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HOW do you get 100 per cent of your employees to wear safety shoes when even with a steady program of safety education they have averaged close to only 50 per cent over the years?

Joliet Parts Department of Caterpillar Tractor Co., Joliet, Ill., showed the way in an intensive one-month foot-safety campaign in June 1963. With teamwork and enthusiasm, the 315 warehouse employees zoomed their average in one month from 54 to 100 per cent coverage.

It didn't just happen. Behind that one month's effort was serious planning that resulted in a program jointly prepared and carried out by management and employees.

Plans actually began to crystallize last January when Parts Stores Manager Bob Shoopman reviewed safety records. Severity and frequency had been at all-time lows during the previous year. But what concerned him was a bill for $91 for one foot injury. He was sure the injury could have been prevented by safety shoes. It meant not only a cost of operation, but more than that, a degree of human suffering and inconvenience. Why didn't employees take advantage of safety shoes when they were conveniently available at cost through the safety store near the cafeteria?

Shoopman asked foremen to survey their men for reasons they didn't wear safety shoes. Answers were typical: "Safety shoes hurt my feet." "Safety shoes are too clumsy." "I can't afford them." "I don't need them on my job."

All were honest problems to the men, Shoopman realized, and the next step was to solve them. How could they do this effectively so all employees would benefit?

The Parts Department Safety Committee of key management and union men agreed that an intensive foot safety education program might be a solution. The idea clicked so well the union representatives asked that their Parts shop stewards also hear about it. Out of the meeting came the specific plan to point up June as "Foot Protection Month."

The planners also agreed that they should be ready with answers for all foreseeable objections to wearing safety shoes. There should be awards for outstanding participation by individuals and groups.

Parts Department Manager Bill Oedewaldt announced the campaign in a letter sent to all employees' homes May 22. The *Bulldozer*, the Joliet Caterpillar Plant and Parts Department newspaper, gave the drive a full editorial send-off. Union leaders urged support of the month.

While the planners may have had an ultimate 100 per cent goal in mind, they aimed initially at informing every employee in as many ways as possible about the value of foot protection. They hoped to make each employee aware of dangers to his feet in an operation in which employees handle thousands of heavy parts every working day. This is how the careful planning paid off:

To prove that safety shoes aren't hard to fit, they brought in a representative from the shoe vendor to spend one full day the first week specially fitting all problem cases. And there were some very real problems: One employee needed a size 10½ for one foot and a size 12 for the other. This required a specially-built split pair.

They answered complaints that safety shoes were awkward, clumsy, and unattractive by setting up a display of all types of safety shoes — including pairs indistinguishable from the best dress shoe. They moved the display to a table employees passed every day going to and from lunch.

They answered the "too expensive" charge by pointing out that shoes average only $9.85 a pair and can be bought on a regular schedule of payroll deductions. They also pointed out that a pair of oxford-type shoes can be worn off as well as on the job. The idea jelled. One employee even wore his safety shoes to church. "I need them for all the people passing in and out of the pews all the time," he quipped. "They're good looking enough to wear anywhere."

There was competition among the 10 warehouse foremen's groups. Each group gave itself a nickname such as the Chubby Checkers, Nite Owls, Toe Savers, or Woodchucks. On a 42- by 36-inch bulletin board set up in the cafeteria, each team was listed on a blue silhouette safety shoe that was moved daily toward the 100 per cent mark as its participation increased.

As incentives, the company offered a handsome quality ballpoint pen to each man on every team that reached 100 per cent. In addition, safety seat belts, installed, were the weekly "award of recognition." The winner's name was drawn from

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Parts department foreman Lloyd Toekington asks assembler Ross Earnest why he objects to wearing safety shoes. Earnest was one of the 50 per cent who had to be sold during the month-long promotion

← CL 62 A

Photo at left shows re-enactment of the $91 injury that set management wondering about foot protection. The upright of a fork from a fork-lift truck fell on worker's toes.

