ENGINEERING FEASIBILITY
AND ECONOMIC IMPACT STUDY
OF A PROPOSED OSHA REGULATION
ON OCCUPATIONAL EXPOSURES TO AIRBORNE ASBESTOS
IN THE CONSTRUCTION INDUSTRY
PHASE I: DATA BASE DEVELOPMENT

Prepared for

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I. INTRODUCTION

A. STATEMENT OF PURPOSE

The data-base information in this report has been produced by Equitable Environmental Health, Inc. (EEH) to meet the requirements of the Asbestos Information Association/North America (AIA/NA), which would allow it to formulate a response to the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) construction industry asbestos standard. These requirements are concerned with the generation of information from which technical feasibility and economic impacts can be determined. This document is Phase 1 of a three-phase study and is primarily a compendium of available data, which will be evaluated and used in analysis during Phases 2 and 3. Phase 2 will be concerned with producing a report on the technical feasibility of engineering control strategies, and Phase 3 will be concerned with an inflationary economic impact statement.

In addressing this project, information was compiled identifying the characteristics of the asbestos manufacturing industry, the construction industry, and the relationship between these two industries. Data were obtained from three general sources: published, correspondence and telephone surveys, and construction site observations.

B. SUMMARY

Initially, a comprehensive bibliographic search was carried out to identify the sources of information germane to this project. It was determined that government publications would be the prime source of the most detailed and authoritative data. A significant percentage of the report

was derived from the U.S. Bureau of the Census quinquennial census of manufacturers and construction industries. Unfortunately, these censuses were last taken in 1972. More current publications from other government organizations were also consulted (e.g., Bureau of Mines, Bureau of Domestic Commerce, Bureau of Economic Analysis, Bureau of Labor Statistics). Using these sources, it was possible to update the 1972 data in certain cases, particularly in regard to the characteristics of the construction industry. However, in these cases, the degree of detail is considerably less than the comprehensive 1972 census. Manufacturing data for 1975 were obtained solely from the EEH survey effort as they were not available elsewhere. A number of other key data elements sought in this study were not available through published sources, and, therefore, survey questionnaires were sent to numerous organizations that might be in possession of the information required. The organizations contacted are classified into the following groups: asbestos manufacturers, manufacturing trade associations, construction trade associations, trade unions, and regulatory agencies (federal, state, and local).

Asbestos product sales figures for 1975, obtained from the in-house survey of asbestos manufacturers, amounted to approximately $400,000,000. At best, this value is a rough estimate since several manufacturers declined to participate in the survey and data from several others were withheld for reasons of confidentiality. In the survey of manufacturers, 73 were contacted and 20 provided sales data. In addition, information was given concerning alternate products, two manufacturers provided information on fiber counts, and almost all were able to identify the trade groups consuming their products.

The correspondence surveys from the other organizations provided varying responses on a number of subjects related to this effort. For example, the result of contacting construction trade unions was relatively nonproductive. Nine were contacted, and only one responded with useful information. This information concerned union member longevity in the trade.

Twenty construction trade associations were contacted; seven responded with useful information, identifying asbestos-containing products and alternate products.

Ten manufacturing trade associations were contacted, and seven responded. The information available from these sources, however, did not add materially to that obtained directly from the manufacturers.

Over 100 regulatory agencies (federal, state, and local) were contacted concerning fiber count information. Of the 50 replies obtained, only nine provided useful data. OSHA provided a considerable amount of information on fiber counts by standard industrial classification from its in-house computer files. However, the information is not in a usable form and requires follow-up for quantification of fiber counts. Data from other sources proved more valuable in terms of identifying ranges of airborne asbestos concentrations encountered in construction. These data were used as the basis for recommendations for the Phase 2 sampling program.

II. METHODOLOGY

A. 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 five 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 II-B-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 and copies of the respective questionnaires are provided in Section II-B-2.

Construction site observations were necessary to provide documentation of actual working situations involving fabrication/assembly and installation of asbestos products. The details of this segment of the program are provided in Section II-B-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.

B. SOURCES

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 Services 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. 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 beginning in September with follow-up continuing through November 15. 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 (Tables 5 through 8).

Tables 1 through 4, respectively, contain the names of the asbestos manufacturing associations, trade associations, trade unions, and public agencies that were contacted. A list of the manufacturers contacted is not included because EEH assured them that their participation in the study would be treated in confidence.

3. Construction 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; a qualitative description of the level and frequency of construction worker asbestos exposure; and identification of alternative materials.

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 as Table 9. In all, 22 sites were visited from October 27 to November 20, 1976. The data obtained during these visits are presented and discussed in Section III. Additional site visits have been scheduled, the results of which will be reported in a supplement to this report, when available.

Table 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

Table 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

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Table 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 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

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Table 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

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Table 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

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Table 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

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Table 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 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

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Table 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 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 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?

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Table 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?

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Table 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 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?

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

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.)

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Table 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 classified
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?

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Table 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

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Table 9

Site Survey Report

1. Contractor/Subcontractor _____ Date/Time _____ Surveyor _____
2. SIC Classification _____
3. 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 _____

5. 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 9 (Cont.)

Site Survey Report (Page 2)

6. Operation Observed _____ Trade Group SIC _____

7. 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		Number Peripherally Exposed and Exposure	Procedures (include all fabrication in field, i.e., mixing, cutting, sanding, etc.)
	Trade Group	Laborers/ Other		

Table 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

III. DISCUSSION OF DATA

A. RESULTS

1. Published Data

The published literature contained a thorough documentation of the types 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 Manufacturers, 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 material was retrieved from publications such as the Annual Survey of Manufacturers (U.S. Bureau of the Census 1975c), the Minerals Yearbook (U.S. Bureau of Mines 1973), and Mineral Facts and Problems (U.S. Bureau of Mines 1975).

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 1976) 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. Results gathered from EEH's in-house survey of asbestos manufacturers, associations, and unions somewhat alleviated this problem by providing information for 1975 and, in some cases, the first half of 1976.

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 the remaining 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.

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. Correspondence and Telephone Survey

a. 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 14 and was also used to develop much of the data presented in Section III-B. 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.

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.

b. 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.

c. 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 III-B.

d. 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 precise 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.

e. Regulatory Agencies

Requests for asbestos fiber counts of construction operations were made to 103 regulatory agencies. These included OSHA, NIOSH, and appropriate health and safety agencies in the 50 states, Guam, the District of Columbia, Puerto Rico, the Virgin Islands, and several counties. A total list of agencies contacted is shown in Table 4. Replies were received from 50 of these agencies with the following results.

1. Thirty-eight agencies had not made any construction site surveys that included asbestos fiber counts. This was usually because

their programs were just starting or their field staffs were small and still responding primarily to formal complaints.

2. Ten agencies were able to provide fiber counts. Of these, the most potentially useful data came from OSHA in the form of a computer printout of all asbestos fiber counts (approximately 1,000) collected by that agency between June 1972 and July 1976. Included in these data were 51 construction site fiber counts, of which approximately 90 percent were below the current state standard. However, the printout does not give detailed information on the specific operations that were surveyed. This information can only be obtained from a follow-up survey of each area OSHA office indicated. The data provided by the other nine agencies were not in any predictable format and often included manufacturing as well as construction operations. Much of it is useful, however, and is included in Table 38.
3. The two remaining agencies submitted information, but it could not be included in the tabulated results because insufficient details were provided.

3. Site Visits/Observations

A summary of the asbestos-containing materials and operations observed during site visits appears in Table 10. The number of sites at which work practices were observed, numbers of workers performing operations and peripherally exposed, and qualitative estimates of exposure are also tabulated. The table contains additional information relating to the observed operations. Typical operational procedures and practices

Table 10

Summary of Site Visit Observations

Asbestos-Containing Material	No. of Sites	Operations	Men Performing Operation	Exposure	Men Peripherally Exposed	Exposure	Comments
Shingles	3	Cutting, punching	1	Low	None	Low	~ to 25% of shingles are cut and/or punched
		Installation	1	Low	None	Low	800 to 900 sq. ft./day, 8-hr day
Asbestos-cement pipe	6	Sawing	1	High	Unknown		15 to 90 minutes/pipe depending on diameter, sporadic operation
		Filing	1	Low	7	Low	Time unknown, sporadic operation.
		Installation	3	Low	5	Low	200 to 700 linear feet/ day, 8-hr day
Asbestos-cement sheet	3	Sawing	2	Low to high	Variable, 2 to 5 plus workers and motorists	Low to medium	34 cuts (17 panels) of 24-inch width/6-hr day
		Installation	2 to 5	Low	Unknown	Low	1,000 to 1,500 sq. ft./ day, 8-hr day
Roofing felt; asphalt-cement	6	Rolling; cutting	5 to 7	Low	Variable, 2 to 8	Low	5,000 to 7,000 sq. ft./ day
		Tear-off	6	Medium	Unknown	Low to medium	1,000 sq. ft./day
Pipeline felt	1	Wrapping; cutting	4	Low	26	Low	100-150 ft./min for short periods, material covers 140-150 ft., then must be changed, 9-hr/day
Drywall taping compound	1	Application of tape	1	Low	5	Low	500 linear ft./4 hrs
		Finishing	4	Low	2	Low	1,000 linear ft./4 hrs each coat, each worker
		Sanding	1	Medium to high	Unknown		No asbestos-compound sanding was observed
Friable asbestos insulation	1	Removal prior to demolition	2	Low to high	2	Low to high	~200 sq. ft./day, 8-hr day
Drilling fluids	1	Addition of fibers	1	High	0	Low	500 pounds/day

and alternative materials were dealt with during the site visits; however, this information has been incorporated in Section III-B.

In general, the exposures resulting from the observed routine installation and application of asbestos-containing materials are considered to be low. Some of the operations required for use of these materials did produce visible dust, which, depending on conditions, was considered to result in moderate to high exposures. Similarly, the removal of certain materials, specifically, tear-off of built-up roofing and friable asbestos (demolition), is considered a potential source of moderate to high exposure, respectively.

The significance of those operations and activities considered to result in moderate to high exposures is directly related to the peak fiber concentration, the duration and frequency of repetition of the operations producing elevated concentrations, and the ambient concentrations during the balance of the workday. Additional factors warranting consideration are the portion of the year workers are involved in activities producing airborne asbestos, and work practices, control techniques, and the use of respiratory protection to reduce exposures. Further discussion of expected worker exposures is found in Section III-B. Quantitative fiber count data obtained from the published literature, government agencies, and other sources are presented in Section III-B and, in conjunction with site observations, provide a more definitive data base. In addition, evaluation of this data base provides objectives for Phase 2 of this program in terms of product/operational modes for which sampling and fiber count should be obtained.

B. SUBTASKS

1. Manufacturing of Construction/Asbestos Products

In identifying types of manufactured products that contain asbestos (Table 11), this study relied upon the 1972 Census of Manufacturers (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 11 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 (i.e., SIC group 2891 is listed in Table 11 because some adhesives and sealants contain asbestos fibers).

Table 12 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 produce will be found.

Table 13 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,

Table 11

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.

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Table 12

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)

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Table 13

Employment and Production for 1972 in the Manufacture of Asbestos Products

SIC	Product	*No. Establishments	*Total No. Employees	Production 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. Census of Manufactures, 1972. Industry Series. Abrasive asbestos and miscellaneous non-metallic mineral products.

* = Primary product class of establishment.

-- = Does not apply.

x = Not available.

Table 13 (Cont.)

SIC	Product	*No. Establishments	*Total No. Employees	*No. Production 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.

the quantity produced, and the dollar value of that production are presented. All information in this table is taken from the 1972 Census of Manufacturers (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, 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 textiles 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 Census of Manufacturers (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 14.

Table 14

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	x
Asbestos-cement shingles	3	452	11.00	518,000 squares
Asbestos compounds	6	530	49.92	x
Asbestos felts	4	4,054	159.01	x
Vinyl asbestos floor tile	2	w	w	w
Other asbestos construction products (includes insulation, paper, textiles, gaskets, etc.)	7	902	11.48	9,523,000 lbs.
Total	20(a)	9,063	420.27	x

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

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 15 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 is tabulated in Table 16 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 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

Table 15

Distribution of Asbestos Products by Consuming Industry

Product	Consuming Industry[a]						Total	Percent of Total
	Construction		Transportation		Appliance and Equipment			
	10^3 short tons	%	10^3 short tons	%	10^3 short tons	%		
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.

Table 16

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. Mineral Facts and Problems. Asbestos.
a. Personal communication from Robert A. Clifton, Bureau of Mines.

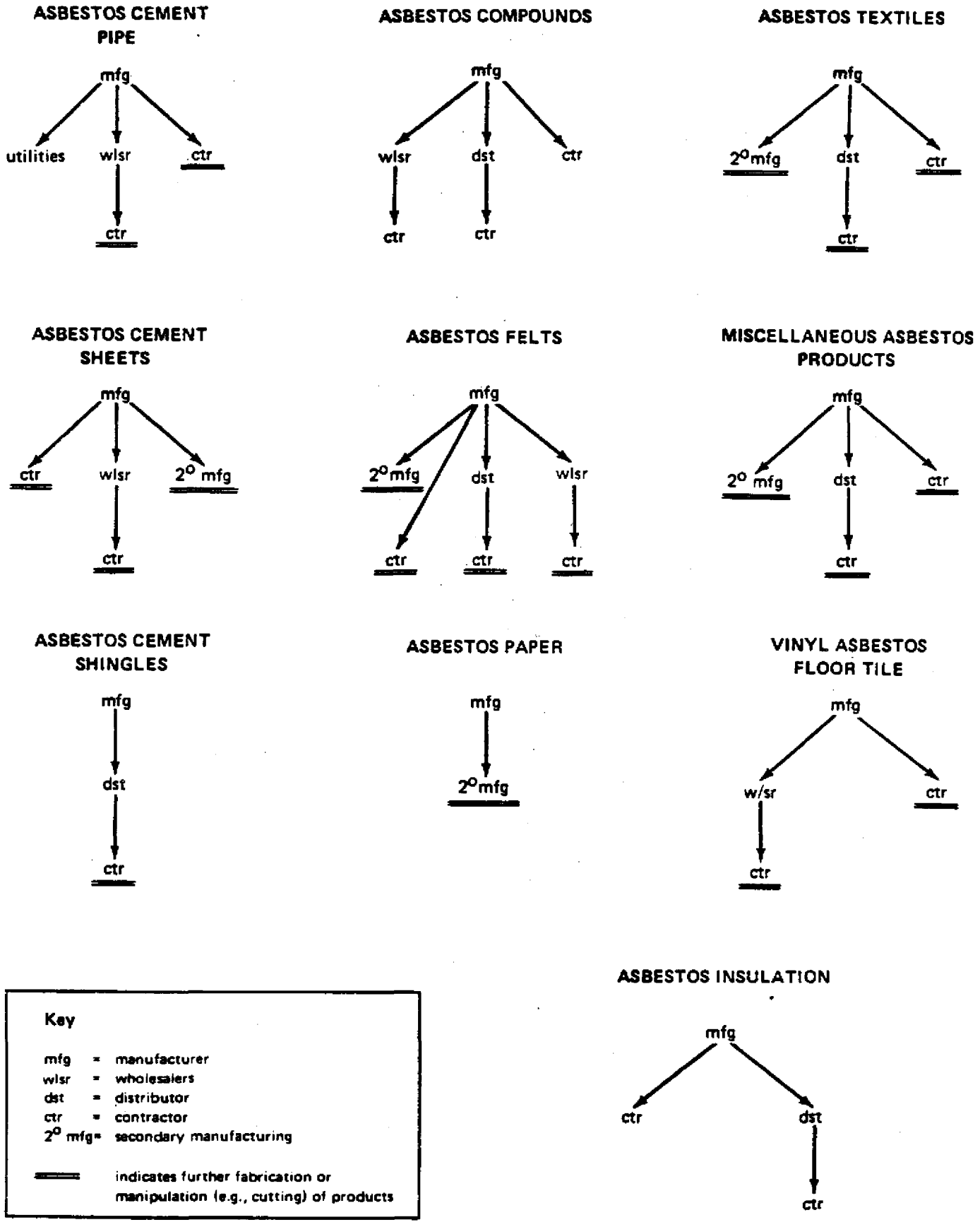

Figure 1. Flow of asbestos products into the construction industry (EEH 1976b).

once a product leaves the manufacturer, further fabrication or manipulation of the asbestos product does not take place until it reaches the construction site.

2. Construction Industry Characteristics

Trade groups that utilize asbestos products in the construction industry were first identified according to their SIC code (SIC Manual 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 its survey of trade unions (1976d), which are presented in Table 17. One group (SIC 1633) exposed to an asbestos product during the construction of bridges was identified by a manufacturers' product in a response received too late to allow incorporating the data into the study. However, low production figures indicate that utilization of the product by the trade group is inconsequential.

Construction workers account for approximately four-fifths of construction employment (the remaining fifth are office and supervisory personnel) with 50 percent of the workers employed by special trade contractors (U.S. Bureau of Labor Statistics 1970). The average number of all employees and construction workers in each SIC group has been tabulated (Table 17) from the 1972 Census of Construction Industries (U.S. Bureau of the Census 1975n). The number of employees and workers for 1975 are reported by month in Construction Review (U.S. Bureau of Domestic Commerce 1976), based on benchmark figures first published in September 1975. The revision figures from Construction Review for 1972 have been listed for comparison

Table 17

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

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 orkers (average)	Number of Employees, 1975[b] All Employees (average)	Number of Employees, 1975[b] Construction Workers (average)
162	Heavy construction, except highway and street construction	549,239	465,014	398,400	329,000	396,000	319,500
1623	Water, sewer, pipe line, communication and power line construction	209,318	184,199	--	--	--	--
17	All special trade constractors	2,106,599	1,817,126	1,895,700	1,559,000	1,716,800	1,362,600
1711	Plumbing, heating (except electric), and air conditioning	456,100	371,113	467,200	368,400	413,800	314,300
1721	Painting, paper hanging, and decorating	136,575	125,807	134,600	116,200	123,000	105,000
1731	Electrical work	323,748	271,441	324,700	259,300	315,900	247,100
174	Masonry, stonework, tile setting, and plastering	366,818	334,820	245,900	220,600	189,100	163,600
1742	Plastering, drywall, acoustical, and insulation work	170,364	151,825	--	--	--	--
175	Carpentering and flooring	168,172	151,866	--	--	--	--
1751	Carpentering	123,910	115,464	--	--	--	--
1752	Floor laying and other floorwork, not elsewhere classifled	44,262	36,402	--	--	--	--
1761	Roofing and sheet metal work	158,051	134,189	121,000	99,000	119,900	96,500
1771	Concrete work	147,942	135,041	--	--	--	--
1799	Special trade contractors, not elsewhere classified	101,294	82,899	--	--	--	--

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.

to the 1975 data. Employment data for all special trade contractors are not given except in the 1972 Census of Construction Industries.

