

1935

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Incorporated

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Foreword

THE TRANSACTIONS of the Twenty-Fourth Annual Safety Congress, National Safety Council, 1935, are published in two volumes. This volume, first, contains the general sessions, the special subject sessions, and the special Section sessions. It is supplemented by a smaller volume containing sessions of the Street and Highway Traffic Section, the Child Education and Home Safety.

If industrial members of the Council automatically receive the large volume, matter is sent to members believed to be chiefly interested in the sessions. It may, however, also be secured by other Council members upon

application; members have found it worth while to distribute copies of these sessions to supervisors, foremen and others in an administrative or supervisory position who may make practical use of them for reference purposes. The benefit of those who desire extra copies the following quantity prices are: 1 to 10 ten copies of the large volume, \$1.50 each; eleven copies and 51 25¢ each; copies of the smaller volume, 50¢ each.

ACCORDANCE with the plan of publication followed for the past several years the Transactions are published again this year as a condensed record of proceedings at the National Congress. The papers of each session or session of the Congress have been edited carefully to eliminate extraneous material to abbreviate the less essential portions because of space limitations. In words, the material herein presented is not a verbatim report of all the sessions presented at the Congress, but rather an abridged version, made as accurate as possible, yet without any injury to the technical aspects of any session. The original manuscripts are on file in the library of the National Council, where they are available for additional reference. In several where illustrations were sent by the speakers to the Council, these also file.

The National Safety Council at its Congresses seeks to eliminate from discussion matters which are not pertinent to the aims of the Congress or which are contrary to Council policies, but it cannot accept responsibility for the views expressed either in the papers presented or in the discussions based upon the

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Occupational Diseases

FRIDAY MORNING SESSION

October 18, 1935

The session was called to order by Mr. W. Dean Kofer, director, Industrial Division, National Safety Council. Dr. C. H. Watson, newly-elected President of The National Safety Council and Medical Director, American Telephone and Telegraph Company, New York City, presided.

Present and Prospective Occupational Disease Legislation

By F. ROBERTSON JONES

General Manager, Association of Casualty and Safety Executives
New York, N. Y.

Since the prevention of diseases is, to some degree, a community problem, the state ought to do its part toward the prevention of occupational diseases, along with all others. The public health authorities should study the causes of such diseases, their prevalence, virulence and the means for their prevention. They should advise as to such means of control, and, as a last resort, appeal to legislatures for power to order compliance with their rules. Statutory regulations for prevention, emanating from other sources, such as are common in "labor" or "factory" laws, have too serious drawbacks to be efficient. They are apt to be inflexible and quickly become "out of date"; and they are too apt to be perverted for the establishment of fictitious bases for wasteful and demoralizing damage-suit litigation. Scientific increases in occupational hygiene, under direction of public health authorities, are the best public instrumentality. Efficient bureaus of that character are now to be found in several states; but, generally, such public health organizations are inadequately manned and equipped. Therefore the primary need in occupational disease legislation is for measures to improve our public health services.

Emphasis should be placed on prevention, not merely because "an ounce of prevention is worth a pound of cure," but because public measures for the assurance of relief to victims are perilously susceptible of being so perverted that those affected will tend to rely upon and abuse the protection afforded as a substitute for, instead of as a supplement to, means for self-protection.

Expert opinion now calls strongly for the entire elimination of employers' liability for "damages" for occupational injuries—by disease as well as by accident—based upon negligence. That remedy is too uncertain in operation, litigious, demoralizing and wasteful; it furnishes relief to too few of the victims unless it be so liberalized as to be grossly unjust and financially perilous to employers—and thereby harmful to industry and all dependent upon industry.

Losses from ill-health among workmen are primarily subjects for self-providence or for "social insurance"—for "sickness insurance" to help out during brief illnesses, and for "invalidity," "old age" and "widows and orphans" insurance where illnesses or infirmities result in long or permanent disability or untimely death. The cost of these insurances against the common misfortunes of life cannot rightly or expediently be imposed wholly upon industry, but needs to be distributed somewhat in proportion

to responsibility. And benefits, at a high scale of maximum earnings, as in workmen's compensation, simply cannot be provided for all such workmen's misfortunes. In fatal, partial, and life insurance, at least, the benefits must be graded, more or less in proportion to the individual workmen's contributions to the requisite reserves; and the right to benefit must be conditioned upon some minimum number of contributing years. It is only for some relatively small proportion of the injuries and physical ills to which workmen are subject that it is reasonable and practicable to impose the full responsibility on industry.

From its beginnings, the workmen's compensation law has covered all injuries to health resulting from occupational accidents. Further it has now in this country and abroad been extended to cover many specified diseases, not resulting from accidents, classified as "occupational." And in a few states in this country and Latin America it has been extended indefinitely further to cover "all inclusive" all injuries to health "arising out of and in the course of the employment" or all "occupational diseases," including "arising out of the employment."

In this country there is strong political pressure in favor of this "all inclusive" coverage of injuries by disease based upon the contention that there is no difference in principle between injuries by accident and "injuries by disease"; therefore, industries ought to be liable for both classes of injuries on the same terms and conditions. This contention is fallacious. The fundamental principles of the compensation law are that industry shall be held responsible and liable to compensate for the losses from those injuries only which are caused by "trade risks," resulting from employment and which the employer can control; and that the liability for such risks shall be sufficiently well defined as to be insurable at practicable and equitable rates, fixed in advance. The standard compensation laws have been framed to carry out those principles in application to injuries by accident. And the factual conditions relative to injuries by disease are so different from those relative to injuries by accident as to necessitate different treatment.

The crucial difference between accidents and diseases is the time factor. An accident is a sudden event, happening at a definite time and place. Generally the causal relation between the employment and the accident and between the accident and the resulting injury can be traced with reasonable certainty. Generally the employer is automatically identified. And there is a clear-cut event from the date of which time-limits on notices, claims, etc., can be measured. In contrast, many diseases attributable to occupational risks are of slow contraction, and may be of equally slow progress to harmful results. In all cases there may be an interval of as much as twenty or thirty years between the first exposure and disability or death. In the meantime, many causes for dismemberment or death, other than the occupational disease may have operated. Often it is a matter of extreme difficulty to determine whether disability or death really has resulted from an occupational disease or from other causes. Medical diagnosis of the mere existence of a particular disease is often uncertain; yet for the proper operation of compensation for occupational diseases it is essential to obtain true medical diagnoses, not merely of the existence of the disease, but also of its causes and consequences.

A further difficulty is that, where the disease is of slow contraction, it may be contracted by a workman under several different employers or insurance carriers. In such cases it is essential for the protection of the workman that some one existent employer or insurance carrier shall be directly liable for the entire compensation. There is a high probability that such liability to impose upon an employer or insurer who has not accompanied by a right to claim contribution from earlier employers and insurers, and, in all fairness, should be subjected to strict limitations.

Moreover there is a difficulty inherent in the provision of new insurance for compensation for such diseases of slow contraction as silicosis. Under such conditions the liability imposed upon the employer includes a liability for disability or death in the first place; in other words, a liability, not merely for future risks but also for the cost of a volume of physical impairments already incurred through the liability thereafter is not yet assumed. In insurance parlance, these are termed "accrued liabilities." Such accrued liabilities, under a law newly imposing a liability to compensate for silicosis, would, it is estimated, in a state such as New York, aggregate many millions of dollars. This cost is additional to losses from current risks; and how to meet it and how to fix reasonable charges for insuring it is a complex financial problem.

The situation, then, in my opinion, is this: The principle of compensation regardless of fault, may well be extended to cover those disabling diseases that are characteristic of and peculiar to and have their origin in the occupation or process in which a person is engaged. This would exclude the diseases of ordinary life, which would be applicable only to the specific hazards which arise out of and because of industrial processes and occupations. The provisions for such coverage should be separate and distinct from the provisions of law applicable to compensating for accidental injuries, and these distinctions should be constantly emphasized. The problem of formulating such provisions is relatively simple with reference to those recognizable diseases set forth in the other occupational and non-occupational. But it is difficult to reliably diagnose, of quick contraction and non-progressive. But it is difficult to respect to such progressive diseases of slow contraction as silicosis and asbestosis—now generally regarded as being truly "occupational." Fortunately, however, there are promising models for our guidance in some of the foreign compensation laws where experience under indefinite, "all inclusive" coverage in Connecticut, Massachusetts, Wisconsin and California is helpful with lessons of faults to avoid.

In my opinion, a law for the compensation of occupational diseases should contain provisions to the following effect:

1. Diseases to be made "compensable" should be distinctly specified—for listing in a "schedule" or otherwise. They should include all those diseases, but only those to be found in the state, which, according to prevailing medical opinion, can be traced in individual cases, to origins in "trade risks"—i. e., risks, not of ordinary life, but created by special practices or processes in industrial occupations.

2. There should be a special regime for expert adjudication of medical questions in occupational disease cases.

3. There should be definite periods of exposure required as a condition to the right to compensation for various occupational diseases; the time within which, in order to be compensable, disability or death must follow exposure should be limited and cases resulting from exposures prior to the effective date of the compensation coverage, or in industries wholly outside the particular state, should be excluded.

4. Prompt notice either of the first manifestation of the disease or of dismemberment—the time of such event to be determined as a medical question—shall be strictly required; and every presumption should be against the validity of action not taken as promptly as practicable.

5. In case an occupational disease merely aggravates, prolongs or accelerates disability or death due primarily or proximately to a non-occupational disease or infirmity or, above all, to old age, the compensation should be reduced to the proportionate to the degree to which the occupational disease contributes to the disability or accelerates death.

