Industrial Hygiene for Insulation Workers

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THE USE OF ASBESTOS in the United States and the world has increased substantially since the early Nineteen Thirties. Among the occupationally exposed, the use of asbestos has resulted in many cases of disabling pneumoconiosis, known as asbestosis. Epidemiological evidence also shows that persons occupationally exposed have a higher incidence of malignancies of the lungs, pleura and peritoneum. Even though the first cases of asbestosis were recognized among textile workers in the early Nineteen Hundred's,[1] Ellman[2] was the first investigator to identify specifically the disease in the insulating worker. Since Ellman's first work in England, Fleischer et al.,[3] Pendergrass,[4] Leathart and Sanderson,[5] Selikoff et al.,[6] Ahlman,[7] and others,[8,9] have described many cases of asbestosis and also identified the increased risk of lung cancer in the asbestos insulation worker.

In England, Leathart and Sanderson[5] have described the environmental hazards associated with insulating materials containing asbestos and showed that the insulator was exposed to asbestos fibers in concentrations high enough to cause asbestosis. Since Fleischer et al.[3] found few cases of asbestosis among the insulation workers in the eastern Navy shipyards, they minimized the potential hazard, as the dust levels were below the recommended standard.

Marr,[10] working in Southern California shipyards, further identified the environmental hazards associated with insulating materials containing asbestos. The purpose of our research is to describe the incidence of penumoconiosis and malignancies among the insulating workers in the San Francisco Bay Area and to make observations and measurements of his working environment. This paper summarizes the preliminary environmental findings.

Union membership: The men who apply insulation materials first organized in New York City as the Salamanders Association of Boiler and Pipe Felters in 1884, and were later rechartered by the AFL in 1910 as The International Association of Heat and Frost Insulation and Asbestos Workers. San Francisco Local 16 is a member of the international union and has a membership of approximately 500 men encompassing the geographical areas of Northern California and Northern Nevada. Over 40% of the members have been in the trade for over 20 years and 70% for over 10 years. The members of this union are primarily employed by the building trades; however, at various times the shipyards demand an increased number of

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men, such as during World War II. In general, insulators who are employed by the U.S. Naval Shipyards have their membership outside of Local 16.

There are over 20 insulating contractors in the Bay Area and most of the men who have been members of this local for over 15 years have worked for almost all of these contractors. Nevertheless, the trade is very stable, due to the high wage rate and the rigid testing and apprentice training program required of all new members. Once the man has qualified and passed through this program, the odds are he will remain in the trade for the rest of his working life.

The uniqueness of this trade is that there are very few specialists; each man can do any insulating job required of him. He may be called upon to work with any one of 50 different products. The only specialization is that some men prefer heavy construction to marine construction and repair, or commercial building. Thus, they may choose to work for one contractor specializing in a particular area. As an example of areas of work preference, 380 active members were surveyed and found employed, on a typical work day during the summer of 1967, in the following three major work areas: 220 men in heavy industrial construction, 100 in commercial building and 60 in marine construction and repair.

Insulating products: Analysis of the materials used by the contractors in the San Francisco Bay Area has been made by on-site evaluation, laboratory analysis, and contacts with salesmen, distributors and contractors. This survey has indicated that fibrous materials (glass and asbestos-containing products) account for 90% by volume of the materials used. The other 10% of the materials are adhesives, corks, foams, glass, polystyrenes, and polyurethanes.

Asbestos materials: The insulator spends approximately 45% of his time working with these materials. Table I summarizes the approximate amounts and types of asbestos fibers used locally in 14 different asbestos-insulating products, manufactured by seven major producers of insulating materials in the United States.

The stated types of asbestos fibers in seven of the materials were confirmed by x-ray diffraction analysis using a Norelco x-ray unit equipped with a copper target and x-ray diffraction tube.

Asbestos, as used by the insulating industry, consists mainly of chrysotile, a magnesium silicate mined principally in Canada, and amosite, an iron magnesium silicate mined in South Africa. Since World War II, amosite has been the most widely used fiber in insulating materials. However, Table I shows that the use of chrysotile has increased to where the two are presently in about the same number of insulating products.