Seasonal variation is a commonly noted characteristic 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 unemployment 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 17 is illustrated in Figures 2 through 8 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 code classifications.

Figure 2 includes highway and street construction workers (SIC code 1611); bridge, tunnel, and elevated highway construction workers (SIC code 1622); and heavy construction workers not elsewhere classified (SIC code 1629) in the averages for employment for water, sewer, and utility line construction workers. Water, sewer, and utility line construction workers account for 50 percent of the data, with heavy construction workers not elsewhere classified accounting for 43 percent (U.S. Bureau of the Census 1975d).

Figure 3 gives the monthly variation for all special trade contractors, which is the only indicator of seasonal employment for the 1970 to 1976 period for construction workers in carpentry, floor work, and concrete work.

Plastering, drywall, acoustical, and insulation workers represented in Figure 7 account for only 33 percent of the data presented, with stone-

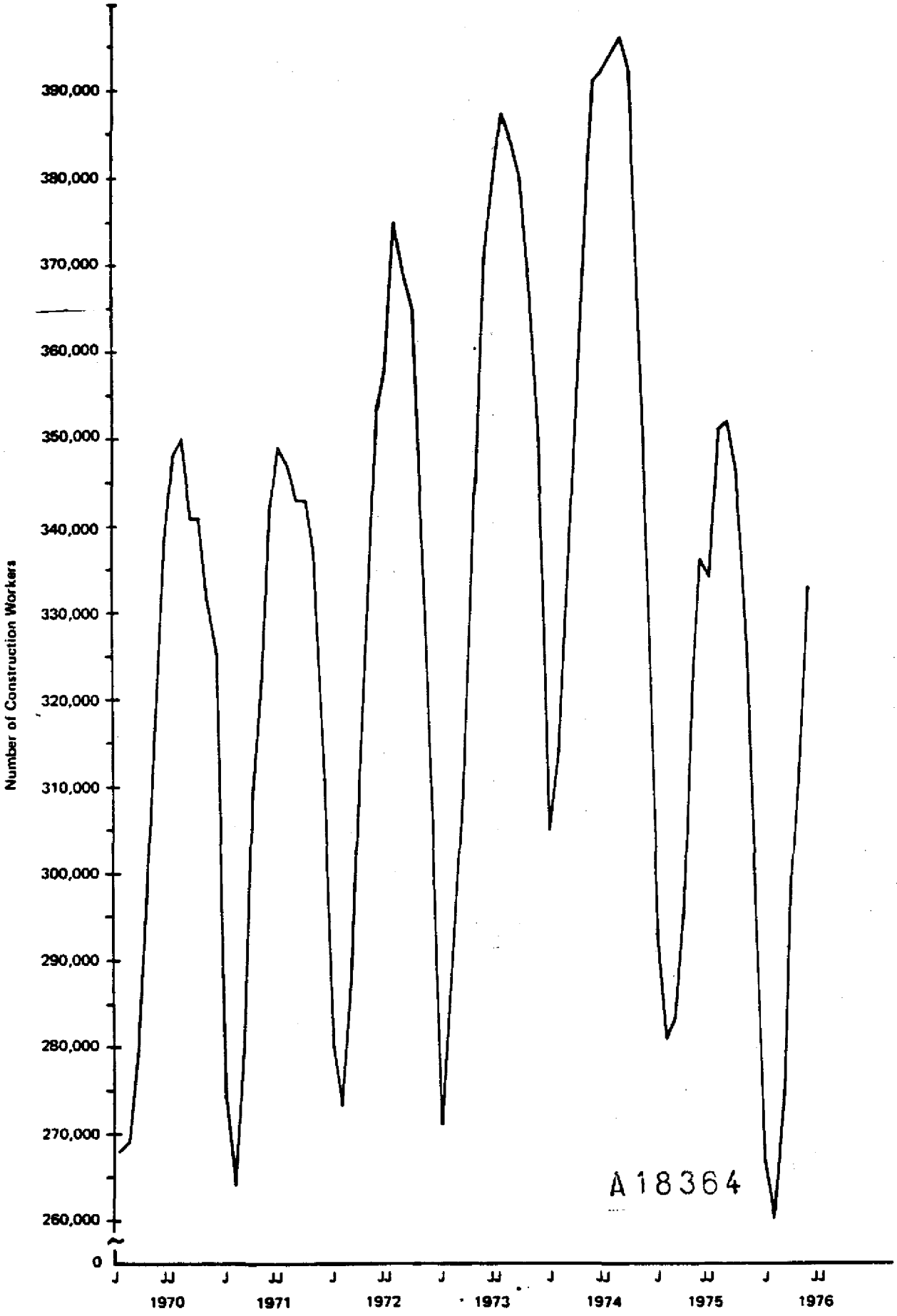

Figure 2. Number of construction workers in the United States by water, sewer, utility line, and other heavy construction contractors (SIC code 161) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

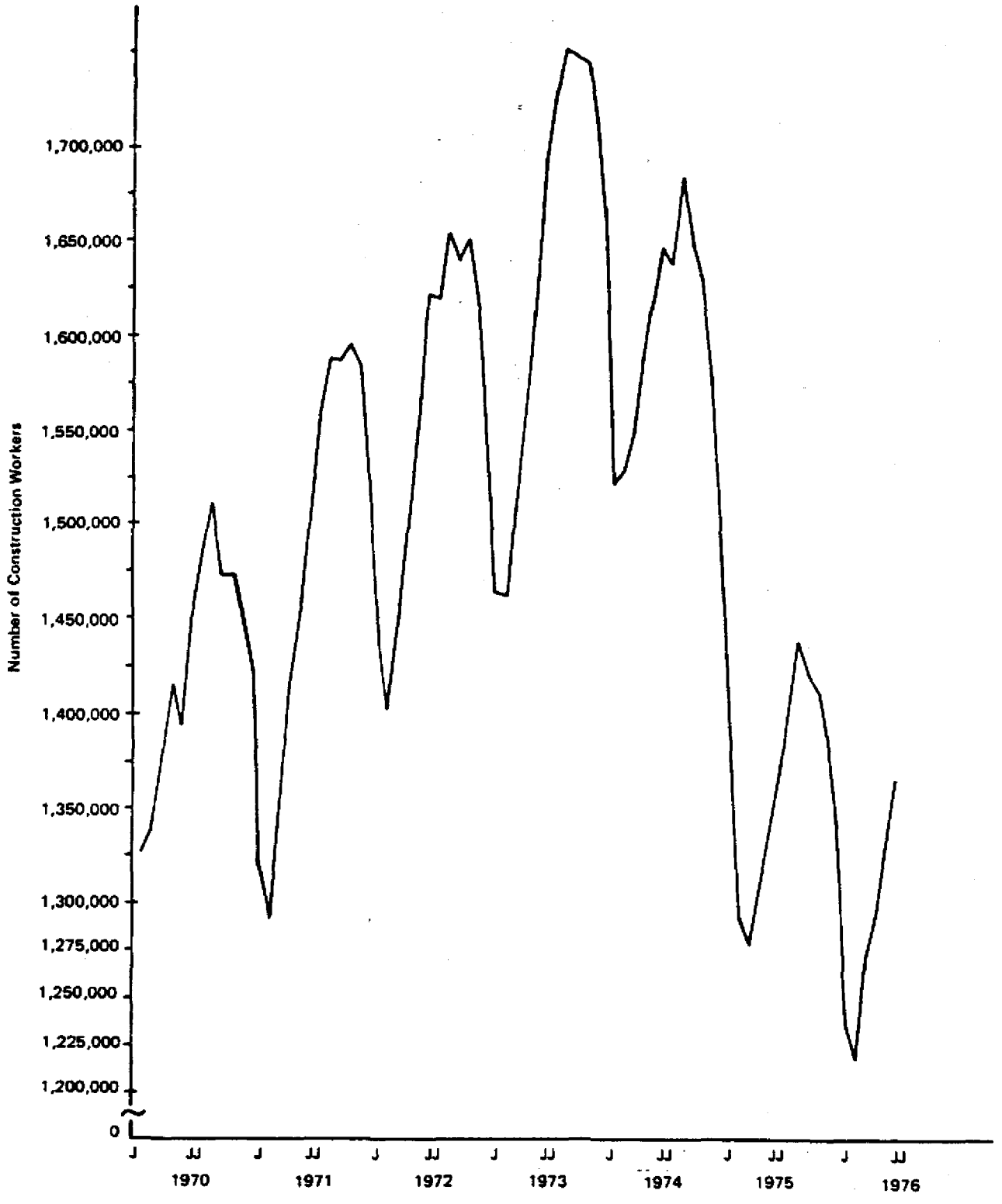

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Figure 3. Number of construction workers employed in the United States by all special trade contractors (SIC code 17) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

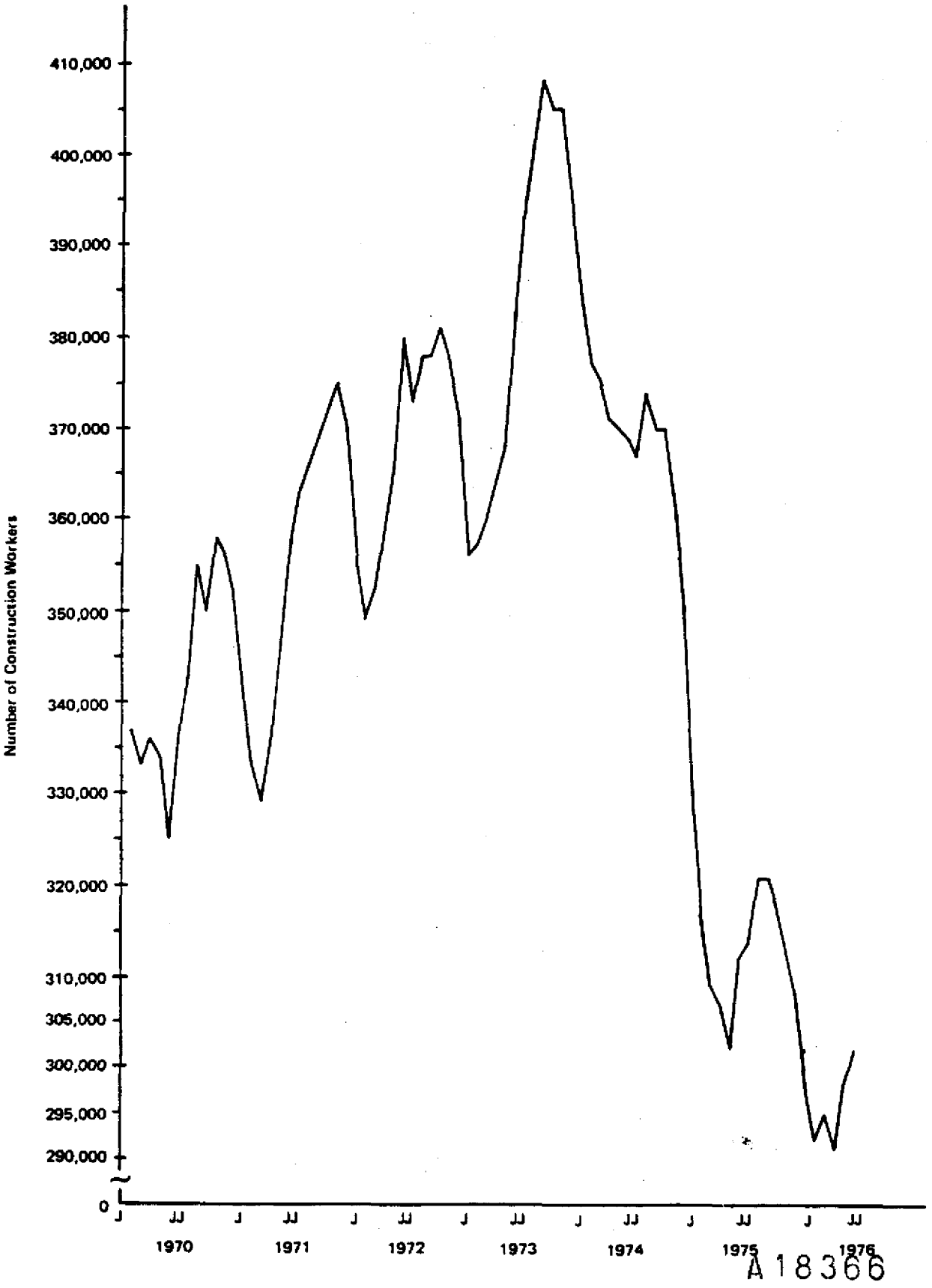

Figure 4. Number of construction workers in the United States by plumbing, heating, and air conditioning contractors (SIC code 171) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

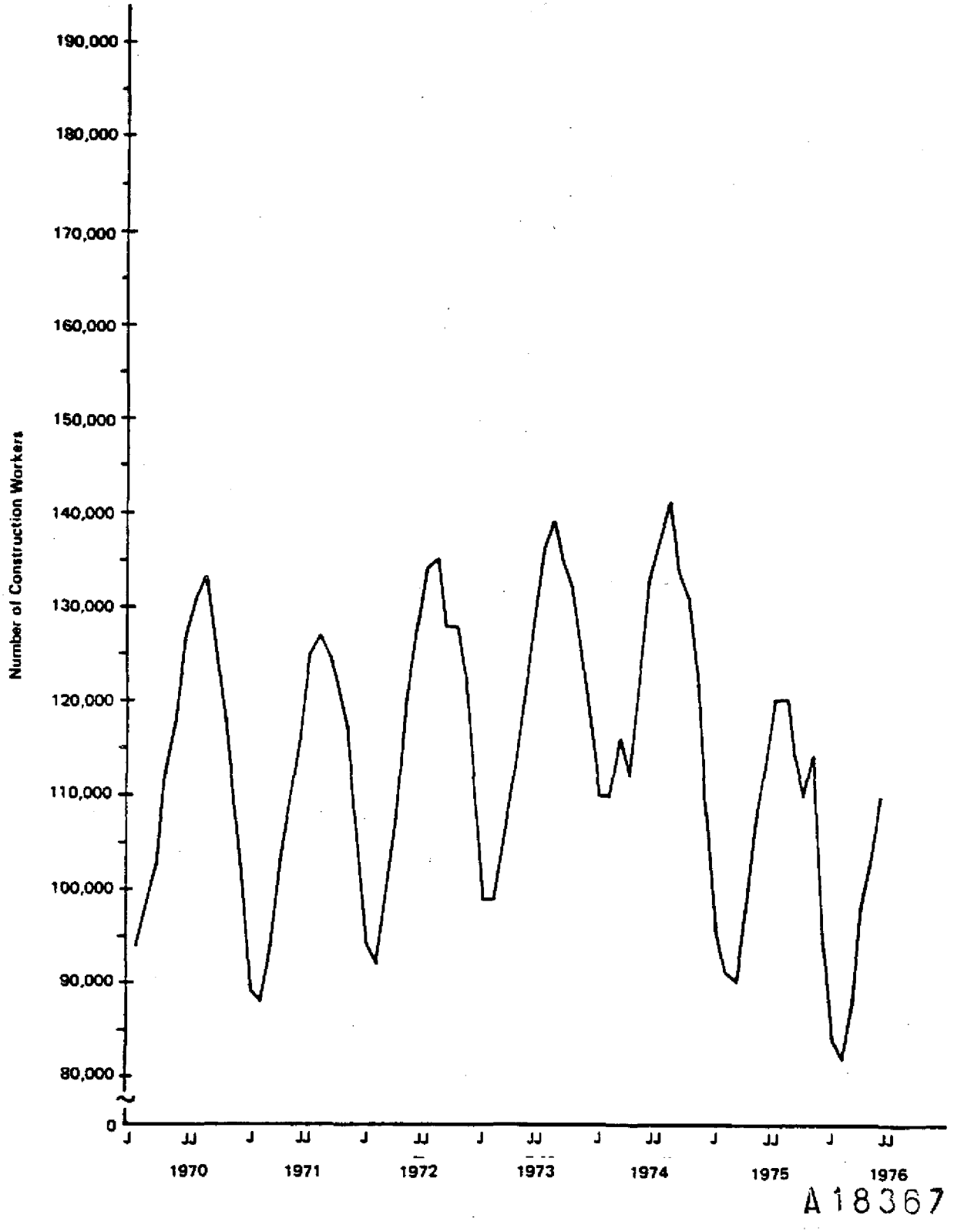

Figure 5. Number of construction workers employed in the United States by painting, *paperhanging, and decorating contractors* (SIC *code* 172) by *month*, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

