LEAD TETRAETHYL

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This memorandum deals with the hygienic requirements for the handling of lead tetraethyl in connection with the following operations:

I) MANUFACTURING, BLENDING WITH OTHER INGREDIENTS AND PACKAGING.

II) TRANSPORTATION.

III) BLENDING WITH GASOLINE.

IV) DISTRIBUTION OF GASOLINE CONTAINING LEAD TETRAETHYL.

V) CLEANING OF TANKS USED FOR MIXING GASOLINE WITH LEAD TETRAETHYL AND FOR STORING GASOLINE CONTAINING LEAD TETRAETHYL.

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I) MANUFACTURING, BLENDING WITH OTHER INGREDIENTS AND PACKAGING:

a) Manufacturing Plant and Equipment: - Hygienic Aspects - The design and construction of buildings and equipment for manufacturing operations is by far the most important factor in determining the degree of safety associated with the manufacture of lead tetraethyl. Other measures of control have been found necessary in order to obtain satisfactory results, but it must be recognized as a first principle that no amount of caution and no amount of medical and hygienic supervision can possibly modify significantly the basic conditions of lead exposure which arise from the character and quality of the equipment. The oily liquid, lead tetraethyl, is sufficiently volatile at ordinary temperatures to give rise to acute danger of death from its inhalation. Fatal poisoning can result from exposure for half an hour or less under suitable conditions. The compound is also capable of fairly rapid absorption through the healthy and unbroken skin, so that all contact with the skin must be avoided. Therefore this material must be kept and handled in closed pipes and containers. This is difficult to accomplish since the liquid tends to creep along a surface with which it is in contact, and if there is the slightest opportunity, it escapes from the joints of the pipes, pumps and storage tanks. The methods of manufacture also involve chemical reactions and separatory processes (distillation, etc.) in which lead tetraethyl occurs in the vapor state, and at times under pressure. In such a state it is even more difficult to prevent leakage. All the equipment employed, such as reaction vessels, distilling apparatus, pipe lines, pumps, separatory tanks and storage tanks must be constructed on precise specifications and with the highest quality of workmanship. Pipe-joints should be eliminated by employing welded construction wherever feasible. Sight-glasses, which are required in certain pipe-lines in connection with several operations, are a potential source of significant leakage and must be specially constructed so as not to leak or be subject to breakage. (The customary type of sight-glass leaks regularly and continuously.) Pumps of the type most commonly used in the chemical industry are quite unsatisfactory for handling lead tetraethyl, for leakage is absolutely inevitable. A vertical, cylindrical type of pump, in which there is a revolving shaft with a packing gland at the top only (which must always be above the liquid level of the material being pumped), is satisfactory. Because of the slight leakage of vapor at the top of this pump local ventilation must be employed so as to carry away all vapors. Reaction vessels or other apparatus may need to be equipped with certain moving parts such as agitators which penetrate their shell. All such vessels, regardless of the excellence of their construction and maintenance, will inevitably leak at stuffing-boxes or packing glands unless they are carefully inspected and maintained. If badly designed and constructed, they will leak profusely.

Accordingly,every effort must be made to obtain the best of workmanship in the construction of such vessels. Even so,it is advisable to apply unit ventilation to these pieces of apparatus,to such an extent as to maintain a safe atmosphere around them.

Avoidance of Exposure to Vapors and Liquid Lead Compounds - All parts of the manufacturing plant in which liquid lead compounds are produced and handled must be carefully ventilated to such degree as is necessary to maintain the atmospheric lead concentration below a toxic level. The lead concentration in any part of the plant should not be permitted to exceed 2 milligrams of lead per 10 cubic meters of air for more than very brief periods,and the basic concentration of any point should not exceed 1,5 milligrams per 10 cubic meters. The lead concentration in the air should be determined regularly by precise methods of air-sampling and analysis,so that there may be no conjecture as to the actual conditions prevailing in the plant. It has been found that the ventilation to be efficient and uniformly adequate must be operated along the following lines:-

(a) Points at which small quantities of vapor may escape regularly or frequently from equipment must be locally ventilated by suction to avoid significant contamination of adjacent areas.

(b) Fresh,clean air must be introduced into individual rooms and working spaces in all parts of the plant so as to produce complete changes with sufficient frequency to overcome the lead contamination from apparatus within such spaces, and to maintain safe conditions as specified.

(c) The air introduced into rooms or buildings must be balanced by the withdrawal of air by suction fans.

(d) Concentrated vapors of lead tetraethyl which regularly escape from the vents or stacks of operating equipment in the course of normal operations must be removed by accessory exhaust ventilation but should not be carried by general ventilating ducts,ie.they should be cared for by a separate system of ventilation.

