TETRAETHYL LEAD - THE DISPOSITION OF AN INTERNATIONAL CHEMICAL HAZARD.

by

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1. Introduction.

This discussion of an international problem of occupational and public health, more than thirty years after its emergence, and at a time when but a few persons appear to be concerned about it, may seem to have little justification. Tetraethyl lead has long been accepted generally as a valuable additive to gasoline for use in automotive and aeronautical gasoline, and satisfactory means have been found for the control of all of the occupational hazards that have been associated with its production, its transportation, and its addition to gasoline. Inasmuch as gasoline containing tetraethyl lead in commercial concentrations, when distributed through normal commercial channels and when used for its intended purpose, is not appreciably more dangerous for its handlers and users than are the petroleum hydrocarbons of which it is mainly composed, no further reference to this aspect of the matter need be made here(1).

The question of the extent and significance of the contamination of urban atmosphere with lead from the exhausts of automobiles was raised long ago for investigation, and has been under examination in one way or another and from time to time, ever since. A degree of concern on this score has reappeared recently in at least one section of the United States in connection with the general problem of the pollution of the air with products of the exhausts of automobiles. This has been heightened to some extent by the decision of the

gasolines in the United States and Canada by a small increment, and by the consideration of the matter on the part of the United States Public Health Service, when consulted by the manufacturers and distributors of antiknock additives in this country, and by the issuance of a formal report thereon, by the Public Health Service(2), a further stimulus to some reexamination of the entire problem relative to the use of lead-containing antiknock preparations has arisen out of technologic considerations that have prompted and initiated the use of tetramethyl lead as a suplement, or perhaps as a substitute in whole or in part, for tetraethyl lead.

It is not the purpose of this paper to discuss the hygienic issues involved in the aforementioned recent developments in the application of lead compounds to the production and distribution of high-octane automobile fuels. Evidence concerning the significance of these developments in relation to industrial and public health has been assembled elsewhere and will be obtained and published more fully in due course. Rather, it is our intention to call attention, briefly, to certain policies and procedures instituted in 1926 by the (at that time) sol edistributor of lead-containing antiknock compounds, with the full co-operation of the (at that time) sole manufacturer of tetraethyl lead, acting with the full knowledge and the informal advice, from time to time, of the United States Public Health Service. These policies and procedures, maintained and extended here and abroad since 1926, with modifications and improvements indicated by extensive research and applied and tested by practical experience in several industrial organizations now involved, have surrounded a hazardous chemical industry of international proportions with hygienic safeguards which have proved to be highly effective. This is not the time or place to talk of details, nor would any useful purpose be served by an attempt to give credit where credit is

due to the many individuals and groups that have contributed importantly to the success of a joint effort. Certain principles have evolved out of the experience of the years, however, and may now be visualized. That these principles are said to have evolved "out of experience" is a plain statement of fact, and in the form presented here they are the product of retrospective synthesis. They may be the more useful for their simplicity and for their applicability to other hygienic problems in the complex fabric of modern industry and technologic life.

2. Certain Principles of Industrial Medicine and Hygiene as Applied in The Manufacture and Transportation of Lead-Containing Antiknock Compounds and in Their Introduction into Gasoline.

(1) Physiologic and Toxicologic Investigation

The first provision for the introduction and commercial exploitation of tetraethyl lead on a broad base lay in a program of investigation which would reveal its overt potentialities for injuring persons who might be subjected to exposure thereto at any point in the operations. That this principle was not recognized and acted upon early enough to ward off all serious trouble, is a fact of history which has served to dramatize the validity of the principle rather than to vitiate it. Suffice it to say, here, that after a tragic start which halted further commercial activities for a time, and brought forth an extensive interim investigation by the United States Public Health Service, the industry resumed its course in 1926, and this time developed the various parts of its hygienic regimen in proper sequence. Every anticipated procedure was planned with an eye to the careful interpretation of the results of preliminary toxicologic investigations, and was carried out under a technologic scrutiny of the resultant environmental conditions and under a clinical surveillance of the personnel involved therein. A point which should be emphasized in this relationship is that the

toxicologic information obtained by more or less conventional procedures of the laboratory were not sufficient for the purposes of industrial hygiene. Such information had to be translated into technologic methods for the quantitative measurement of the relevent features of the environmental hazard, and, more importantly, into meaningful techniques for discovering the physiological and clinical responses of exposed personnel and determining their significance. The impulse to inject some collateral comments into this discussion at this point is almost irresistible, for indeed a volume could be written on the irrelevance and the futility of much of the conventionalized toxicologic rigmarole that has developed during the past two decades, in so far as effective measures of industrial and public health are concerned. Multiplicity and complexity of procedure have been substituted for clarity of thought and singleness of purpose in ascertaining the facts concerning human behavior in a potentially harmful environment. Let the physician, especially, consider the facts of biological life and remember always the classic axiom that "the proper study of mankind is man". This is not to say that there is not virtue and necessity in purposeful and well designed animal experimentation in advance of human experience. Many of the alleged refinements of such experimentation, however, and a large proportion of those not concerned with physiologic mechanisms, are comparatively sterile and wasteful of time and money, in the sense that the time and money could better be spent in the development and application of methods for the investigation of the reversible responses of the human organism to noxious or potentially noxious environmental conditions. Be these controversial matters resolved as they may, the fact remains that it is necessary, in confronting the prospect of human exposure to unexplored chemicals and physical agents, to investigate, in experiments with animals, the means of aceess of such substances or forms of energy into the complex organism, to establish, at

