Problems in the Handling of Ethyl Fluid and Ethyl Gasoline

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In order to clear the way for a detailed consideration of the dangers potentially existent in the handling of Ethyl Fluid, I shall deal very briefly with the hazards speculatively associated with the distribution of Ethyl Gasoline as distinguished from other gasoline. Ten years of experience and of critical investigation have failed to reveal the existence of danger to any group of workmen or to the general public, because of the presence of small amounts of tetraethyl lead in automobile fuel. Various aspects of the question are being further investigated at present, but only two matters deserve mention in a practical discussion of safety problems.

1. Exposure to Lead Compounds in Cleaning Storage Tanks for Ethyl Gasoline.

Tetraethyl lead alone or dissolved in gasoline slowly decomposes to yield crystalline triethyl lead compounds. Under the normal storage conditions this decomposition is almost inappreciable, but over a period of years variable amounts of such deposits can be found in the scale on the sides and at the bottom of storage tanks. If the sides or bottom of such a tank are cleaned in a dry state, finely divided dust containing triethyl lead salts may be suspended in the air, and may be inhaled by unprotected workmen who may enter the tank. The inhalation of these compounds causes irritation of the respiratory mucous membranes and the skin, accom-

panied by violent sneezing, weeping, and burning of the skin. If this sharp warning be ignored further exposure may result in rapid lead absorption and acute intoxication. It is a simple matter to prevent lead exposure of this type either by cleaning the tanks in a wet state, or by the use of air line masks during the cleaning. Actually a combination of these two safety measures is employed in routine cleaning at refineries in general, in guarding against the inhalation of gasoline vapors. Nevertheless since the lead hazard would not be considered of itself, the attention of refinery personnel has been directed toward it through instructions which coincide with or supplement the current practices of tank cleaning. It should be pointed out further, that materials of this type, removed from Ethyl Gasoline storage tanks should be buried or otherwise disposed of so that they may not be resuspended by air currents.

2. Lead Accumulation on the Surface of the Earth.

Through a variety of avenues lead compounds are being brought out of the bowels of the earth and distributed upon its surface. The deposition of finely divided lead bromide by way of the exhaust gases of automobiles and aeroplanes which burn Ethyl Gasoline is only one aspect of this process. I mention the problem in this connection not because the use of Ethyl Gasoline is the most important factor - for it is not - but rather because the whole question arose out of the investigation of the public health problems associated with the distribution of Ethyl Gasoline. I shall not discuss the details of the matter, here, since I have treated it elsewhere, and especially since there is no present reason to believe that it involves danger to the public health. However, it must be recognized that a sufficient general increase in the gross daily human intake of lead, from any and all sources, could result in

widespread damage to health. It becomes a matter of some importance, therefore, to know how much lead we are taking into our bodies through our food materials and otherwise, and to keep a critical eye on the factors which affect such lead intake. This, my associates and I are attempting to do in the Laboratory of Applied Physiology in the University of Cincinnati by means of an experimental technique which seems adequately adapted to develop the facts.

The Hazards of Handling Ethyl Fluid.

The general character of the hazards in the handling of Ethyl Fluid is determined by the properties of the lead compound which is its principal constituent. Therefore, if I appear to ignore the other ingredients through the greater part of this discussion, it is because safety measures must be directed specifically toward the prevention of exposure to tetraethyl lead. The latter is an oily liquid which shows a decided tendency to creep through the seams or joints of containers and pipe lines, thereby supplying abundant opportunities for the danger of leakage. Moreover it is a heavy material, of almost twice the weight of water, so that packages of suitable size for the operation of mixing with gasoline are handled with some difficulty, and with the ever present danger of physical injury to the worker, as well as the likelihood of bursting if dropped or subjected to unusual violence. Tetraethyl lead has an appreciable vapor pressure at ordinary temperatures, and if exposed to heat the vaporization of the Fluid develops a pressure within containers, which under extreme conditions (conflagration) may result in the bursting of the container with ignition of its contents, and which in the hot sun's rays causes a sudden escape of vapor when the container is opened. The oily (fat soluble) and somewhat volatile character of the material gives it a peculiarly hazardous quality among lead compounds in that

absorption takes place into the human body both by way of the unbroken skin through contact, and by way of the lungs through inhalation. The saturated vapor of tetraethyl lead in air at ordinary temperatures contains approximately 5 mgs. of lead per liter of air - a concentration which is lethal for experimental animals after a few hours of exposure. It is apparent, therefore, that the rate of absorption of tetraethyl lead through the lungs is very much more rapid than in the case of particulate inorganic lead compounds, and that the dangers of inhalation are correspondingly great. The tendency of tetraethyl lead to decompose to yield peculiarly irritating and toxic solid compounds has been mentioned previously.

