REPORT

on

Methods for the Purification of Water after Its Transportation and Storage in Cans, Drums, and Tanks That have been Employed as Containers for Leaded Gasoline

From The Kettering Laboratory of Applied Physiology,
College of Medicine, University of Cincinnati, Cincinnati, Ohio

TABLE OF CONTENTS

Table of Contents continued

ABSTRACT

Methods for the Purification of Water After Its Transportation and Storage in Cans, Drums, and Tanks That have been Employed as Containers for Leaded Gasoline

Satisfactory means were sought for freeing drinking water of lead, odors of gasoline, and objectionable color, that might be picked up from the use, in emergency, of various types of containers that had been employed previously for the transportation and storage of leaded gasoline. Methods for cleaning such containers, prior to the introduction of water, were also studied, and the degree of contamination of water stored in the cleaned containers was determined. From the results of these observations, certain facts and principles can be stated as the bases of recommendations for cleaning gasoline containers and for treating water that has been stored therein.

1. Activated carbon is superior to other absorbents for the removal of color, odor, and inorganic lead, and is almost as effective as any other in removing organic lead. It can be used in the granular state in filter beds or added directly to the water in the powdered form and then filtered out by any available sand filter, or strained out of small quantities of water by flannel cloth.

2. 5-Gallon tin cans can be cleaned effectively by a thorough rinse with soap and water, followed by several rinses with clear water. Water stored in these cans does not pick up dangerous quantities of lead, but should be used promptly to avoid the development of color and sediment in the form of rust.

3. 50-Gallon drums can be prepared for use most satisfactorily, by being steamed for 30 minutes and then thoroughly rinsed with water to which a little powdered carbon has been added. Water stored in drums for 8 days shows but little progressive increase in lead content, but it soon develops a lead concentration that may be somewhat above 0.10 p.p.m., when introduced into drums that are coated with scale on their interior surfaces. The lead concentration of such contaminated water may be reduced to safe levels by adding 1/2 lb. to 1 lb. of powdered activated carbon to the contents of each drum, mixing the contents thoroughly by rolling or otherwise, and straining through a flannel cloth or sand filter. Zinc, present as a white sediment, can be removed in the same manner.

4. Gasoline tank-trucks should be steamed for at least 90 minutes and thoroughly flushed with water to remove loose scale. After 40 hours' storage in tanks so treated, water rarely contains more than 0.15 p.p.m. lead, and this, together with the increased color and sediment caused by prolonged storage, can be removed by filtration through mobile or portable sand filters. Added assurance as to the potability of the water may be provided by adding 1/2 gram of powdered activated carbon for each gallon of water and filtering through sand. As much as 0.40 p.p.m. of lead, together with well defined gasoline odors, can be removed in this manner.

5. Gasoline tank-cars should be steamed for at least 6 hours. Loose scale and sludge should be removed by flushing with a pressure hose before the tank-car is filled with water. The possibilities for the contamination of water that is trans-

ported in this type of container do not differ materially from those arising from the use of tank-trucks, and therefore, the same procedures and precautions are required.

6. Water transported or stored in the above containers is not exempt from the usual requirements as to chlorination.

I. Purpose

The purpose of this study was to determine what operations are necessary to ensure the potability of drinking water when emergencies require the use of containers previously used for leaded gasoline. The containers considered were: 5 gallon cans, 50 gallon drums, tank-trucks, and tank-cars.

II. Conclusions

With the use of proper cleaning methods (see recommendations below) containers previously in leaded gasoline service may be used to store and transport drinking water, but such water may have to be chlorinated to ensure its potability. Water stored for any length of time in iron tanks acquires some color and sediment, but these along with a slight odor and small quantities of lead may be removed by filtration through the mobile or portable Army purification units. Gasoline odors and lead appreciably above permissible limits in drinking water can be removed satisfactorily, when necessary, by filtration through granular activated carbon beds or by treatment with powdered activated carbon. This treatment, however, will rarely be necessary if the containers have been properly cleaned and if storage of water in the containers does not extend beyond 40 hours.

III. Procedure

The study was divided into two parts: (A) Laboratory studies to determine the best means of removing lead and gasoline odor when present in drinking water, and (B) methods for cleaning the containers and field studies with containers so cleaned.

A. Removal of Gasoline Odor and Lead from Drinking Water

A number of materials were investigated to determine the most efficient means of removing gasoline odor and lead when present. Table 1 lists the results obtained with various absorbent or ion-exchange materials.

In these tests, one gram of each material was shaken for 1 hour with a sample of each of the prepared solutions containing known quantities of inorganic lead (as lead nitrate), organic lead (as triethyl lead bromide), or gasoline of a known threshold odor value, all samples being of equal volume. After shaking for 1 hour, the absorbent was removed by filtration and the filtrate was analyzed to determine how much of the impurity was still present.

Analyses were made for total lead, any organic lead present being converted to the inorganic form by addition of bromine water. The standard dithizone method for lead determination developed in this laboratory was employed. (Bambach and Burkey, Ind. Eng. Chem., Anal. Ed. 14, 904 (1942)) In testing for threshold odor (T.O.) values the standard method of diluting the sample with odor-free water was employed. Thus the T.O. value, whenever recorded, gives the dilution with odor-free water required to reduce the odor of the sample (in the cold) until it is barely perceptible.