6. The employer, as of the time of the workman's last substantial exposure to hazards of the disease, and the insurance carrier then on the risk, should be liable for the entire compensation—with or without right to contribution from earlier employers and insurers. But all such liabilities, whether directly for compensation or for contribution to the compensation payable by others, should be subject to brief time limitations.

7. In heritable diseases, especially silicosis, the obligatory medical benefits should be specially limited in time and kind.

8. In silicosis and other diseases of slow contraction, there should be special provisions for limited compensation in workmen laid off before actual dismemberment with the alternative, under some conditions, of waiver of compensation for such workmen for aggravations resulting from being allowed to continue in the hazardous occupation.

9. A law newly imposing liability to compensate for silicosis and other diseases of slow contraction should have a substantial interval for preparation between the date of its enactment and that when it shall take effect; the compensation for such diseases should be specially reduced and limited to low what would otherwise be appropriate until the "accrued liabilities" are worked off.

10. Compensation for occupational diseases should be insurable separately from compensation for accidents; and, in the initial stage, at least, of a regime of compensation for such diseases as silicosis, the rating practices now imposed upon insurance carriers need to be radically modified.

The above program is sound and would be highly conducive to occupational prevention. But I am not so confident that it would be safe. The pressure is for "liberality" in compensation laws. Merely a few among a large number of able slight diversions from what I suggest would convert compensation for occupational diseases into unworkable health, wage and life insurance for workmen in industries. The cost might ruin the industries, and, at least, would be so able as to make the risks "uninsurable," except on the unlimited assessment with all its financial perils and uncertainties.

As to prevention, there are still some practices to be decided upon in the regime of compensation for occupational diseases about which there is much doubt. For example: Such a regime will practically compel employers, in compensation, to discriminate against all the ailing or aging—against all the most healthy and robust. That seems to be desirable in occupations when occupational disease hazards are great. But is it desirable otherwise?

Now, an ideal common to those of us who emphasize prevention is to require compensation from experience of workmen manifesting the first symptoms of an occupational disease. But for the elderly or stunted workman the loss of his trade-job would be a severe loss. In every respect, then the danger of continuing his exposure. How could such cases be defined and treated and how should the law be framed to induce such treatment?

One impediment is the chief obstacle in a just and equitable settlement of the occupational disease problem. If those thoroughly informed as to this complex subject have sincerely at heart the welfare of workers could be delegated the authority to devise a solution, some progress might be made. But when political considerations are injected into the situation there is little chance for an adjustment to all concerned. The greatest need today is the disengagement of occupational legislation from politics or political considerations.

Some Practical Considerations in Dust Control

By J. J. BLOOMFIELD

City Engineer, United States Public Health Service, Washington, D. C.

Invention of occupational diseases due to the inhalation of industrial dust is an engineering problem. Until recently, however, little attention had been paid to the control of dust, accounting for the paucity of substantial data about it. The consequences of the neglect to furnish adequate protection from dust are now being felt, and the cost is becoming a serious drain on industry. It is established that exposure to certain kinds of dust, such as those containing respirable amounts of quartz, has increased the morbidity and mortality in respiratory diseases; while metallic dusts, such as lead and its compounds, are associated with general systemic poisoning of workers. It is obvious, then, that any serious attempt to control the dust hazard should be made, resulting in the improvement of the health of workers, but also in a definite economic benefit.

One of the preventive programs in the field of accidents are well known. It is fast realizing the need of a similar preventive program with respect to occupational diseases.

Evaluation of the Dust Hazard

First step in the evaluation of the dust hazard is the determination of the actual exposure to the dust in question. A typical example of such a study is to clarify the methodology involved.

Table 1 shows the various occupations in a granite quarry and the number of employed in each occupation. Drillers are the only persons using occupation known in producing considerable quantities of dust. In other words, 30 of the quarry personnel are shown to be exposed to a potentially dangerous dust. The occupational analysis at once indicates that the dust investigation

Table 1—Occupational Classification of Granite Quarriers

Occupation	Number in Each Occupation
Drillers:	
Layser	17
Plug and jack hammer	37
Other quarry employees:	
Superintendent	1
Foreman	7
Compressor engineer	1
Hoisting engineers	12
Inspective engineer	1
Individual foreman	1
Sign-shovel man	1
Chief operator	1
Derrick man	24
Muckers	24
Blacksmiths	6
Tool boys	2
Water boys	1
Machinists	3
Air-line repairers	1
Pipe fitters	2
Total	142

Table 2—Occupational Dust Exposure of Granite Quarriers

Occupation	Number in each occupation	Dust counts in millions of particles per cubic foot of air. Weighted Average
Layser drillers	17	144.4
Plug and jack-hammer drillers (quarry-hole)	37	112.1
Plug drillers (yard)	88	36.9
All other workers		5.8

should especially concern itself with these workers. The next step involves the determination of the occupational dust exposure. Table 2 shows the results of such a study.

It is apparent in this table that the drillers are exposed to high dust concentrations, especially the Layser and jackhammer drillers working in the quarry hole. From a further analysis of the occupational dust exposure of drillers it is possible to determine which activities are responsible for the dust. For example, experience has taught us that the various activities comprising the processes of most dusty occupations are usually associated with dissimilar dust exposures. For this reason it is essential to estimate the amount of time spent in each activity in any one occupation and to determine the dust exposure for each. Table 3 shows the results of such a study in the case of a Layser driller.

It will be seen that a Layser driller has five different dust exposures. A differential analysis, as presented in Table 3, yields several valuable findings. First, it enables one to obtain a true average dust exposure for workers engaged in the occupation of Layser drilling. (In this case the weighted average is 144.4 as compared with 213.4 million particles per cubic foot found during drilling operations only.) Second, it enables one to determine which activity, or activities, contribute most to the

Table 3.—Summary of Dust Exposure of Layner Drillers in a Granite Quarry

Activity	Average dust exposure in millions of particles per cubic foot of air (a)	Number of hours spent in each activity (b)	Particle-hours in millions per cubic foot (a X b)
drilling	203.4	4	853.6
loading drills	9.8	1	9.8
striking drills	8.0	2	16.0
working	6.0	3	18.0
working off holes	1,085.0	3	3,255.0
Total		8	1,352.2

155.2 particle-hours in millions per cubic foot
 144.4 million particles per cubic foot
 8 hours

It is evident that the practice of blowing off holes by means of inserting compressed air into each hole is attended with a great amount of dust; and such this activity lasts but 15 minutes of the 8-hour working day. It is responsible for 1 per cent of the total dust exposure. It is evident that 23 per cent of the Layner's dust exposure may be at once eliminated by prohibiting this practice. And such an analysis indicates the necessity for devoting all one's efforts to the reduction of dust during the drilling process, since this activity accounts for 74 per cent of the dust exposure, although a Layner driller spends but one-half of the working day at his drill.

So far we have dealt with an industry in which the workers, as a rule, do not once their occupation. Often workers have had several occupations, either in the same industry or in several different kinds of establishments. If the worker has been employed in various occupations in the industry, it is a simple matter to determine total dust exposure in that industry. This is important from the viewpoint of relating a worker's dust exposure and his clinical condition. A typical example is given in Table 4.

Table 4.—Total Occupational Dust Exposure of an Anthracite Coal Worker

Occupation	Number of years in each occupation	Dust concentration in millions of particles per cubic foot		Millions of particle-years per cubic foot
		(a)	(b)	
Picker	2	300	600	700
Driller	2	71	142	142
Driller	3	71	213	213
Driller	3	450	1,350	1,350
Driller	15	450	6,750	6,750
Driller	5	7	35	35
Total	30			9,790

1 millions of particle-years per cubic foot
 326 millions of particles per cubic foot
 30 years

In Table 4 the worker's occupations are arranged in the order of employment, because having his present occupation. It is obvious that had one considered this occupation only, the dust exposure would not have yielded a true state of affairs,

nor would it have been possible to correlate this dust exposure with the man's clinical picture. In the above technique, correct weight is given to the number of years spent in each occupation and the dust exposure associated with each. Only by such an analysis is it possible to arrive at a fair estimate of a worker's dust exposure and his proper designation. Such an analysis is justified by the fact that results obtained with this technique yield excellent correlations with the clinico-pathological studies conducted on anthracite coal miners.

It is thus apparent that there is more to engineering dust surveys than the taking of dust samples and their analysis. Owing to the fact that the making of dust studies is rapidly being adopted in industry, it has become necessary to emphasize the important factors in such investigations. Although the making of dust counts, *per se*, is not a difficult procedure, the collection of dust samples in industry and their proper interpretation should be done by a thoroughly trained investigator. The examples just given show the value of this technique in the subsequent steps to be taken in the control of the industrial dust hazard.

General Dust Control Methods

The selection of any method of dust suppression will depend primarily upon its effectiveness in reducing a given hazard and its adaptability. A large percentage of reduction in dust does not necessarily indicate that the method used is efficient, unless the reduction has actually been sufficient to bring the exposure below the safe limit, and does not interfere with the industrial operations involved. In general, there are four methods of dust control: (1) substitution of non-dust-producing for hazardous substances; (2) isolation of the dusty operations; (3) wetting the dust at its source; (4) local exhaust ventilation. These methods may be supplemented by personal respiratory protection.

The first method has a limited application. One example is the use of a non-silica porting compound for a silica compound in connection with the making of laundry mangle. Table 5 shows that although the use of porting compound, in this particular study, only necessitated an exposure of 53 minutes of the 360 minutes of a worker's work day (10 per cent), actually this activity accounted for approximately 55 per cent of the worker's total exposure. It is obvious that the substitution of a porting compound, which is not as harmful as one composed of free silica, will lessen the dust hazard in this instance to a considerable extent.

