy Construction Contractors	582,865	811,578	28.2
17	Special Trade Contractors	1,609,611	1,942,290	17.1
15, 16, 17	Construction Trades, Total	3,015,737	3,775,163	20.1

Source: U.S. Bureau of the Census 1957n.

Table 2-35

Transient Characteristics of the Construction Industry Based on the Percentage of Workers Remaining in Same Occupation Group and Industry in 1965 and 1970

	Percentage of Workers							
	Remained in Same Industry and Occupation, 1965 to 1970		Remained in Same Industry But Changed Occupation Group in 1970		Remained in Same Occupation Group But Changed Industry in 1970		Changed Occupation Group and Industry in 1970	
Occupational Group	Male	Female	Male	Female	Male	Female	Male	Female
Construction Industry								
Craftsmen and kindred workers	68.9	61.8	5.6	4.4	4	2.7	21.5	31.1
Operatives, except transport	51.5	30.2	11.3	6.2	9.8	18.1	27.4	45.5
Laborers	48.6	36.1	6.3	4.5	4.8	4.7	40.3	54.7

Source: U.S. Bureau of the Census 1973d.

struction industry as a laborer, whereas approximately 70 percent of the craftsmen--special trade contractors (SIC 17)--would remain a fairly stable population for the 5-year period. Operatives--general and highway contractors (SIC 15 and 16)--are the most variable population with 31.3 percent remaining in the same occupation and industry, 11.3 percent changing their occupation, 9.8 percent continuing in the same occupation but moving into another industry, and 27.4 percent leaving the trade and industry altogether.

Although length of service in a trade is a useful indicator for the degree of risk associated with asbestos exposure, Table 2-35 spans only a 5-year period, which falls short of the 10- to 20-year latency period associated with asbestosis; and up to 40 years associated with malignancies attributed to asbestos exposure. Age distribution data then, in addition to further characterizing the construction industry, can be used to estimate the number of workers that could possibly exhibit the health effects associated with exposure to asbestos (i.e., workers over the age of 35). Tables 2-36 and 2-37 have been developed from the <u>1970 Census of Population</u> (1973a-b) to illustrate the age distribution among construction workers. Table 2-36 represents the construction trades in the broad two-digit classifications and Table 2-37 gives the distribution for selected special trade contractors.

The average hours worked per week by the construction trades is given in Table 2-38 for the two-digit SIC codes and selected three-digit SIC codes for 1972 and 1974. The only indication for the average weeks worked per year comes from the <u>1970 Census of Population</u>.

Average hourly earnings presented in Table 2-39 are more compatible

Table 2-36

Age Distribution of Construction Workers by Major Two-Digit SIC Code

SIC Code	Male Employed	Years 16 and 17	18 and 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44
	CONSTRUCTION	43,658	112,939	419,364	508,012	488,005	497,634	538,462
15	General building contractors	9,028	23,492	79,142	94,416	96,468	102,327	114,308
16	General contractors, except building	4,609	20,334	77,518	96,061	98,726	100,125	110,877
	Government workers	1,225	7,113	31,563	37,890	40,020	40,955	47,711
	Other workers	3,384	13,221	45,955	58,141	58,706	59,170	63,166
17	Special trade contractors	21,636	46,800	180,280	222,472	204,424	209,015	217,721

SIC Code	Male Employed	Years 45 to 49	50 to 54	55 to 59	60 to 62	63 and 64	65 to 69	70+
	CONSTRUCTION	511,354	455,141	372,034	176,603	85,450	99,947	55,478
15	General building contractors	112,879	98,077	74,208	33,635	14,974	17,546	6,653
16	General contractors, except bulging	109,376	102,454	95,145	45,953	20,512	20,329	7,247
	Government workers	52,006	53,445	54,855	28,034	13,689	12,723	4,293
	Other workers	57,370	49,009	40,290	17,919	6,823	7,606	2,954
17	Special trade contractors	199,296	173,177	137,940	67,535	34,344	45,053	26,853

Source: U.S. Bureau of the Census, 1970 Census of Population, Subject Report--Industrial Characteristics PC(2)-7B. U.S. Department of Commerce, 1973.

Table 2-37

Age Distributions of Construction Workers, Selected Special Trades, SIC 17

SIC Code	Male Employed	Years 16 and 17	18 and 19	20 to 24	25 to 29	[illegible]	[illegible]	[illegible]
1741	Construction craftsmen	17,752	57,608	260,081	314,419	301,603	309,654	358,367
	Brickmasons and stonemasons	1,143	3,652	14,323	19,360	19,643	21,[illegible]	25,362
	Brickmasons and stonemasons, apprentices	155	503	1,332	574	206	234	191
1751	Carpenters	5,872	19,472	72,528	84,843	49,811	83,395	95,672
	Carpenter apprentices	441	1,951	4,053	1,336	249	95	131
1771	Cement and concrete finishers	397	1,321	5,713	7,574	8,597	9,370	9,373
1731	Electricians	947	6,761	48,705	66,061	56,016	55,498	56,223
	Electrician apprentices	312	2,218	10,161	5,304	1,419	403	329
1752	Floor layers, except tile setters	204	597	1,925	2,666	2,293	2,683	2,887
1721	Painters, construction and maintenance	5,079	9,294	27,190	29,281	29,712	30.759	33,728
	Painter apprentices	86	228	720	230	61	39	--
1721	Paperhangers	20	74	423	617	612	907	876
1742	Plasterers	221	650	1,730	2,351	2,668	3,619	4,322
	Plasterer apprentices	41	125	195	99	--	19	21
1711	Plumbers and pipe fitters	1,194	6,048	34,700	44,599	41,912	40,862	45,031
	Plumber and pipe fitter apprentices	409	1,379	7,251	3,621	927	244	1107
1761	Roofers and slaters	833	2,696	7,940	8,782	7,243	7,342	6,964
1743	Tile setters	331	714	2,650	3,767	4,076	4,248	4,862
	Construction foremen	130	438	5,329	13,001	20,081	20,367	23,622
1761	Sheetmetal workers and tinsmiths	841	3,522	17,729	20,901	17,537	15,743	17,680
	Sheetmetal apprentices	95	617	3,348	1,141	122	25	--
1742	Asbestos and insulation workers	173	207	2,955	3,552	3,359	2,877	3,049
	Carpenter's helpers	3,551	5,362	8,273	4,057	2,379	2,936	3,226
	Construction laborers, except carpenter's helpers	17,257	35,641	81,347	62,291	51,031	51,565	56,359

Source: U.S. Bureau of the Census, 1973a.

Table 2-37 (Cont.)

SIC Code	Male Employed	Years 45 to 49	50 to 54	55 to 59	[illegible]	65 to [illegible]	[illegible]	70+
1741	Construction craftsmen	337,697	309,285	259,370	124,[illegible]	58,565	62,221	32,705
	Brickmasons and stonemasons	20,9[illegible]	13,590	10,518	5,517	2,967	2,766	1,270
	Brickmasons and stonemasons, apprentices	220	168	154	43	47	--	--
1751	Carpenters	103,129	105,127	88,792	42,799	19,979	24,132	14,974
	Carpenter apprentices	68	41	42	20	--	17	--
1771	Cement and concrete finishers	8,500	6,998	5,388	1,876	983	1,040	277
1731	Electricians	56,350	47,938	30,452	18,808	8,334	6,875	3,374
	Electrician apprentices	257	289	144	42	89	--	50
1752	Floor layers, except tile setters	2,458	2,174	1,557	541	359	429	96
1721	Painters, construction and maintenance	34,883	37,611	34,994	17,993	9,442	11,608	5,092
	Painter apprentices	20	21	42	21	--	--	20
1721	Paperhangers	968	1,066	1,442	618	604	647	389
1742	Plasterers	4,412	3,337	2,096	1,428	749	904	311
	Plasterer apprentices	22	--	22	35	--	23	--
1711	Plumbers and pipe fitters	49,107	43,486	35,765	17,333	7,883	7,832	3,709
	Plumber and pipe fitter apprentices	138	116	141	--	23	--	49
1761	Roofers and slaters	4,679	4,108	3,606	1,559	884	514	405
1743	Tile setters	3,860	2,616	2,056	712	409	553	193
	Construction foremen	22,860	18,843	14,276	6,481	2,913	2,693	926
1761	Sheetmetal workers and tinsmiths	19,681	16,337	12,248	5,257	2,380	2,162	824
	Sheetmetal apprentices	75	--	18	19	--	--	--
1742	Asbestos and insulation workers	2,627	2,006	1,687	588	1135	154	14
	Carpenter's helpers	2,991	3,011	3,407	1,392	695	899	302
	Construction laborers, except carpenter's helpers	52,267	50,854	45,731	19,830	8,827	10,549	4,198

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Table 2-37 (Cont.)

SIC Code	Female Employed	Years 16 and 17	18 and 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44
	CRAFTSMEN AND KINDRED WORKERS							
1741	Construction craftsmen	.731	1,690	5,614	5,155	4,449	4,733	5,767
	Brickmasons and stonemasons	42	118	323	237	296	99	215
	Brickmasons and stonemasons, apprentices	--	7	25	23	35	13	--
1751	Carpenters	178	583	1,308	1,184	1,107	1,155	1,165
	Carpenter apprentices		23	30	--	--	--	40
1771	Cement and concrete finishers	--	39	70	154	127	155	90
1731	Electricians	13	243	1,232	1,230	684	1,124	965
	Electrician apprentices	--	--	76	48	--	27	12
1752	Floor layers, except tile setters	15	--	--	51	19	61	69
1721	Painters, construction and maintenance	248	420	1,351	1,184	1,298	1,217	1,741
	Painter apprentices	--	--	--	16	--	--	--
1721	Paperhangers	--	--	--	37	44	74	155
1742	Plasterers	--	18	112	63	67	38	132
	Plasterer apprentices	--	18	21	--	--	--	--
1711	Plumbers and pipe fitters	126	44	511	398	265	344	511
	Plumber and pipe fitter apprentices	--	--	41	--	--	23	--
1761	Roofers and slaters	35	73	175	140	53	86	139
1743	Tile setters	20	29	39	--	88	39	25
	Construction foremen	23	56	58	138	262	191	171
1761	Sheetmetal workers and tinsmiths	58	77	381	325	325	424	308
	Sheetmetal apprentices	30	--	14	--	--	--	--
1742	Asbestos and insulation workers	--	36	106	35	51	20	72
	LABORERS, EXCEPT FARM	14,687	18,062	37,774	25,125	24,280	28,517	29,683
	Carpenter's helpers	54	21	197	173	141	75	113
	Construction laborers, except carpenter's helpers	311	418	1,415	777	564	1,006	854

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Table 2-37 (Cont.)

SIC Code	Female Employed	Years 45 to 49	50 to 54	55 to 59	60 to 62	63 to 64	65 to 69	70+
	CRAFTSMEN AND KINDRED WORKERS							
1741	Construction craftsmen	5,781	4,306	3,422	1,881	751	1,456	1,360
	Brickmasons and stonemasons	274	180	172	20	25	17	36
	Brickmasons and stonemasons, apprentices	21	--	24	20	--	--	--
1751	Carpenters	1,359	798	678	503	193	564	345
	Carpenter apprentices	--	19	12	--	--	--	--
1771	Cement and concrete finishers	142	107	120	55	--	19	--
1731	Electricians	1,182	744	359	177	65	131	134
	Electrician apprentices	22	--	--	--	--	33	11
1752	Floor layers, except tile setters	41	--	54	22	--	23	--
1721	Painters, construction and maintenance	1,557	1,333	1,006	461	242	356	302
	Painter apprentices	--	--	--	--	--	--	--
1721	Paperhangers	103	207	156	170	20	60	56
1742	Plasterers	--	21	18	--	--	--	22
	Plasterer apprentices	--	21	--	--	--	--	--
1711	Plumbers and pipe fitters	387	360	387	161	120	165	269
	Plumber and pipe fitter apprentices	20	--	--	--	--	21	54
1761	Roofers and slaters	50	36	77	43	16	--	15
1743	Tile setters	81	42	--	24	--	--	34
	Construction foremen	75	131	32	53	40	78	108
1761	Sheetmetal workers and tinsmiths	522	300	278	18	--	45	90
	Sheetmetal apprentices	--	--	--	--	--	--	--
1742	Asbestos and insulation workers	55	--	18	21	17	--	41
	LABORERS, EXCEPT FARM	30,478	26,536	21,541	9,254	4,261	5,581	4,020
	Carpenter's helpers	49	68	--	16	--	--	29
	Construction laborers, except carpenter's helpers	1,265	725	628	344	173	329	397

Table 2-38

Average Hours Worked per Week by Construction Trades

Trade Group	SIC Code	Average Hours Worked/Week[a] 1972	Average Hours Worked/Week[a] 1974	Average Weeks Worked/Year[b] 1970
Contract Construction	--	37.0	36.9	45.6
General Building	15	35.8	36.1	44.5
Heavy Highway	16	40.2	40.2	45.8
Highway and Street	161	40.9	41.1	
Heavy Construction, not elsewhere classified	162	39.6	39.4	
Special Trade	17	36.3	36.1	44.6
Plumbing, heating,	171	37.8	37.5	
Painting, paperhanging	172	34.8	34.7	
Electrical work	173	38.4	37.8	
Masonry	174	33.2	33.4	
Roofing	176	32.2	33.0	
Roofers (only)				41.1[c]
Construction Foreman	--			47.5[c]
Construction Laborers	--			40.4[c]
Floor layers	1752			44.6[c]
Carpenters	1751			43.2[c]
Carpenters' helpers	1751			36.8[c]

a. U.S. Bureau of Labor Statistics, 1973, 1975.
b. U.S. Bureau of the Census, 1973a.
c. U.S. Bureau of the Census, 1973b.

Table 2-39

Average Hourly Earnings

SIC Code	Trade Group	1972[a]	1974[b]
15, 16, 17	Contract construction	$6.06	$6.76
15	General building contractors	5.84	6.54
16	Heavy construction contractors	5.42	6.11
161	Highway and street construction	5.15	5.84
163	Heavy construction, not elsewhere classified	5.66	6.35
17	Special trade contractors	6.50	7.17
1711	Plumbing, heating, air conditioning	6.58	7.25
1721	Painting, paper hanging, decorating	5.90	6.61
1731	Electrical work	7.08	7.76
1741	Masonry, stonework, and plastering	6.38	7.15
1761	Roofing and sheetmetal work	5.78	6.47

a. U.S. Bureau of Labor Statistics, 1973.
b. U.S. Bureau of Labor Statistics, 1975.

with the SIC code system and previous data represented; however, Table 2-40 has been included for greater detail in the 17 SIC code group for special trade workers.

Characterization of the construction industry by the type of construction is presented in three tables. Table 2-41 identifies new construction put in place from 1972 through May 1976. Yearly totals are given for private construction and public construction in millions of dollars for 1972 through 1975. Monthly dollar figures for 1976 are given for both private and public construction.

The number of new housing units started and completed are compiled from three sources into Table 2-42; figures are presented yearly for 1972 through 1976 and monthly for 1976. The 1976 figures are only available for number of housing units started.

The percentage of work completed in 1972 for residential, commercial/industrial, and nonbuilding construction by each SIC trade group in Table 2-14 is indicated in Table 2-43, which was extracted from tables in the 1972 Census of Construction Industry, Industry Series (U.S. Bureau of the Census 1975d-m).

The percentage of work performed by wrecking and demolition contractors is broken down by construction receipts received from public or private sources and presented in Table 2-44.

2.2.2.3 Construction Industry's Consumption of Asbestos Products

2.2.2.3.1 Trade Groups That Use Asbestos Products

Table 2-45, the correlation of asbestos product utilization by trade groups (Standard Industrial Classification), was derived from information

Table 2-40

1974 Wages by SIC Code

	SIC Code	Hourly Wage	Hourly Wage plus Overhead and Profit
1711	Plumbing, Heating, and Air Conditioning (avg.)	$ 9.87	$13.50
	Plumbers	10.70	14.70
	Foreman (plumbers)	11.20	15.35
	Labor	7.15	9.60
	Sprinkler installer	10.65	14.60
	Sprinkler installer (foreman)	11.25	15.45
	Apprentice	8.25	11.30
1721	Painting, Paper Hanging, and Decorating (avg.)	8.90	11.90
	Painter	8.75	11.65
	Structural steel painters	9.05	12.15
1731	Electrical Work (avg.)	9.52	13.03
	Electrician	10.40	14.25
	Electrician foreman	10.90	14.90
	Helper	7.25	9.95
1741	Masonry, Stonesetting, and Other Stonework (avg.)	8.75	11.80
	Bricklayer	10.10	13.45
	Bricklayer helper	7.30	9.75
	Equipment operator, Light	8.85	12.20
1742	Plastering, Drywall, Acoustical, and Insulation (avg.)	8.40	11.19
	Plasterer	9.40	12.50
	Plasterer's helper	7.60	10.10
	Laborer	7.15	9.65
	Lather	9.45	12.50
1743	Terrazzo, Tile, Marble, and Mosaic Work (avg.)	8.38	11.30
	Terrazzo worker	9.50	12.65
	Terrazzo worker's helper	7.25	9.95
1751	Carpentering (avg.)	8.38	11.25
	Carpenter	9.60	12.85
	Labor	7.15	9.65
1761	Roofing and Sheet Metal (avg.)	8.75	12.17
	Roofer	8.75	12.45
	Roofing foreman	9.45	13.15
	Roofing helper	6.90	9.60
	Sheet metal worker	10.40	14.35
	Sheet metal apprentice	8.25	11.30
1771	Concrete Work (avg.)	8.30	11.10
	Cement finisher	9.45	12.55
	Building labor	7.15	9.65
1791	Structural Steel Erection (avg.)	10.55	15.40
	Structural steel worker	10.30	15.05
	Structural steel foreman	10.80	15.75
1794	Excavating and Foundation Work (avg.)	8.65	11.84
	Foreman	7.65	10.35
	Equipment operator, medium	9.75	13.45
	Truck driver	7.10	9.60
	Equipment operator, heavy	10.10	13.95
1799	Special Trade Contractors (avg.)	8.61	12.01
	Welders	10.20	14.90
	Equipment operator	8.85	12.20
	Helper	7.15	9.65
	Apprentice	8.25	11.30

Source: McGraw-Hill, Building Construction Cost Data, 1974.

Table 2-41

New Construction Put in Place, 1972-May 1976 (Millions of Dollars)

		Private Construction										
			Residential			Nonresidential						
Year	Total	Total	Total	New Housing	Other	Total	Industrial	Commercial	Other	Public Utilities	Other Private Construction
1972	124,085	93,931	54,288	44,879	9,409	24,038	4,676	13,464	5,893	13,202	2,373
1973	135,953	103,444	57,635	47,853	9,789	27,584	6,243	15,453	5,888	15,192	3,033
1974	135,481	97,079	47,044	37,312	9,733	29,644	7,902	15,945	5,797	17,086	3,305
1975	130,759	90,032	43,045	31,279	11,766	26,244	7,847	12,810	5,587	17,457	3,286
1976											
Jan.	9,353	6,879	3,328	2,603	NA	1,848	563	854	431	NA	NA
Feb.	8,925	6,568	3,072	2,417	NA	1,974	573	937	464	NA	NA
March	10,038	7,349	3,572	2,793	NA	2,053	590	995	468	NA	NA
April	11,193	8,293	4,405	3,383	NA	2,061	582	1,008	NA	NA	NA
May	11,919	8,781	4,776	3,721	NA	2,031	556	995	NA	NA	NA

Sources: U.S. Bureau of Economic Analysis. 1976. Survey of Current Business. S10-S11.
U.S. Bureau of Domestic Commerce. 1976a. Statistical Series. Construction put in place. Construction Review 22(3).

NA = Not available.

Table 2-41 (Cont.)

	Public Construction					
		Buildings				
Year	Total	Total	Industrial	Housing and Redevelopment	Other	Other
1972	30,184	11,500	534	875	10,091	18,684
1973	32,509	12,994	605	941	11,448	19,515
1974	38,402	14,990	763	1,007	13,220	23,412
1975	40,727	15,424	916	969	13,539	25,303
1976						
Jan.	2,474	1,064	76	40	948	1,410
Feb.	2,339	991	79	42	870	1,348
March	2,690	1,102	84	42	976	1,588
April	2,900	1,078	82	49	NA	NA
May	3,158	NA	NA	NA	NA	NA

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Table 2-42

New Housing Units Started and Completed, 1972-1976

Year	New Housing Units Started (thousands of units)			New Housing Units Completed (thousands of units)		
	Total	Privately Owned Housing	Publicly Owned Housing	Total	Privately Owned Housing	Publicly Owned Housing
1972	2,378.5	2,356.6	21.9	1,999.2	1,971.3	27.7
1973	2,057.5	2,045.3	12.2	2,033.2	2,013.8	19.4
1974	1,352.5	1,337.7	14.8	1,707.4	1,691.7	15.7
1975	1,171.4	1,160.4	10.9	1,308.6	1,292.5	16.0
1976						
Jan.	72.9	72.5	0.4	NA	NA	NA
Feb.	91.6	89.9	1.7	NA	NA	NA
March	118.8	119.6	0.4	NA	NA	NA
April	137.4	138.0	0.3	NA	NA	NA
May	149.1	148.8	NA	NA	NA	NA
June	153.7	157.0	NA	NA	NA	NA

Sources: U.S. Bureau of Economic Analysis. 1976. Survey of Current Business.
U.S. Bureau of Domestic Commerce. 1976a. Statistical Series. Construction Review 22(3). Table B-4.
U.S. Bureau of the Census. 1976a. Housing Starts. Construction Reports June. Table 1.
NA = Not available.

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Table 2-43 (Cont.)

SIC	Trade Group	Percent of Total Construction Receipts: Residential	Commercial/ Industrial	Non-building	Not Specified by Kind
1711	Plumbing, heating (except electric), and air conditioning	36.9	51.4	4.6	7.1
1721	Painting, paper hanging, and decorating	43.0	37.4	6.2	12.4
1731	Electrical work	24.2	59.4	12.7	3.7
1742	Plastering, drywall, acoustical, and insulation work	45.8	47.5	3.9	2.8
1743	Terrazzo tile, marble, and mosaic work special trade contractors	48.4	45.6	1.1	4.9
1751	Carpentering	76.4	15.6	1.0	7.0
1752	Floor laying and other floorwork	54.0	29.4	0.4	16.2
1761	Roofing and sheet metal work	34.7	56.3	1.4	7.6
1771	Concrete work	37.4	26.0	28.9	7.7
1799	Special trade contractors, not elsewhere classified	19.5	30.9	38.1	11.5

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Table 2-43

Percent of Total Construction Receipts Received by Selected Contractors From Residential, Commercial/Industrial, and Non-Building Construction in 1972

SIC	Trade Group	Percent of Total Construction Receipts: Residential	Commercial/ Industrial	Non-Building	Not Specified by Kind
1521 and 1531	General contractors--single family houses and operative builders	94.3	4.3	0.4	1
1522	General contractors--residential buildings other than single-family	85.1	13.9	0.9	0.1
1541	General contractors--industrial buildings and warehouses	4.8	91.3	3.8	0.1
1542	General contractors--nonresidential buildings other than industrial buildings and warehouses	6.9	88.2	2.8	2.1
1611	Highway and street construction contractors	2.3 (Building Construction Total)		97.4	0.3
1622	Bridge, tunnel, and elevated highway construction contractors	--	7.3	91.5	1.2
1623	Water, sewer, pipe line, communication and power line construction	3.0		95.4	1.6
1629	Heavy construction contractors, not elsewhere classified	4.9 (Building Construction Total)		94.2	0.9

Table 2-44

Wrecking and Demolition Work Contractors (SIC 1795)
Total Construction Receipts Received by Type of Construction

Type of Construction	Total Construction Receipts	Percent
Public	$ 54,616,000	25
Private	164,796,000	75
Total	$219,412,000	100

Table 2-45

Trade Groups Utilizing Asbestos Products

SIC Code	Construction Industries	Asbestos-cement pipe	Asbestos-cement sheets	Asbestos-cement shingles and felts	Coatings and cements	Asbestos insulation pipe	Other (insulation)	Asbestos textiles	Vinyl asbestos floor tile	Gaskets, packings, and sealings	Paper	Other (SIC 3292798)
15	General Building Contractors and Operatives											
152	Residential Building Construction											
1521 1531	General Contractors, Single Family Homes Operative Builders		x	x	x		x		x		x	x
1522	General Contractors, Residential Buildings		x	x	x		x		x		x	x
154	General Contractors, Nonresidential Buildings		x	x	x		x					x
1541	Industrial Buildings and Warehouses		x									
1542	Nonresidential uildings, not elswhere classified		x									x
16	Heavy Construction General Contractors											
161	Highway and Street Construction											
1611	Highway and Street Construction											
162	Heavy Construction Excluding Highway and Street											
1622	Bridge, Tunnel and Elevated Highway											x
	Construction											x
1623	Water, Sewer and Utility Lines	x				x		x		x		
1629	Heavy Construction, not elsewhere classified	x	x			x	x	x		x	x	x
17	Special Trade Contractors	x	x	x	x	x	x	x	x	x	x	x
1711	Plumbing, Heating and Air Conditioning	x				x		x		x	x	
1721	Painting, Paper Hanging and Decorating											
1731	Electrical Work						x	x		x	x	
174	Masonry, Plastering and Tile Setting											
1741	Masonry, Stone Setting and Other Stonework											x
1742	Plastering, Drywall and Insulation Work		x				x					x
1743	Terrazzo, Tile, Marble and Mosaic Work											
175	Carpentering and Flooring											
1751	Carpentering		x	x	x		x				x	
1752	Floorlaying and Other Floorwork, not elsewhere classified								x			
1761	Roofing and Sheetmetal Work		x	x	x		x	x			x	
1771	Concrete Work											
1799	Special Trade Contractors, not elsewhere classified						x					
15, 16 17	Total Contract Construction	x	x	x	x	x	x	x	x	x	x	x

obtained in the survey and supplemented by consulting the Building Construction Cost Data (Godfrey 1976) and Dodge Manual for Building Construction Pricing and Scheduling (McGraw-Hill 1976). These reference works give information designating the trade group necessary for the installation and application of the various product entries.

2.2.2.3.2 Number of Workers Who Utilize Asbestos Products

The number of construction workers who utilize asbestos products was not available from published sources. EEH attempted to obtain the information from the correspondence/telephone survey undertaken; however, the information was unavailable. From responses received during the survey, it is apparent that the question of construction worker exposure has only recently been addressed by the concerned trade groups.

Thus, the only alternative was to first identify the man-days necessary to install the asbestos products manufactured and then, based on the average number of days worked per year, to determine the number of men required. The number of man-days was determined by dividing the total quantity of asbestos products manufactured by the labor output capacity per man-day, e.g., 10,000,000 tile squares produced per year divided by 500 squares per man-day would equal 50,000 man-days of labor required. Data on labor capacities were obtained from Building Construction Cost Data (Godfrey 1975). The only authoritative and comprehensive source identifying the total amount of asbestos products produced with the product division required is the 1972 Census of Manufactures (U.S. Bureau of the Census 1974a). When units were provided in the census that corresponded to the units in Building Construction Cost Data (Godfrey 1973), it was a simple matter of division. Where units were not compatible or quantities were not given, it was necessary to take the dollar value of product shipments and divide it by the cost per unit to obtain the number of units. These unit costs obtained from Building Construction Cost Data (Godfrey 1973) were then compatible with labor output capacities from the same source, and the number of man-days could be determined. The exceptions for this procedure were, of course, categories previously mentioned in Section 2.2.1.1, in which reliable data could not be obtained identifying unit costs. In these cases, the installation cost was divided by the daily wage rate for all contract construction for the given year, thus providing an estimation of the number of man-days. Unit values for these calculations are in Table 2-46.

