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TITLE	VOLUME No.
General Sessions and Detailed Index to all Volumes	1
Aeronautical Industries	2
Air Transport Industry	3
Automotive and Machine Shop Industries	4
Cement and Quarry Industries	5
Chemical Industries	6
Coal Mining Industry	7
Construction Industry	8
Electrical Equipment Industry	9
Farm Safety	10
Fertilizer Industry	11
Food Industry	12
Glass and Ceramics Industry	13
Home Safety	14
Industrial Nursing	15
Industrial Subject Sessions (Sponsored by ASSE)	16
Maritime Industries (Marine Section)	17
Meat Packing, Tanning and Leather Industries	18
Metals Industry	19
Mining Industry	20
Motor Transportation Industry (Commercial Vehicle Section)	21
Petroleum Industry	22
Power Press and Forging Operations	23
Printing and Publishing Industry	24
Public Employment (Public Employees Safety Committee)	25
Public Utilities Industries	26
Pulp and Paper Industry	27
Railroad Industry	28
Rubber Industry	29
School and College Safety	30
Textile Industry	31
Traffic Safety	32
Transit Industry	33
Wood Products Industries	34
Safety and Its Relationship to Personality	35

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*Committee Advisor and Past General Chairman

Checking Performance of Process Exhaust Systems

By W. G. HAZARD
Dir., Industrial Hygiene, Owens-Illinois Glass Co., Toledo, Ohio

Some two-and-a-half years ago the Health Maintenance Committee of this section undertook to develop a data sheet on the maintenance of local exhaust systems. The job is now about completed, with the help of the whole committee, and your program chairman has asked that we give you a preview of it.

Purpose

The purpose of the data sheet is somewhat different from that of most articles that have appeared on exhaust systems. What's made this possible has been the timely appearance in the last few years of outstanding books on the technical design of exhaust systems. Among these publications are:

1. *Manual of Industrial Ventilation* (1952)
   American Conference of Governmental Industrial Hygienists
2. *Industrial Health Engineering* (1947)
   A. D. Brandt
3. *Industrial Hygiene and Toxicology* (1948)
   Frank A. Patty, Ed. (Chapter 10—Ventilation, by W. N. Witheridge)
4. *Exhaust Hoods* (1952)
   J. M. DallaValle
5. *Accident Prevention Manual* (1951)
   National Safety Council (Chapter 21—Industrial Health Engineering)
6. *Ventilation*
   W. C. L. Hemeon (To be published)
7. *Industrial Dusts* (2d edition)
   Phillip Drinker and T. F. Hatch (To be published)
8. Design data published by numerous manufacturers, such as American Blower Corporation, American Air Filter Company, Buffalo Forge Company, Westinghouse, and others.

The first design and technical maintenance of exhaust systems falls in the lap of the plant maintenance or engineering department, and the above books handle these aspects thoroughly. Little has been written however, directly for the safety engineer. What are *his* responsibilities? What is *his* role, when the engineering phases are handled by the plant engineer?

This data sheet is written for the safety engineer. It does not cover detailed design, instrumentation or maintenance. It contains only such background principles, and comments on popular fallacies, as are needed for the safety man to work profitably with the engineer and department supervisor.

What Can Safety Engineer Do About Exhaust Systems?

1. *Air samples:* Exhaust systems that are meant to control a health hazard succeed or fail according to how well they keep the air contamination in the workroom below dangerous levels. Usually this can be determined only by air samples and analyses that actually measure the amount of the harmful agent in the air. Method used varies according to whether the material is silica dust, or other toxic dust; vapor, as from a solvent or degreaser; fume, as from welding; gas; or even hot air—for the latter can be classed as a contaminant, and exhausted to the outdoors.

When the plant has no full-time industrial hygienist, as most plants do not, the safety engineer should arrange for these tests. They are his responsibility rather than that of the plant engineering department.

Such tests are *not* needed when the contaminant is not harmful, as with wood dust, lime, coal, and other nontoxic materials.