Changes of pH over the range 4-8 had no appreciable effect on the ability of the various materials to remove the undesirable contaminants. From Table 1 it may be seen that organic lead is the contaminant most difficult to remove. It may also be seen that the choice of absorbent is limited to three -- activated carbon, Amberlite IR-100, and Zeo Karb. The pro-

nounced superiority of activated carbon for the removal of odor and inorganic lead (as well as color) and the fact that it is practically on a par with the other absorbents in the removal of organic lead, indicate that this absorbent used alone would be satisfactory for the removal of all the harmful compounds involved in this study.

The next step was to determine the efficiency of granular activated carbon beds in removing the contaminants when present individually or in combination. For purposes of individual study, high concentrations were purposely chosen in order to cover the worst conditions that might occur. The activated carbon used was "granular Hydrodarco." A glass tube of 1" I.D. containing 1-2 inches of sand was covered with Hydrodarco to a depth of 20-24 inches. After flushing away loose particles of carbon, the test waters were passed through the columns at a rate of 50 ml. per minute, which corresponds to a rate of 2.5 gallons per minute for a filter bed of 1 square foot area -- the rate recommended for the most efficient operation of carbon beds. Channeling was avoided by employing a feeding arrangement which kept the beds completely covered with water at a constant head. The standard 42" sand filter of the Army mobile purification unit, when replaced by granular activated carbon, would give an effluent of 25 gallons per minute, at the same rate of filtration, but this rate could be increased considerably with clear waters only mildly contaminated by lead and gasoline. Table 2 gives the capacity of such carbon beds for various types and degrees of contamination.

Again the limiting factor proved to be organic lead. However, when this was present in moderate amounts, as in run #4

(Table 2), the limiting factor was gasoline odor. Although the runs were terminated as soon as the odor of gasoline became definitely perceptible, the capacity to remove moderate amounts of lead had not been reached since the water at the end of the run had a total lead content of only 0.01 p.p.m. Therefore, when water is only moderately contaminated by gasoline odor and lead, the life of the carbon filter bed may be expected to be several times 30,000 gallons of water.

Preliminary work indicated that either powdered or activated carbon could be used. With granular carbon, a special filter case must be used for treating small quantities of water. Such a case was designed and used to study contaminated water stored in 50-gallon gasoline drums (Figure 1). Powdered charcoal could also be added directly to the water and the carbon could be filtered off through a flannel cloth or permitted to settle out. The results of tests with the filter case and various types of lead and gasoline contaminations are given in Table 3.

1. Tests with Powdered Carbon

In these tests, drums which had previously contained gasoline (Sohio X-70) were allowed to drain and air spontaneously. They were then filled with water to which gasoline (to give water with T.O. value of 10-20) and lead (0.15 p.p.m. inorganic and 0.15 p.p.m. organic) had been added. One pound of powdered carbon was added to each drum and the drums were shaken for 30 minutes. The contents of one drum were tested by withdrawing samples every 30 minutes over a period of 2 hours, after which the drum was allowed to stand for 1 week, samples being withdrawn at various intervals. The water in the other drum was sampled

end of 24 hours. The results are given in Table 4. In every sample taken during the 30-minute period, gasoline odor was absent from the filtered water, while the lead level was approximately 0.02 p.p.m. After standing 24 hours, there was a slight but insignificant pick-up in gasoline odor, but no increase in the lead content.

These laboratory tests proved, therefore, that the contaminations resulting from the storage of gasoline in containers previously used for gasoline could be effectively removed either by using carbon filter beds or by adding powdered carbon directly to the water.

B. Cleaning and Field Studies

In order to make satisfactory recommendations for cleaning procedures, it was necessary to establish the degree of contamination of water which could occur in the field and to determine the precise steps which must be taken to render it safe or to reduce the contamination to levels susceptible to effective handling by the methods described in the previous section. All the types of containers that might be used for the storage of water were studied.

1. Five-Gallon Tin Cans

Two cans were filled, one with aviation gasoline, the other with an ordinary grade of leaded fuel (Sohio X-70); they were then emptied, drained, and allowed to air. After sufficient time had elapsed (30 minutes) they were half filled with water, 1 oz. of ordinary powdered soap was added and the can was shaken vigorously for 3 minutes. The soapy water was discarded and the can was rinsed with clear water, filled to overflowing, emptied,

and filled again with tap water. The following results were obtained.

Can #1 - Aviation fuel	0.003 p.p.m. Pb after 24 hr. 0.065 p.p.m. Pb after 1 week No odor
Can #4 - Sohio X-70	0.003 p.p.m. Pb after 24 hr. 0.110 p.p.m. Pb after 1 week Very faint odor

Other methods of cleaning, such as draining and spontaneous airing, followed by rinsing several times with water, or by simple filling with water to displace vapors and droplets of gasoline, gave waters which showed a lead content no higher than those given above, but the gasoline odors were decidedly heavier.

An additional series of observations was carried out to determine the extent of lead contamination that occurs when water is stored in tin cans for an extended period of time. Various types of water were examined in this respect. The results are listed in Table 5. After 1 week there was a decided pick-up in rusty sediment and color, especially with the chlorinated samples, but the increase in the lead content was insignificant and decidedly less than that observed in the case of the cans employed in the cleaning tests. This result was surprising since the cans used in this second experiment were said to have been soldered with a lead-containing solder, and one expected to find an increased lead content in water stored in them for a considerable period. The work was checked, therefore, with 5 fresh cans, with results that agreed substantially with the findings listed in Table 5. As it is hardly likely that water will be kept in such small containers for more than a few days, these observations demonstrate that 5-gallon tin cans can safely be used to transport drinking water.

2. 50-Gallon Drums

Two additional problems presented themselves in respect to this type of container. Since these drums are usually made of galvanized material, there was the possibility of an additional hazard from zinc, and the zinc content of the stored water was determined. Some drums are also known to be coated on the inside with scale and it seemed possible that this scale might increase the lead content of the water if storage periods were prolonged.