(e) The most rigorous care must be taken in locating the air intake and exhaust openings so as not to reintroduce exhausted air into the building through the intake ducts and so as not to pick up other objectionable or toxic fumes or vapors.

(f) Residue or "sludge" removed from reaction vessels must be carried in a tightly closed line to a pit or receptacle which is completely enclosed and kept under slightly negative pressure by exhaust ventilation in such manner that the overlying vapors do not escape into the adjacent atmosphere.

Reaction vessels,in which high pressure may develop,must be equipped with vents and also with pressure disks so as to prevent explosions within the building,if and when the reaction proceeds at an uncontrollable speed.

Every operation in the manufacture and handling of lead tetraethyl and in the maintenance and repair of equipment,requires skill and training and also expert supervision. The repair operations,the removal of old equipment,and the replacement of new apparatus are especially hazardous. It is highly necessary,therefore, that care be exercised in the selection and training of the plant personnel. Complete details of every operation should be worked out and recorded as operating and safety instructions. Careful discipline must be maintained in carrying out

such instructions. The men should be fully informed and instructed as to the dangers of their occupation and the means of protecting themselves against lead absorption at all steps.

Emergency showers, with water, should be available in all parts of the plant where contact with lead tetraethyl may accidentally occur, and a convenient supply of kerosene must always be available at all such points, so that any lead tetraethyl which may come in contact with the skin can promptly be washed off with this material. Ordinary wash stands with soap, and toilet facilities, must be conveniently situated.

Positive pressure air-line hose masks must be provided and must be conveniently available for use in the several operations and emergencies which otherwise involve unavoidable exposure of lead tetraethyl vapors.

Other masks, equipped with full face pieces, and with canisters containing not less than 500 c.c. of high-grade activated charcoal, must be available in sufficient number and at proper locations to be available for use in any emergency in which air-line respirators cannot be used, (as for example, in power failures, or in accidents resulting in extensive contamination of outside air.)

Control of exposure to inorganic lead fumes and lead-bearing dusts:- The handling of inorganic lead compounds in various stages of the manufacturing operations involves opportunities for exposure to fumes of molten metal, and to dusts of lead compounds and lead-bearing wastes and slag. (Certain of these materials, such as sludge from reaction vessels, may also contain lead tetraethyl. Such materials, as indicated previously, must be handled with great care in closed equipment so as to prevent exposure to the vapors of lead tetraethyl and so as to avoid contact with the skin of workmen.) Exposure to the inorganic lead compounds must be controlled effectively at all times, and by means comparable to those used successfully in certain of the more commom dusty lead trades. Contamination of the atmosphere in work areas must be limited by suitable operating devices and by local exhaust ventilation so as to comply with the standards referred to above in the case of vapors of lead tetraethyl. Systematic analyses of the air of work rooms should be made at suitable intervals so as to ascertain the extent of the lead contamination and to keep it under control.

The disposal of Plant wastes:- All waste materials from the plant, including exhausted air, fumes from stacks, waste water from plant operations and that used to wash down floors, together with all lead-bearing materials from reaction vessels, pipe lines and other containers, must be dealt with or diluted in such a way as to prevent hazardous exposure of plant personnel and all others, and so as to avoid the pollution of adjacent soil and streams.

Materials and equipment which are to be discarded should be destroyed, if possible by burning, and should, in any case, be freed of volatile lead compounds by being burned to a dull red heat in a bonfire under conditions which will not give rise to exposure to fumes and smoke on the part of the plant personnel or others. Discarded slag or equipment contaminated with lead compounds must be buried or so disposed of as to prevent harm to uninformed persons.

b) Blending with other ingredients and packaging.

Hygienic aspects - The exposure to lead tetraethyl is of the same type in all other operations in which it is handled after its manufacture. If the finished

lead compound is to be mixed with other ingredients,the same precautions,in principle,as those described previously,must be taken to prevent hazardous exposure on the part of workmen.

It is necessary that such precautions be taken with great care and under expert supervision. Since containers must be filled,the piping system must be open at the point where such filling operations are carried out. A filling booth or hood must be constructed in such a way that all vapors are carried away completely and all control apparatus is operated entirely from the outside.

The ingredients which are to be mixed should be moved by gravity flow so far as possible,but mixture must be accomplished by agitation. Accordingly,the top of mixing tanks must be so ventilated as to prevent leakage of vapors into the rooms from the stuffing box around the agitator shaft.

The containers for the finished product must be limited as to type and capacity to those which are capable of safe transportation and safe handling at the point at which the product is to be used. It is of the most hygienic importance that irregular and improvised procedures for handling lead tetraethyl and concentrated mixtures of it should be avoided. The most important means which can be taken towards this end is to send the product out of a plant only in such packages as can be used safely at their destination. The distribution of small cans of such a product is an inevitably hazardous procedure because of the difficulty of controlling their destination or use. Fragile tin cans containing several liters of lead tetraethyl are dangerous to transport and even more dangerous to handle, because of the weight of the liquid and the likelihood of breakage of the container. The distribution of any quantity of lead tetraethyl or its concentrated mixtures to irresponsible or uninstructed persons would be an act of carelessness and negligence.

