EVALUATION AND CONTROL OF ASBESTOS EXPOSURES IN THE INSULATING TRADE*

by

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It has been recognized for a number of years that insulating workers have an increased risk of asbestosis (Leathart and Sanderson, 1963; Marr, 1964; Selikoff et al., 1965; Ahlman, 1966; Keane and Zavon, 1966; Ferris, 1967; Kleinfeld et al., 1967; and others) and also that they exhibit a higher than expected incidence of lung cancer and other malignancies (e.g., Selikoff, 1964, and Dunn and Weir, 1965). During the past three years, we have had an opportunity to study intensively both the health status and the work practices and environmental exposures of men engaged in the insulating trade in the San Francisco area.

Medical findings will be reported subsequently in greater detail. In the present report, pertinent data will be summarized to verify the magnitude of the problem and to indicate the probability of such epidemiologic studies answering current major questions relevant to asbestos as a health hazard. We will then turn to the practical problems of describing environmental conditions in the trade and appropriate measures to correct them.

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Studies Directed Toward the Insulating Workers

Although information is being collected on more than 1,800 members of the International Association of Heat and Frost Insulators and Asbestos Workers who work in California, Washington, Oregon, and portions of Nevada, Arizona and Montana, the present report will be limited to those in San Francisco and adjacent areas. Local 16 of the union, whose official territory this is, has approximately 400 active members (See map). Its jurisdiction, however, does not cover shipyards operated by the U.S. Navy where there are small local unions but where union membership is not obligatory. The latter employ about 110 insulators in the San Francisco area.

Local 16 was organized in 1911. Like other local unions in the asbestos trade, it has been characterized by stability, excellent pay, pride in craftsmanship, and a strong father-to-son tradition. There has been a liberal pension plan since 1958 as well as a health and welfare program which provides comprehensive medical care by physicians and hospitals chosen by the individual members. Both these programs are jointly sponsored and controlled by union and management.

The local is the collective bargaining unit for insulating workers employed by private industry within its jurisdiction. Members may work for any one of the seven major insulating contractors in the area, or may be assigned by the union for work by other contractors as needed. Thus, one man usually works for many employers over a period of years and union records provide the only reference point for a study that has continuity.

Selection of Group for Study

Information was obtained from union records on all men who were members of the local at any time during the period January 1, 1946, through December 31, 1965. Information on deaths, lapses, withdrawals, retirements, transfers, new members, returns to activity and transfers in or out were collected and used to develop a picture of the work force available for study. There were 161 active insulators as of January 1, 1946; 433 entered during the period until 12/31/65, while 214 left the population for various reasons. Thus, 594 individuals were active members at some time or another during the 20-year period, with active membership ranging from 161 in 1946 to 380 in 1966 (Table 1).

Chart 1 summarizes the time of entering the insulating trade of the 594 men available for study. Only 91 (15%) started before 1936; so this is the maximum number who could possibly have reached 30 years of observation by 1966. Actually, only 72 individuals with this much exposure were observed. The influx of craftsmen during World War II shipbuilding raised new members to the point that a total of 290, or 49%, had joined prior to 1946. Thus, nearly one-half could have had 20 or more years of observation by 1966 and 250 of those under observation had passed 20 years since joining the trade. These figures are important in interpreting current findings, particularly with respect to malignancies with long latent periods.

All men with 30 years since joining the trade have worked in the shipyards, the majority having worked there for 5 or more years. Of those with over 20 years in the trade, less than 1% have never worked in the shipyards. Only when one comes to men who have joined the trade since 1945 do we encounter significant numbers with no shipyard experience.

Evidences of Asbestosis in the Group

There has been a program of voluntary annual chest roentgenograms for all active and retired members since 1957. Films have been taken by any one of several radiologists selected by the Administrator of the Health and Welfare Plan who kept films and interpretations in a central file.

Approximately 1,500 films, taken over a 10-year period, have been reinterpreted, without prior knowledge of work histories, symptoms, or other information. Films with definite or doubtful changes have been independently reviewed by a radiologic consultant who is participating in the UICC-USPHS asbestosis classification project.

For purposes of the present report, negative films were those with no evidence of increased linear or nodular shadows, nor thickened, distorted, or calcified pleura or pericardium. Definite changes consistent with asbestosis included increased linear markings or definite evidence of thickened, distorted, or calcified pleura. Where findings were equivocal including minor pleural changes such as obscured costophrenic angles or questionable parietal thickening, changes were called doubtful.

Excluding all men who died or were lost from the union by transfer or leaving the trade prior to institution of the x-ray program in 1958, there were 480 eligible for films. Of these, 386 took advantage of the opportunity to the extent of having had at least one film. Table 2 illustrates the participation and distribution of those with definite roentgenographic changes, grouped by period of entering trade.

Table 2

Period of Entering Trade	Number Available for Films	Number Having Film(s)	Number with Definite Changes Consistent with Asbestosis Number	%
1906-10	0	0	0	——
1911-15	2	2	2	100%
1916-20	8	5	5	100%
1921-25	7	3	2	67%
1926-30	19	13	8	62%
1931-35	17	13	6	46%
1936-40	49	41	17	41%
1941-45	117	101 178	33 73	33%
1946-50	61	47	12	26%
1951-55	69	57	5	9%
1956-60	74	55	2	4%
1961-65	57	49 209	1	2%
Total	480	386	93	24%

Pleural changes predominated over parenchymal. Including individuals in whom there was evidence for both types of change, 41, or 44%, had definite parenchymal and 79, or 85%, had definite pleural abnormalities.

Calcified pleural plaques were demonstrable in 17 individuals, all of whom had been in the trade for 20 years or more. Nine of the 36 individuals examined who had joined the trade prior to 1936 showed definite calcification. As will be pointed out in analyses of mortality, four deaths from cor pulmonale associated with pulmonary fibrosis were reported over the 20-year period from 1946 to 1965.