Asbestos is usually combined with a filler material such as calcium silicate, in the amounts indicated in Table I, and pre-formed into various shapes to be used as insulating materials. Until recently, magnesium silicate was often used, but except for some in warehouse stock and a few special orders almost all the new silicate-containing insulating materials are made of calcium silicate. In addition, perlite and other materials are used as binders in manufacturing insulating products.

Manufacturers of asbestos insulating materials use varying amounts and types of asbestos fibers in their products and may rebrand their product for distribution by another manufacturer. Contractors will order specific types of insulation because of their thermal properties, disregarding the type of asbestos fibers they contain. These practices on the part of the manufacturers and contractors make it impossible to reconstruct, for environmental evaluation purposes, a working population that has a "pure" exposure to one type of asbestos fiber.

Fibrous glass: The insulator works with fibrous glass about 45% of his time. These glass fibers are made of mixtures of silicon dioxide, oxides of aluminum, calcium, magnesium, boron and other additives. In general, the fibers of most commercial insulating products have a mean diameter of 4 microns or greater. The fibers are bonded together by a water-based phenolic resin and cured. During or after the curing, the glass blankets are formed into the appropriate materials: for example, pipe coverings and blocks.

In our laboratory, we have optically determined the diameter in microns of various samples of fibrous glass insulating materials used in our area. The acoustical materials have the largest diameter, 11 to 14 microns; the building and duct

TABLE I

Type and Per Cent of Asbestos in Insulating Products Used in the San Francisco Bay Area

TYPE OF ASBESTOS	% BY WEIGHT	NO. PRODUCTS
Chrysotile	10-15	2
Chrysotile	85-100	3
Amosite-chrysotile	10-15	3
Amosite	10-15	3
Amosite	95-100	3

insulation, 4 to 7 microns; pipe covering, 4 to 6 microns; and the special high temperature material, 1 to 2 microns.

Adhesives and coatings: In general, the type and per cent of solvents used in the adhesives and coating products were obtained from the manufacturer representatives or technical data sheets. There are nineteen products used in the Bay Area accounting for 90% of the materials applied. They contain the following solvents: aliphatic hydrocarbons (naphtha, hexane and other petroleum distillates), ketones, aromatic hydrocarbons (xylol and toluol), chlorinated hydrocarbons (methylene chloride, trichloroethylene, and perchloroethylene), and isopropyl alcohol. These materials are used by the insulator 5% of his time. The solvents are in combination with a number of plastics, organic and rubber resins, and paraffins.

The use of these solvents can be divided into two groups: those containing from 1% to 10%, two groups: containing from 1% to 10%, and those 10% to 95% by weight. The first group generally contains the alcohols and aromatic hydrocarbons while the second group the chlorinated and aliphatic hydrocarbons. The latter group constitutes the majority of the nineteen products used in the Bay Area.

Other: This group contains the remaining materials that the insulator uses. Foam glass materials are a mixture of glass chips (greater than 10 microns in diameter) expanded by hydrogen sulfide gas into block forms. This product, along with cork and rubber materials, is mainly used for refrigeration insulation. Polystyrenes are being used in an ever-increasing amount, especially in the area of cryogenics. Polyurethanes, at present are not being used because of a lack of adequately trained personnel.

Environmental survey: The insulator is exposed to a multitude of materials and environmental stresses. To obtain a "classical" time-weighted exposure for this trade for every one of these conditions is impossible; however, it is possible to present data that will indicate the variability of these exposures. In contrast to other occupational groups who generally stay in the same working environment, the insulator is in a continuously changing environment; the work locations, materials, position, humidity, temperature, ventilation, noise levels, and other variables are in a state of flux. Environmental exposures to the insulator also result from the trades around him, such as welders, painters and fireproofers. In order to better describe the work environment, the jobs performed by the insulating worker have been divided into six areas: (1) *Prefabrication:* (10% of his time) materials are pre-cut and shaped using hand or power saws; (2) *application:* (40% of his time) materials are fitted, hammered, or carved, and attached to the surface by wiring or gluing; (3) *finishing:* (30% of his time) materials are coated with asbestos containing cements, resins, asbestos or cotton cloth, or petroleum-based sealers; (4) *tearing out:* (10% of his time) removal of old or unusable materials in the process of insulating or reinsulating; (5) *mixing:* (5% of his time) mineral wool, asbestos, fibrous glass, and cements are mixed separately or in combination in buckets or troughs; and (6) *general:* (5% of his time) cleaning up of old insulation, transporting of materials (Fig. 1).