Not only is the use of numerous types of containers (especially small ones) dangerous beyond the limits of the manufacturing plant,but it is also unnecessarily hazardous within the plant. Safety in the packaging operations depends fundamentally upon the simplicity and uniformity of daily procedures. Irregular practices are likely to create new and difficultly controlled hazards and should be kept at a minimum. Moreover,the hazard of filling a small package is as great as that of filling a large one,therefore the packages should be as large and as few as possible with due regard to the limitation of hazard in transportation and in other types of handling beyond the limit of the manufacturing plant.

Drums employed for the shipment of lead tetraethyl or concentrated mixtures containing lead tetraethyl,should be of exceedingly strong and durable construction, with I-beams on which they can be rolled,and with double bungs for the avoidance of leakage. Safety in the continued use of these drums will depend on the care taken in inspecting and repairing them when possible and replacing them when necessary. After every trip to a consignee each drum must be cleaned thoroughly,inspected critically for corrosion,injury or weakness and should be repainted. After being filled each drum should be tested for at least twenty-four hours by standing with the bung downward,and by carefully inspecting the seams for leaks. Such leaks will show up clearly on the freshly painted outer surface of the drum,if the product is highly coloured and if the drums are painted white or light gray. For this and other reasons,the product should be brightly coloured for purposes of commercial handling.

Obviously,the opening,cleaning and testing of returned drums are dangerous operations. They must be handled with highly specialized and thoroughly ventilated equipment if they are to be done satisfactorily and safely. Before any drum is to

be rapaired it must be thoroughly cleaned so as to eliminate all volatile lead compounds and all but traces of inorganic lead compounds which may be suspended in the air by mechanical means or by local heating.

General Hygienic Measures - The potential hazards associated with the manufacture of lead tetraethyl are the most serious that can be found in any of the lead trades. They are capable of complete control if proper provisions are made to maintain an adequate degree of precision and caution in carrying out plant operations. However,it is exceedingly doubtful if this can be done unless the most rigid and critical medical supervision is established and maintained.

The control measures consist of the following co-ordinated types of hygienic supervision,namely,(1) careful and complete clinical study of all workmen,(2) regular study of the magnitude of the lead exposure and lead absorption of representative groups of workmen by means of periodic determination of the rate of lead excretion in the urine and feces,(3) regular periodic critical survey of plant activities and operations by the physician-in-charge,and (4) regular determination of the lead content of the air of all rooms and working spaces in the plant.

Clinical work - Not only is it necessary to maintain a sharp search for clinical evidence of lead absorption,but it is also imperative that all types of illness among workmen be recognized and identified,if there is to be effective medical control based upon a proper degree of mutual confidence between the workmen and the medical staff. It is not enough to be on the lookout for subjective symptoms of incipient intoxication,or to watch for changes in the blood of workmen,or to see the cruder evidences of lead absorption. It is also necessary to recognize the occurrence and character of non-occupational disease and to see that it is adequately cared for or at least that it is brought to the attention of the workmen. These things cannot be accomplished by cursory and slip-shod examinations or by certain partially specific laboratory tests, but only by careful and regular study of each workman.

In these occupations each workman who is potentially exposed to lead tetraethyl should be examined at least once per month,while men whose work involves exposure only to dust and fume of inorganic lead compounds should be examined at intervals of not more than three months. (It is advisable to examine the man more frequently unless and until it has been clearly established that the dangers of normal plant operations have been brought under adequate control.) At such examination each workman is questioned carefully in search of subjective symptoms and other evidences of incipient illness. This must be done without leading questions and without establishing a pattern of interrogation. The temperature,pulse,blood press ure,and weight should be noted and recorded,and the urine should be examined as to its reaction,and the presence or absence in it of sugar,albumin and microscopic abnormalities. Such other clinical study as is required to determine his physical status should be carried out,together with an examination of his blood,including,at least,the determination of the hemoglobin and a quantitative determination of the number of erythrocytes which show basophilic granulation, ("stippling"). The teeth and gums should be examined for sponginess or congestion and for the presence of a lead line,especially on the inner aspect of the gums opposite the molar teeth. The strength of the grip of each hand should be determined and recorded. At least once a year each man must have a complete and detailed physical examination,including a general neurological examination.

