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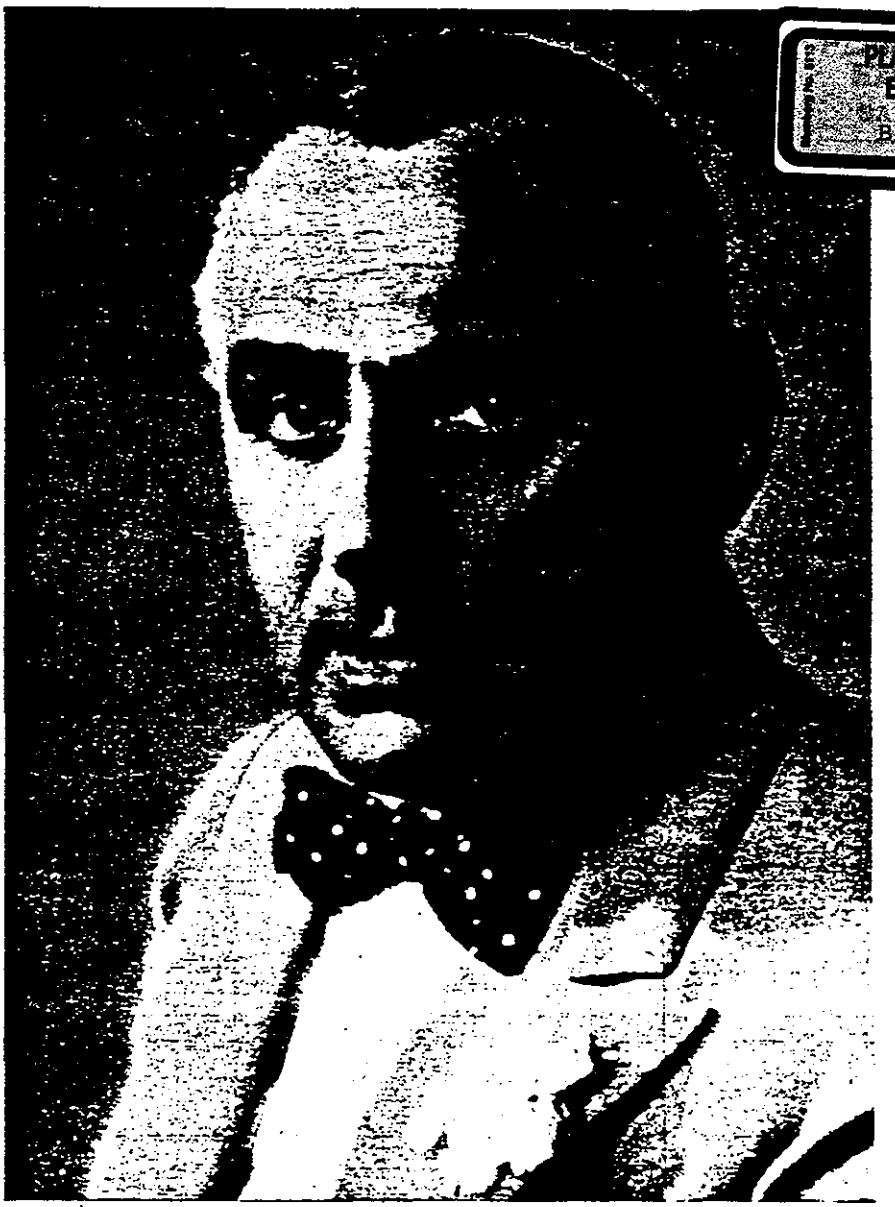

WALTER JODOK KOHLER, 1875–1940

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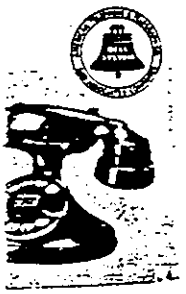

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ENGINEERING CONTROL OF DUST WITH SPECIAL REFERENCE TO RESPIRATORS*

By A. D. Brandt

Abstract

The more common methods of reducing or controlling the respiratory hazard caused by dust are discussed. The specific methods are (1) control of dust at the point of dust generation, (2) isolation of dusty processes, (3) substitution of nonhazardous processes, and (4) reduction of dust in inspired air by respiratory protective devices. The general methods are (1) general ventilation, (2) good housekeeping, and (3) a rigid inspection of all control devices. A detailed discussion is given of respirators, their proper use, construction, maintenance, and Bureau of Mines approval.