Dust exposures: The environmental sampling for dust exposures has been limited to areas in which asbestos-containing materials were being applied.

In order to compare the environmental sampling data with past studies of shipyards and textile mills, one set of samples was taken using the midget impinger. Results of these samples are summarized in Figure 1. The data represents both breathing zone and general air samples. The standard method of counting prescribed by the American Conference of Governmental Industrial Hygienists (ACGIH) was used and both fibers and grains are pooled in the total count.

The standard error of the mean indicates that 66% of the sample means should fall within the indicated area. As can be seen from Figure 1, the areas with the highest dust concentrations and exceeding the present TLV are prefabrication, tearing out, and mixing. However, these three areas account for less than 35% of the man's working time when applying asbestos materials.

Since most investigators doing research in the pathogenesis of asbestos suggest that the fibers play an important part in the disease process, a major emphasis was placed on obtaining fiber concentrations under various working conditions.

The membrane filter has proved successful in evaluating the environmental exposure to fibrous materials. The membrane filter samples were collected using millipore type AA filters in field monitor cases and connected to personal air samplers and attached to the workers for periods ranging from 30 minutes to 2 hours. The fibers

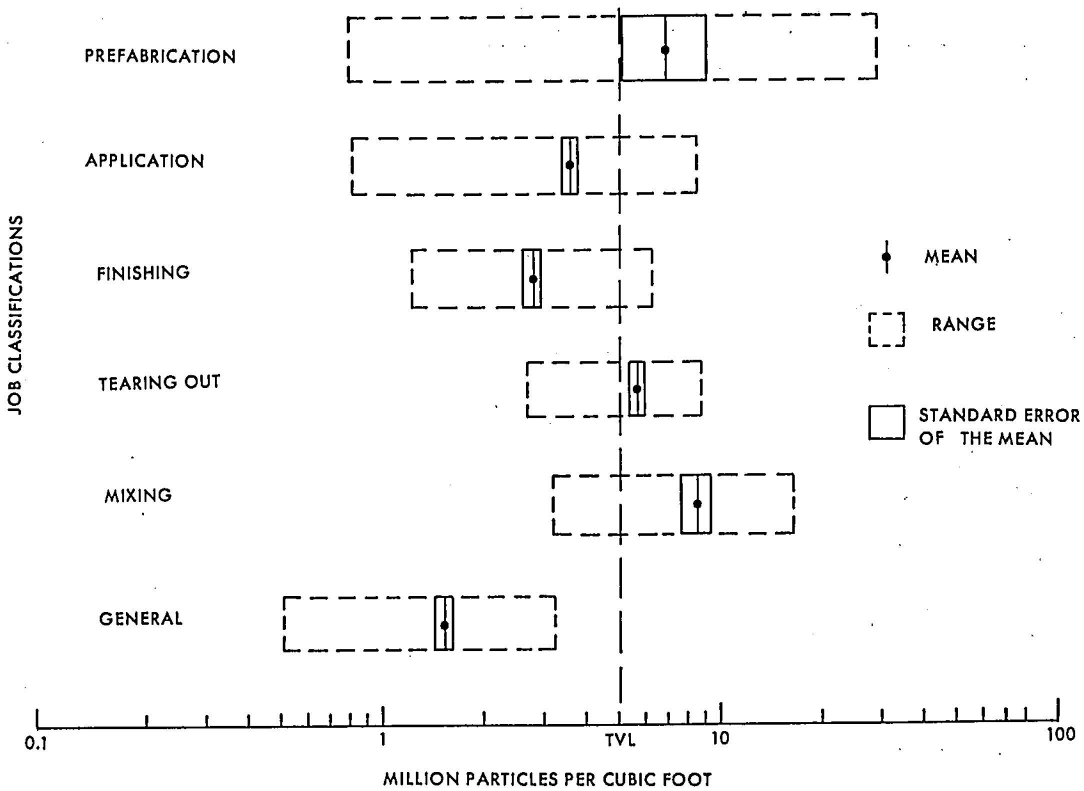

Fig. 1. Midget Impinger Counts by Job Classification.

were counted by clearing a wedge-shaped segment of the filter using a modified technique of the USPHS at 430-X magnification using phase contrast illumination.