2.2.2.3.3 Ratio of Total Materials Consumed Relative to Asbestos Materials Consumed

Data were available on the total expenditure for materials and supplies for each construction SIC from the 1972 Census of Construction Industries. These data were adjusted for 1974 by determining the increase in expenditure for construction materials and supplies from General Business Indicators in the Survey of Current Business (U.S. Bureau of Economic Analysis 1974, 1976). The value of asbestos materials consumed was then determined by adding material values from Tables 2-8 and 2-9, for the respective years, which were appropriate for the SIC's. The selection of material or product categories was based on the data from

Table 2-46

Required Man-days to Install Asbestos-Containing Products, for 1972 and 1974

Product	Quantity (1,000,000) 1972	Quantity (1,000,000) 1974	Labor Output per 8-hr Day	Man-days Required (1,000,000) 1972	Man-days Required (1,000,000) 1974
Flooring					
Plain-backed	1,164.6 sq. ft.	1,386.9 sq. ft.	540 sq. ft.	2.2	2.6
Adhesive-backed	195.9 sq. ft.			0.36	
Asphalt	88.2 sq. ft.	43.2 sq. ft.		0.16	0.08
Vinyl sheet	426 sq. ft.	310 sq. ft.		0.79	0.57
Pipe	41.1	50	91.3	0.45	0.55
Shingles	1.3 squares	1.15 squares	4 squares	0.325	0.287
Roofing					
Felt	1.11	1.33	58	0.02	0.023
Built-up roofing	3.35	4.00	28	0.12	0.15
Cement sheets	51.8 sq. ft.	61.4 sq. ft.	170.5 sq. ft.	0.304	0.36
Felt, not specified by kind	2.58 squares	3.07 squares	58 squares	0.044	0.053
Insulation (pipe)	11.2 linear ft.	12.3 linear ft.	68.5 linear ft.	0.16	0.18
	Installation Cost/Average Wages per Day 1972	**Installation Cost/Average Wages per Day 1974**			
Insulation "other"	12.8/48.5	18.4/54.1		0.26	0.34
Coatings and cement	75.2/48.5	125.4/54.1		1.6	2.3
Building paper and board	54.2/48.5	63.2/54.1		1.1	1.1
Textiles	27.9/48.5	38.3/54.1		0.57	0.71
Gaskets, packings, and sealings	91.6/48.5	114.0/54.1		1.9	2.1
"Other"	13.4/48.5	16.8/54.1		0.28	0.31

Table 2-45. No attempt was made to divide the value of products among SIC, but rather each total product value was assigned to each SIC that utilized the product. The value of the asbestos products consumed for each SIC was then divided by the total expenditure giving the ratio of total materials consumed relative to asbestos materials consumed. The end result is a qualitative index, by SIC, of the asbestos-consuming activities in the construction industry.

2.2.2.3.4 Percentage of Market Held by Selected Asbestos Products

From the 1972 Census of Manufactures (U.S. Bureau of the Census 1975o), it is possible to determine the dollar value of wholesale shipments of a broad range of manufactured products. This information can be useful in estimating the relative economic importance of these products in the marketplace. There are, however, two factors that limit the use of these data in developing comparative information on competing industries or products: (1) for some products, sales figures are not given, and (2) not all products are listed individually or in comparable categories.

For four basic types of construction materials, it was possible to develop comparable data on a major asbestos product and several alternate products that compete directly with it. These are shown in Table 2-47.

Table 2-47

Dollar Value of A Major Asbestos Product and Several Alternate Products

SIC		Value: Million Dollars	Value: Percent
3253	Ceramic wall and floor tile	157.9	
2426	Hardwood dimensions and flooring	579.0	80.11
30796	Floor tile (construction plastic products)	102.3	
32926	Vinyl-asbestos floor tile	199.3	19.89
32925	Asphalt floor tile (containing asbestos)	9.1	
		1,047.6	100.00
32721	Concrete pipe	565.3	
32591	Vitrified clay sewer pipe and fittings	134.7	
32592	Drain tile (clay)	9.5	83.63
26461	Pressed and molded pulp goods, bituminous fiber pipe, sewer and drainage, conduit and fittings	22.6	
32927 73 75	Asbestos-cement products--pipe, conduits, ducts, and pressure pipes	143.3	16.37
		875.4	100.00
29532 51	Asphalt-saturated felts for built-up roofing systems and for sheathing	78.2	69.02
29523 55	Tar-saturated felts for built-up roofing systems	3.1	
32927 81 85	Asbestos felts--roofing, asphalt- and tar-saturated and other	36.5	30.98
		117.8	100.00
32751	Calcined gypsum building materials, building plasters, and prefabricated building components	538.4	95.73
2661	Building papers and millboards	456.2	
32927 41	Flat sheets and wallboard (asbestos)	20.7	4.27
32927 98	Other asbestos and asbestos-cement products, including millboards and prefabricated housing	23.7	
		1,039.0	100.00

4. EXPOSURE TO ASBESTOS

The methods used to obtain information on exposure to asbestos in the construction and demolition industries are briefly described in this section. General methods for controlling asbestos exposure are presented, followed by descriptions of specific asbestos product applications, expected airborne fiber concentrations, and specific control techniques. Work scenarios are included for each product.

4.1 METHODOLOGY

The following sections contain descriptions of the methods of installation, fabrication, and removal of a variety of asbestos-containing materials used in construction. Available fiber count data, work practices, and methods of engineering controls are included in each description.

As noted in Section 2, site visits were conducted for purposes of observation and sampling. Table 2-2 summarizes these site visits by type of material or operation. Data for each sampling survey are reported in Appendix B along with a brief narrative description of the observed operations. The information obtained regarding work elements for various products and operations, as well as information on trade groups, frequency of exposure, work practices, and engineering controls has been incorporated in the following discussion.

Fiber count data for a variety of asbestos-containing materials have been obtained from site surveys, the published literature, state and federal agencies, and from personal communication with industrial hygienists active in the construction industry. Data obtained during previous EEH

In addition, the periods of time that a worker spends in each type of work environment must be known since asbestos fiber concentrations in the air will vary with location. Ceiling concentrations of asbestos fibers can be determined from air samples obtained during those operations that are suspected of contributing the largest exposures to the worker. General air and background air concentrations are also needed to evaluate the exposure to workers not directly involved in field fabrication operations.

Some of the factors generally affecting airborne concentrations of asbestos fibers are the physical form of the material, the asbestos content of the material, and the nature and location (indoors/outdoors) of the field-fabrication/demolition techniques employed. Powders and friable asbestos materials will tend to produce higher fiber concentrations, for example, than will materials in which the asbestos is bound in a matrix composed of cement or bitumen. The influence of asbestos content is obvious. Typical ranges of asbestos content for materials commonly used in construction are shown in Table 4-1. Techniques such as sanding and sawing will produce more airborne fibers than cutting with a knife; however, techniques are often directly related to the form of the material. Indoor operations without benefit of local exhaust tend to be conducive to higher fiber counts than operations performed outdoors.

Work scenarios have been developed for each of the materials discussed. The scenario is a postulated work situation characteristic of those observed in the field. Each scenario includes the number of workers

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industrial hygiene surveys of construction operations involving asbestos-containing materials have been included with the client's permission.

Airborne concentrations of asbestos fibers are determined by collecting a sample of airborne dust on a filter, counting asbestos fibers on the filter, and calculating the concentration of fibers per unit volume. A portable calibrated sampling pump is used to draw air through a membrane filter (pore size: 0.8 microns) at a known flow rate so that the sample volume is easily determined. Airborne fibers are collected on the filter, and the number of fibers is determined with an optical microscope using a phase-contrast procedure. Only those asbestos fibers that are more than 5 micrometers long and that have a length more than three times greater than the diameter are counted during this process. Concentrations of fibers are then expressed as the number of fibers per milliliter whose size is greater than 5 micrometers. This is the standard reference procedure used by OSHA.

Time-weighted-average exposures are calculated estimates of the average asbestos concentration an individual is exposed to during the course of a working day or week, based on measured values. In order to accurately evaluate time-weighted-average exposures, asbestos concentrations should be available for the following: (1) breathing zone air for each operation performed by a worker involving the use of asbestos materials, (2) general air in the areas where a worker is stationed throughout the working period, and (3) background air representative of the air breathed when an individual is not in the immediate workplace atmosphere.

Table 4-1

Ranges of Asbestos Content of Materials Used in Construction

Material	Percent Asbestos
Vinyl asbestos floor tile	15 to 25
Insulation (demolition)	<100
Asbestos-cement sheet	9 to 21
Asbestos-cement pipe	
Pressure	11 to 21
Sewer	10 to 14
Asbestos felts	≥85
Paints, coatings, and sealants	0.5 to 20
Dry wall taping compounds	1 to 5
Millboard incombustible board	20 to 85
Drilling fluid additives	∿100

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involved; installation or removal practices and rates, as applicable; a scenario duration and frequency of repetition; and estimates of the total number of workers and contractors involved on a yearly basis. The numerical data used in developing these scenarios are derived from information contained in Section 2.

4.2 ASBESTOS-CEMENT SHEET

4.2.1 Field Fabrication and Installation

Asbestos-cement flat sheet is manufactured in 4-by-8-foot and 4-by-12-foot sheets. The thickness of the available panels varies, but is generally from 0.125 to 0.75 inches. A wide variety of colors and surface textures are available.

There are two types of asbestos-cement sheet that might be described as general-purpose material. Type F is a flexible board for exterior and interior use where high strength and density, smooth surface, flexibility, and low moisture absorption are needed. Type U is a utility board for exterior and interior use, with sufficient strength for general utility and construction purposes where flexibility, density, smoothness, and moisture absorption are not essential.

Asbestos-cement sheets are shipped to commercial lumberyards and glasshouses as well as to the job site on pallets, with the sheets wrapped in plastic and banded. As material is needed at the job site, each pallet is unwrapped.

The asbestos-cement sheets are installed by a crew of sheet-metal workers and building laborers (SIC 1761). Carpenters (SIC 1751) also install these materials. Installation is by means of counter-sunk screws or back-fastened self-tapping screws. The sheets are fastened directly to the framing or are held in place by clips attached to the framing. The operations necessary to fit the panels include cutting to size, using a carbide-tipped or abrasive-disk power saw, and drilling the mounting holes. In either case, a significant quantity of asbestos dust is generated.

The productivity of an installation crew varies with the weight of the material and the amount of fitting involved. The range of installation values is from 500 to 1,200 square feet of flat sheet per day.

Extruded asbestos-cement sheet materials are also available in different sizes. Handling and fabrication techniques are nearly identical to those for flat sheet materials. Installation is somewhat different because of the greater weight of the individual sections. Asbestos sheet materials that employ inorganic binders other than cement are also available. Although these sheet materials are not technically asbestos-cement products and have somewhat different applications, the construction practices that produce most of the airborne asbestos are the same as those for asbestos-cement products. For this reason, these noncement products are included in this category.

Corrugated asbestos sheet is made of the same ingredients as other asbestos-cement sheet products. By virtue of its corrugations, it can withstand heavy service conditions. In addition, it can be lapped, thus making a weatherseal and eliminating many joint problems.

Corrugated asbestos is available in two types, standard and lightweight. The lightweight product is about half the weight of the standard product and consequently is less dense and lower strength. The corrugated panels are 42 inches wide by 10 to 12 feet long.

The corrugated asbestos-cement sheets are installed by a crew of two sheet-metal workers and two building laborers (SIC 1761). Installation is by nails, bolts, or studs through the ridge of the corrugations into the purlins or girts. The holes for nails and bolts must be predrilled and are sealed by neoprene washers. Side laps are one corrugation, and end laps are 6 inches.

The operations involved in field preparation of the material include cutting to size by hand or power saw, drilling or punching holes, filing, and scoring and breaking for cuts parallel to the corrugations.

The standard crew can install from 750 to 1,100 square feet per day of corrugated asbestos as roofing, depending on the material weight and the framing material. For siding, the installation rate varies from 600 to 945 square feet per day.

Shipping practices, and dust-control and cleanup procedures have not been observed and therefore are not described here. They should, however, be similar to those for asbestos-cement flat sheets.

Alternative materials include wood, brick, stone, stucco, concrete, aluminum, vinyl, steel, tile, and asphalt shingles.

4.2.2 Worker Exposure to Asbestos

Available fiber count data indicate that the uncontrolled cutting and sawing and, to a lesser degree, drilling of asbestos-cement sheet and pipe can produce significant exposure to the worker performing the operation. Background concentrations in the immediate vicinity of these operations are also capable of producing significant exposure of nearby workers spending a long time in the area. Data for asbestos-cement sheet and other similar sheet materials are shown in Table 4-2.

It has been suggested that worker exposure for uncontrolled sawing of sheet material is greater than 25 fibers per cubic centimeter. Available fiber count data indicate peak exposures for a worker using a portable circular saw in excess of 10 fibers per cubic centimeter while cutting. One measurement for a 10-minute sample was 130 fibers per cubic centimeter for dry cutting.

In the case of asbestos-cement sheet, persons applying the material are generally also involved in the cutting operations when they are necessary. However, cutting operations are generally intermittent either on a given workday or during the time spent at a job site; i.e., sheet can be cut as needed on a particular day, or a day or more can be spent cutting all the sheets that will be needed for an extended period of installation. Thus, the intermittent nature of these operations would tend to reduce the long-term exposure of these workers. Time-weighted average concentrations on the order of 5 fibers per cubic centimeter have been reported for workers cutting, sawing, and installing sheet materials.

Table 4-2

Fiber Count Data for Asbestos-Cement Sheet

Operation[a]	Time	Fibers/ Cubic Centimeter
Cutting, Sawing		
1. Uncontrolled		
Band saw, no ventilation	30 min.	5.2
General air	--	3.1
	60 min.	11.2
	--	4.0
Power sawing	--	>25
Jigsaw	--	2-10
Circular saw	--	10-20
	--	19.2
	--	27.5
	--	33.0
Power sawing	15 min. 8 sec.	32.3
	15 min.	30
	15 min. 1 sec.	39.7
	15 min.	68.7
Drycutting	5 min.	13.6
	9 min.	7.0
	15 min.	5.3
	8 min.	5.9
	10 min.	130
	7 min.	10.6
	5 min.	4.5
Manual saw	--	2-4
2. Baghouse ventilation		
Portable circular saw,	--	75.4
General air		3.0
	--	17.0
		7.1
Portable circular saw, Masonry blade	--	0.7
General air		0.5
Portable circular saw, Carbide tip blade	--	3.4
General air		0.0
3. Dry control system (unspecified)		
Circular saw	30 min.	0.7 (TWA)
General air		0.5
Sawing	--	<2
Machine sawing	--	<2
Jigsaw	--	4.9
General air		2.3
4. Shroud Hi-Vol/Lo-Vol System		
Sawing	53.3 min.	1.01
General air	65.5 min.	0.07
Sawing (helper)	32 min.	0.4
Sawing	49.5 min.	0.3
Sawing (system malfunctioning)	16 min.	7.4
General air	16.5 min.	1.6

a. Personal samples unless noted.

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Table 4-2

Fiber Count Data for Asbestos-Cement Sheet

Operation[a]	Time	Fibers/ Cubic Centimeter
Cutting, Sawing		
1. Uncontrolled		
Band saw, no ventilation	30 min.	5.2
General air	--	3.1
	60 min.	11.2
	--	4.0
Power sawing	--	>25
Jigsaw	--	2-10
Circular saw	--	10-20
	--	19.2
	--	27.5
	--	33.0
Power sawing	15 min. 8 sec.	32.3
	15 min.	30
	15 min. 1 sec.	39.7
	15 min.	58.7
Drycutting	5 min.	13.6
	9 min.	7.0
	15 min.	5.3
	8 min.	5.9
	10 min.	130
	7 min.	10.6
	5 min.	4.5
Manual saw	--	2-4
2. Baghouse ventilation		
Portable circular saw,	--	75.4
General air		3.0
	--	17.0
		7.1
Portable circular saw, Masonry blade	--	0.7
General air		0.5
Portable circular saw, Carbide tip blade	--	3.4
General air		0.0
3. Dry control system (unspecified)		
Circular saw	30 min.	0.7 (TWA)
General air		0.5
Sawing	--	<2
Machine sawing	--	<2
Jigsaw	--	4.9
General air		2.3
4. Shroud Hi-Vol/Lo-Vol System		
Sawing	53.3 min.	1.01
General air	65.5 min.	0.07
Sawing (helper)	32 min.	0.4
Sawing	49.5 min.	0.3
Sawing (system malfunctioning)	16 min.	7.4
General air	16.5 min.	1.6

a. Personal samples unless noted.

Table 4-2 (Cont.)

Operation[a]	Time	Fibers/ Cubic Centimeter
4. Shroud Hi-Vol/Lo-Vol System (Cont.)		
Low-speed saw	19.25 min.	0.2
Low-speed saw (helper)	18.75 min.	0.2
Low-speed saw	17.5	<0.1
Low-speed saw (helper)	18	0.2
Portable circular saw (six samples)	4 hours	2.6-10
General air (six samples)	4 hours	1.0-2.8
Portable saw, carbide blade	15 min.	10.2
	15 min.	10.6
5. Vacuum Table, Shrouded Tool		
Sawing	--	0.8
General air	--	0.5
Circular saw	--	0.5
General air	--	0.9
	--	1.8, 2.2
	--	1.0, 0.7
	--	0.4, 0.4
	--	0.2, 0.4
6. Wet Control System		
Portable chain drive saw	--	0.6
General air		0.6
Circular saw		0.6
Mason's saw, diamond tip	18 min.	1.8
	15 min.	1.7
	62 min.	0.3
	45 min.	0.6
Drilling		
1. Uncontrolled		
Drilling	--	2-20
Drilling down	28.75 min.	0.2
Drilling (helper)	27.5 min.	<0.1
Drilling down	37.5 min.	<0.1
2. Controlled		
Drilling	--	<2
Baghouse ventilation	--	0.2
General air	--	0.1
Drilling overhead	1.5 hr.	0.2
General air	1.5 hr.	0.1
Total shroud	--	0.6
Partial shroud	--	0.2
Sanding, Installing		
Vibrating sander with baghouse ventilation	--	0.8
General air	--	0.4
Installing sheet (cooling tower)	--	0.4 TWA
Installing sheet with drilling and cutting	--	0.7

The application of control devices has shown that fiber concentrations can be greatly reduced in the work area, and more importantly, in the worker breathing zone. A variety of devices are available for portable saws. These include baghouses, shrouds, and vacuum tables for dry techniques and also wet control methods. Local exhaust ventilation provided by a baghouse has yielded highly variable results in terms of reducing measured asbestos concentrations. Personal samples range from as low as 0.7 fibers to a high of 75 fibers per cubic centimeter. Shrouded saws using high-velocity low-volume vacuum systems also have shown a variable effectiveness. However, the range is much smaller, that is, from several tenths of a fiber to approximately 10 fibers per cubic centimeter. The available data reflect advances made in this area. Two surveys were performed by EEH at locations where a variety of shrouds were employed. Ceiling concentrations ranged from less than 0.1 to 1 fiber per cubic centimeter. Time-weighted averages for a cutter and helper during one survey were 0.4 and 0.2 fibers per cubic centimeter, respectively. The use of a vacuum table in conjunction with a shrouded tool also shows some variation, but available data indicate a fairly narrow range of ceiling concentrations, i.e., from approximately 0.4 to 2 fibers per cubic centimeter. A similar range is reported for wet control methods.

Drilling asbestos-cement sheet without controls does not produce as high air concentrations of asbestos as sawing. Estimated ranges are from 2 to 5 fibers per cubic centimeter for vertical structures and

4 to 10 fibers per cubic centimeter for drilling overhead, without control devices. With control, the estimated concentration is less than 2 fibers per cubic centimeter. Measurements of ceiling asbestos air concentrations resulting from drilling with control devices range from less than 0.1 fibers to 0.7 fibers per cubic centimeter.

The other operations for which there are some data available include sanding, finishing, and installing. Available data are too limited to reach general conclusions, but all are below 1 fiber per cubic centimeter.

4.2.3 Feasibility of Engineering Controls

The recommended engineering controls that can be used to reduce exposure to asbestos fibers when fabricating asbestos-cement sheet are described in the following subsections.

4.2.3.1 Fixed Tools

If all fabricating operation cutting, drilling, etc. can be performed at a single location, standard engineering controls can be used. A portable enclosure can be established and all operations can be confined to a single location, minimizing worker exposure to airborne asbestos.

4.2.3.1.1 Radial Arm Saw

Dust escapes from the top side of the materials as the saw breaks through the top surface of the asbestos-cement sheet; some of the dust goes to the saw-passed area, and some goes around and out toward the operator. Dust also escapes from the bottom surface as the saw breaks through and goes below the table top.

The dust can be controlled by providing an enclosure and vacuum exhaust; 2,500 cubic feet per minute of vacuum at 14 inches of water are required. Figure 4-1 shows a typical configuration for a radial arm saw.

4.2.3.1.2 Table Saw

The table saw generates dust as the leading edge of the asbestos cement sheet engages the downward moving saw teeth. The dust escapes from the bottom and is propelled downward toward the back of the saw below the table top. Some dust is generated over the top of the material cut, due to the rubbing of the saw or binding as the saw cuts. The dust rises over the saw towards the operator. Figure 4-2 shows a recommended dust control system for a table saw. A total of 2,500 cubic feet per minute at 14 inches of water are required to control the dust generated by the table saw when cutting asbestos-cement sheet.

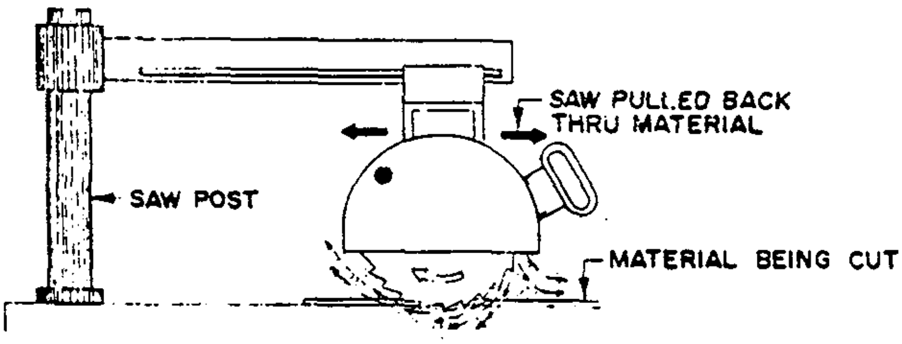
4.2.3.1.3 Stone Saw

Dust is generated when the leading edge of the stone wheel breaks through the top surface of the asbestos-cement sheet. Dust and chips are also emitted from the back edge of the hood.

The recommended dust control system for a stone saw is shown in Figure 4-3. From 2,500 to 4,000 cubic feet per minute are required at 14 inches of water to control the dust generated by the saw shaper, which shapes asbestos-cement sheet.

PRESENT EQUIPMENT -DESIGN MODIFICATIONS

RADIAL ARM SAW:



Recommended engineered dust control system.

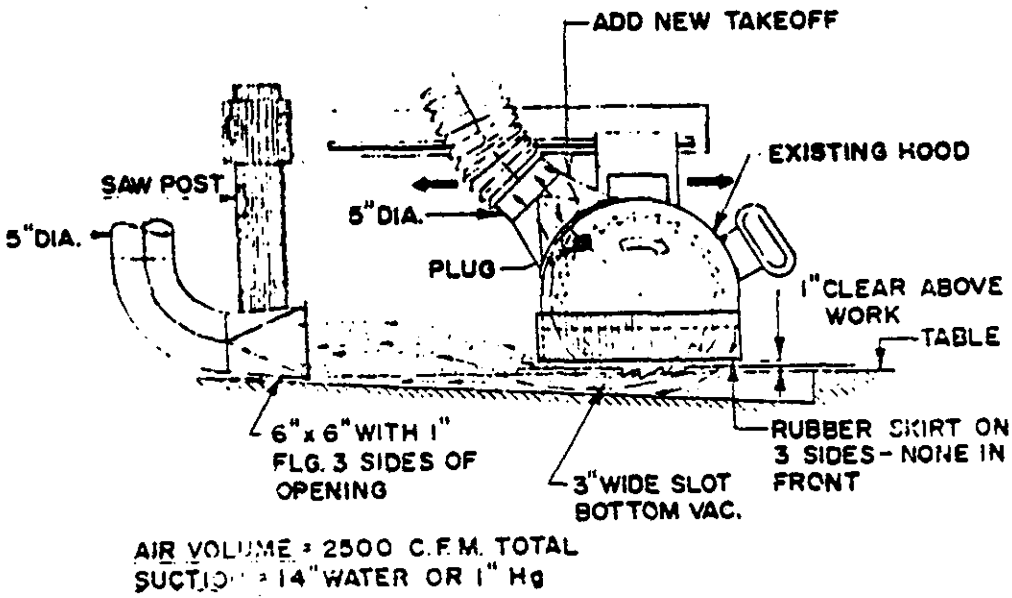
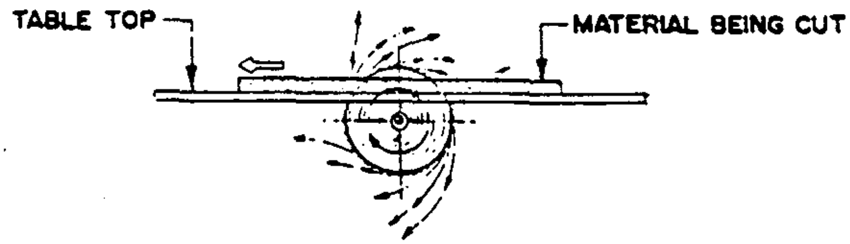


Figure 4-1

PRESENT EQUIPMENT-DESIGN MODIFICATIONS

TABLE SAW



Recommended engineered dust control system.

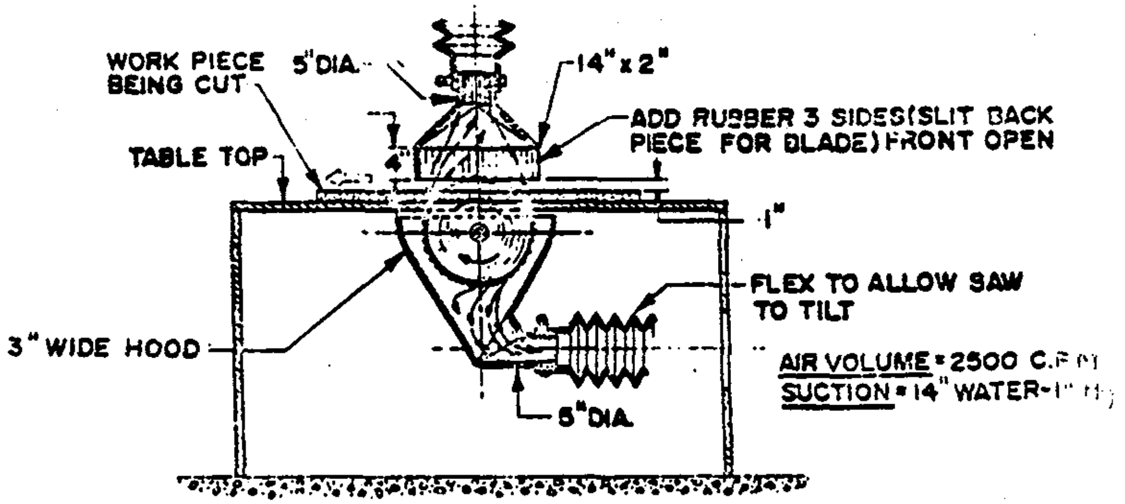
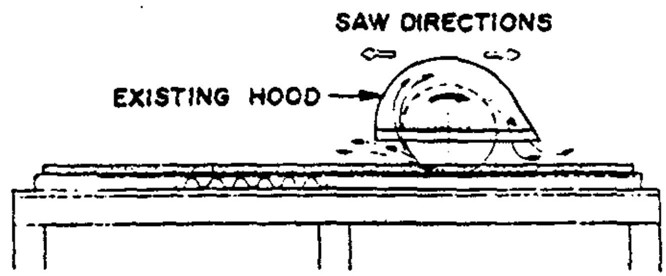


Figure 4-2

PRESENT EQUIPMENT-DESIGN MODIFICATIONS



Recommended engineered dust control system.

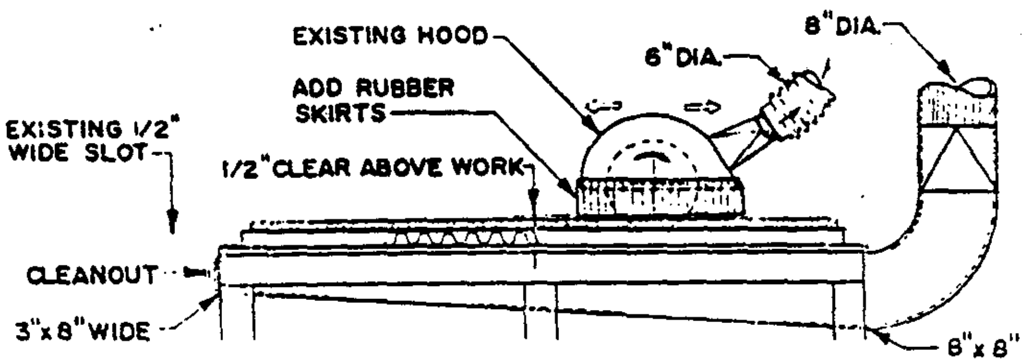


Figure 4-3

4.2.3.1.4 Shaper

The shaper, when shaping or contouring asbestos-cement sheet, generates dust as the cutter blade on the shaper peels off a very fine chip due to the high velocity of the shaper. Dust is also generated by the vibration in the cutter shaft or the chatter in the material being shaped.

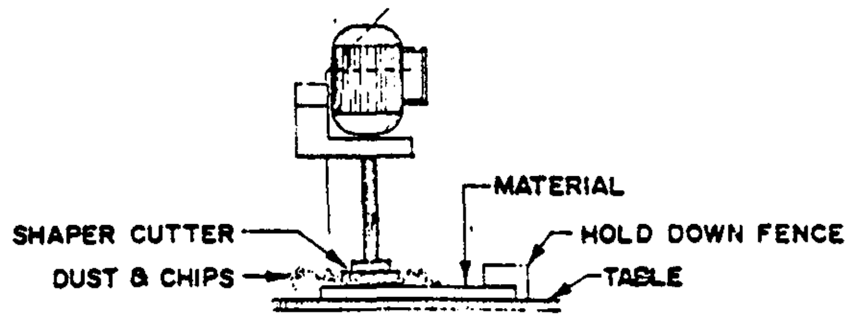
The recommended control system is shown in Figure 4-4. A total of 2,500 cubic feet per minute at 14-inch water vacuum are required to control the dust generated by the shaper.

