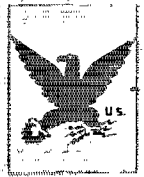


NATIONAL SAFETY NEWS

JANUARY 1935



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Are We Controlling Dust?

THE way damage claims are piling up these days makes it clear that dust counting investigators are not the only ones who can think in terms of millions. Hence the employer has two incentives for reducing injurious dusts—the protection of his employees and the protection of his pocket book.

It is possible in many cases to improve conditions by diluting the dust content of the air through general ventilation. Our subject, however, is limited to the removal of dust by exhaust systems, which, after all, is the more positive method. There are a few simple principles which our day-to-day contacts with 10,000 industrial concerns convince us are not generally understood and certainly have not been applied in the majority of installations that have been made in the past. We shall try to define and then illustrate some of these principles.

State Codes

A number of states have had references to dust elimination in their labor laws for a good many years. It is safe to say, however, that for various reasons, such as lack of funds, inadequate technical staff or indefinite knowledge of desired standards, no state has as yet thoroughly enforced these laws.

Four out of five leading industrial states whose codes we investigated (including Massachusetts, Connecticut, New York, Illinois and Wisconsin) rule substantially that workers on machines or in processes that create dust, fumes, etc., shall be protected by exhaust systems. After this good start some qualifying phrases like "as well as possible," "in amounts which may be harmful," etc., are added, which leave many chances for differences of opinion between the state inspector and the employer.

All five states agree that grinding, buffing and polishing wheels should be exhausted, although two of the states exempt from these provisions wheels on which water is used. This seems ill-advised, since a study of wet and dry grinding in Connecticut by Winslow and Greenburg (U. S. Public Health Reprint No. 616) has shown that the applica-

By **STUART W. GURNEY*** and
DAVID S. BEYER**

Many simple principles involved in dust control are not generally understood or applied. Meanwhile, claims for real and imaginary injuries are accumulating

tion of water does not, by any means, eliminate the dust hazard. Konimeter samples taken in the vicinity of wet grinders will often prove this to anyone's satisfaction.

Illinois goes beyond the mere specification for dust removal and asks for a static suction equivalent to five inches of water; New York is satisfied with two inches. Wisconsin, in their recently adopted General Orders, specifies at what place static suction shall be measured and requires not less than two inches of water for gases—but for dusts, fumes and vapors it is to be measured by the expression 2 plus sp. gr. over 4.

It may be remarked here that, with everything else equal, a high static suction will give a higher velocity at the point of origin of the dust, fume or gas than a low one; but this alone is not a measure of the effectiveness of any exhaust system.

Wisconsin orders call for definite air velocities of 60 feet per minute for gases—and for dusts, fumes and vapors 170

times the specific gravity and not to be less than 500 feet per minute except under certain conditions. This is getting closer to a real measure for exhaust ventilation, for, after all, it is by the velocity we are able to impart to the particles of dust or fumes at their point of origin, by current of air, that we can move them from where they are and put them where we want them.

Wisconsin alone, of all these states, has adopted a different principle—that of specifying a limit to the number of dust particles of respirable size per cubic foot of air. After all, this is what we are primarily interested in, to keep the dust contamination down to a point where it will not be harmful.

Specifications for certain pipe sizes and air velocities may or may not do the work, depending on the shape of the hood, distance from dust source, and other variables. One is reminded of the situation several hundred years ago where argument ran high about the effect of gravitation on falling bodies. Galileo settled the controversy by dropping weights from the leaning tower of Pisa. What we need in the use of exhaust equipment is a few more Galileos who will be satisfied only with actual working tests!

National Standards

These variations and conflicting provisions in the state codes merely reflect the general lack of authoritative standards. It is fortunate that definite steps are now being taken by the American Standards Association to develop the proper basis for such codes. There are two committees working on this problem: the Ventilation Code Committee, sponsored by the American Society of Heating & Ventilating Engineers, and the Exhaust Code Committee, sponsored by the International Association of Industrial Accident Boards and Commissions.