A number of methods for cleaning drums were investigated.

In the case of a first series of six drums, all of the gasoline was permitted to drain out and the drums were allowed to air spontaneously for some time. They were then half filled with water, 1 lb. of soap powder was added to each, and the drums were rolled back and forth over a distance of 20-30 feet for about 15 minutes. The soapy water was discarded and each drum was rinsed with 20 gallons of clear tap water, the rolling treatment being repeated. The drums were then filled to overflowing to displace any remaining droplets of oil or gasoline, and were again emptied. Only one of these drums had a definitely scaly interior.

Two drums (Nos. 7 and 8), containing no visible scale, were cleaned by the procedure described above, with the following modifications: After the gasoline had been drained out, the drums were aerated for 15 minutes with an air hose, and in the washing process 1/2 lb. of powdered activated carbon was added to the rinse water.

One drum with interior scale (No. 9) was treated merely by steaming for one hour.

After being cleaned by one of the foregoing methods, all drums were filled with fresh tap water and stored for 8 days. Samples were withdrawn for analysis at the end of 1, 2, 4, and 8 days. The results are given in Table 6. As may be seen, there was only slight evidence of lead contamination in the water stored in drums with clean bright inner surfaces, and no significant evidence of progressive increase in lead content during prolonged storage in such drums. Water in the drum with the scaly interior, while showing no progressive increase in lead content over the 8-day period, in one case was contaminated promptly with lead to a point slightly above the permissible limit of 0.10 p.p.m., in contrast to an average of about 0.03 p.p.m. for the drums with bright interiors. The gasoline odor in the first 6 drums was sufficiently noticeable to make the taste of the water objectionable (average T.O. value, 25). On the other hand, the water in drums 7 and 8, while entirely free from gasoline odor, possessed a musty unidentified odor which was as objectionable as the gasoline odor. Water from drum 9 was the best since it was practically free from odor (gasoline or musty), until it had been in storage for four days, after which a fleeting gasoline odor was detected.

The zinc content of the water stored in all the drums listed in Table 6 gradually rose as the length of the storage period increased. (The apparent decreases recorded undoubtedly arose from the fact that the sample drawn was not representative because of settling of the zinc deposits.) In no case, however, was the quantity above 10 p.p.m. Most of the zinc was present as a white sediment and tests showed that almost 95% could be removed by filtration, particularly when the water was cloudy. Several

folds of flannel cloth made a satisfactory filter.

3. Gasoline Tank-trucks

The results of observations made on a number of gasoline tank-trucks are shown in Tables 7-11. The tables are self-explanatory and definite conclusions can be drawn from the results. It can be seen that water stored in steamed compartments for 18 hours is safe insofar as lead content is concerned. In the dirtier tanks there was a slight increase in lead content as storage was prolonged but water in well steamed compartments did not contain more than 0.15 p.p.m. at the end of 40 hours. Gasoline odors were faint and while distinct in waters stored in closed containers these odors could barely be noticed when the vessels were kept open to the air. Therefore, if clear water collected in cleaned tank-trucks is used within the first 4 hours of storage, no treatment other than chlorination will be required. Following storage for 18 hours or longer, there was a distinct increase in sediment and color, but both were easily removed in a laboratory test simply by filtering through a sand filter. This operation reduced the odor as well, and, when moderate amounts of lead were present, it lowered the concentration to a safe level.

Water that had been stored in an Army truck (#80482 - two 375-gallon compartments) under various conditions, was filtered through sand by means of a Wallace and Tiernan portable purification unit. The results are listed in Table 12. The unit effectively clarified the water, without coagulation procedures, when the rate of filtration was approximately 5 gallons per minute. Moderate concentrations of lead were also removed. Tests carried

out with water contaminated by lead and having a gasoline odor of the approximate strength observed after 40 hours' storage of water in steamed and cleaned compartments, proved that the lead content of the effluent could be reduced to a safe level even when 3000 gallons were passed through the unit without backwashing (Runs 1-4, Table 12). The lead concentration in the water did not vary from the beginning to the end of the run and averaged approximately 0.065 p.p.m., this fact suggesting that the organic lead may not have been removed (See Table 1). Some confirmation of this possibility is offered, perhaps, by the results in Run 6, in which inorganic lead was the only contaminant. In this instance the lead content of the effluent filtered water was only one-half that obtained in Runs 1-4 and Run 8. The results of Run 5 show that after the unit has been employed to filter water contaminated by lead and gasoline, and after backwashing has been done in the customary manner, it may be used to filter "lead-free" water without danger of imparting significant quantities of lead to the water. The data of Run 8 show that lead removal is not altered appreciably by change in the pH value of the water and confirm the results obtained in Runs 1-4.

Although it is not likely that water stored for 40 hours in properly cleaned tanks will contain lead in excess of 0.15 p.p.m., a test was made with a badly contaminated water (Run 7). In this test, 250 grams of powdered activated carbon were added to each 375 gallons of contaminated water and after thorough mixing (the truck was driven for about 10 miles) and a quiet settling period (2 hours), the water was passed through the unit. Lead and odors were absorbed by the carbon, and the effluent filtered water was odor-free (except for chlorine), and

safe insofar as its lead content was concerned. It is apparent, in fact, that the addition of carbon offers an added assurance that the final water will be safe for use, since it not only removes all of the odor and inorganic lead but is also a more efficient agent than sand for the removal of small quantities of organic lead. The powdered carbon may be added to the water immediately after the tanks have been filled and the only mixing required is that which occurs automatically while the truck is driven to its destination. The effectiveness of the treatment with carbon is not impaired by moderate turbidity of the water. With the amount of carbon employed in Run 7, it was found that there was no clogging of the sand filter during a run of 750 gallons, and it is likely that the number of backwashings of the filter required will not be appreciably greater with carbon than is usually necessary when coagulation is employed.