4.2.3.1.5 Drill Press

Drill presses are normally not significant generators of dust as they remove the material in chip form, which is larger and heavier than the much finer dust from saws or masonry wheels. The dust that is generated when drilling asbestos cement sheet comes from several sources: fine dust at the start of drilling; dust brought up with the chips; and dust caused by breakthrough of the drill at the bottom of the material. A typical system to control dust generated by a drill press is presented in Figure 4-5. The system requires 2,500 cubic feet per minute at 14 inches of water.

The vacuum pickup for the various saws, drills, etc., must be ducted to a fabric filter collector. All exhausts and dust collection systems should be inspected periodically to insure that the various recommended systems are functioning properly. For continuous operation, it is recommended that the system operations and the interior of the baghouse be

PRESENT EQUIPMENT-DESIGN MODIFICATIONS



Recommended engineered dust control system

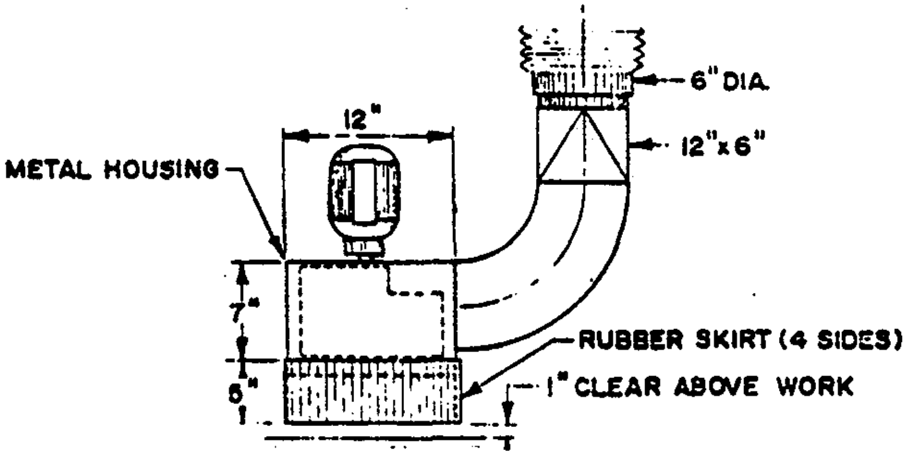


Figure 4-4

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is tabulated in Table 2-7 by group of product (figures are given in thousand short tons of asbestos fiber consumed). The quantity of asbestos consumed in 1975 declined substantially from the level during 1974 and was lower during 1975 than during any other year from 1965 to 1975.

Figure 2-1 indicates the routes by which asbestos products reach the construction industry. This information was derived from the manufacturers of each product (EEH 1976b). Most asbestos products reach construction sites both by direct delivery from the manufacturer to the contractor and through an intermediary distributor or wholesaler. When the manufactured good is sent to a secondary manufacturer, the route from the secondary manufacturer to the construction site again involves either direct delivery or delivery through a distributor or wholesaler. It can also be seen that once a product leaves the manufacturer, further fabrication or manipulation of the asbestos product does not take place until it reaches the construction site.

Data (Tables 2-8 and 2-9) on importation and exportation of manufactured asbestos products are available for 1972 and 1974 (Asbestos 1973, 1975; the source cited in these references is the U.S. Bureau of the Census).

In 1972, $32 million worth of asbestos products were exported, and $1 million worth were imported. The net $20 million worth of asbestos products exported consisted mainly of friction, packing, and nonspecified categories.

In 1974, $60 million worth of asbestos products were exported, and $11 million worth were imported, with a net of $40 million worth exported.

Table 2-7

U.S. Asbestos Consumption (in thousand short tons)

Asbestos Products	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[a]
Flooring products	200	202	179	204	196	184	191	202	218	153	135
Asbestos-cement pipe	151	153	134	155	149	139	144	154	166	222	152
Roofing products	79	80	71	82	79	73	76	81	87	76	78
Friction products	71	72	65	74	71	66	68	73	79	80	66
Asbestos-cement sheet	55	56	51	57	55	51	53	57	64	95	44
Packing and gaskets	24	24	22	25	24	22	23	24	26	29	17
Insulation	24	24	22	25	24	22	23	24	26	14	6
Paper products	16	16	14	16	16	15	15	16	18	63	65
Textiles	16	16	14	16	16	15	15	16	18	20	6
Other	159	162	145	163	154	147	151	162	174	94	36
Total U.S. Consumption	795	805	721	817	784	734	759	809	876	846	605

Source: U.S. Bureau of Mines. 1975. Asbestos. Mineral Facts and Problems.
a. Personal communication from Robert A. Clifton, Bureau of Mines.

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Recommended engineered dust control system

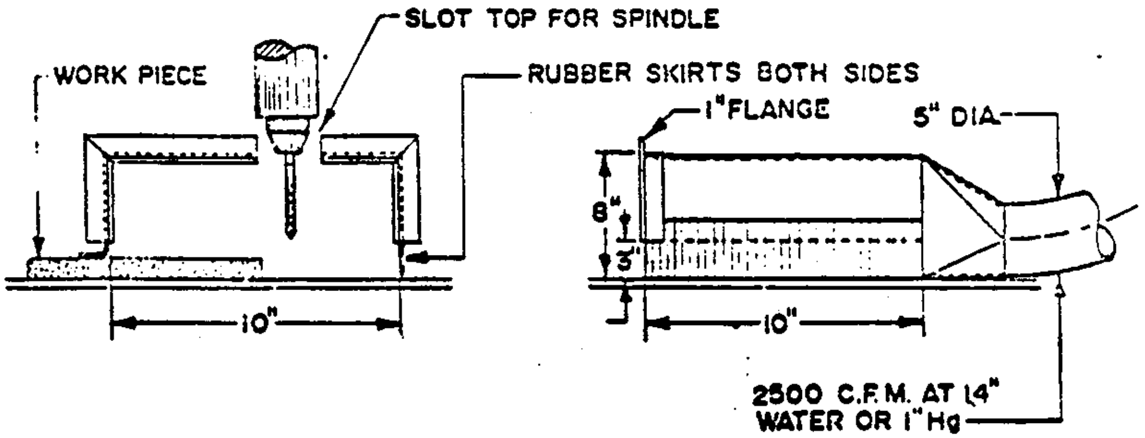


Figure 4-5

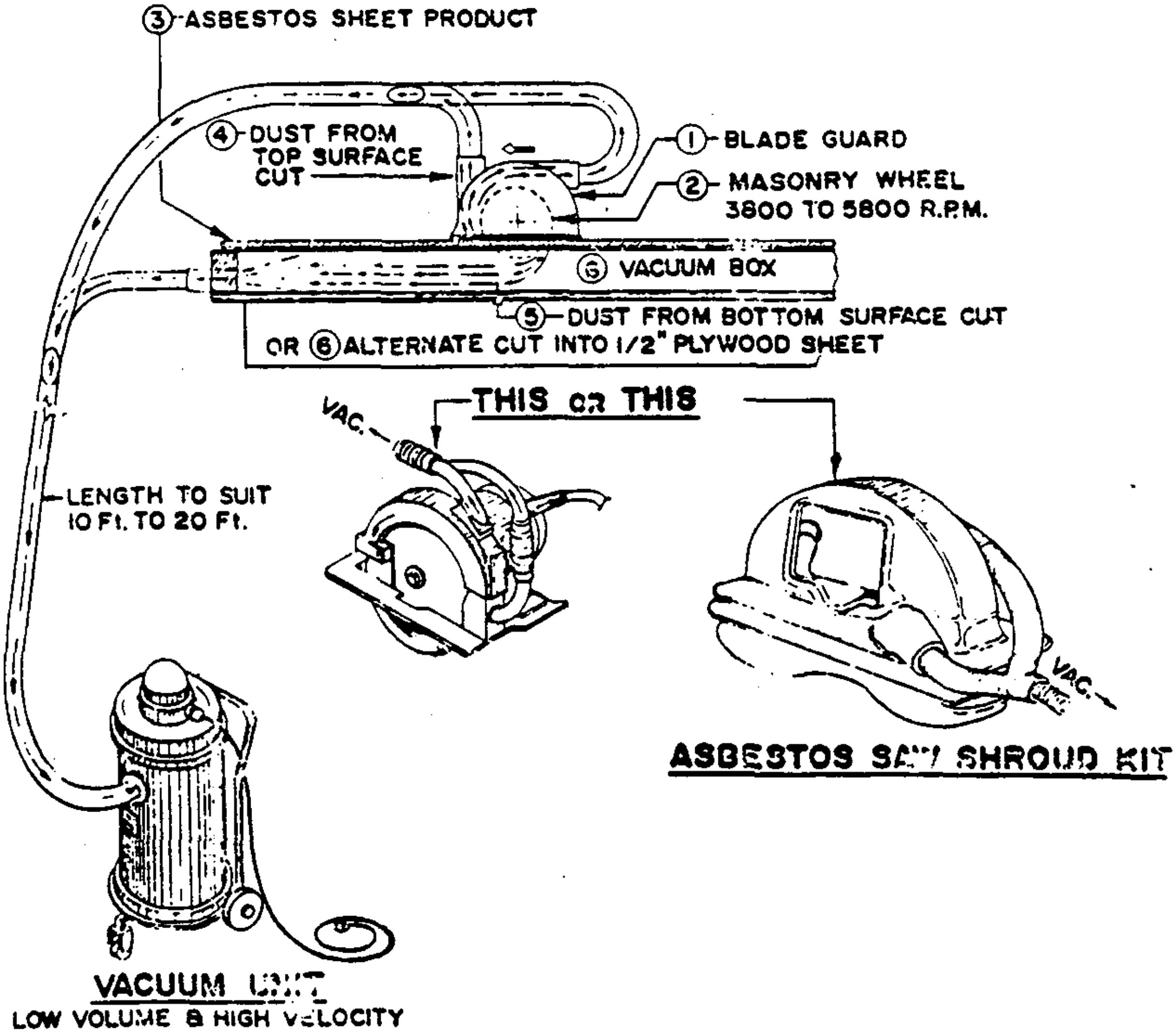
checked daily. A scheduled maintenance program that includes bag replacement should be prepared and followed.

4.2.3.2 Portable Tools with Local Exhaust System

For many job sites where asbestos-cement sheet is installed, it is not feasible to use fixed controls located at one central location. This is due primarily to the fact that many of the operations involved in installing asbestos-cement sheet are performed intermittently and many are performed after the sheet is in place. For these applications, portable hand tools with local exhaust systems are recommended. The following is a description of recommended engineering control techniques for portable hand tools.

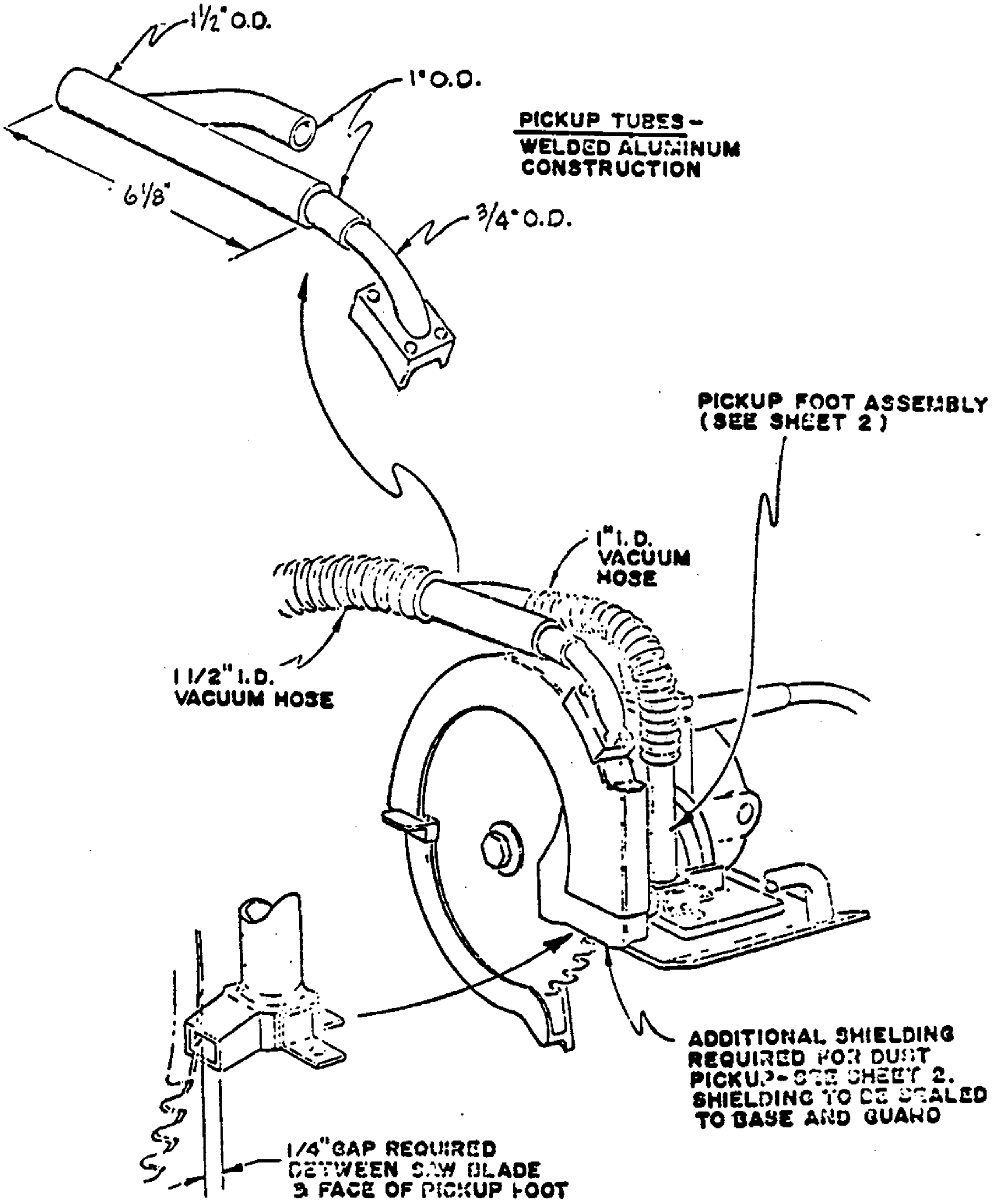
4.2.3.2.1 High-speed Rotary Saw

When a high-speed rotary power saw equipped with a masonry wheel is used, considerable dust is generated as the leading edge of the saw contacts the asbestos material (asbestos-cement sheet). As the saw progresses into the asbestos-cement sheet, the back edge of the masonry wheel enters the cut in the asbestos sheet and rubs both edges of the cut, creating dust below the surface of the cut sheet. In order to control this dusting, saws have been equipped with a shroud attached to a vacuum hose exhausting into a vacuum unit. The vacuum required is 150 cubic feet per minute at 6 inches of mercury. Figures 4-6 through 4-9 present common design configurations and details.



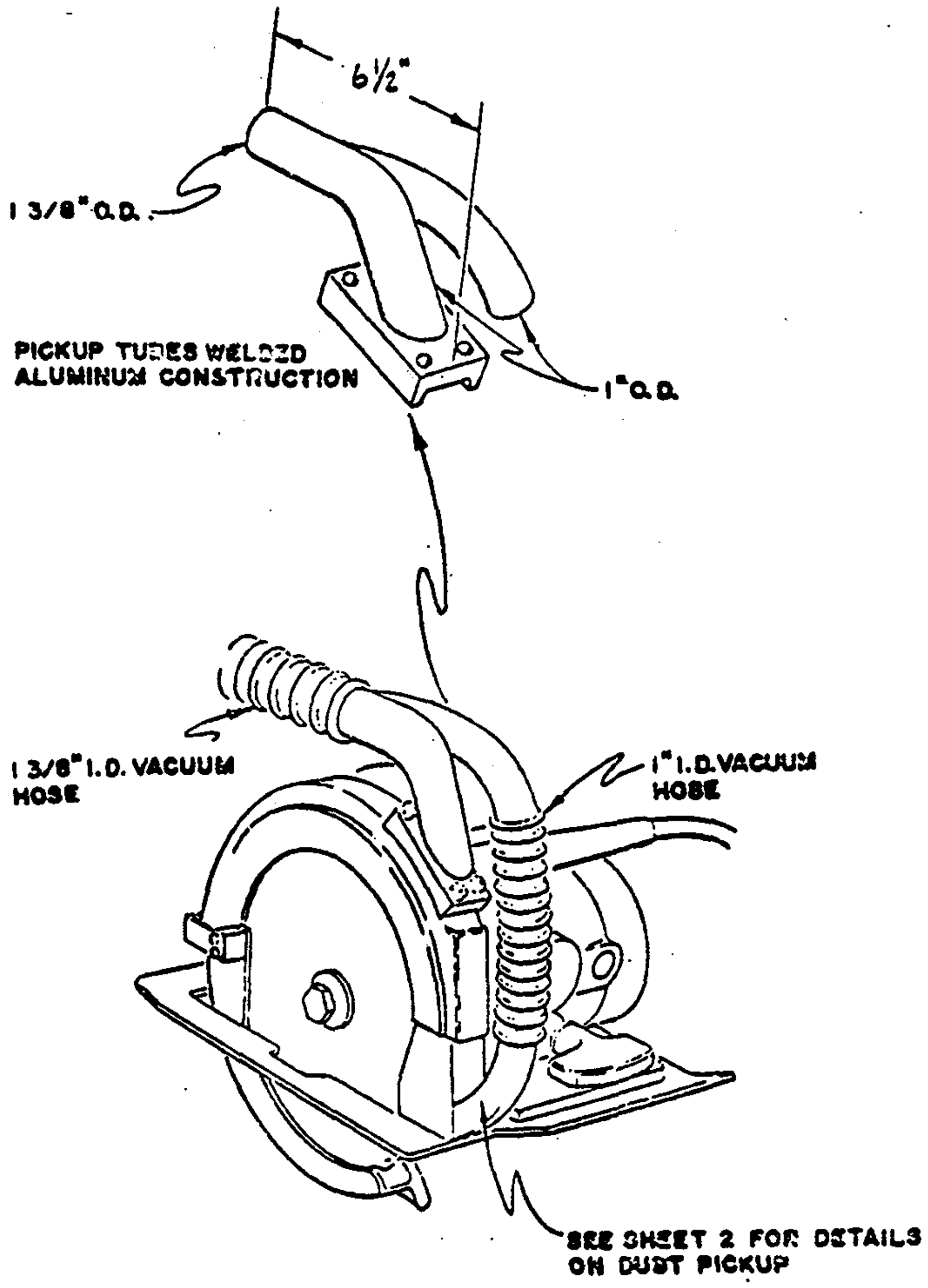
③-ASBESTOS SHEET PRODUCT
④-DUST FROM TOP SURFACE CUT
①-BLADE GUARD
②-MASONRY WHEEL 3800 TO 5800 R.P.M.
⑥ VACUUM BOX
⑤-DUST FROM BOTTOM SURFACE CUT
OR ⑥ALTERNATE CUT INTO 1/2" PLYWOOD SHEET
THIS OR THIS
VAC.
LENGTH TO SUIT 10 Ft. TO 20 Ft.
VAC.
ASBESTOS SAW SHROUD KIT
VACUUM UNIT
LOW VOLUME & HIGH VELOCITY

Figure 4-6



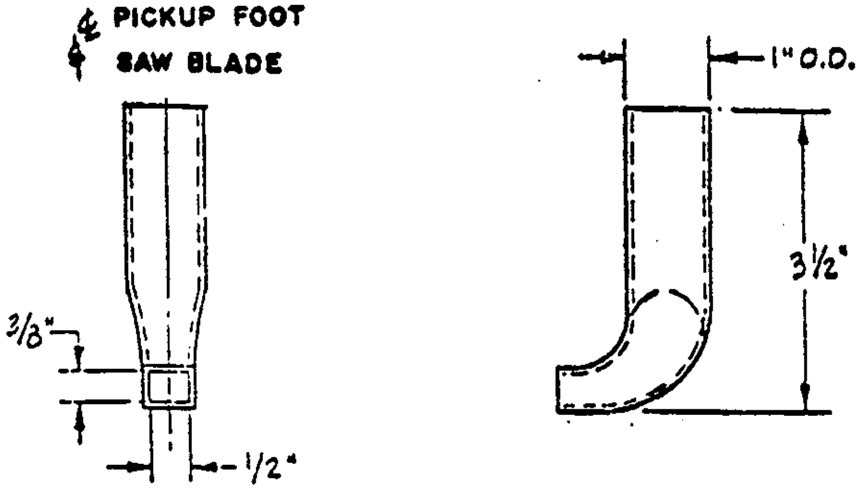
DUST EXTRACTOR-PORTABLE SAW- 10 1/4" DIA. BLADE

Figure 4-7

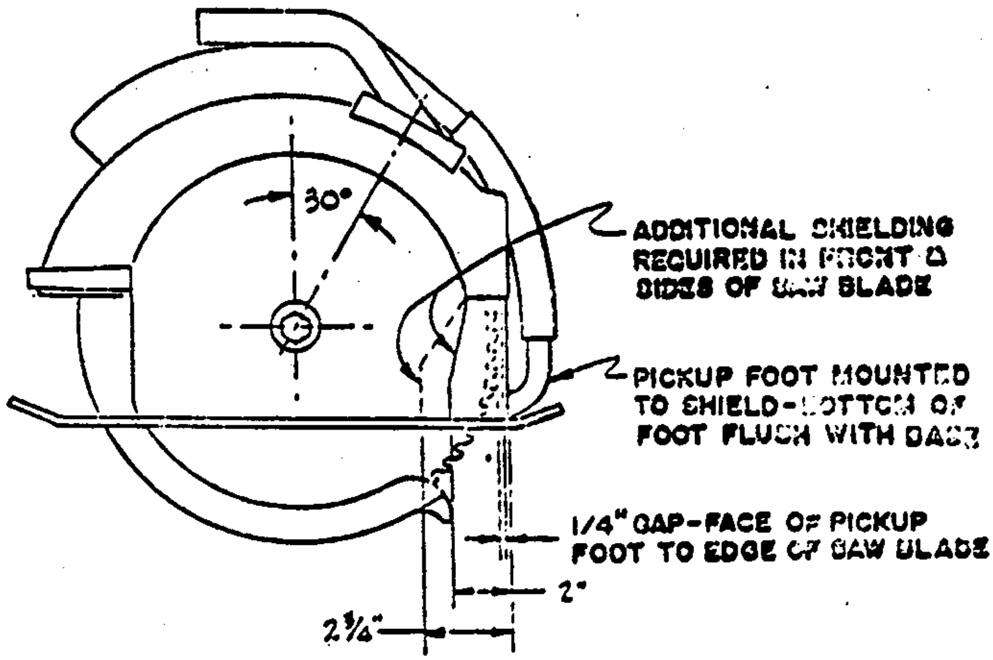


DUST EXTRACTOR - PORTABLE SAW - 7 1/4" DIA. BLADE

Figure 4-8



PICKUP FOOT-WELDED TO SHIELDING



DUST EXTRACTOR-PORTABLE SAW-7 1/4"DIA. BLADE

Figure 4-9

4.2.3.2.2 Portable Electric Drills

Portable electrical drills generally create excessive dust only when drilling vertical or overhead surfaces.

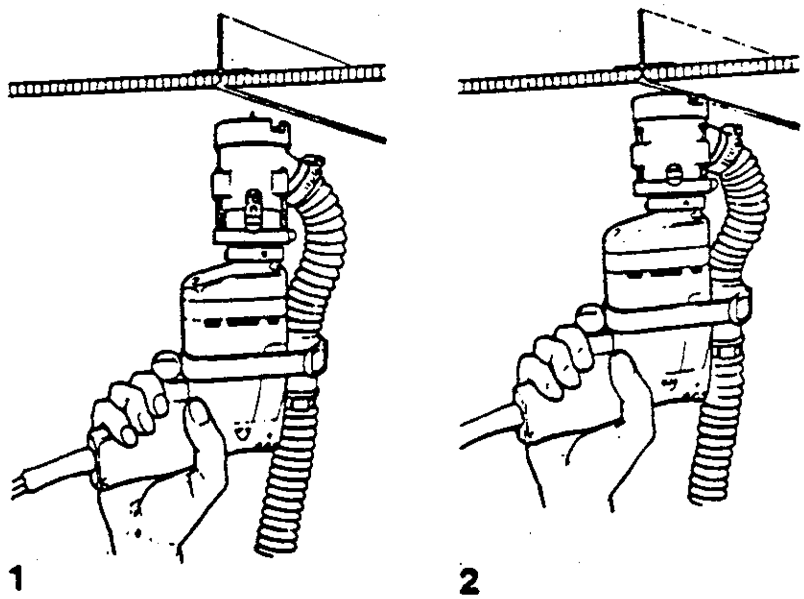
The dust is generated by the uneven angle and pressure applied to the drill. In order to reduce this dusting, portable hand drills are equipped with a nozzle that allows the dust to be picked up by a vacuum line. Usually 75 cubic feet per minute at 5 inches of mercury are required. Here again, the dust is exhausted to a vacuum unit. Figures 4-10 through 4-12 present common design configurations that may be utilized.

4.2.3.2.3 Belt-type Sanders

Belt sanders that utilize a continuous belt of abrasive material scratch against asbestos materials. This scratching action generates loose dust. The dust occurs mainly at the back of the sander, but some dust is emitted along the sides of the belt. In order to prevent the dust from becoming airborne, some belt sanders employ built-in control systems with dust bags. These can be utilized by themselves although because of the efficiency of the collector it is preferrable that they be connected to vacuum units of 50 to 75 cubic feet per minute and 6 inches of mercury vacuum capacity. Figure 4-13 shows a typical configuration that can be employed on a belt-type sander.

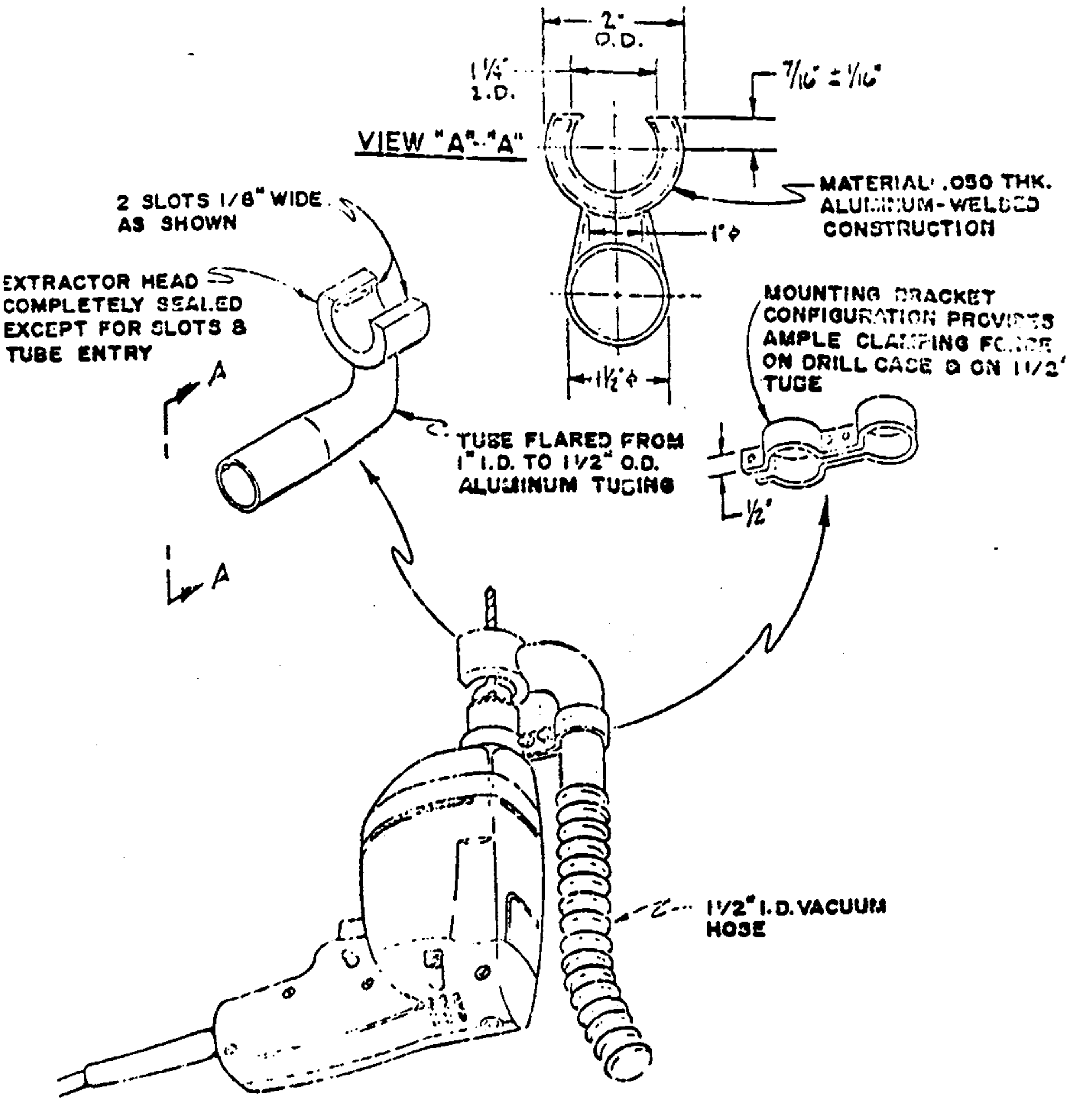
4.2.3.2.4 Vibratory-type Sanders

Vibratory-type sanders are finishing sanders that use a strip of sandpaper below a cushion pad with the ends fastened in various manners.