At a recent meeting of the latter committee it was recommended that a national advisory committee of clinical, pathological and other experts be appointed who could determine "threshold values," that is, the dividing line between permissive and harmful amounts of dust and toxic fumes in the air. While considerable work has already been done,

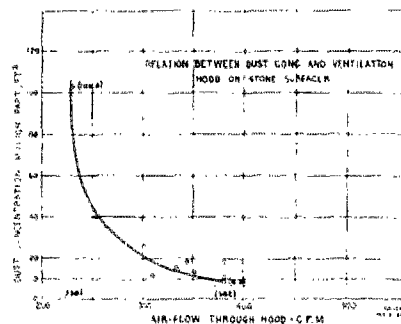


Fig. 1. How an increase in air-flow reduces the concentration of dust.

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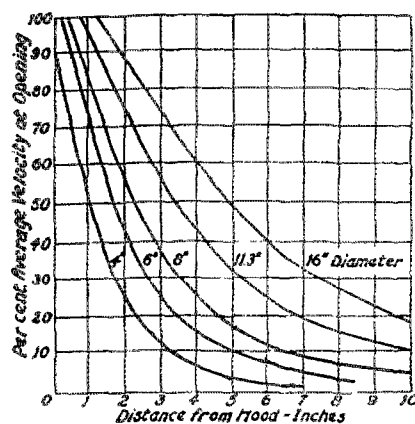


Fig. 2. Velocity of air-flow decreases rapidly with distance from the inlet.

much additional research will be required before these standards, which are the very foundation upon which the others relating to exhaust systems necessarily rest, have been fully determined.

The committee also arranged to appoint sub-committees to take up the following specific subjects:

1. Abrasive cleaning
2. Chromium plating
3. Granite cutting
4. Rock drillings
5. Spray coating

In addition, a Sub-Committee on Fundamental Principles of Design and Operation and Maintenance of Exhaust Systems will be appointed. The work of these committees will take time, but we now have some assurance that a systematic study and evaluation of the various elements entering into the whole problem will be made.

Practical Considerations

The two most important considerations in an effective exhaust system are:

1. Velocity of air flow, and
2. Arrangement of the inlets (from the standpoint of nearness to the dust source, shape, etc.)

Air Velocity:

Many an installation that is otherwise all right fails to remove the dust successfully merely because there is not enough air being drawn through the system.

Fig. 1 illustrates some tests that we made under actual working conditions by Theodore F. Hatch, Department of Industrial Hygiene, Harvard School of Public Health.

These tests were run on a machine used in dressing stone and you will notice that with an air flow through the hood of 250 cubic feet per minute there were over 100,000,000 dust particles in the surrounding air. When the

air flow was increased to a little over 250 cubic feet per minute the dust concentration had dropped to 40,000,000—a marked improvement. As the air-flow was further increased, the drop in dust concentration was relatively slower, and it took a volume of about 380 cubic feet per minute to bring the dust concentration down to ten or fifteen million particles per cubic foot, which was considered reasonably safe for this type of dust.

It is accordingly possible sometimes to take an installation that is not satisfactory and, if the remainder of the system is well designed, by merely speeding up the blower or adding a larger one, to bring about the desired results.

Arrangement of Hood Inlets:

Another very important consideration is to get the inlets of the exhaust system as close as possible to the source of the dust. The drop in efficiency as we get further away from the inlet is really surprising to one who has not studied the principles involved.

If we have the open end of an exhaust pipe or air duct in operation, the air tends to flow in from all sides, even from behind the opening. It is somewhat as though the exhaust inlet were in the center of a sphere and the air was drawn from every part of the sphere into the pipe. As we move away from the end of the pipe the velocity drops very rapidly, so that the velocity at five inches from the hood may be less than 10 per cent of that right at the hood inlet.

This is a most important consideration to keep in mind. It is not uncommon to see an exhaust inlet a few inches

in diameter with which the person making the installation hoped to draw dust from a distance of several feet, and the air-flow even a foot or two away from the entrance to the inlet may be negligible.

Another important consideration in the design of the inlet is the addition of a flange, the effect of which is to cut down the air that would flow in from behind the opening, thus drawing it nearly all from the front. The effect of this is to increase the efficiency of the system substantially and extend the scope of the exhaust without appreciably increasing the power consumption.

Other Considerations:

Aside from these two features there are various other points of lesser importance that should also be given consideration before a good exhaust installation can be hoped for.

