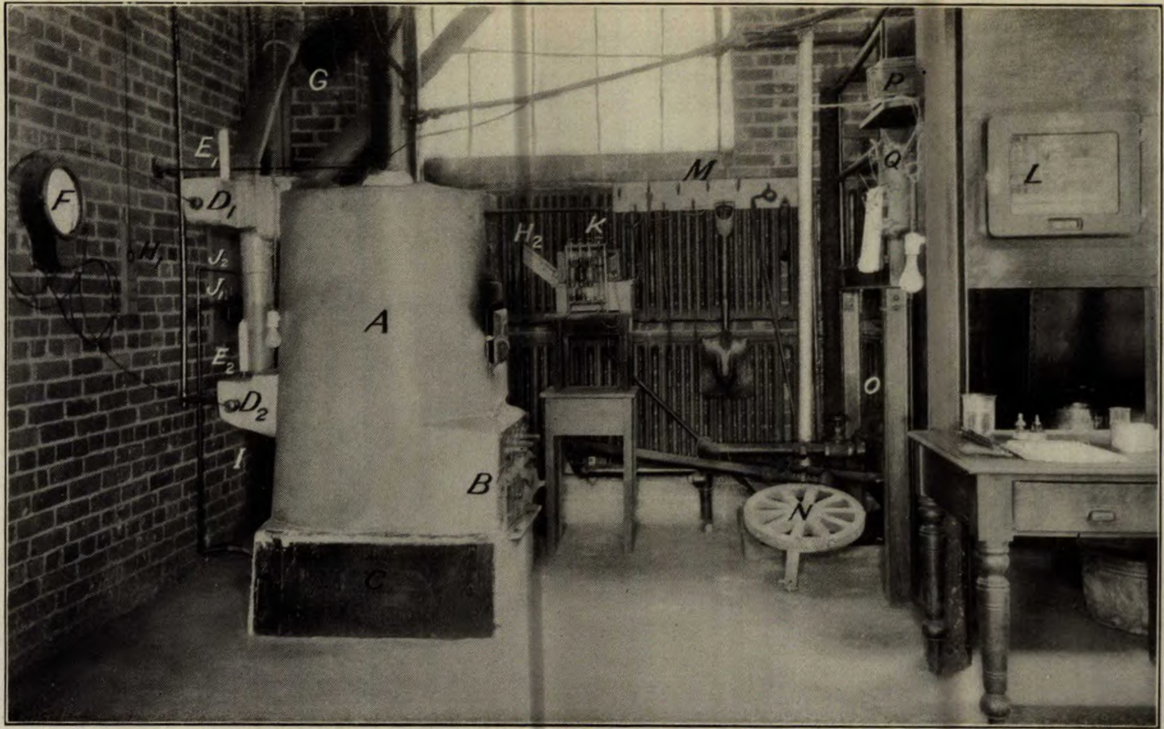

Domestic furnace and auxiliary test apparatus. (Water meter; and radiation, expansion, and water service tanks not shown.) **A.** Domestic hot-water boiler. **B.** Ordinary ash-pit. **C.** False ash-pit into which fuel is dumped for quenching. **D_1, D_2.** Flow and return headers. **E_1, E_2.** Thermometers in flow and return headers. **F.** Thermograph recording flow and return water temperatures. **G.** Flue-pipe entering chimney. **H_1, H_2.** Draught adjustments on butterfly and flap dampers in flue-pipe. **I.** Draught recorder measuring over-fire draught. **J_1, J_2.** Draught gauges measuring over-fire and flue-pipe draughts. **K.** Flue gas sampling and analysing equipment. **L_1, L_2.** Recording pyrometers measuring temperature differential of cooling water and flue gas temperatures. **M.** Fire tool rack. **N.** Wheel-type gas burner for igniting fuels. **O.** Gas meter measuring gas supplied for ignition. **P.** Hydrograph recording indoor humidity. **Q.** Thermograph recording indoor and outdoor temperatures.

CANADA
DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH
BUREAU OF MINES

COMPARATIVE TESTS OF VARIOUS FUELS WHEN BURNED IN A DOMESTIC HOT-WATER BOILER

1935 to 1938

BY
C. E. Baltzer and E. S. Malloch

OTTAWA
J. O. PATENAUDE, I.S.O.
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CONTENTS

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PREFACE

A short time after the termination of the Great War, the introduction into Central Canada of substitute domestic fuels of domestic and foreign origin to replace American anthracite, on which it was believed at that time an embargo would be placed, created the necessity for conducting a series of burning tests in order to determine the comparative value of these fuels with a standard fuel when burned in a domestic hot-water boiler.

Accordingly, during the years 1923–26, one hundred and twenty-three comparative tests were carried out—termed in this report as being the 1925 series. The behaviour of these fuels when burned in a standard domestic type hot-water heater was compared with that of a typical sample of American anthracite coal, which served as the standard fuel since American anthracite was then used almost entirely for domestic heating in the chief fuel-consuming centre of Canada—the Provinces of Ontario and Quebec.

Since the publication of Mines Branch Report No. 705, which contained the results of these tests, a considerable amount of new data has been secured as a result of tests and related research work which has been carried out on many additional fuels. The present publication contains the results which have been obtained during the course of the testing of these fuels. This series of tests is referred to in this report as the 1935 series and were carried out at intervals over an extended period of time mainly for the purpose of assisting various fuel producing and consuming interests which were able to make good use of the data developed by actual burning tests conducted along the lines outlined in the previously mentioned report. The results of these latter tests in the form of individual reports, each dealing with the test of the particular fuel concerned, were distributed as soon as completed to the parties interested. No attempt, however, was made to combine the results as a whole in a special publication for release to the public.

In this report a comprehensive summary of all the burning tests made in these laboratories on domestic coals and domestic coal substitutes is presented. Therefore, it supersedes Report No. 705 except in so far as a complete description of equipment, method of tests, and experimental technique, are concerned.

The determining factor in the selection and arrangement of the matter to be included has been the ultimate usefulness of the data to the fuel producer and consumer and since the original report contained lengthy descriptions of the equipment, methods of test, and experimental technique employed, reference to this has been eliminated or limited only to such description as is necessary for an intelligent understanding of the changes made. The major portion of the report is, therefore, devoted to tabulation of detailed data and results with explanatory matter pertaining thereto.

The report is concluded with a summarized comparison of the economic results obtained for both the 1925 and 1935 series of tests which, it is considered, will be of major interest to the lay reader.

The tests were carried out at Ottawa in the Fuel Research Laboratories of the Division of Fuels of the Bureau of Mines, Department of Mines and Resources, as part of the regular investigational work of that Division. The testing of the fuels, calculation of results, and preparation of the report were carried out by the regular staff of the Mechanical Engineering Section assisted by other members of the Division of Fuels. Messrs. J. R. Kirkconnell and H. P. Hudson acted in the capacity of observers; with W. H. Harper, P. B. Seely, and J. W. Custeau in the capacity of senior laboratory assistants.

Acknowledgment is due to the Solid Fuel Analysis Section for the carrying out of the analyses of the many fuel and refuse samples collected during the investigation.

B. F. Haanel,
Chief, Division of Fuels.

Ottawa, December 6, 1938.

Comparative Tests of Various Fuels When Burned in a Domestic Hot-water Boiler, 1935 to 1938

DESCRIPTION OF THE EXPERIMENTAL HEATING PLANT

For the purpose of this report a lengthy description of the experimental equipment employed for the new (1935) series of tests would be out of place inasmuch as the installation was essentially the same as that described in Bureau of Mines Report No. 705 which outlined the old (1925) series of tests in detail. However, it is in order at this point to briefly describe the salient features of the apparatus in order to give the reader some idea of the layout without reference to the old report.

