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Application of Sprayed Inorganic Fiber Containing Asbestos: Occupational Health Hazards

WILLIAM B. REITZE,* WILLIAM J. NICHOLSON, DUNCAN A. HOLADAY, and IRVING J. SELIKOFF

Mount Sinai School of Medicine of the City University of New York, Fifth Avenue and 100th Street, New York, New York 10029

Over 40,000 tons of inorganic fibrous insulation containing asbestos were used in 1970 by the construction industry as a fireproofing material in the erection of multistoried buildings. The application of this material by a spraying technique produces serious contamination of the working environment. Asbestos fiber concentrations may range from 30 f/cc to more than 100 f/cc. Some early observations of the exposures and health of the workmen in this comparatively new occupation are given with photographs of the working areas. Nearby workers may be indirectly exposed. Such concentrations were found to be 70 f/cc ten feet from the spraying and 46 f/cc seventy-five feet away. Control measures are discussed.

Introduction

Occupational hazards associated with the inhalation of asbestos fibers have been well established, with important risk of asbestosis, bronchogenic carcinoma, mesothelioma (pleural and peritoneal), and possibly other neoplasms.[1] Such hazards have been found in factories manufacturing asbestos products,[2-4] in mines and mills producing the fiber,[5,6] and in the use of asbestos products for insulation work in the construction industry.[7]

Starting in 1966, we undertook an investigation of another commercial use of asbestos in which an occupation hazard seemed possible—the spraying of mineral fiber insulation material for fireproofing and heat insulation.

Sprayed inorganic fiber insulation was introduced in 1932 with the Limpet process, by the J. W. Roberts Company of Great Britain. Mr. N. L. Dolbey, Director of Research for this company, is usually acknowledged as the pioneer developer. British Railway coach makers used the sprayed product containing asbestos in their coaches to control condensation and noise; it also acted as a thermal insulating material. In 1935 the spray process was first used in the United States. Most of the material applied during the late 1930's was used for decorative finishes in night clubs, restaurants, hotels, etc.

When this material was found also to be useful as a fireproofing agent, such use gradually increased, and in 1950 the National Gypsum Company obtained the Underwriters Laboratories' approval of its brand of spray insulation for fireproofing. In early 1951 the Asbestospray Company also had an inorganic fiber blend tested and approved by the Underwriters Laboratories. The first use of sprayed "mineral fiber" as a fireproofing agent in a large multistory building occurred in 1958 with the erection of the sixty-story Chase Manhattan Bank building in New York City. In 1970, well over half of all the large multistory buildings con-

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Mineral fiber materials containing asbestos have four major insulation uses in the construction and shipyard industries: (1) fireproofing, (2) thermal insulation, (3) acoustical and decorative purposes, and (4) condensation control. Fireproofing accounts for the largest amount of mineral fiber sprayed in the United States. Formerly, structural steel in multistory buildings had to be encased in concrete to prevent buckling in the event of fire. The use of sprayed mineral fiber provides adequate fire protection, reduces installation costs, and reduces the weight load upon structural steel components.

The use of sprayed insulation in thermal applications permits powerhouse turbines to be encased in a uniform, continuous coating which greatly reduces convection heat losses. Other industrial uses include coating of vessels in chemical plants and refineries, and insulating electrostatic precipitators, boiler breechings, and stacks.

Because the newly applied surface of sprayed mineral fiber can be shaped, the material not only provides good acoustical control but also can be used for decorative ceiling and wall coatings for large areas in public buildings, restaurants, and similar establishments.

Sprayed products containing asbestos fiber are particularly useful in controlling condensation in indoor swimming pool areas, laundries, textile plants, and other industrial buildings where condensation may cause extensive corrosion of structural steel. The unique wicking action of the individual asbestos fibers serves to keep the inner mass of the insulation free of moisture.

The use of sprayed mineral fiber in the shipbuilding industry was at one time rather extensive in Great Britain. However, because of problems encountered in removal during repair, its use has now been discontinued in Great Britain. Very small quantities were used in the United States for shipboard installations during World War II.

Inorganic Fiber Mixtures Used for Spray Application

Although the composition of the various spray products will vary with the intended use and the individual manufacturer, certain general formulations are similar. Most are termed "mineral fiber" materials, although naturally occurring mineral fibers are usually in a minority, and man-made inorganic fibers dominate.

The material used for fireproofing in building construction usually is a blend of 5 to 30% asbestos fiber (chrysotile), mineral wool, clay binders (as bentonite), adhesives, synthetic resins, and other proprietary agents such as oils. Many of the materials used for thermal insulation on turbines contain nearly 100% asbestos fiber (often amosite or amosite and crocidolite) plus the usual binders and adhesives. The material used for acoustical and decorative purposes may contain a greater percentage of mineral wool and little or no asbestos fiber. Some materials are applied as a sprayed slurry (commonly known as cementitious spray) and will often contain vermiculite, gypsum, and shorter asbestos fibers (see Table I). Because the cementitious material has a much greater density and increased weight per unit area, the supporting structure must sometimes be designed accordingly.