Table 5.—Dust Exposure of Molders

Activity	Average Dust Exposure in Millions of Particles per Cubic Foot		Particle-Minutes in Millions (a × b)
	(a)	(b)	
Use of Porting Compound	54	63.8	3,445
Remaining tasks in molding	412	4.4	1,812
Trimming	58	3.1	180
Trimming molds ("shake-out")	16	32.5	520
Total	540		5,957

595.8 million particle-minutes
 11.0 million particles (per cu. ft.)
 540 minutes

In the case of abrasive cleaning with steel instead of sand, we have the example of the substitution of a substance involving a lesser dust exposure as well as the use of a material not as toxic as sand. Table 6 shows the improvement effected by this type of substitution. Not only is the dust concentration reduced from an average of 902 to 353 million particles per cubic foot, but the potential exposure to quartz dust is diminished from 42.99 to 3 per cent.

6—Showing Reduction in Concentration and Quartz Content of Dust in Sandblast Rooms With the Substitution of Steel for Sand Abrasive

	Average dust concentration in millions of particles per cubic foot	Percentage of Quartz
.....	969	42.98
.....	155	3

second method of dust control, isolating the dusty process, possesses many lines, but unfortunately is not widely used. The theory underlying isolation concentrates the dust sources in one locality or in a single closed space. In this common number of employees are exposed. At present, many foundries, especially out-plant workers who normally are engaged in occupations with low concentrations. Thus, molders in a foundry may be exposed to a dust concentration of 3 million particles per cubic foot under normal occupational conditions, but in out-plant operations are carried on close by, their exposure may be increased to 50 million. The same condition exists when annealing flasks containing molten metal in malleable iron foundries, exposing grinders and tumbling plants at work close by.

This type of isolation of a dusty process is the abrasive cleaning process, which completely encloses a hazardous process and exposes only the blaster who is equipped with a protective helmet. The room is also exhausted, which reduces the dust concentration. Processes which are isolated require good ventilation. Other examples of isolation are the automatic turntable for abrasive tumbling barrels, and high-mixing rooms found in some pottery establishments.

A third method perhaps the oldest known, is the practice of wetting the dust source. In Table 7 an example is depicted in connection with the drilling and loading of rock in anthracite coal mine operations. It is apparent that a tremendous amount of dust has been effected by this method. However, as already pointed out, a particular method is attendant with a reduction of the dust to a safe limit, it is the method of isolation. In the present instance, the workers engaged in the process are still exposed to an unsafe concentration of a highly dangerous dust and a positive method of controlling the dust in drilling operations by dust traps is indicated. For drilling and loading operations involving an exposure to dust or to an atmosphere containing high amounts of free silica, as in the case of coal or slate, the reduction shown by the use of wet methods may be considered

7—Contrasting "Wet" and "Dry" Methods of Rock Drilling and Loading

No. of Samples	Average dust count in millions of particles per cubic foot "Dry"	"Wet"
21	568	31
10	636	32

fourth method—exhaust ventilation—is perhaps the most effective and one which is widely applied. We cannot discuss here the details of the theory and of the various exhaust systems except to point out there is a real need for more and better exhaust systems, which he has presented in Public Health Bulletin 217. The Health and his colleagues on the control of the silicosis hazard in the hard rock industry is another example of a scientific approach to the dust elimination

8—Summary of Results Contrasting the Dust Exposure of Mine Workers Under Controlled and Uncontrolled Working Conditions

Operation	Dust Concentration in millions of particles per cubic foot of air Controlled	Uncontrolled	Remarks
Empty charge	40	834	Unless at least 15 minutes elapsed after firing a charge, miners found to be exposed to high dust concentrations.
Loading coal or rock...	32	636	By wetting the loaded material the dust count is reduced as shown.
Loading coal by	4-26	291-1118*	Mechanical hoisting decreases the dust exposure as indicated.
Drilling	33	568	Wet drilling is effective in reducing the dust concentration. Further reduction would necessitate exhaust ventilation.
Hauling coal in haulage	12	17	Wetting coal and empty cars reduces dust in haulage ways.
Preparation of coal...	24	390	Wet breakers reduce dust counts as shown.

*The best study is associated with the hand loading of wet coal while the higher average is based on the hand loading of dry coal.

It is apparent that there are no set rules for the mechanical protection of workers from the industrial dust hazard. Specific conditions in an industry, or a plant, will determine the type of protection to be employed. The present discussion has emphasized the importance of approaching the problem from the standpoint of the occupational exposure. Studies in representative plants of an industry often reveal the various methods which may be employed in controlling the dust hazard. The following two examples indicate the value of such investigations.

Table 8 indicates the various control measures which were found in use in the anthracite coal mines investigated in the study referred to earlier. Although no single study has been practiced all of the control measures shown in this table, by an occupational study in several representative mines it was possible to show that methods are not known and practiced for the elimination of the dust hazard in this industry.

Another example is indicated in the results of a study now in progress in connection with mercurialism among workers in the battery for cutting industry. Table 9 shows the exposure to mercury dust and vapor of some of the workers in this industry

9—Exposure of Hatters' Fur Workers to Mercury Dust and Vapor Under Controlled and Uncontrolled Conditions

Occupation	Total Mercury Exposure in Milligrams per 10 cubic meters		Method of Control
	Uncontrolled	Controlled	
Blowers	4.6	..	None practiced
Shippers	7.2	..	Local exhaust
Cutters	4.0	1.8	Ventilation
Sorters	3.8	1.7	"
Brushers	3.1	1.2	"
Drummers	2.5	0.6	Segregation
Clipboard	1.5	0.7	"

under controlled and uncontrolled working conditions. It is apparent that where some measure of control is practiced by such methods as segregation or local exhaust ventilation, a material reduction in the exposure to mercury has been effected. It is believed that in the case of the blowers' exposure, a reduction may be effected by mechanical enclosure and local exhaust ventilation, and that the shipper's exposure to mercury vapor may be lessened by a general system of ventilation sufficient to cleanse the air in the store room frequently enough to bring the mercury concentration to a lower level. Unfortunately, in the present investigation, it has been impossible to find a plant in which an attempt has been made to reduce the exposure in these two occupations.

In some dusty occupations the methods of controlling dust have not been developed. In fact, operations such as removing the cores from very large foundry castings, and blasting, handling of used storage battery plates, palm chipping, and cadmium oxide manufacture appear to offer no practical means of adequately controlling the dust generated. In such cases, it is therefore necessary to furnish the worker with some respiratory protection devices to prevent his exposure to the harmful effects of the dusts present. These devices consist of various types of respirators, masks, or helmets.

It is important to hold in mind the limited use of personal protection devices. Once a worker cannot with comfort wear a mask or helmet continuously, such devices must be employed intermittently. Their use is generally extended to those occupations where all other methods have failed or supplementary to them, as in some battery repair where the exposure to small amounts of lead breathed is known to be detrimental to health.

It should be pointed out that the U. S. Bureau of Mines is equipped to conduct actual tests of respirators used for protection against various dusts and fumes (see table 21). These tests are conducted against the dust for which the device is to be used and are rated, not on an efficiency basis, but on the quantity of dust which actually passes the respirator. The results of a study of masks or helmets of the negative pressure type, made during the sandblast investigation conducted several years ago by the Public Health Service in cooperation with the National Safety Council, showed that the only practical safeguard to the worker inside the sandblast room was to provide him with a mask or helmet of the positive pressure type. Studying the efficiency of such devices it was found that a relationship existed between the amount of air supplied to the helmet and the concentration of dust which the helmet during blasting. To determine the optimum air volume to be supplied to such protective devices, it was necessary to obtain dust samples from inside the helmet while varying the air volume, at the same time maintaining the dust concentration in the sandblast room (outside the helmet) constant. The positive supply of dust-free air per minute will protect a worker under the operating conditions now in practice in sandblast rooms. The ultimate criterion of protection, however, is the result of dust determinations of the air within the helmet, that is, the air actually breathed by the worker and not the volume of air supplied.

Too much emphasis cannot be stressed on the necessity of maintaining in good order the personal respiratory devices for the protection of the worker against various dusts. Maintenance of exhaust ventilation systems, and other types of protective equipment, should be a rule in industry rather than an exception. Too often the "good housekeeping" has been interpreted as signifying only the periodic removal of dust collected on floors, rafters, etc. Although such practice contributes to the maintenance of cleanliness of a workroom and should always be in force, the time surely comes when serious attention should be given to the installation and rigid maintenance of all types of dust control devices. In every plant there should be a responsible individual charged with the periodic inspection of all workrooms for ventilation, and maintenance of all dust removal and other protective devices. Perhaps the best criterion of the effectiveness of these devices is the determination of the dust content of the air at the workers' breathing zone, by constant vigilance and an approach to the problem as outlined in this paper in hope to make progress in the control of the dust hazard in industry.

It is to be hoped that even a most extensive program of dust control are not easily realized. This is especially true in dealing with fibrous-producing dusts where some of the workmen have already inhaled sufficient quantities to

cause disability. However, in dealing with such dusts as lead, cadmium, and mercury compounds, control measures may produce salubrious results in a relatively brief period. It is difficult, because of lack of sufficient reliable data, to indicate here the economic benefits resulting from a preventive program of dust control. It has been estimated by Dean K. Newmeyer, statistician of this office, that the minimum expectancy in savings to employer and employee from an indicated reduction of the accident rate and of the time lost on account of illness (for an equivalent reduction in mortality), demonstrated an attainable, is \$30,000 per year per 1,000 employees. And this estimate is for plants whose accident rate is considerably below the average, in which there are no occupational health hazards. In plants where hazards are known to exist the savings should be far in excess of this conservative estimate. When one realizes that in this country there are approximately 15 millions of workers engaged in manufacturing, mechanical, and mineral industries, then it is evident that the magnitude of the problem has not been overemphasized.