2. *Plan:* For existing exhaust systems the safety engineer should get a simple sketch of the layout. This need not be a working blueprint, or even to scale. An example of a simple line drawing is given in the data sheet. All that needs to be shown is the order in which branches come off the main ducts, diameters of all ducts, arrangement of fan and collector, size of fan and motor, and if possible, overall rate of air flow and static pressure as specified by the designer of the system.

FORM 1—Safety Engineer's Inspection Report

Test point	Condition of hood and branch (Battered? removed? plugged? repair?)	Static press. (inches water) Originally	Checked
A		2.1	
B		2.0	
C		2.5	
D		2.0	
E		1.9	
F		2.1	
G		2.2	
H		5.0	
J		8.0	
Filter resistance (J)-(H)		3.0	

Material collected since last check ________ lbs. Hours of operation ________ Interval between reg. shakings ________ hrs.
Comments of men, and Your comments (use back, if necessary): ________

3. *Test holes:* In each branch, near the hoods, at the collector intake, and at the fan intake, the safety engineer should have simple test holes, about 1/16" in diameter, drilled. These should be numbered serially with paint or tags, and on his sketch of the piping he should mark the approximate location of each hole, with its number.

4. *Portable U-tube:* He should then equip himself with a U-tube or water manometer. After connecting one leg of the manometer to a piece of rubber tubing, he can hold the other end of the tubing over each test hole in order and measure the static pressure or suction.

If the system is new, he should see that the plant engineering department "balances" the air flow from each branch—which means that the correct amount of air flow, as called for by the designer, is passing through each branch. If the contaminant is a health hazard, air samples, taken after balancing the system, will tell the safety engineer whether control of the air pollution has in fact been established. From then on, assuming no changes are made in the hoods, piping or process, he can be assured that the equipment is continuing to work right, if rechecks at the test holes give him the same static pressure readings as the initial ones.

Rechecks with the U-tube should be made regularly, probably at intervals of not over a month. He should have a mimeographed form to record permanently the current readings, so they can be compared with the initial readings. These suction rechecks make it unnecessary to take frequent air samples.

Certain other defects, which can be checked merely by looking should be noted: bent or battered hoods, new branches that may have been added, changes in the process, etc.

5. *Meaning of U-tube readings:* Knowing what the static pressures were when the system was properly balanced, changes from these values show if and where trouble develops.

For example: The increased reading in the first branch, with other readings remaining normal, shows something is plugging that branch between the test hole and hood.

A decreased reading in the branch would mean there is some obstruction farther up the branch, that is, between the test hole and the main duct or header.

Decreased readings in several branches and near normal readings would result if the header was partially plugged in branches nearer the dust collector when the header leading to the collector becomes plugged. There will be increased readings on both sides of the collector.

A partly plugged arrester would result in a decreased reading upstream and an increased reading downstream.

Decreased fan capacity due to slipping fan belt, dirty or worn blades, disjointed pipe between fan and arrester, or an open clean-out door would give the decreased suction readings throughout the system.

Thus relative changes in readings at different test holes can be used to track down the trouble.

Certain absolute values are important too. For example, although suction at a hood is no guarantee that the hood will control the contaminant, still some state codes do require that a certain minimum negative pressure be present, often 2" water gauge. The safety engineer should have a copy of codes applying to exhaust systems (usually administered by the state labor department). He should see that their suction requirements are met.

6. *Repair orders:* When maintenance work is needed, the safety engineer should see that the proper work orders are processed, following whatever is his plant's usual procedure for this.

Role of Plant Engineer

Some may think monthly inspections of exhaust system performance, including measuring the static pressure, are more the responsibility of the plant engineer than of the safety engineer. Experience has shown, however, that unless the safety man takes this equipment under his wing, it will often be neglected. This happens for two reasons: first, most local exhaust systems are not *production* equipment; if they were they would be assured of regular care. Second, while they are a collection of sheet metal, fans, motors and other mechanical devices, which are engineering in nature, their basic purpose is to improve the comfort or safeguard the health of the *people* on the job. This aspect is definitely the worry of the safety man, and only indirectly of the plant engineer.