Timbrell's criteria for respirable fibers (diameter smaller than 3.5 microns)[12] was used for classification purposes. His experimental work shows that respirability is dependent on diameter, not length. An aspect ratio (length to width) of 3:1 was used for differentiating between a fiber and a grain. Depending on the working conditions, 98% ± 2% of the fibers counted fall into this respirable category. The fiber counts per cc. are given in Figure 2 by job classification.

Solvent exposures: Only a small number of measurements have been made using a Kitagawa detector kit and a combustible gas indicator for aromatic hydrocarbons. At present no readings have approached the TLV for the solvents listed. However, since there are often welders operating in the same area, there is some concern about the decomposition products from chlorinated hydrocarbons, i.e., phosgene and hydrogen chloride. Additional field sampling for solvent exposures is contemplated especially in areas where men are working under confined conditions, for example, in ships, ventilator shafts, etc.

Temperature and humidity: Another condition that affects most of the workers is the extreme temperatures and humidity. In the commercial and heavy industrial building groups the humidity measurements ranged from 20 to 100% with temperature ranges of 32° to 110°F. The marine construction and repair group experience the most extreme conditions, although the ranges of temperatures would compare with the other groups. The extremes measured on one of the jobs were 95% humidity and 95°F.

Noise: Sound level measurements have been made using a general radio type 1551-A sound level meter. In general, few areas have sustained readings above 90 d.b. However, if chippers, chaulkers, riveters, and grinders are being used in the same area, readings above 100 d.b. are not uncommon. These specific short-time exposures need further study, specifically octave-band analysis. The present sound level data shows a general agreement of readings between the Broad Band Network and the C-Band Network in general work areas when only small grinders and stud welding guns are being used.