In connection with the removal of gasoline odor, it was noticed that a very fleeting odor was obtained occasionally, particularly when the filtration rate was too rapid and when carbon had not been added to the water. In every case, however, the odor disappeared after only a few minutes' exposure of the water to the air, while in most instances the only odor in the effluent water was due to the chlorine added by the chlorinator.

Repeated use of the steamed compartments can be expected to improve the quality of the water, particularly insofar as odor is concerned. Tests on the tank-truck also revealed other things, as for example, the necessity of flushing away loose rust and scale before each filling with water, particularly if the water had remained in the tank for more than a day. They also showed that the water employed to displace gasoline droplets on the water

surface need not be entirely discarded, if the tanks are filled to overflowing, and that the compartments may be filled immediately after cleaning.

4. Gasoline Tank-cars

Two tank-cars which had been in continual leaded gasoline service were studied (Table 13). They contained only small amounts of scale. If a man (provided with a canister mask or an air-line hose mask), enters the steamed tank he can flush away most of the loose scale by means of a fire hose. Water stored in such tanks appears to be perfectly safe insofar as lead content, odor, or color are concerned if used within 24 hours. Steaming beyond six hours is not necessary. Waters having low pH values tend to pick up small quantities of lead and color, but not to a dangerous extent.

IV. Recommendations

The following recommendations are made for cleaning containers previously employed in leaded gasoline service, and for handling the water stored therein.

A. 5-Gallon Tin Cans

1. Choose new cans with bright interiors.
2. Allow the can to drain for 10-15 minutes in order to remove as much gasoline as possible.
3. Fill the can with water until half full, add 1 ounce of any powdered soap (or 3 ounces of powdered activated carbon) and shake for 5 minutes.
4. Discard water and again put in 2-3 gallons of water and shake.

5. Discard rinse water and fill to overflowing with water. Discard this water.
6. Fill with water to be used for drinking purposes.

Water thus stored should be used within a few days. Cans placed in water service rust rapidly and should be cleaned to remove as much rust as possible before each filling. It would be preferable, if possible, to discard used cans and to use only fresh cans for water service.

B. 50-Gallon Gasoline Drums

1. Choose drums that show no interior scale. The interiors should be bright and the galvanized coatings clearly discernible.
2. If steam is available, steam for 1/2 to 1 hour and proceed with step 5 or 8 below, depending on the quantity of water available.
3. If no steam is available, aerate for 15 minutes with compressed air.
4. Add 10-20 gallons of water, 1 lb. of powdered soap, and shake by rolling the drum back and forth for 15 minutes over a short distance. Discard contents.
5. Put in 10-20 gallons of water, 1/2 lb. of activated powdered carbon, and repeat rolling operation. Discard contents.
6. Remove residual carbon by rinsing repeatedly with small portions of water.
7. If time permits and a sufficient supply of water is available, fill drum to overflowing and discard its contents.

8. Fill drum with drinking water.

Water may be stored in these drums for at least 8 days. White sediment (zinc compounds) may be filtered off through several folds of closely woven cloth or flannel. If there is a white scale on the interior of the drums, the lead content of the water may increase to above 0.10 p.p.m. In this case, and also if neither steam nor compressed air is available and step 7 must be omitted, the water may have an appreciable gasoline odor. It may be made fit for use, however, by filtering it through the carbon filter case shown in Figure 1. For most efficient operation, renew the carbon filler for each drum of water filtered. An alternative procedure is to add 1 lb. of powdered activated carbon to the water in the drum, shaking it for 10-15 minutes. The carbon may be filtered off through several folds of finely woven cloth or flannel.

C. Gasoline Tank-trucks

1. Drain gasoline as completely as possible from compartments.
2. Steam each compartment for not less than 90 minutes. (A steam jenny such as is used by building cleaners is satisfactory.)
3. Flush out loose scale with a pressure water hose.
4. Fill to overflowing with water in order to displace all gasoline.
5. Drain to the gage level.

Water thus transported may be used without further treatment (other than possible chlorination) up to 18 hours after

filling, if it shows no color or sediment. If the water has become strongly colored and has picked up sediment, its appearance may be considerably improved by passing it through the standard army mobile or portable purification unit. This procedure not only removes color and sediment but also decreases the gasoline odor and lead content of the water. All water stored longer than 18 hours in trucks with iron tanks should most certainly be filtered through the sand filter to remove lead, for the lead content may have risen above the tolerance limit of 0.10 p.p.m. Increased assurance as to safety of the water may be provided by adding 0.5-1 gram of powdered activated carbon to each gallon of water, after its collection. After thorough mixing, the carbon should be allowed to settle for several hours and the water should be completely clarified by filtration through the mobile or portable water purifier. Trucks once cleaned and placed in water service improve with use insofar as odor and lead content are concerned, but should be flushed with a hose before each filling to remove scale and rust which will otherwise color the water after only a short period of storage.

D. Gasoline Tank-cars

1. Steam for not less than 6 hours. (Locomotive steam or powerhouse boiler steam must be available.)
2. If possible (caution*) have a man enter the tank-car to flush away all loose scale on the surfaces of the tank, by means of a hose and a stream of water under pressure.
3. Fill to overflowing with water to displace any gasoline remaining in pockets, etc.