Mortality Analysis

There have been 72 known deaths in the group of 594 men during the period 1946-1965. Death certificates have been obtained for 64. Table 3 summarizes current information on causes of death for the entire group and for the 250 individuals in whom 20 years or more had elapsed since their joining the trade, either at the establishment of the 1946 cohort or subsequent to that date. All of the 14 deaths from lung cancer occurred in those with 20 years or more since joining the trade. Expected rates were based on California mortality rates for white males, the 1949-50-51 rates being applied for the years 1946-55, and 1959-60-61 rates for the years 1956 through 1965. Observed lung cancer deaths were 7.87 times expected. Two of the deaths from tumors of the respiratory tract were due to pleural mesothelioma. No peritoneal mesothelioma have been reported. Two malignancies of the gastro-intestinal tract (one of stomach and one of colon) have occurred. Four deaths from cor pulmonale and pulmonary fibrosis were included in the cardiovascular renal category in men with 45, 41, 27, and 21 years in the trade respectively.

Table 3

Analysis of Deaths in Study Group
(January 1, 1946 through December 31, 1965)

Cause of Death	Total Population of 594	In 250 Men with Over 20 Years in Trade	
	Observed	Observed	Expected
Malignant Neoplasms (140-205)	13	16	2.54
Digestive system (150-159)	2	1	
Respiratory system (160-164)	14*	14*	1.73
Other & Unspecified	2	1	
Major Cardiovascular Renal Disease (330-334)	30**	18**	19.09
Violent Deaths (300-389)	11	6	
All other causes	5	4	
Not Known	3	5	
	72	49	35.13

1. International Classification of Diseases. 7th Edition, WHO, Geneva, 1957.
* Includes 2 pleural mesotheliomata
** Includes 4 cor pulmonale

Smoking histories are inadequate on many of the early deaths; and meaningful analysis related to this will be possible only with prospective observations. The possibility of useful data is enhanced by the relatively low smoking rate for those currently working. In the half of the current population so far interviewed on this:

Table 4

Never Smoked Cigarettes	16%
Stopped Smoking (at least one year)	36%
Currently Smoke Cigarettes	43%

Whether this is the result of active campaigns against cigarette smoking in this trade, we do not know. If the pattern persists, prospective studies on the interrelations between smoking and malignancies should be of great interest during the next decade.

The foregoing data confirm that insulating workers in San Francisc resemble similar workers in New York and New Jersey and in the United Kingdom in their risk of both asbestosis and lung cancer. What are the prospects of better defining etiologic factors and reducing the risk through environmental studies?

Environmental Studies

General. The insulating worker, or lagger, handles a variety of insulating materials, described below, in jobs that range from commercial and major industrial construction to marine construction and repair. Most insulators are trained and qualified in all phases of their craft and for all materials. Some specialize, but over the years a great variety of jobs is the rule.

We have found it convenient to classify jobs under two major headings: (1) light and heavy industrial construction, which includes covering pipes and ducts in office and factory construction as well as applications of insulating materials to boilers, cracking towers and steam turbines; and (2) marine construction and repair, which involves application of insulating materials to pipes, ducts and boilers in ships, but because of the more rigid specification of materials and their use in predominantly confined spaces and special difficulties in ventilation deserves to be regarded separately.

The insulator's job when working with asbestos containing materials can be divided into 6 general operations: (1) the prefabrication of materials (10% of his time), in which molded pipe covering or blocks are cut and shaped to fit, using either hand or power tools. (2) Application (about 40% of his time) includes fitting, hammering into place, carving, and/or attaching materials by wire or glue. (3) Finishing (30% of his time) where insulating materials are coated with asbestos containing cement, resins, asbestos, or cotton cloth, or petroleum-based sealers. (4) Tearing out (10% of his time) where old insulation is removed or unusable materials are taken off prior to reinsulation. (5) Mixing (5% of his time) in which asbestos fibers, fibrous glass, mineral wool and cements are mixed in various combinations in buckets or troughs or in automatic mixing machines. (6) General work occupies the remaining 5% of his time and includes cleaning up of old insulation, transporting materials and moving equipment. The foregoing are averages based on timing many workers during many jobs using asbestos containing materials. Obviously, they vary from situation to situation; new construction for example would not involve tearing out. At present, less than half the lagger's time is spent with work involving the use of asbestos materials; our current estimate is 45%.

Insulating Materials Used

Asbestos containing insulation materials were introduced into California in the early 1920's, with Canadian chrysotile being used in most products. After the United States Navy accepted amosite asbestos in the mid-1930's, amosite gradually became the predominant type of asbestos used. It was used both to make amosite blankets and in combination with chrysotile in the manufacture of molded insulation materials (Magnesia and Asbestos). Marine construction and repair created the major demand for this type of insulation during the early 1940's. The use of amosite as the predominant asbestos fiber used continued until soon after 1960 when chrysotile was reintroduced into some molded products. (Chart 2). The use of pure amosite blankets has now nearly ceased. Today, molded insulation materials, which contain 10-15% by weight of asbestos, may have pure chrysotile, pure amosite, or a mixture of the two. The 85-90% is usually calcium silicate, made by mixing amorphous diatomaceous earth with lime and curing with heat. This heating is not sufficient to convert the diatomaceous earth to cristobalite. Crocidolite and anthophyllite are not used in insulating materials in our area.

Only about 40% of the insulating materials now being used are asbestos containing fibrous glass is widely used, accounting for 45 to 50% of insulating material applied in San Francisco. The glass most widely used has a fiber diameter greater than 4 microns, but some speciality materials are in the

1 to 2 micron range.

Other materials, which occupy about 10% of the average insulator's time, include the use of foam glass, cork, rubber, polystyrene and polyurethanes. He also has potential dermatologic and inhalation problems associated with solvents, adhesives, and coating materials.

Environmental Surveys

The dust exposures associated with various phases of the trade were appraised using samples collected by midget impinger and by membrane filter. For the midget impinger counts, methods used were those described in Public Health Service Bulletin No. 217, with 95% ethyl alcohol as the sampling medium. Sampling times ranged from 10 minutes to 30 minutes representing a maximum sample volume of 3 cubic feet.