With these characteristics in mind, it is possible to visualize the chief difficulties which attend the manufacture, transportation, storage, and handling of Ethyl Fluid. The necessity for the avoidance of leakage and spillage of Fluid, and for prevention of skin contact or inhalation, is apparent. And not only must safety precautions be designed for the prevention of rapid absorption and acute illness, but also for the avoidance of repeated slight exposure with its resultant slow accumulation of lead which may result in chronic plumbism.

1. Hazards in the Manufacture of Ethyl Fluid.

The preparation of Ethyl Fluid consists essentially of the blending of tetraethyl lead with a sufficient amount of an organic halogen carrier to convert the lead to the corresponding halide when combustion occurs, and with an oil soluble dye to give the Fluid a deep color. The materials must be thoroughly mixed, and checked by chemical analysis for correctness of the quality and proportions of the ingredients. The finished Fluid is stored in tanks, or introduced into drums or tank cars for shipment. The control of the dangers of manu-

facture is relatively simple, since all the operations are carried out by a single isolated group of men who are under constant supervision. The solution of the problem of safety is found in the use of carefully constructed closed systems of pipes, pumps and tanks, with the necessary vents carried well outside working areas. General and local ventilation is employed as a supplementary precaution. The filling of barrels for shipment necessitates a break in the closed system. This operation is carried out, therefore, in a specially constructed, highly ventilated hood, equipped with safety devices which care for either a few drops of Fluid or a large accidental spill. The difficulty is increased by the necessity for accurate measurements of the Fluid, this being accomplished by filling the container up to the desired net weight.

Skin contact with the materials, and inhalation of vapor is obviated through detailed regimentation of the technique of all plant operations, including the carrying out of repairs, and the maintenance of meticulously careful housekeeping in the plant. The adequacy of precautionary measures is checked by regular medical supervision of the workmen and the plant.

An integral part of the manufacturing and shipping procedures is the cleaning, testing and repainting of metal drums before refilling, and the testing of refilled drums for leaks before shipment. The hazards of the cleaning operation are essentially negligible since it is done by equipment enclosed in highly ventilated hoods and operated from the outside. Cleaned drums are given an air pressure test, and filled drums are tested in a specially ventilated room, by setting them with the bung down for a period of twelve to forty-eight hours. The slightest leak becomes readily apparent because of the spread of the deeply colored fluid into the bright new aluminum finish on the surface of the drum. Suitable warnings are pasted tightly on each

drum, tohether with instructions for caring for accidents, or leaks. Mention is made of these details because they are of extreme importance in guarding against danger in transportation. The recognition of such dangers was responsible for the use of a specially designed metal drum, and later a special type of tank car for shipping Ethyl Fluid.

It is evident that the filling and handling of tank cars at the manufacturing plant is a simpler operation than the introduction of corresponding amounts of Fluid into barrels. The construction of the tank is such that leaks are well-nigh impossible except for the occurrence of most unusual transportation accidents. Tank cars are inspected, cleaned if necessary by equipment controlled at a safe distance, filled by weight from a storage tank, sealed, padlocked, and placarded with suitable instructions.

2. Hazards in the Transportation of Ethyl Fluid.

The difficulties in transportation arise largely from the fact that the Fluid may pass into the custody of persons who have not been instructed adequately as to the nature of the dangers with which they are dealing, and the proper means to employ in avoidance of such dangers. There is the greatest necessity, therefore, for anticipating and guarding against the type of handling which is given to ordinary commodities in transit. In fact, every effort must be made to see that no opportunity occurs for contact or exposure from the use of shipment until the material arrives at its destination, where it can be taken in charge by properly trained persons. For this reason shipping of drums, with rare exceptions, is carried out in full car load lots, or at full car load rates, so that the drums may be safely fastened in place in the car at the manufacturing plant and removed in safety by the trained personnel of the purchaser. Where shipment occurs by boat, the drum cargo is under the supervision

of a representative of the shipping plant, until it is properly fastened in place on an open deck of the vessel, from which it is removed at its destination under the supervision of the shipper's or purchaser's trained agent.

The shipment of tank cars of Fluid is not fraught with the same dangers as those associated with the transportation of drums, and for obvious reasons which require no further elucidation. It is true that major accidents might occur which would necessitate special handling of these cars and their contents. Carriers are instructed by placard to notify the shipper in such an event so that instructions may be given or the situation may be handled by an agent of the shipper. No serious difficulties of this type have occurred up to the present.