An initial examination of a complete and thorough type should be employed as the basis for the selection of an essentially sound and healthy operating crew. The results of this examination should be carefully recorded in the case of all men accepted for employment and should be used as a basis for future comparisons. Workmen should be rejected:

1) When they have had significant exposure to lead compounds in other occupations within the period of five years immediately preceding;

2) When they have had an illness associated with a previous occupation which is indicative or strongly suggestive of lead intoxication;

3) When they have a significant degree of organic disease of the circulatory system, especially symptoms and signs of arteriosclerosis;

4) When they have organic disease of the nervous system, a history of epilepsy, or of functional disturbances associated with mental instability;

5) When they have active organic disease of the kidneys, liver or lungs;

6) When they have other well-defined chronic diseases, such as oral or upper respiratory infections of a severe and potentially disabling type which, in the opinion of the examiner, are unlikely to respond to corrective measures;

7) When they are excessively addicted to the use of alcohol, or when because of ignorance, stupidity, undue apprehensiveness or other evidences of unreliability, they are unsuited to employment in a potentially hazardous occupation;

8) When they are less than 21 years of age or more than 45 to 50 years of age.

Men who have been accepted for employment should be removed therefrom:

1) When they develop symptoms suggestive of lead tetraethyl intoxication;

2) When they develop physical signs and laboratory evidences of significant lead absorption;

3) When they develop organic disease, which, in the mind of the examiner, involves undue risk to their safety and that of others;

4) When they show a careless or irresponsible attitude toward the hazards of the occupation, or alternately, when they show undue anxiety with respect to such hazards.

Excretory Analyses - Determination of the rate of the lead excretion of representative workers portrays an highly accurate picture of the conditions of lead exposure to which they are subjected. The interpretation of such results cannot be discussed in any detail here but published information on this subject is available. Under hazardous conditions of employment such as those dealt with herein, in which brief exposure to high concentrations of lead vapor can give rise to prompt and serious effects, adequate hygienic control cannot certainly be maintained without such determinations. The methods employed in the collection of samples and in their analysis must have the utmost precision to be of value, and therefore must be worked out and applied with great care. This work can rarely if ever be done within the

manufacturing plant,but should be carrieddout elsewhere in order to avoid the contanination of samples from the plant environment.

In addition to the control analyses referred to above,access to analytical data on the blood and urine,in suspected or doubtful cases of intoxication,is of the greatest practical usefulness. Facilities for obtaining such data are absolutely essential to sound clinical work in this occupation,in view of the necessity for the prompt interpretation of symptoms.

Criteria based on broad experience in the application of analytical findings of the type referred to above have been set up as practical rules for the guidance of plant physicians in evaluating the significance of the occupational lead exposure and also for the handling of individual workmen under a variety of conditions. It must be remembered in relation to these criteria,that the analytical data on which they are based was of a very high order of accuracy. The same criteria cannot be applied at all to analytical data that are appreciably less accurate. Moreover,it should be stressed that it is a useless waste of money and effort to perform any of these analyses unless the methods of sampling and analysis are such as to yield dependable and highly accurate results.

Safe versus dangerous conditions of occupational lead exposure in terms of analytical data on the feces and urine of regularly employed workmen. - The inhalation of air containing lead fumes and dusts results in the entrapment of a considerable proportion of these lead compounds in the upper respiratory tract, from which they gain entrance to the gastro-enteric tract by being swallowed with the nasopharyngeal secretions. For this reason the collection and analysis of representative samples of the regular (daily approximately) fecal evacuations of a series of men engaged in the several occupations of a trade will give highly valuable information as to the magnitude of the exposure to lead dusts that is associated with these occupations. In this connection each sample will reveal the amount of lead (less 10 per cent.more or less) that was swallowed by the individual in question during the period of time represented by the sample. However,the status of the individual with respect to absorbed lead will not be shown by this means. On the other hand the analysis of a representative sample of urine especially when coupled with that of a sample of blood,will give a very clear idea of the magnitude and hygienic significance of the lead that has been absorbed by the individual. The combination of the information obtained by the analysis of both feces and urine,will show the severity of the exposure to dust on a particular occasion and the general significance of the exposure up to the time of the analyses. When this is done on a series of individuals representing all of the occupations of a lead industry,the location and severity of the dusty exposures as well as the overall magnitude of the lead absorption from this and other types of exposure,can be seen clearly.

It can be said in relation to analytical data of this type that:

1) When the mean fecal lead excretion of the group exposed to lead dusts and fumes is consistently of the order of magnitude of 0.50 mg.per sample (approximately 24 hours) or less,the exposure to dust and fumes (but not to vapors) is within safe limits;

2) When the mean fecal lead excretion of such groups is above 1.00 mg.per 24 hours,the exposure to dusts and fumes is definitely hazardous;

3) When the mean urinary lead concentration of an occupational group in a plant is not in excess of 0.10 mg.per liter the lead exposure (all types) of the entire plant is within safe limits;

4) When the mean urinary lead concentration in any occupational group is in excess of 0.15 mg.per litre,cases of lead poisoning can be expected to occur in that group,and their frequency and severity will be the greater,the higher the mean urinary lead concentration goes above this level.