EM 71 Part of incentive program in month long push toward 100 per cent foot protection was weekly drawing for winner of seat belts, conditional on the winner's wearing safety shoes. Bill Oederwaldt, parts department manager, holds box for Elmer Moore, president, Lodge 851, District 55, International Association of Machinists, AFL. Looking on are Union and safety representatives.

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Darrell Standley, first winner of seat belts, displays them to Eddie Elmore, safety investigator, and Bob Shoopman, parts stores manager. All the weekly winners were wearing safety shoes when their names were drawn, and claimed the prize. Other incentives included ballpoint pens for men on teams that reached 100 per cent, and Golden Shoe Club awards consisting of a special certificate and gold lapel pin.

a box containing the names of all warehouse employees. The only stipulation to claiming the prize was that the winner must be wearing safety shoes when his name was drawn. (All four winners were.)

With the cooperation of the American Society of Safety Engineers and the safety shoe vendor, the Parts Department set up Golden Shoe Club awards. Every man whose feet were saved by safety shoe protection was honored by a special certificate, a gold lapel pin, and his name inscribed on a gold plaque.

Every team area set up its daily score of participation. Each foreman's desk carried an 8½- by 11-inch National Safety Council foot safety poster. Department bulletin boards displayed a weekly foot safety message from the department's safety mascot. At the main employees' entrance, the big safety signboard read: "Foot Protection Month — Let's All Make It a Success."

On the third of June — the month's first working day — all employees saw a foot safety film. As they returned to their areas they received literature on foot safety, and a free pair of shoestrings "for their safety shoes" from the shoe vendor.

It wasn't long until the competitive spirit began to get participation moving in earnest. "I wanted my team to be first," said Chief Steward Don Williams. "I even got permission to borrow the safety shoe catalog to show fellow employees how good looking safety shoes are."

"The employee enthusiasm from the start was the most encouraging sign to us," said Parts Manager Oedewaldt. "We had realized this was going to make or break our campaign."

Teams vied for the honor of reaching 100 per cent first. Don Williams *did* bring his Processors — 28 men — in first. As pressures within each group increased, others followed suit. Even the Toe Savers, who had started out at 30 per cent (lowest among the teams), moved into the 100 per cent spotlight by the third week. By the start of the final week, 315 men were wearing safety shoes and sporting a handsome ballpoint pen that acknowledged their part in success of the one-month drive.

Enthusiasm by the fourth week had reached its peak. The spirit was so contagious that the office-based planning group that regularly works in the warehouse area had also signed up 100 per cent. Even employees from other divisions of the plant coming to and from the warehouse joined the parade of "safety-shoed" marchers.

The management group knew enthusiasm could wane if the campaign suddenly stopped June 30. In addition to continuing the program of Golden Shoe awards, they decided to keep the team standings posted every week in the cafeteria to extend the spirit of competition among the teams. They agreed to keep talking foot safety at every opportunity.

Parts Stores Manager Bob Shoopman viewed the record as a constantly moving target to keep hitting every month.

What effect did the campaign have on employees? Listen to reactions a month later:

Chief Steward Don Williams: "It was the best safety idea I've ever seen put into practice. Every man participated. I think our people are impressed with our record and are keeping it up."

Material handler Jim Wisdom: "I lost the nerves in my foot from a foot accident; I was sold on safety shoes before and I'll keep trying to sell other employees on them."

Tom Berrong (whose power truck ran over the toes of one of the Golden Shoe award winners): "I think our people now are well aware of the need to wear safety shoes all the time on the job — not just for one month to set a record."

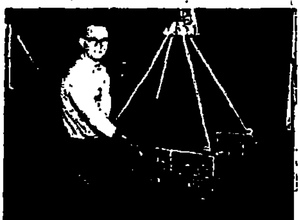
Foreman Clyde Chenoweth, a 33-year employee, said: "I don't think the enthusiasm has died down a bit. After all, the men themselves convinced each other of the need, and everybody's been wearing them since the campaign closed."