Millipore type AA filters for the stated pore size 0.8 micron were used in filter holders, 37 millimeters in diameter with an approximate surface area of 850 square millimeters. These were used with either Casella or MSA battery operated personal samplers, with sampling rates of 1.8 - 2.2 liters per minute. The personal samplers were worn by insulators, while at work, over periods ranging from 30 minutes to 2 hours. Fibers were counted by a modified technique of the USPHS, in which a segment was cut from the filter and placed face up over a drop of 50% dimethyl phthalate and 50% diethyl oxylate, and a cover slip applied. The counting field was defined by a graticule using phase contrast illumination with a 4 millimeter (43x phase contrast objective). Fibers defined as particles having a 3:1 or greater length to width ratio were counted and placed in the following categories: less than 3.5 microns in diameter and less than

5 microns in length; less than 3.5 microns in diameter and more than 5 microns in length; more than 3.5 microns in diameter and less than 5 microns in length; and more than 3.5 microns in diameter and more than 5 microns in length. The 3.5 micron diameter cutoff was chosen because of Timbrell's calculation indicating probable respirability of fibers below that stated diameter.

The minimum fiber diameter routinely counted by this method approximated 0.2 microns.

Dust Counts

A total of 197 midget impinger and 102 membrane filter samples collected in breathing zones while asbestos containing materials were in use are summarized in Tables 6 and 7. Variations in materials, jobs, individual's work habits, other construction activities nearby, temperatures, humidity, air movement, complicated the strategy for environmental appraisal. Samples were in most situations deliberately taken under conditions where the highest dust concentrations representative of a particular job were being developed. Midget impinger samples were taken during the course of the collection of the membrane filter sample for the same man and operation. Comparison of this data did not yield useful correlations between the counts obtained by midget impinger and membrane filter.

It is of interest that time-weighted averages were not unusually high and that current TLV recommendations in the United States for asbestos containing dust (5 million particles per cubic foot) would not have been exceeded, even for a man working 100% of his time with asbestos. The fact that most men work less than half of their time with this material would be an added safety factor. Figures 3 and 4.

Fiber counts similarly were not found to be as high as anticipated. Those in industrial operations averaged within a range that would be categorized as <u>medium</u> by British standards. <u>Figure 5</u>. Those for marine construction and repair were somewhat higher. <u>Figure 6</u>

The clearcut evidence of pneumoconiosis and increased lung cancer make it obvious that these workers have had exposures that cannot be tolerated. Retrospective analysis at this time cannot differentiate effects of (1) peak surges as contrasted with time-weighted averages and (2) the possibility that exposures, particularly in marine construction were higher in the period preceeding and during World Warr II than they are now. We have no evidence, however, to support the latter point. Ferris <u>et al</u> have reported comparative studies done in New England shipyards in 1940 and 1965 using similar instrumentations which indicate no significant reduction in average dust counts, which had not been found to be excessively high in 1940. These findings suggest that a prudent course would be to lower threshold standards and improve present work practices.

<u>Industrial Hygiene</u>

Successful reduction of environmental exposures necessitates a combination of industrial hygiene measures, which must be taken seriously and forcefully implemented. Methods to consider include: (1) substituting less hazardous materials; (2) enclosing certain work areas; (3) providing local exhaust ventilation; (4) requiring personal respiratory protection; (5) changing work habits and improving general housekeeping. These points will be taken up in turn.

Substitution of materials, particularly fibrous glass, has been going on for many years, although not for health reasons. In marine and heavy industrial work, there is, however, no suitable substitute for asbestos insulating products, which have actually been increasingly used in our area in recent years because of the increase in heavy industrial construction. Unless it could be shown that asbestos cannot be used safely, abandoning it or prohibiting it would be a drastic recommendation. In our opinion, efforts to use it safely have not yet been vigorously tried.

Enclosing operations entirely or partially is appropriate for prefabrication of fittings and blocks. Muds and cements should be mixed in enclosed booths or automatic mixers and carried to work sites in containers that would prevent evaporation.

Local exhaust ventilation at application sites is impractical in most situations. Large power boiler and steam generator operations could, however, use local exhaust systems since there work often remains in one location for many hours or weeks. Ultimately, it will probably be found practical, even essential, to ventilate more energetically in marine construction and repair, not only to prevent intolerable dust concentrations but also to ameliorate extreme temperature and humidity conditions under which work is being performed. The technical problems to do this can be solved.

Personal respiratory protection is an important adjunct to other measures. Present masks are not worn regularly, even when provided, because they are hot, uncomfortable, increase the effort of breathing, and interfere with communication. Many filter materials, despite their high resistance, do not adequately filter out fibrous materials. Research leading to the development of better-fitting, low-resistance, fiber-removing masks is imperative. In some situations, the insulating worker may have to depend upon a supplied air system; but because of the need for hose and compressor, its usefulness is limited. Personal air supplied respirators with their own power units would be more versatile and could be used for some particularly dusty exposures such as tearing out aboard ship. Inasmuch as fitting and maintenance of masks is recognized as essential if personal respiratory protection is to be effective, the independent nature of many insulators' work makes it unrewarding to think in conventional terms. The idea of an efficient but cheap throwaway mask is being explored by some.

Changing work practices offers great potential. Examples include increased use of properly designed premolded and cut fittings, the use of water sprays to wet material before cutting, the enclosed mixing of muds, the use of industrial vacuum systems for cleaning up and when tearing out.

It is believed that a combination of all the foregoing, properly planned and tailored to meet the different requirements of the many and varied jobs the insulator must do, could drastically reduce his exposures. It would also protect the members of many other trades who work near the insulator and who are subject over the years to dust created and dispersed throughout construction sites.

Discussion

The pattern of incidence of asbestosis and the nearly 3-fold ratio between observed deaths from cancer of the lung and pleura and the number expected are in general agreement with other studies of insulating workers. Thus, Selikoff et al. found 6.8 times the expected number of respiratory cancer deaths and Kleinfeld et al., 3.4 times, quite similar to our finding of 7.9 times. Our population was exposed to both chrysotile and amosite. There is no evidence that they have ever had significant crocidolite exposure. Prospective studies may develop patterns that relate to the changing usage of chrysotile and amosite; but the use of various combinations of types and the variable latency of tumors make it unlikely that these causative factors can ever be satisfactorily separated.