Drill with dust extractor

Figure 4-10



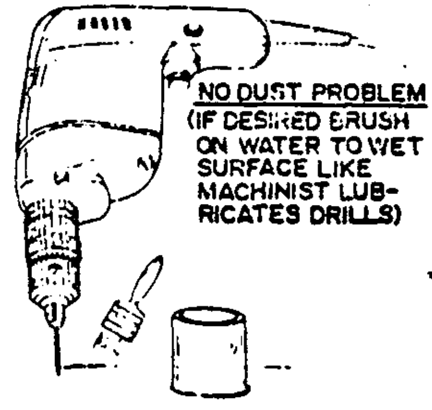
DUST EXTRACTOR - DRILL

Figure 4-11

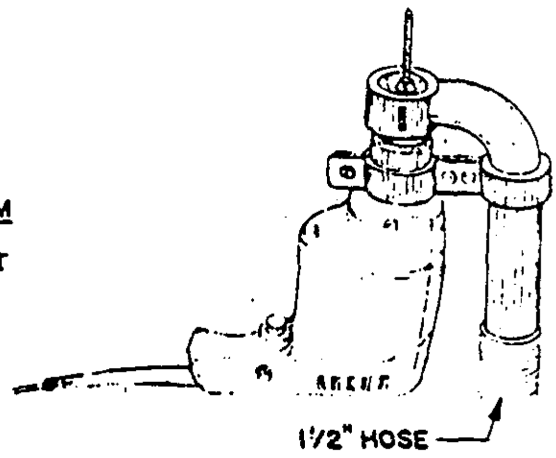
METHODS OF ENGINEERED DUST CONTROL SYSTEMS

PORTABLE ELECTRIC DRILLS

NORMAL DRILLING OF HORIZONTAL SHEETS



DRILLING OVERHEAD OR DRILLING OF VERTICAL SURFACES



OR

CAPE PORTABLE DRILL NOZZLE KIT COMPLETE WITH BACK PACK TANK VACUUM

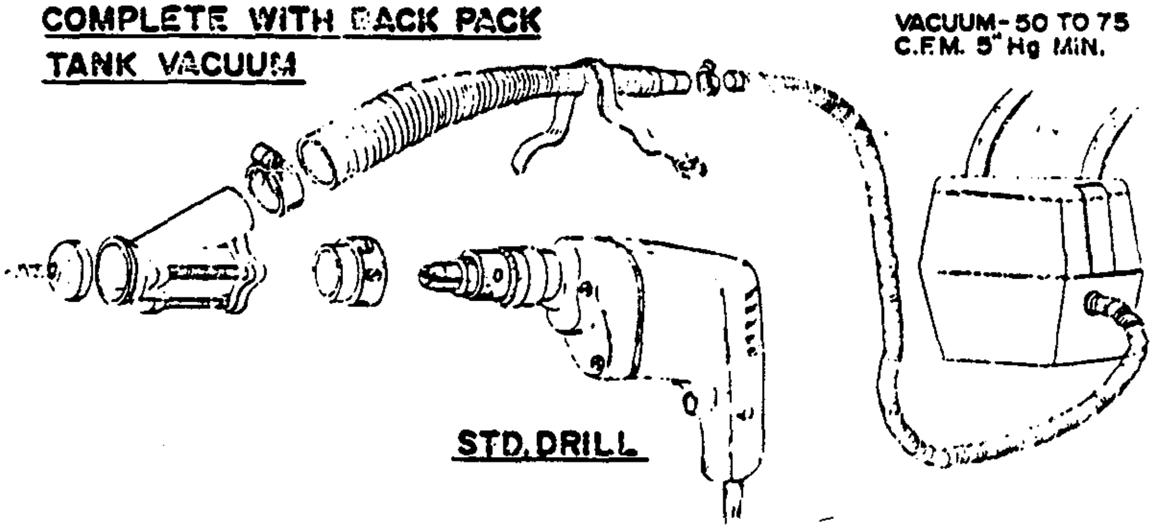


Figure 4-12

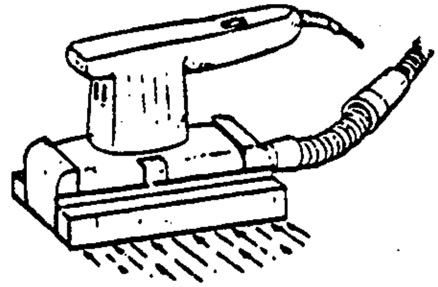


Figure 4-13

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The sanding movement is caused by an offset motion or vibration, which sets up the oscillation causing dusting. At present, there are several dustless sanders that have built-in dustless attachments for use with canister-type vacuum units. Figure 4-14 shows a typical vibratory sander equipped with dust control equipment.

4.2.3.3 Wet Methods

Wet methods can be utilized when practicable to prevent the emission of asbestos dust to the atmosphere. In many cases, the wet methods are not practicable for the following reasons:

a. Water is not available at the site or the location where the actual field fabrication takes place.
b. During freezing weather, it may be impossible to use wet methods.
c. The usefulness of product is diminished by wetting.

The applicability of wet methods is limited. In most situations, engineering controls relying on vacuum systems, as previously discussed, are more appropriate.

4.2.3.4 Summary

On the basis of available fiber count data and the engineering control techniques presently available, it appears practical to limit asbestos ceiling concentrations to a range of 0.5 to 2.0 fibers per cubic centimeter for asbestos-cement sheet fabrication and installation

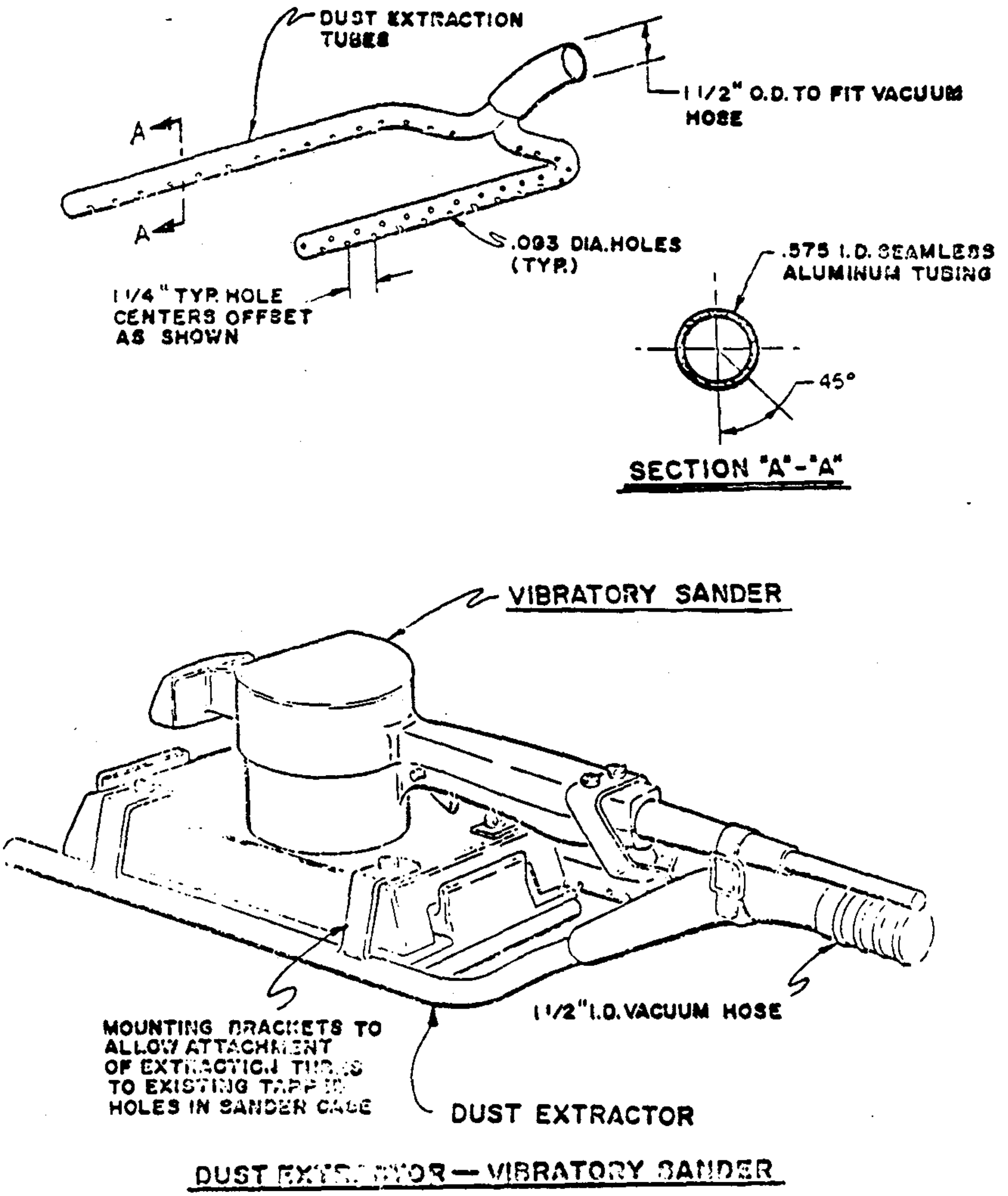
DUST EXTRACTION TUBES
1 1/2" O.D. TO FIT VACUUM HOSE
A
A
.093 DIA. HOLES (TYP.)
1 1/4" TYP. HOLE CENTERS OFFSET AS SHOWN
.575 I.D. SEAMLESS ALUMINUM TUBING
45°
SECTION "A"-"A"
VIBRATORY SANDER
1 1/2" I.D. VACUUM HOSE
MOUNTING BRACKETS TO
ALLOW ATTACHMENT
HOLES IN SANDER CAGE
DUST EXTRACTOR

Figure 4-14

operations in construction. By virtue of the intermittent nature of field fabrication steps, it is expected that application of current technology would result in time-weighted averages of 0.5 fibers per cubic centimeter or less.

4.2.4 Work Scenario

4.2.4.1 Scenario Description

A crew of six carpenters (SIC 1751) is postulated to be involved in the installation of asbestos-cement sheet. One worker drills the corners of the sheets for attachment to fasteners and also cuts sheets to size on an as-needed basis. The second worker assists the first in the handling of the sheet from the area where fabrication steps are performed to the location where the other four workers install the material.

The typical work week is 40 hours long and the postulated installation job lasts 3 weeks. The assumed installation rate is 1,023 square feet per day; hence, some 15,345 square feet are installed during the job. The cost of materials is $0.907 per square foot. The unit cost for labor is $0.623 per square foot; hence, the total labor and material cost per square foot is $1.53 and the cost for the scenario is $23,480.

Table 4-3 lists summary data for asbestos-cement sheet installations. The total quantity product installed, the product value, the installation rate, the installation labor cost, and the average hours worked per year are based on 1974 manufacturing and construction industry data. The average time worked with asbestos-cement sheets, 85 percent, is based

Table 4-3

Summary of Asbestos-Cement Sheet Data

	Item	Quantity	Reference
1.	Total product (ft^2)	61.4×10^6	Table 2-11
2.	Product value ($)	55.7×10^6	Table 2-11
3.	Installation rate (ft^2/day)	170	Table 2-12
4.	Man-days to install (per year)	3.6×10^5	(1) ÷ (3)
5.	Installation cost ($)	38.3×10^6	Table 2-11
6.	Total installed cost ($)	94.0×10^6	Table 2-11
7.	Average hours worked (per year)	1,600 (SIC 1751)	Table 2-38
8.	No. full-time workers (per year)	1,800	(4) ÷ (7) ÷ 8 hrs/day
9.	Turnover rate (peak/low)	1.25 (1972, SIC 17)	Figure 2-4
10.	Average time worked with asbestos-cement (%)	85	Estimated
11.	Adjusted worker No.	2,647	(8) x (9) ÷ (10)
12.	Scenario man-hours	720	4 men x 40 hrs/wk x 3 wks
13.	Repeats of scenario	4,000	(4) ÷ [illegible] ÷ 8 hrs/day
14.	No. contractors	300	(12) x (13) ÷ [(7) x 6 men]

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on EEH survey data and consultations with persons in the industry. The employment turnover rate for SIC 1751 is based on 1972 data and is determined as the ratio of the peak annual employment over the average of the low employment periods occurring at the beginning and the end of the target year. The total number of man-days to install the annual production of asbestos-cement sheet was determined by dividing the total product by the installation rate. The total installed cost is the sum of the product value and the installation cost. The number of full-time workers required to install the total production of asbestos-cement sheet was determined by dividing the man-days to install by the average number of days worked per year (average hours worked per year/ 8 hours per day). The adjusted number of workers, 2,647, is the number of full-time workers multiplied by the turnover rate and divided by the average time worked with asbestos-cement sheet. The number of man-hours for the assumed scenario is the product of 40 hours per week for six workers and a 3-week job length as previously discussed. Based on a scenario length of 720 hours and 3.6×10^5 man-days to install all of the asbestos-cement, there would be some 4,000 repeats of the assumed scenario. A crew will work 3 weeks on a job. Since the average crew works 200 days per year, a single crew can perform 13.3 repeats of the assumed scenario. Thus, assuming one crew per contractor, some 300 asbestos-cement sheet contractors would be required to install the annual production of asbestos-cement sheet.

4.2.4.2 Cost of Standard Implementation

The following discussion is based on the provisions of the October 9, 1975, proposed OSHA standard for occupational exposure to asbestos as modified to reflect the NIOSH-recommended fiber concentrations of 0.1 fibers per cubic centimeter time-weighted average and 0.5 fibers per cubic centimeter ceiling.

In order to develop a summary of costs for implementation of a standard, certain scenario unit costs are required. Labor costs for trade groups of interest are listed in Tables 2-33, 2-39, and 2-40.

Unit costs for the various regulatory requirements are shown in Table 4-4. Monitoring is the first cost shown. Some large contractors have at their disposal the skilled personnel and equipment necessary to perform the monitoring required by the standard. However, in 1972, 80 percent of all contractors in SIC's 15, 16, and 17 had less than 10 employees. These smaller contractors would have to rely on outside resources to fulfill the monitoring requirement. For this reason, the costs for monitoring are based on hiring a consultant to conduct the survey, analyze the samples, and prepare a survey report listing time-weighted average and ceiling concentrations.

A consultant industrial hygiene technician is considered to be satisfactory to perform the survey. A typical rate for a one-day survey exclusive of sample analysis is $200, plus travel and subsistence. Presumably, the consultant retained for the survey would be within driving distance of the job site. This cost element was estimated to be $50.

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Table 4-4

Scenario Unit Costs for Compliance with Standards

Scenario	Cost
1. Monitoring	$370
2. Engineering controls	
Saw	$2,000
Drill	800
Sander	1,700
3. Protective equipment	
a. Respirators	
Reusable	$11.25 each and $0.60 per week for replacements
Disposables	$0.75 each
b. Protective clothing	$2.50/set (disposable)
4. Medical surveillance	
Exam	$52.20
Sputum cytology	$15.30
5. Information and training	1 man-day per year
6. Recordkeeping	$5 per worker per year

The cost of fiber counting varies among laboratories, with discounts being offered for volume. A typical price for the number of samples that might be received is $20 per filter.

In the area of engineering controls, some yards and shops have fixed tool installation. However, most construction fieldwork involves the use of portable electric or gasoline-powered tools for which engineering controls are needed. The capital cost of engineering controls is based on purchasing portable tools with appropriate shrouds and pick-ups and providing a vacuum system sized for the work. Since there are very few, if any, off-the-shelf shrouded tools, each unit must be specially fabricated. Vacuum systems are available for a wide range of flow rates, and costs also vary widely. On the high side, costs for a shroud and vacuum system could be $3,500 for a saw and $1,600 for a drill. At the low end, the estimated capital costs for different kinds of hand tools are: saw, $1,750; drill, $1,100; and sander, $1,700. Costs are predicated on the availability of electric power at the job site. No wet systems have been considered.

In addition to capital costs, there are costs associated with labor. Labor costs are considered to consist of nonproductive time learning to operate the engineering controls, loss of efficiency due to differences in technique and cutting speeds between controlled and uncontrolled tools, time spent in routine maintenance of tools and associated vacuum systems and cleanup of the collectors, and time spent enforcing correct operation of the tools and systems. Labor costs have been estimated for each scenario.

The protective equipment requirement includes respiratory protection and protective clothing. The cost of coveralls is \$2.50 per set and disposable respirators are \$0.75 each, based on current catalog prices. Reusable respirators cost \$11.25 with replacement filters costing \$0.60 per week per worker. Training in the use of such equipment is required and there may be loss of efficiency through its use.

The medical surveillance cost was determined from a survey of selected clinics and medical centers capable of performing the required medical examination. This examination includes a chest roentgenogram (posterior-anterior 14 by 17 inches); a history to elicit symptomatology of respiratory disease; plumonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$); a physician's opinion regarding the employee's ability to function normally wearing a respirator (if required); and maintenance of medical records. Seventeen responses were obtained from 50 clinics. A summary of costs is shown in Table 4-5. The costs for sputum cytology are also listed.

Information and training requirements are difficult to substantiate, but have been estimated to require 1 man-day per man per year. The keeping of records of employee exposure and health examinations is estimated to be \$5 per year per worker. Both of these estimates are from a study performed by Roy F. Weston in 1976.

The following sections serve as an illustration of how these unit costs are employed to derive total compliance costs for asbestos-cement sheet contractors. Total costs are summarized in Table 4-6.

Table 4-5

Summary of Medical Examination Costs[a]

Item	Costs ($) Range	Average	Standard Deviation
Chest X-ray	7-25	17.10	±5.44
Pulmonary function	3-40	15.20	±10.50
History and physician opinion	14.50-35	19.90	±17.20
Subtotal	24.50-95	52.20	±17.3
Sputum cytology	6-45	15.30	±9.96
Total	41-115	66.60	±23

a. The 17 clinics responding were distributed geographically as follows:

California	3	New York	1
Colorado	1	Ohio	2
Florida	1	Oregon	1
Michigan	2	Utah	1
Missouri	1	Virginia	1
Nebraska	1	Washington	1
New Jersey	1		

Table 4-6

Summary: Compliance Costs Asbestos-Cement Sheet

Provision	Annual Cost ($)	Capital[a] ($)
Regulated area	$ 337,500	--
Monitoring	1,480,000	--
Controls	3,141,750	$840,000
Respiratory protection	587,643	32,757
Protective clothes	1,467,000	--
Medical surveillance	265,196	--
Information/training	238,230	--
Signs/labels	1,500	--
Records	13,235	--
Total	$7,532,054	$872,757

a. Estimated life = 5 years; not considered in table, i.e., initial purchase costs listed.

4.2.4.2.1 Regulated Areas

It is necessary to delineate a regulated area with signs or markers to prevent entry by non-workers. It is assumed that it would require 0.5 man-hours per day for the maintenance of regulated areas and entry rosters. At a labor rate of $11.25 per man hour, a 3-week scenario duration, and 4,000 repeats of the scenario per year, the total annual cost would be $337,500.

4.2.4.2.2 Monitoring

Under the proposed OSHA regulations, it would be necessary to perform asbestos monitoring of the work area and the breathing zone at each job site. Based on Table 4-4, a survey with six samples taken would cost $370. Assuming a cost of $370 for each monitoring situation (each scenario), and the 4,000 repeats of the assumed scenario, the total annual monitoring cost would be $1,480,000.

4.2.4.2.3 Controls

Engineering controls involve the use of special dust collection equipment to minimize the airborne asbestos and the consequent worker exposures. The dust collection apparatus would consist of collection shrouds on the power tools used connected to a vacuum system. The capital investment in these tools would be about $2,800 per contractor, $2,000 for a saw and $800 for a drill. Assuming some 300 contractors, the total capital cost of controls would be $840,000.

In addition to this capital cost, there would be an annual cost associated with training in the use of the controls and a loss of efficiency from their use. Training is assumed to require 14 man-hours per year for each of three men per contractor. At a labor rate of $11.25 per hour and 300 contractors in the industry, the annual cost of training would be $141,750. The loss of efficiency engendered by the use of the engineering controls is assumed to be 15 percent of the 8-hour workday for each of the two workers involved in cutting and drilling the asbestos-cement sheets. Assuming 15 days per scenario and 4,000 repeats of the scenario, the annual cost due to loss of efficiency would be $1,620,000.

Work practice controls, involving maintenance and cleanup of the work area, must be used along with the engineering controls. The work practice controls are assumed to require 2 man-hours per day at a cost of $11.25 per man-hour. Assuming 15 days per scenario and 4,000 repeats of the scenario, the annual cost of work practice controls would be $1,380,000.

The total annual cost of all controls is the sum of the annual costs associated with training on the engineering controls, loss of efficiency, and maintenance and cleanup, or $3,141,750.

4.2.4.2.4 Respiratory Protection

Respiratory protection is required to control the inhalation of airborne asbestos fibers. The respiratory protection program for asbestos-cement sheet installation is assumed to consist of the use of respirators, with replaceable filters to provide filtered air to the workers.

The initial purchase of the respirators would require a capital investment on the part of the contractors. At a unit cost of $11.25 and allowing for an additional 10 percent as spares and replacements, the capital cost of equipping the 2,647 asbestos-cement sheet workers with respirators would be $32,757.

The annual cost of the respiratory protection program consists of three components, the cost of disposable respiratory filters, the labor lost in respirator maintenance, and the labor lost during respirator training programs.

The cost of the respirator filters is assumed to be $0.60 per worker per week. For the 2,647 workers and the average of 40 weeks worked per year, the annual cost of respirator filters would be $63,528.

Respirator maintenance is assumed to require 0.1 hours per day from each of the six workers in the crew. At a labor rate of $11.25 per hour, 15 days per scenario, and 4,000 repeats of the scenario per year, the annual cost of respirator maintenance would be $405,000.

The training program in the use and maintenance of the respirators is assumed to require 4 hours per year from each of the 2,647 workers. At a labor rate of $11.25 per hour, the annual cost of respiratory training would be $119,115.

The total annual cost of respirator protection, the sum of the three components, would be $587,643.

4.2.4.2.5 Protective Clothing

To prevent the dispersal of asbestos fiber to nonregulated areas and to areas off the worksite, protective clothing is worn by the workers. This protective clothing would be coveralls worn by the worker and supplied by the contractor. They may be disposable or specially laundered.

The cost of disposable clothing is assumed to be $2.50 per man per day. There are six men in a crew and a scenario length of 15 days. The annual cost for the 4,000 repeats of the scenario would be $900,000.

It is assumed that the six workers would each require 0.1 hours per day for the change of clothing. There are 15 days per scenario and 4,000 repeats of the scenario. At an hourly labor rate of $11.25, the annual cost of clothing changes would be $405,000.

Each of the 300 contractors would have to supply a change room for a crew. A typical mobile change room rents for $45 per month. The annual cost would be $162,000 for all contractors considered to work with asbestos-cement sheet.

The total annual cost of using protective clothing is the sum of the clothing cost, the labor lost during clothing changes, and the cost of a change room. This total annual cost is $1,467,000.

4.2.4.2.6 Medical Surveillance

The basic medical exam required for each of the 2,647 workers is assumed to cost $52 for an annual cost of $137,644. The exam is assumed to require 3 hours for each of the workers. At $11.25 per hour, the annual cost of lost labor is $89,336.

A sputum cytology examination is required for employees with 10 or more years of exposure to asbestos or who are over 45 years of age.

It is assumed that 70 percent of the asbestos-cement workers require this exam. At $15 per exam, the annual cost of sputum cytology is $27,794. This exam requires 0.5 hours for each of the workers in this group. At $11.25 per hour, the annual labor cost is $10,422.

The total annual cost of medical surveillance, the sum of the above components, is $265,196.

4.2.4.2.7 Information and Training

Each of the 2,647 workers is assumed to spend 8 hours per year in general information and training activities relating to work with asbestos products. At an hourly rate of $11.25, the total annual cost of these activities would be $283,230.

4.2.4.2.8 Signs and Labels

Each of the 300 contractors is assumed to spend $5 for signs and labels to indicate regulated areas and to identify bags of asbestos-containing debris and waste. The total annual cost would be $1,500.

4.2.4.2.9 Records

The cost of maintaining OSHA-required employment, exposure, and health records for each of the 2,647 asbestos-cement sheet workers is assumed to cost $5 per year per worker. The total annual cost of record keeping is $13,235.

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APPENDIX A

Table A-1

Survey Contacts, Manufacturers Associations

American Board Products Association
American Concrete Institute
Construction Industry Manufacturers Association
National Insulation Manufacturers Association
Asbestos Textile Institute
Producers Council, Inc.
Sprayed Mineral Fiber Manufacturers Association, Inc.
Asbestos Cement Pipe Producers Association
Fluid Sealings Association
National Paint and Coatings Association

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Table A-2

Survey Contacts, Trade Associations

American Building Contractors Association

American Institute of Building Design

American Institute of Constructors

Associated Builders and Contractors, Inc.

Associated General Contractors of America

Associated Specialty Contractors, Inc.

The Construction Specifications Institute

International Association of Wall and Ceiling Contractors

Mason Contractors Association of America

Mechanical Contractors Association of America

National Association of Home Builders of the United States

National Electrical Contractors Association, Inc.

National Insulation Contractors Association

National Roofing Contractors Association

National Utility Contractors Association, Inc.

Painting and Decorating Contractors of America

Western Insulation Contractors Association

Gypsum Drywall Contractors International

Sheet Metal and Air Conditioning Contractors National Association, Inc.

Council of Construction Employers

Table A-3

Survey Contacts, Trade Unions

Associated Trades and Crafts National Union

International Brotherhood of Painters and Allied Trades

Laborer's International Union of North America

Operative Plasterers' and Cement Masons' International Association of the United States and Canada

Sheet Metal Workers International Association

United Brotherhood of Carpenters and Joiners of America

United Cement, Lime and Gypsum Workers International Union

United Slate, Tile and Composition Roofers, Damp and Waterproof Workers Association

United Steelworkers of America

Table A-4

Survey Contacts, Public and Regulatory Agencies

Air Pollution and Noise Control
Inspection Department
Minneapolis, Minnesota

National Institute for Occupational
Safety and Health
U.S. Post Office Building
Cincinnati, Ohio 45202

Division of Environmental Health
Contra Costa County Health Department
Martinez, California 94553

Alabama State Department of Labor
Montgomery, Alabama 36104

Division of Pollution Control
Occupational Health Services
Tri-County District Health Service
Decatur, Alabama 35601

Bureau of Preventable Diseases
Alabama Department of Public Health
State Office Building
Montgomery, Alabama 36104

Occupational Safety and Health
Department of Labor
Juneau, Alaska 99811

Occupational Safety and Health
Division
Department of Labor
Capitol Hill Building
Little Rock, Arkansas 72201

Division of Occupational Safety and
Health
Industrial Commission
Phoenix, Arizona 85005

Occupational Health Division
Community Health Services
County of Los Angeles Department
of Health Services
Los Angeles, California 90018

Occupational Health Section
Environmental Health Division
Orange County Health Department
Santa Ana, California 92702

Bureau of Environmental Health Services
Division of Occupational Health
Arkansas State Department of Health
Little Rock, Arkansas 72201

Occupational Health Program
El Paso City County Health
Department
El Paso, Texas 79901

Occupational Health Sanitarian
Fresno County Public Health Department
Fresno, California 93702

Air Pollution Control Section
Environmental Health Division
City of Dallas Public Health Dept.
Dallas Texas, 75220

Division of Occupational Safety
Texas State Department of Health
Austin, Texas 78756

Riverside County Department of Public
Health
Riverside, California 92502

Table A-4 (Cont.)

