ETHYL GASOLINE CORPORATION

CHEMICAL RESEARCH LABORATORY

1600 [redacted] WEST EIGHT MILE ROAD

DETROIT, MICHIGAN

January 28, 1941

Dr. Robert A. Kehoe
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Dear Dr. Kehoe

Enclosed please find a copy of our report, "Operation of a Gasoline Stove on Leaded Fuel."

Very truly yours

Harold A. Beatty

HAB:JH
Encl.

LRD #41-5
363-KP-21,22 and 24-28
M. R. Neal
1-26-41
Approved by [signature]

OPERATION OF A GASOLINE STOVE ON LEADED FUEL

PURPOSE

Tests of the U.S. Army Gasoline Field Range were made using leaded fuel (1) to study the performance of the fire unit in operation, (2) to determine the effectiveness of the filter for the removal of lead, and (3) to study the location and amount of deposits and the ease of their removal.

CONCLUSIONS

1. The instructions furnished (see Bibliography) for the operation and maintenance of the stove are adequate, and if they are followed, the performance is reasonably satisfactory.

2. About 62% of the lead input is removed by the filter disk and 10% by other parts of the stove. Of the remaining 28% which escapes into the air, 6% or 1.6% of the input is deposited on the surface of a water-filled kettle placed on the stove.

3. The deposits are largely lead salts rather than gum. Gum solvents, such as a mixture of equal parts of benzene and acetone, are effective in removing the gum present. Hot 20% ammonium acetate is recommended as an effective, non-corrosive reagent for the removal of the lead salts, to supplement the specified mechanical cleaning operation.

INTRODUCTION

The Jeffersonville (Ind.) Quartermaster Depot has designed a Field Range (Model of 1937) to perform cooking operations using either leaded or unleaded fuel. The fire unit parts include pressure tanks for fuel and air pretested at 250 lb., a pressure gauge, valves for fuel, air, and flame control, a combined generator and filter for vaporizing the fuel and removing the lead, and a burner. The fuel tank volume is 1¼ gallons, which is sufficient to operate the unit 5-6 hrs.

OPERATION

The fire unit of the above described Field Range was set up in an outside shed and tested by a series of 7 runs. The best operating pressure was 30-40 lb. which minimizes the surging resulting from the automatic check valve in the fuel line (this is designed to cut off the flow in case of a break in the line). Except during the warming-up period, the burner will run without attention, other than that every 30-60 minutes the setting of the flame valve has to be increased.

In starting the operation, the air pressure is raised to 40 lb., the air, fuel, and flame valves are opened one-half turn, and the burner is lighted. As the generator is heated, the primary air is reduced by the valve until after about two minutes no air is flowing. The fuel is fed under pressure to the generator, vaporized, partly cracked, filtered to remove lead, passed to the flame valve where the rate of flow is controlled, mixed with secondary air, and fed to the burner surface where combustion occurs.

Satisfactory operation of the stove can be had only at the price of a certain amount of "preventive maintenance" which includes (1) change of filter and filling of fuel tank every 4 hrs., (2) cleaning of generator, flame valve, and burner every 12 hrs., (3) lapping-in of ground joints, change of valve packing, and pickling of burner to remove rust, when necessary, and (4) cleaning of tanks and tubing with gum solvent, when necessary.

Care should be taken that all connections are drawn tight; otherwise a serious fire may result from the ignition of fuel flowing from a leaky connection.

The required "preventive maintenance" was performed in Runs 1, 2, 3, and 6 except that only one filter was used in Runs 1 and 2. It is therefore noteworthy that all the "emergency maintenance" and "troubles" occurred in Runs 4, 5, and 7 where "preventive maintenance" was confined to a change of filter disks every four hours.

The points at which a breakdown most frequently occurs are the following:

(1) Flame valve jet, socket, or stem may become plugged or coated with deposit resulting in a luminous flame at burner.

(2) Inlet and outlet tubes of the filter case and the small generator tube may become constricted owing to build-up of deposit.

(3) Filter case ground joint will leak with resultant faulty operation.

(4) Filter disk is good for only four hours, after which rate of flow is reduced.