The quantity of mineral fiber used for spray applications in the United States today is steadily increasing. In 1968 an estimated 40,000 tons of material were used for fireproofing alone. This does not include the amounts used for industrial thermal insulation, acoustical control, and condensation control. A thirty-story building may use 200 tons, while the World Trade Center complex being built for the New York Port Authority will use 5000 tons on the twin 110-story towers (above the fortieth floor, only non-asbestos-containing spray materials were used). The sixty-story Chase Manhattan Bank Building is fireproofed with 1,500,000 square feet of sprayed mineral fiber. The Hol-

TABLE I

Composition of Sprayed Mineral Fiber Products
Depending on manufacturer, the product may contain the following:

Decorative and acoustical[a]	Manufactured silicate fiber (such as Rock Wool) Asbestos fiber Mineral binders Clays – bentonite Hydraulic setting binders Portland cement	Oversprays Emulsion type sealers Latex Acrylic Resin Paint
Thermal[b]	Amosite asbestos fiber Crocidolite asbestos fiber Chrysotile asbestos fiber Manufactured silicate fiber (such as Rock Wool) Hydraulic setting binders Portland cement Aluminum silicate extruded fibers ("ceramic")	Dust-arresting additives Wetting agents Oils
Fireproofing (cementicious)[a]	Chrysotile asbestos fiber Gypsum Portland cement Vermiculite	

[a]Contains 5 to 30% asbestos fiber.
[b]Contains nearly 100% asbestos fiber.

Figure 1. Mixing hoppers and pumps used to convey material to point of application.

land-American ocean liner Rotterdam contains 400,000 square feet of sprayed mineral fiber used for fire protection, thermal insulation, and sound and condensation control. Most sprayed material is used in large cities. During 1970, in New York City, there were six to eight buildings taller than thirty stories being sprayed on any given day. An estimated 2500 tons were used in Great Britain during 1968. Use as a fireproofing agent consumed most of Britain's spray insulation material.

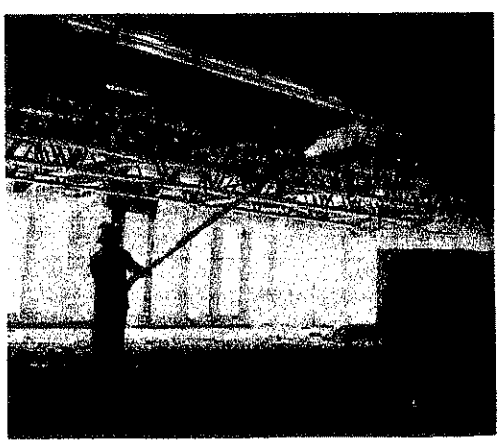

Figure 2. Applicator applying sprayed fireproofing containing asbestos. Note waste material on floor. Worker is wearing respiratory protection, inadequate for such intense exposure.

Methods of Application

There are two principal sprayed mineral fiber. In material is dumped from into a large hopper, wher tated and subsequently 4-inch hose (Figure 1). T dry material to a nozzle application (Figure 2). leaves the nozzle, it passes a ring of fine water jets. this focal point, which is from the end of the nozzle. to control the air, material, valves at the nozzle.

The wet method differs is premixed with water in resulting slurry is pumpe sprayed upon the surface nozzle used is similar to th ter.

Exposure of Workmen

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Methods of Application

There are two principal methods of applying sprayed mineral fiber. In the dry method, dry material is dumped from a paper shipping bag into a large hopper, where the material is agitated and subsequently blown into a 2- or 4-inch hose (Figure 1). The hose conveys the dry material to a nozzle at the actual site of application (Figure 2). As the dry material leaves the nozzle, it passes through the focus of a ring of fine water jets. Mixing takes place at this focal point, which is usually 4 to 8 inches from the end of the nozzle. The operator is able to control the air, material, and water mix, with valves at the nozzle.

The wet method differs in that the material is premixed with water in the hopper, and the resulting slurry is pumped to the nozzle and sprayed upon the surface to be coated. The nozzle used is similar to that used to apply plaster.

Exposure of Workmen

Spraying of mineral fiber is done by men in several different trade unions in the United States, depending on its purpose and local jurisdictional agreements. All material that is used for thermal insulation is applied by members of the International Association of Heat and Frost Insulators and Asbestos Workers (AFL-CIO). This is a very minor part of their work, overall. Material used for fireproofing is often applied by members of the Plasterers' Union. Acoustical and decorative material may be handled by carpenters, or other craftsmen. In New York City, fewer than 1000 men in all would have regular or intermittent exposure to sprayed asbestos insulation.

The application of sprayed mineral fiber compounds containing asbestos is potentially associated with health hazards for two groups of people and possibly for a third. The first group, workmen actually engaged in applying the material, is relatively small in numbers. This group, however, is the most heavily exposed. Air samples taken on site and counted by using a modification of the method described by Ayer and Lynch,[8] counting only fibers longer than 5 microns visible by optical microscopy at 400x, indicated that the worker handling the nozzle was exposed to fiber levels ranging from a low of 30 f/cc to over 100 f/cc. The worker emptying the bags into the hopper was found to be exposed to fiber levels ranging from 5 f/cc to 22 f/cc. The large spread in counts can be attributed to differences in asbestos content of material, work proficiency, and the ever-changing conditions on construction sites (see Table II). These dust levels are much higher than those at asbestos work sites in other trades.