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Silicosis and Silico-Tuberculosis Medical Problems of an Important Industrial Disease

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A hidden element of the cost of production is industrial disease. Industry has reached a stage beyond the current call of wages and hours. Far more important is conservation of man power by preventive medicine and improved engineering. Disease prevention measures are not a cost, but, in the long run, a great economic saving.

Incidence. In the United States it has been computed that there are from 500,000 to 1,000,000 people employed in occupations where a silicosis hazard exists. In New York City there are about 65,000 such employees. In a representative group of granite workers in Massachusetts silicosis alone was present in about 15 per cent and silicosis complicated with tuberculosis in almost 8 per cent. Tuberculosis was the cause of death in over one-third of the granite workers which in turn times the incidence for males of 20 years and over in this country. In industry men studied in Massachusetts, silicosis was less frequent (about 9 per cent) and less advanced in degree than in granite workers. The duration of exposure in forestry workers with pneumoconiosis has averaged many years more than that required to produce silicosis in an industry such as gold mining. The tuberculosis hazard in foundries is nearly as great as that reported for some of the other dusty trades, but the figures are much lower than those of miners of gold, silver, copper and lead, among whom the mortality from tuberculosis is 8 to 15 times the general expectancy. Death rates for all non-tuberculous infections have been reported higher among workers in siliceous dusts than in the general population. It is suggested that the worker in silica environments more often to acute pulmonary infections rather than surviving the chronic fibrosis.

Silicosis is defined as a pathologic condition of the lungs due to the inhalation of silica, whether free or combined in such a state as to be capable of setting up characteristic pathogenic effects. The principal factors that determine the incidence of silicosis are (1) the percentage of free silica in the inhaled dust; (2) the concentration of silica particles less than 10 micra in diameter in the atmosphere; (3) the duration of exposure to the dust; and (4) the susceptibility of the individual exposed as modified by age, complicating infections, etc. The occupational disease resulting from such inhalation has been defined as "harmful results of occupational activity traceable to specific causes or labor conditions and followed by more or less extended incapacity for work."

Metabolism of Silica. Significant amounts of silica are present in all body tissues and fluids. It enters the body through the digestive tract and the lungs. Most of that entering the stomach is eliminated in the stools, but a fairly large amount is absorbed into the blood as shown by the constant excretion of silica in the urine. All vegetable foods contain silicon especially the hulls of grains, hay and straw. The low silica content of the liver, spleen and kidneys indicates the little retention of the absorbed silica in the body. Silica content of the urine of animals may be influenced at will by diet. The body possesses a very efficient mechanism for the disposal of silica because of the low kidney threshold. Silica entering the lungs in particulate form is expectorated in part with its enveloping cells, but most of it is carried into the pulmonary lymph channels. Many such particles reach the lymph nodes and even the spleen by way of the blood. The finest particles, however, may be dissolved in alkaline body fluids and carried away in solution to be excreted in the urine. There may be a constant drainage of silica from the lung through the inhalation of extremely fine particles of silica in dusty atmospheres so small that they are not seen under the microscope.

Attempts to influence the absorption of silica from the lungs by administration of alkali have been inconclusive. Elimination of silica by way of the sputum from patients having deposits of silica in their lungs appears to be higher than those having no history of exposure to dust. Only small amounts of silica are in the blood and this level is little different in normals than in silicotics.

Pathogenesis. This disease is essentially a fibrosis of the lungs developing especially in such industries as hard-rock metal mining, granite cutting, metal grinding and sand-blasting. The pathological changes are believed to result from two causes, a blocking of the lung lymphatics by mononuclear cells laden with dust in addition to the action of colloidal silica, the exact nature of which is in doubt. The small particles under 10 micra are the only ones capable of penetrating the lung tissue.

Although silica plays the dominant role in the production of silicosis, the admixture of other dusts tends to modify the pathological changes in the lungs so that these resemble then those of other forms of dust inhalation, and the modification bears some relation to the percentage of free silica in the mixture. Silicates, as asbestos, produce a definite change in the lung, as well as other dusts such as marble, coal, etc. Such changes are represented by a fibrosis brought about because relatively insoluble minute particles of minerals in sufficient concentration have been brought by the activity of phagocytic cells into intimate contact with the pulmonary connective tissue. This fibrosis is a diffuse cellular one that occurs in the walls of the smaller bronchi and of all their finer divisions and extends to involve the supporting connective tissue of the adjacent blood vessels and to some extent also the walls of adjacent air spaces. However, when the great majority of the inhaled particles are composed of or contain silica, there develops, in addition to specific and localized type of fibrosis called the silicotic nodule—an orderly whorled arrangement of cells and fibres, and with sharp definition from the adjacent parenchyma. Many dusts create a generalized fibrosis but only one, namely one combined with silicon dioxide produces the special fibrosis of silicosis. Sericite, known as white mica which is a hydrated silicate of aluminum and potassium, has not produced in animal experiments the silicotic nodule, but instead generalized fibrosis resulted.

The dust must be absorbed into those which are chemically active and those which are inert when inhaled into the respiratory tract. Silica is a chemically active dust which must necessarily be soluble to a degree in the body fluids and its activity depends on its solubility. This activity which is manifested in the areas where dust particles are carried along the lymph stream by phagocytes, causes lesions of two

"toxic" and "sclerotic" both of which have been reproduced experimentally. Lesions depend upon local necrosis and slow death and appear to favor the growth of tubercle bacilli; the sclerotic lesions produce the nodular fibrosis. The dusts are insoluble in body fluids and cannot exert chemical action in the lung, but if they accumulate to a marked extent their effect is mechanical which is related to a certain amount of diffuse fibrosis around the dust deposits. Certain dusts, such as carbon, may have physical effects, they may absorb toxic substances and it has been suggested that on this basis there is a relatively lower incidence of silicotic clinical tuberculosis in silicon-anthraxosis than in silicotic lungs.

Other dusts may even protect, as in the case of certain clays, gypsum and calcium oxide. Pure pneumoconiosis may be only a laboratory disease, as the primary fibrosis of workers in dusty trades probably results from the combined action of dust and infection, whether it be tuberculosis or not.

In silicosis it is not the mineral particles that are inhaled in doing the work, efficiency and health may be greatly accentuated through the inhalation of finely divided particles even of a chemically inactive dust when there has occurred lymph stasis which is known to follow exposure to silica. This lymphatic blockage tends to retention and accumulation of the inert dust. In soft coal miners who breathe what is called "miner's asthma" we have this accumulation of carbon. Such dusts are very liable to have a high incidence of bronchitis with mechanical and physical changes due to retention of anthracite dust. Furthermore, inquired cases of silicosis, with or without tuberculosis, can no longer be doubted.

Tuberculosis. Most apical tuberculosis is acquired before the age of 25 and so silicosis at the age of 30 makes a previous tuberculosis more serious. Most workers in tuberculosis going into the mines before the age of 30 die of tuberculosis by the age of 45. The silicotic develops a sputum that contains tubercle bacilli late in life and the children who are contacts with tubercular silicotics develop very early clinical tuberculosis. It is impossible to say definitely that tuberculosis engulfs itself upon the silicotic or vice versa, for we see apical tuberculosis in silicosis that spreads downward, while other silicotics show only the tuberculosis in the upper lobes. It has been found that most silicotics die of tuberculosis.

The diagnosis of silicosis is made primarily on two findings, the proper history and occupational exposure to siliceous dust and the presence of abnormal shadows on the pulmonary X-ray. The physical examination and the patient's symptoms are of little value. There are other diagnostic aids such as the finding of large quantities of silica particles in the sputum, quantitative determinations of silica in urine, and roentgen mortem, chemical analyses of the lung ash supplemented by petrographic examination, roentgen-ray spectrum analysis and special incinerating studies of lung tissue. We must at times rely on the pathologist to determine the amount and distribution of fibrosis due to silica and from microscopic studies give an opinion on the importance of this fibrosis as the ultimate cause of disease and death.

Lung fibrosis may be present without any silica. Silica may be present in the alveoli or the pulmonary lymph channels without associated fibrosis. Finely divided siliceous particles from lung tissue may contain innocuous silicates which cannot be distinguished from harmful silica particles. Hydrated silica which is noticeably refractive cannot be demonstrated with prisms. Therefore in the pathological section the presence of siliceous fibrosis can be suspected but cannot be specifically identified with the siliceous material that it may contain. Accordingly the microincineration method of Irwin with hydrochloric acid is now included in the microscopic examination of any lung as a means toward a surer diagnosis.

Diagnostic difficulties in clinical medicine may be more obvious if we examine the occupational history. Quarries grinders working under conditions of massive exposure may develop silicosis in acute form even in a period of months, whereas in other occupations it may take 25 years. Workers in the same industry, indeed in the same room, experience different degrees of exposure dependent upon perhaps the dust-filtering capacity of the nose and functional condition of the lung as determined by constitutional characteristics and antecedent disease. The size and cellular structure of the particles of silica, as well as the dosage and total amount of silica, will influence the rate of development of the disease. Apparently particles that are larger than 10 micra are not phagocytosed in the lung. So a definite

history of exposure must be established and in general hospitals where patients are migratory, conditions under which they worked are very vaguely described and there are not available data on dust counts and silica concentration, so that the history is often misleading.