From time to time drum shipments of Fluid have been made by truck. This has been done usually in order to avoid a transhipment of less than carload lots by rail. Thus a car load of Fluid, shipped to some central point has been split among neighboring purchasers, each of whom has transported a number of drums by truck. This, again, merely represents the attempt to maintain the responsibility for the handling of drums in the hands of persons who are fully informed as to the proper methods of handling.

3. Hazards in the Handling of Fluid at Refineries and Bulk Mixing Points.

The above paragraphs have dealt with the precautions which must be taken by the distributor of Ethyl Fluid, in order to see that the product reaches the purchaser without the likelihood of any injury to anyone in transit. From this point on it is necessary for the purchaser to see that the Fluid is handled only by the proper persons, that it is mixed with gasoline in proper amounts and by acceptable procedures, and that the emptied containers are returned to the distributor with the same care against danger to the carrier that was

observed by the distributor. The difficulties to be overcome my be separated into the hazards of storage and the hazards of the actual mixing procedures.

The Hazards of Storage.

These hazards in the case of drum storage include the mechanical difficulty of handling heavy packages, the possibility of leaks and spillage, the development of pressure in the drum with high temperature, the partial solidification of the Fluid at low winter temperatures, - i.e. freezing out of the halogen carrier, which must be melted before the Fluid can be mixed into gasoline -, and the occurrence of a fire, with the possibility of bursting of drums and ignition of the Fluid. Theft of the Fluid, and tampering with it must also be prevented. Obviously the Fluid should be stored where the containers can be handled with ease, where vapors will not be confined, where spilled Fluid can be readily washed away, where there is protection from direct sunlight (in warm or temperate climates), and from the spread of fire, and where there is security from chance or intentional handling by unauthorized persons.

When Fluid is shipped in tank cars the chief storage problems have to do with the transfer of the large amount of heavy Fluid from the tank cars to a Fluid storage tank without allowing exposure to occur, the prevention of leakage of either liquid or vapor from the storage tank, and provision against excessive cooling or heating of the Fluid. These problems will be given further consideration later.

The Hazards of Mixing.

The hazards of mixing with drums of Fluid arise in moving heavy drums to the mixing site, in removing the bungs, in emptying out accurately measured amounts of Fluid, in mixing the Fluid with gasoline, in rinsing out the drums when emptied of Fluid, and in re-

placing the bungs. All this should be done without leaks or spills, and it must be done without exposure, on the part of the handler, to the liquid or vaporized Fluid. Moreover any implements or equipment used in the process must be cleaned up so as to remove any opportunity for subsequent contact with liquid or vapor at the mixing site.

The most serious aspects of the problem of handling Fluid out of a storage tank are concerned with accuracy of measurement, the prevention of leaks in the pipe lines, and the carrying out of repairs if and when leaks develop. These difficulties can best be appreciated when the type of equipment employed for the purpose is understood.

Methods Employed in the Elimination of Hazards.

It is one thing to bring under control the occupational dangers of a single industrial plant, or that of a series of similar plants which operate under the same management. It is quite another to accomplish this and in the case of hundreds of widely distributed plants which have almost as many different owners and managers. It is inevitable that there should be differences of opinion among the large number of persons who have purchased and used Ethyl Fluid in the preparation of Ethyl Gasoline, as to the requirements for safety in handling the product. It is equally certain that if the manner of mixing had been at any time, or were now left to the discretion of gasoline distributors, there would be a wide variety of methods and equipment, and a correspondingly wide variation in the precautionary measures surrounding the occupation.

Especially at the beginning of this new industry, it was necessary to make a careful apprasial of the hazards. In order to do this some type of centralized responsibility for the manner in which mixing was to be done had to be established. This was achieved through the issuance of regulations and instructions to the purchasers of Ethyl Fluid, together with specifications for mixing equipment. Com-

pliance with these regulations and specifications was made an obligation to which purchasers were bound by contract. Under this regime a high degree of uniformity both in equipment and in technique has been maintained.

Mixing plants are built so as to satisfy not less than minimal specifications supplied by the distributor of Ethyl Fluid. These specifications cover the storage facilities for Ethyl Fluid, the mixing equipment, locker rooms, bathing facilities, ordinary and special protective clothing and equipment, and gas masks. Regulations are provided covering all the procedures, including the requirements in the matter of cleanliness, clothing changes and similar details. Workmen are selected from those available by a medical representative of the distributor of Ethyl Fluid, on the basis of physical fitness, and each man is instructed as to the regulations, and the dangers associated with improper handling of Ethyl Fluid and exposure to it. A placard of instructions to workers is posted conspicuously at the mixing plant.