The relatively large number of currently employed insulating workers who have never smoked cigarettes or who have quit for at least 1 year provide an extremely valuable population for prospective study relating to the interaction between asbestos and cigarette smoking (Selikoff, 1967).

Existing dust levels, whether measured by midget impinger or fiber counts from membrane filters, were not as high as had been anticipated. The time-weighted averages were within the present threshold limit value of 5 million particles per cubic foot, even for men working fulltime with asbestos. In reality, most men work less than half of this with such materials. Fiber counts were on the average between 2 and 10 fibers/cc. Nevertheless, there was evidence, as pointed out above, for both asbestosis and excessive tumor incidence. The possible explanations are (1) exposures in the past were much higher; (2) the peak dust and fiber counts are more important than the averages; (3) there are other substances present in insulating materials which augment the asbestos effect; and (4) our present permissible levels are too high; and (5) the shipyard exposures during the period 1940 to 1945, being largely amosite and continued at rather high levels over several years, may be major contributors to the present situation.

In our opinion, in the absence of any evidence that work practices have changed sufficiently to blame present asbestosis on extreme conditions in the past and uncertainty as to levels necessary to reduce cancer rates, we think it is prudent that insulating workers not be permitted to work under any conditions that exceed 5 mppcf by midget impingers and that industrial hygiene and personal protective equipment be geared toward these objectives. Due to the changing work sites and relatively independent nature of the insulating workers, providing adequate industrial hygiene is difficult. Our experience suggests that at least in the United States joint union-management programs will be necessary for the education of workers and contractors and for the effective implementation of rules for satisfactory work practices.

A medical program to maintain appropriate surveillance over insulating workers should include periodic chest films and estimates of pulmonary function, the latter for comparative purposes, and to detect other respiratory disease upon which even minor asbestosis would be disastrous. The effective early detection of lung cancer is a discouraging problem at present. It is our conviction that sputum cytologic study needs much further application and study than it has here-to-for received.

Summary

The working environment and health status of insulating workers in the San Francisco area and in several other metropolitan areas of the Western United States were studied during the period 1965-67. The installation of insulating materials in these areas is done by members of a single international union with a stable membership now numbering approximately 1,800 men. Their job assignments can be classified as heavy and light

industrial and marine construction and repair. Major insulating materials used are asbestos containing (45%); fibrous glass (45%); with foam glass, cork, and other materials accounting for only 10%. During the past twenty years, amosite has been the predominant type of asbestos; but chrysotile use is again on the increase. No crocidolite has been used. Added environmental problems arise from adhesives, noise, and heat exposures. Work patterns have been analyzed and show that most men now in the trade have performed in all major job classifications and have used all basic materials. Dust concentrations were studied by midget impinger and membrane filter sampling. The former indicated time-weighted averages in nearly all work situations below the present threshold limit value of 5 million particles per cubic foot. Nevertheless, there are roentgenographic changes consistent with asbestosis in 25% of the membership, ranging from none in men under 10 years in the trade to over 50% in those with over 30 years in the trade. The incidence of cancer of the lung and pleura during the period 1946 to 1965 in men with over 20 years since joining the trade was 7.9 times expected. Two deaths from pleural mesothelioma occurred in 1963 and 1964 in men with 43 and 46 years since joining the trade. Recommendations are included for improved industrial hygiene, relating to work practices and respiratory protection, for medical surveillance, including periodic sputum studies.

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Table 1

Active Members as of January 1, 1946	161
Entered to December 31, 1965	433
Total in Population	594
Less Those Who Left	214
Active Members as of December 31, 1965	380

Table 2

Period of Entering Trade	Number Available For Films	Number Having Film(s)	Number with Definite Changes Consistent with Asbestosis Number	%
1906-10	0	0	0	----
1911-15	2	2	2	100%
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1921-25	7	3	2	67%
1926-30	19	13	8	62%
1931-35	17	13	6	46%
1936-40	49	41	17	41%
1941-45	117	101	33	33%
1946-50	61	47	12	26%
1951-55	69	57	5	9%
1956-60	74	55	2	4%
1961-65	57	49	1	2%
Total	480	386	93	24%

ANALYSIS OF D. IN STUDY GROUP
(January 1, 1946 through December 31, 1965)

Cause of Death	Total Population of 594	In 250 Men with Over 20 Years in Trade	
	Observed	Observed	Expected
Malignant Neoplasms (140-205)	18	16	2.54
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Respiratory system (160-164)	14*	14*	1.78
Other & unspecified	2	1	
Major Cardiovascular Renal Disease (330-334)	30**	18**	19.09
Violent Deaths (800-889)	11	6	
All other causes	5	4	
Not Known	8	5	
	72	49	35.13

1. International Classification of Diseases. 7th Edition, WHO, Geneva, 1957.

* Includes 2 pleural mesotheliomata

** Includes 4 cor pulmonale

<u>Table 4</u>

Never Smoked Cigarettes	16%
Stopped Smoking (at least one year)	36%
Currently Smoke Cigarettes	48%

Table 5

The Insulator's Job

Prefabrication	10%
Application	40%
Finishing	30%
Tearing Out or Replacing Work	10%
Mixing	5%
General	5%

