

Memorandum on Hygienic Conditions in The Metalurgical
Products Department of the Magnetic Materials Section
of General Electric Company at
Edmore, Michigan.

This plant was visited on October 16, 1962, in a consultation on certain hygienic problems associated with the manufacture of a magnetic alloy, and for a survey of the operations and processes involved and of the entire premises in which these operations and processes were being carried out. Data derived from measurements of certain atmospheric contaminants, as well as those derived from clinical and laboratory investigations of the personnel of the plant, were also inquired into or examined, in an effort to assess the possible existence and the degree of occupational hazards.

Without entering upon a description of the characteristics of the operations, which are better known in detail to the management of the plant than to this consultant, the matters at issue are as follows:

- (a) The severity and significance of the exposure of a certain group of operating personnel to mercury; and
- (b) The severity and significance of the exposure of another group to lead.

These matters will be considered in some detail, separately, since the group subjected to exposure to the one factor is not appreciably exposed to the other.

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The Occupational Exposure to Mercury

Environmental Conditions.

Considering the nature of the processes and equipment in which mercury in large quantities is involved, it is not a simple matter to determine the probable significance of the exposure by inspection of the premises and the equipment. This brief survey, on one occasion only, yielded remarkably little evidence of a significant degree of exposure, from the aspect of the obvious escape of vapor or process materials, from the operating equipment. At the same time, it could reasonably be expected that batch equipment so bulky, so crowded into a small space, so subjected to mechanical stresses, would be subject to leakage, spillage and failure from time to time, and to the extent of the variable severity of such incidents, contamination of the floors, the surfaces of the equipment, and the air may be expected to occur in varying degree. Some evidence of such happenings in the form of metallic mercury on the floor in several areas, even where it could easily have been picked up promptly and removed, indicated clearly that these occur, and also that they are not regarded with sufficient seriousness by the operators or supervisors.

It was all too evident that the area in which these operations are carried out is unsatisfactory for present purposes. (The adaptation of a pilot plant to production, even developmental production, is rarely satisfactory, in the hygienic sense, or for that matter, from the aspect of efficient operation, while the "bugs" are being removed from the process. In this instance, it appears that the conditions are better

KE 0005552

than might be expected considering the disadvantages. Faulty conditions should not be permitted to persist, however, even if somewhat heroic efforts are required to abolish them. The question may be raised, at this time, as to the wisdom of designing and constructing, very shortly, a plant that can be operated properly. Whether the developmental stage has now been passed, and whether the commercial and economic situation can justify such a course, should be examined carefully. No doubt certain things can be done to improve the operating conditions, but the fundamental difficulty resides in the complete inadequacy of the plant, for reasons that will become apparent when attention is properly focused upon disadvantageous factors.

To return to the results of inspection, mere observation, as indicated above, gave little basis for the appraisal of any existing hazard with respect to mercury. All one could conclude was that opportunity for exposure existed, principally in terms of the basic difficulties of maintenance of equipment and housekeeping, and that the measurement of mercury in the atmosphere in various pertinent parts of the operating area was the only means, applicable to the environment, whereby the sources and extent of the exposure could be assessed. Certain conditions existed, however, which are worthy of comment, with respect to mercury in the air, because they create obstacles to good housekeeping and militate against careful operating procedures (with respect to the avoidance of exposure to mercury) and personal cleanliness on the part of the workmen.

The area of operations, as indicated, is crowded, and while the flow of materials has an orderly sequence necessarily, the entire place

is cluttered and seemingly disorderly. There is nothing to facilitate or encourage precision of performance. Such precision as there is - and it is notable - exists in spite of the general inconvenience and overcrowding. Housekeeping is extremely difficult because of the structural irregularities of the floors and equipment, and therefore, it is poor. The little cell on the edge of the operating space, to which men retire for a forbidden smoke, is just where it should be and just what it should be to encourage such a practice - a dirty cubby hole, at the end of a short, dirty hallway. Just what useful purpose this place serves is not clear to this observer, in retrospect, and it seems now that he must have missed the point, for he can think of no reason for not abolishing this space, so far as present need and significant usefulness is concerned. If these men are to smoke - as they continue to do, some provision should be made for a suitable uncontaminated place in which this can be done after washing the hands.