There are no satisfactory data at present concerning disease among these men with direct exposure to sprayed insulation dusts. Their work experience in general has been too short to have led, as yet, to clinically evident disease. Among other asbestos-exposed workmen, significant disease usually does not become evident for twenty or more years following onset of exposure.[10] No group of workmen engaged

TABLE II

Spraying of Thermal Insulation – Power House Turbine[a]

Man at Nozzel (1)	Man at Nozzel (2)	Man Charging Hopper
68	67	22
85	45	5
31	100	10
24	32	6

Spraying of Fireproofing – Multistory Building

Man at Nozzel (3)	Man at Nozzel (4)
30	99.0
43	94.5
20	
49	
34	

[a]All counts in fibers per cubic centimeter. Fibers longer than 5 microns, visible by optical microscopy at 440x with phase microscopy. Our studies have demonstrated that many more fibers shorter than 5 microns, too small to see by optical microscopy, accompany the optically visible fibers and may exceed them in number (although not in mass) by several orders of magnitude. These smaller and thinner fibers and fibrils are detected only by election microscopy and are not included in counts such as these.[9]

Figure 3. Pulmonary asbestosis following four years of mineral fiber spraying experience, starting twenty-nine years before death due to cor pulmonale.

in spraying asbestos has been examined after such an interval.

In New York City, we have examined a dozen men who have sprayed asbestos. Most had worked only two or three years at the trade; they were asymptomatic, and their chest roentgenograms exhibited few or no abnormalities. Two men had had longer experience. One, a man of 41 with fifteen years of exposure during a span of twenty-one years, was also without shortness of breath, and his film was normal apart from minimal lower lobe reticular fibrosis. The second man, the only one who had gone more than twenty years from onset of exposure, was severely short of breath, had extensive asbestosis on x-ray, and died of cor pulmonale. He had had four years of work experience starting in 1935, twenty-nine years before death in 1964 at the age of 65 (Figure 3).

If experience in other asbestos trades is a guide, and if there is a consistent exposure-disease response relationship, we may predict a most unhappy fate for the men who have been working in the sprayed insulation industry. Among other insulation workers, with much less asbestos exposure, observed for more than twenty years from onset of exposure, approximately one in five deaths has been of lung cancer, one in ten of gastrointestinal cancer, and almost one in ten of pleural or peritoneal mesothelioma. In addition, almost one in ten has been of asbestosis and cor pulmonale.[11] And these disease experiences have been associated, it may be noted, with dust exposure levels much lower than at spraying sites—perhaps one-tenth or one-twentieth as high!

The fate of the sprayed insulation workmen will likely resemble these experiences, although the pattern of distribution of deaths by cause may be different. Jacob and Anspach have demonstrated that, where asbestos work exposure is unusually excessive, there are more deaths of asbestosis and cor pulmonale and fewer of lung cancer; the workmen die of pulmonary insufficiency before they can live long enough to develop and die of lung cancer or mesothelioma.[12]

The second group, which may involve many men working in the building construction trades in the country, especially those engaged in high-rise construction work, is much larger. Pipe fitters, welders, electricians, plumbers, carpenters, and others may be on the construction site during or shortly after mineral fibers have been sprayed. On-site samples taken at various distances from the nozzle show fiber counts ranging from 70 f/cc 10 feet from the nozzle to 3 f/cc 25 feet away. Counts taken 30 minutes after completion of spray still ranged from 1 to 4 f/cc, and 60 minutes after, from 0.25 to 0.76 f/cc. Again, these counts vary because of changes in on-site ventilation.

We have few data to predict the magnitude of the disease hazard among workmen with indirect exposure. That there is a potential serious risk may be inferred from the increasing reports of mesothelioma among men working in shipyards in which asbestos spraying was associated with such risk of indirect occupational exposure.[13] Asbestosis is also found among

Area

Sample
1
2
3
4
5
6
7
Taken 3
8
9
10
11
Taken 6
12
13
14
15
16

[a]See footnote
[b]Samples tak

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tricians, carpenters, painters,
trades, will not become

TABLE III

Area or Stationary Samples Taken during Spray Operation

Sample	Distance from Nozzle Man (ft)	Count (fibers/cc)[a]
1	15	17
2	35	10
3	75	46
4	10	71
5	10	70
6	20	37.6
7	20	66.0
Taken 30 minutes after spray operation had ceased for the day[b]		
8		1.01
9		1.12
10		1.55
11		4.22
Taken 60 minutes after spray operation had ceased for the day[b]		
12		0.55
13		0.51
14		0.28
15		0.76
16		0.26

[a]See footnote, Table II.
[b]Samples taken on same floor as operation.

these men,[14] and asbestos bodies are detected in their lungs more commonly than among other comparable blue collar workers.[15]

The problem of indirect occupational exposure in the construction trades is of importance, if only because of the number of workmen involved: In the United States, more than 3,000,000 men are regularly employed in the building trades. While the incidence of asbestos-associated disease among those indirectly exposed may be lower than among the one-in-a-hundred with direct exposure, the total disease experience can be considerably greater. Our air studies indicate (Table III) that very high asbestos fiber levels are found in the work environments of building trades workmen not associated with spraying operations, but simply working in the same buildings. We may not know the incidence of mesothelioma and lung cancer among men so exposed for twenty or thirty years. In New York City, where spraying was under way in the 1960's, asbestos disease resulting from this practice, among steamfitters, electricians, carpenters, painters, masons, and other trades, will not become evident until the 1980's, and 1990's, and the twenty-first century.