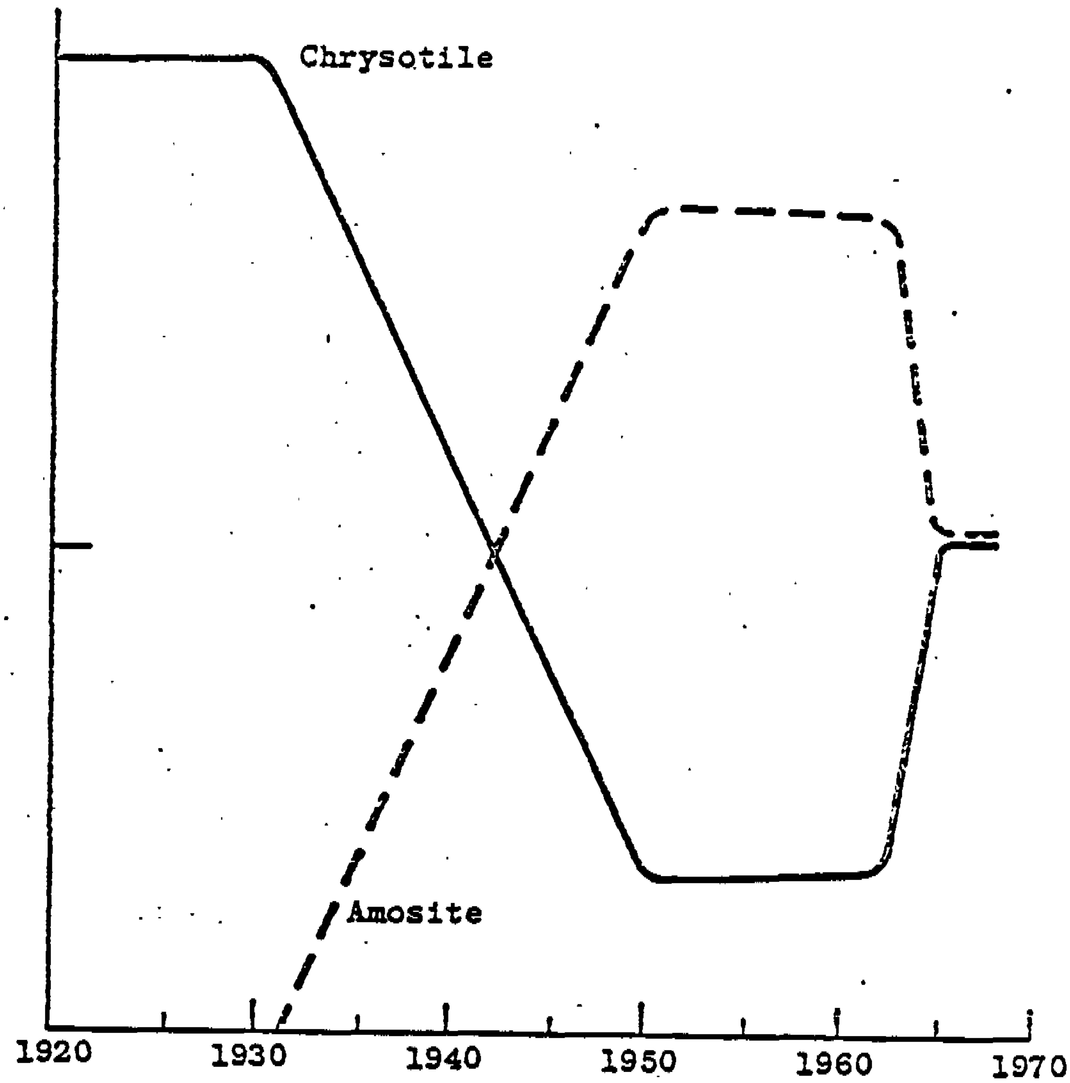
Midget Impinger Dust Concentrations by Job Classification

Job Classifications	Light and Heavy Industrial			Marine Construction and Repair		
	Number of Samples	mppcf		Number of Samples	mppcf	
		Mean	Range		Mean	Range
Prefabrication	21	4.1	0.8-14.0	14	9.2	1.4-28.8
Application	24	2.4	0.4-7.5	19	3.4	1.6-5.9
Mixing	17	4.4	0.9-9.8	15	8.3	1.9-29.0
Finishing	21	1.4	0.2-3.9	20	2.6	0.1-6.2
Tearing Out	17	4.5	1.0-8.6	15	9.1	4.8-28.0
General	24	0.77	0.2-1.8	14	1.2	0.5-1.8

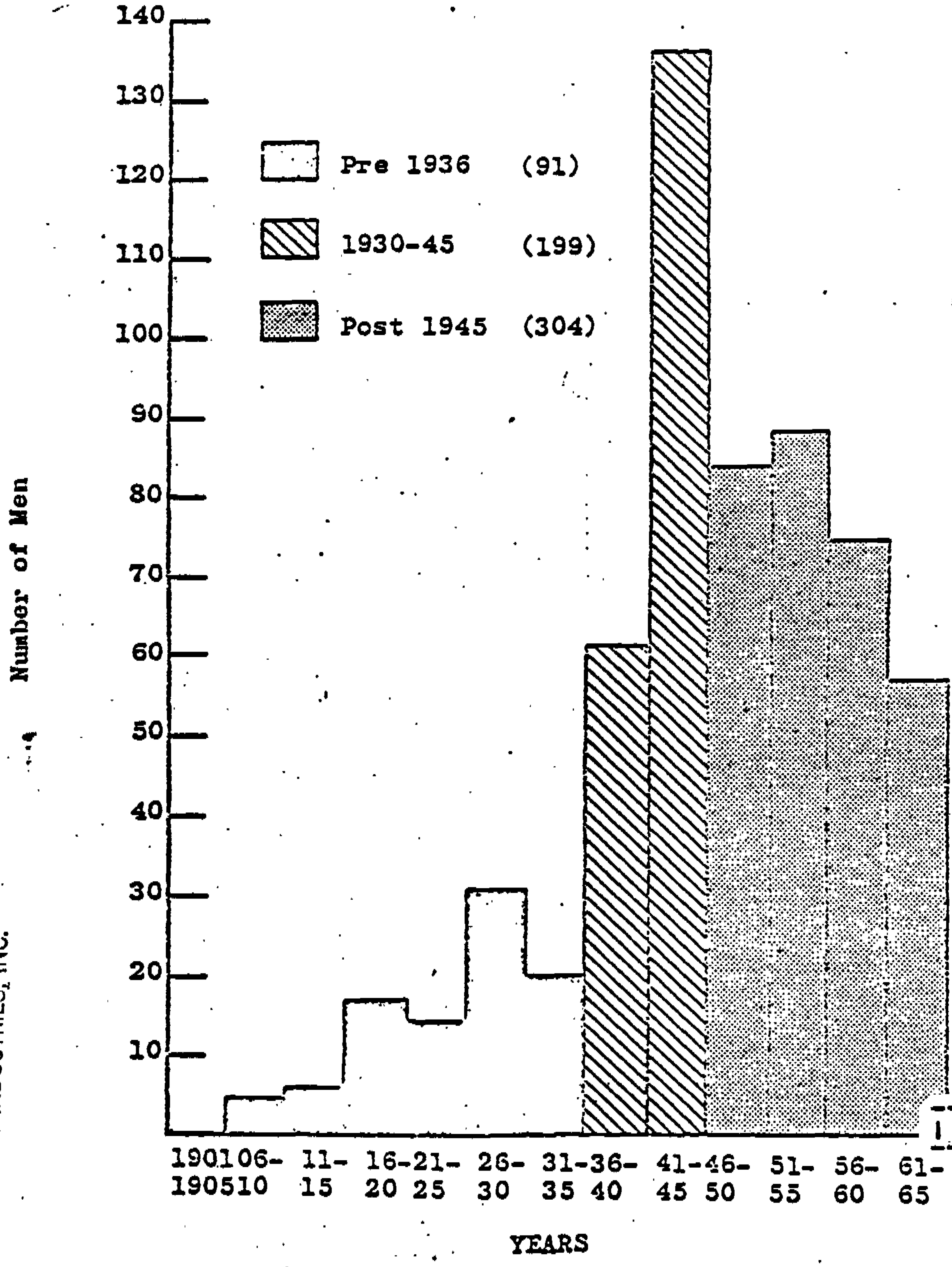
MEMBRANE FILTER FIBER CONCENTRATIONS BY JOB CLASSIFICATION

