complaints if there were no threshold limits.

In conclusion a few remarks are in order dealing with the philosophy of and justification for threshold limits, and are added here because they serve as a reply to the criticisms often leveled at industrial hygiene standards.

It is not unusual to hear that these limits are useless, if not even dangerous, because in the event that the atmospheric concentration is measured inaccurately, reliance on the standards creates a false sense of security on the one hand, or needless alarm on the other, depending upon whether the measured result is in error downward or upward. It requires little mental gymnastics to realize that this is equivalent to concluding that there is no sense in asking your grocer for a dozen oranges simply because he may make a mistake in counting them. By definition, threshold limits are those concentrations of contaminants which in the light of current knowledge will not cause harm to persons exposed continuously day in and day out during the normal working hours. Reference is to the concentration actually existing, not to some value that the investigator might conclude exists. Concentrations can be measured accurately, but to do so requires skill, understanding, patience and energy. It is rather discouraging to note how frequently conclusions are based on wholly inadequate data. It is not surprising either that the concentrations frequently "measured" have little relation to the true weighted average concentration.

The philosophy of threshold limits is that each one represents a concentration of the substance in question that will have no demonstrable adverse effect on the health of exposed persons. Not all persons react the same to stimuli of this nature, but rather any given population follows approximately an average random distribution pattern as regards response to atmospheric contaminants. That is to say, there is an occasional person at one end of the curve who is unaffected by relatively overwhelming concentrations and there is an occasional person at the other end who is affected by extremely low concentrations. To prevent any adverse effect upon every last man may require such low concentrations as to be impracticable. The threshold limit is merely a concentration that intersects the random distribution curve at a very low point. How low this point is for any substance cannot be stated. That it is not the same for all materials is obvious, and that it serves to prevent harm to all but a relatively few is obvious, also. Serious or irreparable damage to the occasional person who falls to the left of the threshold limit on the random distribution curve can be avoided by an appropriate medical examination program.

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Prepared Discussion

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In an endeavor to safeguard the health of the worker and the public from exposure to harmful substances, two basically different types of standards have evolved. One type—the threshold limit, or maximum allowable concentration—is the performance-type of standard. The other, about which little has been said by the previous speakers, is the engineering type of standard.

To make the distinction between the two types of standards more concrete, take the specific example of a stave-type tumbling mill (Fig. 1) in a ferrous foundry. Into it are placed castings with sand both clinging to their outer surfaces and in their internal cavities in the form of cores. The express purpose of placing these castings into the mill is to clean them of this sand. The mill is, therefore, by its very nature, a device designed and operated to cause sand to leave the castings and enter the ambient air. While it is true that most of this sand will

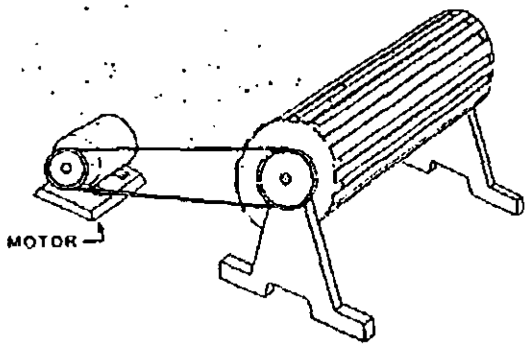


Fig. 1.
Stave mill.

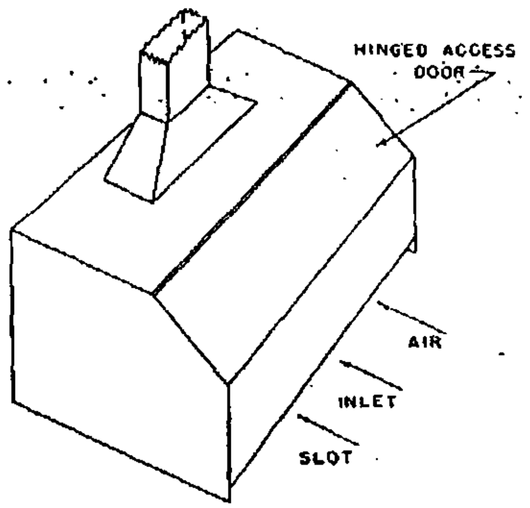


Fig. 2.
Stave mill enclosure.

fall to the floor under the mill, it is equally true that a tremendous number of free silica particles will become air-borne by the process. From the viewpoint of the performance standard, it is necessary to keep the atmosphere of the cleaning room below the threshold limit for free silica by whatever means the owner of the foundry may choose to employ.