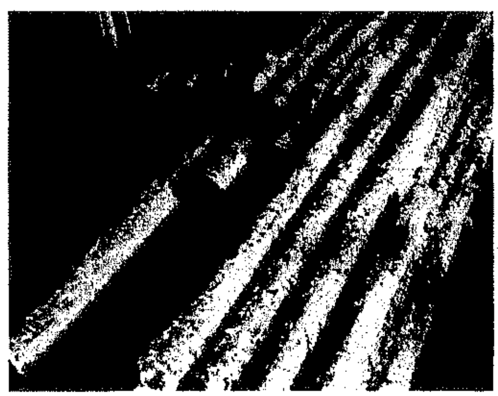

Figure 4. Waste from spray application adhering to building materials used by other trades.

Similarly, we will not be able to assess possible disease among the general public for another twenty or thirty years. We have determined that contamination of the community's air occurs as a result of uncontrolled or inadequately controlled spraying operations. As expected, such contamination is greatest in the vicinity of the construction site.

Since most of the spraying is done before the building curtain walls are erected, some of the spray material may blow outside the site. The quantity that escapes depends on wind, height of building, skill of operator, material, and control measures used. Construction sites have been studied where grossly visible waste from a spray application covered the ground to a depth of 1 inch for a distance extending 100 feet from the site (Figure 4).

Control of Occupational Asbestos Hazards Associated with Sprayed Insulation

The two most important sources for workman exposure during spray operations are (1) material that becomes airborne during the spray operation (overspray), both that which remains at the job site and that which blows into the surrounding air, and (2) material that remains on the site because of poor housekeeping. Until recently, few control measures were used during application of sprayed mineral fiber.

During 1969 and 1970, extensive field investigations were undertaken by our laboratory to ascertain the possible asbestos hazard in this trade and to develop corrective measures. In this, we had considerable cooperation from the Department of Air Resources of the City of New York, and some segments of the sprayed insulation industry, including a number of manufacturing and contracting firms associated with the Sprayed Mineral Fiber Manufacturers Association and the Contracting Plasterers' Association of New York. The International Association of Heat and Frost Insulators and Asbestos Workers, AFL-CIO, although its members did little such work (rather, Plasterers' Union members were engaged), also provided considerable help, since they had had much bitter experience with the problem in general.[16] Similarly, valuable assistance was provided by the Johns-Manville Corporation, in keeping with their general perspective of developing effective controls for such asbestos uses as might be associated with hazard.

In this investigation, work sites were studied in eleven cities in eight states. Practices were found to be very much the same throughout the country, as described above.

It is our general conclusion that sprayed insulation practices can be controlled to a point at which the occupational hazards, both direct and indirect, can be minimized or eliminated, but that such controls will be expensive, tedious, and cumbersome.

Our findings may be summarized by consideration of the Sprayed Insulation Regulations promulgated by the City of New York in April, 1970. These regulations were largely based upon the results of our studies, supplemented by valuable additions derived from the experiences of the Department of Air Resources (Dr. Robert Rickles, Commissioner) and its staff, including those of Harold Romer, P.E., who headed a special group assigned to this problem. These regulations were the first by a governmental agency to seek to control hazards associated with sprayed insulation and have more recently been followed by administrative actions in other cities including Philadelphia, San Francisco, Boston, and Chicago.

In the Matter of the	)	Commissioner's Order
Spraying of Asbestos-	)	
Containing Material	)	

PURSUANT to the authority vested in me by the New York City Charter and the New York City Air Pollution Control Code,

IT IS HEREBY ORDERED that whenever asbestos-containing material is sprayed, the following precautions shall be taken to prevent and control the emission of asbestos-containing particulate matter into the ambient air.

1. Before the start of spraying operations all floor areas shall be shoveled clean. Before the application of asbestos-containing material commences, the floor of the area shall be cleared of all objects, material and equipment other than that employed in the application of the asbestos-containing insulation or all objects, materials, etc., shall be covered with plastic or other approved tarpau-

lins in a manner that pre
quent dispersal of asbestos

2. The entire floor, or the
to be insulated shall be enc
or other approved tarpaul
which shall preclude the es
containing material from t
interior open areas, such a
stairwells, etc., shall be encl
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containing material from t
"Stack effect" of the shaft
shall be considered satisfac
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the enclosure.

3. Wet asbestos-containing
has fallen to the floor shall
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be removed later than at
working day. Swept-up
placed in a heavy plastic b
to resist tearing or breaki
handling conditions and c
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the aforementioned plastic
transferred to another cont
bags shall be placed upon
posal at an approved site.

4. All floors will be vacuu
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strong, single-service dispos
durable material which s
then be placed in a contain
scribed in paragraph 3, whic
be placed on a vehicle for
posal at an approved site.

