

REPORT ON A SURVEY OF VARIOUS FACILITIES OF ETHYL CORPORATION
FOR THE MANUFACTURE AND DISTRIBUTION OF LEAD ALKYL ANTIKNOCK COMPOUNDS

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INTRODUCTION

Sequence of Steps in Conduct of Survey

On February 12 and 13, 1968, Frank A. McCoy, Manager of Manufacturing and Distribution in Ethyl International, D. E. Park, Supervisor of Manufacturing Technical Services in Ethyl Corporation, K. C. Jost, Manager of Product Service and Safety in Ethyl Corporation, and Morris Shonfield of Ethyl Corporation of Canada, Ltd., met with me in Cincinnati, to discuss various matters relevant to the hygienic status of Ethyl Corporation in the United States of America and abroad, as a means of my reorientation within the affairs of the Corporation, in preparation for a general survey of its facilities. The conversations dealt primarily with actually and potentially hazardous conditions associated with present methods of manufacturing and handling alkyl lead compounds in commercial operations throughout the world. It went further, however, to some extent, in response to my questioning of the current attitudes of management and of personnel concerned with local areas, operations and problems, in both Ethyl Corporation and customer companies. Changes in operations and practices as compared with those of an earlier time, and the reasons for changing, were also discussed.

Since my earliest associations in Ethyl Corporation, I have regarded, with special concern, the problems of transportation and the handling of antiknock compounds in transit between manufacturers and their customers. The reason for my concern, which persists, lies in the obvious fact that the control of serious hazards by the manufacturer of lead antiknock compounds is distinctly and unavoidably

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attenuated when the products are in other and less knowledgeable and responsible hands. Therefore, I was especially intent upon learning about any changes in the type or intensity of the precautionary measures advocated and carried out by Ethyl Corporation in its operations.

The same attitude brought me to inquire into the present measures employed in maintaining a constant awareness within the petroleum industry of the hazards of cleaning gasoline storage tanks.

Other matters of policy, organizational structure and performance were discussed, and certain records and reports were made available afterward to enable me to appreciate the changes in various processes and procedures which have come about within domestic and international operations. With this preliminary information at hand, it seemed advisable to visit all of Ethyl's manufacturing plants and terminals, as well as some representative domestic mixing installations in customers' refineries, and to learn as much as possible through conversation with responsible personnel in various fields of operation. While the sequence of such visits was under consideration, it developed that consultation with governmental officials and representatives of the petroleum industry in Sweden and Germany appeared to be urgently required to reach some understanding of, and perhaps to assuage in some degree, a seemingly sudden and acute concern, among certain of the hygienic officials of these two countries, about a public threat thought to be involved in the discharge of lead from the exhausts of automobiles into the air of their cities and adjacent to their highways. This situation, which will not be dealt with in this report, resulted promptly in visits to these two countries, and in the initiation of this survey in Europe, rather than in the United States.

Specifically, the inquiry began in Brussels, in the European headquarters of ETHYL, S.A., presided over by W. J. Rusher. Talks with Mr. Rusher and some of

his associates preceded a trip to Ethyl's Terminal in Dordrecht, Holland, which had been the site, some months before, of a serious operating error which resulted in the spillage of concentrated antiknock compound into the sea at the dock.

Following this visit and a weekend return to London, the next several days were spent in Stockholm, Sweden, and in Bonn and Hamburg, Germany. On returning to London, a series of meetings arranged by Associated Octel Company, Ltd. with representatives of ETHYL, S.A., ETHYL CORPORATION (U.S.A.), and various units of the British petroleum industry, resulted in a fairly full discussion of the nature of the problem and the facts concerning it, and in the achievement of something approaching a consensus as to the position in Sweden and Germany, and what might be done about it by the petroleum industry within the country. (It does not appear that there has been any definitive governmental action in either of these countries, but whether the inactivity is real or only apparent, or what the factors may be that have appeared to bring about a lull in governmental activity, are matters that are open to question.)

Further pursuit of my primary mission took me to Thessaloniki, Greece, to visit the newly constructed plant for the manufacture of antiknock compounds containing either or both tetraethyl-and tetramethyl-lead.

On returning to London, a visit was made to the manufacturing facilities of Associated Octel in Cheshire, which while not a part of my original plan yielded useful information of relevance to my purpose. This concluded the European phase of the survey, although there were other aspects of the international operations in Europe that had been thought originally to be worthy of first-hand investigation. Among items omitted was that of a visit to a shipping terminal in (or near) Cadiz, Spain. Consultation with Mr. Rusher convinced me that there was no likelihood of my turning up anything of importance on making this trip. Likewise, it did not appear that anything worthy of the time and effort could be gained by hurried visits

to petroleum refineries in which facilities for mixing lead antiknock preparations with gasoline had been installed and were in operation--that is, anything beyond what could be learned of difficulties, operating incidents or other potentialities for trouble, through conversation with headquarter's staff, and through the examination of available reports. A matter of considerable concern to me, and, I think, to the Corporation, might have been clarified, to some extent, by a comprehensive coverage of petroleum refiners and refineries being supplied in part or in whole by Ethyl Corporation. Some direct familiarity with the attitude of mind of the responsible people in the refineries toward relevant matters of industrial hygiene and public health might have been very useful in determining what, if anything, should be done by Ethyl Corporation, as the leader in this world-wide industry, toward securing or maintaining an awareness of the necessity not only for an excellent brand of medical and hygienic performance within the industry, but also for a position of responsibility and trustworthiness vis a vis the hygienic authorities within their own provinces and countries. (It was apparent, for example, that the governmental authorities in Sweden and Germany had not turned to the petroleum industry in the first instance, and through them to the antiknock industry, for information about the hazards of their operations.) An effective relationship in such matters between government and industry can be expected to develop only where the industries concerned have examined their own hygienic problems with appropriate care and have demonstrated their capacity to cope with them and their willingness to provide reliable information concerning them. However, it did not appear to be wise or strictly in accord with my mandate to extend my inquiries to Ethyl's customers without authorization, even on a token basis. Moreover, a sampling of the viewpoint of only a few of the responsible persons in the petroleum industry could hardly be expected to yield reliable information, especially to a physician and potential critic on the outside of the petroleum industry. Therefore, this

idea was abandoned, but not without some regret, for reasons which will appear later in this report, in favor of a full discussion of the matter with representatives of Ethyl, S.A. and of the Associated Octel Company, Ltd.

