AMERICAN

Industrial Hygiene

ASSOCIATION Journal

Volume 23 | September-October | Number 5

TABLE OF CONTENTS

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION JOURNAL, published bi-monthly by the American Industrial Hygiene Association. Dohrman H. Byers, *Editor;* Kenneth W. Nelson, Kathleen Kumler, Verald K. Rowe, and Richard F. Scherberger, *Associate Editors.* Editorial offices, 1014 Broadway, Cincinnati 2, Ohio. George D. Clayton, Publications Manager. Business office, 14125 Prevost, Detroit 27, Michigan. The subscription price is $7.50 per year in U.S.A.; $7.75 in Canada; $8.25 elsewhere. Single copies, when available, may be purchased from the business office, $1.50 per copy in U.S.A.; $1.75 elsewhere. Library of Congress Catalogue No. 57-3191.

Second class postage paid at St. Paul, Minnesota

Printed for the American Industrial Hygiene Association by
THE BRUCE PUBLISHING COMPANY, SAINT PAUL 14, MINNESOTA

Some Health Hazards Associated with the Building Trades

MILTON SHEINBAUM

New York State Department of Labor, Division of Industrial Hygiene, 80 Centre Street, New York 13, New York

Technological advancement in building construction has produced some new modes of exposures to some traditional hazards, and has introduced several new types of hazards. Included are those from the use of various dusty materials in new processes, from new chemical products and solvents as they are used in construction, and from fuel exhaust. Recommendations are given for controlling hazards in the pneumatic application of sanded plaster and concrete grinding; in the use of epoxy and polyurethanes; in paint spraying; and in the operation of engines for materials-handling equipment and heaters for construction jobs.

Introduction

TOGETHER with the utilization of many new materials for construction, industry has in recent years made increased use of new methods of applying conventional materials in construction. Incidental to this there has been an increase in the potential health hazards associated with various occupations in the building trades. Several of the new procedures and materials of construction and the hazards which may attend them will be examined in this paper.

Pneumatic Application of Plaster

The combination of high labor costs and the availability of substitute materials such as prefabricated gypsum cement, cement and wood chip, or cement and paper panels has caused a considerable reduction in the use of conventional gypsum plaster on lath. In an attempt to recover the market, the plastering industry has developed and introduced on an increasing scale a pneumatic method of applying plasters. This method consists of pumping either plaster slurries or fluffs to the point of application and spraying them on the receiving surface. This method eliminates the need for hod carriers and reduces troweling.

Gypsum Plaster Base Coat

The application of scratch or sanded plaster base coats is the most extensively performed of all plastering operations. Base coats are usually one-half inch thick and consist of a mixture of about 20% gypsum plaster, 65% sand, and 15% water with trace amount of additives.

For pneumatic appplication, this plaster is mixed in a small ribbon mixer usually located outdoors. Mixing these materials forms a thick slurry having the consistency of heavy cream. The plaster is automatically fed into a reciprocating piston pump which forces the mixture through a two-inch diameter rubber hose to a spray nozzle. It may be applied to any type of lath or to unprepared tile, block or concrete surfaces. The spray nozzle consists of a short Venturi section terminating at a removable perforated cap. Compressed air between 16 and 22 pounds pressure forces the plaster through a three-eighth-inch perforation in the cap. The distance between the spray gun and the surface being sprayed may vary from a minimum of six inches to a maximum of four feet.

A plastering crew consists of five or six men. One is at the mixer; a second operates the spray gun; and the third man acts as a sprayer's helper. The latter assists in moving the hose, preparing the area to be sprayed, and in cleaning up after spraying. The remaining men follow three to five minutes behind the sprayer, leveling and troweling manually.

The spray operation is very rapid. The walls, ceilings, and closets of a 9 by 12 foot

This paper was presented at the American Industrial Hygiene Conference in Washington, D. C., May, 1962.