5. The materials used to fo
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the area. The entire floor a
surfaces including tarpaul
waste insulation material
shall then be vacuumed or
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lins in a manner that precludes the subsequent dispersal of asbestos particulates.

2. The entire floor, or the part of the floor to be insulated shall be enclosed with plastic or other approved tarpaulins in a manner which shall preclude the escape of asbestos-containing material from the enclosure. All interior open areas, such as elevator shafts, stairwells, etc., shall be enclosed in a manner which shall prevent the escape of asbestos-containing material from the working area. "Stack effect" of the shafts, stairwells, etc., shall be considered satisfactory only if visible insulating material cannot escape from the enclosure.

3. Wet asbestos-containing material which has fallen to the floor shall be swept up continuously to prevent dispersal of dried material. Under no condition shall this material be removed later than at the end of the working day. Swept-up material shall be placed in a heavy plastic bag strong enough to resist tearing or breaking under normal handling conditions and clearly marked as containing asbestos waste. The contents of the aforementioned plastic bags shall not be transferred to another container. The plastic bags shall be placed upon a vehicle for disposal at an approved site.

4. All floors will be vacuumed shortly after drying. The vacuum cleaner shall contain a strong, single-service disposable inner bag of durable material which shall be removed, then be placed in a container of the type described in paragraph 3, which shall thereafter be placed on a vehicle for removal and disposal at an approved site.

5. The materials used to form the enclosure shall be thoroughly vacuumed upon completion of the application of the insulation in the area. The entire floor area, all ledges and surfaces including tarpaulins upon which waste insulation material may have fallen, shall then be vacuumed or revacuumed before removal of the enclosures.

6. Enclosures shall not be dismantled until the area has been thoroughly vacuumed after completion of spraying and cleanup.

7. All areas used for opening bags containing asbestos insulating material and/or charging of hoppers shall be enclosed in such a manner that asbestos-containing insulating material shall not be permitted to escape from the immediate area in which such activity takes place.

8. Signs shall be posted outside enclosures warning persons of the hazards of entering the enclosure without appropriate mask and other apparel.

9. All persons involved in the spraying of asbestos at the site must be furnished with Bureau of Mines approved respirators for pneumoconiosis-producing dust or equipment as required by N.Y. State Department of Labor and must be furnished with suitable coveralls which will be left at the site and thereby preclude the removal of asbestos from the site. No person shall be permitted in an area in which asbestos spraying or handling has taken place until final vacuuming referred to in paragraph numbered '5' herein, unless such person is furnished with and wears a Bureau of Mines approved respirator for penumoconiosis-producing dust and coveralls of the type described herein. Facilities shall be provided and procedures instituted and supervised that preclude the removal and dispersal of asbestos-containing material from the construction site on the clothing or other appurtenances of persons leaving the area.

10. Any plenum or other structures coated with asbestos-containing insulation which is intended for use in the circulation of air in the building must be thoroughly cleaned of all debris and waste insulation. All applied asbestos-containing insulation within a plenum or duct must be coated with a sealant which precludes exposure of the asbestos-containing material to the circulating air.

11. A person shall be assigned the full-time responsibility to supervise the spraying and related operations to assure that no asbestos-bearing material is released from the construction site.

12. In case of emission of asbestos from the construction site, immediate steps shall be taken to cause the cessation of such emissions by either effective control measures or work stoppage at the source of the emissions. There shall then be immediate and complete cleanup of all material that has escaped the construction site by measures that will insure that no further dispersal of any asbestos material into the atmosphere can occur.

13. Notice of intent to spray asbestos-containing material on any premises shall be given to the director of Field Services, Department of Air Resources, 134 Centre Street, New York, N.Y. (212-566-2735). Said notice shall be both oral, by telephone, and in writing and shall specify, at least two (2) days prior to said spraying, the floors on which the spraying will take place.

It will be seen that these early regulations (they have since been strengthened) were directed largely to the prevention of the environmental hazard. In addition, we were able to identify a number of other approaches which were more specifically concerned with the occupational hazard.

Reduction of Airborne Asbestos during Spray Operations

Currently, consideration is being given within the industry to several proposals aimed at reducing the amount of asbestos dust which might become airborne during spraying.

An important approach includes elimination of asbestos from the material used and the addition of oils or wetting agents. Formulation changes have met with some success. Several manufacturers are now producing material which contains no asbestos. The disease potential of these substitute materials is largely unknown, and New York City regulations require the same precautions during their application, as with asbestos-containing materials.

In Great Britain, the modification of spray equipment has received considerable attention. A method of prewetting the fiber before conveying material to the nozzle has been developed. Although this prewetting process significantly reduces fiber counts during applications, the method does not yet lend itself to volume spraying as done in the United States.

Progress has been made in developing effective means of enclosing areas during spray application (Figures 5 to 10). Several contractors have custom-designed canvas or reinforced plastic tarpaulins with various flaps and interlocking closure devices. Wooden frames covered with reinforced plastic are in use. Not only must the perimeter be enclosed, but the stairwells and elevator shafts must be sealed to prevent the stack effect from carrying dust and fiber to the outside atmosphere. Some rather unique ways have been developed for enclosing outside spandrels and columns prior to spraying. Since the design of buildings may differ widely, methods for enclosing must be individually tailored for a particular structure. To eliminate the need for temporary enclosure of buildings, some contractors are rescheduling the spray application to permit prior erection of curtain walls and glazing of the window openings.