The fact is, a system can be mechanically OK in that the piping is tight and well supported, the fan is properly chosen, the bearings are well greased, the motor is not overloaded, etc., and yet the system is a failure. It's a failure because it does not succeed in making the air safe which the men breathe. This is the "proof of the pudding"—and the safety engineer (or industrial hygienist) is in the best position, through his air samples and other tests, to see that the equipment does really clean up the workroom air.

There are of course, certain inspections that the plant engineer should make, just as he would with any other moving machinery. On regular schedule he must lubricate the fan and motors, check rapping mechanism of the filter, inspect the latter for leaky bags, check any motor-driven dampers, etc. —and repair them, when necessary.

Facts and Fallacies for Safety Engineer to Remember

Production people and even engineers have misconceptions sometimes, for which safety engineers should be on guard. Here are a few:

1. *Performance Guarantee:* Since the safety engineer is concerned with unsafe work conditions, he should do all he can to see that the purchasing department, when placing an order for a local exhaust system, has a performance guarantee written in.

2. *Adding Hoods:* Many a first-class exhaust system is made ineffective by the hit-or-miss adding of new hoods in later years. Be sure the plant engineer checks the system to see it will handle the extra load.

3. *Makeup Air:* Getting makeup air, tempered in winter, into a room is sometimes a more perplexing problem than the exhaust system itself. Be sure this problem is solved beforehand.

4. *Explain to Employees:* The man on the job must understand the reasons for the exhaust system, and how to operate it, if it is to give him full protection. The safety engineer can assist the supervisor in giving this explanation. Better yet, consult the men before the final design is agreed on—so there will be the least amount of interference with his work from hoods, enclosures, etc.

5. *Smoke Tubes:* One of the handiest gadgets the safety engineer can have is a smoke tube (available commercially) to show the path of air currents as they enter the hoods. With it he can often convince the operator of the importance of baffles, closeness of hood to dust source, etc.

6. *Fallacy of Heavy Vapor:* Because some vapors like benzol, trichlorethylene, carbon tetrachloride, and the like are heavier than air, many people think downdraft ventilation or hoods at floor level are a must. The fallacy is that vapors coming from a process do not persist for long in an undiluted state. They are soon mixed with air by random wind and convection currents. Once mixed, they don't normally settle out to form a heavy, concentrated layer at the floor.

A concentration of 1000 ppm of benzene is 25 times the maximum allowable limit, by health standards. It is far more concentrated than would be permitted in any workroom.

Yet, this mixture is only 0.17 per cent heavier than air, even though *pure* benzene vapor is *three* times heavier than air. Thus the ratio of weight of air to weight of the benzene-air mixture is only 100 to 100.17. There could never be any sinking or stratifying of this 1000 ppm mixture. A side or back hood would be just as effective as a downdraft hood.

7. *Fallacy of "Sucking" the Contaminant Into Hood:* Because people can feel air *blowing out* of an air line some feet away from the end of the pipe, they think that dust-laden air can be *sucked into* an exhaust hood from several feet away. This is not true. Air can be sucked only one-thirtieth of the distance it can be blown. In *exhausting*, the air velocity has fallen to 10 per cent at a distance of only *one* pipe diameter out from the end of the pipe; in *blowing*, this 10 per cent figure is reached some *30* diameters out from the end of the pipe. Suppose for example, we have a six-inch pipe sucking air in so the pipe velocity is 4000 feet per minute. Only six inches out from the "sucking" end of the pipe the velocity will be a mere 400 feet per minute—hardly enough to feel. But at the blowing end, this 400 fpm velocity will not be reached until you go 30 diameters, or 15 feet away from the pipe end.

This misunderstanding also crops up when installing propeller fans in walls or windows to provide ventilation. Such fans are incapable of withdrawing air directly from any operation in the center of the room, or in fact, from any area more than a foot or two from the fan. Beyond that they act only by diluting the room air by drawing in masses of makeup air through doors and windows.