Storage space for drums of Fluid consist of a concrete platform at boxcar or truck height, with at least three sides open to the air and a roof overhead suitably connected with drains so that it can be thoroughly hosed. This platform is continuous with the mixing area, the entire structure being enclosed with heavy wire, locked against entrance, and being of fire proof construction. The storage tank for Fluid delivered by tank car is located adjacent to the mixing equipment. Further details of construction will be referred to later.

Mixing of Fluid supplied in drums is carried out by means of two types of equipment, one for less than full drums of Fluid, the other in which not less than a full drum is used. In the former case a special apparatus is fastened in the bung opening, and the desired amount of Fluid as indicated by gross weight loss, is drawn off by means of an

eductor, attached to the gasoline line. In the other case, the full drum of Fluid is used as the unit of measure, and one or more drums as required are emptied by means of an eductor attached to the gasoline line, and mixed with the proper amount of gasoline in a tank. The operation is completed when the eductor line has been well washed out, when all the Fluid has been introduced into the gasoline, and when the Fluid and gasoline have been recirculated so as to obtain complete admixture. The latter is an important item, for when the heavy Fluid is merely poured into gasoline it drops to the bottom and remains as a separate layer for a long time. Not only would this introduce serious error into the composition of the gasoline, whereby excessively low and - more important in relation to safety - excessively high concentrations of Fluid in gasoline might be distributed, but it may also result in the accumulation of concentrated Fluid at the bottom of the tank, to be encountered, perchance, when the tank is to be cleaned.

The entire procedure of storing the Fluid and mixing it with gasoline in mixing plants which handle tank cars of Fluid is carried out in two steps, (1) emptying the tank car into a storage tank which is suspended on a scales, and (2) mixing weighed amounts of Fluid into gasoline, Both steps are carried out through the use of an eductor on the gasoline line. Since all movements of the Fluid are accomplished by suction, and since sufficient vacuum for the purpose can not be obtained in the presence of leaks in the system, it follows that if the apparatus moves the Fluid at all, there is no opportunity for skin contact with leaking Fluid or inhalation of escaping vapor.

The various factors which influence the magnitude of occupational hazards of the workmen may be listed in the order of their importance as follows: (1) The extent of the cooperation of refinery management in the avoidance of irregular practices such as unnecessary sampling of Fluid,

the removal of small amounts of Fluid into intermediate containers for experimental mixes, and for the correction of errors in mixing - in short, the avoidance of any handling of Fluid except by means of the standard mixing equipment; (2) the quality of the mixing equipment; (3) the frequency of mixing (this depends largely upon the adequacy of storage facilities for Ethyl Gasoline in relation to the volume of Ethyl Gasoline distribution); and (4) the degree of caution exercised by the mixing personnel in following the instructions as prescribed. The importance of the last item is stressed at all times in the promotion of safety, but much greater dependence is put in the automatic safety which is afforded by the installation of proper mixing equipment and adequate storage facilities. It is manifestly impossible to prevent departures from accepted and safe procedures excepting as the refinery management and personnel give their willing and intelligent cooperation toward the promotion of safety, and unless they accept in practice, the point of view that no commercial consideration can justify the violation of a regulation which is reasonably designed to promote safety. The importance of the development and maintenance of this point of view toward the handling of Ethyl Fluid cannot be over-emphasized, for therin is the most significant problem of safety. The chief functions of the medical representatives of the distributor of Ethyl Fluid are to promote such a point of view, to maintain and improve the quality of mixing plants and to prevent the gradual decrease in caution which otherwise is almost inevitable after years of freedom from occupational injury. The periodical medical examination of every person engaged in this work, together with occasional study of the lead excretion of a representative group of such workers, serves largely to determine the degree of success which has been adhieved in the performance of these functions. Perhaps this statement describes a somewhat uncommon concept of the significance of medical

examinations in the promotion of safety. If this is true, it should be understood that such a concept does not arise from any lack of appreciation of the necessity for the utmost care in the performance of examinations, and for the maintenance of proper professional relationships with the workmen. Rather, it springs from the certainty that no amount of excellence of medical care is sufficient, in itself, to prevent the occurrence of lead poisoning among men who are working under conditions of exposure which bring about the absorption of significant amounts of lead. In our opinion, the only successful way to prevent occupational lead poisoning is to so limit occupational lead exposure that poisoning cannot occur.

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