Personal cleanliness is important in an operation of this type. The facilities for the purpose are not inviting. It is one thing to pamper employees, and quite another - and a stern necessity in certain hazardous occupations - to provide attractive and comfortable facilities for cultivating personal cleanliness.

So much for the survey of the premises. The examination of the analytical data, with respect to the concentration of mercury in the air, assuming, for present purposes, the adequacy of the sampling and the accuracy of the measurements, are clearly indicative of the existence of hazard. The findings in the areas of the various operations, and also in areas which would not, of necessity, be unduly contaminated with mercury vapor (nearby

hallway and rest room, the latter being also the site at which the men smoke cigarettes), demonstrate the presence of excessive concentrations of mercury. These findings are not alarming from the aspect of the likely occurrence of acute mercurial intoxication, or even of low-grade intoxication in association with short periods of employment. They are much too high, however, under conditions of prolonged and regular employment, and they have remained high for many months, without any concerted or well directed effort to overcome the factors responsible for them. As time goes on without obvious ill effects, these tend to become part of the accepted occupational conditions. This is not said to be superior or harshly critical; it is rather a recognition of the way practical people are constituted. Despite a certain degree of dissatisfaction, the day's work tends to proceed as usual until or unless a troublesome issue presents itself, because the management, lacking good medical guidance, is uncertain as to the significance of the hazard. Unfortunately, the "troublesome issue" in relation to chronic mercurialism may turn out to be an irreversible type of damage to the brain of an employee due to the maintenance of an unduly high concentration of mercury in his brain. Such an intoxication may develop with little or no warning from prodromal symptoms or signs. This is not the inevitable consequence of such conditions, nor is it even frequent in its occurrence, and it is the unpredictability of such a result that makes this problem difficult to contend with in industry. It does occur, however, from time to time, and when it does, it represents a human tragedy, and a serious obstacle to further production.

The principle which should apply here, with respect to the analytical findings in the air breathed by the men, is that of taking cognizance of the hazard to which reference has been made above, when the accepted standard for the concentration of mercury in the air breathed by workmen, is being exceeded more than slightly and fleetingly. The institution of action toward abating the hazard so revealed is the only logical response to the analytical findings. If one does not intend to abide by this principle, there is no good reason for making the analyses. To be thoroughly cold-blooded about them, they are otherwise a fruitless item of expense and also a possible means of convicting the management of negligence. Certainly a legal action could be based on the latter premise, and would be difficult to defend. (This latter point is made, not because there is the slightest reason to doubt that the management of this plant has a very proper regard for the welfare of the employees or that they would require such economic compulsion, but rather because the legal and economic aspects of this matter are hard facts of life which sometimes come as a shock.)

The Status of the Employees

The workmen in the area in which mercury is being handled are examined at intervals of six months by a physician who has been engaged for this and other purposes. The examinations are carried out at the office of the physician, who maintains the medical records in his own hands. It was not feasible to confer with the physician, and it is likely that little could have been gained in such a conference (within the limits of time available). There seems little reason to suspect, however, that

any of the workmen have complained of, or exhibited, illness attributable to the absorption of mercury. In any case, there have been no frank cases of mercurialism. One would not make such a flat statement on hearsay evidence, but for the smallness of the group of employees and the certainty that the complaints or illness of any one of them would be made known, whereas similar suggestive deviations from good health and well-being might easily be overlooked in a larger group of employees.

The data with respect to the rate of the excretion of mercury in the urine of the employees, and the concentration of mercury in their blood (of which more will be said later, in a different relationship), are such as clearly to demonstrate that the analyses of the air have yielded valid, if not necessarily precise, evidence of excessive exposure to mercury. Here again, this consultant is unable to vouch for the quantitative accuracy of the analytical results (and there should be some cross-checking with the analyst to establish the facts in this regard). Assuming, however, that they are reasonably accurate and at least roughly comparable to the precise results obtained under apparently similar circumstances by the analytical staff of this Laboratory, they show that the men are absorbing potentially dangerous quantities of mercury.