Bureau of Environmental Health Services
Tennessee Department of Public Health
Nashville, Tennessee 37219

Occupational Health Bureau
Department of Health and Environmental Sciences
Helena, Montana 59601

Division of Labor & Industry
Occupational Safety and Health Program
Baltimore, Maryland 21202

San Bernardino County Health Department
San Bernardino, California 92401

Department of Labor & Industry
St. Paul, Minnesota 55101

Division of Environmental Health
Section of Industrial Hygiene
Minnesota Department of Health
Minneapolis, Minnesota 55440

Division of Occupational Health
Santa Clara County Health Dept.
Santa Clara, California 95128

Division of Occupational Safety and Health
Mississippi State Board of Health
Jackson, Mississippi 39205

Radiological and Occupational Health Section
Bureau of Preventable Diseases
Florida Division of Health
Jacksonville, Florida 32201

Department of Health and Engineering Control
Vernon, California 90058

Division of Labor
Department of Commerce
Caldwell Building
Tallahasse, Florida 32301

District of Columbia Government
Community Health & Hospitals Adm.
Occupational & Employee Health Services
Washington, D.C. 20009

Division of Industrial Hygiene & Noise Control
Bureau of Institutional Hygiene & Radiological Health
Department of Environmental Services
Washington, D.C. 20002

Division of Occupational and Radiological Health
Colorado Department of Health
Denver, Colorado 80220

Division of Industrial Affairs
Department of Labor
Wilmington, Delaware

Occupational Health Section
Connecticut Department of Labor

Environmental Health Service
Denver Department of Health & Hospitals

Table A-4 (Cont.)

Environmental Health Section
Office of Consumer Protection
Dade County Department of
Public Health
Miami, Florida 33125

Industrial Hygiene Division
Compliance Division
Technical Assistance Division
Cheyenne, Wyoming 82002

Section of Occupational Health
Wisconsin Division of Health
Madison, Wisconsin 53701

Division of Safety
Occupational Health Section
Department of Labor and Industries
Olympia, Washington 98501

Occupational Safety and Health
Division
Virgin Islands Department of Labor
U.S. Virgin Islands 00840

Bureau of Industrial Hygiene
Department of Health
Richmond, Virginia 23219

Division of Construction Safety
Department of Labor and Industry
Richmond, Virginia 23219

Division of Occupational Safety
Vermont Department of Labor and
Industries
Montpelier, Vermont 05602

Division of Occupational Health
Vermont Department of Health
Barre, Vermont 05641

Occupational Safety and Health Division
Utah Industrial Commission
Salt Lake City, Utah 84113

Bureau of Radiation & Occupational Health
Utah Division of Health
Salt Lake City, Utah 84113

Division of Occupational Health
and Radiation Control
Houston City Health Department
Houston, Texas 77205

Occupational Health Program
Division of Environmental Sanitation
Fort Worth City Health Department
Fort Worth, Texas 76107

Division of Industrial Safety
Department of Labor
Topeka, Kansas 66620

Occupational Safety & Health Adm.
Bureau of Labor
State House
Des Moines, Iowa 50319

Division of Industrial Hygiene
Indiana State Board of Health
Indianapolis, Indiana 46206

Bureau of Building & Factory Inspection
Indiana Division of Labor
Indiana State Office Building
Indianapolis, Indiana 46204

Chicago Board of Health
Chicago Civic Center
Chicago, Illinois 60602

Table A-4 (Cont.)

Industrial Hygiene and Air
Pollution Control
Fulton County Health Department
Atlanta, Georgia 30303

Occupational Health Unit
Georgia Department of Human Resources
Atlanta, Georgia 30334

State Department of Labor
Atlanta, Georgia 30334

Radiological and Occupational Health
Section
Division of Technical Services
Pinellas County Health Department
St. Petersburg, Florida 33733

Hillsboro County Health Department
Tampa, Florida 33601

State Hygienic Laboratory
University of Iowa
Medical Laboratory Building
Iowa City, Iowa 52242

Kansas Department of Health and
Environment
Division of Environment
Topeka, Kansas 66620

Division of Occupational Safety and
Health
Kentucky Department of Labor
Capitol Plaza
Frankfort, Kentucky 40601

Mechlenburg County Health Dept.
Division of Environmental Health
Charlotte, North Carolina 28203

Division of Safety Inspection and
Education
Illinois Department of Labor
Chicago, Illinois 60601

Occupational Health Unit
Section of Categorical Programs
Bureau of Environmental Services
New Orleans, Louisiana 70160

Department of Labor
Boise, Idaho 83702

Division of Occupational Safety and
Health
Department of Labor and Industrial
Relations
Honolulu, Hawaii 96813

Department of Labor and Industrial
Relations
Honolulu, Hawaii 96813

Division of Health Engineering
Department of Health and Welfare
State House
Augusta, Maine 04330

Department of Labor
Government of Guam
96910

Occupational and Radiological Health
Services
Environmental Health Services
Oklahoma State Department of Health
Oklahoma City, Oklahoma 73105

Table A-4 (Cont.)

Division of Occupational Health
Ohio Department of Health
Columbus, Ohio 43212

Bureau of Industrial Hygiene
Baltimore City Health Department
Baltimore, Maryland 21202

Industrial Hygiene & Engineering
Division of Safety and Hygiene
Industrial Commission of Ohio
Columbus, Ohio 43216

Illinois Industrial Commissioner
Chicago, Illinois 60601

Division of Occupational Safety and Health
Department of Industrial Relations
Columbus, Ohio 43216

Occupational Safety and Health Program
Tennessee Department of Labor
Cordell Hull Building
Nashville, Tennessee 37219

Division of Occupational Hygiene
Massachusetts Department of Labor and Industries
Boston, Massachusetts 02116

South Dakota Department of Health
State Capitol
Pierre, South Dakota 57501

Division of Occupational Health
Michigan Department of Public Health
Lansing, Michigan 48914

Bureau of Industrial Health
Division of Occupational Health
State Board of Health
Columbia, South Carolina 29201

Division of Occupational Safety and Health
Department of Labor
Columbia, South Carolina 29211

Division of Labor Standards
Occupational Safety and Health Administration
Department of Labor and Industrial Relations
Jefferson City, Missouri 65101

Division of Occupational Health
Rhode Island Department of Health
Providence, Rhode Island 02908

Bureau of Work Accident Prevention
Industrial Hygiene Section
Department of Labor
San Juan, Puerto Rico 00917

Community Sanitation Section
St. Louis Division of Health
St. Louis, Missouri 63103

Environmental Health Services
Philadelphia Department of Public Health
Philadelphia, Pennsylvania 19146

St. Louis County Department of Public Health
Clayton, Missouri 63103

Table A-4 (Cont.)

Division of Occupational Safety and
Health
Erie County Health Department
Erie, Pennsylvania 16507

Industrial Hygiene Section
Bureau of Occupational Health
Pennsylvania Department of Environmental Resources
Harrisburg, Pennsylvania 17120

Department of Labor
Lincoln, Nebraska 68509

Division of Occupational Health
Oregon State Board of Health
Portland, Oregon 97201

Occupational and Radiological Section
Division of Environmental Services
Oklahoma City-County Health
Department
Oklahoma City, Oklahoma 73105

Department of Occupational Safety
and Health
Nevada Industrial Commission
Carson City, Nevada 89701

State of New Hampshire
Department of Labor
(Occupational Safety)
Concord, New Hampshire 03301

Division of Environmental Engineering
North Dakota Department of Health
State Capitol
Bismarck, North Dakota 58505

Bureau of Occupational Health
Department of Health and Welfare
Concord, New Hampshire 03301

Division of Health Services
Department of Human Resources
Raleigh, North Carolina 27602

Division of Occupational Safety and
Health
North Carolina Department of Labor
Raleigh, North Carolina 27611

Department of Labor and Industry
John Fitch Plaza
Trenton, New Jersey 08625

Industrial Hygiene, Health Physics
and Toxic Chemicals
Albuquerque Department of Environmental Health
Albuquerque, New Mexico 87103

Division of Occupational Safety and
Health
Bureau of Occupational Health
New York State Department of Labor
New York, New York 10047

Occupational and Radiation Protection
Division
Environmental Improvement Agency
Health and Social Services Department
Santa Fe, New Mexico 87503

State of California
Dept. of Public Health
Berkeley, California 94704

Alameda County Health Care Services
Agency Health Department
Oakland, California 94602

Table A-5

Manufacturers of Asbestos-containing Construction Materials

1. What asbestos-containing construction products does your company manufacture?

2. For each of these products, what quantity was produced in 1975?

   For each product, what was the sales value to your organization?

3. How many employees are involved in the manufacture of each product?

4. Who is the ultimate user of each product (i.e., for what purpose is the item manufactured, what trade utilizes the product, and on what type of structure)?

5. How is each product distributed--through wholesalers, direct to contractors, etc.? Typically, how many intermediaries does each product go through before reaching the construction site?

   Do distributors modify the product in any way?

6. What competing products, if any, exist that can be used for the purpose for which the asbestos product was designed?

7. Have any fiber counts been conducted during field installation or application of these products? If so, which products were tested and what counts were obtained?

Table A-6

Association of Manufacturers
of Asbestos-containing Construction Materials

1. How many companies that are members of your association produce asbestos-containing products used in construction?

2. What asbestos-containing construction products are manufactured by the members of your association?

3. For each of these products, what was the quantity and sales value of material produced in 1975 (or in the most recent year for which this information has been tabulated)?

4. How many employees are involved in the manufacture of each product?

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Table A-6 (Cont.)

5. Who is the ultimate user of each product (i.e., for what purpose is the item manufactured, what trade utilizes the product, and on what type of structure)?

6. How is each product distributed--through wholesalers, direct to contractors, etc.? Typically, how many intermediaries does each product go through before reaching the construction site? Do distributors modify the product in any way?

7. What competing products, if any, exist that can be used for the purpose for which the asbestos product was designed?

8. Have any fiber counts been conducted during field installation or application of these products? If so, which products were tested and what counts were obtained?

Table A-7

Questions for Construction Trade Associations

1. Check those sectors of the construction industry represented by this trade association.

SIC Code	Trade Group
1623	Water, sewer, pipe line, communication and power line construction
1711	Plumbing, heating (except electric), and air conditioning
1721	Painting, paper hanging, and decorating
1731	Electrical work
1742	Plastering, drywall, acoustical, and insulation work
1752	Floor laying and other floorwork, not elsewhere classified
1761	Roofing and sheet metal work
1771	Concrete work
1799	Special trade contractors, not elsewhere classified

2. What asbestos products are used by workers in each of these trade groups? (List products by trade group in which they are utilized.)

3. How many workers are employed within each trade group? How many workers (what percent of the total number of workers) utilize asbestos products?

Table A-7 (Cont.)

4. How many contractors, by trade group, are members of this association? What is the size (in number of employees and annual dollar volume of construction work) of these contractors?

5. Within each trade group, when either an asbestos product or an alternate non-asbestos product can be utilized for a particular application, what percentage of the work utilizes the asbestos product and what percentage utilizes the alternate product? What major factors affect the choice of the material used?

6. Have any fiber counts been conducted during installation of asbestos products? If so, what product was tested and what counts were obtained?

Table A-7 (Cont.)

7. What asbestos products and what quantity of these products are typically used in the construction of (a) residences; (b) industrial, institutional, and commerical structures; (c) non-building segments of the construction phase?

	Typical Quantity Used			
		Nonresidential		
Product	Residential	Industrial and Warehouses	Other Non-residential	Non-building

8. To what extent are asbestos-containing products used in their particular application, i.e., what portion of the market do they command? (Example: 20 percent of built-up roofing.)

Table A-8

Questions for Construction Trade Unions

1. What trade group is represented by this union?

SIC Code	Trade Group
1623	Water, sewer, pipe line, communication and power line construction
1711	Plumbing, heating (except electric), and air conditioning
1721	Painting, paper hanging, and decorating
1742	Plastering, drywall, acoustical, and insulation work
1752	Floor laying and other floorwork, not elsewhere classifie
1761	Roofing and sheet metal work
1771	Concrete work
1799	Special trade contractors, not elsewhere classified
	Other (specify)

2. What asbestos products are utilized by workers in this trade group?

3. How many workers are employed in this trade group, and what seasonal variations occur, if any, in the number of workers employed?

Table A-8 (Cont.)

4. How many workers in this trade group (what percent of the total) utilize asbestos products? How often are asbestos products utilized, i.e., how many workers utilize asbestos products regularly (50 percent), frequently (10-50 percent), occasionally (10 percent)?

5. How many workers are directly exposed; how many workers are indirectly exposed to asbestos?

6. Of all workers who enter the trade, what percentage remain in the trade

Less than 5 years

5 to 10 years

11 to 15 years

More than 15 years

Table A-9

Site Survey Report

Contractor/Subcontractor ____________________ Date/Time __________ Surveyor ______

SIC Classification ____________________

Size of Contractor ____________________ 4. Site Location: Residential/Commercial/Industrial/Non-Building

(a) 1-9 Employees
(b) 10-49 Employees
(c) 50-100 Employees
(d) Over 100 Employees

Number Employed on Site __________

Asbestos-Containing Materials in Use:

Product(s)	Quantity (unit/day) (man-hour/unit)	Shipping and Packaging Procedure*	Storage and Handling

* If known indicate importer or manufacturer.

Table A-9 (Cont.)

Site Survey Report (Page 2)

Operation Observed ______________________ Trade Group SIC ____________

Description of Work Site: Indicate Indoors/Outdoors, Weather Conditions, Approximate Location of Peripherally Exposed Persons.

Airborne Exposure (Estimated): L = Light
M = Medium
H = Heavy

Product(s)	No. of Workers and Exposure: Trade Group	No. of Workers and Exposure: Laborers/Other	Number Peripherally Exposed and Exposure	Procedures (include all fabrication in field, i.e., mixing, cutting, sanding, etc.)

Table A-9 (Cont.)

Site Survey Report (Page 3)

8. Cleanup Practice: (Note worker performing task) [If applicable include under procedures column].

9. Protective clothing or practices employed, facilities available (change rooms, showers).

10.

Product	Advantages of Asbestos Product	Asbestos Products Replaced by Alternative Materials

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APPENDIX B

Summary of Field Sampling Surveys

APPENDIX B

Summary of Field Sampling Surveys-

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In order to evaluate airborne asbestos concentrations resulting from the handling, machining, and installation of asbestos-containing materials in construction and demolition, industrial hygiene surveys were performed in workplace environments. Air samples were taken both indoors and outdoors depending on the work site and the type of product being used. Two types of samples, personal and general air, were collected during each survey. The personal samples taken to characterize a worker's exposure are collected from near the worker's face while work is performed. Such samples are considered to be representative of the air that a worker breathes during the performance of a particular operation. The general air sample is collected in the vicinity of the job being performed and is representative of atmospheric levels that may contribute to peripheral exposure of other workers or observers.

Samples were collected by drawing air through cellulose ester membrane filters by means of portable, battery-powered sampling pumps. The filters were 37 millimeters in diameter, with a pore size of 0.8 microns, and were mounted in a plastic cassette and used in an "open face" configuration during sampling. Two sampling pumps were used during the surveys: the Bendix models C115 and BDX-44 samplers. The pumps were calibrated against a standard wet-test meter or bubble meter. Filter cassettes were connected to the pumps with plastic tubing; for breathing-zone samples, the pump was attached to the worker's belt while the filter was clipped on the worker's collar.

All air samples collected were analyzed for asbestos fiber count. Fibers were sized and counted using an OSHA-approved technique employing phase-contrast microscopy. Results are reported as fibers per cubic centimeter greater than 5 microns in length. Airborne concentrations of fibers are obtained by calculating the number of fibers per filter from the microscopic fiber counts and dividing this number by the sample volume. When there are no fibers counted in 100 fields, the result is reported as less than one fiber per hundred fields. Considering magnification, this corresponds to less than 1,600 fibers per filter. Consequently, some of the fiber concentrations are reported as "less than" values. Because of the statistical variability among counters for the same filter, among filter sectors for the same counter, and among laboratories, questions have been raised regarding the accuracy and reliability of the NIOSH method for determination of low airborne asbestos concentrations. Since this study is not intended to resolve the question of accuracy and reliability, the low air concentrations reported for most of the surveys should be viewed as computational results.

Narrative reports for each sampling survey are presented in this appendix. They include data for each sample taken and figures showing the relative locations of sampling points. Wherever possible, time-weighted average (TWA) exposures were calculated from the air sample results.

SURVEY AIA-1: INSTALLATION OF AN ASBESTOS-FELT ROOF

Survey AIA-1 consisted of sampling personnel and general air during the installation of the finish layer of felt on the 75-by-100-foot roof of a two-story building under construction. Approximately 40 rolls of finishing felt were applied during the job. Sampling was performed outdoors where the temperature was approximately 35° to 40° F during the day and the wind was from the northwest.

The work was performed by eight men from a roofing contractor. In the morning, four workers were involved in the application of felt in rolls; two workers applied hot tar using a mop, and the other two rolled and cut the felt. Two other employees were engaged in applying felt to the horizontal surfaces of air conditioning ducts and the parapets. One worker, an apprentice, handled the tar buggy all morning, while the last worker tended the tar kettle on the ground below.

Afternoon work generally consisted of applying strips of felt as flashing around roof openings. All eight workers participated in this process.

Ten air samples were taken during this survey, including three general air samples and seven breathing zone samples. The sampling data are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
GN-1	General air, southeast section of roof, downwind of operations	0822-1033 (131)(a)	0.012(b)
GN-2	Worker exposure, cutting and applying felt and adhesive to vertical surfaces (roof openings)	0833-0940.5 (67.5)	0.035
GN-3	Worker exposure, rolling and cutting felt, and applying over hot tar	0909-1128.5 (139.5)	0.017
GN-4	Worker exposure, mopping (applying hot tar to roof surface with mop)	0916-1132.5 (136.5)	
GN-5	Worker exposure, cutting and applying small sections of felt to vertical surfaces	0945.5-1130 (104.5)	0.022
GN-6	General air, background, taken on elevation above stairwell, approximately 15 feet above work area	1041.5-1308 (146.5)	0.0055
GN-7	Worker exposure, applying felt and adhesive to vertical surfaces	1257-1423.5 (86.5)	0.027
GN-8	Worker exposure, applying felt and adhesive to vertical surfaces	1300-1424 (84)	0.028
GN-9	Worker exposure, applying felt and adhesive to vertical surfaces	1304-1426 (82)	
GN-10	General air, approximately center of roof during afternoon work	1319-1431 (72)	<0.0098
			<0.011

Time-Weighted Averages

Worker Type	TWA
Roll man	<0.019
Mop man	<0.016
Paper setter	<0.023
Kettle man	<0.011

---

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

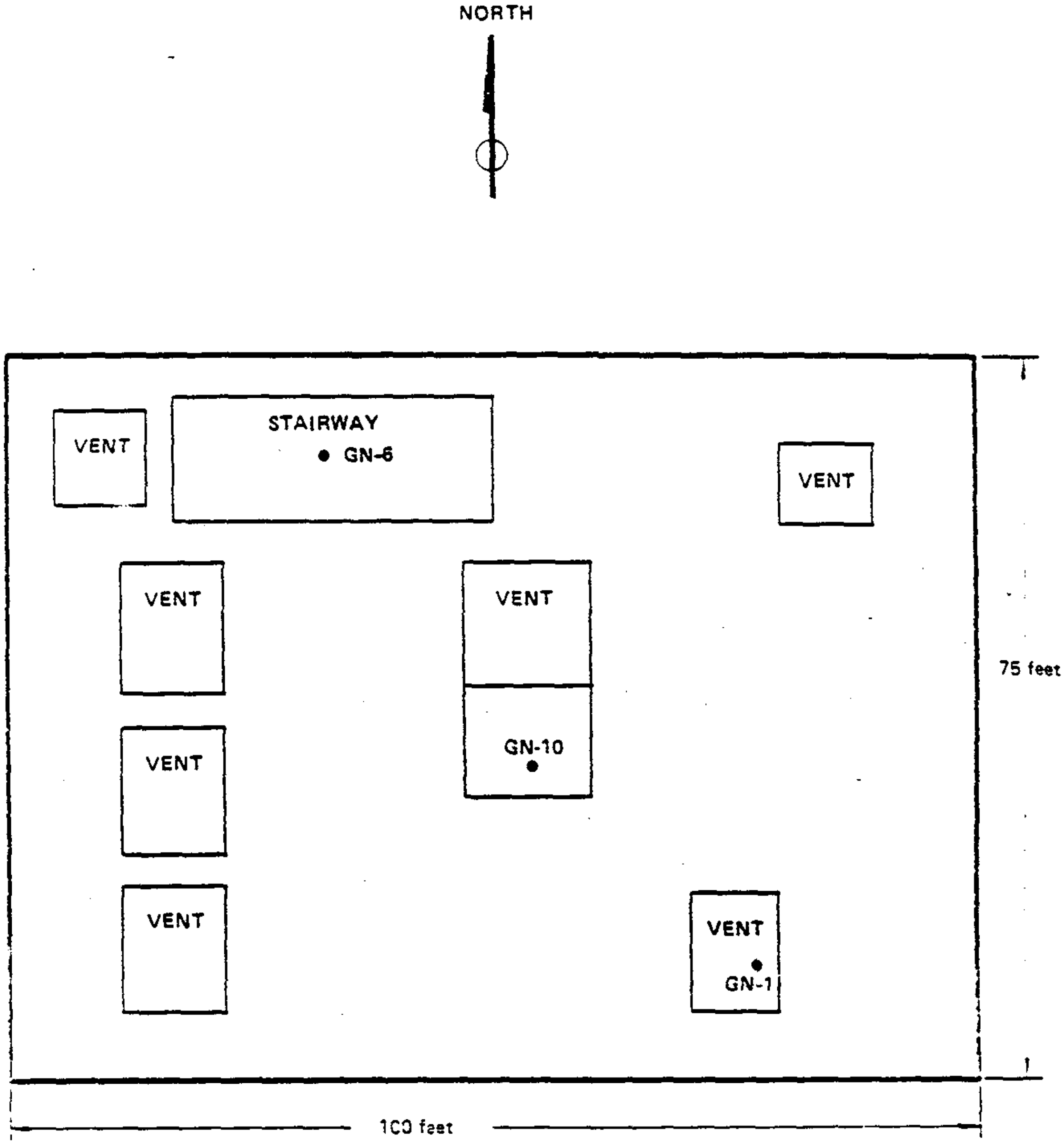

Figure 1. Diagram showing roof layout with locations of general air samples for survey AIA-1.

SURVEY AIA-2: ASBESTOS-CEMENT PANELS, BUILDING CONSTRUCTION SITE

During the AIA-2 survey, breathing zone and general air samples were taken, while asbestos-cement panels were cut in preparation for their installation the following week. Seventeen panels were cut over a 5.5-hour period and all operations were performed outdoors. All cutting was performed by one worker who was assisted by a foreman when the large panels had to be moved.

Operations consisted of cutting off a 2.5-foot section from a 16-foot length of panel, using an 8-inch diameter cutting wheel that was 1/8-inch thick. The saw had an Advance floor machine collector (Model HP501X5) mounted on a 55-gallon drum that served as a dust repository. The exhaust line was a 20-foot length of 1.5-inch flexible hose connected to saw housing on the front and top. The collector appeared to be working well except during the initial cutting when some dusting was observed and when the saw reached the end of the cut. The dust accumulated on the panels during the early cutting and this forced the operator to clear off the dust so he could observe the cutting line. After the first few cuts, very little dusting was visible except when the saw reached the end of the cut.

Thirteen air samples were taken and the results are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
FM-1	General air, background, 75 feet upwind	0850-1018 (88.0)[a]	0.011[b] 1.01
FM-2	Worker exposure, cutting, 6 cuts	0914-1007.5 (53.5)	0.069
FM-3	General air, on dumpster behind cutting operations, approximately 15 feet from operator	0918-1023.5 (65.5)	0.41 <0.038
FM-4	Worker exposure, cutter's helper	0939-1011 (32.0)	0.18 —
FM-5	General air, downwind approximately 40 feet from cutting	0958.5-1020 (21.5)	0.22
FM-6	General air, on vacuum unit, downwind, only while unit was operated	1040-1133 (53.0)	
FM-7	Worker exposure (peak), sampler operated only while worker was cutting sheet material, 6 sheets cut during sample	1102-1133 (31.0)	0.27 0.17
FM-8	Worker exposure, cutting, 8 cuts	1259.5-1349 (49.5)	0.090 0.035
FM-9	General air, approximately 20 feet from cutting, shifting winds during sample	1044.5-1134 (49.5)	0.041
FM-10	General air, background, 75 feet upwind	1300-1354 (54.0)	—
FM-11	General air, on dumpster behind cutting operation	1305.5-1350 (44.5)	0.053
FM-12	Observer exposure, while observer was approximately 10 feet downwind from cutting operation	1311-1349 (38.0)	
FM-13	Observer exposure, while observer was approximately 10 feet downwind from cutting operation	1311-1349 (38.0)	

Time-Weighted Averages

Worker Type	TWA
Cutter	0.35 —
Cutter's helper	0.16

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

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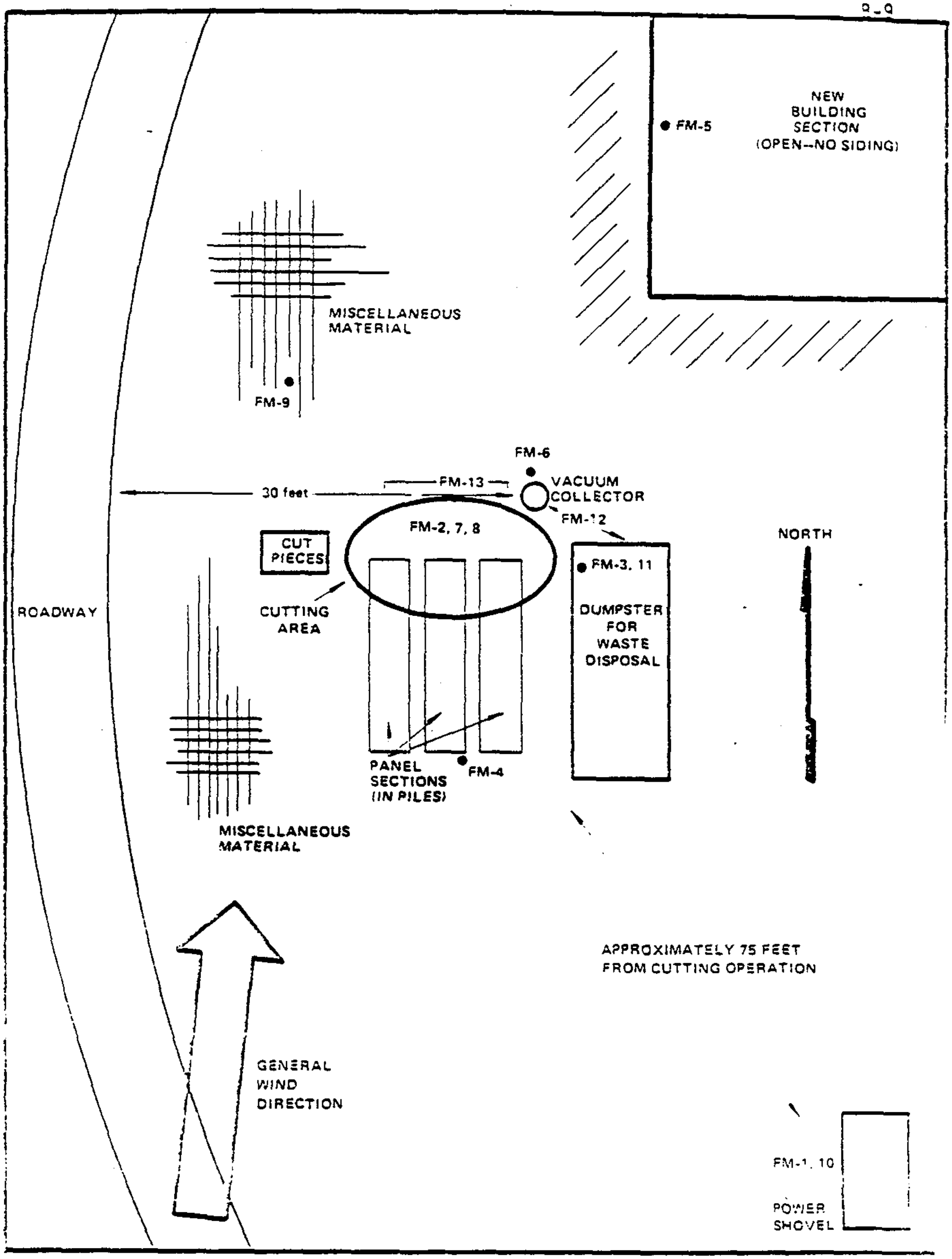

Figure 2. Diagram showing work area sampled for survey AIA-2 including sample locations.

SURVEY AIA-3: BUILDING DEMOLITION, REMOVAL OF ASBESTOS INSULATION

During survey AIA-3, air samples were taken while two workers removed asbestos insulation from a hot water tank and a length of pipe in a building to be demolished. Bagging of asbestos debris was also monitored. Sampling was performed indoors in the basement of the building.

Work in the morning was performed in the boiler room where two workers removed asbestos insulation from a hot water tank 3 feet in diameter and 9 feet long and standing approximately 6 feet from the ground by means of curved "linoleum" knives. The insulation was 1.5 to 2 inches thick and the pieces that were removed ranged from small chunks to pieces about 2 feet in length. The insulation was well wet and, although the lighting was poor, there was no visible evidence of dusting in the cutting and dropping of the debris. Removal lasted for approximately 2.5 hours and the subsequent bagging of the debris slightly exceeded one hour.