Shortly after my return to the United States, arrangements were made to visit the manufacturing plants at Houston and Baton Rouge in the United States, as well as the headquarter offices of Ethyl Corporation of Canada in Toronto and the Canadian plant at Sarnia.

An effort was made, in connection with the visit to Dordrecht, Holland, and Houston, Texas, to observe the operations of one or more of the antiknock tank-ships of Ethyl Corporation and of Associated Octel Company engaged in the transportation of antiknock compounds in bulk to or from overseas manufacturing plants or terminals. It turned out that the scheduled arrivals of none of the ships coincided in time with my visits to any of the loading or unloading facilities, so that this objective was not achieved. This can be done, presumably, at some subsequent, convenient time, although there is no imperative reason for observing the operations of loading or unloading. There are, however, some matters of real concern that do not require my direct observation of the equipment of these, or of other vessels on which drums of antiknock compounds are transported. Comments on these matters will be made in the body of this report.

Despite repeated references to the personnel and facilities of the Associated Octel Company, Limited, above and hereafter, it is not to be supposed that the affairs of that Company and of Ethyl Corporation were lumped together indiscriminately in my discussions with representatives of either or both companies. My professional association with top management, as well as medical and hygienic representatives of Associated Octel, have existed almost as long as that with corresponding representatives of Ethyl. However, it has long been my practice to view the common medical and hygienic problems and performances of the two companies

in the light of their common hygienic objectives and the pertinent governmental relationships, while regarding their different commercial problems and policies, to the extent that they have been communicated to me for my own guidance, as entirely confidential. This has presented me with no troublesome or contradictory responsibilities. It has also been the practice of the management of the several British organizations of which the Associated Octel Company, Ltd. is the successor, to arrange for me, at their expense, European transportation and hotel accommodations in connection with my activities as a medical consultant in matters which fall, clearly, within the common hygienic orbits of the two companies. I saw no reason for refusing to accept this whole-hearted courtesy on this occasion, since it was a great convenience to me, as well as, in my view, an appropriate sharing of the expense of a professional service which was designed to promote occupational and public health without regard to any specific commercial interest. Mention is made of this matter because it seems to be a pertinent, although relatively unimportant, item of information, and also because the source of the compensation of even a strictly professional consultant, as well as that of the reimbursement of his traveling expense, is viewed critically in certain circles.

THE SURVEY. OBSERVATIONS AND COMMENTS

The Terminal at Dordrecht

The visit to this terminal involved an inspection of the facilities, and an inquiry into any further difficulties, if any, associated with an operating error which resulted in discharging overboard at the dock some quantity of the antiknock cargo of Ethyl's tank-ship, from Houston, which was being unloaded into storage facilities at the terminal. The details of this unfortunate incident had been made available to me by George Roush, M.D., Medical Director of Ethyl Corporation following his hurried trip to this terminal some months ago. There had been no

further official or other reverberations of the spillage of Ethyl antiknock compound into the waters at the docksite. The examination of samples taken from the bottom of the dredged out canal in the area of the spillage indicated that the volume of the spilled antiknock compound was much smaller than it had been thought to be, and was too small, in all likelihood, to create a serious hazard. Nevertheless, due consideration is to be given to the possibility of encountering hazardous conditions when the canal is dredged on the next occasion.

The facilities of the terminal appeared to be adequate in all respects, as were the provisions for the safe performance of all of the operations. It is not to be supposed that my inspection of the terminal was carried out critically from the aspect of mechanical engineering, but rather from a degree of familiarity with certain safety devices and with the requirements in personnel protective equipment. The real issues that confront one at this and similar installations is the effectiveness of the original and subsequent indoctrination of the operators in the performance of their duties, and the extent to which equipment and operations have been designed for the avoidance of any and all operating errors. It is hardly possible to make an appraisal of either of these matters in the course of a brief visit during which the operations cannot be observed. There was no reason, however, to suspect that there might be faults in the equipment or in the performance of the operators of the terminal. (Unfortunately, nothing has been done, it seems, to prevent the recurrence of the error on shipboard that was responsible for the previous incident. In fact a similar error was made later on the same ship, but was noted before there were notable consequences. One wonders whether a rearrangement of valves or other operating equipment on the ship, might aid in avoiding such errors.) No evidence of any type of disorder was observed on premises; everything was "spic and span," and every item of needed equipment appeared to be available.

A meeting with the owners of the jetty and the operators of the Terminal,

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at an extremely pleasant luncheon, may have been simply a courteous and generous bit of hospitality, but it appeared, perhaps under the influence of genial hosts, well augmented by excellent food and drink, to be somewhat more--an expression of a sincere interest in this working relationship on the part of the owners of this dock.

A printed Manual of procedures and instructions concerned with the operations of Ethyl's tank-ship, the Eid, and a corresponding Manual relating to the operations at the Dordrecht Terminal have provided the additional information required to visualize the performance expected of these facilities. The Manuals appear to be complete and adequate in all respects, giving the impression, within the limits of my capacity to judge them, of efficient schemes of operation.

