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ETHYL GASOLINE CORPORATION

Chemical Research Laboratory

USE OF "FILTROL" FOR REMOVAL OF TETRAETHYLLEAD FROM GASOLINE

PURPOSE

To test the feasibility of removing TEL (tetraethyllead) from gasoline, in the liquid state at ordinary temperatures, by means of the chemically activated clay, "Filtrol."

SUMMARY

(1) Percolation of liquid gasoline, containing 3 cc. TEL/gal. in the form of ETHYL Fluid, through a tower packed with granular Filtrol at room temperature removes the TEL completely. This is a more efficient method than intermittent shaking of a batch of gasoline with the Filtrol.

(2) The allowable rate of flow of the gasoline through a tower, for reasonably efficient operation, is of the order of 1 gal./hr. per lb. of Filtrol. The space occupied by the 60-100 mesh granular Filtrol is 44.5 cu.in. (710 cc.) per pound, and the free space is 71% of this. Hence, the above rate is equivalent to a time of contact between the fuel and the Filtrol of 8.2 min.

(3) The capacity of the Filtrol, for complete removal of the TEL, depends on the contact time and, particularly, on the kind of fuel treated. This is shown by the following comparison between an inert fuel, such as pure isooctane, and a typical cracked gasoline:

	Capacity: cc. TEL removed per lb. of Filtrol		
	Rate of flow: gal./hr./lb.		
	0.3	1	3
	Contact time: min.		
Kind of Fuel	27	8.2	2.7
Pure isooctane	32	25	18
Cracked gasoline	1.4	1.2	1.0

When the concentration of TEL is less than 3 cc./gal., the above capacity remains about the same for the isooctane but is probably considerably less for the cracked gasoline. At the "end-point," after the capacity of the Filtrol has been reached, the concentration of TEL in the fuel leaving the tower increases abruptly from zero up to about 2 cc./gal. The TEL taken up is tenaciously retained by the Filtrol, and cannot be washed out by

a non-leaded fuel.

(4) The effect of an increase in temperature on the rate of removal is known to be pronounced, although no quantitative experiments have as yet been made in this connection.

(5) There is some evidence that the rate of removal may be much faster from vaporized gasoline than from the liquid.

(6) The halogen compounds in ETHYL Fluid are not removed by Filtrol, whereas the red dye is quickly adsorbed.

(7) An Army Gasoline Field Range, Model M-37, was fitted with two tubes, containing together 1.42 lb. of Filtrol, incorporated between the fuel tank and the burner without any increase in the over-all dimensions of the Range. It was operated for 12 hr., using 5.0 gal. of cracked gasoline containing 3.0 cc. TEL/gal., before any TEL came through. The tubes became quite warm from the heat of the burner, which accounts for the fact that the amount of TEL removed was nearly eight times as great as would have been expected at room temperature.

(8) Possible methods of practical use of the Filtrol are outlined. Experimental work is being continued along the lines of high temperature and vapor phase treatment.

INTRODUCTION

The presence of TEL in a fuel to be used in a cooking or heating unit is undesirable for two reasons. First, there is a health hazard: food must not be contaminated with lead. Second, there is a mechanical problem: burner ports and control valves tend to become clogged with deposits of lead compounds resulting from thermal decomposition of the TEL.

A survey of possible methods of removing the TEL from the fuel shows, at the present time, only two which appear to be suitable for practical use. The first consists of decomposing the TEL in the fuel by vaporizing the fuel at a high temperature, and then passing the vapors through a filter which removes, as a dust, the solid particles of lead. This method is currently used in the Model M-37 U. S. Army Gasoline Field Range developed at the Jeffersonville Depot, Q.M.C. As shown in a previous report from this Laboratory, LTD 41-5, and in a report from Dr. R. A. Kehoe dated June 1, 1941, this method cannot be considered wholly successful, a certain amount of lead finding its way at times beyond the filter, especially during the first half hour of operation.

The second possible method is that of adsorbing the TEL from the liquid or vaporized gasoline by a solid adsorbent. A chemically activated clay appears to be the best type of adsorbent for this purpose, and the use of the particular clay, Filtrol, was

suggested to this Laboratory by a memorandum received from Dr. W. J. Sweeney of the Esso Laboratories. Since this Filtrol was presumably as efficient as any of these clays, it has been the only one tested so far in the present work. Another type of adsorbent, silica gel, was also tested with much less satisfactory results.

The work covered by the present report was designed to apply only to the removal of TEL from liquid gasoline at about room temperature, inasmuch as it appeared that these conditions would probably be the most practicable for actual use of the process. It is known, however, that the adsorptive power of an activated clay increases greatly as the temperature is raised; also, a previous report, LTD 41-30, on the use of Filtrol for removal of TEL vapor from air indicates that adsorption from the vapor phase may be more efficient than from the liquid. Further experiments along these lines are in progress.