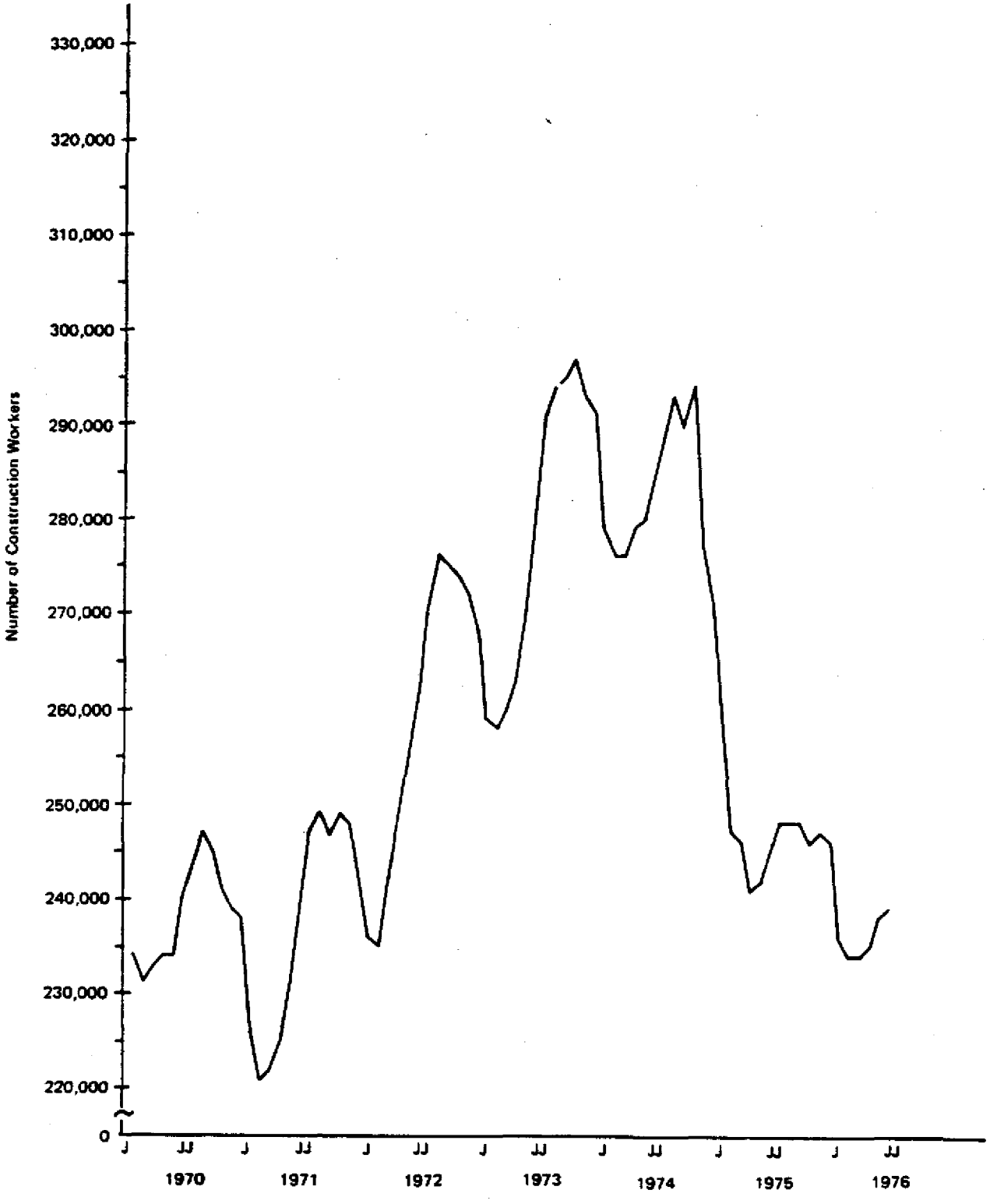

Figure 6. Number of construction workers employed in the United States by electrical work contractors (SIC code 173) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

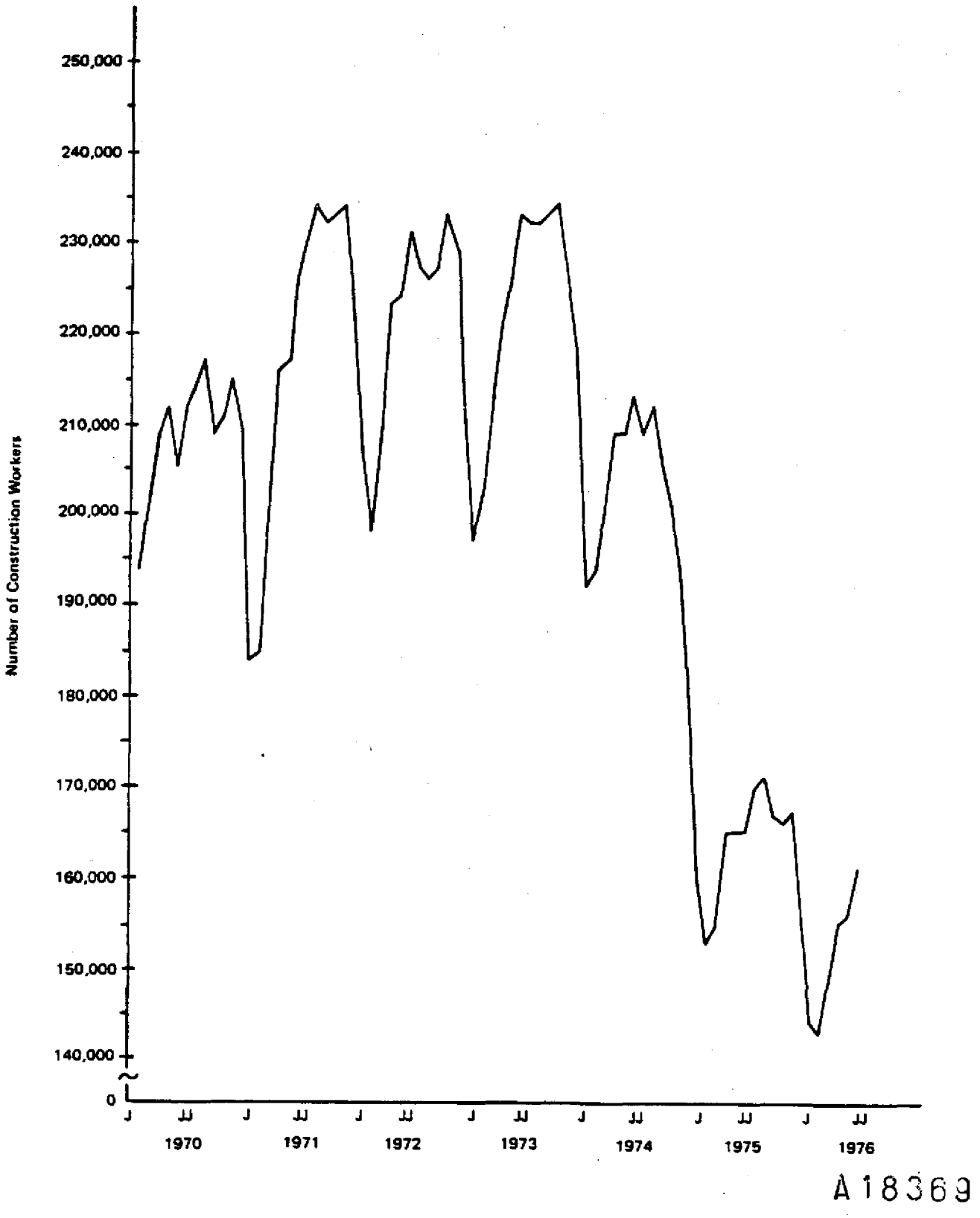

Figure 7. Number of construction workers employed in the United States by masonry, plastering, stone, and tile work contractors (SIC code 174) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

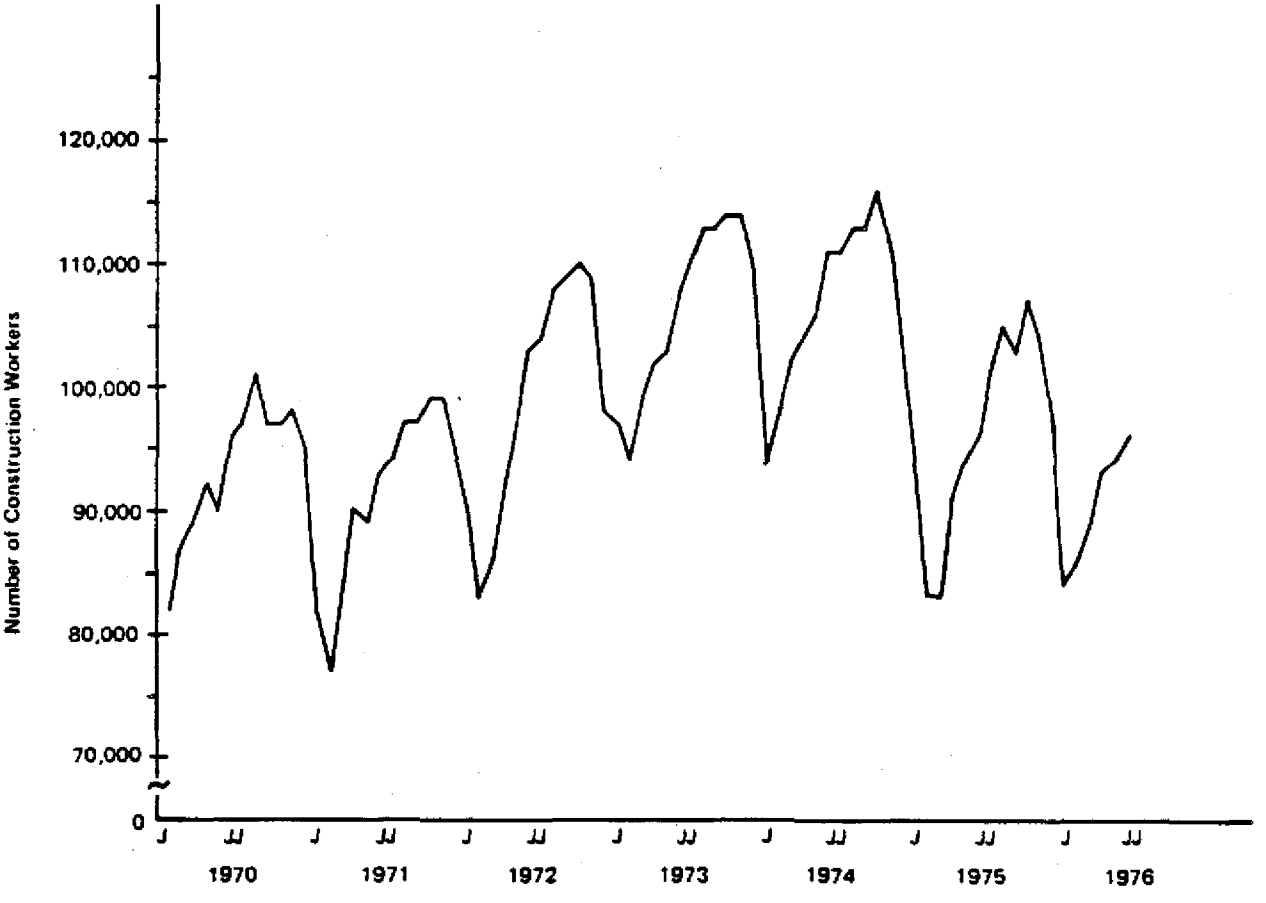

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Figure 8. Number of construction workers employed in the United States by roofing and sheet metal work contractors (SIC code 176) by month, 1970-1976 (U.S. Bureau of Domestic Commerce 1976a,b).

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 4 for plumbing, heating, and air conditioning; Figure 5 for painting, paperhanging, and decorating; Figure 6 for electrical workers; and Figure 8 for roofing and sheet metal workers--are not affected by the aggregation to a three-digit classification.

Although less current, the seasonal variations derived from the 1972 Census of Construction Industries have been included because they give seasonal variations for March, May, August, and November for each trade group listed in Table 17. These monthly variations are presented in Figures 9 through 18.

Characterization of the construction industry by the type of construction is presented in three tables. Table 18 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 19; 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 17 is indicated in Table 20, which was extracted from tables in the 1972 Census of Construction Industry, Industry Series (1975d-m).

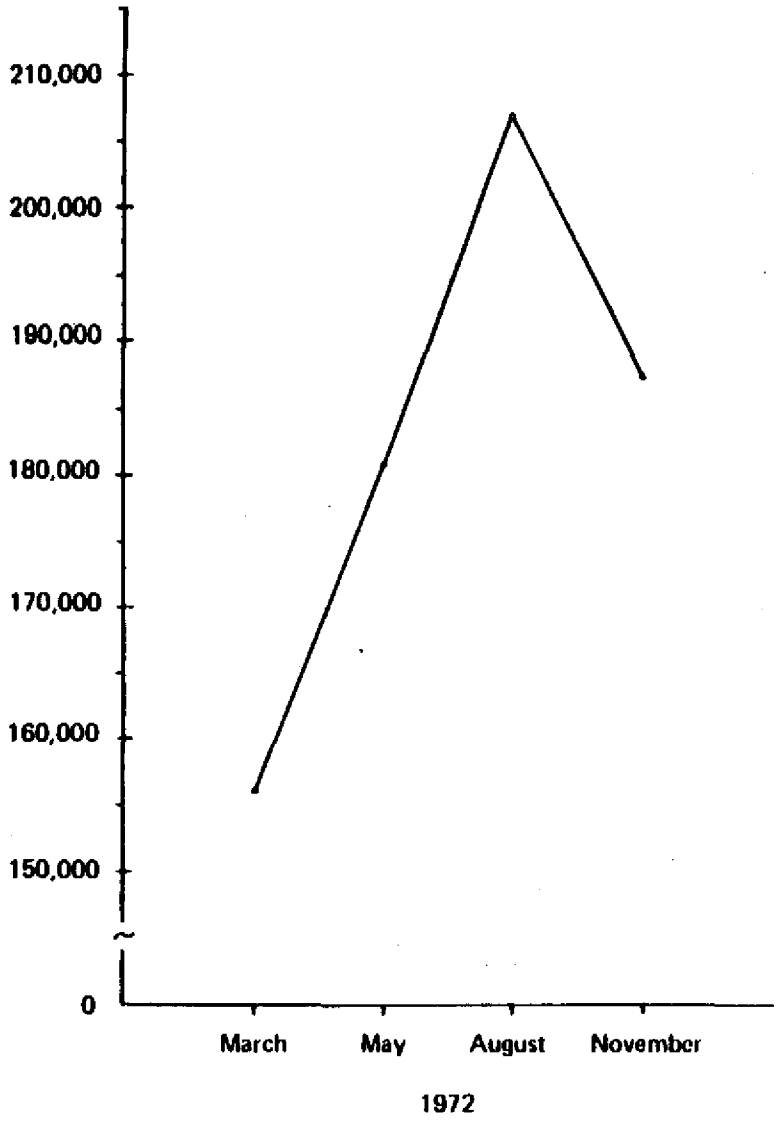

Figure 9. Number of construction workers employed by water, sewer, and utility line contractors (SIC code 1623) by selected months, 1972 (U.S. Bureau of the Census 1976d).

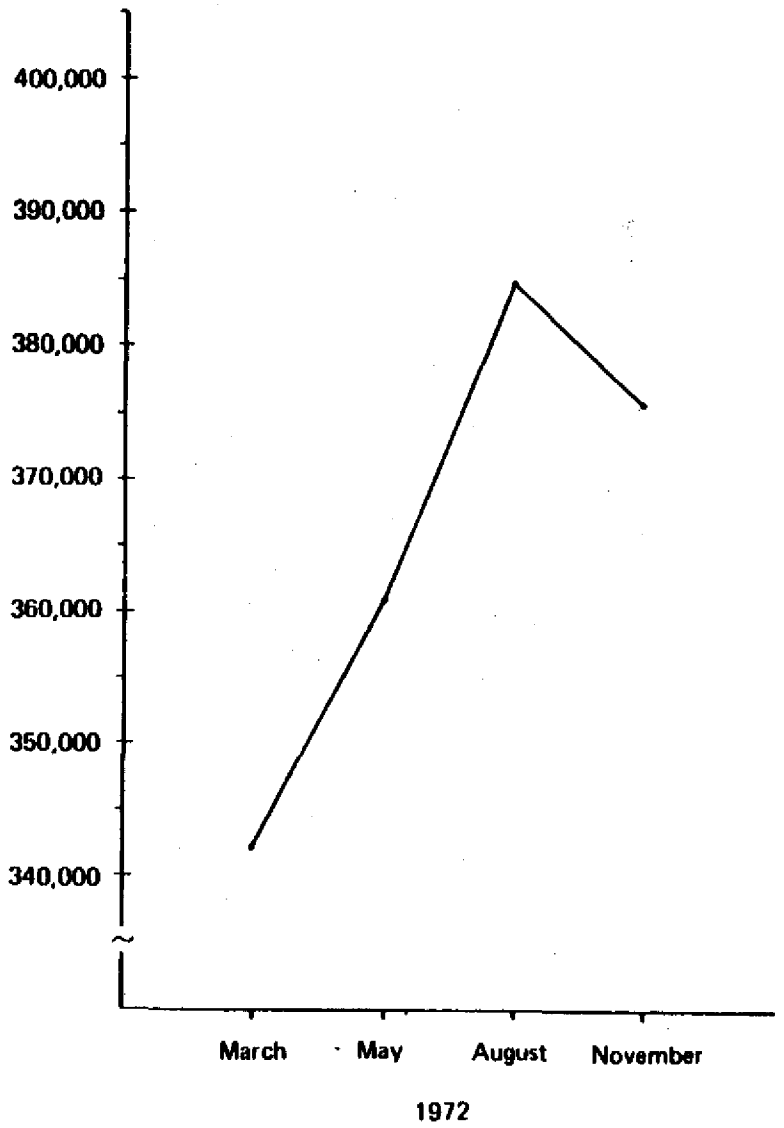

Figure 10. Number of construction workers employed by plumbing, heating, and air conditioning contractors (SIC code 1711) by selected months, 1972 (U.S. Bureau of the Census 1976e).