least in a descriptive manner, the effects of such an invasion in terms of dosage and duration of exposure, and to discover, if possible, means by which the threat or the actuality of the attack on the organism can be ascertained before it shall have caused serious or irreversible damage. With these facts available to the extent that is mandatory under the circumstances, the essential features of environmental control and of medical supervision come to light, at least in preliminary form.

(2) The Design of Commercial Operations

The primary features of the production and distribution of tetraethyl lead, from the hygienic viewpoint, were predetermined by its intended use as an antiknock agent in a low concentration in gasoline. If it was to achieve the wide use which alone would justify its continued existence, a large quantity had to be manufactured, transported to appropriate sites in appropriate containers, and introduced in exact quantities into gasoline. All of the operations that involved opportunities for human contact with, or hazardous exposure to, this toxic material had to be subjected to direct and thorough hygienic control. The feasibility of such control in the nation-wide and ultimately world-wide automotive transport industry depended obviously upon the limitation of such exposure to as few sites as possible and to comparatively small numbers of exposed personnel who could be instructed and supervised both technically and medically. There was no hope that tragic results could be avoided through the more issuance of instructions to the persons responsible for the various operations. Such a pious gesture would only have been a disclaimer of responsibility. Consequently careful consideration had to be given to the development of a pattern of commercial operations to which the essential hygienic regimen could be applied. This resulted in the concentration of manufacturing activities at sites where expert technical and hygienic and

medical facilities and personnel could be assembled and joined in a co-ordinated effort to examine and improve manufacturing processes and equipment, [redacted] and also supplementary measures of environmental control, as well as satisfactory medical procedures, all in the interest of reducing the occupational hazards and eventually bringing them under complete control. It is important to recognize that this can almost never be done completely in a new industry in advance of the work of industrial production. The best of planning in advance is certain to be lacking at certain points and to require modification in practice.

Careful consideration had to be given to the problems of transportation, to the end that accidents in transit would be reduced to the minimum, and that no person should incur exposure inadvertently or without knowledge of the risk incurred and of the means of avoiding such risk. This required the use of special containers, distinctive labeling, special handling adapted to the required methods of transport by rail, ship and truck, with particular reference to transportation from consignor to consignee without intermediate handling by untrained personnel. Fully informed employees of the consignor were always available at sites indicated on the labels as being subject to the call of transport personnel for advice and direct assistance according to need. The acceptance and the handling of shipments at destinations were dealt with by instructed personnel, so as, under normal circumstances, to leave no opportunity for mistakes of judgment or performance by uninformed persons.

The decision was arrived at early to limit the sale and distribution of antiknock compounds to gasoline refiners, and to make every reasonable attempt to maintain at a minimum the number of sites at which the antiknock preparation was to be mixed with gasoline. (The importance of this strategic move, in relation to the numbers of persons who were to handle the concentrated material, may be

appreciated by noting that the initial plan, prior to 1923 and based on convenience of distribution, rather than on safety, was that of dispensing the antiknock compound from small cans supplied to the operators of gasoline service stations. The continuation of this procedure would have subjected hundreds of thousands of service station attendants to a potentially severe and uncontrollable hazard.) Model equipment for mixing was designed (and further developed subsequently to limit the exposure of mixing personnel to almost negligible proportions) by the distributor of the antiknock compound, and the purchaser was required (by contract) to build and employ equipment based on a blue print of this model. Detailed instructions were issued for the mixing procedures and for the application of hygienic measures therein, and a regimen of technical supervision of the mixing plants and of medical selection and supervision of the mixing personnel (employees of the oil companies) was devised and carried out by the distributor of the product. The authority of the technical and medical staff of the distributor to supervise and regulate these operations was provided by contract. The nature of this regimen was such as to enable the distributor to ~~regulate the use of his product~~ follow his product to its destination and to regulate its handling in strict accordance with the hygienic provisions of his own medical advisors. Its effect was to achieve complete control of the occupational hazard. No case of tetraethyl lead poisoning has ever occurred in connection with these mixing operations in the United States and Canada, and it is believed that none have occurred in other countries in which this regimen has been followed consistently. (Documentary evidence is not sufficient to substantiate fully the latter part of this statement, but its essential accuracy is not in doubt.)