I. Introduction

Methods of dust control are not new, but the proper application of engineering principles to such methods is lacking in many cases. Some industries are reluctant to call in qualified engineers to lay out their dust-control plans. No one method, design, or device will solve the problem for all industries or in one large industry, and only a thorough study of the existing conditions can give the engineer a basis on which to determine the best method or combination of methods for the problem or industry in question.

The important methods of dust control are (1) control at the point of generation or dissemination, (2) isolation of dust-producing processes, (3) substitution of less hazardous materials, and (4) reduction of dust in inspired air by means of respirators.

II. Control at Point of Generation or Dissemination

The methods commonly used to control dust at the point of origin are (1) local exhaust ventilation equipment, (2) water or other suitable liquids, and (3) good housekeeping. A local exhaust ventilation system consists of (1) exhaust hoods, (2) air ducts, (3) collector, and (4) fan.

(1) Hoods

The purpose of an exhaust hood, which is the vital part of the system, is not to create "suction" but to produce air currents in the area of dust generation of suitable magnitude and acting in the proper direction to overcome the energy of the escaping particles and to carry them into the exhaust system. A knowledge of the laws of air flow into suction openings of various shapes is therefore essential to proper design. A thorough understanding of the way in which dust is generated is also necessary, especially as it pertains to particle size and to the velocity at which the particles are thrown off. An efficient hood collects the dusts generated with a minimum air flow from the ineffective or clean air areas and with minimum power consumption. A hood is properly designed when it (1) is efficient and (2) does not hinder the operation of the tool or machine.

(2) Ducts and Collector

The ducts include all piping through which the dusts are carried from the hoods to the collector by the air current created by the fan. The final part of the system is the collector, which retains the dust and permits the clean air to escape into the atmosphere.

Routine inspection and maintenance are important. The ducts are clogged all too frequently with worn-out overalls or similar waste materials; properly designed systems are unbalanced by having the tinsmith put in additional branch ducts and exhaust hoods; collectors are not emptied; and bags of collectors are torn or even removed and not replaced. Inspection and maintenance can ensure successful operation for a reasonable period of time.

(3) Fan

To avoid the wear of fan blades and housing resulting from the abrasive action of the dust, the collecting unit should be located on the suction or upstream side of the fan.

(4) Spray

Wetting down with water by hand or by sprays or streams is a method of control at the point of origin that is widely used. Water helps temporarily to lay dust, and a stream carries away many particles, but the procedure is fundamentally impracticable as an effective safeguard. It is impossible to wet most of the particles by the usual means owing to the gas layer which envelops them. Few particles are collected and consequently many of those that are temporarily wetted will remain in suspension owing to evaporation of the surrounding layer of water before complete settling has taken place. When other methods are not available or are impracticable, however, the use of a water stream is worth while.

(5) Good Housekeeping

Good housekeeping as a means of dust control is possibly the least difficult and least expensive to employ and frequently accomplishes remarkable results. It prevents dust accumulations in any part of the plant where the dust may be redispersed by careless operation, shock, or wind currents. Such dust may be wetted down and removed frequently and permanently. Frequent and regular use of large vacuum cleaners on

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beams, rafters, or other inaccessible places is also helpful in solving this problem.

III. Isolation of Dust-Producing Processes

The isolation of dust-producing processes limits the exposure to a few men who may be protected by respirators. The inclosure of these processes in dust-tight chambers or rooms, such as abrasive blasting cabinets, is effective. The chambers and dust-control devices, however, must be kept in good working condition to maintain their effectiveness.