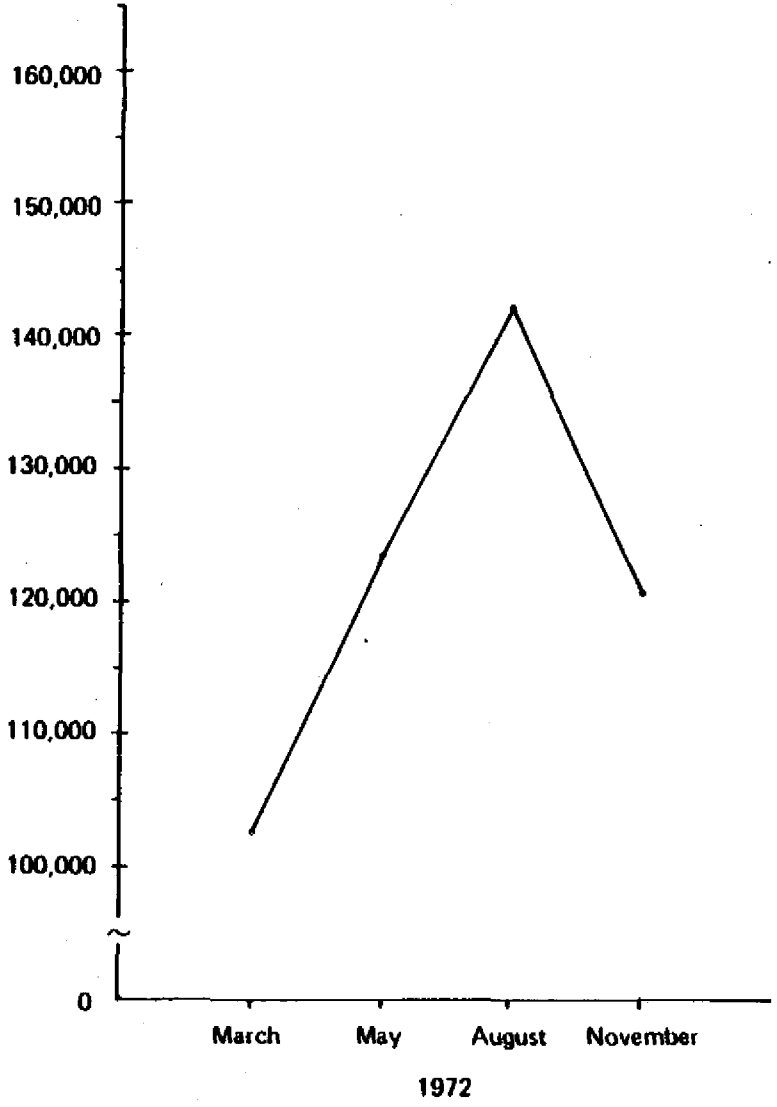

Figure 11. Number of construction workers employed by painting, paperhanging, and decorating contractors (SIC code 1721) by selected months, 1972 (U.S. Bureau of the Census 1976f).

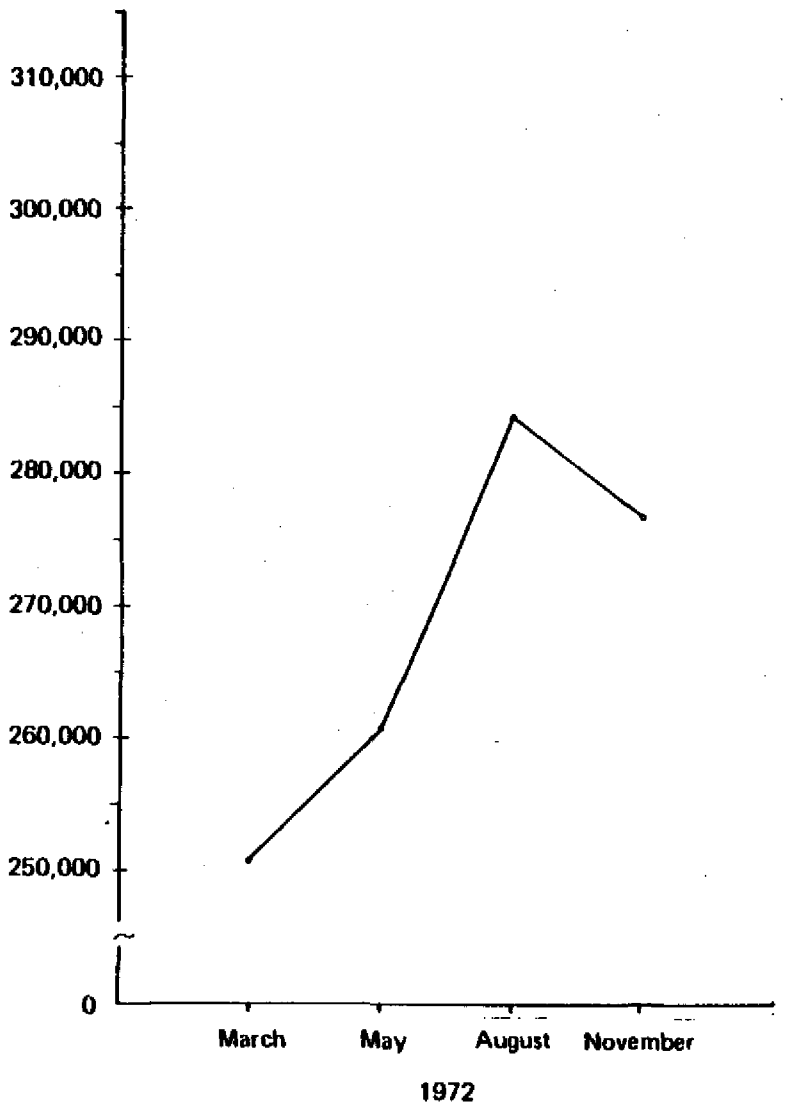

Figure 12. Number of construction workers employed by electrical work contractors (SIC code 1731) by selected months, 1972 (U.S. Bureau of the Census 1976g).

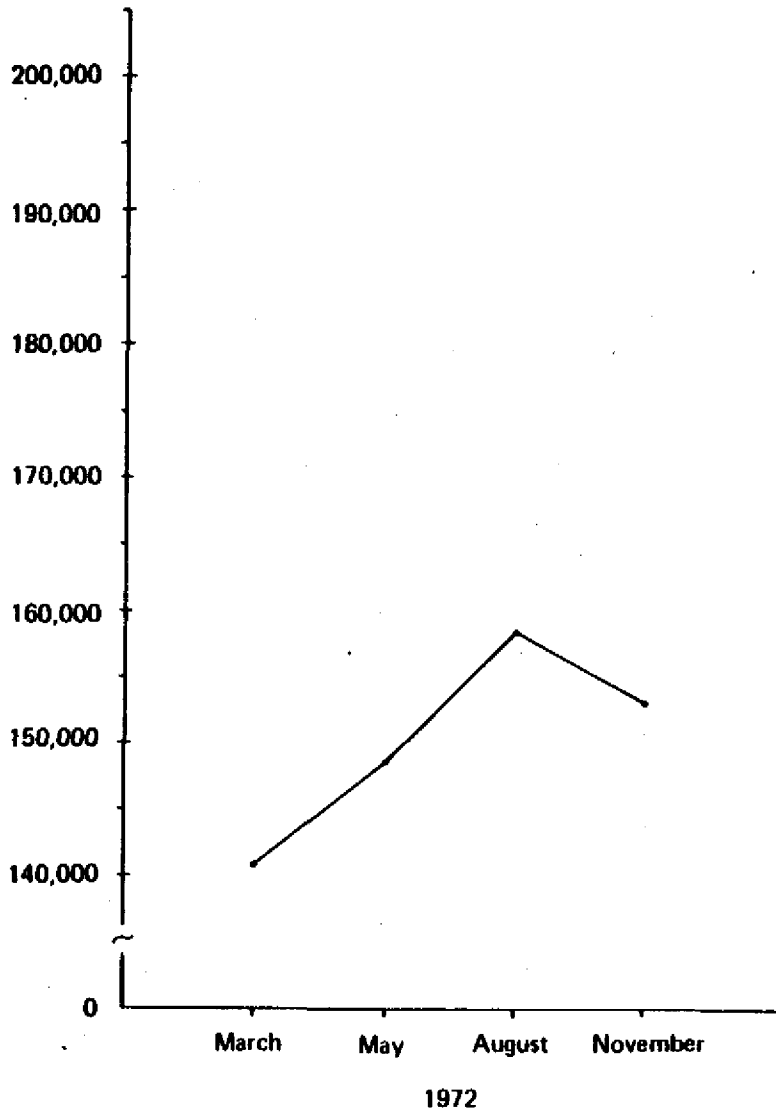

Figure 13. Number of construction workers employed by plastering, drywall, acoustical, and insulation work contractors (SIC code 1742) by selected months, 1972 (U.S. Bureau of the Census 1976h).

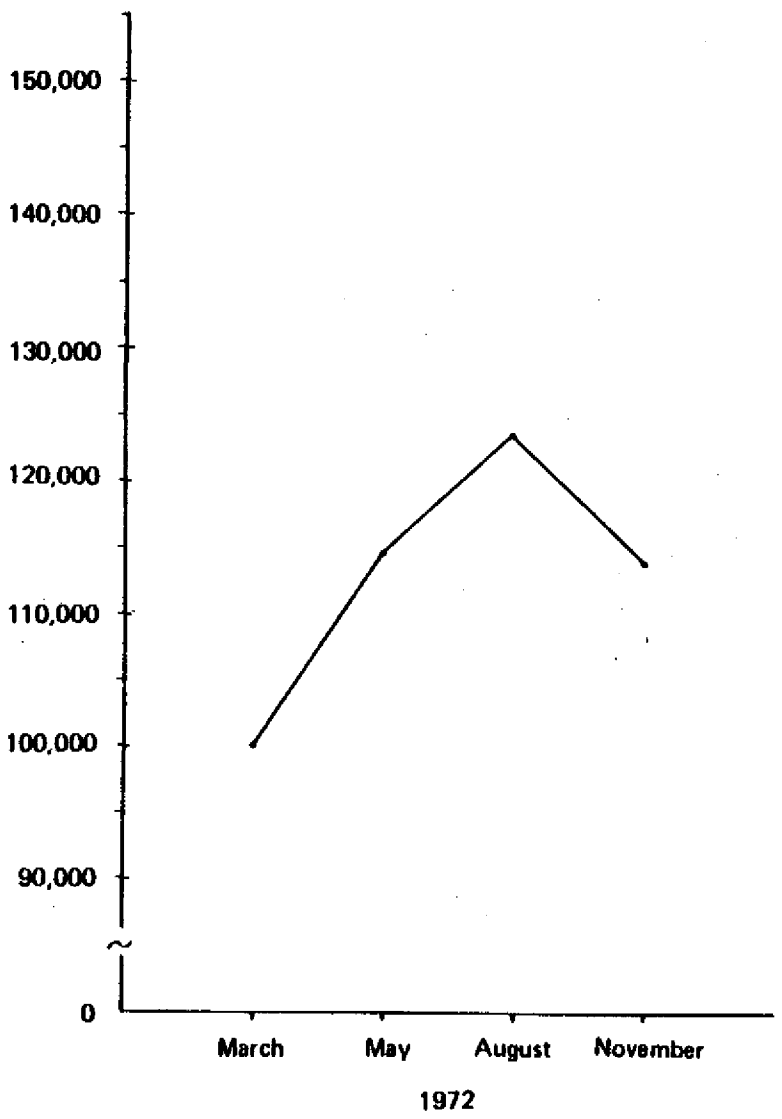

Figure 14. Number of construction workers employed by carpentering contractors (SIC code 1751) by selected months, 1972 (U.S. Bureau of the Census 1976i).

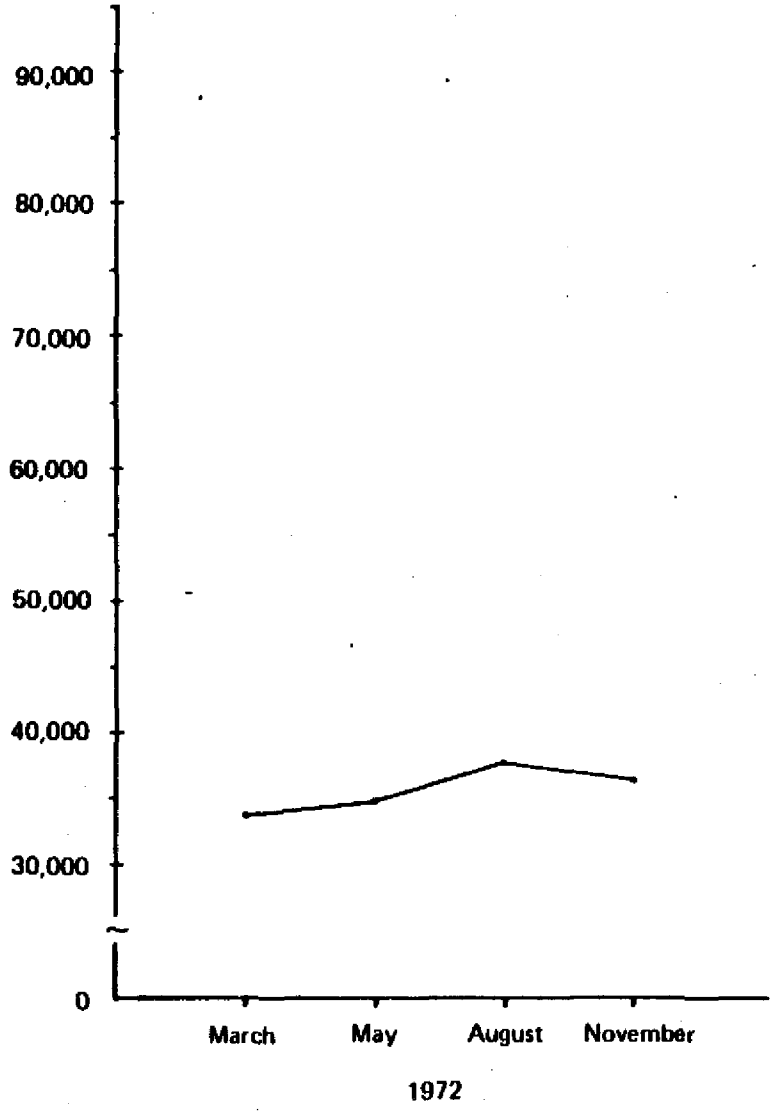

Figure 15. Number of construction workers employed by floor laying and other floor work contractors, not elsewhere classified (SIC code 1752) by selected months (U.S. Bureau of the Census 1976j).

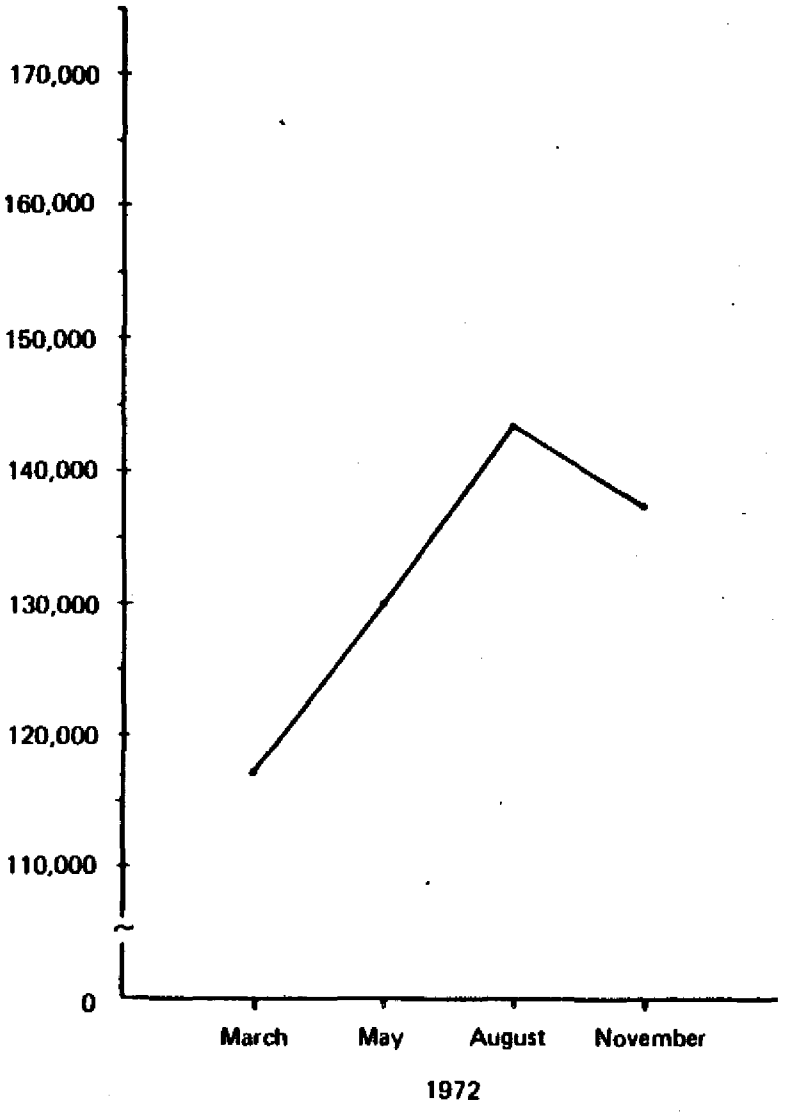

Figure 16. Number of construction workers employed by roofing and sheet metal work contractors (SIC code 1761) by selected months (U.S. Bureau of the Census 1976l).