Engineering Standards

FROM THE VIEWPOINT of engineering standards, the reasoning is somewhat as follows:

A. It is widely recognized in the foundry industry that stave mills are bad dust producers and require enclosure.

B. The industry, by trial and error, has developed a satisfactory type of ventilated enclosure (Fig. 2) which not only keeps the dust out of the workroom, but also keeps the floor below the mill free of much of the sand that would otherwise accumulate there and have to be carted away.

C. This type of enclosure, having been adopted by most of the industry, should therefore become the standard of the entire industry.

D. An engineering standard should therefore be written so specifying this enclosure with respect to structure and ventilation that any foundryman building an enclosure meeting these specifications will achieve dust control of his stave mill (Fig. 3).

Applicability of Standards

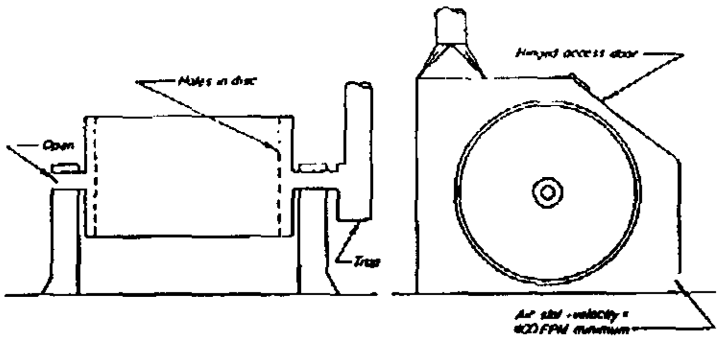
LET US EXPLORE some of the arguments for and against each of these approaches. Both aim at the same objective—the safeguarding of the worker. The principal argument in favor of the performance standard is that it is noboby's business except the owner's as to how he achieves control of the hazard, just so long as he does, in fact, succeed in so doing. The corollary argument against the use of the engineering standard is that there is no positive guarantee that once the owner has invested his money in an enclosure conforming to the standard specification, the exposure of the workers in the cleaning room will be below threshold limit.

The same logic can be used to plead the case for the engineering standard. The dust load in the cleaning room air comes from many sources in addition to the stave mills (Fig. 4). If some of these sources remain uncontrolled after the stave mill has been enclosed and ventilated according to standard specification, it is entirely possible, even probable, that dust concentration in the room will remain above threshold despite entirely satisfactory dust control by the stave mill enclosure. Engineering standards thus have the inherent capacity to allow a step by step orderly approach toward the ultimate goal of achieving below-threshold concentrations in all parts of the plant at all times.

New Construction

ASSUME that a new foundry is being designed. To apply performance standards, the foundry must first be built, placed in operation, and then subjected to air sampling and analysis. No reputable and well-informed engineer would design this new plant without seeking the engineering standards for the control of dust from the cleaning room equipment and applying them to the best of his ability. In this situation, argument arises, not as to the need for such *engineering* standards, but rather as to their accuracy. Should the opening for air be 3½" or should it be 4"? If the standard says 900 cfm, and the designer is firmly convinced that 450 cfm are sufficient, he should be prepared to back up his independence of judgment by later proof that concentrations are below threshold in the completed workroom when the lower value of cfm is employed.

But what if the designer reluctantly makes the capacity 900 cfm to conform to the standard? Is there equal necessity for the sponsors of the standard to guarantee compliance with the threshold limit? The difficulty of so doing in the possible presence of extraneous sources of the contaminant that have already been mentioned almost invariably makes it impossible for the sponsor to undertake such guarantees.