An additional set of formal instructions to the drivers of highway tank-trucks for the delivery of antiknock compounds from the Terminal to customers was provided for my examination. This appeared to cover all of the requirements for the safe transportation of the product, provided accidents on the highway can be avoided. In discussing with Mr. Rusher the difficulties encountered in the transportation of antiknock compounds in tank-trucks from this Terminal, it developed that several trips had been made to points as far from the Terminal as southern Spain. I had thought that it had been a point of fixed policy within the Corporation to limit such deliveries by tank-trucks to relatively short hauls of a type that would permit avoidance of congested areas and heavy vehicular traffic. The trips to Spain struck me as being such a departure from wise policy as to be very nearly foolhardy, and it was with great relief that I learned that they had been discontinued in favor of the establishment of another terminal at Cadiz, Spain. This did not come about, however, until two serious and costly accidents had occurred en route. There should be no further need, I believe, so far as Ethyl, S.A. is concerned, for proof of the unwisdom of the use of such transport facilities for

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long trips. While it is clear that supplies of antiknock compounds may be employed advantageously in certain remote areas of the world, and that they may be transported economically by tank-trucks, if the construction of expensive terminals can be limited, there may well be situations in which this method of transportation cannot be employed safely under the conditions that exist at the time the issue arises. When such is the case, no action should be taken until or unless a more suitable means is at hand. It does not seem to be necessary or wise to jeopardize human lives, as well as the life of an industry, by undertaking an unduly hazardous operation. Nor is it sensible or realistic to conclude that if Ethyl Corporation does not act in such a matter, some competitor will do so; or that Ethyl can carry out an undesirable procedure better and more responsibly, than can its competitors. As to the first of these assumptions, even if it should be true, it is not incumbent upon Ethyl Corporation to act irresponsibly because one of its competitors may be induced to do so. The second assumption can hardly be used as a good defense in the event of a serious accident, while the possibility of "getting by" an imponderable risk is no basis for considered and wise policy. This matter is mentioned because both of these arguments have been advanced, in my hearing, in the past, and because only top management could be expected to take the opposite position with the authority to see it through. The importance of the matter lies in the fact that there have been a number of near disasters in connection with this type of transportation, and one cannot always count on the avoidance of extensive and lurid publicity when disaster (or near disaster) comes. The present period is one in which any such publicity, without regard to its irrelevance as an issue of public hazard, might well precipitate unwise, irreversible governmental regulations or highly damaging legislation.

Some discussion of further problems associated with the transportation of antiknock compounds, especially, but not exclusively, to foreign ports and terminals, in tank ships owned by the manufacturer, or in drums loaded upon other cargo vessels,

as these have been revealed by a number of tragic incidents in recent years, is reserved for presentation later in this report, so as to maintain the continuity of the observations of the survey.

The Manufacturing Plants

1. The Plant in Thessaloniki, Greece.

This, the most recent facility constructed by Ethyl Corporation for the manufacture of tetraethyllead, tetramethyllead and of certain other ingredients of various formulations of lead-containing antiknock compounds, was visited at a time when the springtime had just come to northern Greece. This is mentioned for the reason that the bright open weather affected the attitude of people in the plant and that of the visitor to the area, especially after the rigors of the northern European weather. It was a pleasant time and place, the manager and his associates were in good spirits, the plant had emerged from certain initial difficulties and was operating well, and there was no apparent threat of danger or of impending illness among the employees. The lack of serious operating difficulties at this time contrasted strikingly with the experience of another recently constructed plant with which I was familiar, and so impressed me very favorably. In any case, I came to the conclusion that the plant was operating very well indeed, that Mr. Diederick and his associates had done an extremely good job in getting this plant underway and even in indoctrinating a group of Greek workmen (whom I might have expected to find extremely resistant to such efforts) into a fairly effective operating crew.

My inspection of the plant convinced me of the satisfactory character of the current operations, with two exceptions. One of these was encountered in the blender at the booth for filling drums with finished antiknock compounds. The drumming facilities were of a familiar type, which should not have subjected an efficient operator appreciably to the inhalation of the vaporized ingredients of antiknock fluids. The operator, nevertheless, wore a mask continuously. The explanation offered was

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that this man could not be instructed or induced to adopt a technique which would enable him to avoid such exposure. One may presume that the respiratory protection was a satisfactory substitute for precautionary technique, but the failure of discipline or, perhaps, of understanding, presents an issue which may be inherently significant among other employees, involving as it does a "makeshift" solution which, while it may be effective in the specific instance, poses the likelihood of the existence of similar failures elsewhere that may not be open to prompt recognition and correction. Somewhat subtle inquiry along this line brought out some indication of persistent difficulties of this type elsewhere in the plant. It may be that my anticipation of this difficulty, through some (slight) familiarity with the personal characteristics of these somewhat extroverted and proud people, was father to the suspicion that real difficulty was to be found. In any case, this is something for supervision to look out for and, therefore, it seems likely that a fairly high concentration of supervisory activities should be maintained at this plant for some time to come.

The unsatisfactory qualities of the other faulty operation in this plant are common, with slight differences, to all of the plants in which lead alkyls are produced. This operation is the recovery of lead from the manufacturing process. The disposal of sludge from the stills, along with certain other materials from other processes, has always been a crude operation, perhaps inevitably so because of the nature of the materials dealt with, but nevertheless, by comparison with the other operations in the manufacture of these products, a crude, rugged and dirty operation which thus far has baffled all technical efforts made to rectify it. Improvements have been made in dealing with the sludge pits, the sludge dryer, the furnaces, the stacks and their appurtenances, and the slag, but the process has remained unchanged in its essentials. The wear and tear on the equipment and on the structures of the building in which it is housed are very severe. The concrete (supplemented here and there by steel) floors become broken and pitted to a degree that prevents adequate housekeeping

by appropriate means. This and numerous other factors promote the gross contamination of the area in which the operators work, spreading the contamination throughout this area, into the neighboring areas of the plant, and into its surroundings. The operators have always given physiological (analytical) evidence of a relatively high level of lead absorption. The expenditures for replacements and maintenance of the equipment of this group of operations have been large and will continue so and become even larger in view of the pressure brought to bear on industry to reduce environmental air pollution. A novice, in the technologic sense, can hardly be expected to offer any ideas or even questionable suggestions for the replacement of this entire process by one that would achieve an improvement comparable to that of the replacement of the processes previously involved in producing alloy by those presently employed. If there is any hope, whatever, of devising a different and better process, it would seem well worthwhile to expend modest funds and technical personnel in the exploration of ideas along this line.