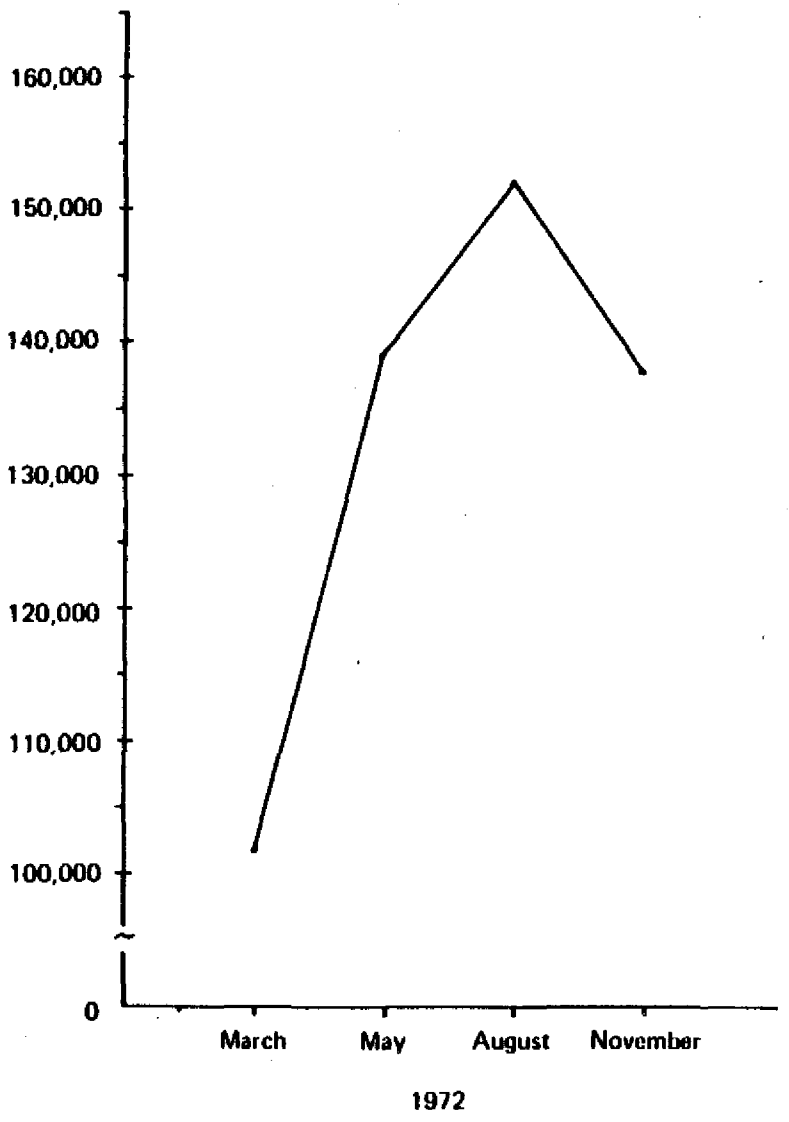

Figure 17. Number of construction workers employed by concrete work contractors (SIC code 1771) by selected months, 1972 (U.S. Bureau of the Census 1975k).

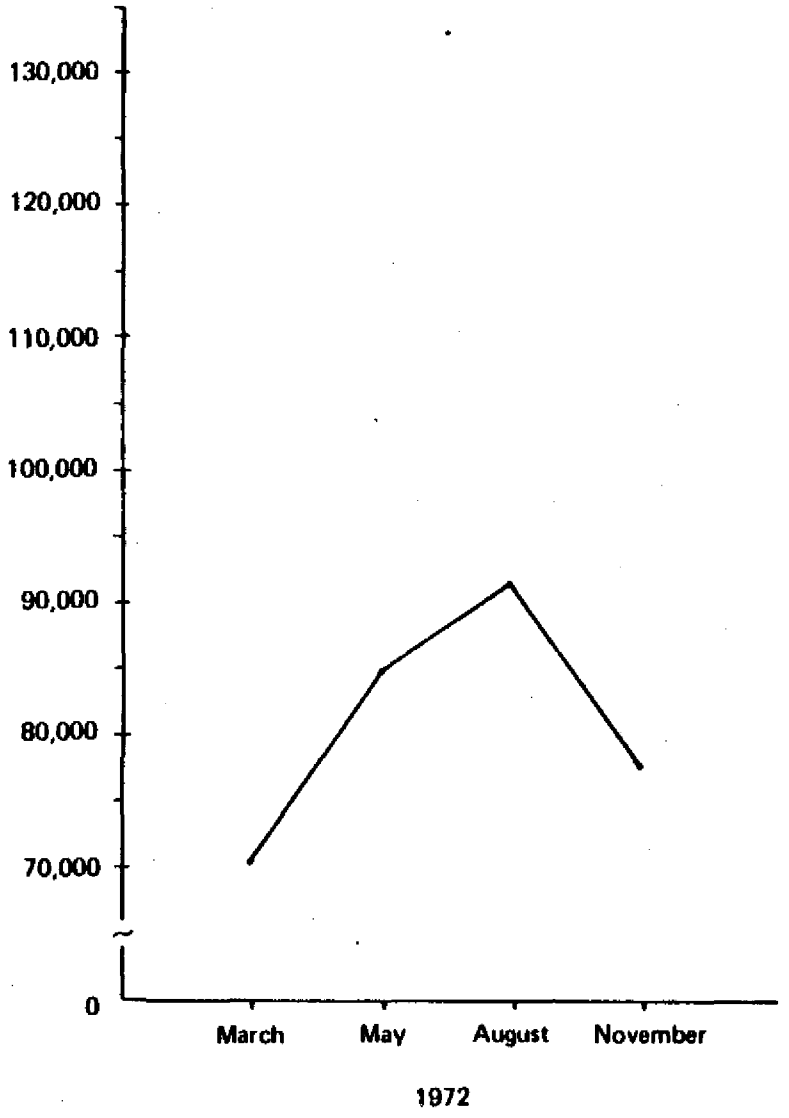

Figure 18. Number of construction workers employed by special trade contractors, not elsewhere classified (SIC code 1779) by selected months, 1972 (U.S. Bureau of the Census 1976m).

Table 18

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

Year	Total	Private Construction									
		Total	Residential			Nonresidential				Public Utilities	Other Private Construction
			Total	New Housing	Other	Total	Industrial	Commercial	Other		
1972	124,085	93,901	54,288	44,879	9,409	24,038	4,676	13,464	5,898	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	7,348	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. 1976. Statistical Series. Construction put in place. Construction Review 22(3).

NA = Not available.

Table 18 (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

Table 19

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. 1976. Housing Starts. Construction Reports June. Table 1.
NA = Not available.

Table 20

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 Site	Total
1623	Water, sewer, pipe line, communication and power line construction	3.0		95.4	1.6	100.0
1711	Plumbing, heating (except electric), and air conditioning	36.9	51.4	4.6	7.1	100.0
1721	Painting, paper hanging, and decorating	43.0	37.4	6.2	12.4	100.0
1731	Electrical work	24.2	59.4	12.7	3.7	100.0
1742	Plastering, drywall, acoustical, and insulation work	45.8	47.5	3.9	2.8	100.0
1751	Carpentering	76.4	15.6	1.0	7.0	100.0
1752	Floor laying and other floorwork	54.0	29.4	0.4	16.2	100.0
1761	Roofing and sheet metal work	34.7	56.3	1.4	7.6	100.0
1771	Concrete work	37.4	26.0	28.9	7.7	100.0
1799	Special trade contractors, not elsewhere classified	19.5	30.9	38.1	11.5	100.0

Establishments of each SIC trade group are further categorized by the size of contractors in Tables 21 through 30. The various contractors are categorized by employee size and total construction receipts for the following characteristics: average number of all employees, total construction receipts, payments for materials components, and supplies.

3. Construction Industry's Consumption of Asbestos Products

a. Trade Groups That Use Asbestos Products

Table 31, the correlation of asbestos product utilization by trade groups (Standard Industrial Classification), was derived from information 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.

b. 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

Table 21

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 Contractors
Total No. Contractors	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	497,924	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

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

Table 21 (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 Contractors
Total No. Contractors	385	625	1,155	1,398	1,893	1,354	1,106	962	291	186	9,
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 22

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 Contractors
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 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 Contractors
Total No. Contractors	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

Table 23

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 Contracts
Total No. Contractors	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 23 (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 Contracts
Total No. Contractors	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	309,288	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 24

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 Contracts
Total No. Contractors	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 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 Contractors
Total No. Contractors	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	79,689	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 25

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 Contractors
Total No. Contractors	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 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 Contractors
Total No. Contractors	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 26

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 Contractors
Total No. Contractors	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. 19751. Census of Construction Industries, 1972. Industry Series (SIC 1751), May 1975.

Table 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 Contractors
Total No. Contractors	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

Table 27

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 Contractors
Total No. Contractors	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 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 Contractors
Total No. Contractors	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 28

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 Contractor
Total No. Contractors	10,968	3,345	2,328	1,452	342	91	7	2	--	18,535
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. 1975). Census of Construction Industries, 1972. Industry Series (SIC 1761), April 1975.
b. Data combined to avoid disclosing figures of individual contractors.

Table 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 Contractors
Total No. Contractors	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 29

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 Contractors
Total No. Contractors	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 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 Contractors
Total No. Contractors	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 30

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 Contrac
Total No. Contractors	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 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 Contractors
Total No. Contractors	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 31

Trade Groups Utilizing Asbestos Products

SIC	Trade Group	Asbestos cement pipe	Asbestos cement sheets	Asbestos cement shingles	Asbestos compounds	Asbestos felts	Asbestos insulation	Asbestos textiles	Vinyl asbestos floor tile	Miscellaneous
1623	Water, sewer, pipe line communication and power line construction	x					x			x
1711	Plumbing, heating (except electric) and air conditioning	x			x			x		
1721	Painting, paper hanging, and decorating				x					
1731	Electrical work		x		x			x		
1741	Masonry, stone setting, other stone work		x		x					
1742	Plastering, drywall, acoustical, and insulation work				x		x	x		
1751	Carpentering		x	x	x	x	x		x	
1752	Floor laying and other floorwork					x			x	
1761	Roofing and sheet metal work		x	x	x	x	x	x		x
1799	Special trade contractors, not elsewhere classified				x		x			

Sources: Godfrey 1976.
McGraw-Hill 1975.
EEH 1976b, d-e.

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of men required. The number of man-days was determined by dividing the total quantity of asbestos product 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 Manufacturers (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. Once the number of man-days had been obtained, further calculations were required to estimate the average number of men needed. First, the average number of days worked for each class of worker was determined from Figures 2, 3, and 8. The worker classifications and percent of the total workers for each subclassification were determined as described in Section III-A-2. Thus, the workers installing felts and asbestos cement sheets were each assumed to be 50 percent of the numbers shown in Figure 8; the pipe installers were 50 percent of the numbers shown in Figure 2; the tile installers were 10 percent of the numbers shown in Figure 3; and the shingle installers were 33 percent of

the numbers shown in Figure 3. For each month of the year of interest, the appropriate number of workers employed was determined, then multiplied by the number of weekdays in that month, and the resulting product summed for each month of the year. This annual total was then divided by the maximum number of workers employed during any month of the year of interest. The resulting value was the average number of days each workers within a subclassification was employed during the given year.

To determine the number of workers, the man-day estimates were divided by the appropriate average number of days worked. The result was the number of workers, employed full-time, required for each product. The required data were available to equate this information for the following products: felts, pipe, tiles, shingles, and cement sheets. The calculations and results are presented in Table 32.

The calculations of Table 32 can also be applied to the data obtained from the EEH survey of asbestos manufacturers for 1975. Four products can be applied. The calculations and results are given in Table 33.

One interesting feature of the estimated numbers of full-time workers required for installation of asbestos-containing materials is the relatively small value obtained. The most obvious area, to cite an example, is felts. In 1972, monthly employment among roofing workers ranged from approximately 42,000 to 55,000 assuming they comprise half of the roofing and sheet metal workers. Only 506 full-time roofers would have been required to install all the asbestos felt produced as roofing. It is much more likely that greater numbers of workers are involved in the installation of asbestos-containing materials, but only for a small portion of the year. The whole subject of worker number and time period

Table 32

Calculated Man-Days Based on 1972 Census of Manufacturers Data

Calculations	Results
FELTS (1972)	
Value of total manufactured	$ 36,500,000
Average value per square	$ 5.20
Number of squares	7,019,000
Labor output capacity	59 squares per man
Man-days; workers	119,000 man-days; 506 workers
PIPE (1972)	
Value of total manufactured	$ 143,300,000
Average value per linear foot	$ 3.61
Number of feet produced	39,700,000
Labor output capacity	274 feet per 3-man crew
Man-days; workers	145,000 (3) = 435,000 man-days; 1,900 workers
FLOOR TILES	
1. Vinyl asbestos plain-backed tile	
Quantity of squares produced	1,164,600,000 square feet
Labor output capacity	540 square feet per man
Man-days	2,157,000 man-days
2. Vinyl asbestos adhesive-backed tile	
Value of total manufactured	$ 48,000,000
Average value per tile	$ 0.255 per square feet
Number of units produced	188,000,000 square feet
Labor output capacity	540 square feet per man
Man-days	349,000 man-days
3. Asphalt floor tile	
Quantity of square feet produced	88,200,000
Labor output	540 square feet per man
Man-days	163,000 man-days
	2,157,000
	349,000
	163,000
Total man-days; workers	2,669,000 man-days; 10,939 workers
SHINGLES	
Quantity of squares	1,300,000
Labor output	4 squares
Man-days; workers	325,000 man-days; 1,332 workers

Table 33

Calculated Man-Days Based on EEH Survey Data

Calculations	Results
FELTS (1975)	
Value of total manufactured	$152,000,000
Average value per square foot	$7.97
Quantity of squares produced	19,070,000
Labor output capacity	59 squares per man
Man-days; workers	329,000 man-days; 1,406 workers
PIPE (1975)	
Value of total manufactured	$160,000,000
Average value per foot	$4.69
Number of linear feet produced	34,115,000
Labor output capacity	274 feet per 3-man crew
Man-days; workers	124,000 (3) = 372,200 man-days; 1,577 workers
SHINGLES (1975)	
Quantity of squares produced	518,000
Labor output capacity	4 squares
Man-days; workers	129,500 man-days; 524 workers
CEMENT SHEETS (1975)	
Value of total manufactured	$28,440,000
Average value per square foot	$1.32 per square foot
Number of square feet produced	21,545,000
Labor output capacity	682 square feet per 4-man crew
Man-days; workers	31,600 (4) = 126,400; 540 workers

spent working with asbestos-containing materials requires further investigation during Phase 2.

c. Percentage of Market Held by Selected Asbestos Products

From the 1972 Census of Manufacturers (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 34.

4. Installation and Application

The following sections deal primarily with installation and applications of asbestos-containing materials used in construction. Two sections deal specifically with alternative materials being used and with data relating to the dollar value of asbestos materials used in various structures.

a. Asbestos Friction Materials

Asbestos friction materials are used in the construction industry as

Table 34

Dollar Value of A Major Asbestos Product and Several Alternate Products

SIC		Value Million Dollars	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	
32925	Asphalt floor tile (containing asbestos)	9.1	19.89
		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	
29523 55	Tar-saturated felts for built-up roofing systems	3.1	69.02
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	
2661	Building papers and millboards	456.2	95.73
32927 41	Flat sheets and wallboard (asbestos)	20.7	
32927 98	Other asbestos and asbestos-cement products, including millboards and prefabricated housing	23.7	4.27
		1,039.0	100.00

clutch facings and brake linings on virtually all moving equipment. This includes trucks and other vehicles, conveyors, cranes, and elevators.

A small quantity of asbestos fibers are released from friction material during normal operation of construction machinery as the clutch facings and brake linings wear. Due to the extremely high temperatures involved in the operation of the friction materials, most of the asbestos fibers released from the materials-wearing surface have been thermally degraded. For example, most samples of material released from motor-vehicle brakes contained less than 1 percent asbestos as compared with 50 percent in the original lining formulation.

During normal usage, the abraded particles of the asbestos linings may be partially trapped in the housings of manual clutches and brake drums. During the servicing and overhauling of motor-vehicle brakes and manual clutches, the accumulated asbestos-containing dust is frequently dislodged from drums and housings by directing a compressed air jet against the deposits. This results in airborne asbestos emissions to the work space and consequent exposure of the mechanics working on the vehicles. Mechanics seldom, if ever, wear respirators for protection against asbestos. The simple use of a vacuum cleaner to collect the lining deposits would remove a majority of the potential asbestos emissions.

Used brake shoes are generally collected and shipped to companies that recycle them. The asbestos friction material, which is removed from the shoe, is disposed of as an industrial waste.

b. Asbestos-Cement Siding Shingles, Clapboard, and Roofing Shingles

Asbestos-cement shingles are made as individual shingles or in long

rectangular strips, some of which are cut to look like several shingles. Either type may have a plain, striated, or wood-textured surface. All have predrilled holes for application.

Asbestos-roofing shingles are similar to siding shingles. The major difference is that the roofing shingles are up to twice the thickness of siding shingles. This extra thickness affords the strength required to support the installers during installation of the roofing shingles.

The composition of the asbestos cement used in shingle manufacture is approximately 80 percent portland cement and 20 percent asbestos fibers.

Asbestos shingles are shipped to the job site on pallets. Each pallet contains a number of bundles. The bundles are edge-wrapped in cardboard and banded. A bundle is one-third of a square, and a square contains sufficient material to cover 100 square feet of area. At the job site, as material is used, each bundle is unwrapped. The possibility of exposure to asbestos fibers during shipment and storage is minimal.

The asbestos shingles are installed by a carpenter (SIC 1751). Most shingles are applied to the rows in their original size. At the end of a row and to fit around wall and roof openings, the shingles must be cut. Shingles are cut and shaped by use of a hand-operated shear. In cases where additional nailing holes are needed, they are formed by use of a hand-operated shingle punch. The use of the shingle punch and shear generates minimal dust. The abrasion of roofing shingle surfaces from the movements of installers over the roof surface may also release some asbestos dust.

The productivity of a single carpenter in the installation of asbestos shingles is four to eight squares, or 400 to 800 square feet, per day. The amount installed is highly dependent on how much cutting and fitting are involved.

Waste pieces of asbestos shingles are generally disposed of by placing them in the excavation along the building foundation. They are then buried during the backfilling operation.

No special cleanup procedures are employed by workers installing asbestos shingles, and no protective equipment is used to prevent inhalation of asbestos fibers.

Alternative siding materials are wood, fiberboard, brick, stone, stucco, concrete, aluminum, and vinyl. Alternative roofing materials are tile, slate, and asphalt shingles and roofing materials.

c. Vinyl Asbestos Floor Tile

Vinyl asbestos floor tile consists of a vinyl wearing surface with an asbestos felt backing. It is manufactured in sheets and in individual tiles measuring 12 inches on a side. It is available with either plain or adhesive backing.

Installation of vinyl asbestos tile involves some cutting or fitting the tiles or sheets along walls and around columns. The tile is generally cut by hand with a knife. Exposure to asbestos during installation is minimal.