For example, air cannot be "pulled" from a distance by merely directing an exhaust pipe towards the point in question, but it can be "pushed" or blown, directionally, for a considerable distance. This principle may be used advantageously in directing the dust towards the opening of the exhaust inlet and thus getting the desired results with a lower exhaust velocity and power consumption than would be required if such suction alone were depended upon. This principle has been applied effectively in drilling material containing asbestos, where the exhaust inlet is placed at one side of the drill and a small air jet at the opposite side of the drill, blowing across the table turns the particles that would fly out from this side and directs



Fig. 3. Placing a curtain in front of the "dolly washer" reduced the opening one half and almost doubled the velocity of air flow at the bottom of the opening.

them back into the exhaust system. It is also being applied to foundry shake-out work.

Other considerations in designing exhaust systems, such as the elimination of unnecessary bends or curves, the provision of clean-out doors, the construction of the joints, etc., are well covered in the current handbooks and State Industrial Codes, such as those of New York (see Bulletin No. 12 of the State Department of Labor, N. Y.) or Wisconsin (see General Orders on Dusts, Fumes, Vapors and Gases, Industrial Commission of Wisconsin) and will not be gone into further here.

Where there is a general ventilating installation and one or more exhaust systems, care must be taken to see that they do not "buck" or offset each other.

One of our engineers recently demonstrated this point in a factory by means of an anemometer, which showed a good draft right at a dust-producing machine, but as it was withdrawn from the machine the anemometer slowed down, coming to a standstill at just about the position of the operator, and then reversing beyond him, showing the air beyond this point flowing toward the general ventilating system. In this case there was a dead space right around the operator from which neither system was effectively removing the dust.

After an exhaust system has been installed it should be tested by taking actual dust counts to see that the dust is really being cut down to the desired point, and such counts or perhaps check Konimeter samples should be taken at intervals, after the installation has been made, to see that it is still functioning properly.

The fact that the dust particles that cause the trouble are so small that they are invisible under ordinary conditions (less than 10 microns or 1/2500 of an inch in diameter) often makes it hard to convince the practical plant manager that there is any dust present; it also makes it impossible to tell, without the use of special instruments, whether the completed exhaust system is actually removing the dust.

Qualitative Dust Analysis

The present consensus of opinion on the development of dust diseases is that besides quantity of dust (usually expressed in millions of particles of respirable size per cubic foot of air) the quality of the dust also must be known, particularly the percentage of free silica (SiO_2) in the particles under 10 microns

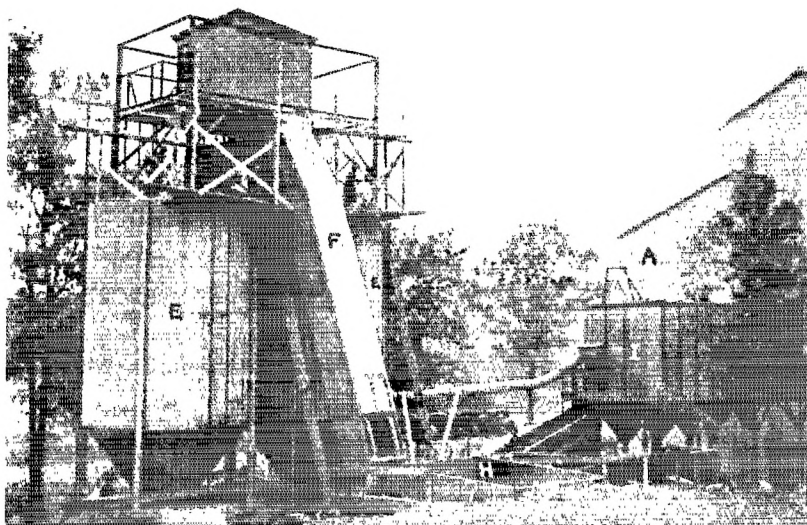


Fig. 4. View of primary rock crusher *H*, enclosed exhaust bucket conveyor *F*, primary hopper *E*, and exhaust ducts leading to filter unit *I*. This rock crushing plant contains many excellent examples of exhaust ventilation for particularly difficult situations. It has resulted in a reduction of dustiness to less than 5,000,000 particles per cubic feet tested by standard impinger, U. S. Department of Public Health technique. (Photo by Division of Industrial Hygiene, State of Massachusetts.)

in size. A chemical analysis of dust will not give this result and so measure accurately the relative hazards of dusts.

In our opinion, the most practical method for analyzing and evaluating these fine dust particles is by means of a complete petrographic analysis. This consists of the microscopic examination of individual dust particles under polarized light, which permits the identification of each particle by determining its optical properties.