3. Special Situations and Supplementary Procedures .

(1) Gasoline Storage Tanks

An unanticipated hazard of serious proportions appeared within the refineries and storage plants of these oil companies after a few years of operation,

in that men engaged in cleaning and repairing large tanks (more than 1000 barrels in capacity) used for the storage of leaded gasoline were found to be subjected to hazardous exposure to tetraethyl lead and its decomposition products. The problem was investigated and adequate precautionary measures for the control of this hazard were developed and issued to all of the distributors of gasoline soon after the first difficulties occured. Afterwards, to the extent that these precautions were applied faithfully, no further cases of poisoning developed. It has been difficult, however, to achieve and maintain a general awareness of this hazard, and to ensure the application of the precautions at all outlying points of storage throughout the world, and especially in those under the control of military organizations. Frequent changes in military personnel, and the practice of farming out the maintenance jobs to contractors who may not understand the problem, plus the difficulties of access to some of these tanks, have been responsible for a number of serious casualties. Never the less, the distributors of lead-containing antiknock compounds have persevered in their efforts to inform and remind the appropriate persons in military circles concerning this matter. Such difficulties have not been limited strictly to military storage tanks. Because of the geographic scope and complexity of the distribution of leaded gasoline in the United States and Canada, the distributors of antiknock compounds have found it necessary to set up elaborate systems for exchanges of information and for on-the-spot consultation between their organizations and those of the oil companies, whereby the cleaning of gasoline storage tanks is supervised by trained personnel throughout the country.

(2) Operating manuals.

Another feature of the hygienic regimen in the varied operations of the tetraethyl lead industry, to which reference must be made for the sake of

completness, is the use of detailed operating manuals in which, generally, but not without exception, instructions for all operations are accompanied by instructions with respect to safety and health. These are put into the hands of the appropriate people and are used regularly both in instructing the new personnel and reminding more experienced persons. These manuals are reviewed from time to time and brought up-to-date. In this manner, a high degree of uniformity of instruction and performance is maintained. It is also the practice to reproduce certain essential operating procedures (such as those concerned with mixing operations, the cleaning of gasoline storage tanks, and the handling of concentrated antiknock compounds in research and testing laboratories) on placards, and to post the latter in convenient places for reference by the operators. Familiarity and compliance with the instructions in manuals and placards is reinforced by close supervision and periodic reindoctrination of all operating personnel.

(3) Consultation with occupational health authorities in areas of operation.

A still further procedure, which grew out of the considered policy of the American tetraethyl lead industry to conduct itself responsibly in its operations and in its informal relations with the United States Public Health Service in the absence of any specific legal regulations or legislative enactments in the United States, was that of informing the responsible authorities, in various other countries into which its product was to be introduced, of all of the hygienic facts and considerations that had come to light out of research and experience. One reason for this policy, no doubt, was the hope of avoiding legislative and regulatory provisions which might complicate international operations and provide serious obstacles to the establishment and maintenance of an essentially uniform program of

industrial hygiene. Probably, however, the principal virtue of such a policy in international commercial operations of an hazardous type, is that of offering full information and co-operation to responsible health authorities and seeking in return their advice and assistance in achieving the best results within their area of responsibility. Almost without exception this has been the outcome of interviews and exchanges of information with governmental authorities in countries outsidd the United States, and the results, in terms of a reasonably uniform international program of industrial medicine and hygiene, have been generally satisfactory. In a world of nations which have failed so signally to find common ground for applying their resources and skills to the basic needs of their peoples, it has been a refreshing experience to encounter reasonableness and willingness to help, singleness of purpose, and general freedom from personal and national prejudices among our own professional colleagues in relation to this international problem of occupational health. I would be negligent and ungracious were I to fail here to give testimony to this nucleus of international understanding and good will.

(4) Medical consultants in operating areas.

One other point may be worthy of brief mention in passing, because of its relevance to the policy and procedure referred to in the previous paragraph. It has been the practice of the American and British companies in this industry to seek out and engage the services of competent and reliable medical consultants in each of the countries in which their product is used. The duties of these consultants vary with their location and the extent of the operations within their area of responsibility. In general, however, these consultants have recognized competence in the field of occupational medicine in their own right, and are informed concerning the medical problems, policies and procedures of this industry. It is their function to act professionally for the industry in seeing that the laws and practices of their own country, as well as the requirements of the chief medical advisors of the industry,

are complied with, and that there is an adequate exchange of pertinent information. Through such a professional arrangement every reasonable provision is made for the instruction and medical supervision of those whose exposure to tetraethyl lead may be hazardous, for the attention of all concerned to their personal and occupational responsibilities, and for the maintenance of an hygienic regimen which for more than thirty years has demonstrated its adequacy when it is adhered to with persistence and understanding.

4. References

(1) Kehoe, Robert A., Thamann, Frederick, and Cholak, Jacob; An appraisal of the lead hazards associated with the distribution and use of gasoline containing tetraethyl lead. Part I; Jour. of Ind.Hyg., 16: 100-128, 1934; Part II. The occupational lead exposure of filling station attendants and garage mechanics. Jour. Ind.Hyg. and Toxicol., 18: 42-68, 1936.

(2) U.S. Dept. of Health, Education, and Welfare. Public Health Service. Public Health Aspects of Increasing Tetraethyl Lead Content in Motor Fuel. Public Health Service Publication No.712, Washington D.C. 1959