SECTION THRU HOLLOW TRUNNION TUMBLER

Duct velocity = 5000 FPM.
* Entry loss = 2.0 to 4.0 VP (depends on design)

STAVE MILL (END SECTION)

Duct velocity = 3500 FPM minimum
Entry loss varies with take-off 0.25-0.50 VP

EXHAUST VOLUMES

Square mill side diam in	Round mill I.D in inches	CFM Trunnion	CFM Stave*
	Up to 24 included	430	800
Up to 24 incl.	24 - 30	680	900
25 to 30 "	30 - 36	980	990
31 to 36 "	36 - 42	1330	1330
37 to 42 "	42 - 48	1750	1750
43 to 48 "	48 - 54	2200	2200
49 to 54 "	54 - 60	2730	2730
55 to 60 "	60 - 66	3300	3300
61 to 66 "	66 - 72	3920	3920
67 to 72 "		4600	4600

*For lengths over 70", increase CFM proportionately.

Fig. 3.
Tumbling mills.

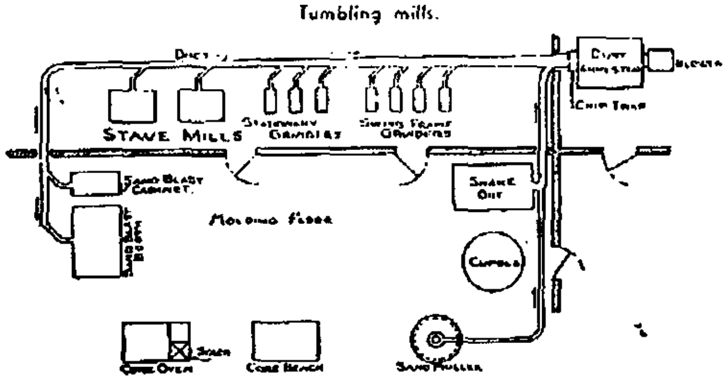


Fig. 4.
Floor plan showing layout of equipment including stave mills.

Double Jeopardy

WHERE the engineering standard is a tool in the hands of an enforcement agency, the user of such standards frequently fears that he is placed in double jeopardy. He has to comply with engineering standards with which he may disagree, and then, having employed all such standards in every operation, may still be not in compliance with the performance standards. The wise enforcement agency will let it be known that it will not permit such double jeopardy to occur, and that any factory owner who adheres throughout to the best engineering standards known to the agency will not be asked to re-do the job.

What, then, is the plight of the workingman caught in the middle? Is he likely to become a pawn, forced to work in an unhealthful atmosphere because the sponsoring agency is unwilling to admit a mistake as to the effectiveness of its engineering standards? We are indeed fortunate that the quality of our engineering standards is so high that such cases occur infrequently. Where they do occur, they are almost always borderline cases with respect to the threshold limit and are well within the factor of safety built into the threshold limit itself.

Emission Standards

THE RELATIONSHIP between performance and engineering standards for in-plant atmospheres has its counterpart in that between atmospheric and emission standards in the field of air pollution. A major difference is that, whereas there are a large number of accepted threshold limits for in-plant atmosphere, there are almost no standards commonly accepted for the outside atmosphere.

The emission standard is very much in the same position as the engineering standard for in-plant controls in that adherence to it by one specific stack does not guarantee the cleanliness of the air of the surrounding community. Thousands of factories have put in-plant engineering standards to the test and proven that when every source of contaminant release is controlled as specified by the applicable engineering standard, the result has been to maintain the factory atmospheric contaminant concentration below the threshold limit. Such beautiful demonstrations, which are easy when the atmosphere in question is confined by four walls and a roof, become almost impossible to find in the open air over cities and towns. However, it is reasonable to believe that what works in a small confined space will also eventually work in the largest of confined spaces, that having the inevitable inversion ceiling as a roof and four topographical or meteorological side walls.

Standard for the Open Air

LET US LOOK once again at the principal argument for performance standard in the in-plant situation, *i.e.*, that it is nobody's business but the plant owner's as to how he achieves control of the hazard—so long as he does so. Is this doctrine equally applicable to the air over a city? It hardly seems so. No individual owner or group of owners could or would be willing to take the responsibility for the maintenance of a specified level of contamination of the air of the community in which they operate. They would quickly recognize the many factors over which they do not have the same measure of control that exists inside the factory building. For them, the emission standard is a boon.