We have satisfied ourselves, in investigations within industry that have extended over periods of years (eight years, in the most instructive set of observations), that respiratory exposure to mercury, during the usual hours of work (approximately 40 hours per week), which results in the excretion of mercury in the urine in concentrations ranging

up to 0.30 mg. per liter, is not associated with any form of mercurialism. Somewhat less satisfactory but strongly suggestive evidence indicates that there is danger of chronic mercurialism when industrial conditions result in significantly greater absorption of mercury, as indicated by the rate of excretion of mercury in the urine. Moreover, when the concentration of mercury in the air of industrial areas is controlled so as not to exceed 0.10 mg. of Hg. per cubic meter of air for more than brief, infrequent periods of time, the concentration of mercury in the urine of regular workmen is maintained within the range indicated previously (rarely in excess of 0.30 mg. of Hg. per liter and usually of the order of 0.20 - 0.24 mg. per liter). It is highly desirable to maintain the exposure of industrial workmen to mercury within limits which will conform consistently to these standards. Failure to do so over any considerable period of time is to assume risks for the workmen and liabilities for the industry, that cannot be justified.

Recommendations

In view of the foregoing comments, it is strongly recommended that every consideration be given to the construction (or utilization) of new (or different) facilities for the operations under consideration. It would seem that any unsolved problems concerning the various processes could be solved promptly, and that an appropriate scale of production could be decided upon, and the space and equipment adapted accordingly.

It seems unlikely that the necessary measures of industrial hygiene can be applied consistently and successfully, with only a reasonable

amount of care and attention, under present conditions. The latter can be improved, no doubt, but only with great difficulty can they be brought into line and so maintained. In speaking here of industrial hygiene, it is not suggested that stress need be put on the measures employed to detect unsatisfactory conditions. These have been adequate if not especially efficient. What is required is not more information, but better control, and the latter, in our view, requires more space, better floors (susceptible of being kept clean by means of vacuum equipment), and, above all, a skillful layout and design of equipment which will be easily accessible, readily maintained, and easily operated. It seems certain that the people in charge know how to accomplish these results, if they are provided with the means of doing so. They are in better position to know how to do this than any other person or persons would be.

It seems likely that the set of operations which are involved in this hazard should be so housed and designed as to have all of the facilities required to establish and maintain the complete armamentarium of good industrial hygiene. Clothes-changing facilities, showers, and a place for eating, coffee drinking, relaxing and smoking, may or may not need to be separate from similar plant facilities for other groups, but to the extent that the general facilities are relatively unsatisfactory, there is need either to make them satisfactory, or to provide separate facilities for special groups. There is no mystery, at present, as to the specifications which should apply to such facilities, but to the extent that consultation along these lines may be useful, it should be obtained.

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It is the firm opinion of this consultant that there is need, periodically, of supervision of these operations, from the hygienic viewpoint, by a person who is on the spot. This could be done by the physician, if he were to find the time and be given the mandate for so doing. It could also be done by a non-medical industrial hygienist, and in some respects this would be a better procedure (although part-time engineering consultation is rarely easy to obtain and is often unsatisfactory), unless the physician were to develop a genuine interest in the techniques of industrial hygiene, and acquaint himself with the attitudes and methods involved. The physician, however, if interested and equal to the task, could exert more influence upon the men, in the exercise of care on their own behalf, than would a technical man. This would not take a great deal of the physician's time, but it would make him a member of the team, instead of an absentee. The role of a physician in his office, in matters of industrial hygiene, is an anachronism. The function of occupational medicine is not the recognition and treatment of disease, but the prevention of disease and the control of the threat of disease. This means that the industrial physician must know what goes on in an industrial plant, how the men work, and under what conditions. This is not said in criticism of this physician, who is unknown to this consultant, but is in sharp criticism of an ineffectual policy and procedure of industrial hygiene. The present policy is that of the management, not that of the physician, or so it appears.