The lead analysis of the deposits found in Run 2 is set down as typical of what may be expected from this unit:

Locus of Deposit	Weight of Lead, mg.	Percentage of Lead Input
Burner Surface	1	0.0
Filter Case	229	5.6
Filter Disk	2552	62.7
Generator Tubes	23	0.6
Flame Valve	20	0.5
Kettle	67*	1.6*
Total	2892	71.0

*Estimated.

Data on the fuels used in the runs are given below:

Fuel	Can	G. Pb/Gal.in 70/45 Fluid	Mg. Gum per 100 ml.	Percent Olefine	Mfr.Lab.No.	Other Identification
1	1	0.00	0	--	249-40D	R.C. Base
2	1	3.17	0	--	249-40D	R.C. Base
3	1	3.13	6	69	217-40D	S.O.N.J. Fuel B
4	1 2	3.23) 3.23)	3	--	149-37	Leonard Ref.Co.
5	1 2	3.14) --)	1	--	297-40D	Pure Oil
6	1 2	3.21) 3.20)	8*	--	303-40D	S.O. Ohio

* ASTM High Temperature Dissolved Gum.

RESULTS

The data are presented in the Table below and in the form of comments on the individual run.

SUMMARY OF RUNS

Run Number	1		2	3	4	5	6	7	TOTAL
Fuel	1	2	2	2	3	4	5	6	--
Duration of Run, Hours	5	4	6¾	12	15	27	4	12	85¾
Fuel Consumed, ml.	-	-	4970	8830	16,390	29,320	5410	13,590	--
Pb Consumed, g.	-	-	4.066	7.31	13.548	24.995	4.49	11.524	--
Pb Recovered, % - Filter Disk		-	62.7	(a)	74.2	69.3	62.7)		62.2 (c)
- Flame Valve		-	0.5	0.1	0.6)	0.6	12.5)	78.3	0.5 (c)
- Other Stove Parts		-	6.2	63.7	2.1	13.2)	)		--
- Kettle		-	-	2.1	1.6	1.2	1.6	1.7	1.6 (d)
- Total		-	69.4	66.0	78.5	74.3	66.8	80.0	72.6 (e)
Gum Recovered, mg., - Generator		-	41 (b)	1.2	29	4.3	--	--	--
- Mixing Chamber		-	--	--	--	794	--	--	--
Preventive Maintenance									
Filter Disk Changed		1	1	3	4	7	1	3	20
Fuel Tank Filled		2	2	5	4	7	1	3	22
Generator Mechanically Cleaned		1	1	1	1	1	1	1	7
Generator Chemically Cleaned		-	--	--	1	1	1	1	4
Flame Valve Cleaned		1	1	1	1	1	1	1	7
Generator Cleaned with Gum Solv.		-	1	1	1	1	1	1	6
Burner Surface Cleaned		1	1	1	1	1	1	1	7
Filter Case Ground Joint Lapped		-	1	--	--	--	--	--	1
Mixing Chamber Cleaned with Gum Solv.		-	--	--	--	1	--	--	1
Emergency Maintenance									
Flame Valve Frozen		-	--	--	--	1	--	--	1
Flame Valve Jet Inspected		-	--	--	1	--	--	--	1
Flame Valve Jet Cleaned		-	--	--	1	1	--	--	2
Flame Valve Stem Cleaned		-	--	--	--	2	--	--	2
Flame Valve Socket Cleaned		-	--	--	--	2	--	--	2
Air Intake Valve Cleaned		-	--	--	1	--	--	--	1
Filter Case Ground Joint Lapped		-	--	--	1	--	--	2	3
Troubles, Miscellaneous									
Difficult Starting		-	--	--	2	--	--	--	2 (f)
Fire		-	--	--	--	1	--	--	1

(a) Combined with "Other Stove Parts".
(b) Largely carry-over.
(c) Average of 4 values.
(d) Average of 5 values.
(e) Average of 6 values.
(f) Due to cold weather.

Run 1. Purpose: Preliminary run to obtain experience. The unit, which had previously been used elsewhere, was mechanically cleaned before and after the run, using the cleaning key, jet reamer, wire brush, and burner knife supplied for this purpose.