As to symptoms, patients can perform strenuous labor despite extensive disease and the symptoms of dyspnea and cough are common to many diseases. Fever is absent unless infection occurs, but most important is the great disproportion between a patient's complaints and what is seen on the X-ray, the latter showing extensive abnormal shadows in comparison with the symptoms.

On physical examination, extensive disease may be present and few abnormal physical signs. The physical signs are merely those of a general pulmonary fibrosis with emphysema, such as restriction of costal and diaphragmatic movement, diminution of or intensified breath sounds and a hyperresonant note. Rales are usually absent unless infection is present.

As to the X-ray, there are 3 essential types of shadows described, linear strands, small discrete shadows, and homogeneous shadows of varying sizes; these correspond to the fibrous strands, silicotic nodules, and the conglomerate masses of fibrosis. The nodular shadows are usually characteristically around the hilum, or conglomerate nodular shadows of bat-wing appearance extend into both upper lung fields, or nodular shadows may be distributed in the upper two-thirds of the lung fields, perhaps more pronounced on the right side, with the lower third kept clear by emphysema. With infection present, the shadows are less sharp or the linear strands interconnect in foci. Large conglomerate shadows appearing out from the hilum leaving the periphery of the lung clear throughout because of emphysema. The distribution of some of these lesions may be determined by the posture assumed by the workers, and infection may likewise determine an ultimate atypical distribution. Many variations from these patterns are seen in the X-ray, especially under excessive exposure or when other dusts are inhaled, or in the presence of infection. It is probable that the main source of the diagnostic difficulties is caused by the emphysema which mingles the physical signs and is responsive with emphysema, such as restriction of costal and diaphragmatic movement, diminution in great part for the absence of symptoms. It may blot out, even on X-ray, the silicotic lesions of fine size. Examples of such difficulties in diagnosis as encountered by us are the following:

Case I—Mr. T. A forty-five year old man entered the New York hospital complaining of mild cough and expectoration of four months' duration. He appeared acutely ill, his fever was 103 degrees and respiration 28. Rales were elicited over the upper half of both sides of the chest. Examination of his eye grounds revealed bilateral retinal tubercles; his sputum contained numerous acid-fast organisms. The X-ray revealed fine mottled shadows distributed throughout both lung fields and a small cavity at the left apex. A diagnosis of milary tuberculosis was made. However, after one week's stay in the hospital, his temperature and pulse returned to normal and during the following month he gained 18 pounds. The signs in his chest now became confined to the left apex. In view of his unusual progress the diagnosis of milary tuberculosis was doubted. His occupational history revealed that up until three years before entrance to the hospital he had worked for 20 years polishing leather on a sandpaper wheel. There were numerous machines in the work room and no precautions were observed to clear the very dusty air. His sputum was examined through the kindness of Dr. Burke of Baybrook, N. Y. who found it laden with numerous doubly refractile silica particles. He expressed the opinion that this was consistent with silicosis for he had found such numerous particles only in cases of silicosis. The patient subsequently died of a tuberculous meningitis. Retinal tubercles were demonstrated on microscopic section. The pathologist's report was milary tuberculosis. Asking of the lung showed increased silica content consistent with undue exposure to dust (more than 2 mgm silica per gram dried tissue).

Case II—Mr. A. aged 54 entered the New York hospital complaining of long-continued dyspnea and chest pain. On physical examination there were rales and dullness over the upper third of the right chest anteriorly. He ran a low grade fever but was robust and felt quite well. The chest X-ray disclosed enlarged hilum shadows particularly on the right, and diffuse mottled discrete shadows

throughout both lung fields with a circumscribed density near the right apex. He gave a history of having worked for twenty-four years as a cutter and sizer of asbestos-containing paper box boards. The rooms were in a continuous cloud of dust. Examination of the dust revealed 5 per cent silica content. The hemoptysis, we felt, was to be explained on the basis of infection or neoplasm, but we did not know whether we were dealing with one of those processes alone or an associated silicosis or asbestosis. A small nodule in the neck was subsequently removed and showed carcinoma. We are inclined to believe that this does not explain the whole process, as the man is still alive and certainly, from the X-ray standpoint, we cannot say that there is no silicosis.

Case III—Mr. C. A dish-washer, aged 46, entered Bellevue Hospital because of cough and expectoration, associated with dyspnea. There was some dullness and rales at the right base posteriorly. Chest X-ray revealed a homogeneous shadow at the right base. His sputum contained no tubercle bacilli and lipid-laden study revealed no abnormalities. Bronchoscopic examination disclosed a bleeding mass in right main bronchus. Symptoms and disease progressed during the following four years. Discrete mottled shadows first appeared in the upper right lung field and the shadow at the right base cleared somewhat. Three years later extensive abnormal shadows were present throughout both lung fields, particularly on the right. Diagnosis of chronic pneumonia of unknown etiology was made. At no time was a diagnosis of silicosis entertained, because as far as could be determined he had no history of exposure. Furthermore if there were silicosis it believed very atypically having the lesion confined practically to the right base at the beginning and then spreading to the left lung. Autopsy however, revealed a typical silicosis associated with a small degree of tuberculosis. A picture of the lung showed how much more extensive the silicotic process was in the right lung. There was necrosis of the right middle lobe bronchus with bronchiectasis in this lobe. Chronic infection in the lung field probably accounted for the unusual necrosis. This case illustrates how necessary it is to have the history of dust exposure for without it here we are unable to even suggest a diagnosis.

Case IV—Mr. C. aged 45, complained of cough and dyspnea with slight expectoration and gave a history of having worked for many years repairing tires, using talc powder. It was difficult to obtain accurate details as to the possibility of silica exposure except that the rooms were filled with clouds of dust. Rales were present at both apices and a few tubercle bacilli were found in the sputum. Discrete and stringy shadows were disseminated throughout both lung fields. We know from the positive sputum that tuberculosis is present. The patient has, however, been well for a period of two years. The doubtful history of exposure together with the numerous discrete nodular shadows in his lung, which are consistent with silicosis, makes this patient a problem. Is this tuberculosis alone or is this tuberculosis with silicosis? The patient is still living a year later and working.

Conclusion. Cases such as these are exceptional, but their existence must always be borne in mind. If occupational history is inadequate and X-ray, clinical and laboratory studies prove misleading, the diagnosis may present great difficulty. However, a comprehensive study of all possible data usually clears up the problem with reasonable certainty.

ADJOURNMENT

Safety Equipment

Safety Equipment

WEDNESDAY AFTERNOON SESSION

October 16, 1935

The session was called to order by Chairman, Irwin W. Millard, president, Industrial Gloves Corporation, Danville, Ill. Chairman Millard mentioned some of the problems of providing adequate safety equipment for industry.

Respiratory Protective Devices

(An interpretation of the U. S. Bureau of Mines, Schedule 21)

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Gas Section, Pittsburgh Experiment Station, Pittsburgh, Pa.

The respiratory protective devices of industrial hygienic importance are those designed to protect against the inhalation of harmful solid, gaseous, or liquid atmospheric contaminants, or the inhalation of air deficient in oxygen.

The devices in common use are the mechanical filter respirator (commonly referred to as respirator) for protection against the inhalation of dusts, smokes, fumes, and mists or what may be referred to collectively as atmospheric particulate matter; gas masks for protection against the inhalation of gases and vapors; oxygen breathing apparatus, hose masks, and air-line respirators for protection against the inhalation of any atmosphere provided it does not contain harmful constituent which can be absorbed readily through the skin; and the abrasive blasting helmet or hood for protection against the inhalation of and the impact and abrasion from the atmospheric particulate matter generated in sand blasting or abrasive blasting with steel shot.

These devices are designed to furnish protection either by making the wearer's inspired air safe to breathe or by supplying the wearer with safe air from a supply which he carries or from outside the contaminated zone.

The wearer of the first or air-purifying type, on inspiration draws air from his immediate surroundings through the device which either removes the contaminant, usually by chemical or mechanical filtration, or converts it into a harmless substance. This type, of course, offers no protection against atmospheres deficient in oxygen as it does not add oxygen to the air.

There are two types of respiratory protective devices of the second type designed to supply the wearer with safe air. In one, the wearer receives his air supply from a cylinder of compressed oxygen, liquid oxygen, liquid air, or from a chemical which yields oxygen upon decomposition. This air supply is part of the self-contained unit, all of which is carried by the wearer. In the other type a hose, attached to a face-piece, is connected to a compressor or blower whose intake is located in safe air. Air is forced through the hose to the wearer.