The heating plant employed for these tests consisted of a round hot-water boiler; a radiation tank and cooling-water system; the usual equipment of scales for weighing fuel and refuse; thermometers; pyrometers; draught gauges; gas sampling and analysing apparatus; and water meter.

Figure 1 shows the general arrangement of the equipment, piping, etc., and Plate I (Frontispiece) illustrates the furnace and auxiliary test apparatus located on the main floor of the laboratory. The round hot-water boiler used was of conventional design, similar in all respects to such as are installed in an average-size house of eight or nine rooms, having a nominal grate diameter of 25 inches, a grate area of 3·4 square feet, and a heating surface of 32·4 square feet. The radiation tank was an insulated box, 6½ feet by 3 feet by 2½ feet, containing 81 square feet of wall type radiation connected to the circulating water system of the furnace. The heat was carried away from the boiler by means of the circulating water, which in turn gave up its heat to the cooling water which flowed through the radiation tank, and the product of the weight of the cooling water and the increase of its temperature in passing through the radiation tank gave the useful heat output of the boiler or furnace. The weight of the cooling water was measured by means of an accurately calibrated water meter, and the increase in temperature was determined by carefully calibrated thermometers as well as a recording pyrograph. All fuel charged to the furnace was weighed and, knowing its calorific value, this gave the heat input, and with the heat output the thermal efficiency could be calculated directly.

The only material difference between the set-up employed for the new tests and that used for the old tests, was the addition of a false or secondary ash-pit to the furnace, and the use of a removable ash-pan into which the hot residual fire remaining on the grate at the close of any test may be dumped for dry quenching with carbon dioxide gas. This procedure provided better control of stopping conditions and gave more consistent results than were formerly obtained.

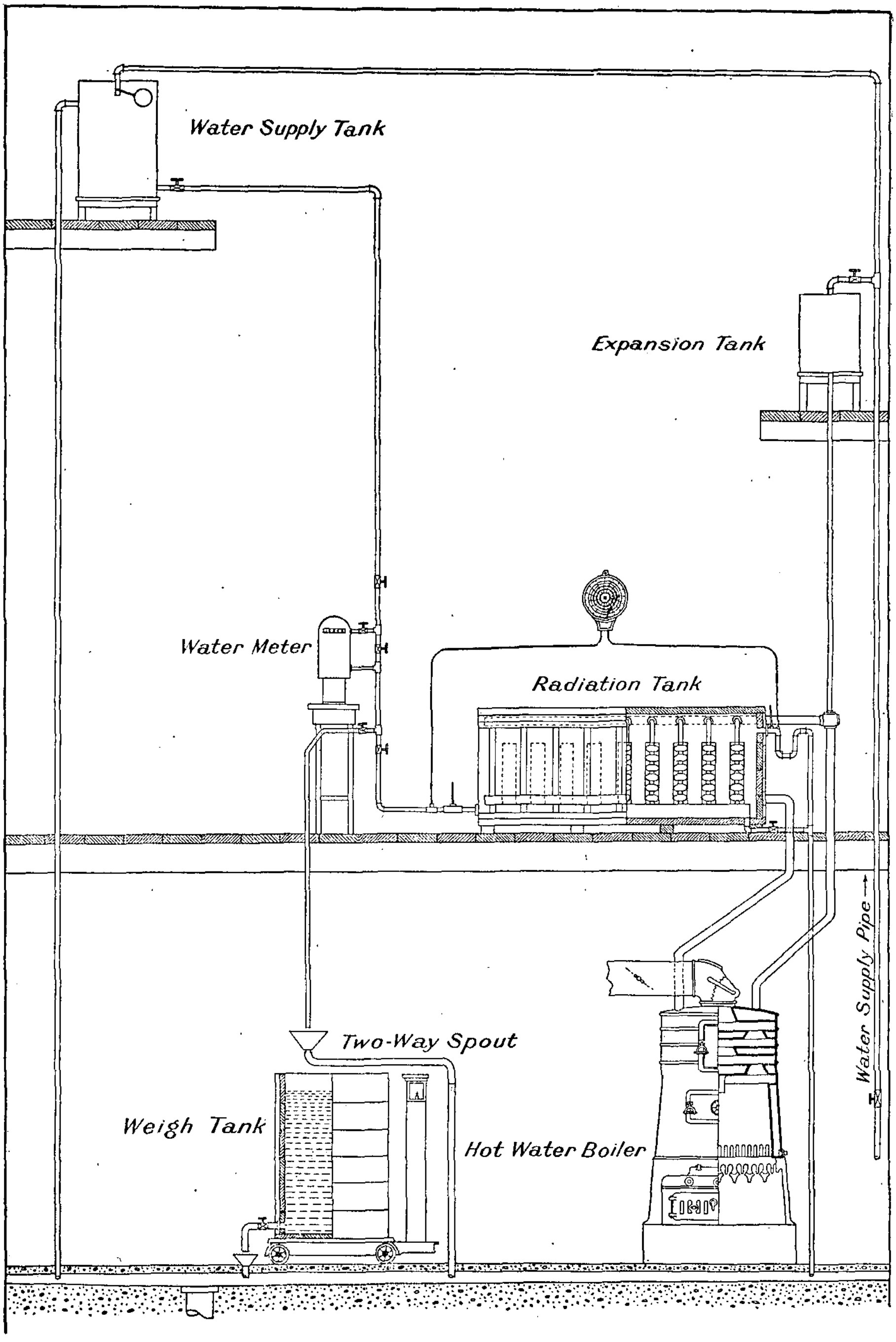

Figure 1. General arrangement of experimental heating plant.

METHOD OF CONDUCTING TESTS

Although the same general practice was followed in making the new series as in the old series, the experience previously obtained served as a basis for improving the operating technique as well as the starting and stopping method. Moreover, changes of a minor nature were necessary for the new series of tests inasmuch as these tests were not made as a connected whole as were the old, but at intervals over an extended period of time as part of several investigations made for various purposes. However, such changes as were made readily supplement the old methods so that a brief outline at this point is all that is necessary to elucidate the new method to the reader. Such minor departures from the standard methods described below as were made for certain tests on particular fuels are amplified in the section of this report dealing with "Discussion of Results".

The same general method of test was used for each trial so that the results are relatively comparable. From Tables A to D (in pocket) it will be noted that the complete or "standard" trial had a duration of 120 hours. This period was divided into two parts: the 4-day "observation" test (first 96 hours of trial), and the one-day "efficiency" test (last 24 hours of trial). Each of these periods was complete in itself and hence the "standard" trial served the dual purpose of providing general burning data over an extended period of observation, and precise efficiency and combustion data over a shorter interval. Each 24 hours of the 120-hour "standard" trial was considered as a complete cycle during which three firings were made, viz. at 9 a.m., 6 p.m., and 11 p.m. The rate of burning between these times was varied as follows: 9 hours at an average useful heat release of 66,000 B.T.U. per hour; 5 hours at 99,000 B.T.U. per hour; and 10 hours at 55,000 B.T.U. per hour; thus giving an average heat release for each 24-hour cycle and the trial as a whole of approximately 68,000 B.T.U. per hour. This roughly corresponds to a constant combustion rate of one-half boiler capacity or in other terms a consumption of approximately 3 tons of anthracite coal in a 30-day period which is about the maximum consumption to be expected for any house this particular furnace would heat during the coldest month of the year.