METHODS AND EQUIPMENT

Materials

Filtrol. - Samples were supplied by Mr. S. R. Funsten, Filtrol Corp., Los Angeles. Filtrol is a hydrated aluminum silicate derived from certain naturally occuring bentonites and activated with sulfuric acid. The designations and characteristics of the samples tested are as follows:

Super - This is the regular powdered Filtrol, stated to contain about 14% free moisture (110°C.) and 19% volatile matter (1700°F.)

L.M. - This is powdered material containing about 10% moisture.

X-215 - This is Super Filtrol which has been extruded, dried to about 4% free moisture (12% volatile matter), and reduced to 60-100 mesh. This material is available in experimental quantities only, at the present time.

X-209 - This is similar to X-215, but is 10-12 mesh in size and contains 14% free moisture.

Fuels. - Most of the test work was carried on with two fuels of widely different characteristics. Isooctane of fairly high purity (C.F.R. Reference Fuel F-3) was selected as being typical of the inert, paraffinic-type fuels. As the other extreme, commercial Mid-Continent gasoline was selected as representative of the highly cracked gasolines, containing a considerable proportion of reactive, unsaturated hydrocarbons. This gasoline, identified as Fuel R (test fuel No. 122-41D), contained 0.071% sulfur and 4 mg. A.S.T.M. dissolved gum.

Other fuels, used in some tests, were: No. 9 Oil, a refined kerosene; Fuel G, a technical isooctane; Fuel H, a 100 octane base stock (No. 281-40); Fuel P, a high-octane paraffinic base stock (No. 334-36); Fuel Q, a commercial 73 octane base gasoline (No. 216-39); Fuels R-2 and R-3, similar to Fuel R (No. 157-41D and No. 53-41D respectively); Fuel S, a different type of commercial cracked gasoline (No. 159-41); and Fuel X, an unrefined, high-sulfur, cracked stock (No. F-12).

TEL (tetraethyllead). - Unless otherwise indicated, 3 cc. TEL/gal. was added to the fuels in the form of ETHYL Fluid. For isooctane, which had been deleaded with Filtrol and was to be re-used, straight TEL was added, since tests showed that the halogen compounds (ethylene dibromide and dichloride) in the ETHYL Fluid were not removed by the Filtrol.

Analytical Methods

The presence of TEL in gasoline in concentrations as low as 0.05 cc./gal. was detected, and a rough estimate of the amount was obtained, by treating a 5-ml. sample in a test tube by dropwise addition of 30% bromine in carbon tetrachloride and observing the volume of lead bromide precipitated. For quantitative analysis, a 100-ml. sample was treated by the standard A.S.T.M. HCl-Reflux method.

Equipment

Percolation method. - The fuel was pumped, by a Zenith pump with adjustable rate of delivery, upward through a glass tube, or through two tubes in series, as shown in Fig. 1. The tubes had inside diameters of 9.5, 21.5, or 41.2 mm., and were uniformly packed with Filtrol for a length of, usually, 482 mm. The tubes were kept at room temperature, about 20°, except in one test where a temperature of 100° was obtained by a steam jacket around the tube. Small samples of the effluent fuel were tested at regular intervals for the presence of TEL, and as soon as a positive test was obtained, larger samples were taken for a quantitative analysis. The pressure drop over the length of the tube was measured by a gauge on the inlet line: it amounted to only a few pounds in all cases.

Batch method. - The desired amounts of fuel and Filtrol in a closed container at room temperature were shaken, either continuously by a motor-driven shaker or at 15-min. intervals by hand during the day. In one experiment, stirring was effected and higher temperatures were obtained by boiling the fuel, with the container open to a reflux condenser. Samples of the fuel were withdrawn at suitable intervals, filtered if necessary, and analyzed for TEL; appropriate corrections were made for these withdrawals, in computing the capacity of the Filtrol for TEL removal.

Army Field Range. - The M-37 Model Range was adapted, as shown schematically in Fig. 2, by placing two tubes in series between the fuel tank and the vaporizer. The filter disc in the vaporizer was omitted. As shown in Fig. 3, the tubes, of steel, each 20 in. long and 1.5 in. i.d., were packed for a length of 17 in. with a total of 1.4 lb. of the X-215 Filtrol, held tightly in place by a pad of glass wool and a spring inside the cap which closed the end of each tube. An asbestos pad 3/8 in. thick shielded each tube, but despite this the tubes became quite warm - about 60°C. - during operation of the unit.