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There is some confusion in the use of the term "respirator," to designate devices for protection against the inhalation of atmospheric particulate matter. Such devices were the first and for a long time were the only respiratory protective devices. They were logically called respirators, and as long as they were the only devices of this kind there was no confusion. The development of other devices of industrial hygienic importance and the development of devices for maintaining artificial respiration over long periods and for enabling men trapped in submerged submarines to reach the surface safely, all called respirators, was responsible for the confusion. The Bureau of Mines suggests that the term "respirator" be retained for all of these devices, but that respiratory protective devices of industrial hygienic importance be called industrial respirators and that the different kinds of industrial respirators be assigned a name which will indicate their operating principle or field of use or both. Satisfactory names in common use should be retained. On this basis, the Bureau of Mines suggests the following classification for respiratory protective devices of industrial hygienic importance:

Industrial Respirators

1. Supplied Air Respirators
 - a. Self-contained type
 - (1) Oxygen breathing apparatus*
 - b. Hose type
 - (1) Hose mask
 - (2) Air line respirator*
 - (3) Abrasive blasting respirator*
 - a. Purifying Respirators
 - (1) Acid gas or type A* chemical filter respirator
 - (2) Organic vapor or type B* chemical filter respirator
 - (3) Ammonia or type C* chemical filter respirator
 - (4) Carbon monoxide or type D* chemical filter respirator
 - b. Mechanical filter respirator†
 - (1) Dust or type A* mechanical filter respirator
 - (2) Fume or type B* mechanical filter respirator
 - (3) Mist or type C* mechanical filter respirator
 - c. Chemical and mechanical filter respirator‡

Testing and Approving of Industrial Respirators by the U. S. Bureau of Mines

Since its organization the U. S. Bureau of Mines has been interested in industrial respirators as a means of protecting workers in the mineral industry against harmful atmospheric contaminants. To this end the Bureau has developed an approval system the purposes of which are: (1) To encourage and aid manufacturers in the development and marketing of safe and suitable equipment; and (2) To encourage the consumer to use such equipment, to aid him in obtaining it and to instruct him in its usage. These purposes are accomplished by establishing a schedule of the material and performance requirements that a safe and suitable device should meet; by making approval tests for conformance to such a schedule; and by informing the public of the

* Sometimes called mine rescue breathing apparatus.

† Sometimes called sand blast respirator or positive pressure respirator.

‡ Commonly called gas mask.

* Entries assigned to categories of chemical filter respirators. See U. S. Bureau of Mines Approval Schedule for Testing Gas Masks for Permissibility, 17 pp., 1935.

† Entries assigned to categories of mechanical filter respirators. See U. S. Bureau of Mines Approval Schedule for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility, 14 pp., 1934.

‡ The entries now referred to as Type N or All Service Gas Mask and the chemical cartridge are also under this heading.

advantages in the use of devices bearing Bureau of Mines approval. If the device is found by examination and test to meet the requirements of the schedule the Bureau of Mines gives the manufacturer a certificate of approval which he may display as evidence of the quality of his product. The approved devices are marked in a manner which clearly distinguishes them and indicates the purpose for which they are approved and the limitations under which they may be used. As an aid to the consumer, the Bureau of Mines periodically issues a list of the devices which have met the requirements.

The submission of equipment is entirely voluntary on the part of the manufacturer. On making application for tests, the manufacturer deposits a fee which is turned into the miscellaneous receipts of the treasury of the United States; none of the money accrues to the Bureau of Mines. The approval system is motivated entirely by the desire of the manufacturers to produce and market good equipment, the interest of the Bureau of Mines in having safe equipment available commercially, and the demand of the consumer for such equipment.

Approval schedules have been issued for oxygen breathing apparatus,* chemical filter respirators or gas masks,† hose masks,‡ and mechanical filter respirators. The schedule covering hose masks is being revised to include the other kinds of supplied-air respirators, namely, air-line and abrasive-blasting respirators. When this revision is completed, the Bureau of Mines will have approval schedules for all types of respirators now in common use. The approval system undoubtedly is largely responsible for the development of fundamentally safe and suitable devices, and the elimination of confusion in their selection and use.

The general plan of the various schedules is similar. The requirements may be divided into 3 parts:

(1) Pre-test requirements, or those with which the manufacturer must comply before examination and test of a device will be undertaken. For example, the respirator must be in a fully developed form ready for market and available for purchase if approval is granted. Also, the manufacturer must be prepared to test and maintain control of the essential characteristics of his device by a method which meets the approval of this Bureau.

(2) Material, construction, and performance requirements which the equipment must meet by examination and test.

(3) Post-test requirements, or those with which the manufacturer must comply after the device is approved. From the viewpoint of the consumer the most important of these concern labeling and marking, provision of adequate instructions for proper use of the device, and maintenance of design and quality of the product marketed under the approval. As a check on the latter, the Bureau of Mines obtains samples of the device on the open market and subjects them to the various inspections and tests of the appropriate schedule. The Bureau reserves the right to withdraw its approval of any device for cause.

Interpretation of U. S. Bureau of Mines Approval Schedule 21, Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility

Among the reasons for the development of Schedule 21, Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility, was the realization by the Bureau of Mines and others that there was a definite need for mechanical filter respirators to protect workers against harmful atmospheric particulate matter in situations where better methods of control of dust production and removal were either not available or practical, the ineffectiveness of existing mechanical filter respirators, and

* Bureau of Mines, Procedure for Establishing a List of Permissible Self-Contained Oxygen Breathing Apparatus, Type, Character of Tests, and Conditions Under which Mine Rescue Breathing Apparatus will be Tested; Sched. 21A, January 20, 1930, 12 pp.

† Bureau of Mines, Procedure for Testing Gas Masks for Permissibility; Sched. 14D, May 5, 1931, 17 pp.

‡ Bureau of Mines, Procedure for Testing Hose Masks for Permissibility; Sched. 19, April 24, 1927, 8 pp.

* Bureau of Mines, Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility; Sched. 21, August 20, 1934, 14 pp.

requests from manufacturers and consumers that this bureau test and approve such devices.

Schedule 21 follows the general plan of the other bureau approval schedules for industrial respirators; the pre-test and post-test requirements are quite similar, and the general principles of the test requirements are the same. The primary purpose of this paper is to explain the reasons for the various test requirements.

Pre-Test Requirements

The pre-test requirements of Schedule 21 require that the manufacturer submit information, drawings, and samples of the device to be tested. The device must be completely developed and ready for release to the public, and the device when tested by the manufacturer or his agent must have passed tests of the nature described in Schedule 21. The reasons for the third requirement are: (1) To assure the bureau that the manufacturer is prepared to control the filtering characteristics of his respirator; (2) to eliminate any question of competition with private consulting agencies in developing respirators; (3) to furnish evidence that the respirator really is ready for release to public market; and (4) to save the manufacturer's and the Bureau's time. After the manufacturer has complied with all the above pre-test requirements he must submit a fee for the examination and test of his device. This fee is turned into the miscellaneous funds of the U. S. Treasury and none of the money reverts to the Bureau of Mines.

Test Requirements

In developing the tests for mechanical filter respirators consideration was given first to the general requirements for a safe and suitable device. These requirements are similar for all types of industrial respirators. The respirator must (1) give adequate protection, (2) be reasonably comfortable and physically convenient to wear, and (3) provide an acceptable service life.

Adequate protection implies that the mechanical filter respirator when properly maintained and worn must prevent the wearer from breathing enough particulate matter to cause a harmful physiological response under the conditions of occupational exposure for which it is designed to be used.

Comfort and physical convenience factors are equal in importance to adequate protection. Even though aware of the ultimate serious effect which will be produced after prolonged daily exposure, workmen are inclined to be difficult and unwilling to suffer much daily inconvenience and discomfort from the respirator.

Encumbrance and discomfort also increase fatigue, cause distraction, and in general handicap the wearer's ability to take care of himself, thus increasing the possibility of accident. Important specific items include the weight of the respirator, its carriage on the face or head, effect on vision, heating of the area of the skin under the facemask, inability to expectorate, difficulty in talking, and resistance to breathing. The importance of comfort and physical convenience cannot be over estimated.

The service life involves elements of practicability in the wearing and maintenance of the device, and indirectly the safety. This type of respirator is primarily not an emergency device, but a part of the workman's equipment for doing his regular job safely. If the service life is short, the burden of changing of filter elements will be reflected in the workman's attitude toward good maintenance and use.

All mechanical filter respirators are subjected to certain inspections and tests and they must fulfill certain requirements. The general design and construction, particularly as to facial fit, freedom from irritating facial contacts, weight, effect on vision and the wearing of goggles, and ease of changing filter elements, and so on, are examined. The materials are examined to determine if they are obviously suited for the purpose for which they are designed. Gasket parts which come in contact with the face must not contain any skin-irritating constituent.

Resistance to Air Flow Requirements

The requirements for resistance to air flow are the same for all approved mechanical filter respirators. At no time during or after the filter efficacy testing period must the resistance to air being drawn through the device at the rate of 85 liters

(3 cubic feet) per minute exceed 50 millimeters (1.97 inches) of water column height or the resistance to air being blown through the device at the same rate of flow exceed 25 millimeters of water column height. An air flow of 85 liters per minute is approximately equivalent to the respiratory rate of a man doing heavy work. The amount of particulate matter pulled to the device during the filter efficacy tests is roughly equivalent to the amount that would be pulled to the filter by a worker wearing the mechanical filter respirator in a moderately concentrated suspension of the particulate matter during an 8-hour period. Thus resistance to air flow of an approved mechanical filter respirator should not become excessive when worn for an 8-hour period in most suspensions of atmospheric particulate matter encountered in industry. The manufacturer is required to give instructions on cleaning or changing the filter elements when the resistance to air flow noticeably increases.

Direct Leakage and Man Test

All mechanical filter respirators are subjected to a direct leakage and man test to determine facial fit, whether there is any direct leakage of unfiltered air, and to obtain information on the comfort of the device. Three of the mechanical filter respirators are worn for 30 minutes by 3 men with different facial features in an atmosphere containing a heavy suspension of bituminous-coal dust. At the end of the period the respirators are removed and that part of the face covered by the facemask is examined for evidence of any leak under the edge of the facemask. Sticks a millimeter thick were wedged under the edges of the facemasks worn by subjects A and C to cause the leaks. The location and approximate magnitude of the leaks are shown by the black streaks on that part of the face covered by the edges of the facemasks. The nasal passages and sputum of the subjects are also examined before and after the tests.

Filtering-Efficacy Tests

In the development of the filtering-efficacy tests, particular attention was given to the physical properties, especially particle size, of the significant kinds of atmospheric particulate matter encountered in industry. Previous studies of filtering materials had shown that, in general, filtering efficacy decreases with a decrease in particle size.