In addition to the application of criteria given above for the interpretation not of the status of individual workman but rather of the conditions of lead exposure in the plant,it is important to have prompt means of determining the level of lead absorption of any workman whose symptomatology or whose hygienic status is in doubt for any reason. For this purpose analysis of samples of urine and blood,taken at the same time,are invaluable. Analytical results on such samples should be obtainable within a few days. Criteria for the interpretation of such data and for determining what should be done are recommended. Their correct application is dependent to some degree on experience and expertness in the recognition of the subjective symptoms and objective signs of lead tetraethyl intoxication. To some extent,however,as may be apparent,they may be accepted in lieu of such clinical knowledge and judgment.

(Reference has been made to microscopic blood examinations,but it must be emphasized that such examinations will be of no value whatsoever in connection with exposure to lead tetraethyl. They will be useful,however,in the case of those men whose work brings them into exposure with metallic lead and inorganic lead compounds. Actually the absorption of lead tetraethyl gives rise to a totally different set of symptoms,physical signs,and laboratory findings from those associated with the absorption of inorganic lead compounds. Therefore,no stippling is seen,and insofar as absorption of lead tetraethyl is concerned there will be no chronic lead poisoning as we know it clinically. Therefore,the doctors will have to be prepared for the recognition of a totally different syndrome of intoxication. For this reason the regulations should not put stress upon blodd examinations as a means of recognizing lead exposure. On the other hand,it is certain that no one will be able to operate a lead tetraethyl manufacturing plant without careful measurements of the magnitude of the lead exposure either by means of comprehensive and frequently repeated air analyses or by a well regulated system of following the exposed personnel by means of analysis of their urine and blood, the urine and feces,or all of these materials. There is no question about the relative importance of following the lead absorption and excretion of the workmen as a control measure. From the medical point of view it is the most important single feature.)

When analytical data are available on persons with symptoms

1) The symptomatology should be interpreted in complete independence of the analytical results in an effort to arrive at a definite clinical conclusion, making use of any and every available diagnostic procedure for that purpose.

2) When the clinical symptomatology is non-specific in character,in the case of men who have been working steadily up to the time the samples were obtained for analysis,a cause and effect relationship between lead absorption and the present illness can be excluded,when

a) the results on a sample of blood and a representative sample of

of urine are within safe limits as herein defined,(i.e.,less than 0.06 mg.Pb per 100 grams of whole blood,and not more than 0.10 mg. Pb per liter of urine);or when

b) the average results on a series of spot samples (approximately 100 ml.) of urine or on at least two large samples (several liters) of urine are within safe limits as defined above.

3) A cause and effect relationship between non-specific symptomatology and lead absorption may be assumed to exist when

a) other causes for the symptomatology have been excluded beyond reasonable doubt,and the analytical results are above the safe limits defined above;or when

b) the cause of symptomatology is quite uncertain and the analytical results are within a dangerous range,i.e. - 0.07 to 0.10 mg.Pb (or more) per 100 grams of whole blood,0.15 to 0.40 mg.Pb (or more) per liter of urine.

4) A cause and effect relationship between strongly suggestive or characteristic symptoms and lead absorption may be assumed to exist,when

a) the analytical results are within the dangerous range;or when

b) the analytical results are known to have been within the dangerous range at the onset of symptomatology and at the time an occupational lead exposure was occurring. (This refers to a man who has been removed from an exposure from some weeks,whose excretory rate has abated somewhat,but whose symptoms persist.)

When analytical data are available on employed persons without symptoms or objective signs of illness.

1) Asymptomatic persons should be removed from lead exposure or transferred to work involving greatly reduced exposure,when

a) the analytical results on blood and urine are within dangerous limits;i.e.,more than 0.07 mg.Pb per 100 grams of whole blood,and more than 0.13 mg.Pb per liter of urine;or when

b) the analytical results on a series of spot samples of urine or on two large samples of urine are within dangerous limits as defined above.

When persons previously removed from exposure or transferred to other work have recovered from all symptoms and signs of illness,they may be returned to their former work,when,

a) the conditions originally responsible for their hazardous exposure have been recognized and substantially corrected;and when

b) the analytical results have fallen to levels that are consistently safe,i.e.,the lead concentration in the blood is down to 0.05 mg.per 100 grams of whole blood or lower,and the average urinary lead concen-

tration of a series of spot samples or of two large samples at least, is not in excess of 0.10 mg.per liter.