Here the argument is not with the concept of the emission standard, but with its numerical value for a particular installation. One of the most interesting developments of the past decade along these lines has been the fact that public utility power plant designers have consistently specified equipment for fly ash control to meet emission standards much more stringent than public regulatory bodies have required. Industrial foresight and conscience is in this, and a number of other industrial hygiene and air pollution control fronts, well ahead of public regulatory demands.

Conclusion

IN BOTH these areas, this is the hope of the future. The dictum of a Massachusetts court of many years ago that the best plants in an industry may reasonably be used to set the standard for the entire industry provides the real key to future progress. America is blessed with real industrial leadership and statesmanship. Neither industry's leaders and statesmen nor the public will tolerate the acceptance of standards which are below the best that industry can, by example, provide.

Summary

THERE are two general types of standards—performance type standards and engineering standards. The former specify threshold limits. The latter specify the performance of a particular piece of equipment. Arguments are given pro and con as to the relative merits of these two approaches to the same objective—the safeguarding of the worker. The engineering standard approach is particularly valuable in new construction where no equipment

exists at which to measure atmospheric concentration before designing safeguards. The similarity of engineering standards for the in-plant situation to emission standards for atmospheric pollution control is noted.

Prepared Discussion

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THIS COMMENT and discussion of the excellent paper presented by Dr. Brandt will be directed to the legal aspects of the application of threshold limits in the form of maximum allowable concentrations for the control of air contamination.

May I identify myself as one who has served as counsel for industrial organizations; and while my views may be prejudiced on their behalf, I feel that the industrial point of view is important in our discussion of this matter.

It is needless to say that today industry is prepared and wishes to accept full responsibility for the control of potential hazards incident to employment. Simply stated, it is good business both from the financial standpoint and also in the promotion of industrial relationships for employers to concern themselves with the protection of employees from all types of industrial injuries, be they accidental or resulting from occupational disease. The ultimate cost of compensation for such injuries may well exceed the cost resulting from installation of effective methods for engineering and medical control, aside from the fact that the employer's relation to his employees is promoted when employees know that the employer is doing everything practical to effect protection.

Question arises to the propriety and advisability of the adoption of codes of industrial hygiene defining maximum allowable concentrations of toxic materials. The word "code" is defined as follows: "A body of law established by the legislative authority of the state, and designed to regulate completely, so far as a statute may, the subject to which it relates." The adoption of codes having the full force and effect of law is unnecessary, inadvisable, and may well lead to unfortunate problems of administration to which brief reference may be made.

Under the constitutions of the various states and the powers granted to state Departments of Health and state Departments of Labor, there exists adequate authority for such departments to effectively control any hazardous condition injurious to health. As a practical matter, there is no legal need for the adoption of codes prescribing maximum allowable concentrations. It is fair to state that state Departments of Health and state Departments of Labor administering divisions of industrial hygiene have enjoyed the confidence of the public, including both management and labor, and our several state departments have been and are doing excellent jobs in the administration of their affairs. Therefore, the use of maximum allowable concentrations should be in the nature of serving as a guide to industry with particular reference to engineering standards. Industry has and will continue to seek the advice of proper state departments to control hazardous conditions effectively, and the desired objectives will be obtained through education and dissemination of information through the cooperation between state divisions of industrial hygiene and industry rather than the attempted enforcement of a given code as a matter of law.

Dr. Brandt and Mr. Stern have discussed in detail the practical uses of threshold limits with the purpose of eliminating or controlling occupational hazards. With all of the information presently available to science, it is seriously to be questioned whether the present schedule of recommended maximum allowances of concentrations are scientifically correct. True, they represent the best thinking of those scientists who have studied the problem; however, it is a fact that from day to day, industrial processes are changing, new chemical compounds are coming into commercial use, and tomorrow some new problem may be presented to industry and to public administrative agencies entirely different from any that may have been presented before. Industry welcomes technical information with respect to the existence of occupational hazards. They will continue to welcome technical advice as to practical methods of control. It must be remembered that in-