During the tests, except for taking the necessary observations, the work of furnace attendance was reduced to a minimum and chiefly consisted of removing clinker, firing fresh fuel, and resetting dampers at the end of each fire period. The grates were shaken as little as possible and only sufficiently to free the excess of accumulated ash which tended to interfere with combustion conditions. In most respects the tests were conducted along similar lines to those reported in Bureau of Mines Report No. 705 previously mentioned, the only marked difference needing further comment being in the methods employed to ignite and quench the fuel at the start and end of the tests respectively.

A preliminary fire was built in the furnace the evening prior to the start of the test, in order to heat up the furnace and water in the system to ordinary operating temperatures. At the end of this period—(approximately at 8.45 a.m. the next morning)—the fire was drawn, the ash-pit and furnace were thoroughly cleaned and the installation in general was made ready for the ensuing test which normally began 15 minutes later.

In starting the trials a fresh charge of the raw fuel under test was placed directly on the bare grate and ignited by means of a gas (wheel type) burner; 100 cubic feet of city gas having a calorific value of 500 B.T.U. per cubic foot were burned to ensure ignition. After ignition was secured and the fire was burning briskly a measured fuel charge was fired and the "observation" part of the test continued for 96 hours. At the conclusion of this 4-day period the "observation" test was quickly ended and the "efficiency" part of the test was immediately started in the same manner as outlined above and continued for the ensuing 24 hours after which the test was ended in the manner described below.

In ending the tests, the residual fire (the whole contents of the fire-pot) remaining at the end of both the "observation" and "efficiency" parts of the test was quickly and completely dumped, drawn, and quenched with dry carbon dioxide gas. The fuel value of the quenched residual fire was then determined and subtracted from the heat value of the fuel fired during the respective parts of each test.

In addition to noting the characteristics of the refuse, i.e. ash, clinker, and unburned fuel, obtained from the "observation" part of the test, a screen examination was made of the quantities obtained during and after this part of the test. This examination was made on three separate fractions, the first of which consisted wholly of clinker which was removed through the fire-door of the furnace; the second fraction consisted of ash, small pieces of clinker, and unburned fuel which normally dropped or were shaken through the grate during the course of test; and the third fraction consisted of the residual fire (ash, clinker, and partly burned fuel) which was dumped at the end of test, i.e. after the expiration of 96 hours of burning.

The refuse, in the same three fractions, obtained from the "efficiency" part of the test was sent to the Chemical Analysis Section of the Division where the various fractions were carefully and representatively sampled and analysed as was also a representative sample taken from the raw fuel fired during the test.

Careful note was made of the quantities of gas consumed during the ignition period of the fuel charged during the whole test, and of the quantity, composition, and sensible heat residue of the residual fire dumped at the trial end, and these factors were taken into account when reckoning the quantity of fuel actually burned during the test.

DESCRIPTION OF FUELS TESTED

In all, forty-five different samples of fuel, ranging in rank from high-grade anthracite to low-grade lignite and peat were tested in the experimental heating plant. These samples, originating from various sources in Eurasia, the United States of America, and Eastern, Central, and Western Canada, were either secured by purchase from retail coal dealers in Ottawa, or from co-operating agencies who furnished samples gratis so that they might have a report on the relative merit of the samples so provided for domestic heating purposes. In arranging for the samples special effort was made to ensure that they would be representative of the fuel to be tested and the samples so secured were what the general public might expect to receive from the various producing sources.

Table I lists and classifies the fuels that were tested and also states where and from whom they were obtained, the trade size under which they were sold, the quantity received, the date the fuels were received in storage, and finally the number of tests made on each shipment.

Immediately on receipt the samples were unloaded into individual bins in a covered storage shed. Either at this time or sometime later, as time permitted, but before any test was made, a representative (bulk) sample was taken from the total quantity received into storage from which the physical and chemical properties of the fuel were determined. The method of handling the "bulk" samples is illustrated in Figure 2. Table II lists the fuels in the same order as in Table I and gives the proximate and ultimate analyses and other relative information regarding the respective fuels as they were received in Ottawa.

Two to three days preceding test of any fuel, the fuel was withdrawn from storage and if not already done was sampled in accordance with the procedure illustrated in Figure 2, after which a sufficient quantity of the fuel was placed in a conical pile in a sheltered position on the laboratory floor, adjacent to the furnace. The raw fuel for test was drawn from this pile as needed. Fuel was charged to the fire in specified amounts at regular times, usually three times in 24 hours. Each time fuel was fired a small sample, 3 to 5 pounds, was taken from the charge and placed in a covered container. Immediately after the test was concluded the contents of this container were sent to the chemical laboratory for analysis, calorific value determination, ash fusion temperatures, etc. The method of handling the "test" samples is illustrated in Figure 3, and the proximate and ultimate analyses and other relative information regarding the respective fuels as fired during test are given in Tables A to D, in pocket at end of this report.

