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PRACTICAL METHODS OF CONTROLLING EXPOSURE TO METALS

Read at the Symposium on the Practical Aspects of Industrial Toxicology sponsored by the Gulf Coast Section of the American Industrial Hygiene Association in Houston, Texas, April 13, 1962, by Don G. Fowler, Director of Health and Safety, Lead Industries Association, Inc., 292 Madison Avenue, New York 17, New York.

For as far back as we may go in recorded history metals have been mentioned as useful. For almost the same length of time metals and their compounds have been mentioned as toxic. Because we have such a long history of metal usage and toxicity I suppose the mystic aura which tends to influence our thinking is inevitable. In our western civilization, for instance, we have records of a period of over three hundred years where the main and almost the sole concern of science was an investigation into transmutation of metals by means of the philosopher's stone.

Also, I think, from this same past is a sort of mystic apprehension regarding toxicity, and poisonings. From this legacy, I suppose, comes the vague and sometimes unreasoning fear of "poisoning". Just say, for instance, arsenic "poisoning", or lead "poisoning" and you have an audience immediate in its apprehension.

Let us this afternoon consider where we may help dispel this mystic gloom somewhat from metal toxicity and inquire into a rational approach to prevention and control of excessive metal absorption on the industrial scene. Our main concern in this discussion will be control and since the previous papers have made us all experts on toxicology, all we need is to organize our toxic expertise into a workable system.

I think it was Dr. Robert Kehoe who pointed out, speaking to a group of plant managers and plant engineers, that control of intoxication from metals can be accomplished by means of readily available industrial and management techniques. Nothing esoteric or magic is necessary for control of metallic poisonings in industry.

Why is it that a plant management that is quite capable of handling its personnel and labor relations problems, of handling the many supply, coordination and production problems involved in making the product will often literally throw up its hands and be afraid to tackle the problems involved in protecting personnel from potentially toxic materials? There is nothing special about such problems once the facts are available and once we have the conviction to act in accordance with the facts.

I am reminded of the only time I found it necessary to close a plant due to an unhealthy condition. At the time I was working with the State Health Department in Michigan and the owner-manager of a small powdered metal plant called, sounding quite desperate on the phone, and asking me to drop everything and get over to his plant right away as he had a terrible problem with people in the hospital and he didn't know what to do about it. Of course I hurried, thinking on the way of such things as cadmium poisoning, iron carbonyl and other possibilities. The distraught plant manager was awaiting my arrival at the gate, and when we entered the plant I found only a few scared employees half-heartedly attempting to operate their equipment. I was told that several employees were already in the hospital in oxygen tents and more were in ambulances en-route to the hospital. After a quick look around I made the obvious suggestion that we ought to clear the plant of personnel--a suggestion received by the owner with profuse and grateful thanks--and then we were able to make an investigation in a better mental atmosphere and to find that carbon monoxide was the offending agent--carbon monoxide leaking from a reducing atmosphere heat-treat furnace.

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Isn't this an example of the difficulty that an otherwise rational manager encounters when faced with a situation involving poisoning?

Of course, this is an extreme example but I believe it illustrates the effect of management attitude which is so important in instituting and making controls effective, whatever means of control are selected.

First we must decide to eliminate the toxic effect of a material and then we may proceed to take the necessary steps to do so. This may sound like Dale Carnegie opening a course for salesmen. But let me illustrate again.

I recently visited a small foundry that produces a variety of brass and other alloy castings which contain lead. The place has been in business a long time and is managed by an old-timer in the business; a man, who two years ago, knew that you would always have lead poisoning when you pour lead alloys in production. Today this man knows differently. He decided to eliminate the toxic effect, and he has done so. This foundry now has an excellent ventilation system which removes air-borne dusts and fume at all places where they are likely to be generated. All melting furnaces are enclosed and exhaust ventilated. Plant housekeeping is excellent and adequate medical supervision of employees is provided. Of course the excellent results now being obtained at this foundry are not due entirely to the change in attitude on the part of the plant manager, surely the exhaust ventilation helped some; but without the change in attitude the ventilation system would not have been as well-designed and it might have been used poorly by employees who did not understand its purpose. Surely plant housekeeping (so necessary in a foundry) would not have been as good, and I am sure that employee attitude would not have equalled the cooperating helpful attitude so apparent.

We should also mention the converse of this situation, where an unconvinced management reluctantly and under pressure (often by a government agency) buys a ventilating system, starts a medical examination system, and still suffers employee disability. It happens this way; I have seen it many times.

The importance of mental attitude in this business must be stressed again and again. In this connection I wish to leave a concept with you, which I am sure you will find useful as long as you have anything to do with prevention of poisoning.

"There are no harmless substances. There are only harmless ways of using substances." Taken from the 1962 Report to the Surgeon General of the United States Public Health Service by his Committee on Environmental Health Problems.