RESULTS

Percolation Method: Rate and Capacity

The data for isooctane and cracked gasoline R with X-215 Filtrol at room temperature are given in Table I and Fig. 4. It is seen that, over the range of contact time used, from 2.5 to 50 min., the relation between the logarithm of the contact time and the amount of TEL removed completely per lb. of Filtrol is roughly linear, and is independent of the diameter of the tube. The individual points are somewhat scattered, but this may simply be due to variations in room temperature. For contact times of 27, 8.2, and 2.7 min. (flow rates of 0.3, 1, and 3 gal. of fuel per hr. per lb. of Filtrol), the lines drawn in Fig. 4 show amounts of TEL removed from isooctane of 32, 25, and 18 cc. per lb. of Filtrol, and from the gasoline, 1.4, 1.2, and 1.0 cc., respectively. These lines, of course, cannot be extrapolated: as the contact time approaches zero, the TEL removed must do likewise, and the indication from the experiments as a whole is that a contact time of less than 2.7 min. (flow rate greater than 3 gal./hr./lb.) would not be efficient; on the other hand, there is no evident advantage in prolonging the contact time far beyond 27 min.

Batch Method: Rate and Capacity

With continuous shaking, the time required for complete removal of TEL from isooctane is only about one-half as great as in the percolation method, as shown by the data in Table II and Fig. 5. Removal of 32 cc. TEL per lb. of Filtrol requires 16 hr. by the batch method, compared with 36 hr. by percolation; removal of 18 cc./lb. requires 1.5 hr. shaking and 2.0 hr. percolation. For complete TEL removal from the gasoline R, the capacity per lb. of Filtrol is 2.1 cc. TEL in about 15 min. shaking and 2.9 cc. in 45 min.: again, this is much faster than the removal by percolation.

On the other hand, when intermittent shaking is employed (agitating the batch vigorously once every 15 min. during the working day), the rate of removal is much slower than in the percolation method. For isooctane, complete removal of 31 cc.(av.) TEL per lb. of Filtrol required 70 hours. The data are shown in Table II.

Concentration of TEL

When isooctane containing 1 cc. TEL/gal. is treated by the percolation method, the amount of fuel deleaded is three times as great as for the fuel containing 3 cc. treated at the same rate of flow. In this experiment, the isooctane used had been re-leaded following previous treatment with Filtrol, and therefore the fuel itself was probably entirely inert.

On the other hand, in another experiment in which two towers were used in series, with isooctane which contained 3 cc. TEL and had not previously been treated, the amount of fuel deleaded by the second tower was no more than that by the first tower, despite the fact that the concentration of TEL in the fuel entering the second tower averaged only about 2 cc./gal. The data are given in Table III.

With gasoline, no comparable tests were made, but it may be anticipated from the known effect of the fuel itself (see below) that the amount of fuel deleaded will not be much, if any, greater at low concentrations of TEL.

Maximum Capacity

A sample of F-215 Filtrol was shaken with isooctane containing 3 cc. TEL/gal., and additional TEL was added to maintain the concentration at the 3 cc. level. After no more TEL was taken up, the Filtrol was removed and analyzed for lead. It contained an amount equivalent to 56 cc. TEL per lb. of Filtrol. This value was confirmed by analysis of a sample of Filtrol taken from the bottom of the first tower after the 90-hr. run shown in Table III. Also, in one experiment by the batch method an amount of TEL at least as great as this was completely removed from the fuel, indicating that the capacity of the Filtrol does not depend on the concentration of TEL remaining in the fuel.

Further confirmation was given by the fact that when the above sample of Filtrol saturated with 56 cc. TEL/lb. was removed and then shaken with TEL-free fuel, no TEL whatever was desorbed or dissolved by the fuel. The tenacity with which the Filtrol retains the lead was further shown by the failure to remove any lead from this sample on treatment with absolute ethyl alcohol, or concentrated aqueous ammonia, or bromine and hot water, or by high-temperature vacuum distillation. Hence, it remains unknown in what form of chemical combination the lead is held. The saturated Filtrol does, however, have a pronounced odor, and it probably should be considered as a hazardous material, to be disposed of by burning or burying.

Adsorption Rate and Gradients in Towers

Evidence from several experiments shows that the rate at which the Filtrol adsorbs TEL is by no means constant, but decreases as the lead content builds up, and this decrease is not

uniform but occurs in a somewhat stepwise fashion.

Samples of the Filtrol from near the top and bottom of each of the two towers in series used in the 90-hr. run (Table III) were taken at the end of the run, at which time the effluent fuel contained about 1 cc. TEL/gal. Analysis showed a fairly uniform gradient in lead content from top to bottom, the amounts found being equivalent to about 20 cc. TEL per lb. of Filtrol at the top and 60 cc./lb. for the saturated material at the bottom.