It was decided that most of the significant industrially generated atmospheric particulate matter could be classified into the following three groups in accordance with method of generation, physical state, and particle size:

1. *Mechanically generated dusts* resulting from the disintegration of a solid, such as the dust clouds produced in the various processes of mining, quarrying and tunneling and the grinding, crushing, and general processing of solid materials. This type of atmospheric particulate matter is referred to as Type A atmospheric particulate matter and mechanical filter respirators designed to furnish protection against these suspensions are referred to as Type A mechanical filter respirators.
2. *Fumes of various metals* (usually their chemical compounds, as oxides or carbonates) such as lead, mercury (except mercury vapor), manganese, magnesium, aluminum, antimony, arsenic, copper, chromium, iron, cadmium, and zinc resulting from sublimation or the condensation of their vapor, or from the chemical reactions between their vapor and gases. This type of atmospheric particulate matter is referred to as Type B atmospheric particulate matter and mechanical filter respirators designed to furnish protection against these suspensions are referred to as Type B mechanical filter respirators.

3. *Mists* as produced by spray-coating with paint and vitreous enamels, chromic acid mist as produced in chromium plating, and other mists of materials whose liquid vehicle does not produce harmful gases or vapors. This type of atmospheric particulate matter is referred to as Type C atmospheric particulate matter and mechanical filter respirators designed to furnish protection against these suspensions are referred to as Type C mechanical filter respirators.

The mechanically generated dusts and fumes consist of solid particles while the mists consist of liquid or liquid-coated solid particles. The particle size of mechanically generated dusts extends over a wide range, in some cases, from particles visible to the naked eye probably down to molecular dimensions. The range in particle size of fumes is much smaller. The upper limit is in the lower microscopic

range (about 0.5 micron), while the lower limit probably approaches molecular dimensions. The particles of some fumes, particularly zinc and magnesium, readily join and form large flake-like clusters. The effect is least pronounced in the case of lead. Most particles are spherical and probably more uniform in particle size than those of dusts and fumes.

Suspensions of each of the types of industrially-generated atmospheric particulate matter were selected for use in the filtering-efficacy tests. These suspensions were chosen on the basis of their industrial hygienic significance and their physical properties, such as particle-size distribution and tendency to aggregate, which have an appreciable effect on filtration. It was desired to test the mechanical filter respirators against the most common or widespread harmful suspensions of each type, the test suspensions to have physical properties, such as particle size and aggregation tendency, which would render them as difficult to remove by filtration as any other suspension of the same type. The test suspensions selected are:

(a) For testing Type A mechanical filter respirators or those designed to furnish protection against mechanically generated dusts a suspension generated from very fine (99+ per cent through 325 standard mesh sieve) silica dust consisting of 99+ per cent free silica (SiO_2) is used. The suspension is generated in such a way that all particles larger than about 3 microns are removed before the suspension enters the test chamber. The particle-size distribution of the test suspension must not exceed a geometric mean of 0.6 micron and a standard geometric deviation of 1.90. The particle-size determination is made by collecting samples of the suspension by the Thomas jet dust counter and determining the particle size distribution by a microprojection method developed by the Bureau of Mines.*

(b) For testing Type B mechanical filter respirators or those designed to furnish protection against fumes, a lead oxide fume generated by the combustion of a metal gas containing lead tetraethyl vapor is used. The particles of this fume are extremely small and have about the least tendency to aggregate of any fume, hence they are very difficult to remove from the air by mechanical filtration. A suspension of magnesium oxide is also used to determine the effect of a fume, whose particles readily aggregate in large clusters, on the resistance to air flow of the filter of the device.

(c) For testing Type C mechanical filter respirators or those designed to furnish protection against mists, three different suspensions are used. Chromic acid mist generated by electrolyzing an aqueous solution of chromic acid, as is done in industrial chromium plating; lead paint mist generated by spray-coating with lead paint; and a water mist carrying silica dust generated by spraying a 2 per cent aqueous suspension of silica dust are used. The water-mist carrying silica dust is used to simulate the mists generated in spray-coating with vitreous enamels.

The concentration of the particulate matter in the test suspensions was chosen to represent more or less the higher concentrations found in industry. Since the concentration of mechanically generated dust found in industry varies over such wide limits it was decided to test Type A mechanical filter respirators against two concentrations; one to represent the more or less average dusty industrial conditions, and the other to represent very dusty conditions.

The complete mechanical filter respirator is tested on a mechanical testing apparatus. The test suspension is pulled through the device at the rate of 32 liters (113 cubic feet) per minute, continuous flow. The volume of air pulled in through the mechanical filter respirator is 10 cubic meters in all cases except in some tests against particular kinds of suspensions as mechanically generated lead dust and in the high-silica dust-concentration test and the magnesium oxide test whose primary object is to determine the increase in resistance to air flow of the filter with the amount of particulate matter retained. Ten cubic meters is approximately equivalent to the volume of air breathed by a worker in 8 hours. The samples of particulate matter for concentration determinations are precipitated electrically from the air of the test suspension both before and after it has passed through the mechanism of filter respirator. The samples are collected in containers which can be weighed readily on an analytical balance. For reasons of convenience, speed,

* Dr. W. A. J. and Van W. P. The Microprojector for Determining Particle Size Distribution and Number Concentration of Atmospheric Dusts. U. S. Bureau of Mines Report of Investigations 329, 1935.

and accuracy the samples of silica dust are quantitated by weight rather than by volume. Samples of the other particulate matter are quantitated chemically.

The requirements as to the amount of particulate matter that the mechanical filter respirators must remove from the air pulled through them is based on the best available information on the concentration of the particulate matter that is safe to breathe. These requirements are subject to change with the accumulation of knowledge on the physiological effects of industrially generated atmospheric particulate matter. In other words, the filtering-efficacy requirement is that the air inhaled by the wearer of such a device must be safe to breathe, and not that the device have any particular percentage filtering efficiency.

Mechanical filter respirators are not approved for any substance more harmful than the particulate matter in the test suspension against which they are tested. Thus Type A respirators are not approved for any substance more harmful than free silica (SiO_2) dust. However, Schedule 21 provides for testing and approving mechanical filter respirators against any kind of industrially generated atmospheric particulate matter. For example, Type A mechanical filter respirators are not approved for protection against poisoning by breathing dusts whose main harmful constituents are metals or their compounds. However, two mechanical filter respirators have been submitted and approved for protection against the inhalation of mechanical generated lead dusts.

Table 1 summarizes the details of the filtering-efficacy tests and lists the mechanical filter respirators which have been approved to date. (Pages 140-141.)

Post-Test Requirements

The manufacturer of an approved mechanical filter respirator is required to mark his device with the name of his company, the name letter, or number by which the type is designated for trade purposes, and the approval number assigned to the device by the Bureau of Mines; and the filter unit must be marked with the approval number and with the type or kind of atmospheric particulate matter for which it is approved.

The mechanical filter respirator and replacement filter units must be provided with substantial and durable containers. Copies of the approval labels issued to the manufacturer by the Bureau of Mines must be attached to these containers. The approval label gives the approval number, shows to whom the approval is issued, states what the device is and is not approved for, and cautions the wearer to follow the manufacturer's instructions for the use and care of the device.

The following is a sample of the required instructions furnished by the manufacturer. These instructions are similar for all of the approved mechanical filter respirators.

Instructions for Use of Mechanical Filter Respirator

1. Respirators will not protect unless placed on the face properly each time they are worn. Carelessness in face-fit means dangerous leakage. In general, a better fit is obtained if the mask is worn not too tight on the nose.
2. To fit the respirator to the face hold the respirator, exhaust valve pointing downward, by the metal screw connection with either hand, and hold the headstrap with the other hand. Place the facepiece against the face and hold it in place while pulling the headstrap over the head and below the ears. Then adjust the facepiece until a firm snug fit is obtained. The headstrap may be adjusted while the respirator is in place by holding the metal slide between the thumb and forefinger of one hand and pulling on the proper strap with the other hand.
3. To instruct the wearer in the proper adjustment of the headstraps and position of the respirator on the face a cardboard disc is enclosed. To use this disc unscrew the filter bag, place the disc against the felt washer in the metal connection on the felt bag, assemble the respirator, and put it on. The wearer should not be able to breathe through the respirator or feel any inward leakage of air under the edges of the facepiece.
4. The presence or absence of dust streaks on the face inside the line of fit of the facepiece after wearing the respirator in a dusty atmosphere can also be used to tell whether a proper fit was obtained.
5. The recommended procedure for cleaning the filter bag is to invert loosely the mouth of a high-pressure air hose into the bag opening and to blow several