There may, however, be significant asbestos exposure during tear-up of old flooring by virtue of the work practices employed. In the past, the tile was ripped up, and any asbestos backing left adhering to the

floor was sanded off. This operation created large amounts of dust containing asbestos.

Currently, there are two newer methods for removal of the old floor, both of which greatly reduce asbestos dust. The newer flooring is designed so that the wearing surface will delaminate from the backing felt at removal. The felt remaining on the floor is not sanded; instead, a new floor is laid on top of the old asbestos backing. Another method is to nail underlayment (i.e., masonite or plywood) over the old floor material, which is not removed. The new floor surface is then laid on the underlayment. When removal of this newer surface is necessary, it is removed with the underlayment. Then, new underlayment is installed.

Additionally, the manufacturers of vinyl asbestos floor tile are trying to develop a suitable substitute for the asbestos backing material.

It is not known what control procedures for cleanup and dust control, if any, are currently in use by the industry.

Alternative materials include stone, ceramic tile, hardwood, and carpeting.

d. Asbestos Textiles

Asbestos textiles are used primarily as firehoses, fire blankets, welding pads, strain reliefs, and gasketing rope. The asbestos fibers are firmly woven into the materials binder. It is unlikely that any exposure to asbestos would occur from normal use of the products.

The only likely field operation would be the cutting of lengths of asbestos rope for use in applications such as cadwelding and manhole gasketing.

e. Pipe Insulation and Other Asbestos Insulation, Including Block Insulation

Asbestos insulation for the construction industry is no longer manufactured in the United States. A telephone survey of 12 members of the National Association of Insulation Contractors confirmed that none of the contacted contractors were using asbestos insulating materials. These materials are of concern, therefore, from the standpoint of demolition rather than installation.

The U.S. Environmental Protection Agency (Federal Register, October 14, 1975) has imposed regulations for the removal and disposal of friable asbestos materials from any building to be demolished, in order to prevent emission of particulate asbestos to the outside atmosphere. The regulations stipulate removal of any friable asbestos from materials used to insulate or fireproof ducts, pipes, boilers, tanks, reactors, furnaces, turbines, or any structural units if the asbestos content exceeds 1 percent by weight.

The operations involving the removal of friable asbestos materials from structures to be demolished generally consists of wetting, stripping, bagging and cleanup, and disposal. The materials to be removed are first wetted to prevent dust from becoming airborne during the subsequent stripping operation. Water, which is most often used as the wetting agent, is either sprayed onto the materials by means of a pressure hose or can be poured on the surfaces. In some cases, it is difficult to adequately soak the materials to be removed. Insulation on pipes is often thick, and water sprayed or poured on the surfaces will not completely penetrate

underlying layers of insulation. In other instances, the materials can be easily wetted. The thickness condition and type of asbestos material will influence the wetting operation.

The stripping of asbestos materials consists of mechanically removing insulation or sprayed coatings from the surfaces of ducts, pipes, or equipment. The wetted material is usually removed by means of hand scrapers, knives, or other implements convenient for the purpose. Sizes of material removed can range from dust to large chunks. In some cases where thorough wetting of the materials cannot be accomplished, considerable dust may become airborne. Control techniques such as a local exhaust or a water spray could be used to minimize dust but in actual cases, these measures may not be employed. Stripped material is generally allowed to fall to the floor and may be wetted if still dusty.

After stripping is completed in an area, the resulting waste material is placed into containers. Large pieces are usually placed into containers by hand while smaller pieces are shoveled or swept up. Plastic bags have been used as containers for disposal purposes. If the waste material has not been thoroughly wetted, considerable dust may be generated by handling during this operation. Overloading of plastic bags with waste material has caused bags to tear when moved from the stripping site. Cleanup operations also include personal hygiene. In some cases, there may be no provisions for workers to change clothes and shower before they go to lunch or go home for the day. Asbestos materials deposited on work clothes or in the hair have the potential to become airborne after the worker leaves the demolition site.

f. Asbestos-Cement Products

Pipe, Conduit, and Ducts; Pressure Pipe

Asbestos-cement piping is an extruded product. Pipe is supplied in various diameters and in standard lengths, depending on the manufacturer. Pipe lengths are machined at the ends to accept a bell coupling with rubber O-rings for integrity. Most pipe is factory-belled on one end.

Belled pipe is supported on lumber between layers and checked and strapped during shipment. Unbelled pipe is generally nested. Shipment is by flatbed truck or flatcar by rail. Asbestos-cement pipe is seldom covered during transport. Asbestos cement is not shock-resistant, and, during unloading and handling, the smaller diameter pipes, with their thinner wall thickness, can be easily damaged, especially on the machined ends. Such damage may require field operations for salvage or repair of the undamaged portion.

The standard crew laying an 8-inch gravity sewer pipe consisted of eight persons. These include a foreman, four laborers, two machine operators, and an oiler. Two persons work in the trench with the pipe, and two persons at ground level lower the pipe into the trench. Operations vary depending on pipe diameter. Basically, the machined end of each pipe length is lubricated, then levered into the previous bell. There is no exposure during routine installation practice.

The productivity of this crew is from 200 to 700 linear feet per day, depending upon the depth of the trench and water-table depth.

Most pipe is installed in the lengths delivered from the factory. The most common operation at the job site is the beveling of damaged

pipe ends, which is performed by hand filing. Very little dust is generated, and no control procedures are followed. Occasionally, a length of pipe is cut on the job site for entry to a manhole. In such cases, small diameter pipe can be snap cut, causing minor dusting, or broken with a hammer or pry bar, causing potential asbestos exposure. No control measures are used for such nonmachine cuts. Pipe cutting by abrasive disk is also practiced. When pipe is to be cut and machined for unusual lengths or for salvage of damaged material, these operations are performed in the contractor's storage yard. Cutting is by a gasoline-powered saw with carbide-tipped blade or abrasive disk. Machining is performed with a portable, powered pipe lath. These operations generate a significant amount of asbestos-containing dust. The worker performing these operations may on occasion wear a respirator. Dust-control measures can be employed for these operations. There is no cleanup of the area. On a recent site visit, the cutting area was covered with asbestos cement chips and dust. No changing or cleanup rooms were provided for the workers in the yard. In addition, the exposure of the peripheral yard workers could be high during cutting and machining.

Alternative materials are cast iron as a replacement for asbestos-cement pressure pipe and vitrified clay or plastic pipe for asbestos-cement gravity pipe.

Asbestos-cement conduit and duct is similar to pipe except that it is much lighter and is not generally buried.

Asbestos conduit is installed by a single electrician at the rate of 140 to 230 linear feet per day, depending on pipe diameter.

Shipping practices, installation methods, and dust control and cleanup procedures have not been observed at this time.

Flat Sheets and Wallboard

Asbestos-cement flat sheet and wallboard are made as rectangular sheets, usually 4 by 8 feet. The thickness of the available panels varies from 0.125 to 1.25 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 the job site on pallets, with the sheets wrapped in plastic and banded. As material is needed, each pallet is unwrapped. The possibility of exposure to asbestos fibers during shipment and storage is negligible.

The asbestos-cement sheets are installed by a crew of two sheet-metal workers (SIC 1761) and two building laborers (SIC 1761). Carpenters 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 values is from 500 to 1,200 square feet of flat sheet installed per day.

Control procedures include the use of vacuum- and wet-control-equipped tools and approved respirators by workers engaged in cutting and drilling. Waste material collected by the vacuum is mixed with water and cement and disposed of by burial. Waste pieces of the sheets are disposed of as ordinary construction wastes.

No special cleanup procedures are observed by workers installing asbestos-cement sheets.

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. Also available are asbestos sheet materials that employ inorganic binders other than cement. Although these sheet materials are not technically asbestos-cement products and although they have 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.

Alternative materials include wood, brick, stone, concrete, stucco, aluminum, and steel.

Corrugated Sheets

Corrugated asbestos 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 workers. 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.

g. Asbestos Felts: Asphalt or Tar-Saturated Roofing, and Others

Asbestos roofing and finishing felts consist of asbestos fibers imbedded in an asphalt or bitumen matrix. These felts are used to construct built-up roofing.

A standard roofing crew consists of a roofing foreman, four roofers, and two helpers. The installation rate is about 2,400 square feet of five-ply asbestos felt on a flat roof per day.

The installation procedure is to spread hot tar on the roof or previous layer of felt, and then to unroll the felt over the tar. Cuts are made by knife to fit the felt at edges and around obstructions. Generally, three layers of roofing felt and two layers of finishing felt, all with staggered seams, are used in a five-ply built-up roof. The top layer of asbestos felt is covered with hot tar, and gravel is spread on top for a wearing surface. Because the asbestos fibers are firmly embedded in the felt matrix, exposure during installation should be minimal.

Tear-off of built-up roofing produces more dust than installation. Typically, the tear-off crew consists of a tear-off machine operator, one or more pickup men, a shovel man, tractor operator, and chute man. The roofing is cut through and lifted out in sections, which are dropped directly from the roof or down a chute. Although the operation produces dust, the asbestos fibers are contained in an asphalt or bitumen matrix, and, hence, are not expected to be released in significant quantity.

No special cleanup or dust-control procedures are observed for installation or tear-off. Waste felt is disposed of in the same manner

as other construction wastes. Alternative materials are organic and plastic-filled felts.

h. Asbestos Sprays, Coatings, and Sealants

Asbestos-containing spray coatings are used as a texture paint on the interiors of structures. Dry spray texture paint consists of 4 to 5 percent asbestos fiber.

The dry spray texture paint is shipped to the job site in 31-pound bags. Spraying is accomplished by use of a small portable sprayer, or, on large jobs, by a truck-mounted unit.

The typical installation crew consists of a spray operator and an assistant. The spray operator mixes the dry paint with water in the spray unit. The mixed paint is pumped through a hose to a 4-foot wand with a nozzle on the side of the tip. Compressed air to atomize the liquid is supplied to a second hose. During spraying, the operator walks slowly through each room with the nozzle pointed toward the ceiling and sweeping back and forth about 4 feet from the floor. The assistant moves the hoses and immediately removes any overspray from the walls with a scraper.

This two-person crew can mix paint and texture-spray about 1,000 square feet of ceiling per hour. Using a portable unit, about 240 pounds of 5 percent asbestos paint are required. From a truck-mounted unit, 360 pounds of 2.5 percent asbestos texture paint can be mixed and applied to 1,300 square feet in 50 minutes.

Cleanup consists of washing out the spray unit and disposing of excess paint.

i. Wallboard-Taping Compounds

Wallboard-taping compounds are plaster-like materials used to cement joint reinforcing tapes to wallboard, repair holes and imperfections in wallboard surfaces, and to provide a smooth, continuous surface. These compounds sometimes contain asbestos fibers.

A single worker is involved in the taping operation even on larger jobs. The dry compound delivered as a powder in 10- to 25-pound bags is added to water in a 5-gallon drum. Additional water is added, and the mixture is stirred to an even consistency. Unless care is exercised in emptying the bags of compound during wet-out, the worker could be exposed to a significant level of asbestos dust. Extensive use is being made of premixed compound, which eliminates the potential exposure during wet-out of dry powder. This compound, along with the paper joint tape, is applied to the joints by use of a gun of bazooka. While the compound is still wet, excess material is removed with a taping knife. When the joint compound has dried, a finish coat of a compound is applied for a smooth surface. The finish coat may contain asbestos or be asbestos-free. Sanding of the finish coat and subsequent cleanup of dust by sweeping are, along with wet-out, the primary operations resulting in exposure when asbestos-containing compounds are used. The use of premixed compounds prevents exposure during wet-out. Similarly, nonasbestos compounds used for the finishing coat eliminate sanding and sweeping as asbestos-generating operations. From an interior design standpoint, the use of textured walls precludes the need for sanding the finish coat of compound, thus eliminating sanding and sweeping as dust-generating operations.

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No specific cleanup or dust-control procedures are followed. Waste materials, including empty asbestos-compound bags, are disposed of along with other construction wastes.

Alternative materials are compounds that contain no asbestos.

j. Millboard and Asbestos Insulating Board

Millboard and insulating board are pulp products containing asbestos in the matrix. They are used primarily in manufactured products and are not used extensively in construction, according to EEH contacts.

k. Drilling Fluids

In the oil industry, fibrous asbestos material is used as an additive to drilling muds to improve the carrying capacity of the mud for removal of drilling impurities. The materials used are essentially pure asbestos and may be added in a wetted granular form or a coarse ground form.

The asbestos material is generally shipped in heavy sealed paper bags that are enclosed in a thick, plastic outer covering. During shipment and handling by rail or truck, breakage of the bags can occur. The material is stored at the drilling site in trailers or sheds, or outdoors.

The addition of the asbestos material to the drilling mud is accomplished using a mud hopper consisting of a drum or funnel connected to the intake line of the mud pump. The material is dumped into the hopper and is drawn into the fluid by the venturi action of the mud flowing by the intake to the pump. Generally, one worker wearing a respirator pours

the material during the operation; however, in some cases, the worker is aided by an assistant. The quantity of asbestos product used will vary depending on the size of the drilling fluid system and the properties of the mud required. The mud hopper may be located in a shed or trailer, or in the open.

Waste materials that contain asbestos from these operations are the empty asbestos bags and the drilling muds. Muds are usually disposed of by means of a landfill operation on the drilling site. In some cases, the muds are trucked out in tank trucks and pumped into disposal wells approved by regulatory authorities. The bags are disposed of either by burning or by landfill.

1. Value of Asbestos Materials in Various Structures

Only limited data are available on the value of asbestos-containing materials used in various structures. A breakdown of product groups is presented in Tables 35 and 36 for single- and multiple-family dwellings. As can be seen from Table 35, for single-family dwellings, the amount of asbestos-containing materials is less than 3 percent of the cost of the structure, based on 1969 data. From Table 36, for apartment houses, the amount of asbestos-containing materials is less than 2 percent of the structure cost, based on 1971 data. There are no data presently available that provide a breakdown of asbestos and nonasbestos products in commercial and industrial structures and in areas other than building construction, such as pipelines.

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Table 35

Typical Amounts of Asbestos Products Contained in Single-Family Housing Construction, 1962-1969

Material	Cost per $1,000 of Construction Price		Cost per 100 sq. ft. Livable Space		Percent Distribution	
	1962	1969	1962	1969	1962	1969
Stone, clay, glass products	116.60	95.30	137.10	153.40	24.2	21.5
Cement, concrete, gypsum	76.70	54.50	90.20	87.00	15.9	12.3
Structural clay products	19.70	22.00	23.20	35.00	4.1	5.0
Others	20.20	18.90	23.80	31.40	4.2	4.3

Material	Value per $1,000 of Construction Price	Value per 100 sq. ft. of Livable Space	Percent Total Materials and Equipment
Total material	434.02	692.87	98.00
Construction paper, fiberboard insulation, asbestos board insulation, acoustical tile	1.91	3.04	0.43
Roof pitch, asphalt board insulation rolls, asphalt shingles, asphalt sheathing siding, building felts, composition, asphalt for mastics, and emulsions	7.07	11.30	1.60
Stone, clay, glass, concrete products	94.45	150.55	21.33
Plaster, wallboard	13.54	21.59	3.06
Asbestos-cement shingles, siding, asphalt floor tile, asbestos-cement pipe, vinyl asbestos tile, asbestos-cement adhesives	2.76	4.40	0.62
Asbestos (pipe) insulation	0.59	0.94	0.13

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Table 36

Typical Amounts of Asbestos Products Contained in Apartment Construction, 1971

Product	Cost per $1,000 of Contract Cost	Cost per 100 sq. ft.	Percent Distribution
Total materials and supplies	445.33	577.02	93.51
Construction paper	0.36	0.47	0.08
Stone, clay, glass, and concrete products	105.35	136.51	22.12
Asbestos-cement products	0.14	0.19	0.03
Vinyl asbestos tile	3.41	4.42	0.72
Asphalt floor tile	1.04	1.35	0.22
Adhesives, asbestos-cement	0.23	0.30	0.05
Insulation, asbestos (including sprayed-on)	0.95	1.23	0.20

m. Alternative Materials to Asbestos

A number of asbestos-containing materials used in construction have been or are being replaced due to government regulations and economics. The various types of asbestos containing materials used in construction and alternatives for each are listed in Table 37.

Asbestos-cement pipe is used extensively in water and sewer work as the preferred material, one reason being that it is less costly than alternative materials offering similar properties.

Asbestos-cement sheets and shingles seem to have a lesser cost advantage over the alternatives than asbestos-cement pipe, and aesthetics is one of the main factors influencing the use of asbestos products.

There are a number of alternative materials being used as foundation and roof compounds and as alternatives to asbestos felts. In the latter case, the alternatives do not possess the desirable properties of asbestos felts and are more difficult to work with.

Asbestos insulation (both sprayed-on and block) has been essentially eliminated in construction by EPA regulations; it is of concern because it relates to demolition and renovation.

A number of alternative materials are available for asbestos textiles and vinyl asbestos floor tiles. In the case of sheet floor coverings, manufacturers are actively pursuing development of suitable substitutes.

5. Exposure to Asbestos

Asbestos-containing materials presently used in the construction

Table 37

Alternate Materials

Asbestos-Cement Pipe	Asbestos-Cement Sheets	Asbestos-Cement Shingles	Foundation and Roof Compounds	Other Asbestos Compounds	Asbestos Felts	Asbestos Insulation	Asbestos Textiles	Vinyl-Asbestos Floor Tile
Aluminum	Aluminum	Aluminum	Hot asphalt	No substitute (for some)	Bituminous coatings	Aluminum foil	Ceramics	Carpet
Cast iron	Brick	Asphalt	Hypolan		Glass fiber	Calcined diatomite	Fiberglass	Non-asbestos tile
Clay	Cement	Brick	Latex rubber		Organic fiber	Cellulose cork		Sheet vinyl flooring
Concrete	Concrete	Fiber-board			Plastic membrane	Fiberglass		Solid vinyl flooring
Ductile iron	Fiber-board	Glass fiber				Kaolin wool		Wood
Metal	Metal	Metal				Mineral wool		
PVC	Plastic	Plastic				Perlite		
Steel	Plywood	Steel				Plastic		
	Slate	Stone				Rubber		
	Steel	Stucco				Vermiculite		
		Vinyl				Wood fiber board		
		Wood						

Sources: Asbestos--Production losses prolong the shortage. Industrial Minerals 93: 19-39, 55. 1975.
Survey of Manufacturers. 1976.
Williams, F. E. 1971. Residential siding products. Construction Review August: 4-11.
Williams, F. E. 1973. Thermal insulation in building construction. Construction Review November: 1-11.

industry and those no longer used but encountered in demolition work and removals have been divided into 12 categories. Fiber counts have been obtained for these categories from a variety of sources including the published literature, government agencies, a survey of manufacturers, trade unions, and construction and manufacturing trade associations, as well as personal communications. These data are presented in Table 38 and discussed, by category, in the following sections. Observations made during site visits and from discussions with knowledgeable sources have been included to aid in interpretation of these data and in application to exposure estimates.