In any case, the furnace area in a new plant which, presumably, is the last word in the manufacturing facilities and techniques for the production of a moderate volume of lead alkyls (in a wide-open area where general atmospheric contamination is not now a matter of crucial significance), was in poor condition. The housekeeping, whether because of unusual circumstances, at the time of my visit, had been neglected, and the opportunities for exposure of the operating personnel to lead resembled those in one of the plants that had been in operation for many years. The contrast between these conditions in the furnace area and those in other parts of this plant was much too obvious to escape notice; it was, indeed, a dramatic representation of the relative crudity of this portion of the general manufacturing technique.

(Something will be said later, in connection with locations where it will be more apt and timely, about the provision of equipment and process for the limitation of the pollution of the general atmosphere and the waters of a community

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(or area) with lead discharged from these manufacturing operations. It is not too early in this discussion to raise this issue as a part of the plans and specifications of future manufacturing plants at home and abroad. The necessity for the control of industrial (and other) pollution of the air and water supplies of this country is with us to stay, and it seems likely, as a generalization to which there may well be exceptions, that the control of industrial air and water pollution can be built into the design of new manufacturing plants so as to achieve both efficiency and economy, while avoiding the necessity for "crash" measures in response to mandatory legislation or official regulation.)

An inspection of the facilities of the shipping dock at this plant raised no doubt in my mind as to their adequacy.

The report of the visit to this plant would not be complete or realistic without some reference to its medical services. One of my most gratifying experiences was the recognition of the great good fortune incurred by Ethyl Hellas by the availability of Dr. Sotiris G. Falsis as its plant physician. Dr. Falsis has assumed the responsibilities of his position in the manner of a truly competent physician. He went about the presentation of the medical status of the operating personnel like a veteran, and documented his views with the clinical and analytical evidence in a thorough manner. While making it quite clear that he was open to advice and to different interpretations of the data than those which he had made, he was, quite clearly, the responsible advisor of the management of the plant. His relationship to the management and to the general personnel of the plant appeared to be excellent, and in every other way I was convinced that the medical affairs of this plant are in excellent hands. Only once, previously, have I encountered such a wholly satisfactory physician in a foreign industrial organization, outside of England where this type of professional relationship has existed and been well understood, within certain medical circles, for many years.

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An unusual feature of the work of Dr. Falsis is that of his development of an analytical facility, within the medical service, for monitoring the urinary excretion of lead by the employees of the plant. Numerous difficulties, including a prolonged and crippling delay in obtaining the analytical results, were caused by a temporary resort to the Kettering Laboratory for the analytical work. Meanwhile, exploration of the feasibility of making use of an analytical facility in the University of Thessaloniki failed to pave the way for such a development. Thereupon Dr. Falsis set up an analytical laboratory in the medical facility of the plant, trained a technical assistant to carry out the analyses under his supervision, and through cross-checking with the Kettering Laboratory demonstrated the satisfactory quality of the analytical work. No doubt further cross-checking will be required to maintain the assurance of accuracy in this work, but a most troublesome problem has been solved, at least for the present, by this forthright assumption of responsibility by Dr. Falsis.

At the time of my visit, the hygienic status of the workmen, as revealed by the investigation of the rates of their excretion of lead in their urine, was satisfactory. There had been a fairly rapid increase in the rate of excretion among certain of the employees in indication of their increased exposure to and absorption of lead. In no instance had it reached threatening proportions, but because of the relatively brief period of operation of this plant, one could not be certain that this increase had reached its peak as an expression of the individual and combined opportunities for exposure to lead in all of the areas of operation of the plant. I saw nothing in the environmental situation to justify any great concern in this matter, but was aware of the unreliability of observations made during a single, brief visit in an appraisal of the potential hazards of the operations. This question must remain open for a time. I have asked Dr. Falsis to supply me with his next set of analytical findings, so that I can see for myself any trend that appears in them.

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(I would suppose that the responsibilities of Dr. Falsis to me in this matter are negligible after the completion of my survey of the Greek plant, and that he may have his own reasons for keeping his own counsel or for following the wishes of the management of Ethyl Hellas. I doubt that any such conventional issues have arisen, but I have no intention of repeating my request for additional information.)

2. The Manufacturing Plant in Houston, Texas.

The visit to this manufacturing plant, on May 22 and 23, was high-lighted by two highly rewarding events, apart from the main purpose of observing the conditions associated with the manufacture of antiknock compounds. One of these was an evening meeting and dinner with Mr. Hudgins and his staff, the sequel to a similar smaller meeting that afternoon, in which a serious but largely one-sided discussion of the problems to be met and the responsibilities involved, along with the challenging of the obvious capabilities of the group to solve the problems. My talk was designed, simply and earnestly, to dispel any complacency that might exist in relation to the present conditions and performance in the plant, while at the same time displaying complete confidence in the willingness and ability of this technical group to recognize, appraise and deal with them effectively. My role was strictly that of a critic, not an advisor as to the specific methods of approach, the "know-how" here being in their province. It was my impression, hopefully not autocatalysed, that the response to my words, in the discussions that ensued, was serious and deep-seated. My only reason for remarking on this meeting and on the dinner meeting (which in some respects, while being a social occasion, was really a continuation of the spirit of that of the afternoon session), lies in the further impression that I gained from it, that it was an highly unusual experience for this group. It seems to me that this should not be the case, but that similar meetings and frank discussions between medical and technical personnel in the Corporation, should be of reasonably frequent, although not necessarily or even desirably, of routine occurrence. I shall refer

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again to this matter, but there is considerable evidence of an ebb and flow of real concern about vital matters of industrial hygiene in the organizations of the manufacturing plants. Conditions which contribute to the absorption of lead by the operators are, I believe, permitted to develop and persist until the numbers of "restricted" workmen have increased threateningly, whereupon a concerted effort is made to counteract the trend. This is, of course, a common human performance, but it is not a good performance, and I do not believe it is an inevitable one. It is a function of physicians in industry to be somewhat of a conscience, and somewhat less objectionable than a gadfly, within the organization. This is not a romantic notion, but is a fact of life, and when this function is exercised with dignity and honesty, that is, in a manner that springs from special knowledge and evidence rather than emotionalism, it can serve to maintain good performance in preference to restoring it after it has lapsed.