TABLE 1. DETAILS OF FILTERING EFFICACY TESTS AND LIST OF APPROVED MECHANICAL FILTER-TYPE RESPIRATORS

Kind of mechanical filter-type respirator	Industrially generated atmospheric particulate matter against which the device is designed to furnish protection	Test suspensions used	Description of test suspension	Volume of test suspension pulled through the device, cubic meters	Maximum amount of particulate matter permitted to pass through the device	Name and manufacturer of mechanical filter-type respirator approved to date, September 25, 1934
Type A	Mechanically generated dusts resulting principally from the disintegration of a solid, such as the dusts of lead, zinc, iron, and copper, produced in mining, quarrying and tunneling, and the industrial operations of grinding, crushing, and processing of minerals	Air-suspended ground flint, which consists of 99+ percent free silica (SiO ₂). Over 99+ percent of the dust passes through a No. 10 mesh standard sieve	2.00	4 mg. for any 1 of 3 devices, or an average of 3 mg. for each of the 3 devices	1.0 ^a	M. S. A. Condo Respirator, Approval No. 2101, issued to Mine Safety Appliances Co.
Type B	Fumes of various metals (usually their chemical compounds, as oxides or carbonates) such as lead, mercury (except mercuric vapor), manganese, copper, chromium, cadmium, zinc, magnesium, aluminum, antimony, and arsenic resulting from volatilization or combustion of their vapor, or from chemical reactions between their vapor and gases.	(a) Lead oxide fume produced by the composition and combustion of tetraethyl lead (b) Magnesium oxide fume, freshly produced by burning magnesium ribbon (c) Chromic acid mist produced by dissolving an aqueous solution (20 percent) of chromic acid in water	2.00	1.5	0.15	M. S. A. Condo Respirator, Approval No. 2101, issued to Mine Safety Appliances Co.
Type C	Mist produced by spraying a 2 percent aqueous suspension of ground flint, which is dusted (99+ percent through 25 mesh sieve) with 1 percent free silica (SiO ₂) and 1 percent free lime (CaO). The mixture is used in making negative plates for storage batteries. Contains 7 percent lithium carbonate, 25 percent red lead, and 3 percent lampblack	(a) Lead paint mist produced by spraying a paint having the following composition: white lead (paste having approx. 91 percent white lead and 9 percent linseed oil by weight), 10 percent linseed oil, 50 cubic centimeters; and steam-distilled turpentine, 50 cubic centimeters (b) Lead paint mist produced by spraying a paint having the following composition: white lead (paste having approx. 91 percent white lead and 9 percent linseed oil by weight), 10 percent linseed oil, 50 cubic centimeters; and steam-distilled turpentine, 50 cubic centimeters (c) Mist produced by spraying a 2 percent aqueous suspension of ground flint, which is dusted (99+ percent through 25 mesh sieve) with 1 percent free silica (SiO ₂) and 1 percent free lime (CaO). The mixture is used in making negative plates for storage batteries. Contains 7 percent lithium carbonate, 25 percent red lead, and 3 percent lampblack	2.00	1.5	0.15	M. S. A. Condo Respirator, Approval No. 2101, issued to Mine Safety Appliances Co.
Mechanically generated dusts	Mechanically generated dusts whose main hazardous constituent is lead, such as lead dusts generated in manufacturing storage batteries, enameling, pottery making, rubber compounding, sandpapering and chip-putting, painting, soldering, and mining, including the processing of lead ores	(a) Lead dust (b) Lead dust (c) Lead dust	2.00	1.5	0.15	M. S. A. Condo Respirator, Approval No. 2101, issued to Mine Safety Appliances Co.

^a 100 milligrams = 0.0001 gram

^b 1 cubic meter = 35.315 cubic feet

^c Weight of sample = 1/2 liter (11.3 cubic feet) per minute.

^d The milligram is the unit of weight used in this method as described by the U. S. Public Health Service. Hence, 1 milligram per cubic meter of dust is approximately equivalent to 8.3 milligrams of particles per cubic foot.

^e See "Notes" listing of company for complete address.

short blasts of air into the bag. This procedure removes from the bag dust and grit which clogs the pores of the filter and makes breathing difficult. The proper time for cleaning the bag is when the wearer experiences discomfort in breathing. When compressed air is not available some dust may be removed by tapping the bag lightly and brushing the outside of the bag.

5. To prevent irritation of the skin and for general sanitary purposes the respirator should be cleaned after each day's use. The rubber and metal parts may be cleaned with soap and water, and for general sterilization they may be dipped in a 3 per cent solution of carbolic acid, a 2 per cent solution of lysol, or a 70 per cent solution of denatured alcohol, then rinsed with water, assembled, and hung up by the loop in the felt bag to dry. The filter bag and headstrap always must be removed before the respirator is washed or sterilized.

6. While not in use the respirator should be kept in a dust-free place, preferably in the original container.

The manufacturer is required to maintain the quality of his product and to see that each mechanical filter respirator in all its parts is constructed according to the drawings or records that have been accepted by the Bureau for this device and that are in the Bureau's files. Mechanical filter respirators that exhibit changes in design or include any parts that have not been approved are not permissible respirators and must not bear the Bureau's approval label. Schedule 21 provides for the manufacturer to apply for an extension of approval on any change in the mechanical filter respirator which does not affect the filtering characteristics of the filter.

Changes in the filter require the application for a new approval. The Bureau obtains information on the maintenance of design and quality of approved mechanical filter respirators by testing samples of the devices obtained on the open market. The Bureau reserves the right to rescind for cause any approval issued.

A Safety Style Show

By E. J. SMITH

Safety and Health Director, Western Electric Company Hawthorne Works,
Chicago

For the purpose of assisting our foremen in the selection of the proper safety equipment we have standard specifications and every foreman has a copy. In it he will find the protective equipment required for every class of work.

Molders, cupola tenders, furnace tenders and helpers in foundry and forge are equipped with heavy duty metal or composition cap goggles with hardened lenses. The lenses in the furnace tender's goggles are of a forge and furnace shade. Electric furnace tenders, however, wear a welder's goggle, described later. When a goggle is equipped with clear lenses, it is used for such operations as breaking defective castings, cleaning castings with compressed air, grinding castings to remove gates or fins, pounding on castings to remove sand cores, pouring molten metal into molds with hand or bull ladles, removing gates or fins from castings with air chisels or hand chisels and hammers, and working in vicinity of chipping hammers.

Leggings are of the non-facings, non-buckling and snap buttoning type held in place by hidden steel springs similar to the old bicycle pants guard. They will come off instantly from a tug at any point. There are no gadgets to confuse you or those who are trying to help you in an emergency. Just one simple thing to remember—grab anywhere and pull.

Men wear safety hats when chipping slag out of cupolas. Our construction crews of masons, carpenters, millwrights, and so on, wear them whenever they are engaged in work where there is the slightest chance of objects falling from overhead. Our employees wear "Congress" safety shoes for their protection in addition to the leggings.

We use a leather steel faced glove when charging a cupola or handling pig iron. Full leather palm gloves with band top are used in chipping casting fins, loading and unloading tumbling barrels, and removing castings from sand.

For the protection of healthy workers in the brass foundry are provided with overalls—undergarments with full length sleeves. This is in accordance with Illinois

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labor laws. At the termination of a shift molders take shower baths on company time. Workers in this classification are provided with two buckets, one for working clothes and the other for street clothes.

For protection against solid non-volatile particles suspended in air men cleaning inside of a cupola are provided with respirators.

Incidentally, our supervisors make periodic inspection of respirators and other safety equipment to insure that they have not become worn, damaged, or deteriorated to such an extent that they no longer provide adequate protection. Special precautions are also taken to see that cracked, broken, or pitted lenses in goggles are not used, leggings are not worn threadbare nor with torn places so as to permit molten metal to get into the upper portion of the shoe and Congress shoe soles are not worn though, nor upper torn outside the area covered by leggings.

Employees operating watchtanking machines are required to wear goggles, when, in the opinion of the supervisor there is the slightest eye hazard present. Goggles are mandatory on all tool grinding operations.

The hands of all employees handling rough lumber on machines such as swing saws, rip saws, molders, automatic and glue jointers are protected against cuts, scratches, and splinters with leather-palm canvas gloves.

Those engaged in shellac dipping operations are supplied with rubber gloves. The fingers of employees gluing wooden parts are protected with finger cuts.

The personal clothing of employees dipping parts in shellac or spraying parts is protected with overalls.

In the manufacture of rubber and in other operations our supervisors instruct employees in the proper manner in which equipment is to be worn to insure the greatest possible protection.

When mixing rubber compound, sifting or handling sulphur or powdered shellac, cleaning dust collectors, sacking powdered rubber, breaking rubber scrap, blowing cupstone and sandblasting rubber parts, our employees wear heavy duty cup type goggles. They protect against large heavy particles, severe impacts and high dust concentrations.

When handling india-rubber yellow or vermilion, or cleaning brass equipment in acid dip tank our men wear light acid gloves.

Gauntlet gloves are worn when mixing shellac or rubber compounds containing poisonous substances on milling rolls. They are also used in handling hot molds subsequent to vulcanizing operations.

The type of respirator, named before, is also worn when mixing rubber compound containing a high percentage of hard rubber powder, handling sulphur, sifting powdered shellac and in the performance of other work, where harmful kinds of dust and material are encountered.

A special goggle is used to protect against sprayed or splashed corrosive solutions and irritating liquids.

Undergarments and overalls are also furnished for platers and acid dippers. Protective clothing is laundered weekly.

Rubber gauntlet gloves are worn by those engaged in all plating and dipping operations.

Wooden soled shoes are well known in plating circles. The kind we use, however, are equipped with safety toe caps.

Rubber aprons are worn whenever acid is changed or tanks are cleaned. All are welding at Hawthorne is performed inside special enclosures. Welders, helpers, and others in the welding booth are provided with eye and face protection and safety clothing which, with their personal apparel, affords complete protection from the heat and the rays of the arc.

Protective goggles are worn under the helmet. They protect the eyes against galvanutritional flash which sometimes occurs while men are arranging their work with the helmet in the tip or overhead position.

The arms, hands, body, and feet of welders are protected with such clothing as tanned leather gloves, tanned leather sleeves, chrome leather aprons, chrome tanned leather leggings, jumpers.

Periodic inspection is made of this equipment too. Special precautions are taken which make to insure that they do not look light, cover glasses are not broken or cracked, colored lenses are protected by cover glasses, cover glasses are replaced