Since employees went on vacation the first two weeks in July, Parts Manager Oedewaldt sent them the traditional letter of "best wishes." This time it expressed his appreciation for their excellent safety record on the job and the hope they would return safely to the job too. Enclosed was a brochure on vacation safety hints.

Employee Relations Manager Gerald Plank, of Joliet Plant, who had admitted doubts about the effectiveness of "gimmicks" to stimulate participation in such a campaign, quickly acknowledged the worth of the one-month drive with this observation:

"The spirit of success for any effort has to originate within the employee group itself. Enthusiasm is contagious and must be started by the top man and carried down through the organization. It must, therefore, originate within the group. By knowing their own people and carefully planning in advance, Parts Department, through its safety committee, proved it could gain their wholehearted support."

One hundred per cent foot protection means including the man at the top. Here Parts Department Manager Oedewaldt is fitted for his pair of hard-toed shoes.



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I think our people now are well aware of the need to wear safety shoes all the time on the job — not just for one month to set a record — Power Trucker Tom Berrong tion up to one-half to three-quarter mile radius. It seems likely that this will be modified as data accumulates.

The medical control of beryllium poisoning involves careful pre-placement examination so that no worker who has had previous chest disease or unusual x-ray findings would be placed in a job involving beryllium exposure. From what I've said obviously anyone with previous beryllium disease would not be allowed near operations involving further exposure. We have learned that loss of weight is one of the early symptoms of beryllium effect, so in plants that must use beryllium the workers are weighed at regular intervals such as once a month. At this time the physician or nurse who sees the worker can decide whether or not weight loss if it is present is important or related to the worker's job.

Chest x-rays are taken if weight loss is persistent and in all cases at least once and in some instances twice a year as a kind of check up. I think it is a mistake to be over-anxious about medical scrutiny of these workers on the one hand, but on the other hand I think steady, conscientious observation of the workers' general health correlated with what is known of the character of their exposure can be very reassuring and doubtless will result in the disappearance of cases, certainly of chronic beryllium poisoning and one can hope as operations are made safe, acute beryllium poisoning.

I would like to close with a kind of teaching warning to this group asking that you be careful to interpret correctly what is now appearing in the literature in regard to illness following beryllium exposure. For a long period of time nothing appeared in print while illness was being experienced in industry, but now we have a great flood of literature and for the most part it is conscientious and helpful. However, for various reasons that are complicated, from time to time there appear articles suggesting that this great discussion of beryllium toxicity is without foundation. Unfortunately, this sometimes seems to be related to the interest of the author and for those of us who are professionally interested in the prevention of illness in industry the reading of this material must be undertaken with critical judgment. I am sure you agree with me that there isn't any hazard in all of industry that can't be met if one is willing to make the effort and so it is not necessary to whitewash beryllium, to use a catch expression, but it is necessary to accept its toxic possibilities and take the necessary engineering and medical steps to anticipate possible ill effects.

Safety in Maintenance

By F. C. GEDGE
Plant Engineer, Caterpillar Tractor Co., Peoria, Ill.

All men at work in industry are subject to the common hazards of industry in general and to the specific hazards of their particular surroundings. So here are the principal factors in the pursuit of safety:

1st.—A careful man.
2nd.—Sincere and competent supervision.
3rd.—A decent work place.
4th.—A voice in the program.
5th.—Proper tools.

And what are the A-B-C's of safety? Always be careful. Regardless of all other factors this is the essence. The man himself is more than half the total of the sum that equals safety. He must be healthy, both physically and mentally. After his application for work is recorded through a statistical report and before induction to the plant, the first procedure is physical examination. Minor defects should be corrected. Vision checked and if prescription safety glasses are required, a fair part of the expense borne by the employer. The doctor must be sincerely helpful — not a critic. Adaptability tests and interview to determine mental aptitude and attitude are equally essential. It pays to spend two days in a proper study prior to putting the new man to work. This on the company time—not at the man's expense. If then he is healthy, and if he fits the needs of an open job, then take the time to conduct him through the plant.