A second experience at Houston, which excited my interest greatly, was that of learning something of the background and the potentialities of the new facility for the manufacture of certain alcohols of relatively high molecular weight. Dr. Leo Kingrea first introduced me to the chemistry of the processes with an exciting and contagious enthusiasm, after which I was taken through the manufacturing facilities

Prior to the trip through the alcohol plant, which was of an unexpected dividend, the facilities for the manufacture of tetraethyllead for the blending of antiknock compounds, for the storage of the compounds (including those based on tetramethyllead which are transported in tank cars from Baton Rouge for intermediate storage and subsequent shipment overseas), had been examined in detail. The hygienic status of the plant over the period of several years to the present time was also reviewed with Dr. Burdick. This included the examination of the results of the air analyses and the monitoring of individual workmen and the occupational groups, the records of the restrictions put on workmen in the past and at present.

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The conditions in the buildings, and in the operation of equipment, together with the analytical data of the air within the buildings and of the urine (and blood) of the operators, provided little reason for concern. None of the employees was on the "restricted" list at the moment, the restrictions of the past having been lifted, without others being made to replace them.

There had been a relatively unsatisfactory record in the past--evidence of undue contamination of the air of certain operating areas, notably the third and fourth floors of the tetraethyllead building. Concerted efforts had brought about improvement, and the record had been reversed. One could not be sure, however, whether the corrective measures had gone far enough and with such thoroughness as to achieve their purpose, or whether certain difficulties were now recurring with some relaxation of effort. There were signs, here and there, of less than satisfactory maintenance of operating equipment. A faint, but unmistakable, odor of tetraethyllead was detected on entering the third and fourth floors and was noted also opposite certain autoclaves and stills. Whether this was unusual or frequent was not determined, but did not appear to be a matter of great concern, and whether it resulted from unusual leaks or from faults of ventilation was uncertain. At any rate, the condition was real. A minor operating fault was observed, in that most of the hinged covers on the open side of the housing of the agitators of the stills had been left wide open during the operation of the still.

Reference was made, in passing through the building, to a policy of ignoring defects in the external coverage of equipment with paint on the basis that these had to do with appearances only and not to deficiencies in the adequacy or the preservation of equipment. A question was raised concerning the effect of the continuation of this policy upon the attitude of workmen toward the meticulous maintenance of equipment in ways that definitely affect the contamination of the atmosphere of the work areas. It is a good question, and there is real doubt as to the correct answer.

As a generalization, one may hold that housekeeping is an essential part of careful operation, and that any type of seeming negligence in matters of appearance is bound to affect the attitude of persons who have been accustomed to faultless appearance, toward hazardous as well as merely unsightly conditions. It may be that a precise and regularly applied technique for seeking out and identifying defects in equipment which result in leaks, would differentiate between mere appearance and significant fault. It is with this idea in mind, plus the recognition of the fact that technical evidence is preferable to assumption, that I welcome the acquisition at Houston of a leak-testing device which is being used effectively at the Baton Rouge plant. I must confess, however, to having been impressed adversely by the unsightly appearance of operating equipment and ductwork from which the paint had flaked off in large and small irregular patches. I am not prepared to condemn a policy of economy in such a matter, but I doubt its wisdom unless it is offset by a technique that will eliminate the likelihood of negligence in matters of importance. The adoption of a systematic program of lead detection, scheduled so as to accord with the facts as they relate to the operating efficiency of various items of vulnerable equipment, would go far, I believe, toward the elimination of guesswork and supported impressions, in connection with operations which should be carried out as nearly perfectly as possible.

The automatic equipment for filling and moving alloy hoppers appeared to be a major improvement in these operations. The noise associated with one phase of this operation seemed excessive, and despite the fact that it is inconstant in an area in which very few people will be subjected to exposure, it should be investigated and, if necessary, reduced.

The contamination of the hoppers with the vapor of tetraethyllead displaced from the stills, and that derived from the oiled slide valves of the hoppers, are lesser problems in Houston than in plants in which tetramethyllead is manufactured, but it may well be significant.

The furnace area in this plant was in better condition (at the time of my

visit) than it ^{has been} ~~was~~ found to be in other plants. The slag pits, however, were not similarly unobjectionable in appearance, although there was no noteworthy evidence of significant environmental contamination with dry lead-bearing substances to be readily dispersed into the air. The furnace stacks in this plant, in keeping with the pressure being exerted now by local authorities for the control of air pollution, were relatively free of significant emissions. This was attributed to recently installed, improved equipment for the removal of particulate material from the furnace effluents. The use of this equipment in the Houston plant will serve to demonstrate the extent of the overall benefit to be achieved in this manner.

One very real and highly objectionable feature of the general situation at Houston is that of settling basins (if that is the proper term) into which a variety of odoriferous materials, including lead-containing wastes, find their way. I am not as clear as I should be on whether these so-called basins exist by chance (as depressions in which drainage accumulates) or by design. In any case, they are unsightly, if in no other sense than that they represent disorder, as well as rank sources of unpleasant, if not hazardous, vapors (questionable qualitatively and quantitatively), and they should be cleaned out and replaced by such a facility as may be required (if any) for impounding liquid wastes. This may not be urgent from the aspect of hazard, but I would be easier in mind if the facts in this regard were ascertained by analyses of the air in their vicinity.

One other environmental factor in the local situation should be mentioned. I have spoken previously of the advisability of moving, with such speed as would accord with reasonable economy in situations that are not urgent immediately, into the development and application of equipment for the containment of atmospheric contaminants within the confines of the plants. A local official responsible for the control of air pollution has remarked upon the paradox of a company that has performed remarkably well in most matters of industrial and environmental hygiene while permitting the gross discharge, from time to time, of contaminants, in the

form of the entire volume of the reaction mass within operating equipment, into the immediate environs of the plant and its employees. Viewed in this manner, this is indeed a paradox, and one that is not likely to be ignored by governmental authorities who are attacking much less significant hazards. There is little doubt that the regulation of emissions of this type is in the offing, and that a plan of action should be devised and implemented, to anticipate such regulation and the deadline for its fulfillment which is the usual accompaniment of such regulation. This is more likely to occur in Houston than it is elsewhere, although the need for it is considerably greater in Baton Rouge.