Job Classifications	Light and Heavy Industrial				Marine Construction and Repair			
	Number of Samples	Fibers/cc Mean		Range	Number of Samples	Fibers/cc Mean		Range
		All Lengths	Length >5µ			All Lengths	Length > 5µ	
Prefabrication	23	10.1	6.6	1.6-19.4	7	30.4	20.0	3.5-100
Application	36	3.1	2.0	0.2-18.3	25	6.2	4.2	0.2-47
Mixing	17	4.7	3.1	0.1-19.4	19	21.2	14.2	0.7-120
Finishing	19	0.9	0.6	0.1-6.3	18	0.6	0.4	0.2-1.3
Tearing Out	8	12.8	8.4	1.2-49.3	14	31.5	20.3	1.4-126
General	16	1.6	1.0	0-14.0	19	0.3	0.2	0-2.9

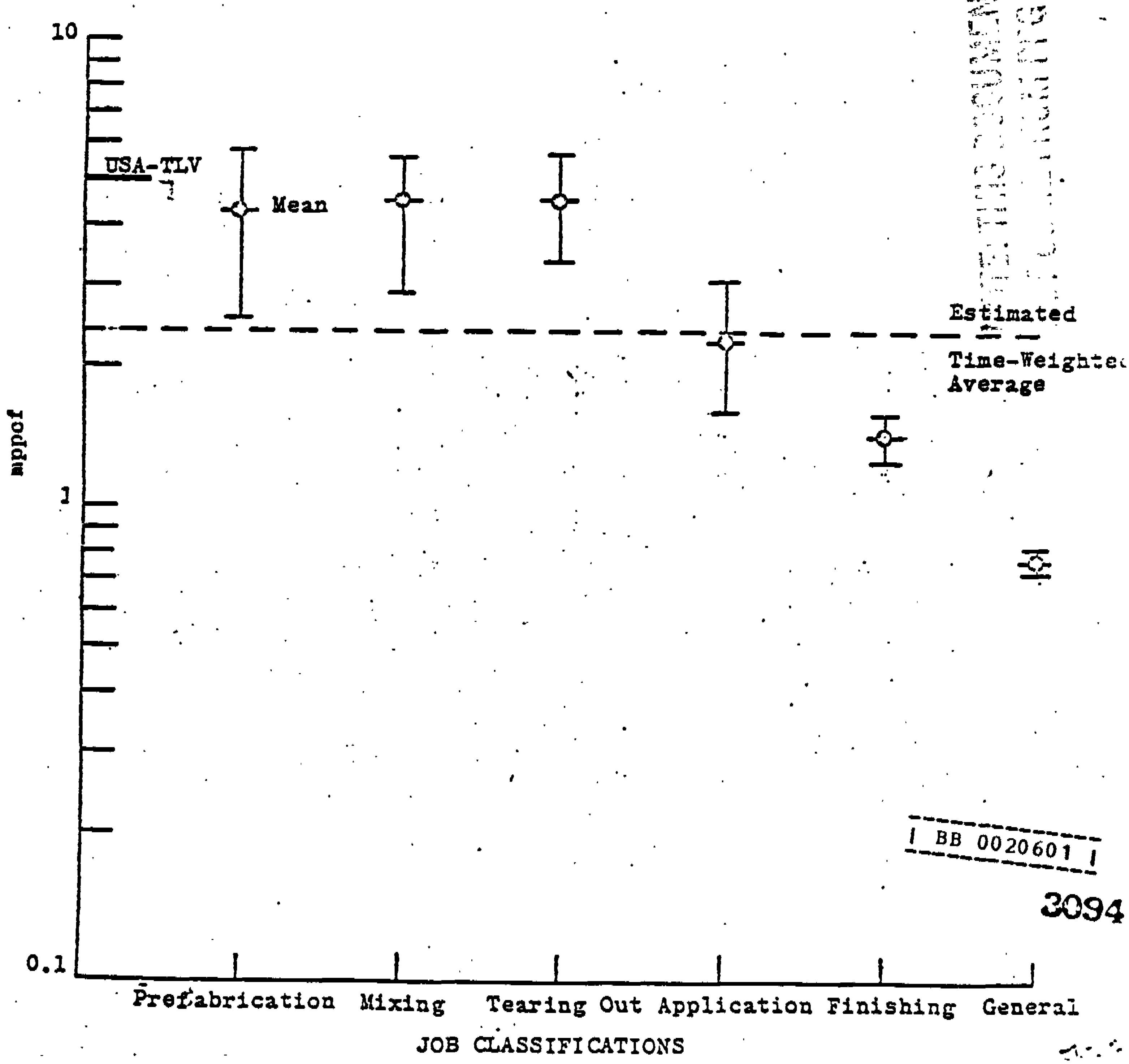
Relative Use of Chrysotile and
Amosite in Insulation Products
In the Western United States.