Let him see what makes the wheels go round: what you produce and with what kind of men. Tell why you have a right to a market and how you hope to continue to supply that market. With this done then take him to the supervisor with whom he is to work. That supervisor, of course, he has already met in the preliminary interview with the personnel manager at the time he applied for employment. This supervisor will show him where he is to work. Introduce him to the men he will be in immediate contact with while at work, show him where the tools are kept and how to get them, where his locker, toilet, washrooms and cafeterias are located, and do all this with friendliness and without haste and in a manner that does not confuse.

Again, this is the essence. Do you expect a man to be careful if you, the employer, are not careful in his selection and considerate of him during this, the most critical and difficult time of his employment? Say you'll grant this. Now he is at work.

Be sure he is placed with a journeyman (since here we are dealing with maintenance trades work) who is an extrovert, a salesman. Salesmen know their way around and they like people. He will sell. Sell the plant, the supervision and the job. Sell the new man the job and you sell safety. Safety is sold by practice, not by books.

The supervisor is the management as far as the workman is concerned. He must know this himself or there is no sale in the long run. He must spend his time supervising—not doing the work, writing papers or attending meetings. These two latter items are necessary evils. If a check indicates the supervisor is spending more than 25 per cent of his time at them, do not expect good supervision or full practice of safety by the men. If each supervisor has not time to talk with each of his men at least twice every day he cannot control the work nor guide in the observance of safety. And while you are looking over this angle take an overall look at your theory of supervision in maintenance.

Industrial plant maintenance is an outgrowth of construction trade labor. As the American industrial system grew we saw a rapid expansion from the small, individually owned, built and operated factory to the larger complex mass production type of industry. Instead of the handy man type of maintenance we introduced the tradesmen—carpenters, pipefitters, millwrights, sheet-metal workers, electricians, etc.

Each tended his last and the best man usually advanced in the ranks till he became supervisor of that trades work. The country and industry grew rapidly. With it, if the business served legitimately, the plant expanded. As more space was covered, the more machines and men were put to work. Likewise the maintenance requirements increased. Has yours increased to the point where the maintenance trade foreman spends too much time running from job to job rather than running the job? If so—can you expect real safety?

Should this be the case, consider revamping your system to that of area control rather than trades control by trades foremen over the whole plant. One maintenance supervisor should better be responsible for all work and maintenance workmen in a suitable sized area rather than a trades foreman be responsible for all trade work over an entire plant. The area supervisor should be officed in his area within close reach of the production management of that area. He still should report to a maintenance engineer in charge of maintenance of the entire plant and he should draw his men from a common group under control of a maintenance shop superintendent, who in turn also reports to the maintenance engineer. Such a method of area control reduces the maintenance supervisor's leg work, lets him be with his men and their work almost constantly and takes big out of big business. The trades knowledge had better be placed in the maintenance shop foremen and thus permit the area supervisor the time to concentrate on his ability to get along with people and in turn by close association with the area work to get the men along with the work. He is thus the only boss in that area as far as maintenance is concerned and is in a perfect position to get done what needs to be done at a proper time and so avoid delays and duplication of supervision which so often occurs where responsibility is split.

With sole responsibility for the maintenance of a definite area the supervisor, since he sees all of that area every day, can then give proper attention to the physical conditions of the property and hence develop a decent work place. This is important to

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safety. If the shop is clean, the roof is tight, the lights are sufficient, the wiring and piping are standard, the machine areas and floors are clean and smooth and there is clean air to breathe, then the setting for needless accidents is automatically removed. Certainly the figures prove cleanliness breeds good safety records.