A small child while playing with a can of ordinary baby powder released the container lid and inhaled an excessive amount. The baby died in the hospital twenty-four hours later, poisoned by talcum powder.

Two patients were hospitalized with symptoms of poisoning of unknown etiology. The attending physician diagnosed their symptoms as being caused by ingestion of too much water. The medical report concludes: poisoning by drinking water.

These incidents, both recorded in the New England Journal of Medicine, illustrate for us, I believe, that "There are no harmless substances."

Now before we discuss specific control methods there are a few aspects of metal toxicity that should be mentioned. Metals as a class differ from almost all other substances of potential toxicity.

Almost all metals are present and detectible in the normal human body at all times.

Metals are essential elements in animal nutrition and health. Each year science adds additional metals to the list of essential elements.

It follows that we need and must have quantitative information before we can characterise a metal as toxic. Simple analysis showing the presence of a metal in the human body is a meaningless bit of information. The mere presence of a metal in the environment is a meaningless bit of information.

To illustrate I have listed for you some characteristics which may be of use in controlling exposure to metals in industrial plants.

	INHALATION (Current Value for 8 hr. daily exposure in milligrams per cubic meter of air)	INGESTION (Amount in grams immediately hazardous to life)	POSSIBILITY OF SKIN ABSORPTION?	CAUSE DERMATITIS?
Aluminum				yes
Antimony	0.5	0.1		yes
Arsenic	0.5	0.1-0.3		yes
Barium (Soluble compounds)	0.5	0.8-0.9		
Beryllium	0.002			yes
Bismuth				yes
Cadmium (Oxide)	0.1			
Chromium	0.1	6.0-8.0		yes
Cobalt	0.5			yes
Copper		20.0 copper salts		
Iron (Oxide)	15.0			
Lead	0.2	10.0-50.0 soluble salts.		
Magnesium (Oxide)	15.0			yes
Mercury	0.1	1.0 mercuric salts	yes	yes
(Organic compounds)	0.01		yes	yes
Nickel				yes
Selenium	0.1		yes	yes
Strontium	No toxic effects reported.			
Tellurium	0.1		yes	yes
Tin				
Tungsten				
Vanadium (Oxide)				
(Dust)	0.5			yes
(Fume)	0.1			
Zinc (Oxide)	15.0			yes

As you may see, the sheet is not complete in any respect nor is it intended to be, but I believe it illustrates for you the wide spread of values that exist in our present day knowledge about toxic effects. You will note gaps or blank spaces in several columns. This does not indicate a lack of hazard or that there are no cases of

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poisonings on record, but merely that values reported by toxicologists and others differ to such an extent that they would not help in our control efforts. None of these values can be construed in any manner as giving a relative toxicity rating, as Dr. Smyth has mentioned to you previously today. Under aluminum, for example, there is no value for inhalation of air-borne dust and yet there are several reports of fatalities following breathing of sufficient quantities of aluminum dust. Remember "There are no harmless substances."

Now let us get into our discussion of control of metal poisonings by a sort of back-door route. I want to outline for you the requirements for a case (or cases) of industrial metal poisoning. Unless all of these requirements that I am going to list are met we will not be able to produce such poisonings. Once we fully understand the nature of these requirements, control of the situation is easily possible through readily available methods.

First, there must be an exposure, or exposures, to enough of the metal. This is almost too obvious to mention but sometimes we forget that arsenic, cadmium and so forth are used without ill effects every day in thousands of applications and in thousands of industrial plants.

The next requirement for poisoning is that there must be exposure to the right kind, the right form of the metal. We could multiply examples here ad infinitum. Barium in soluble form can be quite hazardous but the insoluble barium sulfate is in daily use in hospitals as a contrast medium for x-ray studies of the intestinal tract. A skid box of cadmium-plated bolts in the factory aisle is hazardous to no one, but let that load of bolts be placed in a poorly-ventilated heat-treat furnace (as has happened) and there is a serious potential hazard from fumes of cadmium oxide. Iron is usually a fairly safe metal but iron in the form of iron carbonyl is definitely not.

Another necessary requirement for industrial poisoning is that protection for the man must be inadequate. If he is protected by means of a well-designed ventilation system, for instance, he can work without ill effects even while surrounded by dangerous concentrations of metals. Or he may be protected with personal respiratory devices for such exposures as metallizing, for example. Or he may need to be isolated in his own booth or room as in an air-conditioned crane cab in a foundry.

The last requirement for industrial poisoning is that the individual must be in a physiological state of readiness to suffer a toxic effect. Now this is hard to explain but easier to illustrate, so I am going to give you some examples. Incidentally I don't like this last requirement; I didn't invent it, and I would just as soon leave it out, but it happens so we must take note of its existence.