Plant supervision - The plant physician should make a critical inspection of the plant under operating conditions at intervals of approximately one month,at which time he should criticize all the procedures and recommend such changes as are advisable for the maintenance of safety.

Air analyses - Equipment should be available and operated regularly to test the air of all working spaces for its lead content. A high degree of accuracy is necessary both in the collection of samples and in the analytic procedures, and the methods must be such as to determine both organic and inorganic lead compounds and to distinguish between them when this is necessary.

All the data referred to above should be reported to the physician-in-charge and should be used by him to keep himself and the management fully informed as to the higienic status of the plant as a whole.

Clothing,Protective Equipment,and Washroom Facilities - Adequate facilities for the protection and cleanliness of the workmen must be made available. Each workman must be provided with complete clothing,so that he may not,under any circumstances,make use of his regular clothing in the plant. There must be a system of double lockers, and comfortable and adequate washrooms,shower baths and toilets. At the beginning of the day's work the workman must change into work-clothing. At lunch-time they must wash carefully and eat their lunch in a clean lunch room. At the end of the day they must remove all their clothing,bathe and change into their own clothing. The proper arrangement of these facilities will not only add to the willingness of workmen to comply with the regulations,but also will provide for such supervision as will not permit carelessness on the part of the workmen.

Impervious gloves,dust masks where required,and air-line masks as needed,must be supplied and maintained in satisfactory condition by the management of the plant. Their use must also be supervised.

II) TRANSPORTATION

The spillage in transit of lead tetraethyl or of mixtures containing high concentrations of lead tetraethyl may cause serious difficulties,in that dangerous exposure may involve carriers as well as other persons who may have no knowledge of the dangers and no means of protecting themselves. Moreover,other commodities may be so contaminated as to cause the dissemination of serious danger into remote regions. The utmost care must be exercised to confine the hazards to points at which they can be controlled.

Containers filled with lead tetraethyl or with concentrated mixtures of lead tetraethyl,when shipped by rail should be secured by suitable means so as not to move about in transit. They should not be mixed with other cargo but should be sent direct from manufacturer to destination and should be handled at both ends of the trip only

by trained and experienced persons. When transported by water, they should be loaded on deck under the supervision of fully informed and experienced persons, and should be secured firmly in place so as not to be damaged and so as not to be a source of danger in transit. Any of the material which may leak or spill on the deck of a ship or barge should be washed overboard promptly and any leaking or broken drums should be disposed of by being cast overboard if possible or necessary, or by being so placed that further leakage will not occur. Every practicable safeguard should be thrown around this phase of the industry and to the extent that this commodity requires unusual care in transport, it should be incumbent upon the manufacturer and shipper to provide conditions compatible with reasonable safety.

III) BLENDING WITH GASOLINE

Hygienic aspects - As in the case of Manufacturing, the design and construction of the blending plant, as well as the type of protective equipment used, are by far the most important factors in determining the degree of safety of the operations.

Lead tetraethyl should be extracted by vacuum from the container (drum) and carried by gasoline through a closed system into the mixing tank previously filled with the gasoline to be treated. In no case should lead tetraethyl, or any concentrated mixture with gasoline, pass through any mechanical part, such as a pump, etc. The system which has been safely used for many years is to pump gasoline from the mixing tank and discharge back into the same tank. A venturi type eductor is installed in a by-pass located in the plant, described below, and the drop in pressure accross this eductor creates a vacuum which draws lead tetraethyl through a stand pipe in the drum, into the gasoline stream returning to the mixing tank.

The plant in which the by-pass is installed consists of a concrete platform, covered by a roof, open on three sides and completely surrounded by a kerb, - with a view to localizing any leakage. The platform should be suitably graded to drains which should discharge into an interceptor, or trap, before passing into the main drainage system (or sea). The fourth side of the platform - which should be large enough to provide a mixing area, where the by-pass is installed, and enough storage capacity - may be of solid construction to form one of the walls of a dressing room, to be provided for the operators. The dressing room should be equipped with a shower and wash basin, and a small kerosene tank should be installed connected to a tap over the wash basin (kerosene is used to wash off any fluid which may accidentally be spilled on the skin of any of the operators.)

Water and kerosene points should be installed on the platform for the purpose of washing down the platform after the mixing operation. Complete specifications of the minimum requirements of such a plant can be provided.

The operators should change into special clothing while working in the plant. The clothing recommended, apart from underwear, consists of a white overall, acid-proof rubber boots, apron and gloves - preferably white - (Heavy clothing to be worn under the overall must be provided as needed.) The operators should also be supplied with a gas mask equipped with a rubber face piece (preferably white) covering the entire face, eyes, nose, mouth, with eye pieces of splinterless glass, a rubber breathing tube, and a canister separated from the face piece, containing not less than 500 cc's of high quality activated charcoal. This gas mask must be worn by the operators whenever they are

present on the platform while a drum of lead tetraethyl is open. The canisters have a limited life and should be changed after 100 hours use or after being in service for six months.