A further benefit to be obtained by area supervision, important to safety, is that by daily familiarity with the physical premises and full knowledge of job progress in each case, the area supervisor is in the best position possible to protect his men from location and process materials and practice hazards. He knows what dangerous chemicals are used, if any; what power is present and where; which are steam, water, gas, oil or air lines and where to shut them off. He knows where cranes are installed and what they lift and countless other details only to be known by constant daily association with his area.

Knowing these things automatically places the area supervisor in a competent position when inviting the full cooperation of all maintenance workmen in the safety program. Bet your bottom dollar if your program is not based on the participation of the men in the forming and constant revision of the practice of safety, your frequency rate not your profits are due for an increase.

Safety is taught by practice, not by books. The practice is formed by the men performing work properly. Who then but the men can be the promulgators of methods. The supervisor is the interpreter, he asks the man what is required to make this job safe. He can aid the man by pointing out what made the last job safe, but this is only an aid—a reference to precedent. The man must tell the supervisor what he thinks the job requirements are and then they can work it out together, beforehand. The Army Air Force did a good job a few years ago by the use of this method in their practice of "briefing the crews" in the ready room before each flight. We in industry should do likewise.

It takes but a few minutes to discuss the job, on the site, before the start of work. For instance, how do you enter gas filled rooms? Who supervises unloading of tank cars of L. P. gas, acids, etc. Who supervises electrical construction projects and if only one person is so qualified, what do you expect to happen if *he* gets hurt? This is the time also when the matter of proper tools should be considered. The use of proper tools is definitely a part of a well rounded safety program. However, the years have taught—even with the best tools, the safest tools and best possible tool maintenance in the world—that frequency rates will still climb unless the man who uses them, the supervisor who guides him and the plant in which he works all form a combination in which safety thinking can dwell in safety.

Industrial safety found a beginning in the early 1900's, here in the central west. The original effort was directed towards elimination of mechanical accident hazards and hand tool accidents. The effect on frequency rates was a bitter disappointment and the hullabaloo that accompanied these campaigns backfired, with the resultant creation of the cynical attitude on the part of the worker, which lives even today in many industries and amongst some labor organizations. However, though least important of the principal factors in safety, tools must be kept safe. Those bearing the closest scrutiny are:

(1) Personal Tools. It is common practice for each maintenance worker to provide the small tools used in his trade. Screw drivers, hammers, pliers, chisels, adjustable wrenches, etc., are usually purchased by the employee as he finds need for them. A periodic inspection by a member of the safety committee in the course of a day's work is usually sufficient to remind the owner when repairs or replacements are in order.

(2) Special tools of the larger more seldom used variety such as sledges, moil points, jacks, large pipe and machine wrenches are usually company owned and made available by the tool crib. Their proper maintenance is a function of the crib tool dresser. These tools should be issued on tool checks only; hence their periodic return to crib at completion of that job affords opportunity for ample periodic inspection and repairs.

(3) Ladders are dangerous tools. It is amazing to find in culling over the old records how many accidents involve this most generally used tool. Maintenance of ladders is a subject often under dispute. Actually the proper procedure must be patterned to suit your own shop conditions.

It is our practice to place ladder orders through carpenter shop supervision. Upon receipt, they inspect for quality, particularly as to density, grain conditions and tightness of assembly. The rails are then primed and painted. Each trades department has its own number and their particular ladders receive a specific color paint identifying them as belonging to millwright, electrician or other trade department as the case may be. This prevents general usage by all trades and helps to place responsibility for proper keys and usage with a particular group.

At the end of a job all ladders are returned to the shop storage rack and there inspected by the shop man responsible for their upkeep. The workman using a ladder is instructed in safe ladder practice while still an apprentice. He is taught the allowable angles, how to seat the pads or spikes, how to mount, and how not to over-reach and how to carry. It is amazing how much the men can teach you about ladders. Try using this subject in a safety committee meeting, assuming your workmen have full representation.