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

Table 38

Summary of Available Fiber Count Data

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
ASBESTOS FRICTION MATERIALS				
Brake lining	Repair	<0.5	<30 minutes	Four samples
Brake lining	Replacement	<2.0	--	Heavy construction equipment
ASBESTOS-CEMENT SHINGLES AND CLAPBOARD				
Siding and shingles	Shearing	<2.0	--	--
VINYL ASBESTOS FLOOR TILE				
Vinyl asbestos floor tile	Application	nil	--	--
Vinyl asbestos floor tile	Belt sanding	1.2	20 minutes	Ventilated room; 4 changes/hour
		1.3	20 minutes	Ventilated room; 4 changes/hour
TEXTILES				
Asbestos cloth (shipbuilding)	Conventional application	5-10	--	--
	Dust-suppressed application	1-3	--	--
	New process application	0.2-1.5	--	--
Asbestos cloth (shipbuilding) (untreated)	Ripping cloth	7	--	Mean of 5 samples, worker breathing zone
		0.3-16.5	--	Range
	Background	33	--	Mean of 2 samples
		23-43	--	Range
Asbestos cloth (shipbuilding) (treated with manufacturer's dust suppressant)	Ripping cloth	<1.0	--	Mean of 12 samples, worker breathing zone
		<1.0	--	Range
	Background	<1.0	--	Mean of 12 samples
		<1.0	--	Range
Amosite rope (shipbuilding)	Fitting cloth	112	--	Mean of 13 samples, worker breathing zoe
		5-340	--	Range
	Background	118	--	Mean of 4 samples, personal air sampler
		1-280	--	Range
Asbestos rope	Cad welding	<2.0	--	Welding of large reinforcing bars
INSULATION				
Sprayed crocidolite asbestos (shipbuilding)	Removal of insulation	334.0	1-2 hours	Mean of 5 samples, 100% asbestos stripping area of aircraft hanger (ship)
		117-484	1-2 hours	Range, 100% asbestos
	Background	56.5	1-2 hours	Mean of 4 samples, 100% asbestos, adjacent areas (rooms, passageways)
		19-131	1-2 hours	Range, 100% asbestos, adjacent areas (rooms, passageways)
	Removal of insulation	219.9	1-2 hours	Mean of 15 samples, 100% asbestos, small compartment (ship)
		35-384	1-2 hours	Range, 100% asbestos, small compartment (ship)
	Background	82.6	1-2 hours	Mean of 4 samples, 100% asbestos, adjacent rooms and passageways
		43-177	1-2 hours	Range, 100% asbestos, adjacent rooms and passageways

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
INSULATION (Cont.)				
Sprayed crocidolite asbestos (shipbuilding) (Cont.)	Sweeping and bagging of debris	353.0	1-2 hours	Mean, 100% asbestos, aboard ship
		213-493	1-2 hours	Range of 2 samples, 100% asbestos, aboard ship
	Sweeping and bagging of debris	1,000-2,000	--	Range, 100% asbestos, Dräger hand pump (200-2,000 ml)
	Removal of insulation	311	Over workshift	100% asbestos
	Background	109	Over workshift	100% asbestos, one deck above source (of stripping)
	Background	30	Over workshift	100% asbestos, two decks above source (of stripping)
Pipe lagging (90% amosite), pipe lagging (calcium silicate and 15% asbestos), asbestos cloth and cement (shipbuilding)	Removal	97	Collected over workshift	Mean of 20 samples, boiler rooms of aircraft carriers, cruisers, and frigates, breathing zones of workers
		25-220	Collected over workshift	Range
	Background	171	Collected over workshift	Mean of 153 samples, samplers located at convenient points in compartments, distance from source unknown.
		0.04-1,062	Collected over workshift	Range of 153 samples. Source unknown. Boiler rooms consist of two levels in ship.
	Removal	93	Collected over workshift	Mean of 25 samples, tear-out in engine room
		2-490	Collected over workshift	Range of 25 samples, tear-out in engine room
	Background	88	Collected over workshift	Mean of 45 samples, samplers located at convenient points in engine room
		0.16-3,021	Collected over workshift	Range
Asbestos pipe lagging	Demolition			
	with thorough soaking	1-5	--	% asbestos varies
	with use of water sprays	5-40	--	--
	carried out dry	>20	--	--
Boiler insulation	Removal	5.2	<30 minutes	One sample
Insulated ductwork	Removal	1.3	<30 minutes	--
		3.6	<30 minutes	--
		11.6	<30 minutes	--
		32.0	<30 minutes	--
ASBESTOS-CEMENT SHEET MATERIALS				
Asbestos-cement sheets (flat, corrugated, laminated, extruded)	Power drilling without dust control	2-20	--	--
	Power drilling with dust control	<2	--	--
	Power sawing without dust control	>25	--	--
	Power sawing with dust control	<2	--	--
Asbestos cement sheet and pipes	Machine drilling	<2	--	--
	Hand sawing	2-4	--	--
	Machine sawing without effective local exhaust			
	jigsaw	2-10	--	--
	circular saw	10-20	--	--
	Machine sawing, effective exhaust ventilation	<2	--	--

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
ASBESTOS-CEMENT SHEET MATERIALS (Cont.)				
Asbestos-cement sheet	Overhead drilling	0.2	1.5 hours	Personal; drill with dust-control attachment
		0.1	1.5 hours	Area; drill with dust-control attachment
	Sawing	4.9	--	Jigsaw with control device; area 2.3 fibers/ml
	Sawing	0.8	--	Jigsaw with control device; vacuum table
		0.5	--	Jigsaw with control device; vacuum table
	Sawing	75.4	--	Peak personal; portable circular saw ventilated by baghouse
		3.0	--	Peak area; portable circular saw ventilated by baghouse
	Drilling	0.2	--	Personal; drill ventilated by baghouse
		0.1	--	Area; drill ventilated by baghouse
	Sawing	17.0	--	Personal; portable circular saw ventilated by baghouse
		7.1	--	Area; portable circular saw ventilated by baghouse
	Sawing	0.7	--	Personal; portable circular saw, masonry blade; baghouse
		0.5	--	Area; portable circular saw, masonry blade; baghouse
	Sanding	0.8	--	Personal; vibrating sander with baghouse
		0.4	--	Area; vibrating sander with baghouse
	Sawing	0.6	--	Personal; portable chain-drive saw; wet dust removal system
		0.6	--	Area; portable chain-drive saw; wet dust removal system
	Sawing	3.4	--	Personal; portable circular saw, carbide tip blade; baghouse
		0.0	--	Area; portable circular saw, carbide tip blade; baghouse
	Sawing	0.5	--	Personal; hooded portable circular saw; vacuum table
		0.9	--	Area; hooded portable circular saw; vacuum table
	Sawing	1.8, 2.2	--	Personal, hooded portable circular saw; vacuum table
		1.0, 0.7	--	Area; hooded portable circular saw; vacuum table
	Sawing	0.4, 0.4	--	Personal; hooded portable circular saw; vacuum table
		0.2, 0.4	--	Area; hooded portable circular saw; vacuum table
	Drilling	0.6	--	Personal; drill with total shroud
		0.2	--	Personal; drill with partial shroud
	Sawing	19.2, 27.5, 33.0	--	Personal; portable circular saw; no shroud
		11.5	--	Personal; partial shrouding
	Sawing	0.6	--	Personal; portable circular saw with wet control system
Asbestos acoustic panels	Removal	131	--	Mean of 6 samples, worker breathing zone
		48-271	--	Range
	Background	413.5	--	Mean of 6 samples
		30-684	--	Range

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
ASBESTOS-CEMENT SHEET MATERIALS (Cont.)				
Asbestos building panel	Sawing, portable power with carbide blade. Local exhaust attachment on saw	10.2	15 minutes	30.1 liters of air
	Sawing, mason's type saw with diamond-tipped blade, water spray on blade	1.80	18 minutes	Four saw cuts per 18 minutes 36.8 liters of air
	Same as above	1.74	15 minutes	Three saw cuts per 15 minutes 22.9 liters of air
	Same as above	0.30	62 minutes	Five saw cuts per 62 minutes 123.5 liters of air
	Same as above	0.56	45 minutes	Six saw cuts per 45 minutes 62.3 liters of air
	Sawing, portable power with carbide blade. Local exhaust attachment on saw.	10.6	15 minutes	29.0 liters of air
Asbestos insulation board	Drilling vertical structures	2-5	--	--
	Drilling overhead	4-10	--	--
	Sanding and surforming	6-20	--	--
	Scribing and breaking	1-5	--	--
	Hand sawing	5-12	--	--
	Machine sawing		--	Without effective local exhaust ventilation
	jigsaw	5-20	--	--
	circular saw	20+	--	--
	Unloading deliveries of board (short-term sample)			
	cut pieces	5-15	--	--
	standard size	1-5	--	--
Asbestos cement sheet	Sawing	2.6 to 10	4 hours	Six personal measurements; HiVelocity/LoVolume system on Skil saw
		1.0 to 2.8	4 hours	Six area measurements
	Sawing	5.2 (TWA)	30 minutes	Bandsaw, no ventilation; area 3.1 fibers/ml
		11.2 (TWA)	60 minutes	Bandsaw, no ventilation; area 4.0 fibers/ml
	Sawing	0.7 (TWA)	30 minutes	Skil saw with control device; area 0.5 fibers/ml
Asbestos cement pipe	Cutting with Wachs power abrasive saw (8-inch pipe)	64	--	Measured ceiling concentration
	Background	40	--	Measured ceiling concentration within 4 feet of source
	Tapering and trimming (8-inch pipe)	1.1	--	Measured ceiling concentration/pilot manual tapper and trimmer
	Background	1.7	--	Measured ceiling concentration/within 4 feet of source
	Cutting and trimming (12-inch pipe)	0.2	--	Measured ceiling concentration/pilot electric cutter and trimmer
	Background	0.2	--	Measured ceiling concentration/within 4 feet of source
	Cutting (8-inch pipe)	0.8	--	Measured ceiling concentration/pilot manual cutter
	Background	0.0		Measured ceiling concentration/within 4 feet of source
	Hand sawing (8-inch pipe)	1.1		Measured ceiling concentration
Pressure pipe	Fabrication, using recommended procedures	<1	--	--
Nonpressure pipe	Hole saw drilling	5	--	--
	Cutting with power portable circular saw	>25	--	--
	Installation	nil	--	--

struction uses of asbestos textiles. However, acrylic-bonded asbestos blankets used for stress relief have been observed after repeated use to shed fibers. Insufficient data are available for estimates of construction worker exposure due to use of asbestos fire blankets for stress relief.

Recommendations

Conduct site visits to observe applications of asbestos rope and blankets in construction. Based on observation of operations, determine need for sampling and fiber counting.

e. Insulation

The removal of asbestos insulation from structures rather than its application, which has been restricted, is of present concern. Most of the available data are for removals from ships but may be relevant to land-based demolition.

The shipboard removal of sprayed crocidolite asbestos and the subsequent sweeping and bagging of debris have resulted in ceiling fiber concentrations as high as 484 and 2,000 fibers per milliliter, respectively. Mean fiber counts over extended time periods are reported as high as 334 and 353 fibers per milliliter for removal and for sweeping and bagging, respectively.

Shipboard removal of asbestos pipe lagging has been observed to result in a mean breathing zone concentration of 97 fibers per milliliter based on 20 full-shift samples. Other data show mean background counts in compart-

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
ASBESTOS FELTS				
Roofing felt	Installation	<1	--	--
		0.1	--	Mop man
		0.1	--	Roll man
		0.2	--	Hot man
		0.1-0.4	--	Downwind, G.A.
Roofing felt	Tear off	0.8 and 1.5	--	Two pickup men
		1.6	--	Tear-off machine operator
		1.4	--	Shovel man
		1.7	--	Tractor operator
		1.3	--	Chute man
PAINTS, COATINGS, AND SEALANTS				
Texture ceiling spray	Dry mixing	0.6-3.2	--	Canadian asbestos (Grade 7M0S)
		1.5-2.7	--	California asbestos (Calidria HPO)
	Spraying	0.8-1.6	--	Canadian
		0.5-0.9	--	California
	Spraying ceiling	0.1	70 minutes	Soya protein binder, 2% (by weight) asbestos
		0.5-0.8	14-15 minutes	Starch binder, 1% asbestos
		0.5	19-20 minutes	Starch binder, 1% asbestos
	Wiping walls after spraying ceiling	0.1	68 minutes	Soya protein binder, 2% asbestos
		0.2	22 minutes	Starch binder, 1% asbestos
		0.1	24 minutes	Starch binder, 1% asbestos
Texture wall spray	Spraying walls	0.3;0.8	51 minutes	Starch binder, 2% asbestos
		1.6	21 minutes	Starch binder, 2% asbestos
		1.1	12 minutes	Starch binder, 2% asbestos
		0.07	24 minutes	Starch binder, 2.5% asbestos
	Carrying hose during spraying	0.1	34 minutes	Starch binder, 2% asbestos
	Spraying glitter after ceiling	0.0	26 minutes	Starch binder, 2.5% asbestos
Plas-Tex ceiling texture (Hamilton)	Mixing	4.4	10 minutes	SIC 172, one sample
Texture wall and ceiling spray	Mixing	3.9	10 minutes	SIC 172, one sample
Coatings, cements, paints, and adhesives	Materials Application--laboratory-controlled tests	Nil	--	--
Exterior coatings--wall and roof spray	Spraying vertical wall panel	0.0	15 minutes	Vinyl latex binder, 3.7% asbestos
		0.2	12 minutes	Vinyl latex binder, 2.8% asbestos
		0.2	4 minutes	Acrylic latex binder
Roof spray (exterior coatings)	Spraying roof (downward)	0.0, 0.0	28, 14 minutes	Acrylic latex binder, 0.7% asbestos
Fibrated roof coating	Spraying on vertical steel surface	0.02, 0.03, 0.07, 0.11		Cutback asphalt binder, 8% asbestos
Emulsified-asphalt fibrated roof coating	Spraying on vertical steel surface	0.16	43 minutes	Steam-refined, emulsified-asphalt binder, 3% asbestos
	Spraying on vertical steel surface	0.17	23 minutes	Steam-refined, emulsified-asphalt binder, 3% asbestos
Alkyd resin-exterior paint	Spraying exterior wall of building	0.0	9 minutes	Alkyd resin, 12% asbestos
	Spraying exterior wall of building	0.06	5 minutes	Alkyd resin, 12% asbestos
Roofing and foundation	Application	Nil	--	--
Cements, sealing compounds	Application	Nil	--	--
Roofing compounds	Application	Nil	--	--

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
DRY WALL TAPING COMPOUNDS				
Gypsum board joint compound	Sanding	0.8	30 minutes	--
Tape joint compounds	Sanding (drywall finishing)	0.4-3.6	--	Samples from 7 locations (0.4, 1.0, 1.1, 1.3, 1.8, 3.4, 3.6)
	Sanding (drywall finishing)	8-hr TWA: 0.1-0.9	--	Samples from 7 locations (0.3, 0.4, 0.1, 0.9, 0.1, 0.6, 0.2)
Dry-mix tape joint compounds	Wet-out of dry-mix	1-60	--	Samples from 2 locations, 3 and 4 samples/location
Tape joint compounds; texture paint	Cleanup after sanding and spraying	5.5	--	Dry sweeping
		1.8	--	With sweeping compound
		0.3	--	Moist sweeping
Taping compound	Pole sanding	8 hr. TWA; 1.2-19.3	--	Range of 10 samples (5-12% asbestos), 1.0-1.5 m from source
		10.0	--	Mean (5-12% asbestos)
	Background	3.5-19.8	--	Range of 3 samples (5-12% asbestos), 2.5 m from source, same room
		8.6	--	Mean (5-12% asbestos) 2.5 m from source, same room
	Background	0.7-0.8	--	Range of 2 samples (5-12% asbestos), 7.5 m from source, adjacent room
		4.8	--	Mean (5-12% asbestos) 7.5 m from source, adjacent room
	Hand sanding	1.3-16.9	--	Range of 11 samples (5-12% asbestos), 1-1.5 m from source
		5.3	--	Mean (5-12% asbestos)
Joint compound	Sanding, 80 grit paper	0.81	20 minutes	All samples collected in breathing zone of worker
	Sanding, 80 grit paper	0.31	15 minutes	
	Sanding, 80 grit paper	0.55	25 minutes	
	Sanding, 80 grit paper	1.32	15 minutes	
	Sanding, 80 grit paper	1.75	15 minutes	
Taping compound	Applying and sanding in dry wall construction	3.64	1-2 hours (estimated)	Sampled throughout job
		1.95	1-2 hours (estimated)	Sampled throughout job
		0.57	1-2 hours (estimated)	Sampled throughout job
		3.42	1-2 hours (estimated)	Sampled throughout job
		2.99	1-2 hours (estimated)	Sampled throughout job
		0.83	1-2 hours (estimated)	Sampled throughout job
Pre-mixed joint compound	Sanding	5.0	21 minutes	One sample, Applied by tapers
	Sanding	5.0	29 minutes	One sample, Applied by tapers
	Sanding	5.0	19 minutes	One sample, Applied by tapers
	Sanding	1.5	16 minutes	One sample, Applied by tapers
	Taping (general air)	6.0	21 minutes	One sample, Applied by tapers, just after completion of sanding
	Sanding (general air)	1.0	49 minutes	One sample, Applied by tapers, sampler located 10-20 ft away
	Sanding (general air)	2.0	63 minutes	One sample, Applied by tapers, sampler located 20-30 ft away
	Sanding	10.0	13 minutes	One sample, Applied by tapers, sanding above sampler
	Taping and sanding	5.0	TWA	Two samples, Applied by tapers, 82-minute sampling period

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
DRY WALL TAPING COMPOUNDS (Cont.)				
Pre-mixed joint compound (Cont.)	Taping and sanding	3.4	8-hr TWA	Two samples, Applied by tapers, 82-minute sampling period
		4.0	TWA	Two samples, Applied by tapers, 35-minute sampling period
		2.9	8-hr TWA	Two samples, Applied by tapers, 35-minute sampling period
Dry wall all purpose joint compound Taping compound	Mixing	5.4	10 minutes	One sample; SIC 172
	Hand sanding			
	Background	2.1-2.5	8-hr TWA	Range of 2 samples (5-12% asbestos), 2.5 m from source, same room
		2.3	8-hr TWA	Mean (5-12% asbestos) 2.5 m from source, same room
	Background	1.5-7.1	8-hr TWA	Range of 2 samples (5-12% asbestos), 4.5 m from source, adjacent room
		4.3	8-hr TWA	Mean (5-12% asbestos) 4.5 m from source, adjacent room
	Dry mixing	35.4-59.0	8-hr TWA	Range of 2 samples (5-12% asbestos), 1-1.5 m from source
		47.2	8-hr TWA	Mean (5-12% asbestos) 1.5 m from source
	Background	0.5-13.1	8-hr TWA	Range of 3 samples (5-12% asbestos), 3-6 m from source, same room
		5.8	8-hr TWA	Mean (5-12% asbestos) 3-6 m from source, same room
	Background	2.1-3.1	8-hr TWA	Range of 2 samples (5-12% asbestos), 5-10 m from source, adjacent room
		2.6	8-hr TWA	Mean (5-12% asbestos) 5-10 m from source, adjacent room
	Sweeping floor	41.4	8-hr TWA	One sample (5-12% asbestos), 3-15 m from source, 15 minutes after sweeping
	Sweeping floor	26.4	8-hr TWA	One sample (5-12% asbestos) 3-15 m from source, 35 minutes after sweeping

Table 38 (Cont.)