During the course of this same run, after 39 hr., the concentration of TEL in the fuel leaving the top of the lower tower rose rapidly from zero to about 1 cc. TEL/gal., then more slowly to about 2 cc., after which -- from 59 hr. to 90 hr. -- it remained essentially constant. A similar result was obtained in a percolation test with gasoline where the concentration of TEL in the effluent fuel remained at about 2.3 cc. for many hours.

Further evidence of the change in rate of removal of the TEL is given by one test of the batch method with continuous shaking, using isooctane and X-215 granular Filtrol, with 11 cc. TEL per lb. of Filtrol. The concentration of TEL was reduced from 3 cc./gal. to less than 1 cc. in 5 min., but complete removal required 22 min.: This marked change in rate occurred despite the fact that the amount of TEL was only one-fifth of the maximum capacity of the Filtrol.

Removal of Halogen Compounds and Dye

Analyses of the samples of Filtrol taken after the 90-hr. run showed an average of only 0.1% halogen (as bromine), an amount negligible in comparison with the lead present, although greater than in the original Filtrol, 0.007%. Analysis of a sample of deleaded fuel showed the expected amount of halogen present. Evidently, the ethylene dichloride and ethylene dibromide present in the ETHYL Fluid used are practically unaffected by Filtrol.

The red dye used in the Fluid is, as expected, very rapidly and completely adsorbed by Filtrol.

Effect of Fuel

The nature of the fuel itself is unquestionably the most important factor in the use of Filtrol for removal of TEL. As indicated above, at a given flow rate the amount of isooctane completely deleaded is some 20 times as great as the amount of gasoline R. This result is undoubtedly due principally to the presence of unsaturated hydrocarbons in the cracked gasoline, which evidently combine with the Filtrol and in so doing greatly reduce its effectiveness for combination with TEL.

Tests made with a technical, somewhat impure grade of isooctane (Fuel G) gave a much poorer lead removal than those with the nearly pure, F-3 isooctane, as shown in Table I and Fig. 4. This suggests that the nature, rather than the amount, of unsaturated hydrocarbons present is the important factor.

Direct comparison of a variety of fuels was made by the batch method with continuous shaking. Four tests were made, with amounts of TEL equal to 12.7 and 6.35 cc. per lb. of Filtrol, and with shaking times of 5 and 10 min. The results, given in Table IV, show that the rate of removal varies widely. Of the three inert fuels -- H, F-3, and P -- at the head of the list, the amounts taken were very much less than could be completely deleaded by the amounts of Filtrol used: nevertheless, there is a distinct difference in the rate of removal of TEL in these three fuels, and it is of interest to note that Fuel H, the 100 octane base, was deleaded even faster than the standard F-3 isooctane.

The four gasolines -- Q, R-3, R-2, and S -- next on the list in Table IV probably contain enough TEL to saturate the Filtrol present, or nearly so, but the differences in rate of removal are still conspicuous. The two gasolines, R-2 and R-3 are presumably nearly identical in composition, and their behavior in this test is likewise the same.

In this test, gasoline S appears somewhat less rapidly deleaded than gasoline R. However, in a percolation test (Table I and Fig. 4) where complete removal of TEL was effected by using more Filtrol (the amount of TEL removed per lb. of Filtrol being about the same as in the present test), gasoline S was deleaded a little more readily than gasoline R. Hence the above shaking test is not an absolutely accurate measure of the relative ease of complete deleading of the fuels.

The result for the final fuel, X, in Table IV is of interest, since this is an unrefined, cracked stock containing 2.84% sulfur, and the removal of TEL therefrom was practically nil. It is therefore possible that the presence of sulfur compounds in a fuel may contribute to its effect on the ability of Filtrol to remove TEL.

Comparison of Different Filtrols

As shown in Table II, X-215 Filtrol which has been reduced to a 200-mesh powder (with care to avoid exposure to moist air) is no more effective than the regular 60-100 mesh granular form, but at the same time is definitely better than the ordinary Super Filtrol powder. Other preliminary tests showed no marked difference in effectiveness between the Super, the L.M., and the X-209 grades.

Further drying of the X-215 grade by heating to 155° or 172°, with loss in weight of 7.7% or 8.4% respectively, did not further improve its efficiency (Table I).

Effect of Temperature

Although no systematic study of the effect of temperature has been made (inasmuch as the original understanding was that room-temperature operation was of principal importance), a few isolated experiments were carried out. The results indicate that an increase in temperature effects a substantial increase in the rate of removal of TEL and, perhaps, in the maximum capacity of the Filtrol as well.