The use of signs and guards in and around areas under construction or repair is another practice that warrants study and checks. I am reminded of an accident in which the workman, engaged in floor block repairs placed a sign ahead of the job that read "danger, workman above." The tractor driver approaching saw the sign, looked above and seeing no one detoured the sign and struck the worker on the floor ahead of him. Another pitiful case. A sign on a door lintel of a door opening onto a plant highway—"watch out for trucks." A foreman of 30 years' experience, saw a truck approaching from the north, stepped into the roadway with his eyes on that approaching truck, directly into the path of a second truck approaching from the south.

These accidents are typical, not of the fact that signs are bad, but that we often misread their meaning or in some cases misuse them. The tendency has been toward the use of too many signs and warning signals. A review is often interesting in what it will divulge. Have you seen the color red used to *identify fire protection* equipment, water pails for instance, and in the same locality bright red cans marked gasoline?

These few statements of practices and incidents are but a small cross-section of our own particular plant and practices. They have but this one thing in common with the practices in all industry. They teach that true safety depends not on one or a dozen factors. Rather to go back to the beginning of this subject, a careful man, properly supervised in a factory that is clean and bright, with a voice in the program that means safety to all, and given the proper tools with which to work, all this is the sum of maintenance in safety.

Foundry Hygiene

By JAMES F. MORGAN
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Although recognition of the fact that there is a silicosis hazard problem in foundries came many years ago, there is a continuing need for more precise means of evaluating the hazard. Throughout the years, dustiness in the foundry has undergone a steady reduction, chiefly by eliminating the most obvious sources.

Replacement of natural stone wheels with artificial non-silica abrasive grinding wheels, changes in sandblast techniques, widespread substitution of non-silica parting compound for tripoli and mechanization with built-in exhaust systems have all contributed greatly to a reduction of the hazard. Nevertheless, the fact that silica sand remains as one of the basic materials of foundry operation demands that the inherent hazard be recognized, understood, and controlled.

The complexity of the problem of evaluation of a silicosis hazard in foundries can be illustrated by a comparison with that in granite cutting. In the latter case, the manufacturing process is essentially dust producing, in which the parent material, stone, is violently broken down into dust of approximately the same composition; the foundry processes are in most cases dust-dispersing as in sand cutting and molding, rather than dust producing as in sand-chipping: in addition, foundries have the combination of the two in sand-blasting. The result is that *in the foundry* the aire-borne dust shows great variation in composition related to particle size from place to place.

This complexity and variation in foundry dustiness is reflected in the results of silicosis case-finding surveys in foundries. The 1938 New York state study disclosed silicosis in 2.7 per cent of 4,000 workers examined, with wide variation in the incidence between different occupational categories within a foundry. North Carolina, in the same year, discovered silicosis in 1.3 per cent of 680 workers examined; total dust pathology amounted to 9.7 per cent of employees. This study also disclosed some surprising differences in the rates for different occupational groups. Sander, in Milwaukee, in 1939, found silicosis in 5.8 per cent of 8,377 workers examined. Variation between occupations in his study ranged from 28 per cent incidence among sand chippers and grinders down to 0.1 per cent in coremakers.

There are several obvious reasons for attempting to evaluate the silicosis hazard for each occupation in the foundry. The physician needs an adequate description of the dust hazard in order to diagnose illness and assist in proper placement of workers; management needs evaluation in order to plan and design control measures at the necessary places; in routine operation, maintenance and utilization of control measures have to be judged by effectiveness in controlling the hazard.

Four factors have come to be recognized as influencing the significance of a dust exposure.

1. The concentration of dust in the air in the working environment.
2. Duration of the exposure.
3. The chemical composition of the dust.
4. Its effective particle size.