Since the frequency of mixing is a general factor in determining the extent of exposure of workmen, the number of mixes is usually limited to six per month.

After each operation, the men should bathe before dressing in their own clothing. Should any lead tetraethyl have been accidentally spilled on the skin, it should be first washed off with kerosene, then with soap and water. Lead tetraethyl should be coloured so that any stain will be visible immediately.

It is emphasized that operations in the type of plant and with the type of equipment described above have been carried out safely for about 20 years.

Medical control - All men engaged in blending operations should be examined by a physician at least every 6 months. The type of examination should be as described in chapter (I) - MANUFACTURING, BLENDING WITH OTHER INGREDIENTS AND PACKAGING - Clinical Work - but there is no need for examinations of feces and urine.

The analyses of air in the plant is also unnecessary.

IV) DISTRIBUTION OF GASOLINE CONTAINING LEAD TETRAETHYL

Gasoline containing lead tetraethyl in the concentrations permitted, as detailed below, has been distributed practically all over the world for between 15 and 20 years. From time to time over this period of years, detailed investigations have been carried out in the United States, and in certain other countries, in search of evidence of lead absorption or lead poisoning among persons whose work involves skin contact with such gasoline, or exposure to its vapors. Moreover, critical laboratory studies have sought to determine the magnitude and importance of the hypothetical dangers of lead absorption from this source. The results of both the practical field investigations and the laboratory studies have been published in medical literature, and are now generally accepted as fact, since the conclusions of various investigators, including official public health agencies of four different countries (United States of America - Great Britain - France and Denmark) have been in agreement.

The status of the problem is outlined in the following paragraphs for the information of those who have not had access to the reports of the investigations.

1) No cases of lead poisoning have ever been found by investigators, or reported in medical literature, among refinery workers, garage mechanics, or other persons engaged in handling and dispensing leaded gasoline for automobiles or aeroplanes. (The only cases of lead tetraethyl poisoning that have ever been seen or reported have resulted from exposure to concentrated lead tetraethyl. Some few cases of poisoning from decomposition products of lead tetraethyl have been seen among men employed in cleaning gasoline storage tanks that had been in prolonged service. This type of exposure is wholly different from that arising from handling gasoline, and is dealt with separately).

2) No evidence has ever been obtained that contact with commercial leaded gasoline

or exposure to its vapors,results in actual lead absorption,even among severely exposed persons. In fact,all the evidence demonstrates that lead tetraethyl in high dilution in gasoline (one part of lead tetraethyl to about 1,000 parts or more of gasoline) is not absorbed through the skin in measurable amounts,even though large skin areas be in contact with gasoline repeatedly and for long periods of time. Moreover,the boiling point of lead tetraethyl is so much higher than that of gasoline,that more than ten per cent.of the gasoline can be evaporated before measurable quantities of lead tetraethyl come off in the vapor of leaded gasoline.

3) From time to time certain cases of carbon monoxide poisoning and acute gasoline intoxication (from the inhalation of vapors) have been mistakenly attributed to the effects of lead absorption by laymen,only to be recognised subsequently by physicians in their true light. This has occurred because persons who have heard of the early cases of poisoning from exposure to the concentrated lead tetraethyl,have continued to confuse the real dangers of exposure to the concentrated product,with the purely hypothetical possibilities of exposure to commercial leaded gasoline.

4) Cases of skin irritation of a variety of types have also been mistakenly attributed to the minute lead content of gasoline. Investigation has shown that gasoline itself is much more irritating to the skin than are the ingredients of lead tetraethyl,and it has further been demonstrated that certain products of vapor phase and other type of "smoking" are especially irritating to the skin of susceptible persons.

In view of these facts,the precautions required for handling and dispensing commercial leaded gasoline,differ from those necessary in the case of ordinary gasoline only in the following respects: (1) the concentration of lead in the gasoline may not exceed those limits which experience has shown to be safe (3,0 cc. of lead tetraethyl per liter in automobile fuel,and 1,0 cc.lead tetraethyl per liter in certain aeronautical fuels); (2) the gasoline must be coloured to differentiate it from ordinary gasoline and containers and dispensing equipment must be labelled to show that it contains lead and that it is designed for use as a motor fuel only. The reasons for these provisions are fairly obvious. The low concentration of lead in gasoline is definitely the most important factor of safety against lead absorption. This concentration,therefore,must be maintained within proper limits. The differentiation of leaded gasoline from other gasolines is advisable in order to insure its use for the purpose for which it is intended, and for which it is known to be both safe and useful,namely,as a motor fuel. Its use for other purposes such as for cleaning tools and clothing and as a fuel in stoves and lamps,is unnecessary,inadvisable,and perhaps unsafe,although no cases of lead poisoning have been found as the result of such misuse of the product.