In a preliminary percolation test at 100°, isooctane containing 3 cc. TEL/gal. was deleaded with X-209 Filtrol in 8.2 min. contact time to an amount equal to 40 cc. TEL per lb. of Filtrol, nearly twice as good a removal as obtained with the superior X-215 Filtrol at room temperature.

In a batch treatment in boiling No. 9 Oil at 165°, or in isooctene at 95°, 1 lb. of L.M. Filtrol removed completely about 27 cc. TEL in less than 1 hr., whereas at room temperature removal was not complete in 5 hr.

In Table IV, the data for the two fuels which were shaken with Filtrol at 0° and at 50°, as well as at 21°, show a distinct effect of temperature. The comparison between the results for the Fuel P at 0° and 21° is striking, the lead removal being, respectively, 53% and 90% in 5 min., or 76% and 99% in 10 min.

The results, given below, of the test made with the modified Army Field Range can scarcely be accounted for except by the temperature -- about 60° -- of the Filtrol tubes in this test.

Removal of TEL from the Vapor Phase

In a previous report, LMD 41-30, it was shown that the X-215 Filtrol effected complete removal of saturated TEL vapor from moist air at room temperature in a few seconds' contact time. The amount of TEL removed was 28 cc. per lb. of Filtrol, and further complete removal might be obtained at a slower rate since the Filtrol was far from completely saturated. The flow rate, in terms of TEL, was close to 2 cc./hr. per lb. of Filtrol. Hence the efficiency of the Filtrol in this case was almost as good as in the removal of TEL from isooctane, despite the fact that the Filtrol was simultaneously saturated with water vapor. This result encourages a test of TEL removal from vaporized gasoline.

Removal of TEL with Silica Gel

Two samples of silica gel (which appeared to be in the active state as judged by the heat generated on wetting them with water) were tested with isooctane containing TEL. The rate of removal of the TEL was very much slower than when using Filtrol; whether the maximum capacity was also less was not determined.

Test of Modified Army Field Range

The Range, modified as described above, was operated on gasoline R containing 3 cc. TEL/gal., at an average rate of 0.4 gal./hr. This rate is some 50% greater than normal, probably a result of the lowered resistance to the flow of fuel due to removal of the filter disc. Samples of the fuel taken from the line between the Filtrol tubes and the burner showed that the TEL began to come through after 12 hr. when approximately 5.0 gal. of fuel had been delivered. The amount of TEL completely removed by the 1.42 lb. Filtrol used was therefore over 10 cc./lb., an amount eight times as great as that removed in the percolation tests at room temperature. As stated above, this must have been due to the higher temperature -- about 60° -- of the Filtrol in this test. Operation was continued up to 21 hr., and during the last 4 hr. the TEL content of the effluent fuel remained essentially constant at about 1.8 cc./gal.

DISCUSSION

Based on both general considerations and the present results, it appears that there is a good possibility for the practical use of Filtrol or a similar clay for removal of TEL from any commercial gasoline, and that this may be accomplished either by a high-temperature, vapor-phase or by a low-temperature, liquid-phase process. The former method is at present under investigation.

Treatment of liquid gasoline for use in the Army Field Range can conceivably be carried out in several ways, such as:

(1) To attach a large container of Filtrol in series with one delivery pipe on a tank truck, discharging lead-free fuel from this container into 5-gal. cans for distribution. A 50-gal. container would hold 260 lb. of Filtrol, and 35 gal. of fuel, and at a flow rate of 1 gal./hr./lb. would deliver 260 gal./hr. or fill one 5-gal. can per min. However if the amount of TEL which could be removed were only 1.2 cc./lb. (as found in the present percolation tests on gasoline at room temperature), then only 100 gal. of fuel could be treated before renewing the Filtrol. If advantage were taken of the time of contact between deliveries, by delivering not more than about 5 or 10 gal./hr., then the capacity of the Filtrol might be increased several-fold.

(2) To add directly a suitable amount -- about 5 lb. -- of Filtrol to each 5-gal. can of leaded gasoline, shaking the can frequently for at least one hr. before using the fuel. An allowance of 0.3 gal. would be made for the volume occupied by the Filtrol. Care to exclude water, and filtration of the gasoline taken from the can, would be required, and the removal of the spent Filtrol from the can would be a problem.

(3) To install Filtrol tubes directly in the Range, as was done in the present work, but with the Filtrol supplied in a sealed cartridge which could be inserted into the tube, punctured by the cap of the tube, and later removed as a unit for disposal and replacement.

B:B

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References: Notebook Nos. 265, 301, 307, 365, 371, 393.