TABLE I
Measurement of Average Particle Size

Device Used	Size in Microns	Per Cent Greater than Reference Size
Cascade impactor Group 1	2.0	100.0
	3.5	63.0
	8.0	36.0
	20.0	9.8
Group 2	2.5	100.0
	4.5	75.0
	9.0	42.0
	25.0	4.5
Group 3	2.75	100.0
	6.0	69.0
	11.0	26.0
	30.0	12.3
Microscope graticule	2.0	99.8
	4.0	17.3
	8.0	6.2
	16.0	1.5
	32.0	0.8

room can be completed in less than half an hour. However, the operation is extremely dirty because of the considerable quantities of underspray, rebound and drippings. Air movement within the area affects the operation and steps must be taken to close all exterior openings prior to spraying.

Environmental Conditions

In the course of an extended study of spray plastering operations, the Division of Industrial Hygiene collected over seventy-five air samples using midget impingers and cascade impactor slides. Impinger samples were used to determine dust counts, dry state particle size, and airborne free silica concentrations. Phase microscopy methods described by Crossman[1] and the author[2] were used for airborne free silica concentration determinations. Dry state particle size determinations were made at the same time by measuring particles with a calibrated graticule containing circles of various sizes.

Samples were secured on cascade impactor slides in accordance with the methods outlined by Littman.[3] The number of dust particles in standard areas of each stage of each slide was counted. Counts in each stage were then converted to percentages of totals for each sample. The separate percentages of the totals of the several samples were averaged and converted to percents showing increase over the respective reference sizes. The averaged percent of increase then fell into three groups which differed only in the velocity of air flowing through the apparatus at the time the samples were secured. The dry state particle size determinations were made by similar calculations based on the sum of all counts in each size range. Table I shows the results of these calculations.

Parent material samples were obtained at each sampling location and were analyzed for free silica by wet chemical methods in accordance with the procedures outlined by Talvitie.[4]

Table II indicates the physical characteristics of the dust found at the breathing zone of the operator during plaster spraying operations. The samples obtained with the cascade impactor contained the dust with its water content whereas the impinger samples were dry. It was also found that the dust concentration tends to diminish inversely with the distance from the spray operator. Sampling at a distance of six feet showed the average count was about 10 MPPCF.

TABLE II
Physical Characteristics of Dust Created by Sanded Gypsum Plaster Spraying(a)

Dust counts	26-75 mppcf
Free silica concentration(b)	61%
Mean particle size, dry state	1.5 microns
Mean particle size, wet state	6.4 microns

(a) As indicated in breathing zone sampling.
(b) The free silica concentrations found in the air samples were in close agreement with those found in the parent material.

In the course of pneumatic application of gypsum plaster, the spray operator may be exposed to a variety of health hazards. First, there is always the possibility he might inhale dust containing silica. Second, he is exposed to a constant barrage of wet alkaline gypsum particles and droplets that may cover the exposed skin area and enter the eyes. Thus, the dermatitis problem normally present in plastering is extended because the face and neck as well as the hands are exposed. Irritations of the eye are also likely for the same reason. In addition the spray operator may be required to work on narrow wooden scaffolds or ladders, or at best on semi-finished floors, and the likelihood of falls and tripping is increased by the presence thereon of considerable quantities of wet plaster and construction debris.

Protective Devices

The need for using protective devices other than hand creams is limited to the spray operator since the concentration of dust in the atmosphere diminishes inversely with distance, and because all members of the crew other than the spray gun operator are well behind the spray nozzle in terms of time and distance. The only practical means of protecting the spray operator is by means of a supplied-air respirator. A supply of air is readily available in the compressed air hose feeding the spray gun. Experience has shown that a nozzle respirator coupled to a full face shield to protect the face and eyes is practical and adequate.