Any other attempts to regulate the manner of handling leaded gasoline must now be regarded as wholly unnecessary. In fact the investigations and the experience of the past 13 years have given no evidence of the existence of danger from the normal handling and use of leaded gasoline greater than that associated with the corresponding practices in the case of ordinary non-leaded gasoline.

V) CLEANING OF TANKS USED FOR MIXING GASOLINE WITH LEAD TETRAETHYL AND STORING GASOLINE CONTAINING LEAD TETRAETHYL.-

One of the greatest hazards connected with the handling of gasoline containing

lead tetraethyl arises in connection with the cleaning of tanks used for mixing this compound with gasoline and for storing gasoline containing lead tetraethyl.

The following precautions have been recommended for the safe handling of these operations:

1) STORAGE AND BLENDING TANKS - The tanks considered under this section include all storage and blending tanks which have at any time contained leaded gasoline. The regulations as set down are to be regarded as the minimum requirements for the avoidance of lead exposure.

A) A blower-type or positive-pressure full face-piece airline hose mask must be worn by any person who enters a tank which has at any time contained leaded gasoline,and which has not been thoroughly cleaned. This applies not only to tank cleaners but to all others who go into the tank for any purpose.

NOTE: - Experience has indicated that in general the quantities of residual materials to be removed and the time of exposure are much smaller in the case of tanks of under 50 tons capacity. Preferably a full face-piece blower-type airline hose mask is to be worn by any person who enters such a tank,which has at any time contained leaded gasoline and which has not been thoroughly cleaned. When such a mask is not available a free airline mask with a breathing tube extending well to the outside of the tank may be worn.

B) Hoselines for air maks have a limited life and must be kept clean. If a workman notices any odour such as gasoline while wearing his mask,he must leave the tank at once and find and remedy the cause.

C) All workmen must change into special clothing,consisting of clean overalls, shirts,underwear (in cold weather) and socks;also heavy rubber or acid proof gloves and rubber boots of good quality and in sound condition.

D) Clothing must be changed (and laundered) and a bath must be taken every day, either at the end of each day's work or when the job has been finished. If at any time the clothing gets soaked with sludge,the workman must bathe at once and put on clean clothes. At the end of each day and after the job has been completed,respirators,boots,gloves,and tools must be thoroughly cleaned. Before taking any meals, the face and hands must always be washed and clothing must be changed if inspection shows that it is badly contaminated.

E) Sludge or scale is dangerous to handle,even after it has been taken out of the tank. It should be kept wet and buried at once,in a place where it will not be uncovered later.

PIPE LINE OPERATIONS:- Storage tanks employed in connection with the pumpimg of leaded gasoline through trunk pipe lines,such as Surge,Balancing,or Settling Tanks, etc.,are subject to the above regulations.

Deposits which may periodically be removed from separators should be buried promptly whilst in the wet state. Similarly,when renewing the charges of filtering medium in separators,the old charges should be disposed of promptly by burying.

PRECAUTIONS FOR REPAIRMEN:- Repairmen engaged in any type of work in tanks which have not been thoroughly cleaned must follow the instructions given above. If possible,all cold work should be done only after the tanks have been thoroughly cleaned. Attention is drawn to the possibility that dust or scale or sludge may

remain on ledges or projections in the tank,or may settle there during the course of the cleaning operations. It shall be the duty of the responsible person in charge of cleaning to see that these sources of dust or vapor are removed so as to prevent exposure during any subsequent operations in the tank. Welding and other hot work should never be done until the tanks have been cleaned and all areas that may get hot are scraped down to clean metal.

Work conducted on the outside of tanks or on any component thereof must be undertaken under conditions of adequate natural or artificial ventilation,and in such a manner as to avoid prolonged exposure to dusts,sludge,vapors,or fumes. This regulation also applies to pipe-line filters and separators,etc.

2) GARAGE AND FILLING STATION TANKS - Work conducted on the outside of these tanks,or on any component thereof,must be undertaken under conditions of adequate natural or artificial ventilation,and in such a manner as to avoid prolonged exposure to dusts,sludge,vapors,or fumes.

If for any reason the tanks have to be entered,then the full regulations set down in SECTION (I) must be followed.

3) RAIL AND ROAD TANK WAGGONS:- The only special precautions required under this heading are associated with scaling or repair operations. Steps should be taken to prevent the undue exposure of workmen to lead-bearing dust in cold work and to lead fumes in hot work,by the wearing of suitable masks. Goggles should also be worn during the performance of such work.