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TABLE I

REMOVAL OF TEL FROM FUELS BY PERCOLATION METHOD

All tests made with glass towers packed with X-215 Filtrol at room temperature; letter (a) denotes Filtrol dried in oven.

Towers				Fuels	
	inside diameter		packed length	symbol	type
A	9.5 mm.	1	457-476 mm.	F-3	pure isooctane
B	21.5 mm.	2	914-965 mm.	G	technical isooctane
C	41.2 mm.			Q	73-octane gasoline
				R	Mid-Cont. cracked gasoline
				S	different cracked gasoline

Run No.	Tower	Filtrol grams	Fuel	TEL content of fuel cc./gal.	Rate of flow ml./hr.	Volume of fuel deleaded ml.	Contact time min.	cc. TEL removed per lb. Filtrol
20	A-1	22.6	F-3	3.02	1084	542	1.32	8.7
23	B-1	119.6	"	"	3000	5202	2.46	15.7
109	A-1	23.8	"	"	561	1495	2.50	22.8
108	"	22.1[a]	"	"	571	1000	2.51	16.4
21	"	23.1	"	"	555	1148	2.59	18.0
115	"	24.3	"	2.94	545	1180	2.63	17.1
127	"	24.5	"	2.68	545	1453	2.63	19.0
128	"	24.7	"	3.03	543	1265	2.64	18.6
126	"	24.5	"	2.95	542	1040	2.65	15.0
139	"	24.0	"	1.16	542	3567	2.65	20.7
110	"	24.8	"	2.70	506	1475	2.83	19.2
111	"	24.9	"	"	267	1502	5.33	20.7
22	"	22.4	"	3.02	265	1471	5.43	23.8
125	B-1	120.0	F-3	2.51	693	9020	10.6	22.6
113	A-1	24.4	"	2.70	130	2044	11.1	27.2
131	B-1	120.0	"	2.95	660	7538	11.2	22.2
134	"	115.0	"	2.98	657	6980	11.2	21.7
138	"	120.0	"	2.95	282	10762	25.8	31.6
101	C-1	384.0	"	3.02	1000	39000	27.1	36.6
"	C-2	784.0	"	"	1000	80000	54.2	34.9
107	A-1	21.2[a]	G	2.99	582	320	2.47	5.4
105	"	21.7[a]	"	"	551	275	2.61	4.5
103	"	23.1	"	"	367	245	3.90	3.8
102	"	22.6	"	"	124	240	11.5	3.8
135	A-1	25.6	Q	3.29	142	760	10.0	11.7
119	B-1	120.0	R	3.02	1460	365	5.03	1.1
118	A-1	24.1	"	"	187	125	7.65	1.9
117	"	24.3	"	"	141	129	10.2	1.9
122	A-2	46.5	"	"	131	175	21.8	1.4
120	B-1	120.0	"	"	344	430	21.4	1.3
121	"	131.0	"	"	141	531	52.3	1.5
133	A-1	24.5	S	3.27	144	120	9.95	1.9
129	"	24.4	"	"	150	100	9.55	1.6
130	A-2	46.1	"	"	142	178	19.6	1.5

TABLE II

REMOVAL OF TEL BY BATCH TREATMENT OR SHAKING METHOD

Isooctane or gasoline (Fuel R) containing about 3 cc. TEL/gal. shaken continuously with Filtrol in a closed container at room temperature.

Kind of Filtrol	Fuel	Initial TEL content cc./lb. Filtrol	Time hours	Removal of TEL, %
X-215	isooctane	70.6	0.5	19
			3	30
			7	35
"	"	42.0	0.5	34
			3	46
			7	58
"	"	35.3	23	75
"	"	32.6	16.5	99+
"	"	23.8	3.42	100
"	"	17.2	1.25	100
"	"	12.7	0.08	62
"	"		0.16	77
"	"	6.35	0.08	93
"	"		0.16	99+
Super	"	38.5	22.25	22
"	"	32.6	23	34
X-215 powder	"	38.5	22.25	68
"	"	32.6	23	91
X-215	"	32.6	21[a]	69
			45[a]	96
			70[a]	100
"	gasoline	2.9	0.75	100
"	"	2.1	0.25	100

(a) Intermittent shaking, once every 15 min. during 9 hr. each day.

TABLE III

REMOVAL OF TEL FROM ISOOCTANE IN A 90-HOUR RUN

Two towers in series used with 384 and 400 g. (a total of 1.73 lb.) X-215 Filtrol; contact time 27.1 min. in each tower; through-put of fuel 0.264 gal./hr.; TEL content 3 cc./gal. TEL removal corrected for samples withdrawn for analysis.