Until recently, petrographers have generally considered that mineral particles must be over 10 microns before they could be identified with any degree of accuracy. As health hazards are affected only by the sizes under 10 microns and the mineralogical composition of the larger sizes is not necessarily the same as those under 10 microns, it became desirable to further refine the technique of petrographic analysis. It has been found that, working with magnifications of about 1800 diameters and a light source of high intensity, mineral particles as small as one micron can be accurately identified.

Before an exhaust system can be definitely approved as giving satisfactory health conditions, some such determination of dust composition must be made, in addition to the count of dust particles.

Fig. 3 illustrates an interesting case in connection with a "Dolly Washer" used in textile plants for spotting fabrics, etc. While this system deals with fumes, the principles are identical with those involving dust.

This equipment uses trichlor-ethylene and in spite of the exhaust system which you will see over the washer, the fumes were escaping into the room as indicated by qualitative tests with a Turner Halide detector (which depends on the color of a flame to indicate roughly the intensity of the concentration).

Readings (Kata) were taken at six locations in the opening, as indicated below the drawing; a curtain was added which reduced this opening by about one-half and further readings showed the air velocity at the bottom of the opening had been approximately doubled. Tests of the air indicated freedom from contamination.

Maintenance

It might seem like an insult to one's intelligence to say that after an exhaust system has once been installed it should be maintained in good operating condition. However, the numerous cases one encounters in the plants where this obvious necessity is not carried out, indicate that it is really one of the major considerations.

Cases are not unknown where the blower has in some manner become reversed so that the air is being ejected and diffusing the dust rather than drawing it in; other instances where the efficiency of the system has been lowered or its value nullified by clogging up, disconnection or wearing out of the piping, etc., are all too common.

One concern of which the writers have (Please turn to page 56)

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RAIL CLAMPS

PROVIDE SAFE CONDITIONS

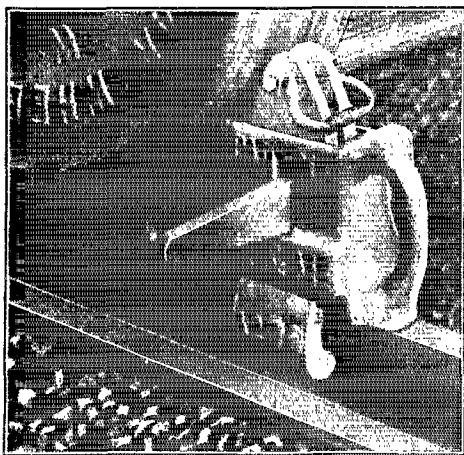
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Are We Controlling Dust?

(Continued from page 23)

knowledge, has a "U" tube permanently installed in one of its main exhaust systems so that the foreman or safety man can tell at a glance whether there are any changes that would indicate a break-down in the system. All such installations should have regular inspections by some competent person as a routine part of their upkeep.

Checking Exhaust Systems

There are several instruments that may be used in checking up the results of exhaust systems as follows:

For Air Velocities:

Anemometer — (useful, but results must be used with judgment much below 500 feet per minute).

Kata thermometer — (depends on cooling effect of air current; requires rather careful manipulation — good for low velocities less than 500 feet per minute).

For high velocities in ducts — pitot tube (for velocities over 1000 feet per minutes special vane anemometers).

For Air Volumes:

Orifice meter, or venturi meter.

Where none of these instruments is available a rough check can be taken by the use of smoke, or flags or streamers, held near an exhaust opening to make certain that there is a good draft intake; however, this does not tell definitely whether all of the dust or vapors are being drawn in.

The Smith-Greenburg impinger as used by the United States Department of Public Health is the generally accepted standard for dust counts in this country. For the purpose of an approximate dust check, however, probably the best and simplest instrument that has yet been evolved for field use without special laboratory training is the Konimeter in which the dust-laden air is impinged at high velocity against a dry or coated glass slide. While this instrument was originated abroad and at the present time must be imported, steps are under way to make available a simplified type of Konimeter along the lines described in a paper by Hatch and Thompson in the *Journal of Industrial Hygiene* for March, 1934. (It is believed that such an instrument could be made up for around \$100, or about half of what the corresponding imported instrument would cost.) One important

advantage of this instrument is that it gives the sample on a standard glass microscopic slide which is excellently adapted for direct petrographic analysis to which reference is made later.