Enclosure with canvas and plastic has markedly improved since enactment of more stringent regulations. Ambient air samples taken near spray job sites that have been enclosed by means of newer methods have shown that excellent containment is possible. Asbestos fiber emissions from properly enclosed spray operations were not detected with the light microscope. Electron microscope examination of samples is currently under way to determine if the spray process adds significantly to the asbestos fiber background level in ambient air. In limited studies, it did not. Enclosure tarping, however, still has not solved the problem of wind erosion during the interval between com-

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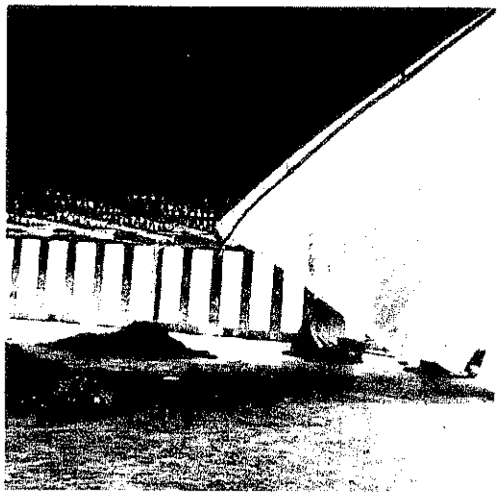

Figure 5. Floor of building after spray application. Note piles of waste asbestos-containing materials and flapping tarpaulins, inadequately secured.

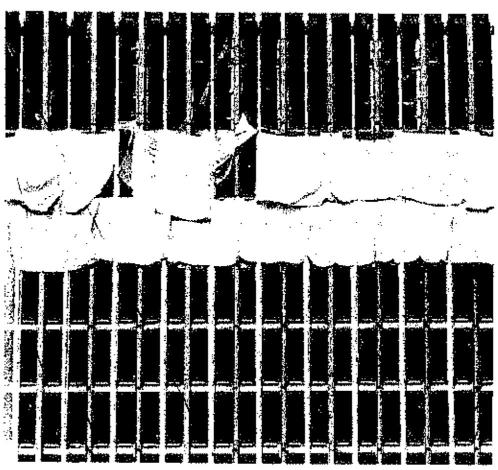

Figure 6. Multistory building inadequately enclosed with canvas. Note openings where tarpaulins have not been secured.

pletion of spray and erection of "skin" or curtain wall. Architectural awareness of this problem may permit design of future multistory buildings to ensure erection of curtain walls before spray fireproofing is applied. Scheduling is no simple matter, however, and this may be very difficult.

Work Practices

It is our conclusion that much can be done to reduce dust by the individual workman on the job, in his everyday handling of the spray material. Methods of opening, emptying, and stacking bags, proper methods of using and adjusting the nozzle, and methods of personal protection are important. Attention to seemingly small details by the worker are important, and these should be the object of training and education programs. The sprayed mineral fiber manufacturers association has prepared a booklet outlining such improved work practices. Too

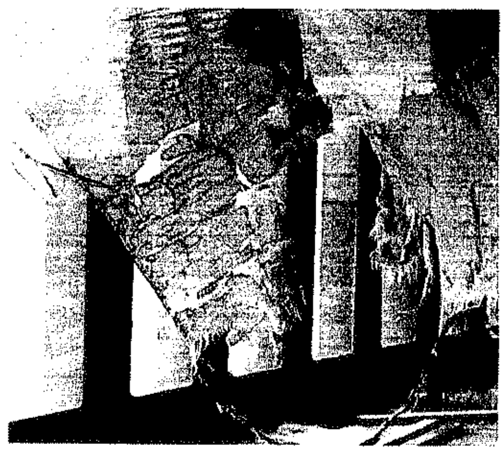

Figure 7. Wind and weather damage to enclosure canvas.

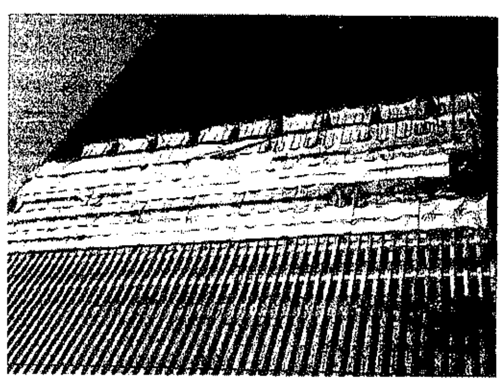

Figure 8. Enclosure of multistoried building with laced canvas and plastic tarpaulins.

Figure 9. Custom-fabricated tarpaulins for building enclosure. Note tongues and tie-downs to prevent materials from dropping along the side of the building.