In another powdered metal plant which produces a variety of small parts, one of the metals used is copper of high purity and finely powdered state. Every spring at the first onset of warm weather between 30% to 50% of the employees who work with the copper report to the Medical Department with a dermatitis or skin irritation of the forearm and upper arm. This condition requires no specific treatment and generally disappears in about two weeks. It doesn't recur until the next spring. Now here is a situation where there is no change in our other listed requirements (amount, kind and protection) but there is a change in employee readiness. We could think of many other examples--the condition known as metal fume fever which follows exposure to the oxide fumes of several metals, notably zinc, and which appears to evince an almost allergic type of response but which doesn't usually recur in the same individual. A very good example here, I think, is a mention of industrial cancers that are alleged

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to occur following exposure to several metals and their compounds. I like the discussion of the Messrs. Goldblatt as quoted by Dr. Browning in the book "Toxicity of Industrial Metals."

"The arsenical compound which produces no tumour in a workman is not a carcinogen for him until he, in a given tissue, brings about a meeting between a cell in the appropriate state and the compound in a sufficient concentration....and....from the very few cases of occupational arsenical cancer hitherto reported it may be considered that a combination of an appropriate state and sufficient concentration is rare."

Let's recapitulate a moment to see where we have arrived. We have outlined four requirements necessary to produce a toxic situation in industry.

First exposure to enough--quantity.

Second exposure to the right kind--either quality or form.

Third inadequate protection.

Fourth a ready subject.

If we consider each of these requirements as a link in a chain of toxicity, and if we separate or destroy any of the links, we will not have a complete chain--consequently no toxic exposure.

Now it remains to discuss how we proceed to destroy one or more links in the chain, and eliminate the toxic effects from metal use and exposure in any given situation.

You will remember Dr. Kehoe's statement that esoteric knowledge is not a requisite, that straight-forward engineering controls are adequate. You will remember also that management must be convinced, must be sold, if you will, of the necessity for action.

This latter point is so important that I would like to illustrate it for you with an example taken from my experience in the automobile industry. Twenty-five years ago there was a veritable epidemic of poisonings resulting from the use of lead solder on car bodies to smooth out seams and imperfections.

Up until about 1935 in the industry small amounts of lead solder were used and commonly hand-finished by means of files and sandpaper. However, around 1935 automobile stylers began designing the smooth contours and rounded body surfaces which we now expect as a matter of course. At that time a significant increase in the use of lead body solder was necessary to fill in the gaps and help produce the contoured effect. The hand-filing system of finishing encountered difficulty in keeping up with production requirements, and Engineering decided to use mechanical methods such as powered disc grinders and sanders to smooth out the solder. Within about three months of this decision several thousand body-shop workers were hospitalized with undoubted lead poisoning due to the inhalation of huge amounts of lead dust. Here was a situation which met all of our requirements for poisonings, but hazards were eliminated by application of ordinary protection and engineering techniques.

First, of course, management had to be convinced that it had a problem. That was easy. Next management had to be convinced that a solution to the problem was practical. And this was done.

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The solution to this problem involved the breaking of the chain of toxic requirements by several straight-forward techniques and I want to mention them for you and outline the manner in which the same situation is handled today in the industry. As far as production is concerned, the same type of lead solder is used, the amounts that are used are comparable and the end result as far as production is concerned is the same. However, all exposures are monitored and proper protection is provided to reduce these exposures in amount to that which will not result in a toxic effect. Ventilation systems are provided to exhaust excessive amounts of dust away from employees. Where necessary, airline respirators are provided. All exposed employees are routinely checked by measurements of the body burden of lead. In this manner the toxic level is not reached and with an exposure potential just as great as that that existed twenty-five years ago, there are no toxic effects in the automobile industry today from the use of body solder.

In summary then, I believe that for practical control of toxic effects involved in metal use in industry today we should continually keep in mind that precise knowledge gleaned from facts available to us is a prime necessity. The statement that a certain material is toxic, however much meaning this may have for a toxicologist, is meaningless to those of us who need to use the knowledge in a control situation. We have to know how much, what kind, how it is used and what the exposure potential is.

This knowledge is available. Almost all state health departments and many city and county health departments are staffed with specialists in the field, or may obtain the needed information from agencies such as the Federal Public Health Service. There are many private agencies such as universities, trade associations and large manufacturers who have a ready store of information to help in answering your questions and in the solution of your problems. There are also consultants available who can answer specific questions and provide necessary design information and testing facilities where required.

Rather than attempting a detailed listing of all metals and all types of engineering control methods in the brief time at my disposal, I have outlined a rationale for action predicated on the assumption that a positive approach coupled to the conviction that the necessary information is available in usable form is the most important factor in controlling industrial exposure to metals.