3. The Plant in Baton Rouge, Louisiana.

The visit to this plant was made on May 29, 30 and 31, with an additional visit to Texaco's Convent Refinery on the afternoon of May 29.

Again, discussions with members of Mr. Bergin's staff in two meetings at the plant, and a dinner meeting at the City Club in Baton Rouge (at which, Mr. Armstrong was host) were high-lights of the visit from the aspect of interchanges of information and viewpoints on the local situation, and on more general problems in the domestic and foreign scenes. Furthermore, from the aspect of my acquaintance with a younger group of technical men in the Corporation, as well as from that of the renewal of older associations, these were highly agreeable and refreshing experiences.

A cursory survey of the entire plant was made by car, in order to visualize the layout and the relationships of the various areas to each other, after which attention was concentrated on the building in which tetramethyllead is being manufactured. This building, in which the escape of vapors from operating equipment was magnified with the initiation of the manufacture of tetramethyllead, is the site of systematic alterations in the ventilation (and in certain other equipment) following a survey of the conditions by Melvin W. First, Sc.D. of the faculty of the

Harvard School of Public Health, whose report and recommendations I have examined carefully. This survey and report have altered the approach to the problems of industrial hygiene in this plant, as these derive from the manufacture of the lead alkyls, in a very fundamental manner, and so has altered this report. Dr. First's visit and advice have initiated a systematic investigation of the underlying factors that have been a source of trouble in the plant since the inauguration of the program for the manufacture of tetramethyllead. His influence has extended even deeper into the general problems, especially those of ventilation, which relate to all of the operations in all of the plants in which the lead alkyls are being manufactured. Two approaches to these problems are being developed; both have been employed previously but not so systematically or so effectively; they are (1) improvements in the techniques of ventilation, and (2) identification and appraisal of sources of leakage from operating equipment, by means of a satisfactory analytical device. The additional severity of the contamination of the atmosphere induced by the necessity of dealing with the more volatile tetramethyllead has made it essential to increase the efficiency of the mechanisms of control, and to concentrate the necessary technique and effort toward this end. Dr. First has succeeded, through his wealth of experience and his articulate presentation of his ideas, in catalysing the capabilities of the group assigned to this effort in the Baton Rouge Plant, and I have complete confidence in the outcome of these efforts. The real hurdle has been to focus the necessary attention on the task, and Dr. First has demonstrated that it is worthy of this attention. It would be the height of futility on my part to speak of shortcomings in the procedures of industrial hygiene that have existed in this plant presently or in the past. These are now being examined and determined beyond anyone's prior knowledge of their sites and significance. What is important at this stage in the pursuance of Dr. First's advice, is the development and maturation of a systematic program for the detection of the escape of the lead alkyls into the air of the manufacturing areas, and for the further application of

appropriate techniques for the prevention of leaks, so far as possible, and for the utilization of ventilation that will control the hazards associated with unavoidable types of contamination of the air. The extension of this mature program into the other manufacturing plants should follow in due course, in accordance with need. I would make the additional suggestion that, at an appropriate time, Dr. First should be invited to return to Baton Rouge to review the results of the application of his advice and to report thereon.

It is obvious that the same type of effort as that described above, should be applied throughout the area in which the alkyl lead compounds (especially tetramethyllead) are being handled. The timing and the intensity of the effort may well depend upon the apparent urgency of the situation, but the application of the results of the present investigation should be extended to all areas in which they are applicable.

Dr. First recommended the extension of his own efforts, by proxy, through the acquisition by the Corporation of a full-time professionally trained industrial hygiene engineer. I may have something to say about this later, but it may be pertinent, at this point in my report, to point out some of the difficulties involved in following this recommendation. First and foremost among these, is that of finding a person of such scientific ambivalence, on the one hand, and of such technical competence, on the other, as to obtain and maintain the respect and enthusiastic cooperation of the group of technically trained persons who are now involved in this program. Second is the necessity of staffing other plants of Ethyl Corporation similarly, if they are to be essentially autonomous organizations, or of setting up a unified organization that will operate throughout the Corporation. In times past, I found it possible, over a prolonged period, to obtain the willing advice and services of able technical men in various parts of the organization of the Corporation, to bring their knowledge and influence to bear on various problems

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that arose, and to maintain cross currents of consultation and advice. Perhaps the time has come when this procedure will no longer work, and when industrial hygiene in the several units of the Corporation should be organized into a single continuing service concentrated solely on this function. This matter should be given careful consideration, if anything is to be done about it, so as to affect a satisfactory function rather than a local makeshift. Any such program should be integrated thoroughly into or in professional association with the medical functions, in which precisely the same set of organizational problems exist. There are certain virtues, no doubt, in autonomous units, such as manufacturing plants, in a large industry. There is, however, little virtue and much of vice, in autonomous units of a medical and hygienic function in an industry, even one composed of multiple, similar units. There are notable examples of both types of organization in American industry, at present, from which much has been learned (within the professions). There should be but one medical and hygienic policy, and there should be a chief medical and hygienic authority, answerable to a top executive, with a staff position that enables him to express and apply general company policy. Such policy should come about not out of the vagaries of individual experience, but from the considered judgments that stem from mature appraisal of our society and of industry's place in it, by those responsible for the conduct of the business of the company in accordance with law and the national welfare.

Inspection of the alloy and furnace areas disclosed nothing of striking importance beyond the apparent advantages associated with the automatic filling and handling of the hoppers. A heightening of the contamination of the hoppers in service in the manufacture of tetramethyllead presents a problem that is not altogether easy of solution. The areas through which such hoppers are conveyed, including the elevators in which they are hoisted, and the basement aisle in the manufacturing buildings, are subjected to appreciable contamination (which requires additional ventilation).