Asbestos-Rockwool Cement

Asbestos and asbestos-rockwool cement or fiberglass mixtures may be applied as interior finishes on solid surfaces to achieve a high fire-resistive rating and to deaden sound. They are most commonly used on exposed steel beams and girders in buildings which fireproof construction is required, as well as on ceilings and ceiling aprons of auditoriums and meeting rooms. Because these finishes are soft and friable they are limited to use in areas where they may be protected by either their inaccessibility or additional coverings.

Asbestos cements may be applied either manually or pneumatically. The machine used for the pneumatic application of these finishes consist of a finger stirrer which functions to fluff and to break up the asbestos strands of the raw material, a paddle wheel fan, a length of three-inch diameter flexible hose and a nozzle. Because of mechanical limiations the hose is relatively short, not exceeding 50 feet in length. The nozzle consists of two parts. The first is an outer annular section that is fed water at 80 to 100 pounds per square inch pressure and capped with a perforated ring. Its function is to create a fog to wet the asbestos. The second, or inner section, is essentially a Venturi tube which serves to accelerate and further separate the asbestos fluff. Compressed air at about 100 to 120 pounds pressure is fed into the Venturi immediately in front of the taper.

The stirrer and accompanying dumping operations are usually located near the spraying operation within the building. Asbestos-cement may be applied either before or after the structure is closed in. The distance between the spray gun and surface may vary from 6 to 24 inches. Surfaces may be previously treated with water or a water-latex emulsion or may be dry. Wetting the surface improves adhesion. Sometimes a latex emulsion may be added directly to the asbestos for the same purpose.

The plastering crew normally consists of three men: a mixer, a spray operator, and a helper. Occasionally one or two additional men may be assigned to the crew to level and smooth by hand. The general working conditions are the same as experienced in spraying sanded gypsum plaster, except that the use of scaffolds and working over large areas are the rule rather than the exception.

The Division's studies of this operation, although not completed, have shown the presence of extremely dusty conditions. The average dust count in the breathing zone of the operator is about 200 mppcf. Considerable dustiness was noted at distances of 50 feet from the operation as well as in the area about the mixers. It was impossible to secure dust samples in areas where asbestos cements containing admixtures of latex emulsion were being sprayed since the adhesive formed a gel in the impinger tubes. Besides a high percentage of asbestos, the airborne dust may contain mineral wool, clay, fiber glass and cement, a mixture which is potentially harmful to the lungs and irritating to the skin. The hazards produced by the pneumatic application of asbestos cement plaster are not limited to the spray operator, but may affect anyone working within 50 feet.

Recommended procedures for health protection tentatively call for use of airline respirators by the spray operators, approved dust respirators for the mixer tenders and helpers and the exclusion of all other persons from the general area in which asbestos is being mixed or sprayed.

Expanded Aggregates

Gypsum mixed with expanded aggregate, cement and additives may be applied instead of various other combinations of materials to produce highly fire-resistive finishes. Because this mixture is relatively light as compared to concrete, it is sometimes used in its place to reduce weight. However, expanded aggregate plaster is not used widely because it is very expensive and does not improve the structural integrity of the building. Moreover, it is relatively soft and friable, and does not have the good accoustical properties of asbestos plasters. Plasters made with expanded aggregates may be applied in a manner similar to that used for sanded gypsum plaster. If they are applied pneumatically they must be leveled and troweled for a fine finish.

Perlite and vermiculite are the most commonly used expanded aggregates containing practically no free silica. Operations at which expanded aggregates are being applied pneumatically have not yet been studied by the Division and consequently no data is available.

Concrete Grinding

Concrete is poured as a semi-fluid material into molds or forms constructed of wood or steel. After pouring, it is vibrated to fill all the voids and spaces within the form. The joints at which the sections meet are not necessarily flush, smooth, or tight. The sections themselves contain irregularities and surface imperfections. Thus, after the concrete sets and the forms have been removed the surface is rippled and ridged and contains numerous spines and bumps. If the concrete surface is to remain exposed these imperfections may spoil the appearance of the finished construction or may pose a hazard to the occupants of the building. It is therefore necessary to remove them, and grinding is the process best suited for the work.