While the Konimeter does not give a precise dust count that can be compared exactly with the U. S. Public Health Standard, it does give an excellent check on relative conditions and can be used in picking out the worst conditions, registering improvements, etc. It enables the skeptical manager to actually see the "invisible" dust, hence has a great educative and sales value to the safety engineer, if used with judgment.

Perhaps you have inferred from this discussion that it is a real engineering job to lay out a proper exhaust system, and not one that can be taken care of satisfactorily by merely calling in the "tin-knocker" and telling him to go to it, as is so often done.

Even the so-called "ventilating engineer" is frequently "stumped" when it comes to problems of removing dust of the type we are considering. He has been used to ventilating schoolhouses and other buildings, or removing visible dust particles, and usually thinks in terms of so many air changes per minute. He often loses sight of the fact that he may be changing the air in one part of the room ten times and in another part may be changing it only slowly, or it may be completely stagnant.

In a case which recently came to our attention, a well-known firm of consulting engineers insisted that the general exhaust system which they had put in a plant was the best possible method for minimizing the exposure, and must be producing satisfactory results because it was arranged to move 27,000 cubic feet of air per minute. Even when it was pointed out that there had been eight claims for disability resulting from fume inhalation during the year, it was hard to convince them that further steps were necessary.

Respiratory Equipment

The simplest form of respiratory equipment is the filter respirator. Improvements have been made in recent years along the line of providing more efficient filters and larger filter areas that reduce the breathing effort. Such res-

pirators have a definite value for temporary use such as sweeping up, cleaning out bins, shoveling materials, etc., but they require careful fitting and constant supervision to see that they are being properly used.

It is our opinion, after watching the sincere efforts in a number of plants to enforce the use of these respirators, that it is rather impracticable to require them to be used on a full-time operation. One notices the men, under these conditions, surreptitiously pushing the respirator aside and gasping in free air like a fish out of water. Certainly, if they are to be used any considerable length of time, frequent rest periods should be allowed where the men can get out into the free air for a few minutes refreshment. There are the large air-fed helmets, with which most of us are familiar, used for sand-blasting, etc., which have been carried to a high state of perfection for the purposes to which they are adapted.

We believe, however, that much more use could be made advantageously of the type of apparatus that lies midway between the filter respirator and the air-fed helmet, namely, the light, air-fed respirator which covers the nose and mouth but leaves the rest of the face exposed. With a light hose attachment this device offers considerable freedom of movement, and if air outlets were supplied so the hose could be quickly transferred from one outlet to another, it would seem to be practicable to use them over a considerable area. They afford the advantages of a pure air supply without excessive weight and without the restriction to breathing that is imposed by the filter respirator.

Conclusions

1. A properly designed and maintained exhaust system which captures the dust at its source and removes it is, in general, the most effective means of combating the dust problem. It is more positive and effective than general ventilation because there are fewer uncontrollable factors, and it does not require the constant attention necessary to enforce the use of respirators.

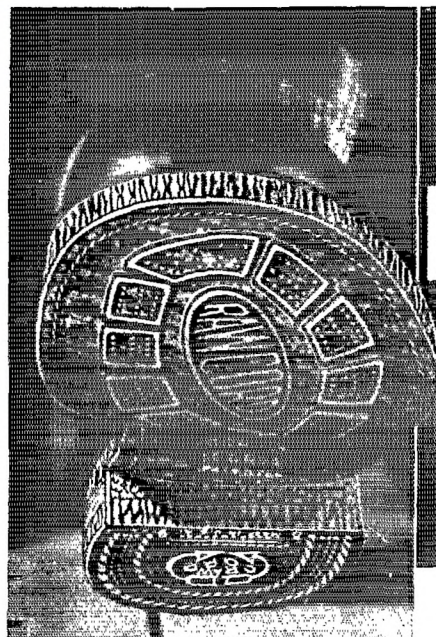
2. A well-designed exhaust system requires a thorough knowledge of engineering principles. Many industrial installations in the past have been notable work in this respect.

3. Careful tests with dust counting or sampling equipment are necessary after the installation has been completed, to see whether or not it brings about the desired reduction in dust concentration.

4. Provision must be made for systematic maintenance and upkeep, preferably with check tests of dust concentrations at regular intervals, after a satisfactory installation has once been secured.

5. A plan for determining the required performance of an exhaust system, standardized codes of permits to dustiness are necessary.

JANUARY, 1935



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