It is apparent that the contamination of the air in the lead area, derived from a variety of sources, including the effluents from the furnace stacks, compromises the cleanliness of the air which enters the buildings, so that at times the air contains half as much lead as is regarded as permissible within the buildings. (Following disk ruptures, the air taken into an individual building may exceed the generally acceptable limit in its lead content.) It is evident, therefore, that a well maintained reduction of the emission of lead from the furnace stacks must be achieved, and that it will be necessary ultimately to contain the lead compounds discharged into the air when the safety disks of operating vessels are ruptured.

Other areas of the plant were entered for at least cursory observation. These include the sodium production area and the general shop of the lead area. No special comment need be made concerning them.

The plant for the production of polyvinylchloride resins was inspected with considerable interest generally, and with specific interest in the development of a mechanical means for cleaning the reaction vessels in which the main product is manufactured so that entry into them for manual cleaning can be avoided. The occurrence of injury to the hands of men who have performed manual cleaning has made the development of such equipment highly desirable.

4. Visitation of Ethyl Corporation of Canada, Limited.

In view of the interval of several years since my last trip to the headquarters of the Canadian company, and in acceptance of the invitation of President Alan Tully, seconded by Douglas Warren, M.D., Medical Consultant, I visited Toronto on June 17. Some general discussions with Mr. Tully and members of his staff were followed, in the afternoon, by a visit to the offices of the provincial (Ontario) officers responsible for occupational health, as arranged by Dr. Warren. Later, I met with a group of physicians and managers from certain local lead-using industries, who had been invited by the head of the occupational health service of the Province

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to attend a talk (by me) on lead absorption and lead poisoning and to raise such questions, afterward, as they might choose. I had not been informed in advance of this arrangement, and it was just as well that I had not, since it was the purpose of the chief of the service to impress upon some of these people the error of their ways, and the need for proper measures of industrial hygiene. (The problems of Canada in this regard are like those in the United States, in dealing with entrepreneurs and companies that produce "secondary" lead, by reclamation from scrapped storage batteries, cables and from other sources, such as lead-containing slag and scrap metal from a variety of industrial operations. The latter type of smelting is notorious throughout the world for the crudeness of its technical and hygienic facilities, and is one of the most outstanding sources, currently, of occupational lead poisoning.) More or less unwittingly, I supplied the lesson and the pertinent advice, to the very considerable satisfaction of the chief. My point in mentioning this incident, in relation to Ethyl of Canada, is that of calling attention to the familiarity of this governmental agency with the conduct of Ethyl's hygienic affairs over the years (including our initial and subsequent interviews with Grant Cunningham, M.D., now retired, who was formerly in charge of the work of this division of the Provincial Health Department, concerning the hygienic problems and purposes of the Corporation). Some regulatory and legislative efforts are being made in the Province of Ontario, without, as usual, the familiarity with current methods of operation and control, so that this provided an opportunity for an exchange of views and ideas concerning appropriate techniques and the feasibility of carrying out certain proposed regulations, and for providing some documentary information.

Early on the next morning, June 18, Dr. Warren and I flew to Sarnia, and visited the manufacturing plant on that and the following day (until 11:30 a.m.), when Mr. Mills took me to the airport in Detroit.

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There is very little that need be said of this plant. This state of affairs is due, in part, to the modest size (volume of production) of the plant, and in part to the care that has been exercised in its operation, under the considerable and beneficial influence of Dr. Warren (who was responsible for its medical services until recently, when he entered the faculty of the Medical School of the University of Toronto, to develop its facilities in Occupational Medicine, and has continued since as its Medical Consultant). The common hygienic problems of the industry are readily visualized in this plant. They have been reasonably well controlled by current conventional techniques in the hands of effective management and technical services, and by competent medical supervision. Since Dr. Warren's resignation as chief medical officer, the routine medical services have been provided by Drs. David Duncan and Robert Pritchard, both of whom are engaged in private medical practice, while supplementing each other's efforts (Dr. Duncan is the regular attendant) in providing adequate service to the plant. There are no current cases of "restricted" employment in the plant. The same type of problems of environmental air and water pollution exist in connection with the operation of this plant as in those in the United States, and while these are not matters of quite as much immediate concern in Canada as in the States, they may become so very soon. Therefore, the extension of the most effective procedures of control to the Canadian plant, insofar as this has not been anticipated and done, is a logical expectation. One of these problems, while not acute, is nevertheless in evidence now--namely, that of the emissions from the furnace stacks. This is not a serious problem at present, in view of the situation and the surroundings of the plant, but it is a significant one.

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The Operations of Ethyl Corporation and Its Foreign Subsidiaries or Affiliates in Relation to Customer Companies and the Problems Arising out of the Distribution and Use of Alkyl Lead Antiknock Compounds and of Gasoline Containing These Compounds

The foregoing heading is much more elaborate and seemingly much more impressive than is the information which will appear under it. The purpose of the heading is to lay out the area of the operations and to bring together for recognition a series of potential hazards to the health and safety of a considerable number and variety of persons. It will not be possible in this report to say anything new or important about these hazards. Very little has been learned, through this survey, of their significance. Questions have been raised, but few answers have been obtained. I shall attempt to formulate the questions in such a manner that they may suggest possible avenues for inquiry into more facts and more reliable information.

1. The Transportation of Ethyl Antiknock Compounds.

Certain specific aspects of this general problem have been discussed previously and need not be repeated here, except, perhaps, in passing. It is important, I think, to recognize that the problems of transportation have been altered considerably, over the years, first, chronologically, by the necessities of transporting the products beyond the shorelines of North America and hence by ship. This came about at a time when all antiknock compounds were packaged in drums, and it introduced certain hazards that have materialized infrequently yet expensively and tragically, not only in connection with the products of Ethyl Corporation but also ~~that~~ of its competitors. A great deal of expert attention has been given to the location and the secure confinement of drums of antiknock fluid in their proper place on shipboard, and to their manner of storage and handling at terminal ports, customers' docks and Ethyl's terminals. Nevertheless, especially during the war, drums of fluid have been carried with other cargo under conditions that resulted in the contamination of the holds of ships (where they should never be placed, but

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have been on orders of the masters of ships) and of the cargo as well. Drums have been torn loose from their lashings in storms at sea, and broken open, to contaminate decks, holds and cargo. They have been perforated by gunfire, and they have been landed unannounced at the nearest ports in storms or other emergencies, where there were no facilities for storing or handling them. There have been occasions on which costly cargoes have been contaminated and destroyed, and costly procedures of decontamination have been required. A number of gross errors in their handling have resulted in illnesses and fatalities, and in more or less futile (after the fact) but costly trips, in emergency, by technical and medical personnel, in order to prevent such tragedies or to do what could be done to limit their consequences.