The same criticism applies to the procedures involved in the analytical investigation of the employees. This is, strictly speaking, a medical problem, which should be handled on the spot or by a consulting

industrial hygiene laboratory operating through and reporting to the local physician. No medical judgment has been exercised in the choice of the material (urine or blood or both) for analysis. Incidentally, there is no good reason for the analysis of both blood and urine, as a measure of industrial hygiene in relation to mercury. (There may be some reason for this duplication in the study of a sick man, but for the protection of the employee who is not ill, the information obtained by the analysis of one of these is as good as that obtained from the other, and both have the same meaning. No useful information is provided by both procedures that is not capable of being obtained from one of them. Whichever is the easier to obtain and handle is the material of choice. The urine is preferable, usually, because of the ease of sampling, from the viewpoint of the employee). The point is that this work is being done in a laboratory which has no knowledge of the plant facilities and little knowledge of the medical problem, and is unprepared to give advice and guidance. This is alright, provided someone who is capable of interpreting the data is responsible for so doing. In this instance, the procedure is being followed fruitlessly, since no advice concerning the people involved is being provided. The environmental, physiological (analysis of urine, etc.), and medical work should be tied together and converted into a functional program of industrial hygiene. Otherwise, these separate and incoordinated activities are in the nature of going through the motion and incurring the expense, without benefit of the substance of industrial hygiene. (This consultant cannot avoid making these comments, which he might, with some justification, keep to himself on the grounds of professional courtesy. The reason for

frankness in this respect is that this very lack of effective application is the principal source of the weakness and ineptitude of hygienic efforts in much of American industry. Since my advice has been sought in this matter, I feel constrained to give it and to relate it to the principal issue).

Recommendations for Improvement of the Present Facilities

As indicated above, the improvement of the present facilities will prove to be difficult. Not only are there serious obstacles in the physical features of the present area of operations, but the habits and attitudes of the operating personnel have been conditioned and will be hard to change. Emphasis on the necessity for improvement, as a matter of safety, may fall on deaf ears, or alternately it may cause undue apprehension. On this latter account, in part, and also in recognition of the fact that no dramatic move made at this time will effect a prompt cure of the situation, a gradual but steady campaign for correcting its worst evils is recommended. Those directly responsible for the development and the operation of the process will know best whether such evils are resident in the equipment, which may need repair or improvement, or whether the exposure is mainly the result of "sloppy" operating techniques. The facts in these matters, if not certainly known, can be established by a judicious application of air analyses at strategic points and times. Someone with understanding and responsibility should attend to this and develop the results in sufficient number and type to portray the facts as a basis for action. Appropriate action should not be delayed but instituted as promptly as possible. It is necessary to reduce the concentration of mercury in the air to the lowest

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possible limits, and eventually to bring it within the accepted safe concentration throughout the operations.

It is certain that the housekeeping is not adequate. Altogether too much reliance is put upon the flow of water on the floors to inhibit the vaporization of mercury. The floors should be clean and free of mercury at all times. Whenever anything happens to contaminate them, cleaning procedures should be instituted at once, i.e., just as soon as the operation which has produced the contamination has been completed. It may or may not be feasible to have the operators do the cleaning. This is a matter for managerial judgment. However, the opportunity is afforded thereby to indoctrinate the operators into the relationship between the techniques of operation and the preservation of environmental safety. It is their environment, their safety and their responsibility. It is not something the "boss" wants, but something that concerns themselves. This attitude can be cultivated by putting the burden of responsibility on the men for the proper performance of their work toward both production and safety.

The proper use of the sanitary and hygienic facilities can be improved by being ^{their} cleaned up and brightened up with paint. A place should be provided for smoking, unless effective supervisory and disciplinary measures are to be taken. The latter will be difficult to effect, in all likelihood, and this consultant favors the cultivation of proper performance by reviewing the obstacles and providing satisfactory opportunity for men to do what they wish to do within reason.