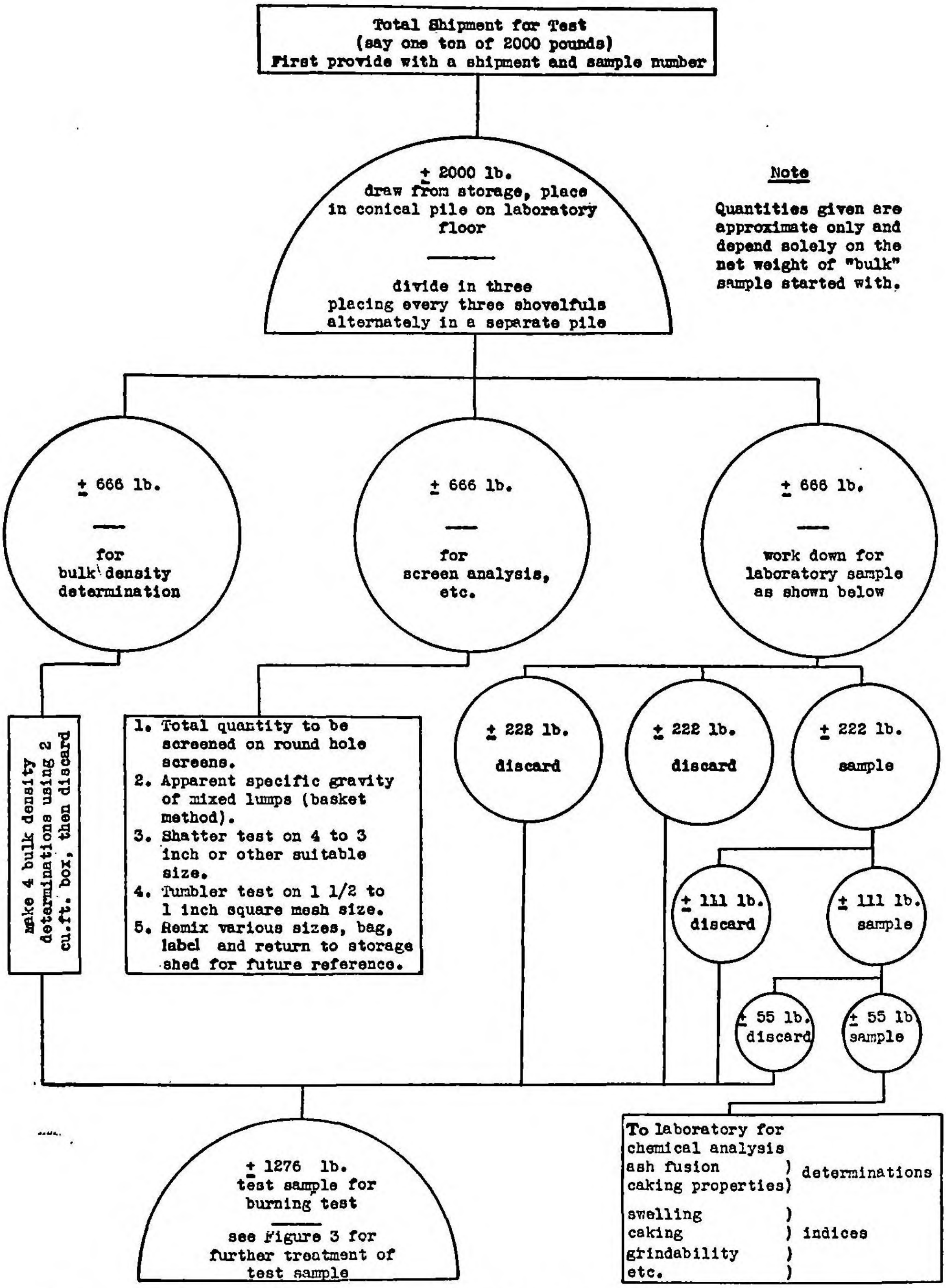

Figure 2. Illustrating procedure for handling "bulk" samples previous to burning test.

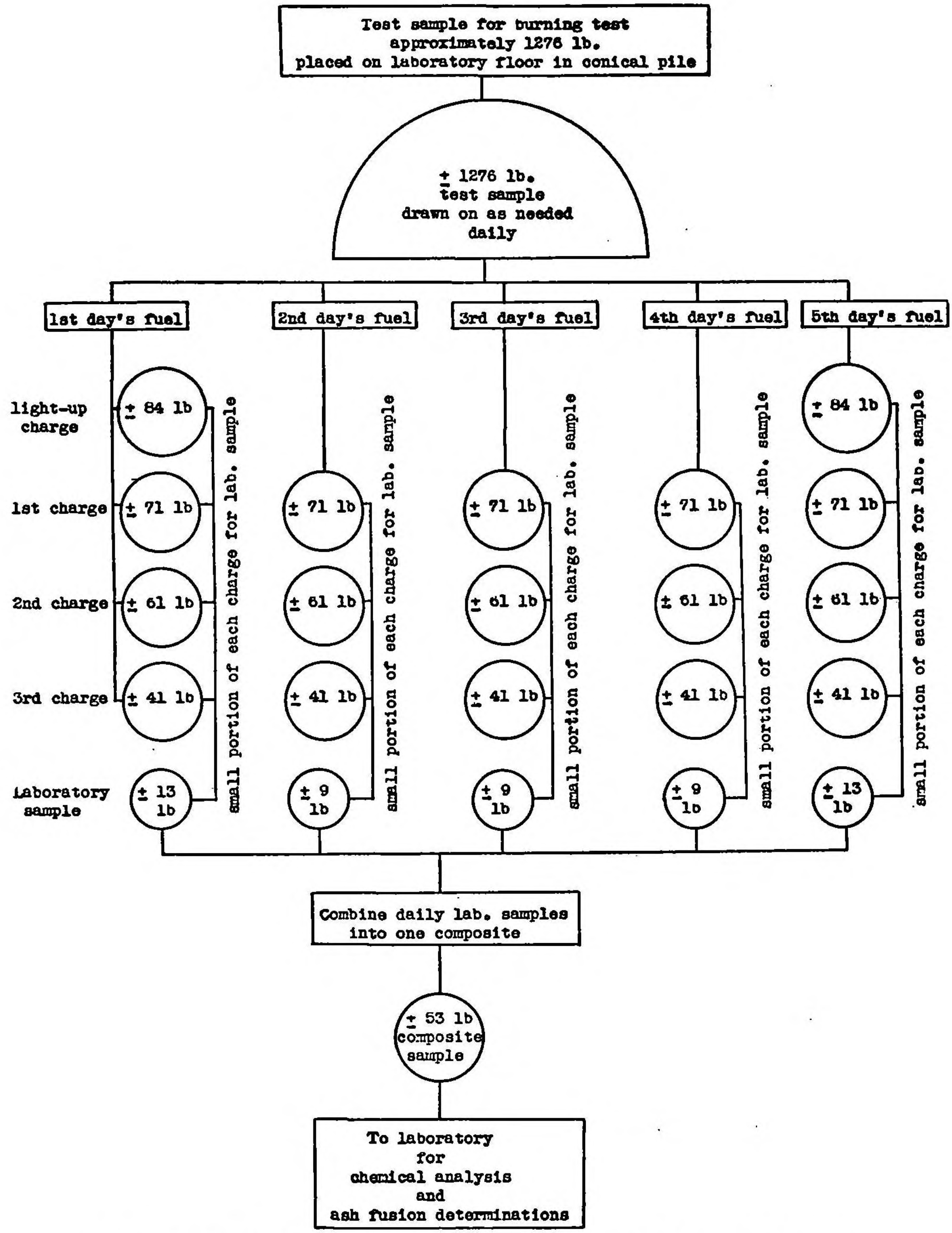

Figure 3. Illustrating procedure for handling "test" samples during burning test.

TABLE I

List of Fuels Tested[1]