A second development came about when the volume of antiknock compounds used by specific oil companies at specific refineries reached such proportions that bulk storage of antiknock compounds became both feasible and mandatory. Bulk shipping in rail tank-cars and road tank-trucks became logical procedures (the latter for short hauls, considering the many hazards of highway and city traffic), to the accompaniment of the involvement of rail tank-cars in wrecks and fires and of a few comparatively minor accidents to tank-trucks in transit, (until recently, when more serious ones occurred abroad).

Bulk shipments on this continent led inevitably to bulk transportation of Ethyl antiknock compounds beyond its shores, by sea-train and in commercial vessels, and later in tank-ships designed for that specific purpose. These methods of transportation required, or seemed to require, a delegation of responsibility for the disposition and handling of drums on shipboard to the carriers and ultimately to the masters of their ships. Bulk shipments by sea, likewise, are made in vessels designed, so far as cargo and its handling are concerned, and owned by Ethyl Corporation, but operated by commercial shipping companies. Here too, the master of the ship, ultimately, is the responsible person, with such capability for the purpose as may happen to

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have developed out of his character and experience. Detailed indoctrination and written instructions are provided for the guidance of those in charge, but no representative of Ethyl is on hand at crucial times with the authority to act for the Corporation.

A third development came with the advent of competition in the United States, which was soon extended into the foreign field.* The principal variant introduced thereby into the quality of the hygienic regimen developed by Ethyl Corporation was the initial attenuation of the previously unshared relationships between Ethyl Corporation and its customers, associated with the insinuation of competitive commercial considerations into hitherto undiluted hygienic issues. With these developments, and the later intrusion, speaking in hygienic terms, of other competitors at home and abroad, the principles and practices of the Corporation in matters of health and safety suffered severe depreciation. The general concept concerning these matters, at present, is that the original regimen became unnecessary. The facts are, however, that it could not be made to operate under the competitive commercial conditions that existed, and that it was reduced to such an extent that an optimistic (unduly optimistic in my view) dependence now rests on the previously established attitudes and practices developed within the organizations of customers, and upon the conventional use of equipment designed especially for the purposes of moving alkyl lead antiknock compounds.

2. Operation of Mixing Installations in Refineries.

What has been said above, with reference to the attenuation of the medical and hygienic services of Ethyl Corporation in relation to transportation, is even more applicable in both domestic and foreign fields in relation to the mixing

* Competition of a sort had existed in Italy and had been threatened elsewhere. The hygienic activities of Ethyl Corporation had not been involved here at any time, and were not affected by them to any considerable degree.

installations in oil refineries. Here, however, the risks are not as great for two very good reasons, one being that the performance of this work has been so standardized, and the personnel involved have been so indoctrinated, that good practice is likely to persist for some time to come. The other factor of safety lies in the fact that mixing installations based on the use of drums of antiknock compounds have decreased in number to such a point that only very small quantities of antiknock compound are so handled. The bulk mixing plant has been so designed and so operated as to provide virtually no hazard of lead exposure to the operators so long as it is in good condition. Extensive maintenance work, generally, is infrequent, while the simpler procedures of maintenance are carried out with little likelihood of hazard. However, the hazards of mixing from drums, while readily avoidable through compliance with all of the regulations issued by Ethyl Corporation, are very real, and it is virtually certain that, with changes in the personnel of the oil companies, in management, in medical and hygienic services and in the operations of mixing, adherence to the precautions will lapse, attention to the details of good performance will diminish, and casualties will occur. There is no doubt whatever in my mind that the hygienic and medical personnel of the Corporation should act to maintain an awareness of these hazards, and of the methods of controlling them, within the oil companies. The means by which this is to be done, and the frequency with which physicians of the Corporation should visit the refineries, in addition to or in association with the visits of the personnel of the Customer Services and Safety group, will depend to a very considerable extent on local and regional conditions. The medical and service (technical) personnel should maintain continuous working relationships, however, to the end that each is fully informed of the activities and problems of the others, and that information and aid are provided reciprocally.

I am not prepared, at present, to provide satisfactory information as to the extent to which the activities of either the medical department or the Customer

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Services and Safety group are integrated, so as to meet what seems to me to be the requirements. My impression, which may simply express my unfamiliarity with current performance, is that such a relationship as I have described does not exist. I suspect that this aspect of the development and performance of the organization has not kept pace with the commercial developments or with the organizational changes that have occurred elsewhere within the Corporation.

3. The cleaning of Large Tanks for the Storage of Leaded Gasoline in Refineries and Terminals.

Despite our accumulated knowledge and our better understanding of this problem, the severity of the hazard of lead poisoning in connection with such work within the petroleum industry throughout the world, does not provide any proper basis for complacency within Ethyl Corporation. Here, again, the relationship between the informed medical and hygienic personnel of Ethyl Corporation and the responsible personnel within oil company customers should be examined for its adequacy, in connection with such changes in the operations of the petroleum industry as may have occurred. As to the latter, I am told that the frequency of cleaning gasoline storage tanks has decreased generally and considerably in recent years. This, I think, should be investigated so as to establish the facts in some detail. It may be, also, that the information now available as to the mechanism by which the hazard of exposure to tetraethyllead (and tetramethyllead as well and perhaps more importantly) is induced or at least augmented, as secured by the experiments of L. Snyder at Baton Rouge, could be employed to alter precleaning procedures that heighten this hazard, where such procedures exist within the petroleum industry. In any case, in my view, these matters should be made the subject of a careful review, for the purpose of deciding upon and taking appropriate action. These matters were discussed briefly, but there is not that information at my command that would permit me to make specific recommendations beyond those suggested above.

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