4. Drain water to level of dome.

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*Caution: A gasoline tank-car should not be entered in the absence of facilities for testing its freedom from harmful or explosive gasoline vapors, except with the following precautions:

1. The man who enters shall be equipped with a full face-piece (covering the eyes, nose, and mouth) or with partial face-piece (covering nose and mouth) and goggles, to which is connected a canister with an adequate supply of fresh activated charcoal, or a hose line with a constantly supplied and adequate stream of fresh air. The Army service mask will be adequate, if the canister is fresh, but after use in entering a tank-car the canister should be replaced by a new one.

2. A safety line shall be firmly secured to the person entering the tank, by means of a suitable harness or belt, and led to the outside of the tank into the hands of observers who shall be constantly prepared to remove the individual from the tank at the first sign that he is being affected by gasoline vapors. At least two persons shall be present on the outside to rescue the entrant, and to resuscitate him if need be, by prompt application of artificial respiration.

3. Care against fire or explosion must be taken by all persons in and on the tank-car by employing spark-proof tools and nozzle, and wearing shoes free of hobnails.

In using water transported in gasoline tank cars, the same precautions should be followed as in the case of tank-trucks.

In the case of tanks (either trucks or cars) which show heavy rust and scale deposits, flushing away of the deposit may open up pockets containing droplets of gasoline or uncover fresh surfaces that may be high in their lead content. The result may be to increase the gasoline odor or the lead contamination of the water. Possibly such pockets open up after water has been stored in the tanks for extended periods and this may account for the gradual increase in the gasoline odor and lead content noticed especially in the rustier tanks. Many of these pockets can surely be eliminated in the case of tank-trucks, if the walls are hosed prior to the steaming operation, in addition to the final

hosing. In the case of tank-cars, it may be good practice to interrupt the steaming after 4 hours in order to hose down the walls. The steaming should then be continued for 2 hours longer, followed by the final hosing procedure as outlined in the recommendations.

Since this study was carried out principally during the summer months, it is probable that the results are representative of the worst conditions, because of the generally increased chemical activity attending high temperatures.

Kettering Laboratory of Applied Physiology

Approved: Robert A. Kehoe

Robert A. Kehoe, M.D.,
Director

Experimental work performed by:

J. Cholak, Ch.E.
R. R. McNary, Ch.E., A.M., Ph.D.
Karl Bambach, A.B., Ph.D.
R. K. Burkey, B.Ph.

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Report prepared by:

J. Cholak, Ch.E.

Table 1

Relative Effectiveness of a Number of Materials in Removing Inorganic L
Organic Lead, and Gasoline Odor from Drinking Water

Material	Milliequivalents of Pb as $PbNO_3$ removed/g. material	Milliequivalents of $PbEt_3Br$ removed/g. Material	T.O.* Va after Abs
Powdered Activated Carbon	2.8	0.81	N
Amberlite IR-100	1.54	0.98	
Zeo Karb	1.60	1.07	
Activated Alumina	0.55	0.01	
Amberlite IR-4	0.42	Practically nil	
Fuller's Earth	0.42	Practically nil	
Supercell	0.196	Practically nil	
Sand	0.166	Practically nil	1

*150 ml. of water with a T.O. value of 300 used with 1 g. of material in these test

Table 2

Removal of Inorganic Lead, Organic Lead, and Gasoline Odor from Water by Granular Carbon Filter Bed 42" D by 2' Deep

(Rate Filtrate 2.5 gallons/sq. ft. area)

(1) 10 mg. Pb (inorganic) per liter distilled water*	16,000 gal.	
(2) 7 p.p.m. lead triethyl bromide in tap water*	1,430 gal.	
(3) Water saturated with gasoline	10,000 gal.	(To T.O.
(4) Tap water mildly contaminated with lead (0.12 p.p.m. each of organic and inorganic lead), plus gasoline to give a T.O. value of 100	29,000 gal.	(To T.O.

*Tests were discontinued when Pb content of 0.10 p.p.m. was reached.

Table 3

Removal of Lead and Gasoline Odor from Water by 15" x 6" Granular Hydrodarco Bed in Filter Case (cf. Figure 1)

Run	Water artificially contaminated	Pb content by analysis	Amount filtered (gallon)	Pb in wa at end of p.p.m
1	0.5 p.p.m. inorganic lead + 2 p.p.m. organic lead + gasoline odor	3.05 p.p.m.	40	0.105
2	Same as above	2.56 p.p.m.	38	0.16
3	0.5 p.p.m. inorganic lead + 0.5 p.p.m. organic lead + moderate gasoline odor	1.16 p.p.m.	40	0.11
4	0.1 p.p.m. each of organic and inorganic lead and gasoline odor to T.O. value of 300	0.29 p.p.m.	122	0.030

Table 4

Lead Content and Gasoline Odor of Water Stored in 50-Gallon Drums, Following Treatment with 1 Pound of Powdered Activated Carbon

Duration of storage	Drum 1		Drum
	Pb in filtered water p.p.m.	Gasoline odor in water	Pb in filtered water p.p.m.	G
Control	0.30	Very strong	0.20	
10 min.*			0.025	
20 min.*			0.017	
30 min.*	0.005	Very faint	0.025	
60 min.	0.000	Very faint		
90 min.	0.000	Very faint		
120 min.	0.015	Very faint		
18 hr.	0.020	Very faint		
24 hr.			0.011	
42 hr.	0.016	Definite		
3.5 days	0.018	Definite		
5.5 days	0.009	Definite		
6.5 days	0.010	Definite		

*During these periods the drums were shaken.