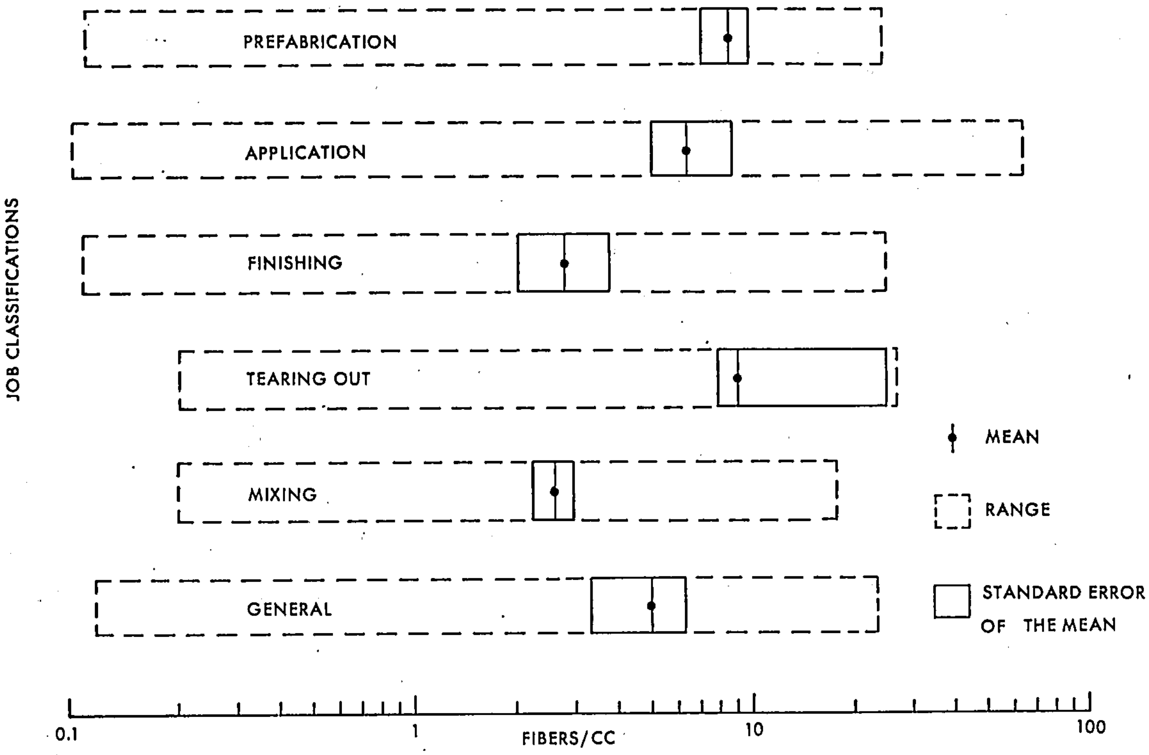

Fig. 2. Fiber Concentration Based on Membrane Filter Samples by Job Classification.

Discussion

Anyone looking at the present basis for the threshold limit value (TLV) or 5 mppcf as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) in 1946 realizes that it is not based on solid evidence. The method used in setting the standard includes all dusts (both grains and fibers); and a large portion of the asbestos fibers that were collected had a diameter, when viewed at 100-X magnification, well below the resolving power of the light microscope.

Recognizing these inherent errors, most industrial hygienists have used the impinger count as an indirect measure of dust control and until recently thought that dust counts averaging below 5 mppcf would control the incidence of asbestosis. Cooper,[13] in his reviews of recent epidemiological studies regarding the incidence of asbestosis and its relationship to the present threshold limit value (TLV), makes it very clear that this supposition is no longer true.[3,10,14,15] Our own studies of the insulation workers in the Bay Area also show over-all environmental dust counts to be below the TLV; however, definite radiologic changes have been observed in our Asbestos Union population.[16] These observations indicate that the present time-weighted average of 5 mppcf for asbestos is not preventing asbestosis. The better asbestos industries, by reducing dust counts well below the TLV, have shown to their satisfaction and others a decreased incidence of asbestosis.[17] However, even with the reduced exposures, the malignancy question has not been answered.

Asbestosis in the insulating worker can be prevented by instituting the following: total work enclosures, exhaust and forced air ventilation of dusty areas, personal respiratory protection, changes in work habits, and substitution of materials. All of these preventive measures cannot be adopted immediately and are all not applicable to every job. The industry must adopt some of these changes in order to reduce the environmental dust exposures and, thereby, extend the working life of the insulator.

Prefabrication of materials should be done in an open-end booth with exhaust fans, such as the spray paint booth. This will substantially reduce the operator's dust exposure. The mixing of muds should also be enclosed in a booth and an automatic mixer be utilized, thereby controlling dust levels that occur when these materials are mixed in open areas. This operation could also be done in central areas and trucked to the job since many of the materials do not dry out if they are kept tightly covered.

The use of local exhaust and forced air fans in the work area and on certain equipment, i.e., saws, will also reduce dust exposures. It is also realized that this is impractical on some jobs because few men work in one area long enough to justify the setting up of an elaborate ventilation system. However, when large boiler and generator jobs are in process, local exhaust or forced air fan systems should be used. This type of system could also be used to cool the men in areas of extreme temperature and humidity, such as in marine construction and repair.

The use of personal respiratory equipment is very important, but what is more important is the development of a mask that has a filter with a low resistence to air flow and a face piece that is easily fitted to the man and wearable. Most of the present masks do not fit properly and the filters, besides having a high resistence to flow, clog very quickly. This makes it necessary to change the filter frequently, or as is most often the case the men simply remove the mask and continue to work. Another form of respiratory equipment is the supplied air respirator which should supply enough air to cool the man as well as meet his physiologic needs. This requires elaborate hose and compressor systems and is seldom economically feasible or desirable. But it is suggested that personal air supplied respirators with their own power units be used in areas of high dust exposure such as prefabrication and tearing out. Appropriate respiratory protection should also be made available for use in areas where high solvent concentrations exist.