There are three main types of machines for grinding concrete, each of which uses a high-speed carborundum wheel to do the actual grinding. The first type, used for overhead and vertical surfaces, consists of a large wheel mounted on the ends of extended counterbalanced arms. It is driven by an electric motor through a belt and pulley arrangement. The entire assembly is mounted on wheels for portability. The arms and grinding head move through a vertical plane and may be independently controlled. Ceilings can be ground by setting the arm and head position and by moving the carriage. Vertical surfaces are worked accordingly by a reverse arrangement.

Another machine in common use consists of a fixed wheel mounted below a motor and set on wheels. It is used to grind and to polish floors. This machine may be used for wet as well as dry grinding. The last type of machine is essentially a hand-held portable face-grinder. It is used in areas that cannot be ground with either of the larger machines.

Repairs which require repointing on stone and brick buildings are related to cement grinding insofar as the portable grinder is used for the removal of the old grout. The edge of the wheel is used instead of the face and whatever is said of concrete grinding may be applicable to repointing operations as well.

Concrete surfaces are usually smoothed prior to the erection of the exterior walls; however, special work may be done after the exterior has been completed. Floor grinding and terrazzo finishing is usually done after both interior partitions and exterior walls have been completed. The operation is quite rapid, and normally only one man is required at a location. On large jobs, however, additional personnel may be assigned to portable hand grinding to help shorten the total work time.

The Division's experience with concrete grinding operations show that the dust concentrations may very widely depending on the physical conditions of enclosure, direction of wind, and other factors. It is likely that the concentrations of dust in the working area will be well above the MAC unless the process involves wetting. If the wind is blowing toward the operator's back and the distance between the wheel and the operator is at least 6 feet, the dust concentration in the breathing zone may remain within tolerable levels. However, when the conditions are not so favorable, the potential hazard to the operator may be considerable since the free silica content of the mortars and concrete he grinds ranges from 30 to 80 per cent.

Epoxy Resins

Epoxy resins have gained widespread use in a relatively short period of time in many diverse industries. Inherent limitations and high costs have limited their use by the building trades as agents for producing very hard floor surfaces and as components of impermeable paints.

Epoxy resins are manufactured by reacting ethylene glycol with various complex amines to form a liquid prepolymer which may under certain circumstances be mixed with fillers such as sand or talc. To form the polymer, diethlenediamine or other complex polyamines are added as catalysts. Polymerization may be rapid or slow and may or may not require heat and curing. During polymerization various toxic amines are given off which may cause severe dermatosis on contact with the skin or lung irritation if inhaled.

For use as a pavement over clean, dry concrete or wood epoxy prepolymer is supplied with a mixture of sand. The hardener, or catalyst, is supplied in a separate container to be mixed on the job in small batches which must be poured immediately after mixing. After some polymerization has taken place, the mixture stiffens and can be spread to proper depth and smoothed by troweling. The pavement usually becomes hard overnight.

The tools and containers for mixing and working epoxy resin mortars are usually cleaned with toluol, acetone, or mixtures of solvents sold as lacquer thinners. Since the plastic is not soluble after it is fully polymerized, the utensils must be cleaned prior to full set. The trowels and hand tools required for smoothing are cleaned frequently by wiping with solvent saturated rags.

The use of solvents adds to the significant hazards inherent in the use of epoxy resins. Measures to protect the health and safety of workers should be taken accordingly. The crew is usually small, with one man mixing and up to five men carrying, pouring, and troweling.

Epoxy resins may be used in paints wherever hard, durable surfaces are required, as in food processing plants and lavatories. Such paints are supplied either in ready-to-use mixtures containing the prepolymer, catalyst, and colors suspended in solvents; or more commonly, in two containers, one holding the resin and the other the remaining materials, all of which are mixed immediately before use. The solvents normally constitute 50 to 60 per cent of the paint, which is usually applied by spraying. Polymerization is very rapid and the coat is set within an hour after spraying. The hazards involved are due principally to the solvents and may be controlled in a manner indentical to that used in spray painting with other materials.