Table 5

Lead Content of Water Following Prolonged Storage in 1 Gallon Tin Cans

Experiments with Various Types of Water

Type of Water	pH Water before storage	Pb (p.p.m.)		
		Before Storage	After 1 week	After 2 weeks
Cincinnati City Water	7.88	0.016	0.006	0.007
Cincinnati City Water + Cl_2 (5 p.p.m.)	7.80	0.001	0.003	0.003
Norwood City Water	7.57	0.002	0.007	0.004
Norwood City Water + Cl_2 (5 p.p.m.)	7.1	0.005	0.005	0.004
Distilled Water	6.5	0.004	0.006	0.007

Table 6

Lead, Zinc, and Gasoline Odor in Water After Prolonged Storage in 50-Gallon Gasoline Dr

Drum No.	Cleaning method	Storage period								
		1 day		2 days		4 days		8 days		
		Pb p.p.m.	Zn p.p.m.	Pb p.p.m.	Zn p.p.m.	Pb p.p.m.	Zn p.p.m.	Pb p.p.m.	Zn p.p.m.	
Control	Water from city main	0.006	0.10							
1	Washed with soapy water, rinsed, flushed and filled	0.013	1.33	0.018	2.70	0.036	4.60	0.030	6.1	Str cre sed hou
2	The same	0.048	3.45	0.029	3.50	0.031	4.00	0.030	5.8	The
3	The same	0.020	2.14	0.019	2.40	0.029	4.95	0.035	4.7	The
4	The same	0.011	1.31	0.010	1.83	0.010	4.90	0.012	4.6	The
5	The same	0.021	1.43	0.014	1.47	0.022	3.70	0.025	7.6	The
6	The same (white scale on interior of drum)	0.135	1.11	0.090	1.80	0.130	2.25	0.060	3.17	The
7	Aerated with pressure hose, washed with soapy water, rinsed with water and powdered carbon	0.011	2.2	0.012	3.9	0.010	4.5	0.014	2.85 0.17*	No as
8	The same as (7)	0.010	5.8	0.015	6.8 0.45*	0.009	3.49	0.012	2.72	The
9	Steamed for 60 minutes and rinsed (white scale on interior of drum)	0.020	0.55	0.040	1.27	0.040	1.55	0.050	2.45	Gas sam 3rd

*Represents soluble zinc content of water after removal of suspended material by filtration.

Table 7

Lead Content and Odor of Water Transported and Stored in Gasoline Tank Truck

Truck #1 -- 805 Gallon Capacity -- Sohio #4410 (3 Years Old)

Capacity of compartment gallons	Treatment	After 20 min.		After 4 hr.		After 16 hr.	
		Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.	Odor
300	90 min. steaming, flushed to remove loose scale; filled to overflowing, emptied, filled to gage level	0.032	+	0.020	+	0.013	+
250	Control, not steamed; other treatment same as above	0.066	++++	0.115	++++	0.040	++++
150	60 min. steaming; otherwise same as 300	0.029	+	0.015	+	0.025	+
105	30 min. steaming; otherwise same as 300	0.039	+	0.016	++	0.026	++

After steaming operation, compartments appeared slightly rusty, with little loose sediment, and very slight odor from steamed compartments.

Average threshold odor value of water stored in steamed compartments - 3, unsteam Waters acquired some color in 4 hours with marked increase toward end of run. Sli taste was observed after 4 hours. In general, there was no objectionable taste.

Lead content of water from Cincinnati mains, used in this and all subsequent tests where noted), = 0.008 p.p.m.

Table 8

Lead Content and Odor of Water Transported and Stored in Gasoline Tank Truc

Truck #2 - 825 Gallon Capacity - Sohio #4616 - 2-1/2 Years Old

Capacity of compartment gallons	Treatment	After 1 hr.		After 4 hr.		After 18 hr.	
		Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.	Odor
305	90 min. steaming, flushed to remove loose scale; filled to overflowing, emptied, filled to gage level	0.030	+	0.031	+	0.019	+
255	Control - not steamed; otherwise same as 305	0.029	++++	0.029	++++	0.016	++++
155	60 min. steaming - otherwise same as 305	0.029	+	0.013	+	0.010	+
110	30 min. steaming - otherwise same as 305	0.015	+	0.012	+	0.013	+

Following steaming, compartments had faint but distinct gasoline odor, with somewha and sediment than in case of truck 1. The water in all compartments (except contr from oily taste. There was somewhat greater pick-up in color and sediment after 4 ing than in case of truck 1. There was slight odor in water; disappeared on heati exposure to air. Color and sediment were completely removed by addition of 1 g. c gallon and filtering.

Table 9

Lead Content and Odor of Water Transported and Stored in Gasoline Tank Truc

Truck #3 - 1600 Gallon - "Autocar" Trailer - Ethyl "Q" Service

Capacity of compartment gallons	Treatment	After 30 min.		After 4 hr.		After 18 hr.	
		Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.	Odor
300	30 min. steaming, flushed to remove loose scale; filled to overflowing, emptied, filled to gage level	0.042	+	0.074	+	0.053	+
375	60 min. steaming; flushed to remove scale; filled to gage	0.041	+	0.039	+	0.088	++
350	Control - not steamed; other treatment same as 300 above	0.038	++++	0.040	++++	0.042	++++
575	90 min. steaming; other treatment same as 300 above	0.017	+	0.020	+	0.027	+

Steamed compartments had a very slight odor before filling. All compartments were and had loose scale which was flushed away. Odor and taste of water in steamed co were about the same as in previous tests. Pick-up in color and sediment was the s other tests.