Shipment and Sample No.[2]	Kind of Fuel	A.S.T.M.[3] Classification by rank (of coals): Class	A.S.T.M.[3] Classification by rank (of coals): Group	Origin	Obtained from	Trade size	Quantity received tons[4]	Date received	Number of tests made
3-34	Anthracite	Anthracitic	Anthracite	U.S.A.—Penna.	Ottawa fuel dealer	Stove	6	13/ 8/34	Thirteen
24-36	Anthracite	Anthracitic	Semi-anthracite	U.K.—Wales	Ottawa fuel dealer	Cobbles	2	31/10/36	Three
2-37	Anthracite	Anthracitic	Anthracite	French Indo-China	C.N.R.[5]—Fuel Dept.	Stove	1	21/ 6/37	One
17-36	Coke	(By-product coke)		Western Ontario	C.N.R.—Fuel Dept.	Range	1	23/ 9/36	One
16-36	Coke	(By-product coke)		Western Ontario	C.N.R.—Fuel Dept.	Nut	1	23/ 9/36	One
1-35	Coke	(By-product coke)		Quebec	Ottawa fuel dealer	Stove	1	27/ 2/35	One
11-35	Coke	(By-product coke)		Eastern Ontario	Ottawa fuel dealer	Stove	1	10/10/35	One
12-35	Coke	(By-product coke)		Eastern Ontario	Ottawa fuel dealer	Nut	1	10/10/35	One
27-31	Coke	(Petroleum coke)		Ontario	Ontario Oil Refinery	Lump	1½	20/10/31	Two
9-35	Coke	(Low-temperature coke)		Nova Scotia	F.R.L.[6]—Experiment	Washed lump	1½	16/11/29	Two
10-35	Coke	(Low-temperature coke)		Nova Scotia	F.R.L.—Experiment	Unwashed lump	½	16/11/29	One
4-35	Semi[7]-bituminous	Bituminous	Low-volatile	U.S.A.—Penna.	C.N.R.—Fuel Dept.	Lump	1	24/ 4/35	One
15-36	Semi-bituminous	Bituminous	Low-volatile	U.S.A.—W. Va.	C.N.R.—Fuel Dept.	Egg	2	23/ 9/36	One
17-34	Bituminous	Bituminous	High-volatile A	U.S.A.—Penna.	C.N.R.—Fuel Dept.	Egg	1	1/12/34	One
16-34	Bituminous	Bituminous	High-volatile A	U.S.A.—Ohio	C.N.R.—Fuel Dept.	Lump	1	3/12/34	One
7-35	Bituminous	Bituminous	High-volatile A	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	7/ 5/35	One
6-34	Bituminous	Bituminous	High-volatile A	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	Two
12-34	Bituminous	Bituminous	High-volatile B	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
8-34	Bituminous	Bituminous	High-volatile B	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
10-34	Bituminous	Bituminous	Medium-volatile	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
9-34	Bituminous	Bituminous	High-volatile A	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
7-34	Bituminous	Bituminous	High-volatile B	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
11-34	Bituminous	Bituminous	High-volatile B	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
2-38	Bituminous	Bituminous	High-volatile B	Nova Scotia	F.R.L.—Survey sample	Screened lump	1	26/ 8/37	One
6-35	Bituminous	Bituminous	High-volatile C	Nova Scotia	C.N.R.—Fuel Dept.	Lump	1	7/ 5/35	One
3-38	Bituminous	Bituminous	High-volatile C	Nova Scotia	F.R.L.—Survey sample	Lump	1	26/ 8/37	One
13-34	Bituminous	Bituminous	High-volatile A	New Brunswick	C.N.R.—Fuel Dept.	Lump	1	23/10/34	One
14-34	Bituminous	Bituminous	High-volatile A	British Columbia	C.N.R.—Fuel Dept.	Lump	1	17/12/34	One
15-34	Bituminous	Bituminous	High-volatile A	British Columbia	C.N.R.—Fuel Dept.	Lump	1	17/12/34	One
1A-37	Bituminous	Bituminous	Medium-volatile	Alberta	C.N.R.—Fuel Dept.	Lump	1	10/ 5/37	One
22-36	Bituminous	Bituminous	Medium-volatile	Alberta	C.N.R.—Fuel Dept.	Lump	2	9/10/36	One
13-35	Bituminous	Bituminous	High-volatile C	Alberta	Ottawa fuel dealer	Lump	1	30/10/35	One
23-36	Bituminous	Bituminous	High-volatile B	Alberta	C.N.R.—Fuel Dept.	Mine-run	2	9/10/36	One
21-36	Bituminous	Bituminous	High-volatile C	Alberta	C.N.R.—Fuel Dept.	Lump	2	9/10/36	One
18-36	Bituminous	Bituminous	High-volatile C	Alberta	C.N.R.—Fuel Dept.	Lump	2	9/10/36	One

28-36	Sub-bituminous	Sub-bituminous	Sub-bituminous B	Alberta	C.N.R.—Fuel Dept.	Egg	2	29/12/36	One
20-36	Sub-bituminous	Sub-bituminous	Sub-bituminous B	Alberta	C.N.R.—Fuel Dept.	Lump	2	9/10/36	One
19-36	Lignite	Lignitic	Lignite	Saskatchewan	C.N.R.—Fuel Dept.	Lump	2	9/10/36	One
10-31	Lignite	Lignitic	Lignite or Brown coal	Ontario	Ontario Dept. of Mines	Mine-run	30	29/ 7/31	One
5-34	Briquetted coal	(Made from bituminous fines)		Alberta	Ottawa fuel dealer	Stove briquettes	1	19/ 5/34	One
14-35	Briquetted coal	(Made from anthracite fines)		U.S.A.—Penna.	Ottawa fuel dealer	Stove briquettes	1	6/11/35	One
1-38	Briquetted coal	(Made from bituminous fines)		Alberta	C.N.R.—Fuel Dept.	Stove briquettes	2	3/ 2/38	One
1-37	Briquetted coal	(Made from bituminous fines)		Alberta	C.N.R.—Fuel Dept.	Stove briquettes	2	10/ 3/37	One
5-37	Briquetted lignite	(Made from charred lignite fines)		Saskatchewan	C.N.R.—Fuel Dept.	Stove briquettes	2	13/12/37	One
4-34	Briquetted peat	(Made from peat)		Imported	Dominion Fuel Board	Bricks	½	13/ 8/34	Two

[1] Arranged in the same order in which the respective fuels are tabulated in Tables A to D (in pocket).

[2] These numbers were assigned to the fuel samples as they were received in storage and have been retained throughout this report for convenient reference. They have no other significance.

[3] American Society for Testing Materials.

[4] Ton of 2,000 pounds.

[5] Canadian National Railways.

[6] Fuel Research Laboratories—Bureau of Mines. For experiment referred to see Bureau of Mines Report No. 721-1.

[7] Also known as low-volatile or smokeless coal.

TABLE II

Proximate and Ultimate Analyses, etc.[1], of a Representative Sample of the Total Bulk Shipment of Each Fuel, Taken either at Time of Unloading into Bins in Covered Storage Shed or Immediately Preceding Test

Shipment and sample No.[2]	Date sampled	Moisture condition of sample	Proximate Analysis				Ultimate Analysis						Calorific value B.T.U./lb. gross	Caking properties as judged by "coke-button"	Ash fusibility		
			Moisture %	Ash %	Volatile matter %	Fixed carbon %	Carbon %	Hydrogen %	Ash %	Sulphur %	Nitrogen %	Oxygen %			Initial temp. °F.	Softening temp. °F.	Fluid temp. °F.
8-34	13/ 8/34	As received.	2·8	9·2	5·2	82·8	82·5	2·8	9·2	0·9	0·9	3·7	13,250	Non-caking....	2710	2865	2910
		Dry........	....	9·4	5·4	85·2	84·8	2·6	9·4	0·9	1·0	1·3	13,620				
24-36	2/11/36	As received.	2·2	6·4	8·3	83·1	84·8	3·3	6·4	1·2	1·1	3·2	13,870	Non-caking....	2040	2215	2540
		Dry........	....	6·5	8·5	85·0	86·8	3·1	6·5	1·2	1·1	1·3	14,190				
2-37	22/ 6/37	As received.	4·0	4·5	2·9	88·6	87·6	2·0	4·5	0·8	0·6	4·5	13,180	Non-caking....	2000	2170	2440
		Dry........	....	4·7	3·0	92·3	91·3	1·6	4·7	0·8	0·6	1·0	13,740				
17-36	1/10/36	As received.	4·9	9·3	1·3	84·5	83·2	1·3	9·3	0·7	1·0	4·5	12,090	Non-caking....	2500	2650	2750
		Dry........	....	9·7	1·4	88·9	87·5	0·8	9·7	0·8	1·1	0·1	12,710				
16-36	30/ 9/36	As received.	4·4	8·9	1·2	85·5	83·9	1·3	8·9	0·7	0·9	4·3	12,170	Non-caking....	2460	2650	2750
		Dry........	....	9·3	1·3	89·4	87·8	0·8	9·3	0·8	0·9	0·4	12,740				
1-35	28/ 2/35	As received.	0·5	7·4	1·1	91·0	89·7	0·4	7·4	0·9	1·0	0·6	12,670	Non-caking....	2180	2530	2650
		Dry........	....	7·4	1·1	91·5	90·1	0·4	7·4	0·9	1·0	0·2	12,730				
11-35	11/10/35	As received.	3·4	9·8	1·2	85·6	83·8	0·9	9·8	0·7	1·3	3·5	12,170	Non-caking....	2670	2780	2900
		Dry........	....	10·2	1·2	88·6	86·7	0·6	10·2	0·7	1·3	0·5	12,590				
12-35	23/10/35	As received.	7·7	9·7	1·3	81·3	80·3	1·2	9·7	0·7	1·0	7·1	11,760	Non-caking....	2660	2770	2890
		Dry........	....	10·5	1·4	88·1	86·9	0·4	10·5	0·7	1·1	0·4	12,740				
27-31	30/ 9/35	As received.	1·0	0·6	9·8	88·6	90·3	3·7	0·6	1·6	1·5	2·3	15,260	Non-caking....	....	....	....
		Dry........	....	0·6	9·9	89·5	91·2	3·7	0·6	1·6	1·5	1·4	15,420				
9-35	23/ 9/35	As received.	3·6	8·7	9·0	78·7	79·2	2·8	8·7	2·0	1·5	5·8	12,770	Non-caking....	1960	2070	2210
		Dry........	....	9·1	9·3	81·6	82·2	2·4	9·1	2·1	1·5	2·7	13,250				
10-35	25/ 9/35	As received.	4·1	10·7	8·4	76·8	78·2	2·6	10·7	2·3	1·4	4·8	12,450	Non-caking....	1900	2020	2150
		Dry........	....	11·2	8·7	80·1	81·5	2·2	11·2	2·4	1·5	1·2	12,980				
4-35	24/ 4/35	As received.	0·7	9·5	15·9	73·9	80·9	4·3	9·5	1·5	1·3	2·5	14,190	Good..........	2730	2860	2860+
		Dry........	....	9·5	16·1	74·4	81·4	4·3	9·5	1·5	1·4	1·9	14,280				
15-36	25/ 9/36	As received.	0·9	10·8	15·7	72·6	80·5	4·2	10·8	0·5	1·2	2·8	13,760	Good..........	2330	2300	2350
		Dry........	....	10·9	15·8	73·3	81·2	4·1	10·9	0·5	1·2	2·1	13,880				
17-34	3/ 4/35	As received.	1·7	8·7	32·3	57·3	77·1	5·2	8·7	1·4	1·5	6·1	13,920	Good..........	2560	2650	2740
		Dry........	....	8·9	32·8	58·3	78·5	4·9	8·9	1·4	1·5	4·8	14,160				