Source of Fiber	Operation	Fiber Concentration (No./ml)	Sampling Time	Comments
MILLBOARD/INCOMBUSTIBLE BOARD				
Asbestos millboard (perforated)	Sawing and fitting	2.4	--	Mean of 9 samples, worker breathing zone
		0-10	--	Range
	Guillotining	0.1	--	Mean of 8 samples, worker breathing zone
		0.04-0.5	--	Range
Incombustible board--shipbuilding	Cutting (without exhaust)	100	--	--
	Cutting (with portable exhaust)	1.1-4.5	--	--
	Drilling (without exhaust)	1.0-1.9	--	--
	Drilling (with portable exhaust)	0.7-0.9	--	
Millboard	Sawing	0.7	--	Personal, portable circular saw with ventilation by baghouse
		0.5		Area, portable circular saw with ventilation by baghouse
Incombustible board Unveneered	Hand sawing	31.4		
	Hand sawing	13.8-44.8		
	Hand sawing, with dust extraction	3.4		
	Power handsaw	87		
	Power handsaw	>200		
	Power handsaw, with dust extraction	1.6		
	Power handsaw, with dust extraction	1.5		
	Bench saw	7,100		
	Bench saw	109-186		
	Bench saw, with dust extraction	4.5		
	Bench saw, with dust extraction	1.5		
	Power drill	1.9		
	Power drill, with dust extraction	0.9		
Incombustible board Veneered	Hand sawing	58.4		
	Hand sawing, with dust extraction	1.1		
	Power handsaw	63-109		
	Power handsaw, with dust extraction	1.7		
	Bench saw, with dust extraction	1.4		
	Power drill	1.0		
	Power drill	5.4		
	Power drill, with dust extraction	0.7		
DRILLING FLUID ADDITIVES				
Wet refined asbestos	Drilling fluid operations	0.3-0.4	TWA	Typical operation
		0.4-1.9	var.	Range of ceiling concentrations
		0.3-0.7	TWA	Simulated North Slope conditions
		0.4-5.5	var.	Range of ceiling concentrations
Oil-based drilling fluid additive	Introduction of uncoated fibers	<0.1-0.7	TWA	
		0.3-0.4	avg.	

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. 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. 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.

a. Asbestos Friction Materials

While asbestos friction materials are not employed directly in the construction industry, repair and replacement of these materials in brake linings and clutch facings of heavy construction equipment is often necessary on work sites.

The available data are very limited, but fiber counts of four samples show <0.5 fibers per milliliter for repair of brake linings (type unknown) and <2 fibers per milliliter for replacement of brake linings on heavy construction equipment (type unknown, number of samples unknown). While these values are low, they are inadequate to determine time-weighted-average exposure to laborers performing these operations. In addition, no ceiling concentrations or downwind concentrations are available.

Recommendations

As a minimum, site visits should be arranged to observe the above operations and to determine worker type performing the operation, duration of exposure, and frequency for different types of equipment.

Personal and area samples and fiber counts should be obtained at at least one location.

b. Siding and Shingles

The single value for shearing of siding and shingles is <2 fibers per

milliliter. Asbestos shingles are edge-wrapped and strapped during shipment and have prepunched nail holes. The installation procedure described previously notes that shearing and punching are performed on shingles at the end of a course and on those fitted around doors, windows, louvers, etc. It is unlikely that concentrations away from the shingle cutter would be as high as that in the breathing zone during shearing and punching. Hence, the time-weighted average for the worker installing shingles, including punching and shearing, should be less than 2 fibers per milliliter. Exposure of other workers in the area should be significantly less than 2 fibers per milliliter.

The one operation that is likely to result in a short-term ceiling concentration is cleaning off the crumbs that collect on and around the shingle cutter. No data are available for this operation.

Recommendation

Obtain fiber count data for one typical site where asbestos shingles are being installed.

c. Vinyl Asbestos Floor Tile--Sheet Floor Material

The installation of vinyl asbestos tile produces negligible airborne fiber concentrations since the asbestos fibers are encapsulated in vinyl and cutting with a knife is the only field fabrication technique. One practice employed prior to the installation of new sheet or tile floor covering was sanding to provide a suitable bonding surface. A pair of personal samples taken during belt sanding of a vinyl asbestos tile floor

resulted in fiber concentrations of 1.2 and 1.3 fibers per milliliter for a 20-minute sample. Since no general air samples or personal samples were taken during cleanup, the worker's time-weighted average-exposure cannot be determined.

Although sheet floor coverings contain no asbestos in the wearing surface, they are bonded to an asbestos felt backing. Installation of these materials is also expected to produce negligible airborne fiber concentrations. Since new flooring would not bond properly to sheet materials, tear-off of old sheet flooring was practiced, with subsequent sanding to remove the asbestos felt that adhered to the floor. Sanding could result in significant exposures.

Some changes by the manufacturers and contractors have been made to minimize exposures. Sheet material can be delaminated at the time of tear-off, i.e., the wearing surface can be removed, leaving most of the felt backing in place. With this practice, new sheet flooring can be bonded directly to the felt left in place. An alternative work practice that can be employed with either vinyl asbestos tile or sheet materials is to nail a nonasbestos-containing underlayment directly over the existing floor. New material is then bonded to the underlayment. When removal is necessary, the floor material is removed with the underlayment, and new underlayment is installed.

Recommendations

Obtain fiber counts for tear-off and sanding to remove asbestos felt to determine worst-case exposure. Installation work practices

presently employed are not expected to result in significant exposures. Fiber counts could be obtained for the present practices to confirm negligible worker exposure.

d. Asbestos Textiles

The fiber count data for asbestos cloth and amosite rope are from shipbuilding applications. However, these data have been included because of their possible relevance to identified construction activities. Asbestos rope is used in the cadwelding process for large reinforcing bars. Asbestos cloth is used for stress relief of large welds and as fire blankets.

While marine application of amosite rope resulted in a mean concentration of 112 fibers per milliliter, the construction application of asbestos rope resulted in less than 2 fibers per milliliter. The latter value is considered to be more representative of the construction industry. Ripping and application of asbestos cloth in shipbuilding are areas where changes in work practices and manufacturers' treatment of materials have resulted in significant reductions in exposure. Ripping untreated cloth produced counts as high as 16.5 fibers per milliliter with a mean of 7 fibers per milliliter. Treating the cloth reduced the upper limit of the range as well as the mean concentration to less than 1 fiber per milliliter. Similarly, new process applications reduced fiber concentrations to 0.2 to 1.5 fibers per milliliter compared with 5 to 10 fibers per milliliter for conventional application. No data are available for con-

ments where removals are being conducted as high as 171 fibers per milliliter (153 samples collected over workshift).

While demolition data are limited, they indicate fiber concentrations considerably lower than shipboard removals, perhaps because generally less confining operating areas are involved. A single short-term concentration measurement for removal of boiler insulation was 5.2 fibers per milliliter. Four short-term samples for removal of insulated ductwork ranged from 1.3 fibers per milliliter up to 32.0 fibers per milliliter. Some data for pipe-lagging removal indicate the importance of work practices. Dry removal results in concentrations greater than 20 fibers per milliliter. When water sprays were used, concentrations ranged from 5 to 40 fibers per milliliter. Removal after thorough soaking produced concentrations of 1 to 5 fibers per milliliter.

Available data are incomplete in terms of estimating worker exposures.

Recommendations

Obtain fiber-count data for various types of asbestos insulation removals during demolition operations noting worker type, work practices, and duration of exposures relative to the overall demolition job.

f. Asbestos-Cement Sheet and Pipe

Available fiber-count data indicate that the uncontrolled 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. The basic installation of these materials produces negligible exposure.

In the case of asbestos-cement sheet, work practices are such that persons applying the material are 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. Furthermore, the application of control devices has shown that fiber concentrations can be reduced to acceptable levels in the work area, and more importantly, in the worker breathing zone.

Asbestos-cement pipe, as noted earlier, is provided in various precut, straight lengths, and there are a variety of couplings and connectors that can be used. These features tend to minimize field fabrication. In general, machine operations are performed in the yard. Salvaging damaged pipe by cutting off broken portions is a fairly common yard practice. The use of machine tools for cutting and drilling asbestos cement pipe produces fiber concentrations similar to those measured for the same operations using asbestos-cement sheet. The control devices used for sheet fabrication can probably be applied with similar benefit in asbestos cement pipe fabrication.

Recommendations

Obtain samples for fiber counting for controlled and uncontrolled cutting and drilling operations on both pipe and sheet. Field fabrication of pipe should receive more emphasis than sheet because of the definitive data available for asbestos-cement sheet products.

g. Asbestos Felts

Review of the tabulated fiber counts for installation of asbestos roofing felts indicates negligible worker exposure. Tear-off operations, on the other hand, produced fiber concentrations ranging from 0.8 to 1.7 fibers per milliliter during one observed operation. Tear-off and installation are commonly performed by the same workers; hence, determinations of exposures would require weighting between installation and tear-off operations.

Recommendations

Obtain fiber-count data for tear-off of asbestos felt built up roofing, noting work practices.

h. Paints, Coatings, and Sealants

The dry mixing of asbestos containing texture coatings for walls and ceilings has produced measured fiber concentrations ranging from 0.6 to 4.4 fibers per milliliter over short time periods. Spraying walls and ceilings has resulted in airborne asbestos concentrations ranging from 0.1 to 1.6 fibers per milliliter, with most values reported being less

than 1 fiber per milliliter. Exterior application of asbestos-containing coatings resulted in concentrations lower than those measured indoors. Reported ranges are from 0.0 to 0.2 fibers per milliliter. Thus, the reported data indicate potential for minimal exposures during spraying and peak exposures during wet-out of dry materials of less than 5 fibers per milliliter.

Limited data for products such as roofing and foundations cements, and roofing and sealing compounds indicate minimal release of asbestos during installation. This result is expected because of the nature of the product matrix.

Recommendations

Review practices for wet-out of dry materials. Obtain samples for fiber counts during interior applications emphasizing wet-out practices.

i. Dry Wall Joint Compound

Wet-out of powdered compound, sanding of dry compound, and sweeping of floors after sanding have all resulted in relatively high fiber counts. Wet-out of dry compound has resulted in short-term concentrations as high as 60 fibers per milliliter. Time-weighted-average exposures for taping and sanding have ranged from as low as 0.1 fibers per milliliter to 5.0 fibers per milliliter depending on the time distribution of the work. Short-term concentrations during sanding range from several tenths of a fiber per milliliter to 19.3 fibers per milliliter. Sweeping and cleanup after sanding have produced ceiling fiber counts as high as 41.4 fibers per milliliter 15 minutes after completion.

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Manufacturers are producing premixed compounds that eliminate wet-out of dry powders as a potential source of exposure. During one site visit, it was observed that asbestos-containing compound was used only for the actual taping, the finishing compounds being nonasbestos. Another practice involved no sanding because of the texture finish to be applied to the walls. In many commercial and industrial facilities, only spot sanding is necessary because of the smooth finish that can be achieved by the worker.

There are some data that indicate how the use of modified practices during sweeping can reduce exposures. Dry sweeping resulted in 5.5 fibers per milliliter, while the addition of a sweeping compound reduced the count to 1.8 fibers per milliliter. Moist sweeping resulted in a further reduction to 0.3 fibers per milliliter, overall a factor of 18 lower than dry sweeping.

Recommendations

Additional site visits and discussions with workers are necessary to determine how widespread the use of premixed compound has become and what general work practices are with regard to finish coat sanding and cleanup. Sampling and fiber counting should be performed at at least one location.

j. Asbestos Millboard/Incombustible Board

Fiber concentrations are available for a variety of operations performed on these materials including sawing by hand and machine, guillotining, and drilling. Power drilling has resulted in measured counts as high as 5.4 fibers per milliliter, although most of the values are less than 2 for

uncontrolled operations. The provision of dust extraction reduces these levels to less than 1 fiber per milliliter. Power sawing without dust extraction or local exhaust has produced levels in excess of 100 fibers per milliliter. Levels can be reduced to less than 5 fibers per milliliter with either type of control. In one series of tests, guillotining, as an alternative method to sawing, produced concentrations ranging from 0.04 to 0.5 fibers per milliliter with an average value of 0.1 fiber per milliliter.

Recommendations

There have been no visits to sites where millboard or incombustible board were employed. If extensive use of these materials is practiced in construction, such visits should be arranged. The technology appears to be available to effect significant reductions in fiber counts, and the site visit would be primarily for confirmatory data.

k. Drilling Fluids

Fiber-count data for the addition of asbestos to drilling fluids indicate time-weighted-average exposures from less than 0.1 to 0.7 fibers per milliliter, with an average value of approximately 0.3 to 0.4 fibers per milliliter. During typical operations, a ceiling concentration of 1.9 fibers per milliliter has been measured. A set of measurements designed to simulate exposure under North Slope conditions resulted in a range of ceiling fiber concentrations of 0.4 to 5.5 fibers per milliliter.

Recommendations

Obtain samples and fiber counts for a typical site as confirmation of existing data.

1. Summary

Considerable data on work area concentrations of airborne asbestos dust in the construction industry exist for operations involving some classes of materials but, in many cases, very limited data are available on the use and handling of other products. It is often found that where fiber count data do exist, the concentrations are presented in the form of a mean value or a range based on several samples, with insufficient descriptions of specific worker activities and times of exposure to estimate time-weighted-average exposures. Very limited time-weighted-average data exist for exposures to asbestos in construction-related activities although some ranges and ceiling concentrations have been reported and are useful in determining which materials and operations may be contributing significant quantities of asbestos dust to the workplace atmosphere.

Due to the limited quantity of worker exposure data, additional sampling efforts are necessary to determine time-weighted-average and ceiling exposures due to activities associated with the handling of asbestos products in various construction trades. Table 39 lists the recommendations that would be necessary to evaluate these data, and emphasizes those materials and associated operations that may prove to be problem areas from the standpoint of high exposure levels. In several cases, additional sampling is suggested as a means of confirming areas that may not be problem areas based on existing fiber counts.

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Table 39

Summary of Conclusions and Recommendations

Class of Materials	Conclusions	Recommendations for Further Investigation
Friction materials	Data very limited; fiber counts <2 per milliliter	Site visits, sampling at one typical site
Siding, shingles	Only one fiber count sample available (<2 per milliliter); no data for dustiest operation	Measure exposures at a typical site during installation
Vinyl asbestos floor tile	Data very limited; minimal exposures expected; no data for tear-off operation	Perform sampling for tear-off and sanding operations
Asbestos textiles	No data for use of textiles in construction	Conduct site visits to determine the need for sampling
Insulation	Limited data available for removal in demolition operations and insufficient for determining worker exposures; some removal operations may cause significant exposures	Measure fiber concentrations during insulation removal for various types of asbestos insulations
Asbestos-cement sheet, pipe	Uncontrolled cutting or drilling may cause significant exposures; little data exists for pipe fabrication in the field	Sample both controlled and uncontrolled cutting and drilling of sheet and pipe, emphasizing field fabrication of pipe
Asbestos felts	Generally, only small exposures are anticipated based on existing data	Measure fiber counts for tear-off of layered felt roofing
Paints, coatings, sealants	Minimal exposures were found during spraying but wet-out of dry materials may cause elevated exposures	Obtain samples during interior applications, emphasizing wet-out of dry materials
Drywall joint compound	Wet-out of dry materials has caused significant exposures while dry sweeping has been associated with elevated dust levels; many compounds are available in a premixed form	Investigate extent to which premixed compounds are used; sampling should be performed at one location
Millboard/incombustible board	Low exposure levels are expected from the use of these materials when controls are used, but no site visits were made when these materials were in use	Make site visits if these materials are used extensively
Drilling fluids	Generally low time-weighted averages obtained for additional operations	A typical site should be sampled to confirm existing data

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