Water from compartment 375, when filtered through sand bed, gave clear, colorless lead content reduced to 0.01 p.p.m.

Table 10

Lead Content and Odor of Water Transported and Stored in Gasoline Tank Tru

Truck #4 - 500 Gallon Capacity - In Use for at Least 15 Years (3 Compartme

Capacity of compartment gallons	Treatment	After 30 min.		After 4 hr.		After 18 hr.	
		Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.	Odor
280	90 min. steaming, flushed to remove loose scale; filled to overflowing, emptied, filled to gage level	0.040	+	0.065	++	0.085	++
140	90 min. steaming; flushed to remove scale; filled to gage	0.090	+	0.085	++	0.075	++
75	Control - not steamed; other treatment same as 280 above	0.275	++++	0.37	++++	0.540	++++

Somewhat increased odor in water stored in steamed compartments, but oily taste ab
increase in color and sediment, particularly after 4 hours' storage. Water from c
after 42 hours' storage was filtered through sand filter; it was then clear and co
lead content reduced to 0.006 p.p.m. Slight odor was present, but disappeared rap
to air.

Table 11

Lead Content and Odor of Water Transported and Stored in Gasoline Tank Trucks

U.S. Army Truck #80482 - 750 Gallons - Two 375-Gallon Compartments

Compartment	Treatment	After 1 hr.		After 4 hr.		After 21 hr.		After 45 hr	
		Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.	Odo
1	90 min. steaming, flushed to remove loose scale; filled to gage	0.006	None	0.008	None	0.009	None	0.008	Non
2	180 min. steaming; same as above	0.003	None	0.007	None	0.010	None	0.010	Non
1	Following above test, both compartments were emptied and refilled with water (second filling).	0.011	None	0.009	None	0.004	None	--	--
2	Same as above	0.007	None	0.006	None	0.004	None	0.004	Non
1	Third filling - Following above test, both compartments were flushed out with hose and immediately filled with tap water	0.002	None	0.002	None	0.004	None	0.005	Non
2	Same as above	0.007	None	0.002	None	0.007	None	0.005	Non

Note: This truck evidently had not been in recent gasoline service. It was contaminated with gasolin gasoline in it for 3 days. Before steaming and introducing the gasoline, accumulated rust and away.

Table 12

Performance of Wallace and Tiernan Portable Water Purification Unit

Run	Type of water	Pb before passing thru unit p.p.m.	Water passed thru unit gallons	Pb in effluent water (range)* p.p.m.	Pb in effluent (average) p.p.m.	Appe wa
Control	City water stored in Army truck #80482 for 60 hours. (Rust and sediment)		750	0.01	0.01	Clea Colo
Runs 1-4	Water contaminated by adding 0.15 p.p.m. total lead (0.10 inorganic + 0.05 organic) + small amount of gasoline	0.16	3000	0.06-0.075	0.065	Clea Colo
Run 5	Uncontaminated city water run following backwashing of unit to remove sediment collected in Runs 1-4	0.007	750	0.007-0.010	0.008	Clea Colo
Run 6	Water contaminated with inorganic Pb (0.15 p.p.m.), passed through unit following backwashing after Run 5	0.15	750	0.030-0.045	0.035	Clea Colo
Run 7	Water contaminated with Pb (0.40 p.p.m. -- 0.30 inorganic + 0.10 organic) + gasoline. Water treated with 1 lb. activated carbon before passing through unit.	0.01**	750	0.015-0.030	0.020	Clea Colo
Run 8	City water contaminated as in Runs 1-4 but adjusted to pH 5.2	0.15	750	0.065-0.075	0.069	Clea Colo

Note: pH of water in runs 1-7 = 7.8 - 8.4

*Analysis made at end of each 187.5 gallons of effluent.