The general organization of industrial hygiene into an integrated and well directed effort has been referred to in preceding paragraphs.

Such improvement in these respects as may reasonably be achieved should be attempted promptly in the present situation. By the time new facilities come to be available, a reasonably effective program should have been developed.

The Occupational Exposure to Lead

The potential exposure to lead in the course of the operations now being carried on in one section of the plant arises out of the high percentage of lead in the material being handled. The product of the operations referred to in the preceding portion of this report is delivered to this section, where it is introduced first into a grinding machine from which it is discharged in a granular form.

On inspection, the material being ground is seen to be a rough, porous material which breaks up fairly readily - that is, without the application of great force - and tends to disintegrate into chunks or granules rather than into a fine dust. Accordingly, little dust is discharged into the air by the grinder, and only a minimum of fine impalpable powder is visible on any of the equipment or flat surfaces in the area. The impression given, on observing these operations, was that the nature of the material is such that little of it remains air-borne within the area, and that the hazard of lead absorption must be slight.

It cannot be said with certainty that the exposure to lead in connection with the operations in this area is wholly negligible. It seems certain, however, that it is slight, and that it can, if necessary, be controlled easily by adequately designed and installed local exhaust ventilation. Further and somewhat detailed examination of the operations, coupled with a few properly taken samples of particulate material from the

air, will indicate clearly what, if anything, needs to be done. (These remarks are intended to relate to expanded operations and to any new procedures which may be carried out, if and when this group of operations is altered to provide for larger production.) For the present it does not appear that there is a lead hazard in these operations. One must be cautious in making this statement for it is not certain that the facts have been portrayed fully by the available data. No results of analyses of the air were submitted for examination. It would be helpful if reliable results of this type were available. The results of analyses of the urine and blood of the workmen were examined, however, and to the extent that these can be accepted as quantitatively reliable, they fail completely to show that any of the men (so tested) has absorbed an abnormal quantity of lead. There was no single result that was certainly indicative of the absorption of lead from the occupational environment. There was no evidence of dangerous absorption of lead. All of the results obtained were within the normal range, but there were not sufficient numbers of analyses (the employees involved being few in number) to enable one to establish whether the average of all of the findings was normal or somewhat above the average. (To clarify this point, the facts to be stated are as follows: The range of normal findings in samples of urine of small volume extends from a little more or less than 0.01 mg. of lead per liter to (occasionally) a little more than 0.14 mg. of lead per liter. Samples of urine of large volume (which are difficult to collect in such a manner as to avoid all contamination with lead), vary less, ranging from about 0.02 to 0.08 mg. per liter. The mean (or average) value in either instance is approximately 0.03 mg. per liter. If a group of workmen has been

subjected to a slight amount of occupational exposure to lead, the range of the findings may be essentially the same as that above, although, more likely, there will be a few higher results, but the evidence of the occupational exposure is found in the fact that there are larger numbers of samples in the higher part of the range, and a smaller number in the low segment of the range, and therefore, the average will be displaced upward. If the exposure has been of a dangerous magnitude, much higher values will certainly appear among the findings, and the low findings will diminish in number or disappear, while the average will go up as high, in some instances, as ten times the normal average.)

It is likely that the data of these analyses are reasonably accurate, since there are wholly satisfactory methods of analysis for lead, and the head of the laboratory in question may be expected to be familiar with these methods. One cannot be certain, however, of the care that is exercised in this regard in various laboratories (whether the work is done by competent chemists or thoroughly indoctrinated (and supervised) technicians, or whether it is entrusted, hopefully, to more or less run-of-mine technicians. In any case the results obtained in various laboratories tend to vary somewhat, and it is not certain that their reported findings have the same meaning. It is necessary to reserve judgment, somewhat, as to the strictly quantitative significance of the available data. There can be no doubt, however, that the hazard of lead absorption in connection with these operations is slight and that it can readily be controlled. It will not be necessary, therefore, to apply elaborate procedures of industrial hygiene either to the environment or to the personnel, so long as the present conditions (in quality and scope) persist. A satisfactory regimen can be prescribed after some consultation with the people who have provided the results thus far reported.