Figure 10. Where a long span exists between columns, the tarpaulins must be securely fastened at the bottom to prevent flapping in the wind.

much reliance should not be placed, however, on diligence and training of individual workmen. We have found that work crews are inconstant, with inexperienced men often added as the volume of work increases. These men, at other times, do plastering, and spraying of insulation may be only intermittent employment for them. Few contractors employ a constant work force, and apprenticeship programs have been scant and fragmentary, where they exist, in this country.

Rather, education will have to be a constant, on-going affair and often the responsibility of the supervisor or foreman. His task, however, should also be lightened by the development of procedures which do not depend upon workman cooperation, skill, knowledge, training, or dedication to safety. Elimination of hazards should be built into the work procedure. Otherwise, if anything can go wrong, it well may, and the price of failure is unacceptable.

This is not to say that the on-site operations of the workman are not important; of course, they are. One area in which no planned program, however effective in principle, can be successful without workman cooperation and understanding is housekeeping. In our studies, we found that quantities of waste sprayed mineral fiber are still allowed to remain on the floors, ledges, and nearby equipment (Figures 11 to 13). Asbestos-containing waste is often tracked underfoot on a construction site for many months. In some cases, because of poor housekeeping, waste fibrous material is allowed to remain in ventilating ducts and dropped ceilings to contribute to lifetime contamination of the structure.

Experimental work is now under way to redesign existing commercial vacuum cleaners to permit their use in construction cleanup. Wet pickup of large volumes of material and collection in disposable bags are two features which must be included in a redesigned unit (Figures

Figure 11. Asbestos-containing waste allowed to remain in limited access areas and ventilating plenum of completed buildings.

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Respirator Protection

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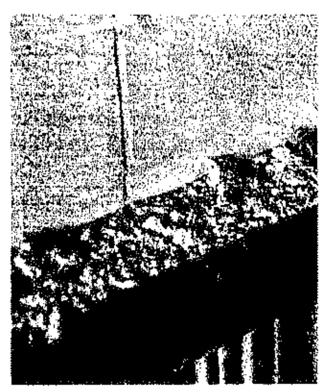

Figure 12. Poor housekeepi
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14 and 15). To reduce the number of men exposed and to facilitate easy cleanup, several of the general contractors have begun a program of carefully planned work schedules. The men and material of other trades are kept off the floor until the spray and cleanup are completed (Figure 16).

Respirator Protection

Personal protection of the workers applying the spray material is an area that needs considerable attention. We found that many men applying sprayed mineral fiber containing asbestos did not wear any personal respiratory protective device. A very few wore disposable respirators, and a few wore more conventional types. Prior to 1970, all disposable respirators available on the market were totally unsuitable for this specific use.

Progress being made in development of new respiratory protective devices is indeed encouraging. Many major manufacturers of such protective devices will probably have an effective disposable unit available sometime during 1971. It is hoped that a device of this type will have an overall efficiency great enough to adequately protect many men working in the general area of the spray operation although not near the spraying itself, nor within the spray enclosure.

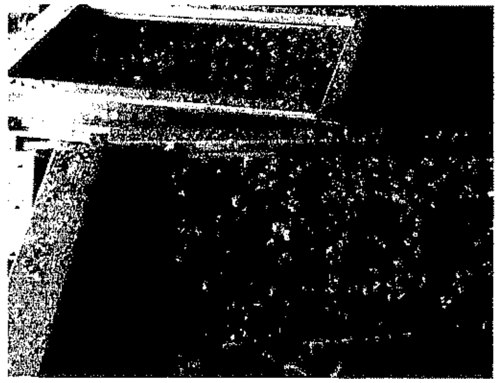

Figure 13. Uncovered pieces of equipment left on the floor during spray application collect debris from the spray operation.

Figure 14. Waste material should be picked up and packaged in tightly closed containers.

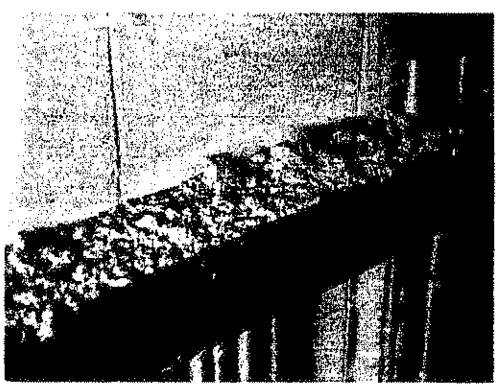

Figure 12. Poor housekeeping. Waste asbestos spray material covering conduit box where other crafts may work weeks or months later.

Nevertheless, because of the high fiber counts, 100 f/cc, a conventional filter-type respirator will not provide adequate protection for the worker handling the spray nozzle or for other workers in the enclosure. In such areas, some type of supplied air respirator must be used. The chief fault of many of the available supplied air units is their bulk. Here again, great progress is being made in the development of small belt-carried units (Figure 17). A quick look at the fiber counts in various areas at or near the spray operation points the need for mandatory effective respiratory protection.

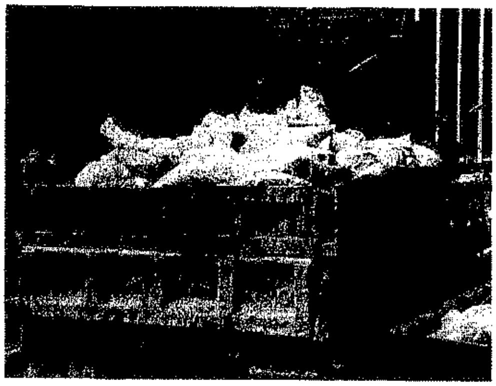

Figure 15. Waste material being transported to designated landfill areas in covered trucks with packages secured to prevent the spread of material through streets and roads.