**Reduced from 0.38 p.p.m. after addition of carbon.

Table 13

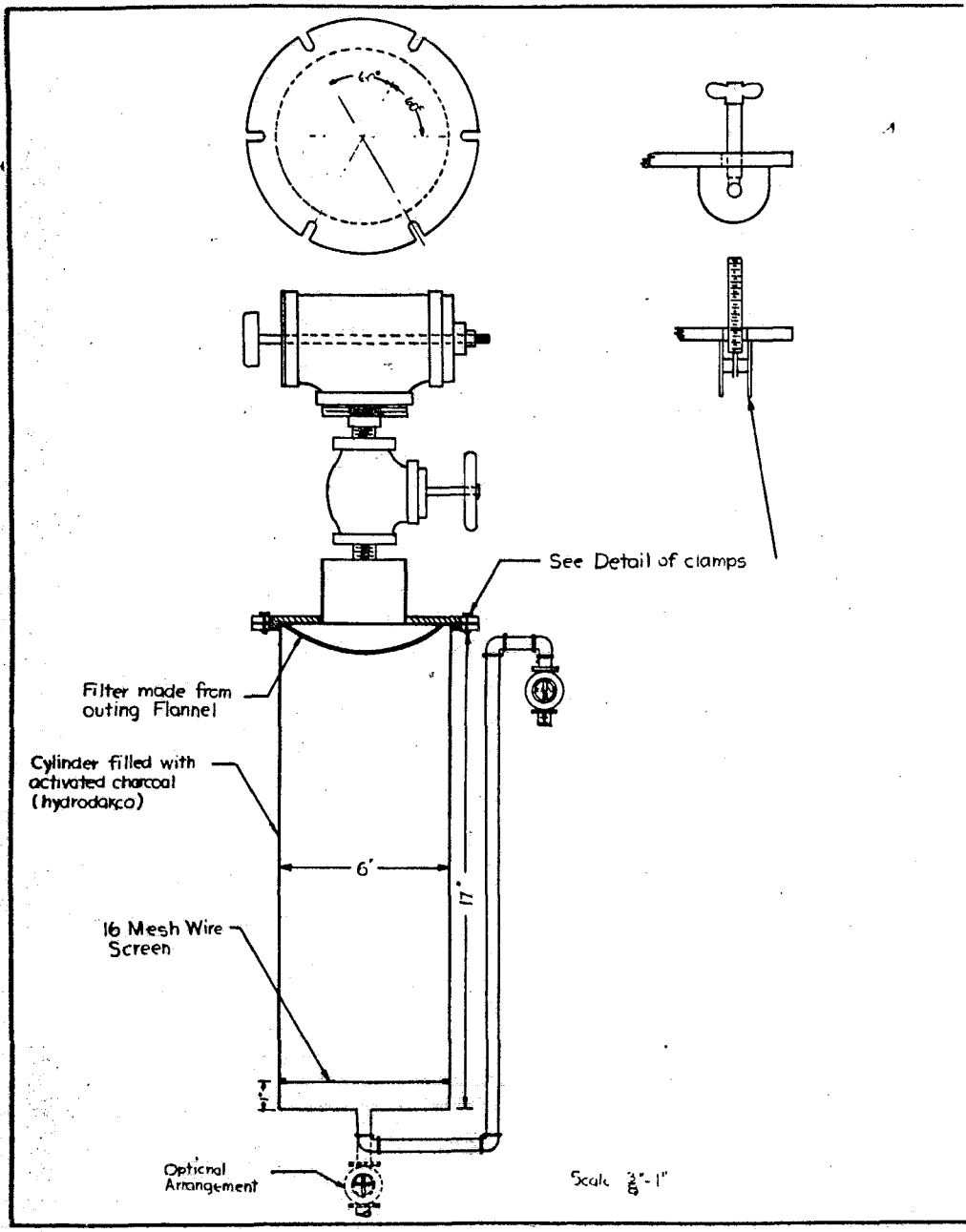
Lead and Gasoline Odor of Water Stored in Gasoline Tank Cars

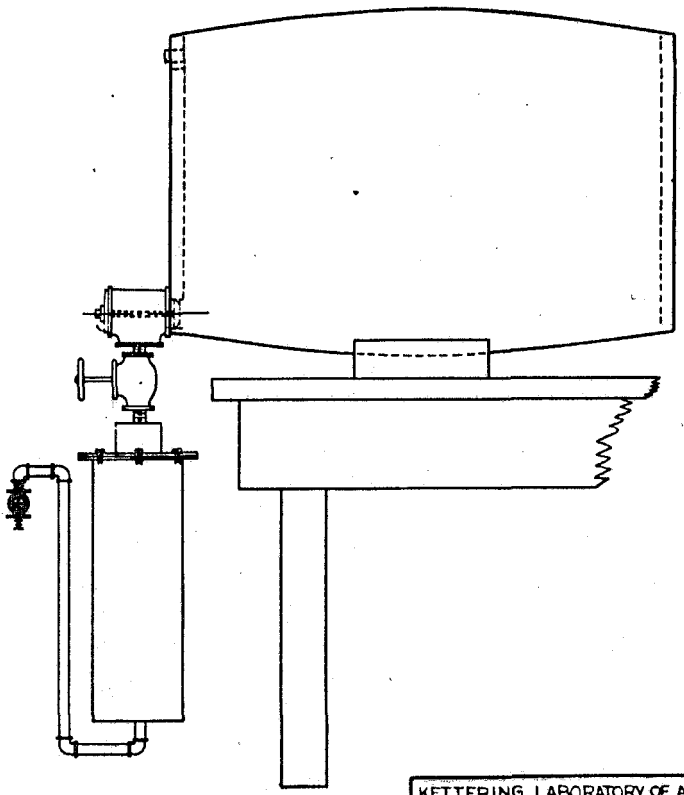
Car No.	Capacity gallons	Treatment	After 1 hr.		After 4 hr.		Aft
			Pb p.p.m.	Odor	Pb p.p.m.	Odor	Pb p.p.m.
GRCX 2931	8117	Steamed 12 hours. Hosed to remove loose scale. Filled to overflowing and drained. Filled to gage mark.	0.01	Very faint	0.007	Barely perceptible	0.006
GRCX 2842	8096	Steamed 6 hours. Hosed to remove loose scale. Filled to overflowing, drained to gage mark.	--	--	0.004	Very faint	0.011
GRCX 2842	8096	Above water emptied and tank refilled to gage.	--	--	0.006	?	0.009
GRCX 2842	8096	Above water adjusted to a pH of 5.0	1 hr. after mixing: 0.033	(b)	0.031	? (b)	0.029

Note: Water employed was well water at pH of 7.3. Lead content 0.007 p.p.m. No

(a) Very slight yellow-red color, perhaps due to dye of gasoline.

(b) Slight but significant increase in color.


See Detail of clamps
Filter made from outing Flannel
Cylinder filled with activated charcoal (hydrodarco)
6"
17"
16 Mesh Wire Screen
Optional Arrangement
Scale 3"-1"



Scale: $\frac{3}{16}$" = 1"

KETTERING LABORATORY OF APPLIED PHYSIOLOGY
UNIVERSITY OF CINCINNATI

Steel Water Filter

Drawn By: E. Dunham
Date: 7-31-42

Dwg. No. 42-B-5