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Some discussion arose concerning the desirability of following the urinary coproporphyrin of the employees who are subjected to potential exposure to lead, as an additional means of hygienic supervision and control. There would be no disadvantage in the performance of satisfactory tests of this type upon the urine of these men. No useful medical or hygienic purpose would be served thereby, however, for several reasons. First, the test for Coproporphyrin III is not related specifically to lead. Positive findings would have to be substantiated, therefore, by analyses for lead, preferably in the blood, before being regarded as significant. Second, under the conditions indicated by the available analytical data for lead, no positive findings could be expected. Only negative results would be obtained unless some other cause of abnormal porphyrinuria existed, for the amount of absorption of lead by these men, as judged on present evidence, is incapable of inducing porphyrinuria of an abnormal type or degree. Third, a quantitative determination of Coproporphyrin III in the urine is useful (if one does not have access to better and more specific analytical data) as a means of screening men who are being subjected to potentially dangerous exposure to lead, so as to detect the abnormal quantities of Coproporphyrin III which appear as the first sign of lead intoxication (i.e., as an interference with the synthesis of hemoglobin). The test is of no value whatever unless there is exposure sufficient in severity to produce at least a few cases of lead poisoning within the group under investigation.

Recommendations.

It is believed that the analytical results supplied to the management of the plant (this in itself is an error of professional

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technique, for the results should be confined to medical records and not be available to non-medical personnel except in second hand, verbal communications) should be inquired into, as to the methods of analyses and the professional competence of the analyst or analysts. Some cross-checking with the Laboratory might be desirable.

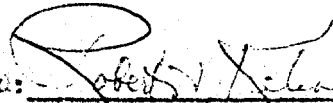
It is recommended that the various procedures of the normal operations be checked, at least in a limited manner, by means of air sampling and analysis during the operating procedures. By such means one can determine the need, if any, and the proper point of application, of exhaust ventilation.

It may be that there is little or no need for continuing elaborate measures of industrial hygiene in relation to lead. In any case such measures as are taken should be tailored to the precise need, and not carried out as a blanket procedure by rule of thumb.

From The Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati, Cincinnati, Ohio

Observations and Memorandum by:

Robert A. Kehoe, M.D.

Approved: 

Robert A. Kehoe, M.D.
Director

Date: November 8, 1962

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January 15, 1963

George F. Martelon, M.D.
Plant Physician
General Electric Company
1285 Boston Avenue
Bridgeport 2, Conn.

Dear Doctor Marleton:

Some weeks ago I sent a fairly elaborate report, with recommendations, to Mr. Hooper at Edmore, following my visit to the plant. I did not send a copy to you at that time, although I was prepared to do so, but rather asked Mr. Hooper to let me know his wishes in the matter of its distribution. I have just received a letter from him asking me to send a copy to you, which is as I hoped and expected.

I gather from Mr. Hooper that he is making progress in carrying out some of my recommendations, and I trust that he will continue in so doing. I should be pleased to have any comments or suggestions which you may care to make.

You will note that I have been critical of the manner of handling the medical and hygienic program. I realize fully that this is one of the fundamental difficulties of industry and especially of the smaller industrial operations, whether these are units in themselves, or relatively decentralized units of a large organization as in this instance, but I have thought it wise and necessary to state the correct principle, however wide of the mark one may have to go in the specific situation. I do not think I was unreasonable or pedantic in my approach to the problem at Edmore, nor do I think Mr. Hooper would think me so. I found him a highly agreeable and intelligent person with whom to deal, and I was pleased to have had the opportunity to deal with him.

Sincerely yours,

Robert A. Kehoe, M. D.

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Enclosure: 1 copy of Memorandum on Hygienic Conditions
at Edmore, Michigan

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