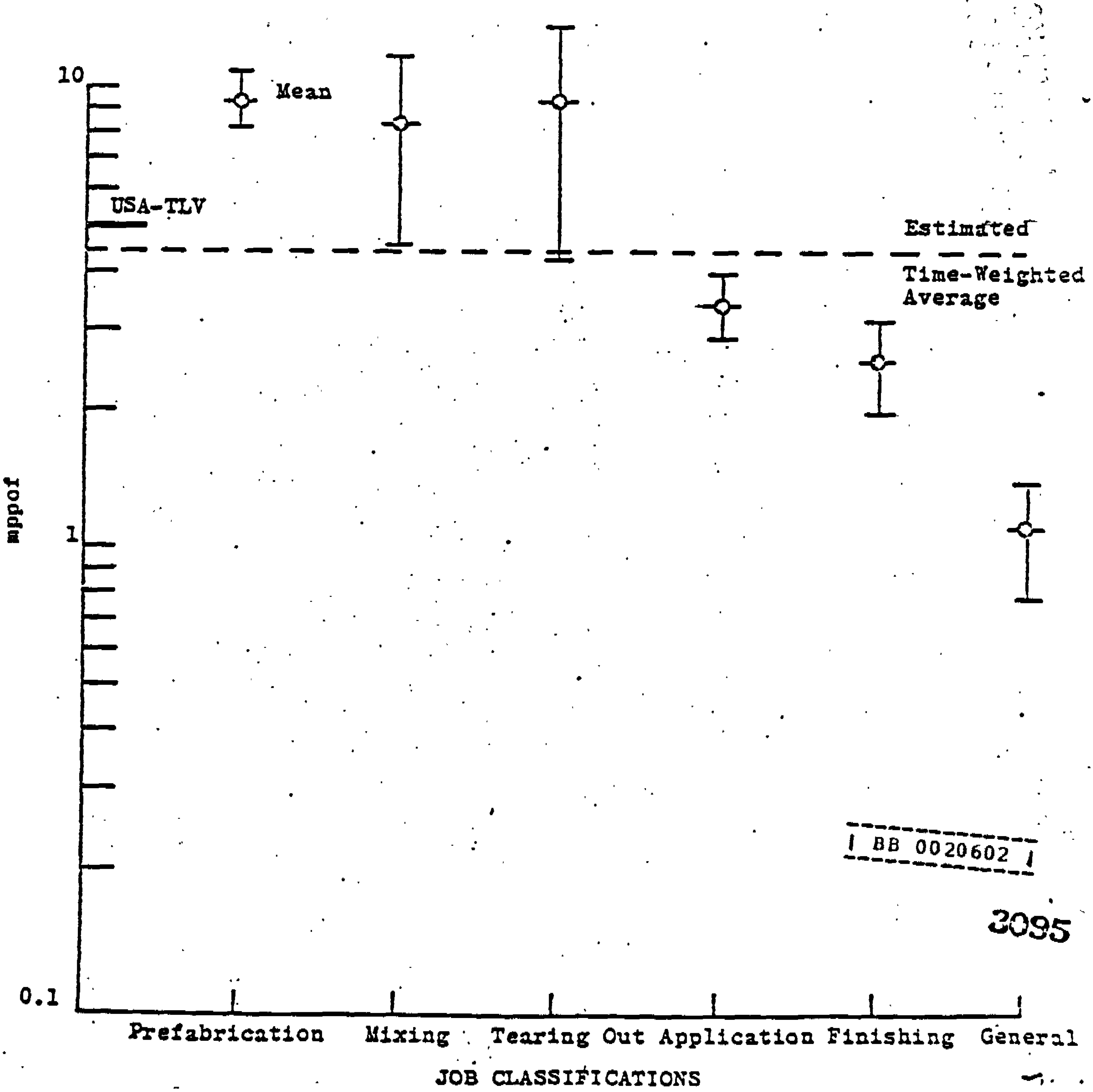
Insulating Workers in Local 16 During 1946-65.
Grouped by Years They Entered Trade.



Midget Impinger Counts in Light and Heavy Industrial Construction by Job Classification (95% Confidence Interval)



Midget Impinger Counts in Marine Construction and Repair by Job Classification (95% Confidence Interval)