IV. Substitution of Less Hazardous Materials

The substitution of less hazardous materials offers an absolute method of dust control, but extensive changes in the manufacturing process are often required which may not be practicable. This method should not be recommended unless or until it is established that the quality of the manufactured item will not suffer by such change. The replacement of sandstone grinding wheels by artificial abrasive wheels and sand by steel shot in abrasive blasting has effected a substantial reduction in the silicosis rate of the pertinent industries.

V. Use of Respirators for Reduction of Dust in Inspired Air

Respirators are misused and abused more than any other dust-control device.

The amount of dust in the inspired air may be reduced to a safe value by suitable respiratory protective devices. These alone are not the solution to many of the dust-control problems in industry, but they are a necessary and helpful adjunct to other methods. Although there are a number of different types of respirators, the two types which are used most commonly in dust control are (1) the mechanical filter or dust respirator and (2) the supplied-air or air-line respirator and abrasive blasting helmet. These respirators are used extensively on jobs such as abrasive blasting, paint chipping, handling used storage battery plates, cadmium oxide manufacture, welding operations, spraying of paints and glazes, and manufacture and use of pigments and dyes. Their most important use is found under conditions where protection is required intermittently, as in cleaning-out operations; sweeping; after blasting; removing cores from large foundry castings; shoveling, screening, and handling of materials; and the operation and maintenance of processing equipment.

Respirators should not be considered to be part of the worker's wearing apparel. They are safety devices and should be supplied by the employer. The employer, moreover, must see that they are distributed to all employees who need them, and he must tell the workers when and how to use them, which is a difficult task and is accomplished only by incessant instruction.

(1) Mechanical Filter Respirators

When the mechanical filter respirator is worn on a man's face, a certain percentage of the dust is filtered out from the inspired air. The air movement through the filter is produced by the respiratory action of the wearer. A filter respirator which is to be accepted by industry as satisfactory should (1) be comfortable and fit the face well, affording an air-tight contact between the face and the mask, (2) have little or no interference with vision and permit the use of glasses or goggles, (3) have a highly effective filter which is not bulky, (4) have low resistance to breathing over a period of use, (5) have small dead air space, and (6) have both inhalation and exhalation valves.

Dust respirators are usually constructed of a rubber or part-rubber facepiece and a filtering medium of felted or paperlike material. Exhalation valves are now almost universal, and inhalation or check valves are supplied in most respirators. Inhalation valves are intended to prevent (1) rebreathing exhaled air and (2) the humid exhaled air from getting into and fouling the filter. Rebreathing exhaled air, which has a high carbon dioxide content, induces panting and causes the wearer to think that there is a lack of air or that the resistance to breathing is high. He will attempt many solutions to eliminate these difficulties, all of which will seriously impair the performance of the respirator.

(2) Supplied-Air Respirators or Helmets

The air-line respirator and the abrasive blasting helmet are the supplied-air devices most commonly found in industry. The respirator consists of a face mask with an attached hose or rubber tube through which air is supplied, and the air is pumped or blown from a source of clean air to men in the various exposures. These devices afford positive protection if they are properly installed and maintained. The intake to air-supply systems used for this purpose must be located at a point where the air is clean and where it will not be contaminated by dust from nearby buildings. For the removal of oil, water, and odors from the air, a good air cleaner or purifier should be installed in the supply line. The cleaners, however, do not remove carbon monoxide which may be given off in antiquated or worn compressors. To avoid the possibility of carbon monoxide poisoning in men wearing supplied-air respirators, it is imperative that the air pump or blower should receive adequate routine inspection and periodic overhauling.