In the afternoon, the workers removed asbestos insulation from a 25-foot length of pipe located about 8 feet above the floor in a room down the hall from the boiler room. One worker on a ladder used a knife to strip off the insulation and the other worker bagged the debris as it fell to the floor. The pipe insulation was wetted using a pressurized fire extinguisher. This operation was relatively dusty due to the failure of the water spray to penetrate the cloth wrapping around the pipe. When the wrapping was removed, heavy dusting was observed. Continued applications of water helped to an extent, but did not adequately penetrate the insulation.

From a dust control standpoint, the work performed was unsatisfactory, particularly since the workers did not wear approved respirators. Tests on the removal of pipe insulation were basically exploratory and the work was done to determine the character of the removal operations. Better wetting techniques were suggested to the foreman.

The results of the 15 air samples taken during the survey are summarized as follows:

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Sample No.	Description	Local Time	Fibers/Cubic Centimeters >5 Micron
TOD-1	General air, middle of boiler room, north side during stripping of insulation from tank approximately 10 feet away	1017.5-1132 (74.5)[a]	0.23[b]
TOD-2	General air, middle of boiler room, south side, during removal of insulation from tank approximately 15 feet away	1020-1133.5 (73.5)	0.30
TOD-3	Worker exposure, removal of insulation from tank	1030.25-1102.5 (32.25)	1.00
TOD-4	Worker exposure, removal of insulation from tank	1032-1104 (32.0)	0.67
TOD-5	General air, in room adjacent to boiler room, east side near doorway, during stripping of insulation	1039-1137 (58.0)	0.26
TOD-6	General air (same location as TOD-1), during bagging of stripped insulation	1136-1243.5 (67.5)	0.24
TOD-7	General air (same location as TOD-2), during bagging of stripped insulation	1137-1245.5 (68.5)	0.13
TOD-8	General air (same location as TOD-5), during bagging of stripped insulation	1139-1246 (67.0)	0.0082
TOD-9	General air, in hall outside south door of boiler room during bagging of stripped insulation	1147-1251 (64.0)	0.10
TOD-10	Worker exposure (same worker as TOD-3), for bagging of stripped asbestos	1150.5-1248.25 (57.75)	0.42
TOD-11	Worker exposure (same worker as TOD-4), for bagging of stripping asbestos	1151.5-1249 (57.5)	0.34
TOD-12	Worker exposure (same worker as TOD-3), during cutting and removal of pipe insulation	1518.5-1549 (30.5)	4.08
TOD-13	General air, north wall of room, during stripping and bagging of pipe insulation	1522.5-1558 (35.5)	4.4
TOD-14	Worker exposure (same worker as TOD-4), during bagging of stripped pipe insulation	1520-1547 (27.0)	5.7
TOD-15	General air, east wall of room, during stripping and bagging of pipe insulation	1526-1559 (23)	6.8

Time-Weighted Averages

Worker Type	TWA
Worker No. 1	0.93
Worker No. 2	1.01

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

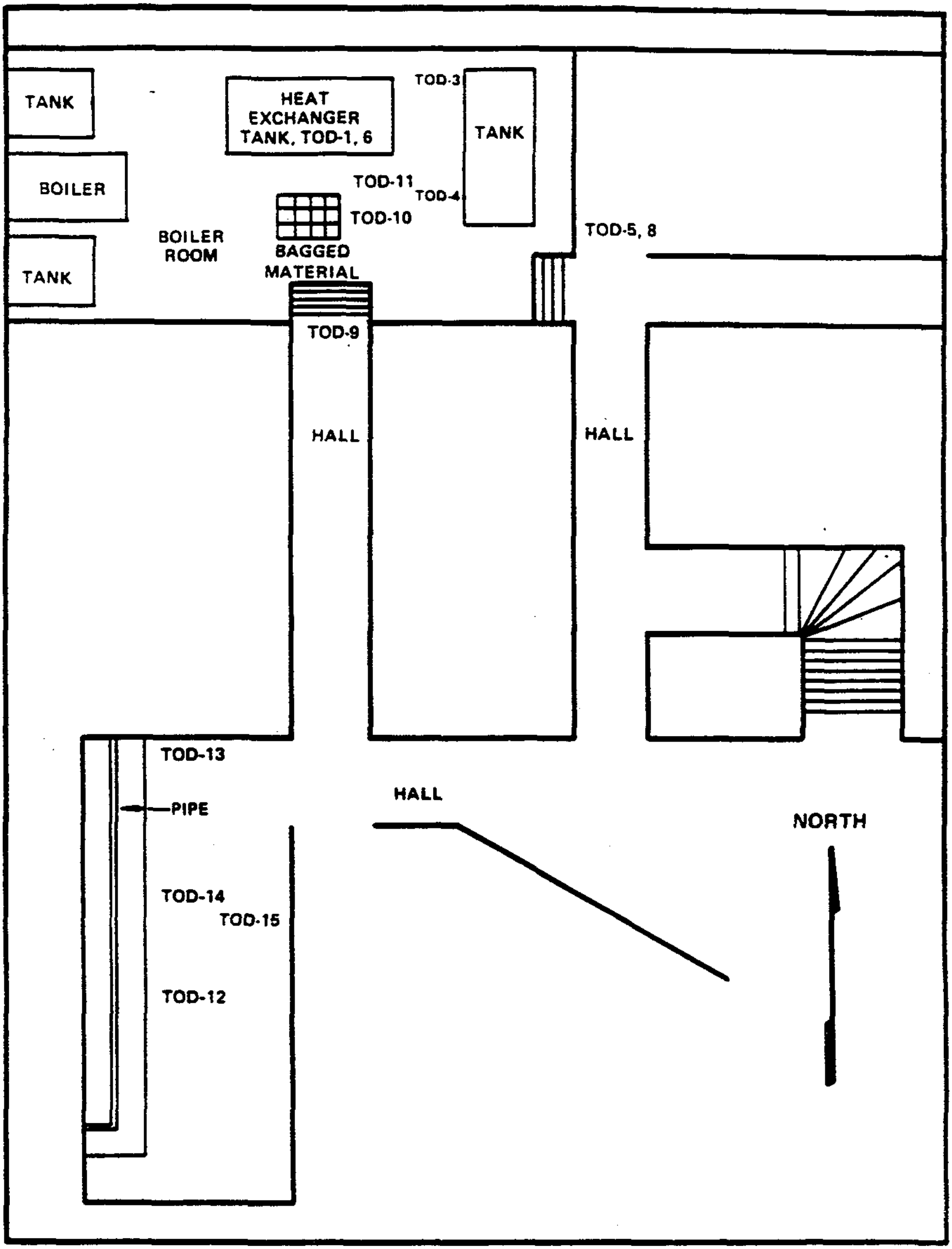

Figure 3. Diagram of work site for survey AIA-3 showing sampling locations.

SURVEY AIA-4: DRILLING MUD ADDITIVES

The AIA-4 study covered the operations involved with the use of fibrous asbestos as an additive to the circulating muds of an oil drilling rig. The work onsite was performed by one worker, and air samples were collected both outdoors and inside of a small trailer that housed the mud hopper.

The trailer was approximately 20 feet long by 8 feet wide with two open doors on opposite sides, each about 4 feet wide and extending from floor to ceiling. The mud hopper consisted of a 30-gallon drum open at the top with a suction hose connected at the bottom. The task of the worker was to slowly pour the asbestos material (dry) from a 50-pound bag into the drum. The material is fed into the drilling mud by the venturi action of the mud as it flows past the hose opening to the drum. Generally, four to six 50-pound bags of material are used during each addition and approximately 100 bags of material are used per drilling site in the area. The asbestos material is packaged in 50-pound paper bags that are sealed in a thick plastic outer covering. After the bag has been emptied, it is usually stored in a pile outside and disposed of either by burning or burial in a landfill at the site.

Conditions during the sampling varied. Generally, the wind was gusting slightly through the open doors of the trailer for both the first and second set of samples taken while the worker was pouring the product into the hopper. During the first pouring, the material fed smoothly into the hopper and six bags were poured in a 23.5-minute time interval. Some difficulty was experienced during the second pouring as the hopper appeared to be clogged and only two bags were fed over the next 23 minutes. Considerable dusting was observed during both pourings.

Results for the nine air samples collected during this survey are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
OCO-1	General air, center of trailer, approximately 6.5 feet above floor and 4 feet from dumping operation, during dumping of 6 bags	0836-0904 (28)[a]	0.95[b]
OCO-2	Worker exposure, pouring 6 bags of asbestos fiber into mud hopper	0837.5-0901 (23.5)	2.4
OCO-3	General air, directly over mud hopper, 6.5 feet above floor, during pouring of 6 bags	0837-0905.5 (28.5)	0.75
OCO-4	General air, background, approximately 50 feet upwind of trailer	0847-0937 (50)	0.016
OCO-5	General air (same location as OCO-1), no operations performed in trailer	0910-0953.5 (43)	0.090
OCO-6	General air (same location as OCO-3), no operations performed in trailer	0911-0954 (43)	0.036
OCO-7	General air (same location as OCO-1), during dumping of 2 bags	0958-1020.5 (22.5)	1.7
OCO-8	General air (same location as OCO-3), during pouring of 2 bags	0959-1019 (20)	2.9
OCO-9	Worker exposure, during dumping of 2 bags, hopper appeared to be clogged	0958-1021 (23)	7.0

Time-Weighted Averages

Worker Type	TWA
Mud hopper operator	0.51

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

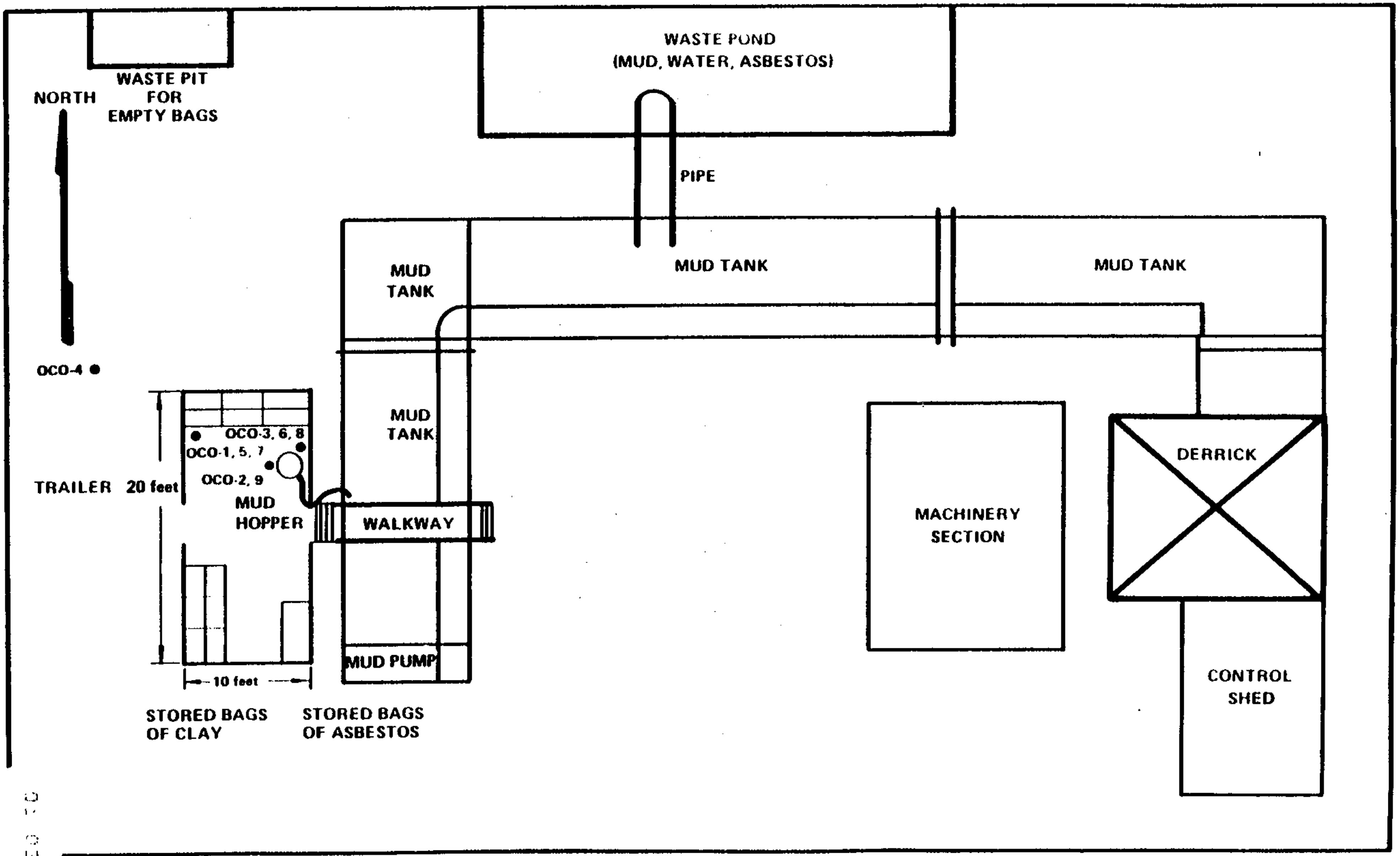

Figure 4. Work area diagram including sampling locations for survey AIA-4.

SURVEY AIA-5: VINYL-ASBESTOS FLOORING

The work performed during the AIA-5 survey included the sanding of an existing vinyl-asbestos tile floor and the installation of an asbestos-felt-backed sheet floor over the sanded floor. Two flooring installers completed the job, which was done in the kitchen of a private residence.

The dimensions of the room were approximately 12 by 17 feet with an 8-foot ceiling. There were three doors to the room, which were kept closed during sanding to prevent dust from entering other areas of the house. Sanding was done with a circular sander equipped with a grit pad and having no exhaust controls. Considerable dusting was observed during the sanding operation; however, the installers did not wear respirators. The sanding operation lasted for 15 minutes.

When the sanding was completed, the floor was swept, an operation which took 8 minutes. Two doors to the room were open during this time. Considerable dusting resulted from this operation.

Approximately 10 minutes after the completion of sweeping, the installers started to bring in the new sheet flooring and some supplies. The laying of the new floor was accomplished by placing a large sheet of flooring over the area to be covered and making cuts in the sheet with a razor knife to fit the dimensions of the room. Adhesive was applied with a trowel and the sheet floor was pressed into place. The floor-laying operation did not appear to cause any significant dusting, but dust was present in the air from the previous sanding and sweeping. The samples obtained for floor laying cannot be considered to be representative of the dust exposures due to floor laying only. The entire job was completed in approximately 2.5 hours.

A summary of the air sampling data measured during the survey follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
BF-1	Worker exposure, sanding vinyl asbestos tile	0955-1010 (15)[a]	0.052[b]
BF-2	General air, on kitchen countertop, south side of room during sanding and sweeping of vinyl asbestos tile	0956-1025 (29)	0.053
BF-3	General air, on kitchen countertop, west side of kitchen during sanding and sweeping of vinyl asbestos tile	0957-1026 (29)	0.027
BF-4	Worker exposure, sweeping floor after sanding	1015-1023 (8)	0.29
BF-5	General air (same location as BF-2), during laying of sheet floor	1033-1143 (70)	0.075
BF-6	General air (same location as BF-3), during laying of sheet floor	1034-1144 (70)	0.055
BF-7	Worker exposure, installation of sheet floor, includes cutting, applying adhesive, pressing floor into place	1032-1142 (70)	0.055

Time-Weighted Averages

Worker Type	TWA
Floor installer	0.020

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

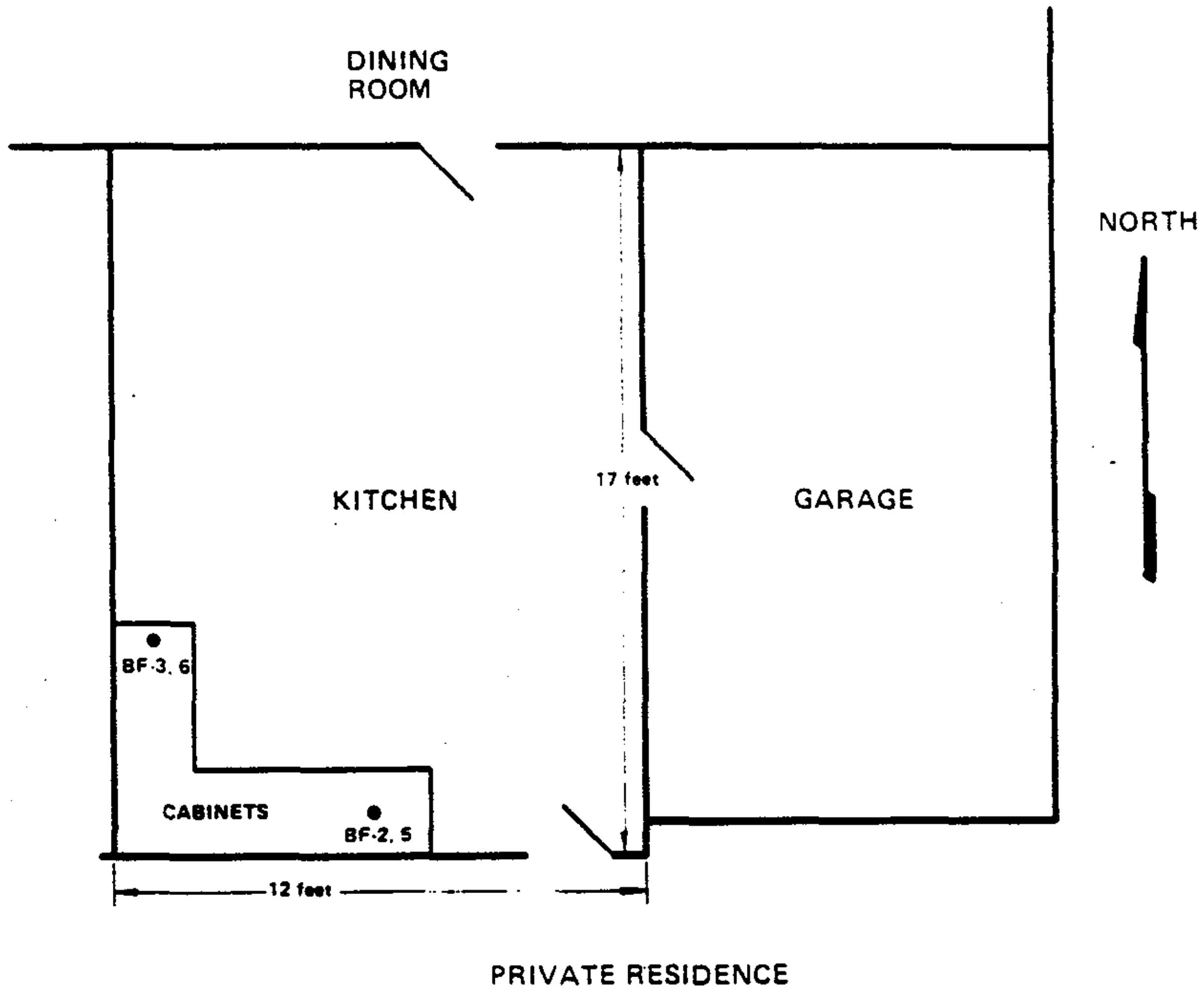

Figure 5. Diagram of work area for survey AIA-5 showing locations of general air samples.

SURVEY AIA-6: INSTALLATION OF ASBESTOS-CEMENT SHINGLES

Sampling survey AIA-6 involved monitoring dust concentrations during the installation of asbestos-cement shingles on new homes in a residential area. Two carpenters performed the installation outdoors. Weather conditions during sampling ranged from partly cloudy to cloudy, with temperatures ranging from 40° to 45° F.

Installation consisted of nailing the shingles to the plywood exterior of the building, and cutting the shingles where necessary for proper fit using a shingle cutter. The shingle cutter is used to make three types of cuts in the shingles. Cutting is performed using the large blade and a quick shearing action. Notching is made with a smaller blade using a scissoring action and generates crumbly material. Hole punching is accomplished with a punch on the machine and sometimes causes a short burst of dust. It is common practice during the installation to make cuts, notches, or holes as the material is being installed; that is, batches of material are not cut all at one time, but this operation is spread out over the time that the shingles are nailed in place. A worker breathing-zone sample collected over the time when the worker is installing the material (including unwrapping of the packaged shingles, nailing, cutting, notching, hole punching, and moving of the cutting machine) can be considered representative of the worker's exposure throughout a working day.

Each carpenter worked on a different house. Carpenter No. 1 worked on a house where Type A shingles were used, while carpenter No. 2 installed

Type B shingles on a house where he was working. Type B shingles tended to crumble more easily than Type A when cut, punched, or notched.

During the installation, it was often necessary for the worker to nail overhead on a vertical surface. When this was done, it was noticed that a short burst of dust was generated by the abrasive action of the nail on the shingle. The dust would sometimes float down into the vicinity of the worker's breathing area.

Since the operation of cutting shingles has been of interest from the viewpoint of dusting, two 5-minute simulated tests were sampled inside a building where workers sometimes cut shingles. One breathing zone sample (SPS-7) was collected during a 5-minute period where the worker cut scraps of shingles. Another breathing zone sample (SPS-7) was collected when the worker notched and punched holes for 5 minutes. Both simulated tests were performed in doors and although the room was open to the outside, little or no wind was blowing. The full-time workers from this company perform asbestos-shingle installations on the average of 4 days per week with a 7-hour work day.

Air sampling data are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
SPS-1	General air, background, upwind from operations	1103-1203 (60)[a]	0.014[b]
SPS-2	Worker exposure, carpenter No. 1, installing Type A shingles	1111-1156 (45)	0.017
SPS-3	General air downwind approximately 100 feet from carpenter No. 2 installing Type B shingles	1255-1413 (78)	<0.010
SPS-4	Worker exposure, carpenter No. 2 installing Type B shingles on pitched roof	1257-1409 (72)	0.011
SPS-5	General air, approximately 50 feet downwind from carpenter No. 1 installing Type A shingles	1308-1438 (90)	<0.0085
SPS-6	Worker exposure, carpenter No. 1 installing Type A shingles	1314-1419 (65)	<0.012
SPS-7	Simulation, worker exposure, cutting Type A shingles, indoors	1420-1425 (5)	<0.16
SPS-8	Simulation, worker exposure, notching and hole punching type A shingles, indoors	1430-1435 (5)	<0.16

Time-Weighted Averages

Worker Type	TWA
Carpenter No. 1	<0.013
Carpenter No. 2	0.010

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a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

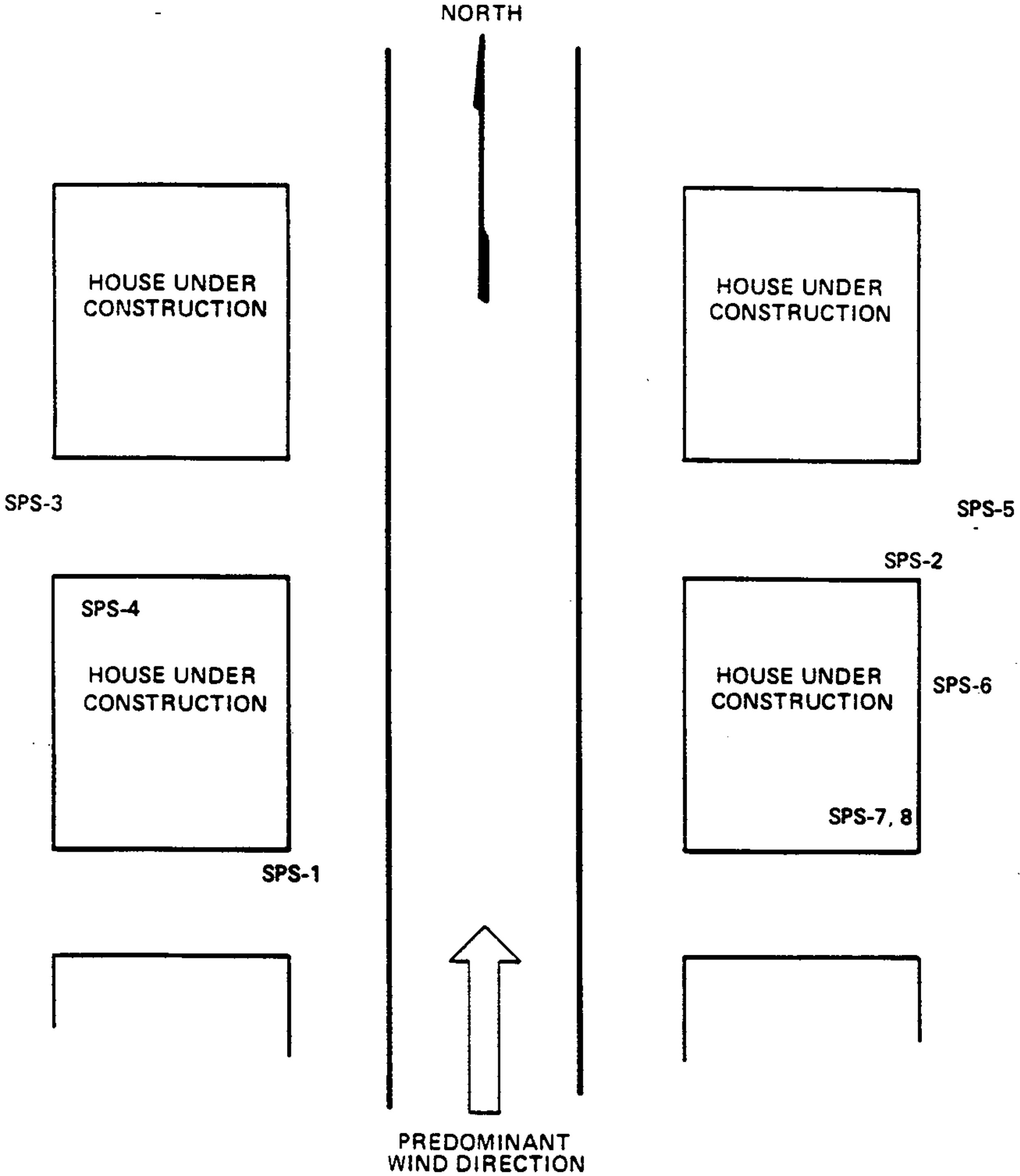

Figure 6. Diagram of housing construction site for survey AIA-6 showing sampling locations.

SURVEY AIA-7: ASBESTOS CEMENT SHEET

The AIA-7 study was performed to measure asbestos dust exposures in the cutting of asbestos composition panels (4 by 8 feet by 1 inch). The simulated work was set up in the work yard of a construction firm. All operations were performed outdoors. The work was conducted about 10 feet from an open door on the east side of a large storage building. Weather was cloudy and cold; the temperature was about 40° F with a minimum of any discernible winds. Occasionally, a back draft toward the building was noted.

The work consisted of cutting approximately 4-inch sections from the panel along the 4-foot side. The strips were not used for any specific application; the cutting was done to evaluate exposures in this type of work. A secondary purpose associated with the work was to compare the performance of a Nilfisk dust collector with that of the Advance collector normally used by the construction company.

The panel was placed on a pair of sawhorses and a series of cuts made. The first saw used was a standard circular saw with an 8-inch diamond-tipped blade provided with exhaust inlets on the blade housing connected through a 4-inch flexible hose about 4 feet long to the Advance collector. In the first series of cuts, the motor of the saw burned out after six full cuts and a partial cut were made. In this work, 8.5 minutes of cutting time were involved, and the first series was concluded.

The second series of cuts was made employing a slower speed Skil saw with a makeshift enclosure of the saw housing by means of cardboard and fabric tape with an opening in the enclosure transverse to the saw. This modification required a second person holding the hose at the opening in the enclosure as the cuts were made. This series of cuts required 14 minutes to complete the six cuts. The collector used was the Nilfisk.

The final series was a duplicate of the second series except that the Advance collector was used. The six cuts required 13.8 minutes to complete. Both workers wore "3M"-approved dust respirators. The most significant observation was that settled dust remained on the panel during and after the cuttings of the first series where it could be disturbed and become airborne. The second and third set of cuttings using the improvised enclosure of the saw housing resulted in practically all of the dust being removed by the collectors; no visible differences between the performance of the two collectors were observed. However, it is quite possible that the improvement may have been related to the differences in the saws and rate of cutting to some degree, but the general impression is that the improvised closure of the saw housing resulted in much better capture of dust from the sawing operation.