1. The concentration of dust in the air—The determination of the concentration of dust in the air by means of the dust count is such a familiar procedure that it hardly need be mentioned here except in its relation to the other three factors. It is a valuable first step in the appraisal of a dust hazard. By means of it we obtain an index of dustiness of a given environment at the different steps in a process cycle. On infrequent occasions, the dust alone can be made the basis for a recommendation that dust control be installed. Such instances are those where a massive concentration over an extended period of time creates an undesirable situation regardless of dust composition. Most often, the dust counts are useful in comparing lesser exposures with data for similar dust in other situations wherein the health hazard has been adequately defined. In order to permit such comparisons, even though the values obtained are not absolute, but arbitrary—*depending for their magnitude* on the manner of collection and method of counting—the technique has been standardized.

The standard procedure of counting attempts to hold variation of particle size as a constant by defining the limits of the sizes which shall be included in the count. This succeeds only partially because particle size distribution curves vary with different types of dust.

In making the most common use of data from dust counts, the comparison with other exposures having known effects on health, we must assure ourselves that we are making a valid comparison by investigating the composition of the dust.

2. Duration of exposure—The influence of exposure time on the evaluation of a silicosis hazard refers to the actual time per day spent in the dusty environment, or conversely, how much time per day the dusty phase of a given job lasts. Study of the actual operations and surrounding operations for each foundry job is necessary to clarify this part of the total evaluation.

3. Composition of dust—The necessity for determining the amount of free silica in various size fractions of air-borne dust, in order to evaluate the foundry silicosis hazard, was pointed out by Hatch and Moke, in 1936. They showed the error of applying the quartz content of a settled rafter sample or the bulk material from which the dust was derived to an evaluation of a silica hazard.

Unused molding sand contained 85 per

cent quartz in the fraction consisting of particles greater than 10 microns, 27 per cent in the 5 to 10 micron fraction, 19 per cent in the 2 to 5 micron fraction, and 18 per cent in the fraction consisting of less than 2 micron particles.

Compare this with an analysis of air-borne dust from the breathing zone of molders in the same foundry: 54, 36, 20, and 12 per cent quartz for the comparable size fractions.

The explanation for this variation in quartz content with particle size is that sand-conditioning and molding are not dust-producing jobs, but rather dust-dispersing jobs. The molding sand consists of large particles of quartz sand surrounded with clay of very fine particle size plus possibly coal and oil. Analysis of the gross sample shows this high free-silica content. However, when dispersed in air, the coarser quartz particles settled more rapidly, leaving the air-borne dust relatively more rich in the fine clay and combustible matter.

Air-borne dust in the vicinty of shakeout operation shows a similar decrease in quartz content with decreasing particle size. So do the other important dust sources: mechanical cleaning of castings, sand chipping, sand-blast, and the general foundry air.

This study revealed that the true dust producing operations of sand-chipping and sand-blasting in which particles of quartz are actually broken down into finer particles resulted in a high quartz content in the finer fractions of air-borne dust. More than 30 per cent free silica was found in the less than two micron fraction of each.

Comparisons of the incidence of silicosis among the foundry occupations tend to reflect the relatively greater hazard of sand-chipping revealed by these data. Unprotected sand-blast is more rarely encountered and has not been included in the tabulations to a sufficient extent.

Data from Industrial Hygiene Foundation analyses of foundry dusts show average free silica content of total air-borne dust of shake-out, core room, and molding, to amount to 29, 17, and 16 per cent by weight respectively. The less than five micron fractions of the same dusts showed 8, 10, and 4 per cent.

Recently acquired data in a Foundation study of eight foundries making a particular type of light iron casting showed that air-borne dust around molding operations consisted of 5 to 15 per cent quartz in less than 5 micron fraction and 2 to 6 times as much in the fraction greater than 5 microns. Analysis of the less than 5 micron fractions of the mold sand itself showed 10 to 30 per cent quartz. The recent study of Illinois foundries by U.S.P.H.S. showed an average of 75 per cent free silica in the total mold sand.