The abrasive blasting helmet completely incloses the wearer's head, forming a seal at the neck and shoulders or having a directly connected cape which may be tucked in under an over-all jacket or may be even extended to the waist. Blasters move about very little, but the helmet should be light in weight and the window or port which affords vision should be large and correctly placed. If the helmet is too small, a large volume of air must be supplied to prevent an undesirable decrease in the pressure within the helmet when the wearer inspires. The volume of air supplied to a helmet should be sufficient to provide a continuous leakage outward. Some helmets require only about 100 liters per minute; others require twice this amount. The air should be wasted through the collar or down around the neck and out through the clothing. Collars should be permeable to air to eliminate the possibility of building up a dangerous pressure within the helmet.

Exposed escape valves are unsatisfactory because dust from a blast may easily be driven into the helmet against a strong air current.

(3) Selection of Respirator

The hazards as well as conditions of use of respirators in industry are many and varied. It is as illogical to recommend the same respirator for all purposes as it is to expect to find a respirator specifically designed for each different operation. No worker would use the same respirator for hay-fever prevention that he would wear if he were exposed to a dangerous concentration of quartz. In the selection of the proper respirator for any particular operation, the buyer should specify the conditions as fully as possible when asking for recommendations from respirator manufacturers or from the U. S. Bureau of Mines.

(4) Care and Maintenance of Respirators

Because the use of respirators, compared to other methods of dust control, is inexpensive, little or no thought is given to their maintenance. Only too frequently good respirators are purchased, distributed carefully, and then forgotten, and in a short time they are dirty and function ineffectively.

The respirator will soon become defective if it is not properly maintained and will fail to give the necessary protection, even if it is worn correctly and continuously. A defective respirator, moreover, is worse than none because the wearer is given a false feeling of security and will not exercise the precaution which he would take if he had no respirator.

Individual and central maintenance are the two general systems of respirator maintenance in use today. In the individual maintenance system, the care and upkeep of the respirator is left to the user, who must wash, sterilize, and repair the respirator. In the central maintenance system, all respirators are assembled at one central point for cleaning and repairing.

The central maintenance system usually is worked out somewhat as follows. Each worker who needs respiratory protection is supplied with two respirators which are marked with the employment number of the user by stamping the number on metal parts, riveting metal number plates on the rubber masks, or sewing laundry tabs on the headbands. When he goes to work in the morning, the worker passes by a row of pigeonholes in one of which (indicated by his employment number) he finds a clean and well-kept respirator. At the close of the shift, he again places the dirty respirator in the pigeonhole. All of the dirty respirators are collected by one man who cleans and repairs them in a room laid out for this purpose. One respirator per worker is sufficient if the maintenance is carried out between shifts. Two respirators usually are supplied, however, and the repairs and cleaning are done by one man on the regular shift. The worker in charge of the respirator maintenance need not be a new or special worker. He may be the man in charge of the stock room or any individual whose work will permit. The maintenance of respirators may frequently be combined with that of such equipment as goggles and protective hats. In some industries where relatively few respirators are in use, the maintenance is one of the duties of the nurse.

The advantages of the central over the individual system are obvious. Each worker has a clean, well-kept respirator daily. He will object less to wearing it and will get real protection at all times. The monetary saving effected by the increased life of the parts and decreased need for new respirators usually will more than offset the additional cost (if any) of setting up and maintaining the central system. The idea of a central maintenance bureau is not a new one. Such bureaus have been in use in a number of industries for several years. The results produced are remarkable, as evidenced by the condition of the respirators and the apparent satisfaction of the users.

Respirator maintenance usually consists of cleaning, sterilizing, and repairing. Effective methods of cleaning and sterilizing are (1) wash in warm water with a brush and soap; (2) immerse for ten minutes in a solution of formalin, made by placing 1 part of 40% formaldehyde solution into 9 parts of water; (3) dip in a 3% solution of carbolic acid, a 2% solution of lysol, or a 70% solution of denatured alcohol; or (4) subject the respirator to sterilization by a moist atmosphere of antiseptic gas, preferably formaldehyde, for a period of 10 minutes at room temperature. After following any one of these procedures, the respirator should be rinsed with water and hung up to dry. The filters, felt screens, and headbands (if elastic) must be removed before cleaning or sterilizing the respirator.