Changes in work practices such as the use of a water spray to wet down some materials before they are cut would substantially reduce the dust exposure. Industrial vacuum sweepers could be used for clean-up instead of brooms, thus reducing the dust level. In addition, tearing out of old insulation could be done with local exhaust hoses connected to a vacuum sweeper. All these steps would reduce the present high levels of dust exposure at these various jobs. Mixing of muds in closed plastic bags has also been suggested and tried, but data on acceptibility is presently not available.

Substitution of new materials such as fibrous glass is possible under certain conditions, but at present we do not know enough about the physiologic effects of fibrous glass to suggest the total change to this product. When proposing the substitution of new materials to replace asbestos, the engineers often have reasons, too, for not changing these materials. Asbestos, they feel, is the only product that will withstand the day-to-day impact of man, weather, and machines without adding some additional protective covering, such as metal. Thus, at present for the marine construction and heavy industrial insulation jobs, there is no economical or desirable substitute for asbestos insulation products. In fact, the use of asbestos-containing insulating materials in the Bay Area is on the increase in heavy industrial construction.

Summary

The asbestos worker is exposed to amosite and chrysotile asbestos-containing materials, fibrous glass, cork, plastics, and adhesives. Working in industrial and commercial building projects and marine construction and repair, he is exposed to many other environmental hazards not created by his own trade.

Although he works with asbestos-containing products 45% of the time, the over-all time-weighted average exposure to asbestos-containing materials is below the presently recognized TLV of 5 mpccf. The three work areas in which the dust levels were above the TLV (prefabrication, tearing out, and mixing) account for less than 20% of his total work time. However, the incidence of radiographic changes indicative of asbestosis is over 25% in our men with 20 years or more of work. This and other evidence suggests that the present TLV is too high.

Incidence of asbestosis and the risk of malignancies in the asbestos worker can be reduced by local and general ventilation, substitution of materials, changes in work habits and personal respiratory protection combined with education of the men to reduce their own exposures to asbestos-containing dusts.

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The Clinical Mind

By and large, I think it can be said that the practitioner has a different view of his work than the theoretician or investigator—in fact, a different way of thinking about the world. *First,* the aim of the practitioner is not knowledge but action. Successful action is preferred, but even action with very little chance of success is to be preferred over no action at all. There is a tendency for the practitioner to take action for its own sake on the spurious assumption that doing something is better than nothing. *Second,* the practitioner is likely to have to believe in what he is doing in order to practice—to believe that what he does does good rather than harm, and that what he does makes the difference between success and failure rather than no difference at all. Insofar as work characteristically revolves around a series of concrete and individual problems, determining whether or not one has achieved success is difficult enough, let alone the causes of success. Given a commitment to practical action, in the face of ambiguity the practitioner is more likely to manifest a certain will to believe in the value of his actions than to manifest a skeptical detachment, else why act at all? (How could a present-day psychiatrist work if he believed the equivocal results of careful studies of the reliability of diagnosis and the effects of psychotherapy? And how could physicians work 300 years ago?) *Third,* perhaps because of his action orientation, perhaps because of the complexity and variety of the concrete, the practitioner is a fairly crude pragmatist, prone to rely on apparent "results" for his guide rather than on theory, and prone to tinker if he does not seem to be getting "results" by conventional means. *Fourth,* the clinician is prone to trust his own accumulation of personal, first-hand experience more than abstract principles or "book knowledge," particularly when it comes to dealing with those elements of his work that cannot be treated routinely. This represents a certain subjectivism in his approach. And *finally,* the practitioner is more prone to emphasize the idea of indeterminacy or uncertainty than the idea of regularity or lawful behavior. Whether or not that idea of indeterminacy faithfully represents actual deficiencies in available knowledge or technique, it does provide the practitioner with a basis for defending himself from failure.

In his commitment to action, his faith, his pragmatism, his subjectivism, and his emphasis on indeterminacy, then the practitioner is quite different from the scientist.

—From "The Professional Mind" by Eliot Freidson, Ph.D., in CA, Journal of American Cancer Society, Inc.; May-June 1967.