78673—2

16-34	25/ 3/35	As received.	2·5	8·0	40·5	49·0	72·3	5·3	8·0	4·0	1·4	9·0	13,110	Good..........	1900	2020	2040
		Dry................		8·2	41·6	50·2	74·1	5·2	8·2	4·1	1·4	7·0	13,450				
7-35	25/ 5/35	As received.	2·2	4·9	38·3	54·6	78·4	5·8	4·9	2·2	1·7	7·0	14,080	Good..........	1940	2020	2205
		Dry................		5·0	39·1	55·9	80·1	5·7	5·0	2·2	1·8	5·2	14,400				
6-34	3/ 1/35	As received.	1·5	10·6	31·7	56·2	74·8	5·0	10·6	4·6	1·3	3·7	13,500	Good..........	1900	1980	2080
		Dry................		10·7	32·2	57·1	76·0	4·9	10·7	4·7	1·4	2·3	13,710				
12-34	20/ 2/35	As received.	1·9	9·7	30·5	57·9	75·8	5·1	9·7	1·7	1·9	5·8	13,520	Good..........	2100	2230	2365
		Dry................		9·9	31·1	59·0	77·3	4·9	9·9	1·7	2·0	4·2	13,780				
8-34	16/ 1/35	As received.	4·3	9·5	33·7	52·5	69·6	4·9	9·5	4·9	1·3	9·8	12,730	Good..........	1950	2060	2160
		Dry................		9·9	35·2	54·9	72·7	4·7	9·9	5·1	1·4	6·2	13,300				
10-34	7/ 2/35	As received.	1·9	16·8	24·9	56·4	70·1	4·5	16·8	1·0	1·9	5·7	12,390	Good..........	2200	2430	2550
		Dry................		17·2	25·4	57·4	71·4	4·4	17·2	1·0	1·9	4·1	12,620				
9-34	23/ 1/35	As received.	1·6	16·9	28·4	53·1	70·8	4·7	16·9	0·7	2·0	4·9	12,620	Good..........	2270	2530	2570
		Dry................		17·2	28·9	53·9	71·9	4·6	17·2	0·7	2·0	3·6	12,810				
7-34	9/ 1/35	As received.	3·9	14·5	34·0	47·6	64·9	5·0	14·5	7·3	1·3	7·0	11,860	Fair...........	1910	2060	2160
		Dry................		15·0	35·4	49·6	67·5	4·7	15·0	7·6	1·4	3·8	12,350				
11-34	13/ 2/35	As received.	2·7	16·7	36·1	44·5	63·7	4·7	16·7	6·4	1·9	6·6	11,680	Fair...........	1920	1990	2010
		Dry................		17·2	37·1	45·7	65·4	4·5	17·2	6·6	1·9	4·4	11,990				
2-38	26/ 9/38	As received.	4·3	13·9	29·3	52·5	68·2	4·8	13·9	1·2	1·8	10·1	11,980	Poor...........	2250	2590	2680
		Dry................		14·5	30·6	54·9	71·2	4·5	14·5	1·2	1·9	6·7	12,510				
6-35	25/ 5/35	As received.	5·7	12·2	37·5	44·6	62·4	5·2	12·2	7·8	1·2	11·2	11,220	Fair...........	2005	2100	2240
		Dry................		12·9	39·8	47·3	66·2	4·8	12·9	8·3	1·3	6·5	11,900				
3-38	13/10/38	As received.	4·7	17·7	33·6	44·0	58·7	4·7	17·7	8·4	1·3	9·2	10,490	Poor...........	1880	2000	2080
		Dry..		18·6	35·3	46·1	61·5	4·4	18·6	8·8	1·4	5·3	11,000				
13-34	27/ 2/35	As received.	1·0	19·2	30·7	49·1	65·7	4·3	19·2	7·5	0·8	2·5	12,100	Good..........	1950	2010	2140
		Dry................		19·3	31·1	49·6	66·4	4·3	19·3	7·5	0·8	1·7	12,230				
14-34	13/ 3/35	As received.	3·6	11·3	27·4	57·7	73·7	4·7	11·3	0·8	1·1	8·4	12,780	Fair...........	2300	2390	2520
		Dry................		11·7	28·4	59·8	76·5	4·5	11·7	0·8	1·2	5·3	13,250				
15-34	20/ 3/35	As received.	3·1	12·8	39·4	44·7	68·3	5·2	12·8	1·3	1·4	11·0	12,190	Fair...........	2150	2180	2210
		Dry................		13·2	40·7	46·1	70·5	4·9	13·2	1·4	1·4	8·6	12,580				
1A-37	10/ 5/37	As received.	0·9	12·6	23·7	62·8	76·6	4·5	12·6	0·2	1·1	5·0	13,140	Fair...........	2330	2410	2450
		Dry................		12·7	23·9	63·4	77·3	4·4	12·7	0·2	1·1	4·3	13,262				
22-36	21/10/36	As received.	1·3	8·4	28·4	61·9	79·6	4·9	8·4	0·3	1·2	5·6	13,830	Good..........	2280	2365	2450
		Dry................		8·5	28·8	62·7	80·7	4·8	8·5	0·3	1·2	4·5	14,020				
18-35	30/10/35	As received.	8·8	8·0	33·8	49·4	65·9	5·0	8·0	0·3	1·0	19·8	11,250	Slightly agglomerating.	2200	2255	2270
		Dry................		8·8	37·1	54·1	72·2	4·4	8·8	0·3	1·1	13·2	12,320				

[1] Arranged in the same order in which the respective fuels are tabulated in Tables A to D (in pocket).