Many dust respirators employ so-called "long-life" filters which are intended to be used over and over. Such filters are cleaned by blowing the dirt or dust off with compressed air, by brushing the surface, or by tapping the filter. If the filters are moist, they must be dried before the dust can be removed effectively. The filters may be dipped in a dry-cleaning solution for a short time to remove grease and the like. This process, however, should be carried out only infrequently because it decreases the life of the filter.

VI. Bureau of Mines Approval

Dust respirators are tested and approved by the U. S. Bureau of Mines under Schedule No. 21 entitled "Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility," and supplied-air respirators are tested and approved under schedule No. 19A entitled "Procedure for Testing Supplied-Air Respirators for Permissibility."

The only important difference between the air-line respirator and the abrasive blasting helmet is that the latter provides protection to the face and head of the wearer from the rebounding abrasive.

Seven supplied-air respirators of this type are approved; two are air-line respirators and five are abrasive blasting helmets.

The U. S. Bureau of Mines, through these approval schedules, has done a great deal to raise the standards of the respiratory protective devices manufactured in the United States and has been of great service to industry in the selection of the proper devices.

WILLSON PRODUCTS, INCORPORATED
READING, PENNSYLVANIA

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Surface Combustion Corp., Toledo, Ohio
Swindell Brothers, Baltimore, Md.
Swindell-Dressler Corp., Pittsburgh, Pa.

Taylor, Smith, & Taylor Co., Chester, W. Va.
Texas Mining & Smelting Co., Laredo, Texas
Titanium Alloy Mfg. Co., Niagara Falls, N. Y.
Toyo Toki Kaisha, Kokura City, Japan
Trenton Potteries Co., Trenton, N. J.
Twyfords, Limited, Stoke-on-Trent, England
Tyler, W. S., Company, Cleveland, Ohio

Union Electrical Porcelain Works, Inc., Trenton, N. J.
United Clay Mines Corp., Trenton, N. J.
United Glass Bottle Mfrs., Ltd., London, England
United States Gypsum Co., Chicago, Ill.
Universal Clay Products Co., Sandusky, Ohio
Universal Dental Co., Philadelphia, Pa.
Universal Sanitary Mfg. Co., New Castle, Pa.

Vanderbilt, R. T., Company, New York, N. Y.
Vereeniging Brick & Tile Co., Ltd., Vereeniging, Transvaal, South Africa
Vesuvius Crucible Co., Swissvale, Pa.
Victor Insulators, Inc., Victor, N. Y.
Vitrefrax Corporation, Los Angeles, Calif.
Vitreous Steel Products Co., Cleveland, Ohio
Vitro Manufacturing Co., Pittsburgh, Pa.

Wallace China Co., Ltd., Huntington Park, Calif.
Waltham Grinding Wheel Co., Waltham, Mass.
Washington Porcelain Co., Washington, N. J.
Wayne Laboratories, Waynesboro, Pa.
Western Brick Co., Danville, Ill.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Derry, Pa.
West Virginia Brick Co., Charleston, W. Va.
Wheeling Steel Corp., Yorkville, Ohio
Wisconsin Porcelain Co., Sun Prairie, Wis.

CORPORATION MEMBERSHIPS ARE PROFITABLE INVESTMENTS

The American Ceramic Society

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I hereby certify that the attached copies of **Bulletin of the American Ceramic Society, Volume 20, 1941**, are true and accurate copies, which are maintained in the normal course of business at the American Ceramic Society, 735 Ceramic Place, Westerville, Ohio 43081.

Christine Schnitzer

Christine Schnitzer
Product Manager
Ceramic Information Center

735 Ceramic Place
Westerville, Ohio 43081-8720
614 • 890 • 4700
TWX: 7101109409