The air sampling data are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
HS-1	General air, background, approximately 65 feet from operations	1021-1053.25 (31.25)(a)	0.025 (b)
HS-2	General air, approximately 12 feet from cutting operation, during cutting of asbestos cement sheet with high-speed saw	1028-1052 (24)	0.096
HS-3	Worker exposure (cutter), cutting high-speed saw with shroud, Advance vacuum cutting time: 8.5 minutes, 6.5 cuts	1034-1050 (16)	7.4 —
HS-4	General air, on exhaust of Advance vacuum during cutting with high-speed saw, 3 feet from cutting	1035-1051.5 (16.5)	1.6
HS-5	General air (same location as HS-1)	1103-1151 (48)	0.016
HS-6	General air (same location as HS-4) during cutting with low-speed saw, Nilfisk vacuum used	1129-1150 (23)	<0.034
HS-7	General air (same location as HS-2) during cutting with low-speed saw, Nilfisk vacuum used	1129-1150.75 (22.75)	0.034
HS-8	Worker exposure (cutter), cutting sheet with low-speed saw and Nilfisk vacuum, cutting time 14 minutes	1130.75-1149.25 (19.25)	0.17
HS-9	Worker exposure (helper), held vacuum hose from Nilfisk collector to make-shift shroud on low-speed saw	1131-1149.75 (18.75)	0.25
HS-10	General air, background (same location as HS-1)	1130.75-1356.25 (25.5)	<0.030
HS-11	General air (same location as HS-2) during cutting with low-speed saw, Advance vacuum	1336-1355.25 (19.25)	<0.041
HS-12	Worker exposure (cutter), cutting sheet, low-speed saw, Advance collector, cutting time 13.8 minutes	1336.5-1354 (17.5)	0.047
HS-13	Worker exposure (helper), held hose from Advance vacuum to makeshift shroud on low-speed saw	1336-1354 (18)	0.18

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

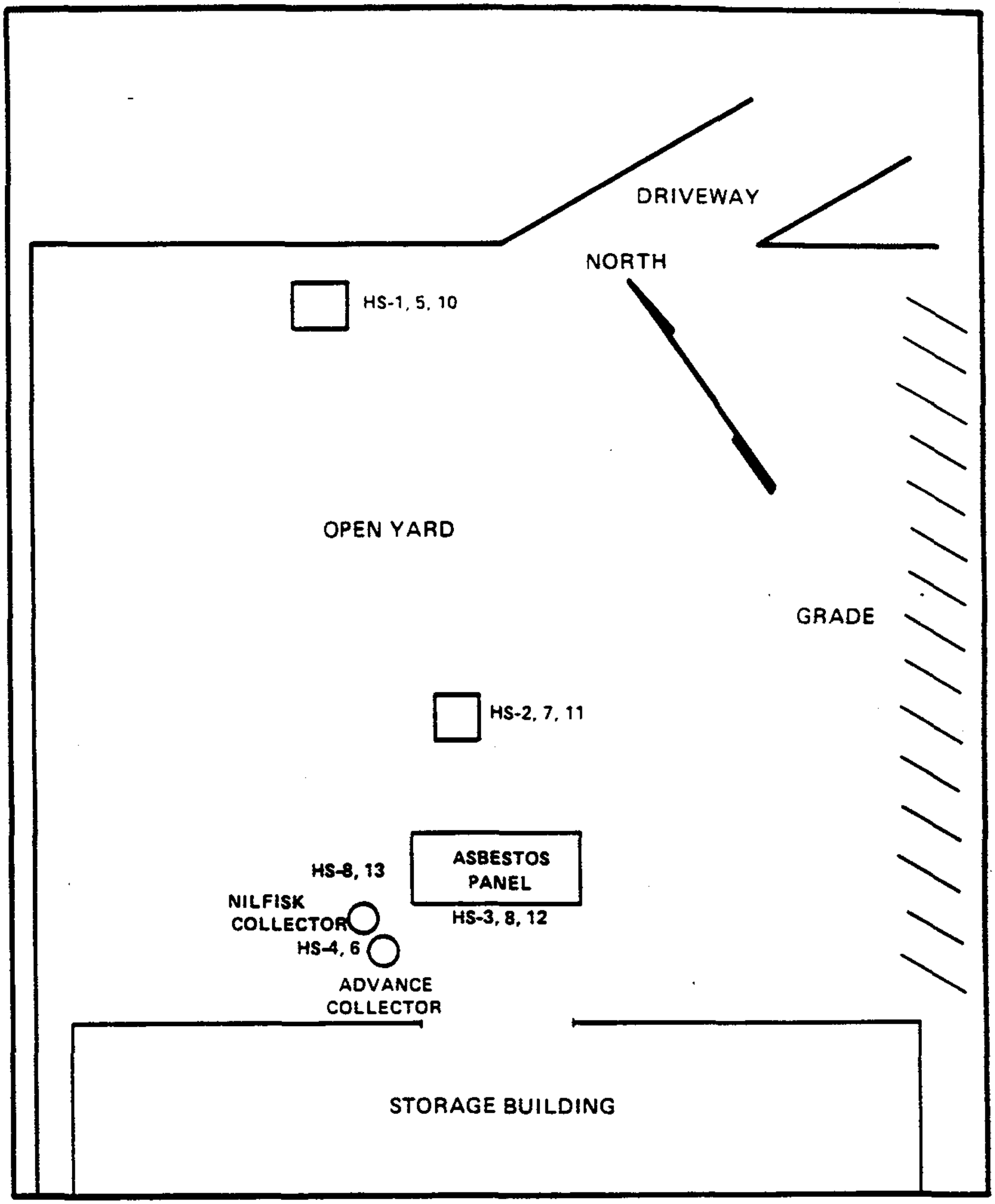

Figure 7. Diagram of work area for sheet-cutting simulation on survey AIA-7 showing sampling locations.

SURVEY AIA-8: ASBESTOS-CEMENT PRODUCTS, COOLING TOWERS

A study of asbestos dust was made in the installation of asbestos composition material in the construction of a cooling tower at an electric power plant. The weather at the time of the survey was cold--estimated at about 20° F or less--with an extremely strong and gusty wind blowing through the ground-level opening during the morning of the tests.

The outer shell, or veil, of the cooling tower had been completed and the inner structure was being erected. The tower was some 500 feet high and an estimated 300 feet in diameter; the shell was open at ground. The work being performed was the initial stages of installing some 600,000 sheets of asbestos board, each about 9 feet by 16 by ¼ inches, as "drift eliminators" by positioning them in the framework in the internal structure of the cooling tower. About 100,000 of the sheets are drilled with four ½-inch diameter holes for hanging. Some of the sheets--an unknown number, but relatively small--are "cut" by scoring and breaking off to fit properly in some positions. The only operations carried out at the time of the visit were drilling and installing. No "cutting" was observed. Asbestos-cement pipe is a component of the structure and was also being installed at the time.

Air samples were taken of workers drilling the four holes in 100 sheets on a pallet (bundle) in an area at the center of the tower partly protected from the wind by a horizontal section of 8-foot diameter piping. Another sample was taken of worker's exposure during the drilling of four bundles located near the periphery of the structure where the bundles had been stored, a location where the wind was possibly at its greatest. A set of samples was taken of installers' exposures positioning the sheets some 75 feet above ground in the structure.

The drilling operation would appear to be the major exposure. Airborne dust was not readily visible although visual observations were handicapped by the absence of sunlight within the structure. Heavy dust accumulated on the panels as the drilling proceeded, but these particles were relatively heavy and large from the slow-speed operation of the drill. The workers did not wear respirators although it was reported that respirators were provided. On some occasions in the drilling at the periphery area, wind-gusts were sufficient to blow the heavy dust from the surface of the sheets as it was generated. It is believed that the winds were abnormally high and conditions were hardly representative of normal work. (It was too windy for ironworkers to work on that day.) The wind at the upper level where installation of the sheets was carried out was minimal although there may have been some upward draft through the cooling tower. The time of actual drilling of a hole through the 100 sheets in a bundle normally varied from 70 to 90 seconds; on one bundle, which was reported to be wet or damp, the time of drilling one hole ranged from 105 to 120 seconds. Eight bundles, or 32 holes, were drilled during a 2-hour period; the workers estimated that up to 30 bundles could be drilled in a good, or average, day. The time between drilling involved miscellaneous duties such as changing bits, positioning the template, and positioning the rack for lifting of the bundles by crane, that offered no asbestos exposure. The installation at the upper level was continuous. A sample of pipe installation on the upper level was obtained.

The description and results of air samples measured during the study are as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
CT-1	General air, 10 feet from workers drilling asbestos cement sheet	1004.5-1042.25 (37.75)[a]	0.082[b]
CT-2	Worker exposure, driller, drilled one pile of asbestos cement sheet, drilling time: approximately 6 minutes	1005.25-1034 (28.75)	0.24
CT-3	Worker exposure, driller's helper, approximately 6 minutes drilling time	1006-1033.5 (27.5)	0.030
CT-4	Worker exposure, driller, drilled 4 bundles of asbestos cement sheet, approximately 28 minutes drilling time	1105.5-1143 (37.5)	0.050
CT-5	Worker exposure, sheet setter, installed asbestos cement sheet	Not recorded (23.0)	0.50
CT-6	Worker exposure, pipe setter, set asbestos cement pipes into place (did not include joining pipes with fitting)	Not recorded (17.3)	0.37

Time-Weighted Averages

Worker Type	TWA
Driller	0.13
Sheet setter	0.44
Pipe setter	0.32

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

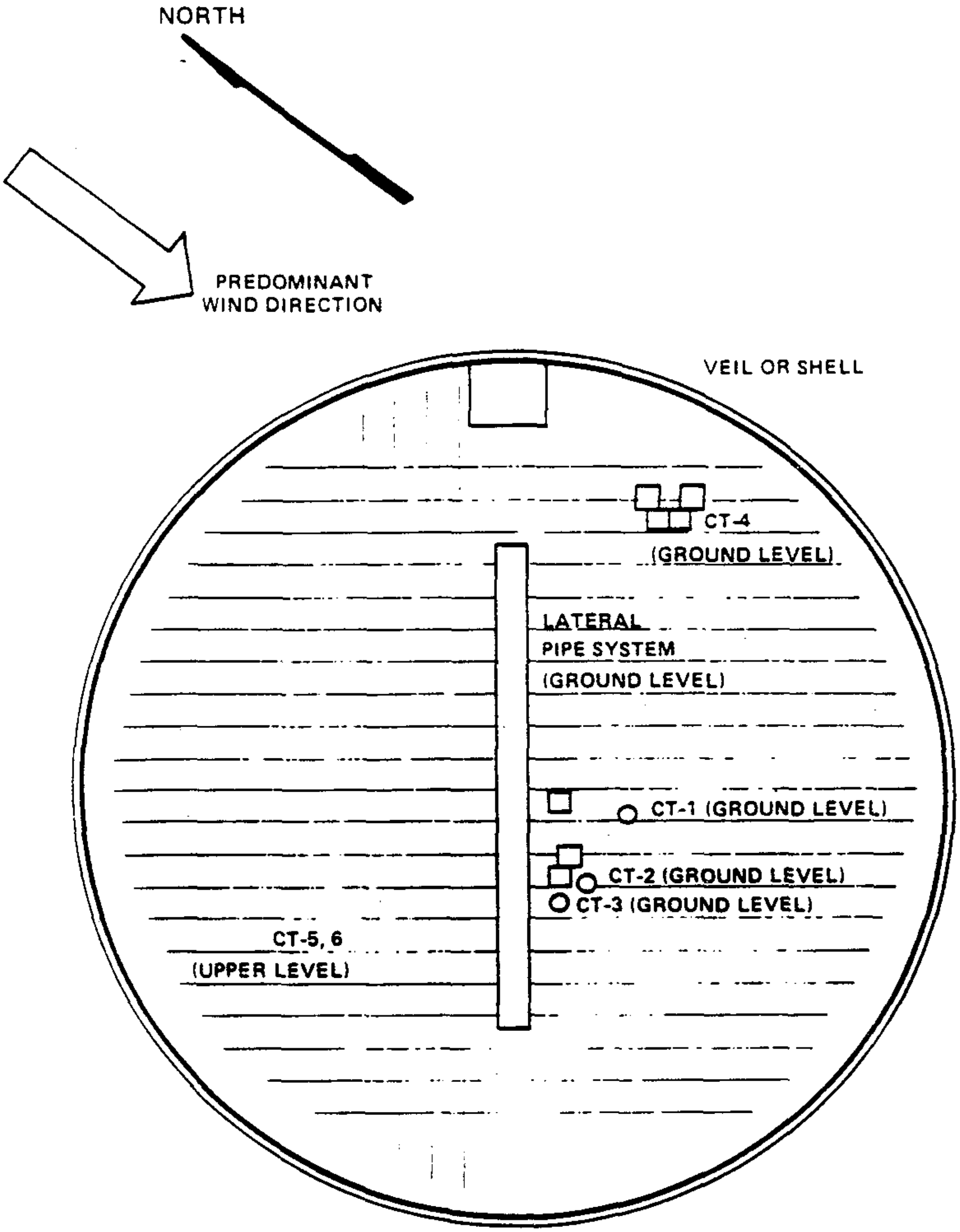

Figure 8. Diagram of working area inside cooling tower (top view) for survey AIA-8 showing sampling locations.

SURVEY AIA-9: DRILLING MUD ADDITIVES--SHIPMENT, STORAGE

Survey AIA-9 was performed in the warehouse of a retail drilling mud company during the handling of bags of asbestos additives for shipping. Sampling was done indoors, while it was drizzling rain outdoors.

Work was performed in the warehouse by a lift truck operator and an unloader on the truck. Several other persons were working in the warehouse during the survey. The operations consisted of moving pallets of the bagged asbestos additive with a lift truck to the bed of the truck used for shipping the product to the customer. A full pallet was placed on the bed and an additional 10 bags of material were unloaded from the pallet to the truck by hand and stacked. A diagram of the work area is shown in Figure 9.

All bags of the material were in good condition and no broken bags were observed. The condition of the warehouse was clean and the bags of material were handled carefully by the workers. No visible dust was observed during the handling of the bags.

Five air samples, including four general air and one breathing zone sample, were taken. The sampling data are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
AW-1	General air, center of warehouse on lift truck	0841-0917 (36)[a]	0.063[b]
AW-2	General air, center of warehouse during loading of truck	0934-0944 (10)	<0.077
AW-4	General air, on cab of truck during loading	0931-0941 (10)	0.078
AW-5	Worker exposure, lift operator during truck loading	0933-0945 (12)	0.065
AW-6	General air, center of warehouse after loading	0947-0957 (10)	0.077

Time-Weighted Averages

Worker Type	TWA
Warehouse workers	**0.074**

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

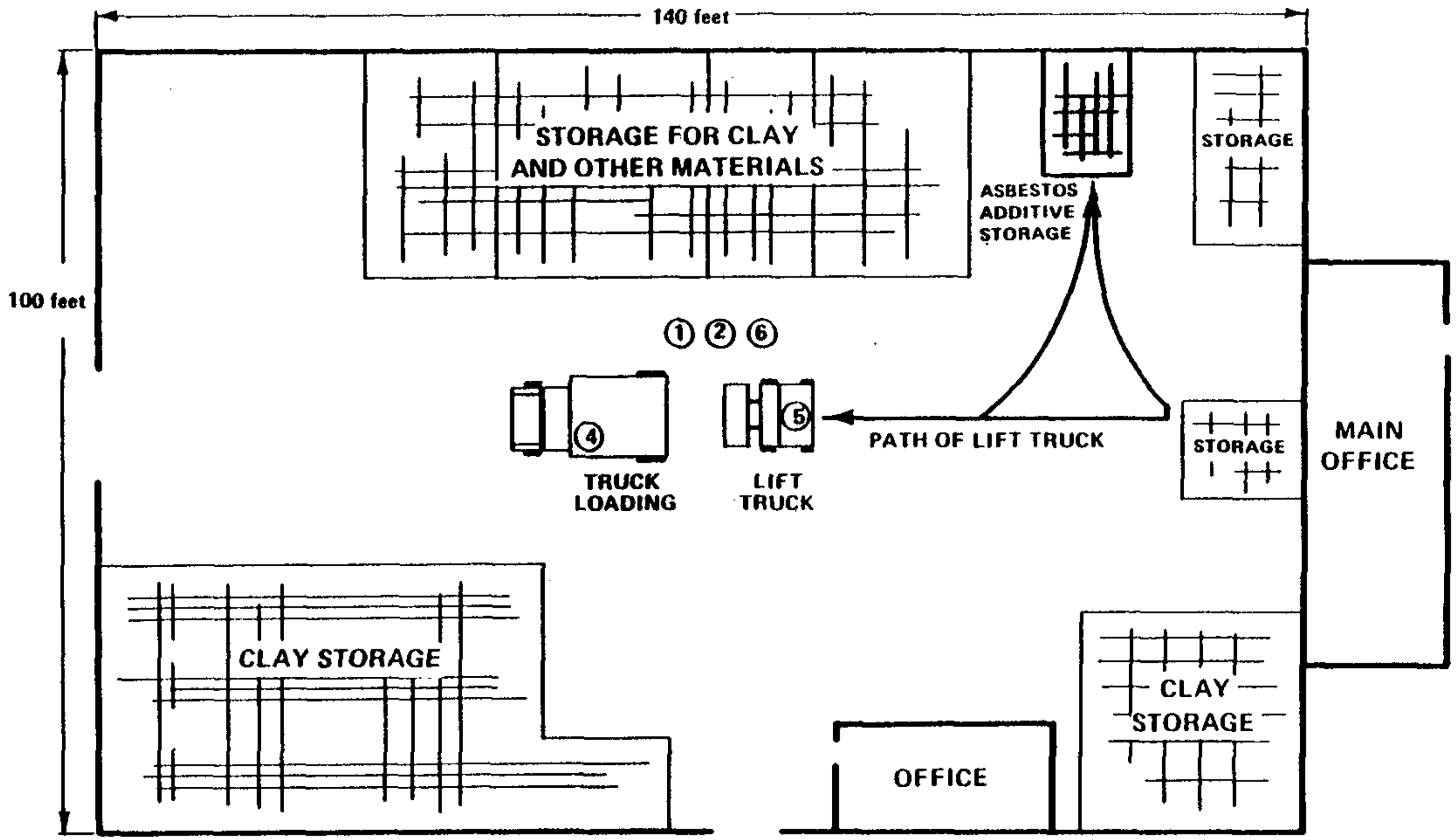

Figure 9. Diagram showing work area and sampling locations for survey AIA-9.

SURVEY AIA-10: DRILLING MUD ADDITIVES--SHIPMENT, STORAGE

During field survey AIA-10, air samples were collected in the warehouse of a retail drilling mud firm, while workers loaded a truck with bags of asbestos additive for shipment to a job site. Sampling was performed indoors while rain fell outside.

The work area is shown in Figure 10. The operations monitored consisted of moving a pallet of bagged asbestos additive over to a truck using a lift-truck, loading a full pallet onto the bed, and then unloading an additional 10 bags onto the truck by hand for shipment. Work was performed by a lift-truck operator and two warehouse employees.

The general condition of the warehouse was dirty with considerable airborne dust and settled dust throughout the area from past bag breakage--primarily clays. Apparently, no cleanup procedures were in effect.

Four air samples were collected consisting of two general air and two breathing zone samples. The sampling data are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
AG-1	General air, warehouse	1032.5-1056 (23.5)[a]	<0.033[b]
AG-3	Worker exposure, lift operator loading truck with pallets	1111-1119 (8)	<0.098
AG-4	Worker exposure, helper unloading bags from pallet	1111-1120 (9)	0.59
AG-5	General air, warehouse after loading	1125-1140 (15)	0.15

Time-Weighted Averages

Worker Type	TWA
Fork lift operator	0.11
Loader	0.11

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a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

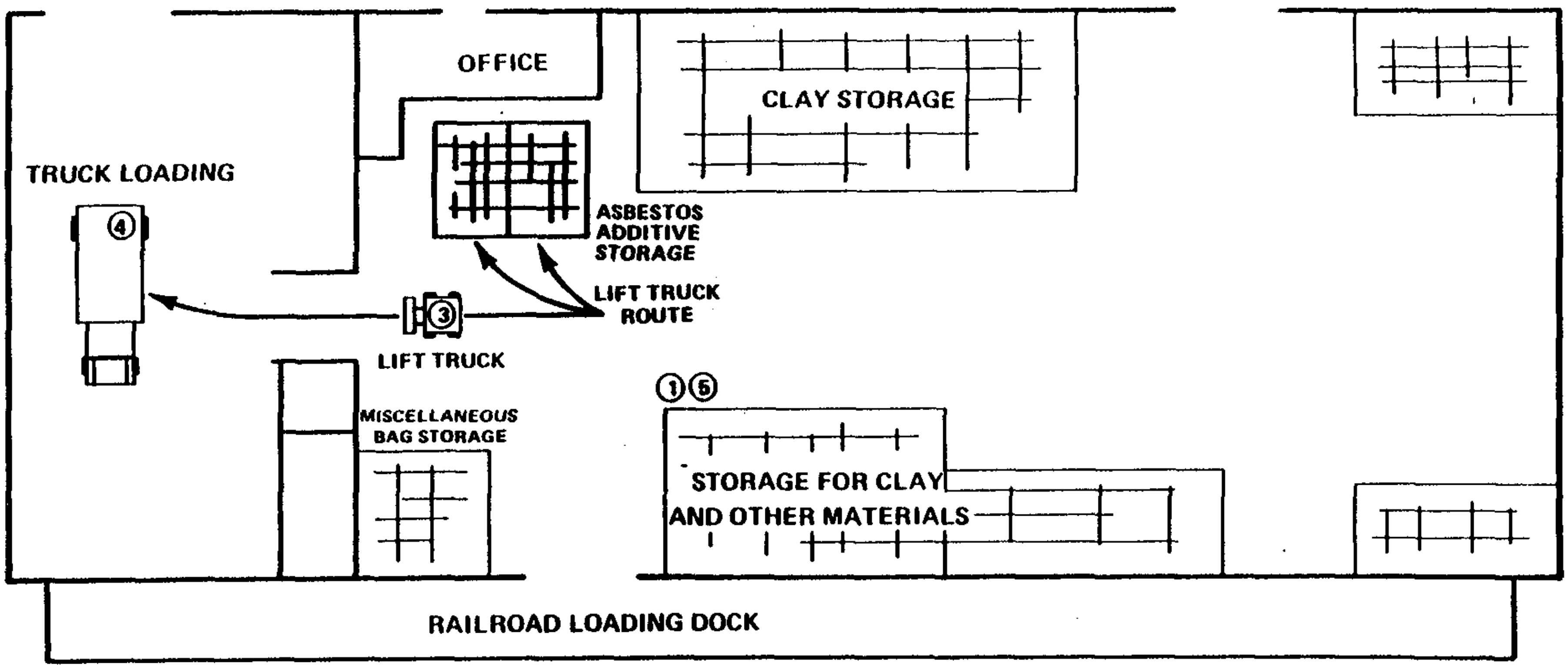

Figure 10. Diagram showing work area and sampling locations for survey AIA-10.

SURVEY AIA-11: DRILLING MUD ADDITIVES, DRILLING SITE

Survey AIA-11 covered the operations involving the use of an asbestos additive to the muds at an oil drilling rig. Sampling was performed outdoors and the weather was cold and rainy with a slight wind.

The operation at the drilling site involved one worker who was responsible for adding the material to the drilling mud through the mud hopper, which was outdoors. The operation consisted of the worker carrying a 50-pound bag of the additive to the side of the hopper, cutting the bag open, and slowly adding the asbestos material to the hopper. As the bags were emptied, the operator would put them in a pile. Upon completion of the pouring (usually 5 to 6 bags of additive), the operator would step on the bags to compress their size and then carry them off to a pit for disposal. At one point during the pouring, one of the bags tore slightly and the asbestos material spilled onto the worker's clothing.

Four general air samples and two breathing zone sample were collected during the survey. The air sampling data are summarized as follows:

Sample No.	Description	Time (minutes)	Fibers/Cubic Centimeter >5 Micron
DB-1	General air, 10 feet north of hopper during cleaning	19.5	0.039 [a]
DB-2	General air, 3.5 feet south of hopper during cleaning	19	0.041
DB-3	General air, 10 feet north of hopper during dump	28	0.027
DB-4	General air, 3.5 feet south of hopper during dump	31	0.099
DB-5	Worker exposure (operator) during dump into hopper	29.5	0.13
DB-6	Worker exposure, disposal of empty bags	2	0.39

Time-Weighted Averages

Worker Type	TWA
Hopper Operator	0.047

a. Computational results not intended to imply accuracy of counting.

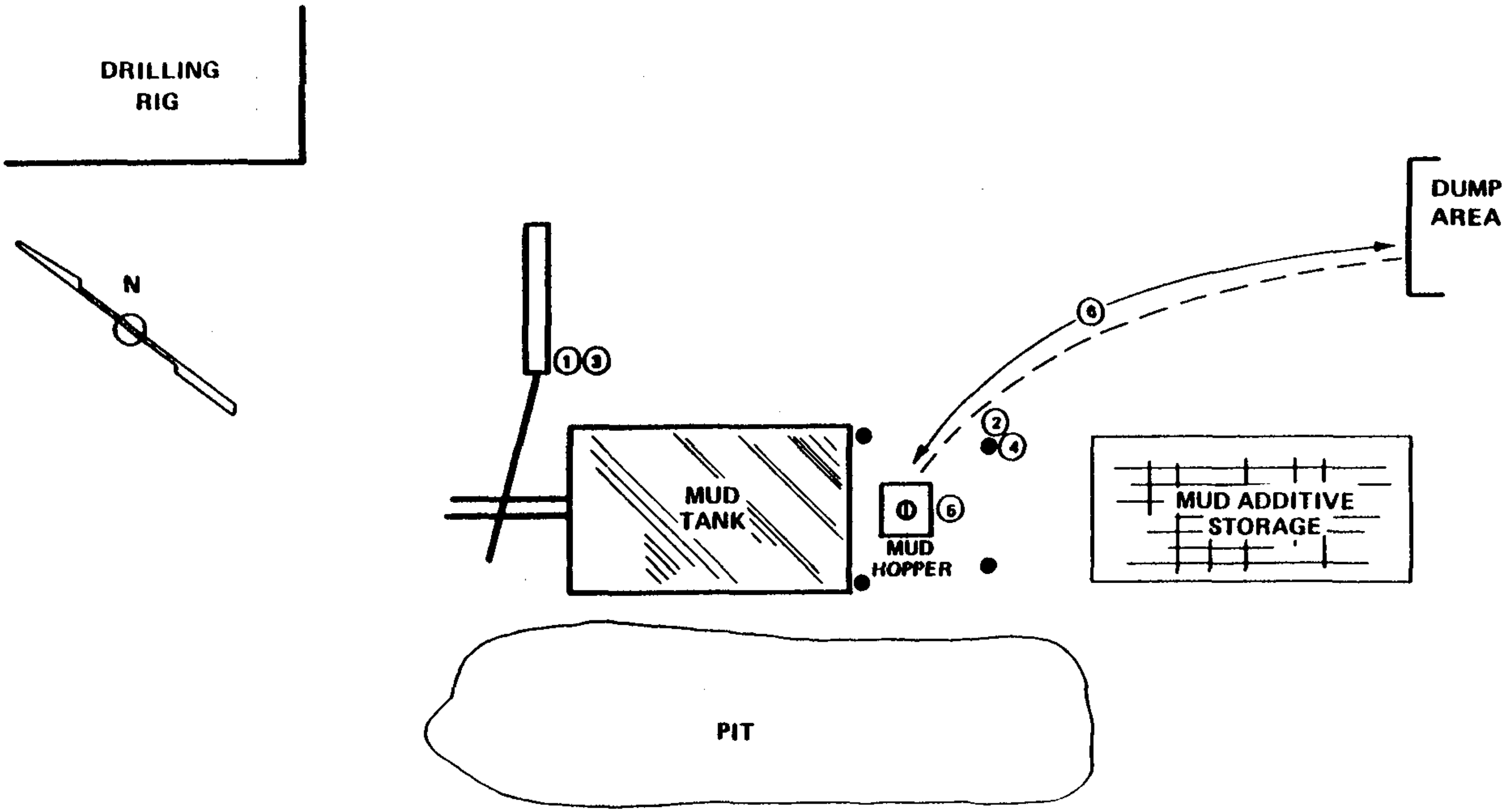

Figure 11. Diagram of work area showing sampling locations for survey AIA-11.

SURVEY AIA-12: DRILLING MUD ADDITIVIES--OIL RIG

Survey AIA-12 consisted of monitoring asbestos exposures at an oil drilling rig where asbestos additives were used in the drilling muds. Sampling was performed outdoors during a rainy, cold, and slightly windy day.

The operation consisted of one worker carrying a 50-pound bag of additive to the side of the mudhopper, breaking open the double bag (plastic outside, paper inside), and slowly pouring the asbestos additive into a mudhopper. The hopper was located outdoors. After pouring, the worker crumpled up the empty bag and, at the completion of operations, brought them to a disposal area. Nine bags of asbestos were added during the survey.

Three general air and two breathing zone samples were collected, and the air sampling data are summarized as follows:

Sample No.	Description	Time (minutes)	Fibers/Cubic Centimeter >5 Micron
WT-1	General air, 3 feet upwind of hopper	14.8	<0.053[a]
WT-2	General air, 3 feet upwind of hopper during dump	27.6	0.14
WT-3	Worker exposure (operator) during dump and disposal of empty bags	26.8	0.20
WT-4	Observer exposed during dump	28	0.08
WT-5	General air, 3 feet upwind of hopper after dump	15	0.10

Time-Weighted Averages

Worker Type	TWA
Hopper operator	0.083

a. Computational results not intended to imply accuracy of counting.