[2] These numbers were assigned to the fuel samples as they were received in storage and have been retained throughout this report for convenient reference. They have no other significance.

TABLE II—Concluded

Proximate and Ultimate Analyses, etc.,[1] of a Representative Sample of the Total Bulk Shipment of Each Fuel, Taken either at Time of Unloading into Bins in Covered Storage Shed or Immediately Preceding Test—Concluded

Shipment and sample No.[2]	Date sampled	Moisture condition of sample	Proximate Analysis				Ultimate Analysis						Calorific value B.T.U./lb. gross	Caking properties as judged by "coke-button"	Ash fusibility		
			Moisture %	Ash %	Volatile matter %	Fixed carbon %	Carbon %	Hydrogen %	Ash %	Sulphur %	Nitrogen %	Oxygen %			Initial temp. °F.	Softening temp. °F.	Fluid temp. °F.
23-36	21/10/36	As received.	7·1	15·3	33·4	44·2	63·1	5·3	15·3	0·3	1·3	14·7	11,150	Poor to fair....	2205	2360	2440
		Dry........	....	16·4	36·0	47·6	68·0	4·8	16·4	0·3	1·4	9·1	12,000				
21-36	20/10/36	As received.	9·0	13·5	33·8	43·7	59·9	4·9	13·5	0·2	0·7	20·8	10,290	Slightly agglomerating.	2055	2160	2200
		Dry........	....	14·8	37·2	48·0	65·9	4·3	14·8	0·2	0·7	14·1	11,300				
18-36	13/10/36	As received.	7·7	17·1	31·8	43·4	58·8	4·7	17·1	0·3	0·8	18·3	9,880	Slightly agglomerating.	2100	2240	2375
		Dry........	....	18·6	34·4	47·0	63·6	4·1	18·6	0·4	0·9	12·4	10,700				
28-36	4/ 1/37	As received.	16·1	10·5	31·1	42·3	55·9	5·7	10·5	0·6	1·1	26·2	9,450	Non-caking....	2050	2150	2320
		Dry........	....	12·6	37·0	50·4	66·6	4·6	12·6	0·7	1·3	14·2	11,260				
20-36	19/10/36	As received.	17·2	8·0	31·6	43·2	57·1	5·9	8·0	0·6	1·1	27·3	9,790	Non-caking....	2235	2330	2430
		Dry........	....	9·6	38·1	52·3	69·0	4·8	9·6	0·7	1·4	14·5	11,830				
19-36	15/10/36	As received.	33·5	5·4	26·8	34·3	44·8	6·8	5·4	0·5	0·8	41·7	7,570	Non-caking....	2315	2420	2480
		Dry........	....	8·2	40·3	51·5	67·3	4·5	8·2	0·8	1·2	18·0	11,390				
10-31	Re-sampled 20/10/38	As received.	21·0	7·8	36·6	34·6	50·0	5·5	7·8	0·9	0·5	35·3	8,120	Non-caking....	2040	2180	2260
		Dry........	....	9·9	46·3	43·8	63·3	4·0	9·9	1·1	0·6	21·1	10,270				
5-34	No bulk sample taken. See analysis of test sample, items 10, 11, 12, 15, and 16, column 14, Table D, in pocket.																
14-35	6/11/35	As received.	1·7	9·4	11·7	77·2	81·6	3·6	9·4	0·7	1·0	3·7	13,500	Non-caking....	2100	2440	2550
		Dry........	....	9·5	11·9	78·6	83·1	3·5	9·5	0·7	1·0	2·2	13,740				
1-38	14/ 9/38	As received.	1·0	12·4	19·6	67·0	78·2	4·5	12·4	0·6	1·0	3·3	13,610	Poor..........	2850+	2850+	2850+
		Dry........	....	12·5	19·8	67·7	79·0	4·4	12·5	0·6	1·1	2·4	13,760				
1-37	11/ 3/37	As received.	1·6	11·7	18·0	68·7	78·8	4·7	11·7	0·6	1·1	3·1	13,690	Poor to fair....	2860+	2860+	2860+
		Dry........	....	11·8	18·3	69·9	80·1	4·6	11·8	0·7	1·1	1·7	13,910				
5-37	21/ 9/38	As received.	6·8	12·4	17·3	63·5	73·1	3·3	12·4	0·7	1·1	9·4	11,750	Forms agglomerate.	1865	2005	2115
		Dry........	....	13·3	18·6	68·1	78·4	2·7	13·3	0·8	1·2	3·6	12,600				
4-34	13/ 8/34	As received.	14·0	4·7	58·1	23·2	47·6	6·1	4·7	0·4	1·7	39·5	7,860	Non-caking....	....	....	....
		Dry........	....	5·5	67·5	27·0	55·4	5·3	5·5	0·4	2·0	31·4	9,140				

[1] Arranged in the same order in which the respective fuels are tabulated in Tables A to D (in pocket).

[2] These numbers were assigned to the fuel samples as they were received in storage and have been retained throughout this report for convenient reference. They have no other significance.

RESULTS OF TESTS

In all, one hundred and thirteen tests were made during the period under review, but only sixty-four of these are reported because some of the tests were made for specialized purposes having no direct connection with the work of the general investigation. The determining factor in selection of the tests included was the ultimate usefulness of the data to the general reader.

The detailed data and results of the sixty-four tests reported on are given in Tables A to D (in pocket at end of this report) which form the real basis of this report. These tables alone when considered with their respective headings and footnotes probably contain sufficient information for the use of the technical reader; but inasmuch as this report has been prepared for general distribution a summary and simplication of results as well as descriptive matter related thereto has been included for the lay reader.

It should be particularly noted that the arrangement of Tables A to D is in accordance with a definite plan of fuel grouping:

Table A. Presents the results of the preliminary "standardizing" tests with stove-size American anthracite coal.

Table B. Presents the results obtained for anthracite coals and cokes of various sorts.

Table C. Presents the results obtained for American and Eastern Canada semi-bituminous and bituminous coals.

Table D. Presents the results obtained for Western Canada bituminous and sub-bituminous coals, lignite, and briquetted fuels.

This grouping not only gives a logical arrangement for the discussion to follow but also permits orderly review of the results as a whole. Each table contains fifty-six main items of results for each test. Moreover, the items in each table are further arranged in three sections, the first of which (Section "A", items 1 to 20 inclusive) gives the general data regarding the tests as well as the physical and chemical characteristics of the fuels used; the second section (Section "B", items 21 to 35 *(c)* inclusive) gives the detailed results of the "observation" part of the tests; whereas the third and final section (Section "C", items 36 to 56 *(a)* inclusive) gives the detailed results of the "efficiency" part of the tests. Further, and in so far as possible, the fuels themselves, exclusive of the "standard" American anthracite, within the various groupings are arranged roughly in the order of decreasing calorific value. Those particularly interested in a detailed analysis of the results for the various tests will find that a careful study of the tabulated information given in these tables will bring out the many points of interest much better than any written description can.

Table III gives summarized results for all tests; eighteen of the most salient items being selected from Tables A to D for this summary. It will be noted that this table is divided into four parts, viz. A, B, C, and D, each corresponding to the similarly lettered Tables A to D previously mentioned. Likewise the item numbers in Table III are the same as the item numbers in the same main tables so that they may be readily referred to.