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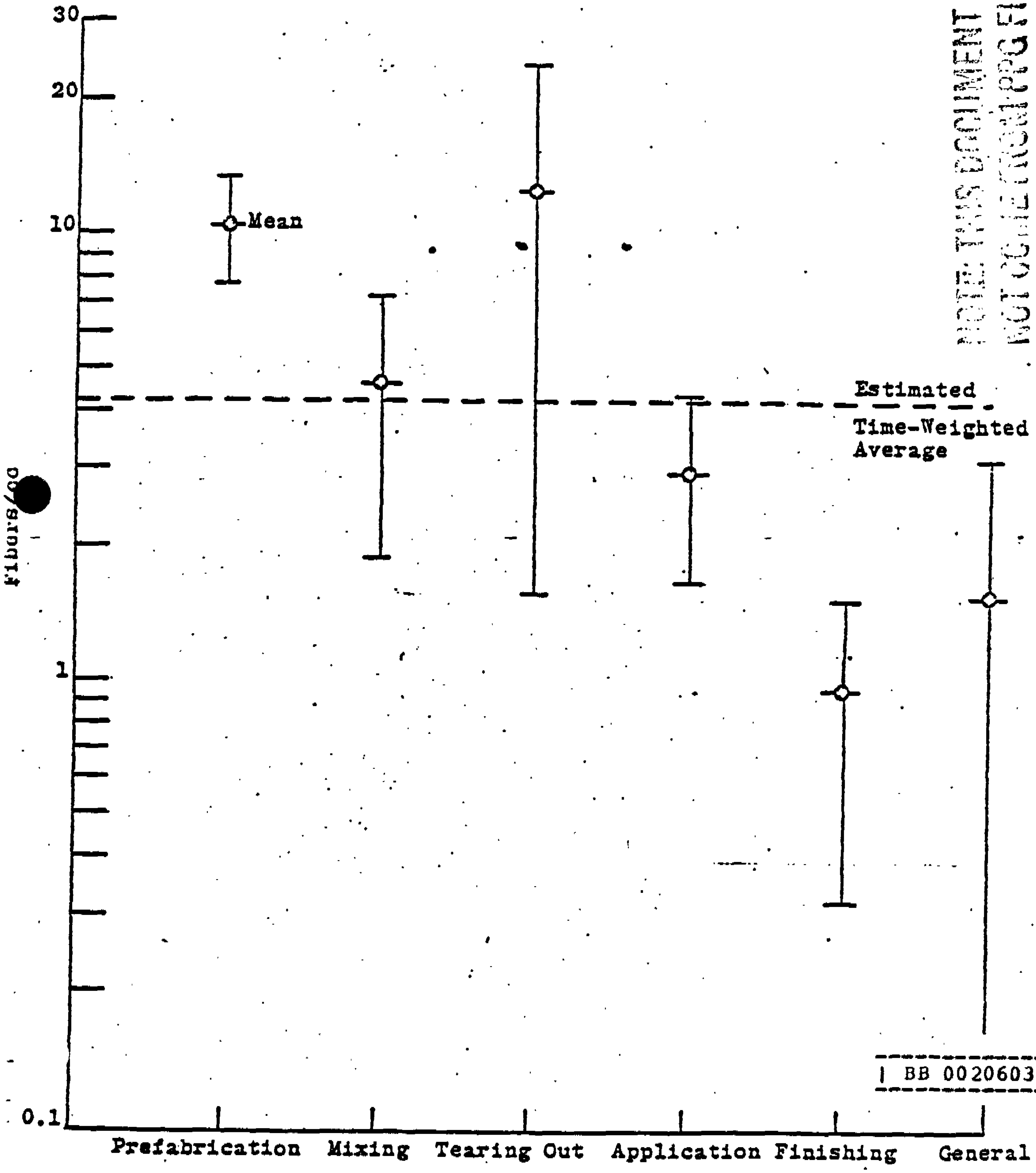
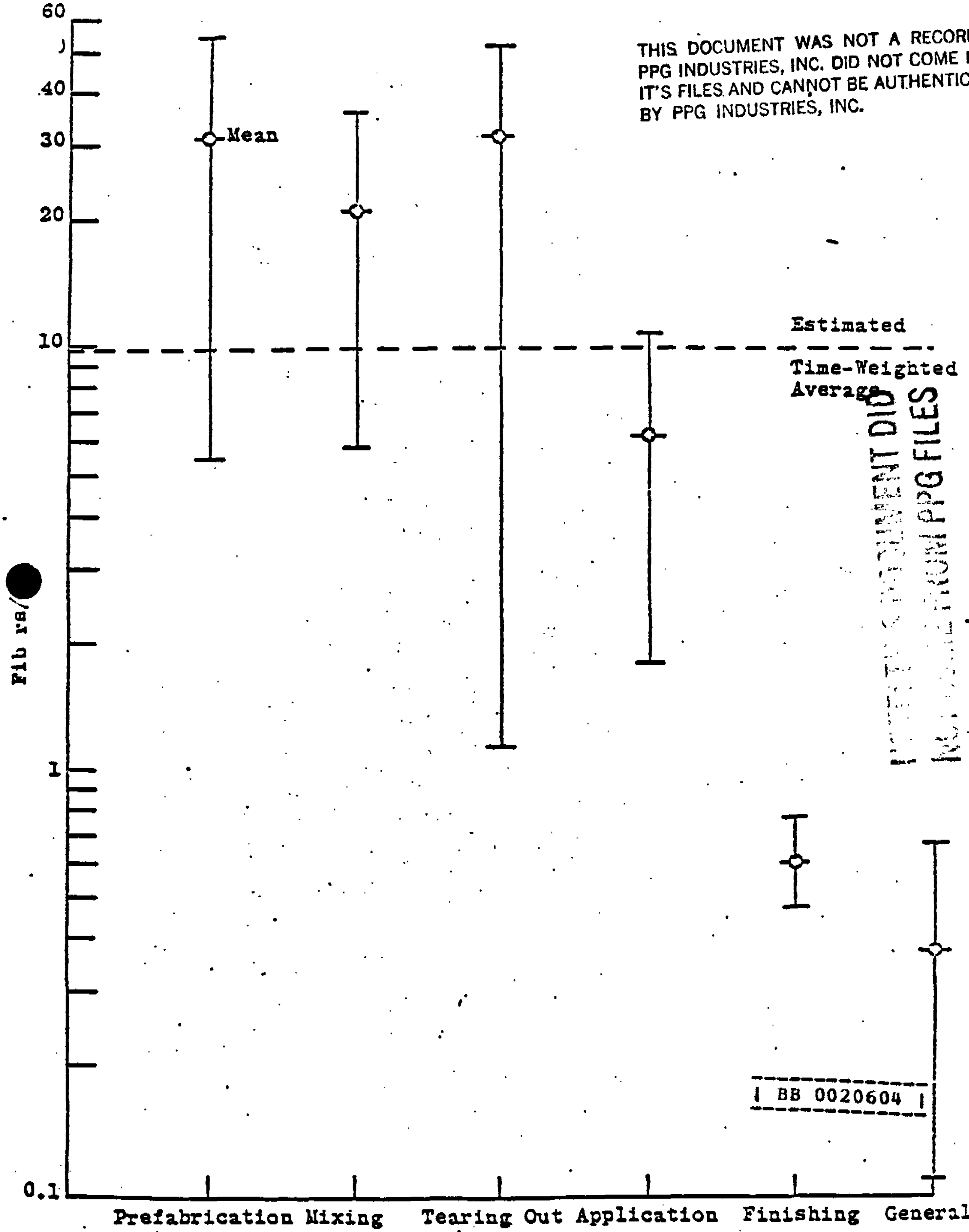
Fiber Counts in Light and Heavy Industrial Construction by Job Classification (95% Confidence Interval)



Fiber Concentrations in Marine Construction and Repair by Job Classification (95% Confidence Interval)



JOB CLASSIFICATIONS