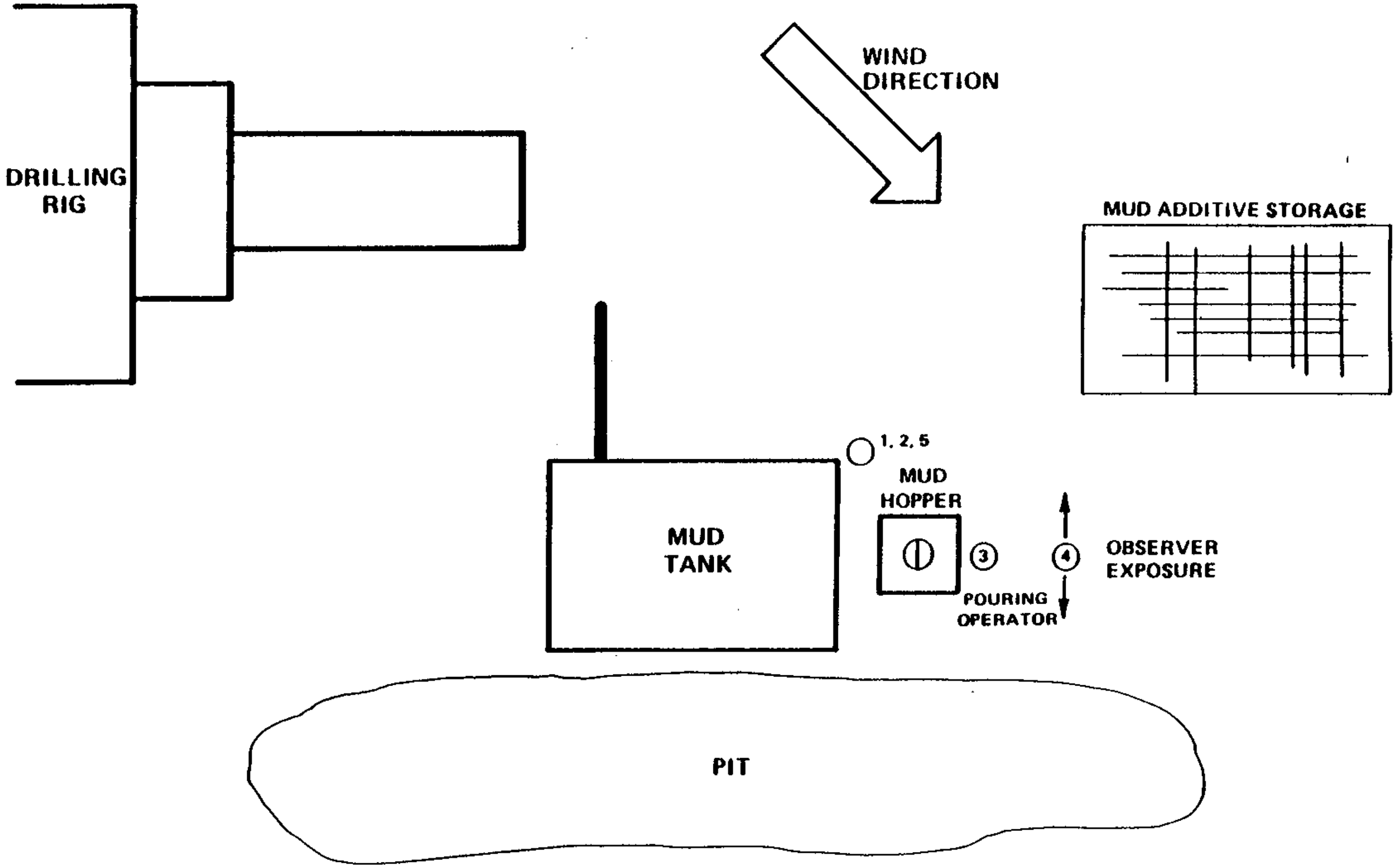

Figure 12. Work area for survey AIA-12.

SURVEY AIA-13: DRILLING MUD ADDITIVES--SHIPPING, STORAGE

During survey AIA-13, air samples were collected in a drilling mud company warehouse during handling and shipping of an asbestos additive for drilling muds. Work was performed indoors with the door to the warehouse open and the wind blowing slightly.

The work performed consisted of moving a pallet of bagged asbestos material to a nearby truck (inside the warehouse) using a lift truck and loading the bags on the truck by hand. Two workers and one lift-truck operator completed the work.

The condition of the warehouse was clean, the materials were stored and arranged in an organized fashion, and the work was performed carefully.

Two general air and two breathing zone samples were collected. The air sampling data are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
MW-1	General air, middle of shed before operations	0811.5-0843 (25.5)[a]	0.031[b]
MW-2	General air, middle of shed during loading	0902-0917 (15)	<0.052
MW-3	Worker exposure, lift-truck operator during loading	0901-0918 (17)	0.23
MW-4	Worker exposure, loader's exposure transferring bags from pallet to truck bed	0901.5-0918 (16.5)	0.36

Time-Weighted Averages

Worker Type	TWA
Fork lift operator	0.038
Loader	0.042

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

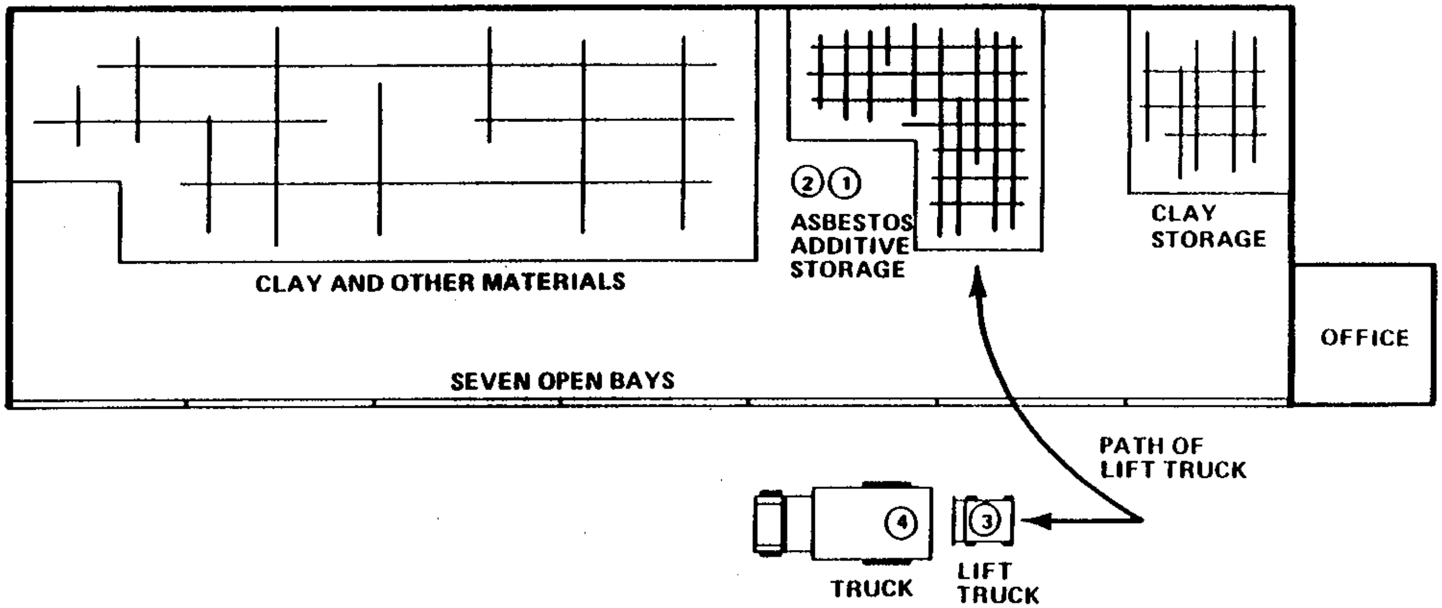

Figure 13. Diagram showing work area and sample locations for survey AIA-13.

SURVEY AIA-14: DRILLING MUD ADDITIVES--OIL RIG

General air and worker breathing zone samples were collected at an oil rig during the operations involving the use of asbestos drilling mud additives. The sampling was performed outdoors where the weather was cloudy and cool and the winds were blowing from 5 to 10 mph.

Work consisted of those operations previously described, that is, one employee cutting open a 50-pound bag of additive, pouring the asbestos into the mudhopper, and at completion bringing the empty bags to a waste disposal pit. Five bags of additive were used during the survey. A diagram of the work area is shown in Figure 14.

Four samples were collected and the air sampling results are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
BD-1	General air, 20 feet upwind of hopper	1116-1144 (28)[a]	0.027[b]
BD-2	Worker exposure, dumping sacks and disposing of empties	1145-1202.5 (17.5)	0.13
BD-3	General air, 3 feet downwind of hopper during dumping	1146-1201 (15)	<0.052
BD-4	Observer, 10 feet from hopper	1152.5-1204 (11.5)	<0.067

Time-Weighted Averages

Worker Type	TWA
Hopper Operator	0.031

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

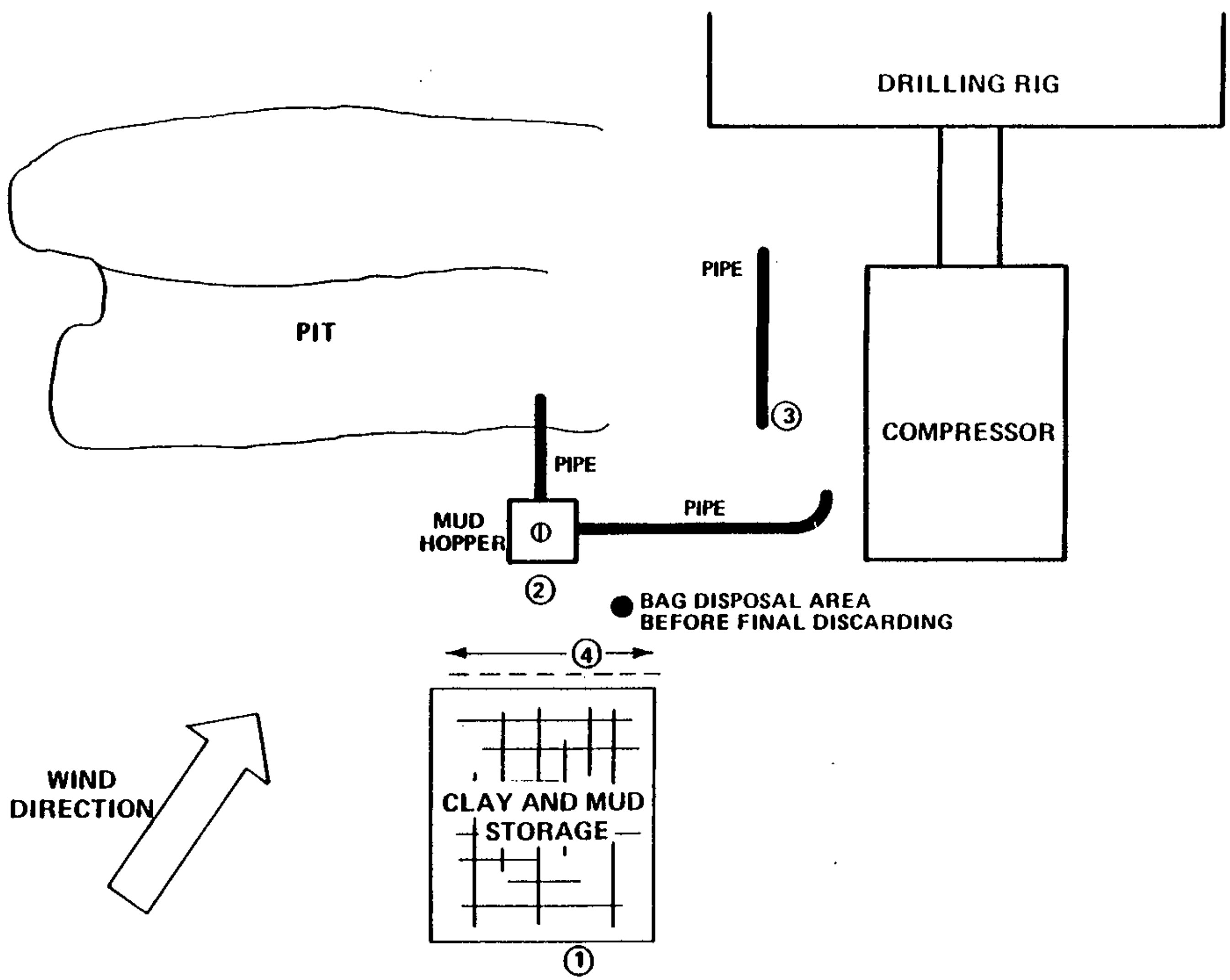

Figure 14. Diagram of work area with sampling locations for survey AIA-14.

SURVEY AIA-15: DRYWALL COMPOUNDS

Survey AIA-15 was conducted in a new annex to an existing building. The walls and ceiling of the annex had been sheet rocked and two coats of tape joint compound applied. The first coat was of a non-asbestos compound. The second coat used on one portion of the ceiling contained asbestos. The asbestos-containing compound was premixed by the manufacturer so that wet-out on the job site was unnecessary.

The operation observed was pole sanding of the ceiling. The worker performing this operation wore work clothes, including a head covering and glasses. A disposable respirator approved for toxic dust was worn during sanding. A 100 grit paper was used. The worker, using stilts, moved about freely, sanding along joints as he went. Heavy visible dusting occurred throughout the 25-minute sanding operation. At the completion of sanding, the worker's clothing was covered with dust.

After a short break, the worker proceeded to another area of the annex and sanded the ceiling joints. The compound used was a non-asbestos type. Sanding of this portion of the ceiling took approximately 30 minutes.

Seven samples were taken during the survey. Two background samples were obtained prior to sanding of the ceiling. Dry-sweeping was being performed at this time. During sanding of the ceiling having asbestos compounds, a personal sample and two area or environmental samples were obtained. Sample locations are shown in Figure 15. Additional area samples were obtained after sanding was completed and during sanding of the non-asbestos compound. A personal sample was also obtained during the second sanding operation.

Results of fiber counts are summarized as follows:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter >5 Micron
CB-1	General air, center of area	0820-0835 (15)[a]	0.15[b]
CB-2	General air, on side wall	0814-0834 (20)	0.42[c]
CB-3	Worker exposure, operator during sanding	0837-0903 (25.5)	0.15
CB-4	General air, center of area during sanding	0837-0904 (27.33)	0.082
CB-5	General air, center of area after sanding	0910-0949 (39)	0.077
CB-7	General air, on side wall non-asbestos mud being sanded	0917-0947 (29.33)	0.13
CB-8	Worker exposure, during sanding of non-asbestos mud	0917-0946 (29)	0.13

Time-Weighted Averages

Worker Type	TWA
Finisher: Area where asbestos was used	0.13
Finisher: Area where no asbestos used	0.16
Sander (excludes protection afforded by respirator)	<0.15

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a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.
c. Note: Ceiling concentration. Dry sweeping was being performed during sampling prior to sanding. Results appears anomalous since non-asbestos compound was used on previous day.

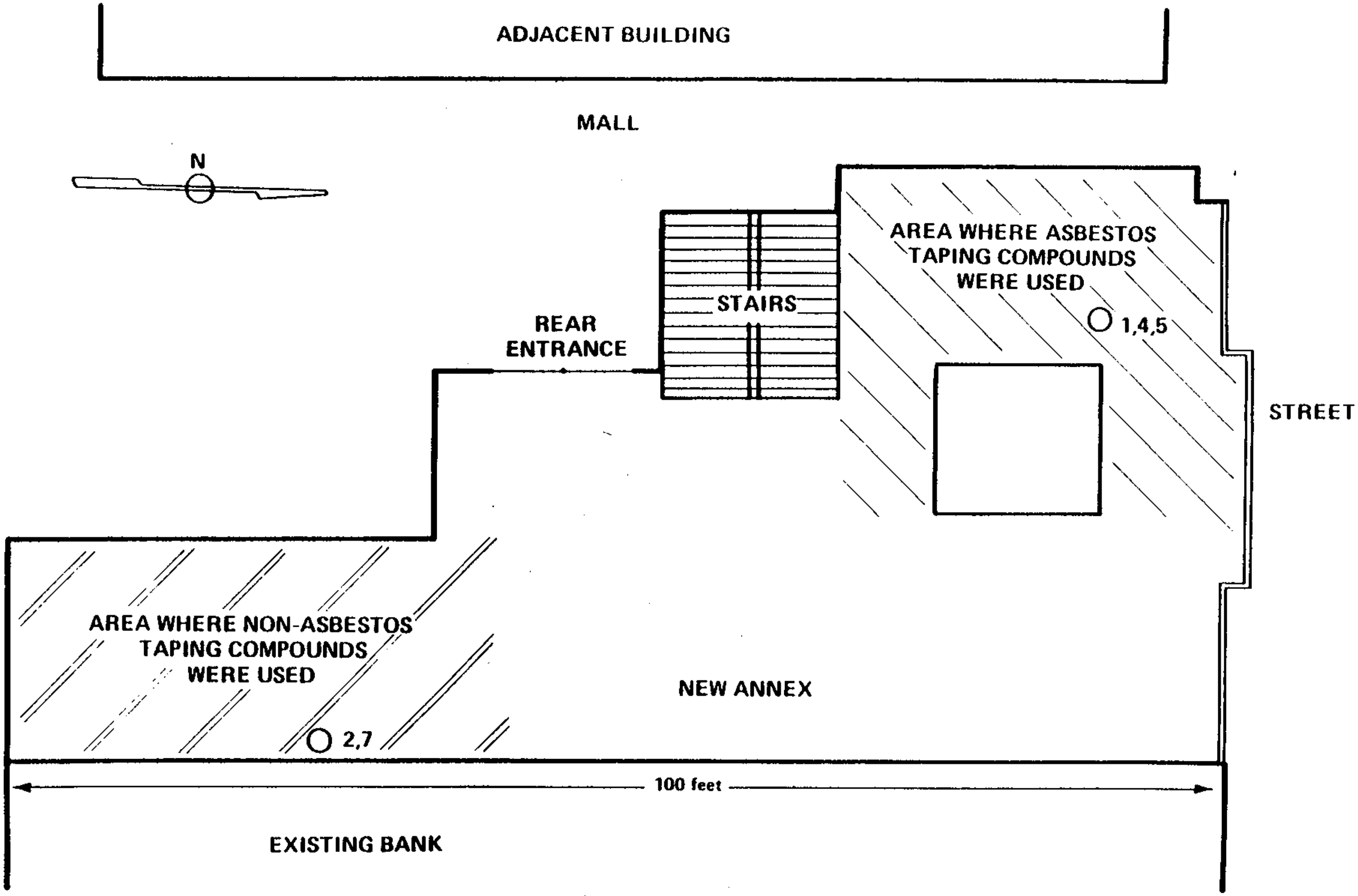

Figure 15. Diagram of working area for survey AIA-15.

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SURVEY AIA-16: VINYL ASBESTOS TILE AND FELT-BACKED SHEET FLOORING

Survey AIA-16 consisted of monitoring asbestos exposure levels during the sanding of a vinyl asbestos tile floor, tear-off of an asbestos felt-backed sheet floor, and sanding of felt-backing remaining on a floor after tear-off was performed. The tests were simulations performed at a training school for apprentice floor layers. Work was performed in a warehouse-type building 50-by-50 feet, with a 20-foot ceiling. The area was ventilated by two roof fans.

Simulation 1: Sanding Vinyl Asbestos Tile

A section of the concrete floor was covered with vinyl asbestos tiles 4 days prior to the survey. These tiles were sanded using an electric circular sander with a built-in vacuum. The sander was a small portable unit and the operator had to stoop or kneel in order to operate it. The floor area was 38 feet square. A personal sample was obtained during sanding.

Simulation 2: Tear-off of Sheet Flooring

A personal sample was obtained on a floor worker while he removed the wear surface from an asbestos-felt backed sheet floor. The type of sheet goods used had a backing that was supposed to separate and remain on the floor when the vinyl surface was removed. The condition of this floor was poor and the vinyl had numerous cuts in it such that it could not be torn up in large pieces. Tear-off was accomplished by making long cuts in the sheet to form a strip. Then the edge of the strip was lifted and the strip pulled up. In this case, a 4-by-6-foot section was removed and the backing did not separate cleanly.

Simulation 3: Sanding of Adhered Backing Material

The felt backing remaining on the 4-by-6-foot floor after tear-off was then sanded. A personal sample on the operator sanding the floor was collected.

The air sampling data are summarized as follows:

Sample No.	Description	Time (minutes)	Fibers/Cubic Centimeter >5 Micron
FL-1	Worker exposure during sanding of tile	25	0.35 [a]
FL-2	Worker exposure during tear-off of sheet material	30	0.16
FL-3	Worker exposure during sanding of sheet backing	15	84

a. Computational results not intended to imply accuracy of counting.

SURVEY AIA-17: BUILDING DEMOLITION, REMOVAL OF ASBESTOS INSULATION

A 6-man crew, including the foreman, removed asbestos insulation from an estimated 95 feet of 4-inch piping and from a horizontal boiler roughly 30 inches in diameter and 8 feet in length. The removal was from the basement of a building prior to demolition. In both work areas, air movement was generally negligible, giving undisturbed exposures. The building layout is shown in Figure 16.

The piping insulation had been well soaked by water from a heavy hose stream. The pipe was about 10 feet from floor, necessitating work from a rolling scaffold. Two men worked on the scaffold, cutting and bagging; two men were on the floor, bagging and picking up any fallen chunks of insulation; and two men, including the foreman, assisted in various duties, i.e., moving the scaffold, clearing the path of the scaffold, and taking filled bags to a central repository space in the center of floor. There was relatively little visible dust except for one section of insulation removed from a vertical length of pipe that had apparently not been well wetted. The pipe covering was of gauze and thus easily dislodged and cut. The entire pipe removal was accomplished within one hour. Five air samples were taken of the operations of pipe insulation removal: AD-1 to AD-5, with AD-1 and AD-2 representing general air and AD-3 to 5 representing workers' exposures.

The boiler room in the basement, approximately 20 by 25 feet in area and 10 feet high, contained two boilers. Boiler size was 2-1/2 inches in diameter and 8 feet long. Five men were involved in the removal of the insulation from one boiler with the sixth man, the foreman, in the

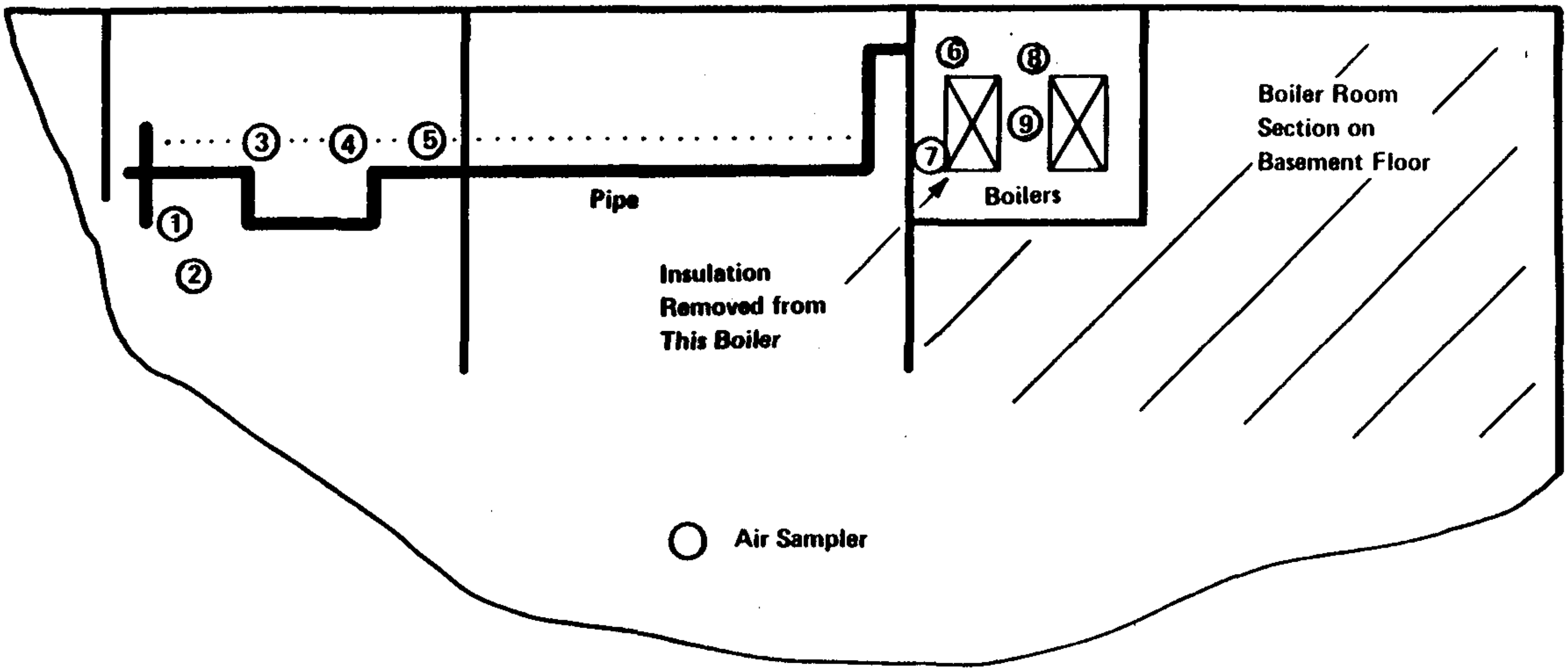

Figure 16. Diagram showing work area and sample locations for survey AIA-17.

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immediate area assisting in various duties and directing the procedures. One man was assigned to the top of the boiler in cutting the wire frame and loosening the insulation. This man had a co-worker to lift off the blocks of insulation, which were about 1-1/2 inches thick, 4 inches wide, and varying from 2 to 24 inches in length depending on breakage lengths, and bagging the chunks in plastic bags. Two men were in similar work from the floor on the right (east) side, while a fifth man assisted both groups by removing bags, providing new bags, or picking up dropped chunks. This operation appeared somewhat dusty at times, apparently because the wetting did not satisfactorily penetrate the insulation, which had an external covering of 1/4-inch cement material. Four air samples were taken: one of general air at the middle of the room on the west side of boiler, and three of workers' exposure, AD-6 to AD-9. The work was completed in about one-half hour.

The results of sample analyses for asbestos are:

Sample No.	Description	Local Time	Fibers/Cubic Centimeter <5 Micron
AD-1	General air, side of room before start of pipe insulation removal	0854.5-0918 (23.5)(a)	0.033(b)
AD-2	General air, side of room during pipe insulation removal	0939.5-1028 (48.5)	0.047
AD-3	Personal air sample on first worker; cutting pipe insulation from scaffold	0937-1019 (42)	0.096
AD-4	Personal air sample on second worker; bagging debris on scaffold	0937.25-1018 (40.75)	0.22
AD-5	Personal air sample on third worker; bagging and carting debris	0939-1022 (43)	0.09
AD-6	Personal air sample; worker cutting on top of boiler	1415-1441 (26)	4.5
AD-7	Personal air sample; second worker on top of boiler, left side	1415-1440 (25)	4.1
AD-8	Personal air sample; third worker on floor bagging debris on right side of boiler	1416-1441.5 (25.5)	5.4
AD-9	General air sample; center of boiler room between two boilers (east side of boiler being stripped)	1413-1438 (25)	1.4

a. Numbers in parentheses are sample duration in minutes.
b. Computational results not intended to imply accuracy of counting.

SURVEY AIA-18: VINYL ASBESTOS TILE AND FELT-BACKED SHEET FLOORING

Survey AIA-18 consisted of monitoring asbestos exposure levels during the sanding of a vinyl asbestos tile floor, cleanup after sanding, tear-off of sheet flooring, and removal of sheet backing using solvent rather than mechanical means. The measurements, as with survey AIA-16, were performed at a training school for apprentice floor layers. Work was performed in a room 20-by-20 feet with a 9-foot ceiling. There was no mechanical ventilation in the area.

Simulation 1: Sanding vinyl asbestos tile and cleanup. A 5-by-3-foot section of floor covered with vinyl asbestos tile was repeatedly sanded for 15 minutes. The electric sander was vacuum equipped and the operator was standing during sanding. The worker then proceeded to clean the area using a duster broom. Working on hands and knees, the worker also checked the smoothness of the floor while sweeping. Six minutes were spent on cleanup.

Simulation 2: An 8-by-8-foot area of asbestos-felt-backed sheet was removed in 14 minutes by one worker. Backing material that had adhered to the floor was removed with a 50 percent solution of isopropyl-alcohol in water using a scraper.

The results of these two simulations are:

Sample No.	Description	Time (minutes)	Fibers/Cubic Centimeter <5 Micron
FA-1	Personal sample. Worker sanding vinyl asbestos tile with electric sander, vacuum equipped	15	0.4[a]
FA-2	Personal sample. Worker clean-up of floor after sanding	6	0.7
FA-3	Personal sample during tear-off of sheet flooring	14	0.4
FA-4	Personal sample during stripping of backing material using solvent and scraper	14	0.9

a. Computational results not intended to imply accuracy of counting.