Time hours	TEL content cc./gal. of fuel leaving Lower tower	Upper tower	TEL removed cc. per lb. of Filtrol Lower tower	Upper tower
0-38	0			
39	0.20		36.6	--
40	.88			
43	.44			
47	1.75			
51.5	1.45			
55	0.86			
59	1.99			
63	1.93			
67	1.34			
72.5	1.93	0		
80		0 est.	55.0	15.7
82	1.93	0.73		
84		.97		
86		.98		
88		1.03		
90	1.64	0.86	58.7	21.1

TABLE IV

RELATIVE EASE OF REMOVAL OF TEL FROM DIFFERENT FUELS IN SHORT-TIME SHAKING TEST

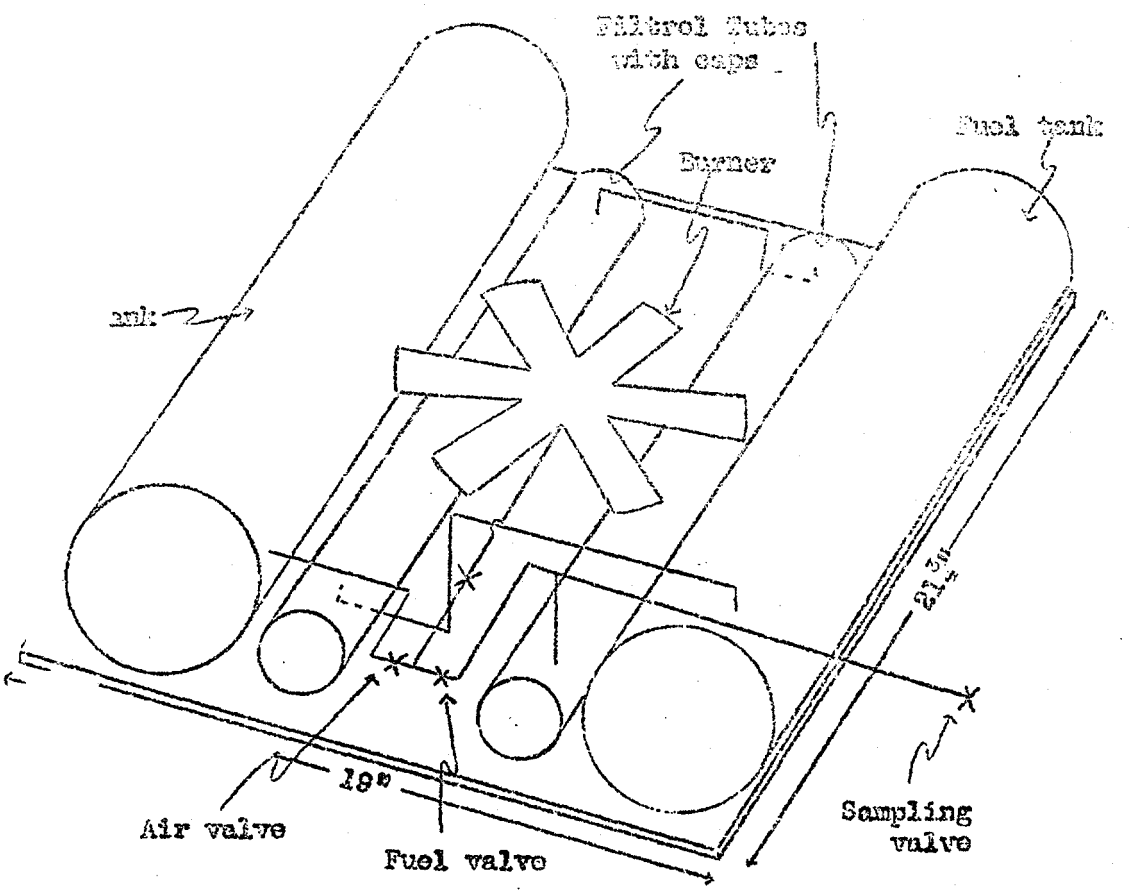
150 ml. fuel shaken with 5 or 10 g. X-215 Filtrol (about 12 or 6 cc. TEL per lb. of Filtrol) for 5 or 10 min. at 21°C.