Run 2. Purpose: Endurance test to determine how long stove would operate without a filter change. Conclusion: Not more than 7 hours.

Purpose: To determine the lead in the two halves of the filter disk. Conclusion: Since the upper (outlet) half contains 1051 mg. lead, and the lower (inlet) half, 1501 mg., it appears that the filter is not thick or dense enough.

Unit was mechanically cleaned after the run.

Run 3. Purpose: To obtain additional quantitative data on a run with a regular 4-hr. change of filter disks. Unit was mechanically cleaned.

Run 4. Purpose: To determine the point at which the stove fails when improperly operated. The filter disks were changed regularly, but no other preventive maintenance was performed. The fuel was fed at such a fast rate that soot collected on the kettle.

At 20°F., and in another run at 6°F., the gasoline failed to vaporize properly in starting so that liquid fuel eventually overflowed from the mixing chamber with the consequent hazard of fire. If the fuel is shut off and the air increased, enough vapor will be picked up to run the stove a short time, but when the volatile portion is used up more fuel will have to be run in. The procedure is then repeated, and the unit will run longer, being warmer, and eventually will be "generating" its own gas. At this point enough heat is produced to cause the fuel in the mixing chamber to vaporize gradually. About 15 minutes time and much pumping may be required.

Fuel 3 is a special fuel used in knock tests, and it is believed that less trouble will be encountered with a regular winter gasoline, even at the above temperatures.

After the regular mechanical cleaning the generator was washed with hot 20% ammonium acetate. The latter operation removed 546 mg. lead, or about 5% of the total recovery.

Run 5. Purpose: Breakdown test as in Run 4.

The unit operated better and for a longer period than previously, which is attributed to the chemical cleaning in Run 4.

The best reagent for removing the deposit from the bottom of the copper kettle was hot 10% HCl.

The data below show no discernible trend in the efficiency of the filter during the run:

Period, hr.	Ml.	L. per hr.	Pb used, g.	Pb retained by filter, g.	% Recovery
0-4	4000	1.00	3.414	2.140	62.6
4-8	4530	1.14	3.866	2.159	55.9
8-12	4360	1.09	3.722	2.490	66.9
12-16	4380	1.10	3.738	1.945	52.0
16-20	4560	1.14	3.881	2.406	62.0
20-24	4330	1.08	3.685	2.182	59.2
24-27	3160	1.05	3.689	1.516	56.3
TOTAL 27	29,320	1.09*	24.995	14.838	59.3*

* Average.

The 794 mg. of gum found in the mixing chamber is not large considering the quantity of fuel which was evaporated in these five runs and, presumably, during the previous use of the unit.

Following the three successive cleanings described below, it is estimated that the generator retained less than 5% of the original lead deposit:

Type of Cleaning	Mg. Pb Found	% of Total
Mechanical - Cleaning Key	765	47.3
Chemical - Hot 20% ammonium acetate	542	33.6
Chemical - Hot 20% HNO_3	309	19.1

A resinous deposit collected on the flame valve stem at one point during the run, which is the only instance encountered where the deposit could be ascribed to gum.

Run 6. Purpose: To determine whether multiple filters air in the removal of lead. Conclusion: Three filters in a special case removed no more than the percentage obtained for any single filter. The use of three filters is impractical also because of increased difficulty in operating the unit.

The unit was tested at 90 lbs. and operated at 80 lb. for starting and 60-70 lb. for running.

The first disk removed 47.7% of the lead input, the second 2.5% and the third 2.5%, a total of 52.7%.

Run 7. Purpose: To make a run on a high-gum gasoline. Conclusion: No trouble was experienced because of gum.

Some nodules found in the filter case analyzed 66.15% lead and 11.50% halogen as chlorine or 29.95% as bromine.

BIBLIOGRAPHY

(1) Instructions for the operation and Care of the Gasoline Field Range, Model of 1937 (U.S.A.M.D. 5M-10-10-40 r-4).

(2) Operation, Care, and Maintenance of Field Range, Model of 1937 (Section II, Memorandum Number 10, Hq. Armored Force, Oct. 31, 1940).

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