Spray Painting

The pneumatic application of paint is not new. It has been used as a labor-saving technique for more than twenty years in the construction industry. Some recently developed paints such as those containing epoxy resins and the so-called speckled paints must be sprayed, while others such as synthetic enamels may be applied by either brush, roller, or by spraying.

Conventional paints usually contain petroleum naphtha; however, the newer types have a mixture of solvents as a part or as the total constituent of their vehicle. Toluol, xylol, methyl ethyl ketone, isobutyl ketone, benzol and similar solvents may be used in various percentages which may exceed 60% of the total weight of the paint. These solevents evaporate far more rapidly and are anywhere from 3 to 30 times more toxic than naphtha.

In the construction industry the spray operator does not have the protection of a spray booth, and may frequently work in confined areas for relatively long periods of time. He may be provided with a cartridge type respirator for protection; however, cartridge filters rapidly clog with paint solids, and filter absorbents become saturated with the solvents in such atmospheres. The respirator is then inoperative. Protection may better be secured by an airline respirator as suggested for use with plaster sprayers.

Since organic thinners used in paints are highly flammable, and because the electrical power supplies, sparking devices, and other sources of ignition used in work areas are usually not enclosed, a considerable fire and explosion hazard is added to the inhalation hazard present when using paints.

A recently developed airless spray gun is claimed to reduce substantially (if not to eliminate altogether) the hazards attendant to spray painting. This gun uses heat to reduce the viscosity of the paint. Air pressure is applied directly onto the paint to cause the required flow. The paint is atomized by the nozzle and the sovents evaporate very quickly. Since the solvent concentration in the paint is unchanged the hazards associated with the operation of an airless spray gun are identical to any other spray painting where no heat is involved.

Conclusions

The construction industry faces numerous traditional health hazards along with some new ones that have emerged. Plaster-spraying, concrete grinding, the use of epoxy resins, and paint spraying have been included in this discussion. Respirators afford a means of protecting the worker but their use is practical and effective only for relatively short exposures. Further work remains to be done in devising adequate control of hazards during extended exposures.

References

1. Crossman, G.: Determination of Free Silica by Dispersion Staining Microscopical Methods, *Amer. Ind. Hyg. Assoc. Quart. 12:* 117 (September 1951).
2. Sheinbaum, M.: Experiences with Phase Microscopy, *Amer. Ind. Hyg. Assoc. J. 21:* 518 (December 1960).
3. Lippman, M.: A Compact Cascade Impactor for Field Survey Sampling. *Amer. Ind. Hyg. J. 22:* 348 (October 1961).
4. Talvitie, N. A.: Determination of Quartz in Presence of Silicates Using Phosphoric Acid, *Analytical Chem. 23:* 623 (April 1951).

WHO Fellowships Available

The World Health Organization will provide to United States health workers in 1963, at the request of the Government of the United States, a limited number of short-term fellowships for the "improvement and expansion of health services" in the United States. All applications will be screened by a Selection Committee established by the Surgeon General of the U. S. Public Health Service.

Applications will be considered in public health and related fields. Applicants must be engaged in full-time public health or educational work. In making selection, the Committee will consider the ability of the individual, the field of study proposed and the contribution which foreign study will make on his return. Officers and employees of the United States Government are not eligible. These fellowships will cover per diem and transportation and, except in very unusual circumstances, will be limited to short-term travel, *i.e.,* two to four months. Employers of successful applicants will be expected to endorse applications and to continue salary during the fellowship.

Fellowships will be awarded up to the total of the funds available but successful applicants could probably not start their fellowships before May 1, 1963. The deadline for the receipt of applications is January 1, 1963. Further information and application forms may be obtained from Howard M. Kline, Ph.D., Secretary, World Health Organization Fellowship Selection Committee, U. S. Public Health Service, Washington 25, D.C.