Fuel	TEL content cc./gal.	TEL removed %			
		5 g. Filtrol		10 g. Filtrol	
		5 min.	10 min.	5 min.	10 min.
H	3.34	67	84	96	100
F-3	3.53	62	77	93	100
P	3.42	48	65	90	100
Q	3.37	36	46	70	89
R-3	3.10	13	18	32	44
R-2	3.41	12	17	29	40
S	3.41	8	10	21	27
X	3.35	0	0	2	2
P -- at 0°				53	76
at 50°				97	99
R-3 -- at 0°				17	23
at 50°				38	45

Fig. 2

Schematic Diagram of Modified M-57 U.S. Army

Gasoline Field Range



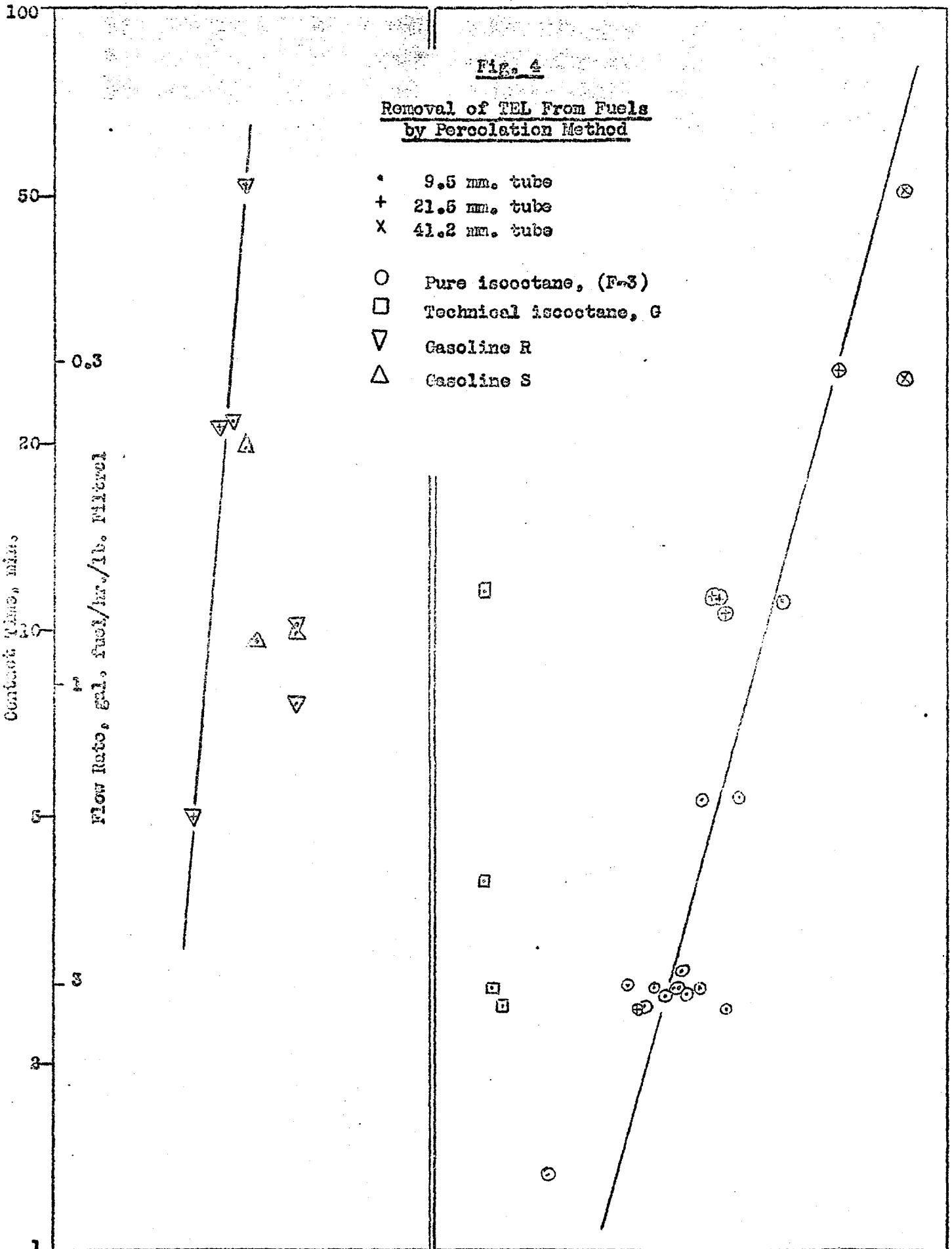


Fig. 4
Removal of TEL From Fuels
by Percolation Method
9.5 mm. tube
21.6 mm. tube
41.2 mm. tube
Pure isooctane, (F-3)
Technical isooctane, C
Gasoline R
Gasoline S
Flow Rate, gal. fuel/hr./lb. Filtrol
Contact Time, min.
100
50
20
0.3

KE 0005334

Fig. 5

Removal of TEL from Isooctane by

Batch Method with Continuous Shaking

Note: The figures ( ) represent initial cc. TEL per lb. of Filtrol