Two steps are essential to speed the use of respiratory protection in the spray insulation trade: (1) a device more acceptable from a standpoint of worker comfort and (2) a massive educational program among these workers.

Discussion

Investigation of the sprayed mineral fiber industry indicates an important asbestos hazard exists for workmen employed in this trade. It is too early to tell how severe the death toll will be—few men have reached twenty years from onset of work—but of young men who have been regularly employed in spraying asbestos-containing insulation materials it is possible that a majority will die of asbestos disease, including lung cancer, pleural and peritoneal mesothelioma, and asbestosis. Our studies indicate

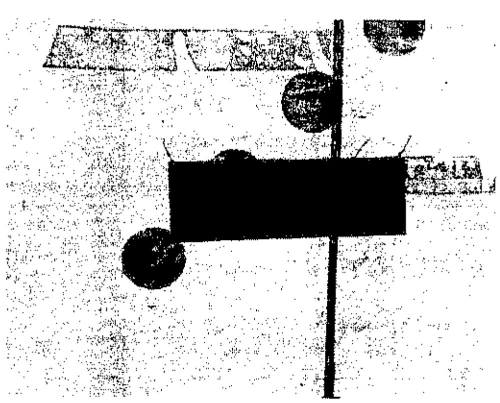

Figure 16. Enclosed areas should be appropriately marked to prevent other trades from entering the area being sprayed.

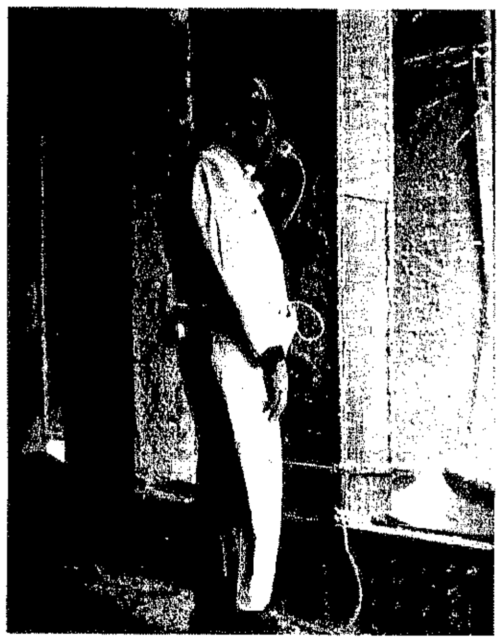

Figure 17. Because the spray applicators are subjected to high concentrations of asbestos fibers, some type of air filtration or supplied air respirator is necessary. A prototype of the Burgess filtered air respirator.

that they have been exposed to asbestos dust levels otherwise seldom seen nowadays in the asbestos industry.

An equally unacceptable hazard may exist for other construction workmen, exposed on construction sites to dusts derived from spraying operations. While such indirect occupational exposure is intermittent, it is still at levels found in other trades to have high risk. Unfortunately, intermittent high peak exposures may carry the potential of serious disease twenty, thirty or more years later. The inhaled fibers

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become lodged in the lung. Once *in situ*, the fibers continue to exert their effect on contiguous tissue; while the individual may be spared further exposure, his lung and other tissues are not. Construction trades workmen employed in buildings in which spraying of asbestos fiber insulation was done should be considered to have been subject to asbestos exposure and risk. Information is inadequate to predict the magnitude of this risk; it may be considerable.

Such occupational hazards are intolerable, and it is evident that they will not be permitted. In addition to efforts by regulatory agencies mentioned before, construction unions, too, have taken steps to protect their members. Work stoppages have occurred in New York City, Westchester County, and elsewhere, with men in various trades refusing to work during spray operations. If administrative regulation is unavailable or ineffective, self-regulation by labor and employers in the construction trades may be substituted.

Our studies suggest that the occupational hazard associated with spraying of asbestos insulation can be minimized or eliminated by suitable industry procedures. Such controls, as noted, will be expensive for the sprayed fireproofing industry; the burden in the competative market place may make the product and process uneconomical, to give way to other means of fireproofing and insulating. Should this occur, it will simply mean that the health of workmen must be considered in weighing the cost of work done. On some scales, as this one, health will weigh heavily.

The alternative to controls will be banning the spraying of asbestos materials. While, as a general rule, *control* of environmental hazards seems preferable, if control measures are neither feasible nor effective, or if they are ignored or disregarded, *banning* will be considered.

Note: Since this manuscript was submitted, it was determined that the existence of the N.Y.C. Department of Air Resources had failed to ensure adequate compliance for the control of the spraying of asbestos mineral fiber insulation. The New York City Council thereupon banned all spraying of asbestos in N.Y.C. effective February 25, 1972—Local Law 49, 1971, Air Pollution Control Code, Section 1403.2-9.11(B); enacted August 25, 1971.

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