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Problems in Handling

Ethyl Fluid and Ethyl Gasoline

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TO CLEAR the way for a detailed consideration of potential dangers 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 from 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.* Tetraethyl lead alone or dissolved in gasoline slowly decomposes to yield crystalline triethyl lead compounds. Under normal storage conditions this decomposition is almost inappreciable, but over a period of years variable amounts 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 inhaled by unprotected workmen who may enter the tank. Inhalation of these compounds causes irritation of the respiratory mucous membranes and the skin, accompanied by violent sneezing, weeping, and burning of the skin. 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. Actually, these two safety measures are employed in routine cleaning at refineries 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 earth and distributed upon its surface. The deposition of finely divided lead bromide by way of the exhaust gases of automobiles and airplanes 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. 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.

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. Tetraethyl lead 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 leakage. Moreover, it is a heavy material, of almost twice the weight of water, so that packages of suitable size for 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 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 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.

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 which may result in chronic plumbism.

1. Hazards in Manufacture

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

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drums or into tank cars for shipment.

The control of the dangers of manufacture 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 any accidental spill. The difficulty is increased by the necessity for accurate measurement of the fluid.

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 meticulous housekeeping. The adequacy of precautionary measures is checked by regular medical supervision.

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 12 to 48 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 on each drum, with instructions for caring for accidents, or leaks. 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.

2. Hazards in the Transportation

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 and the means to employ in avoidance of such dangers. There is the greatest necessity, therefore, for anticipating 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 time 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 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 fastened in place on an open deck of the vessel, from which it is removed at destination under the supervision of the shipper's or purchaser's trained agent.

From time to time drum shipments of fluid have been made by truck. This has been done usually 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 method of handling.

3. 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 that was observed by the distributor.

Storage. 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 temperature, and the occurrence of fire. Theft of the fluid, and tampering 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 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, the prevention of leakage of either liquid or vapor from the storage tank, and provision against excessive cooling or heating.

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 replacing 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.

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. It is equally certain that if the manner of mixing were left to the discretion of gasoline distributors, there would be a wide variety of methods, equipment and precautionary measures.

Especially at the beginning of this new industry, it was necessary to make a careful appraisal of the hazards. To do this some type of centralized responsibility for the manner of mixing had to be established. This was achieved through regulations and instructions to the purchasers of ethyl fluid, together with specifications for mixing equipment. Compliance with these regulations was made an obligation to which purchasers were bound by contract. Under this regime a high degree of uniformity has been maintained.

Mixing plants are built 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,

(Please turn to page 50)

Ethyl Gasoline

(Continued from page 20)

locker rooms, bathing facilities, ordinary and special protective clothing and equipment, and gas masks.

Regulations cover all the procedures, including the requirements in the matter of cleanliness, clothing changes and similar details. Workmen are selected by a medical representative of the distributor 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.

Storage space for drums of fluid consists of a concrete platform at box car or truck height, with at least three sides open to the air and a roof overhead 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.

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, but it may also result in the accumulation of concentrated fluid at the bottom of the tank which might be encountered when the tank is 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 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; (2) the quality of the mixing equipment; (3) the frequency of mixing; and (4) the degree of caution exercised by the mixing personnel in following prescribed instructions.

The importance of the last item is stressed at all times, but much greater dependence is put in the automatic safety afforded by the installation of proper mixing equipment and adequate storage facilities. It is manifestly impossible to prevent departures from accepted procedures excepting as the refinery management and personnel give their willing and intelligent cooperation, and unless they accept the point of view that no commercial consideration can justify the violation of a reasonable regulation.

The chief functions of the medical representatives are to promote such a point of view, to maintain and improve mixing plants, and to prevent any relaxation of caution. The periodic medical examination of every person engaged in this work, together with occasional study of the lead excretion of a representative group of workers, serves largely to determine the effectiveness of the precautions.

Perhaps this is a somewhat uncommon concept of the significance of medical examination. Such a concept, however, does not arise from any lack of appreciation of medical service. Rather, it springs from the certainty that no amount or excellence of medical care is sufficient in itself to prevent the occurrence of lead poisoning. In our opinion, the only way to prevent occupational lead poisoning is to so limit exposure that poisoning cannot occur.