The Industrial Hygiene Foundation now makes it a routine practice to separate dust samples into two size fractions at the 5 micron level, before determining free silica by x-ray diffraction.

This placing of emphasis on the necessity for making separations into several size fractions before analysis to help determine the existence of a silicosis hazard is, of course, based on the evidence that the larger particles do not enter the depths of the lungs and do not contribute to lung pathology.

There is another reason. Hamlin has related that experiences over a number of years with foundry grinders and burners showed that diffuse nodular shadows occur in roentgenograms of the chest. These are shown on autopsy to be caused by deposits of finely divided iron oxide. The condition is apparently non-disabling, non-progressive, and does not enhance the progression of superimposed infection, yet, it can be mistakenly diagnosed as silicosis. In order to make a diagnosis, a physician will want to be supplied all the pertinent facts concerning a man's working environment and history. He cannot depend on roentgenology alone. If the fine fraction of the dust to which a man has been exposed over a number of years is rich in iron oxide and lean in free silica, that is a pertinent fact that should be supplied the physician.

In a 1947 paper, Holden, Hemeon, and Hyatt, of Industrial Hygiene Foundation, describe a technique for collecting air-borne dust in amounts sufficient for analysis, and a method for the routine separation by sedimentation into two fractions at the 5 micron level.

4. Influence of particle size — In enumerating the factors that influence the significance of a dust exposure, effective particle size was mentioned. This is probably the most complex and least understood fac-

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tor on the list. For its consideration, let us put aside for a minute what has just been said about variation of composition of a dust with variation of particle size and think of a dust of uniform composition. A certain amount of this dust will consist of particles too large to get very far into the respiratory system of a man before it is stopped by the hairs of the nose, the moist surfaces, and the cilia in the bronchi—all of which tend to trap it and prevent its inhalation to the deeper passages. The smaller particles, ranging downward from, let us say, *10 microns to 0.1 micron or less*, will be acted on by several influences: they will penetrate, to an unknown extent, the deeper passages to the alveoli; they will be wafted in and out of the alveoli with each respiratory cycle, being deposited to an unkown extent; and finally, at least in the case of quart dust, they will exhibit toxicity to a varying and unknown extent, depending on their size. Penetration, retention, and toxicity as related to particle size are beginning to be recognized as having fundamental importance in activity of dusty particles. Active research programs are underway today to improve an understanding of these subjects.

Hatch and Hemeon last year reviewed the questions of penetration, deposition, and toxicity of dust in the lungs. They constructed a curve, based partly on experimental studies of retention of dust in the entire respiratory system, and partly on theoretical considerations, which suggests that "there is a given particle size having the greatest probability of being deposited in the alveoli and that the chance of such an event occurring falls off rapidly for particles both larger and smaller than this optimum size."

An extension of these considerations to include the qualitatively demonstrated fact that toxicity increases with decreasing particle size leads them to construction of a curve representing relative toxicity per unit concentration of inhaled dust. The sharp peak of this curve suggests that damaging capacity is very sensitive to particle size.

These interesting suggestions were presented by them to point out that although particle size is not generally taken into account in appraising dust hazards, its influence may be very great. Research on the relationships between particle size and penetration, retention, and toxicity is now being pursued and has begun to show in a preliminary way that the peak on the deposition curve of Hatch and Hemeon has a basis in fact and is fairly close to the correct numerical value. Needless to say, much remains to be done on these subjects.

It is interesting to note that one of the most vexing problems to confront the research men investigating the inhalation and retention of dust of various particle sizes is the flocculation of fine particles. Flocculated aggregates having an effective size many times that of the individual small particles behave like large particles as far as entrapment in the upper respiratory system is concerned. The same thing occurs in industrial dust exposures, not uniformly, but with considerable variation with type and source of dust. This is another factor having an influence on the evaluation of dust exposure about which little is understood.

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