The first three columns of Table III list the distinguishing numbers for the respective trials; the fuel sample numbers, which have no other significance other than that they have been retained throughout this report simply for convenient reference; and give the kind of fuel tested for each trial. The remaining fifteen columns under their respective item numbers are as follows:

Item No. 7. Gives the average combustion rate as a percentage of the rated capacity of the furnace and, except for the last eight tests of Part A, is quite uniform in the neighbourhood of 52 per cent for all tests.

Items Nos. 10 (a), 10 (b), 12 (a), and 16 (b). Summarize the chemical properties of the fuels tested in respect to moisture, ash content, gross heating value, and ash fusion temperature, which roughly indicated the point at which the ash and refuse begins to soften.

Item No. 40 (e). Gives the fuel used per therm (100,000 B.T.U.) of useful heat delivered and this expression is translated in,

Item No. 40 (f). Fuel used to equal one ton of the "standard" American anthracite. Item 40 *(f)* is the most important from an economic standpoint since, when knowing the prices of the various fuels concerned, comparisons of cost may easily be made between them.

Item No. 42 (b). Gives the total refuse recovered as a percentage of the fuel used and is indicative of the relative amounts of refuse to be handled.

Items Nos. 44 (e) and 44 (f). Give, in B.T.U., the useful heat delivered per hour and per pound of fuel used. The former is a measure of the useful heat output of the boiler, whereas the latter is a measure of the quantity of useful heat obtained from each pound of fuel fired.

Items Nos. 45 (a), 45 (b), 46, 47 (a), and 49 (b). These five items, in the order stated, give the average temperature of the flue gases and the average CO_2 content of these gases at the boiler outlet; the average excess air used during the combustion process; the average draught over the fire; and the overall thermal efficiency, i.e. the percentage that the total useful heat obtained from the boiler is of the total heat supplied to the boiler. These items are indicative of the combustion conditions prevailing during the various tests.

DISCUSSION OF RESULTS

"Standardizing" Tests with American Anthracite

Part A, Table III and Table A (in pocket) summarize and give complete results for tests made on a composite 6-ton sample of average stove-size American anthracite, during development of the "standard" method of test. The first three trials tabulated, namely trials Nos. DS–49, 50, and 51, were made first in accordance with procedure worked out for a "standard" method. While waiting for chemical analysis of fuel and refuse samples for these trials and preliminary to work-up of results on same, eight short, 24-hour "efficiency" tests (last eight trials tabulated) were made at progressively increasing rates of combustion in order to determine if the efficiency result of tests made with the "standard" method would be comparable to the average efficiency of the boiler when worked over its entire capacity range. The average efficiency result for the first three trials was 66·6 per cent, whereas the average efficiency for the last eight trials was 66·3 per cent, a difference of only 0·3 per cent. It was, therefore, concluded that the "standard" method gave efficiency results within the practical limits of boiler operation and that the efficiencies so obtained could be safely used as a basis for comparison. Before proceeding with tests on other fuels, however, two more tests, trials Nos. DS–61 and 62 were made by the "standard" method in order to see if the results would be similar to those obtained for the first three tests previously mentioned. Although the efficiencies obtained for the last two tests were a little lower than those obtained for the first three tests the results so closely approximated each other within the limits of experimental error, that the method was accepted as the basis for future testing. The results of the five tests made by the "standard" method were then averaged to give the results of the "Standard Trial" No. DS–X5 which is used throughout this report as the true basis for all comparisons.

Anthracite Coals and Cokes

Part B, Table III and Table B (in pocket) summarize and give complete results for tests made on various anthracite coals and cokes. For certain of these fuels, namely, Welsh and French Indo-China anthracites and petroleum coke due to their low ash content and peculiar behaviour in the fire, the furnace grate had to be modified in order to obtain consistent results comparable with the other fuels. Without this modification it was found that radiation losses through the grate and the loss due to unburned combustible matter in refuse were abnormally high with consequent abnormally low efficiencies. This, of course, indicated a definite weakness in the "standard" method of test for fuels of this nature and hence to this extent only was the "standard" procedure varied for the tests on these fuels. It should be clearly understood, however, that the modification applies only to test procedure and not to the use of these fuels, with probably the exception of petroleum coke, for ordinary domestic use. In ordinary use the time factor allows for accumulation of ash on the furnace grate and this accumulation properly regulated with shaking automatically gives positive combustion control for the average user.

The modification consisted of partially sealing off the grate from the burning fuel by the introduction of a foreign substance between the grate and the fuel being tested. The first scheme tried with Welsh anthracite (*see* trial No. DH–144, column 2, Table B) was the use of a known quantity and quality of broken clinker. A quantity of Welsh anthracite clinker was obtained from previous firings of the same fuel, this was broken into pieces $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in size, and a definite quantity of which a representative sample had been previously analysed, was placed over the grate immediately before start of the test. The fuel undergoing test was then fired on top of the broken clinker and the test proceeded in accordance with the usual "standard" method of procedure. Although this first scheme was quite successful it was very difficult to obtain the requisite quantity of clinker for the several tests on these fuels. The scheme was further complicated by the necessity of determining the quality of the several clinker samples in order to apply corrections in the calculations involved. For these reasons a second scheme was tried which consisted of the use of a definite quantity of inert broken firebrick, sized, and handled similarly to the broken clinker previously used. The second scheme gave consistent results equally as satisfactory as the first with none of the inert difficulties of handling and hence was adopted for the remaining trials, namely trials Nos. EDH—145, 146, 149, and EDS–93, columns 3, 4, 5, and 12 of Table B.

Inasmuch as the use of either broken clinker or crushed firebrick has disadvantages for continuous use as a grate protection by the home owner, a third scheme was tried for petroleum coke only. The ordinary coal grate is not at all suited to the use of this fuel, which has an extremely low ash content of about 1·5 per cent. Either the ordinary coal grate should be replaced with a new one of the pin-hole type, or a metal plate with closely spaced ¼-inch perforations should be laid over the existing grate. This was tried for trial No. EDS–94, column 11, Table B, and gave good results, quite similar to the results obtained with broken firebrick for the same fuel. *See* trial No. EDS–93, column 12, Table B.

American and Eastern Canada Semi-bituminous and Bituminous Coals

Part C, Table III and Table C (in pocket) summarize and give complete results for tests made on various American and Eastern Canada semi-bituminous and bituminous coals. The first test made, namely trial No. DS–65, column 7, Table C, with bituminous coal gave a lower efficiency result than was obtained for other bituminous coals of a like nature. For this reason this sample was retested. *See* trial No. EDS-77, column 8, Table C. The results of the two trials were in such close agreement that it is safe to assume that the results of the first trial are not in error and, therefore, are representative of the fuel tested.

Western Canada Bituminous and Sub-bituminous Coals, Lignite, and Briquetted Fuels

Part D, Table III and Table D (in pocket) summarize and give complete results for tests made on various Western Canada bituminous and sub-bituminous coals, lignite, and briquetted fuels. The only explanation necessary regarding these results is in regard to trial No. DH–202, column 13, Table D, which was made with Northern Ontario lignite. The only sample of this fuel available for test had been in storage for several years during which time it had become abnormally dry. The economic result for this trial is, therefore, probably higher than would obtain had freshly mined fuel been used with a moisture content of approximately 45 per cent. Due to the low calorific values of the low-rank lignite fuels and peat briquettes six firings had to be made each 24 hours for the four tests made on these fuels instead of the normal three which obtained for all other tests on higher ranking fuels. These additional firings were necessary in order to maintain the same comparative combustion rate for all the tests. The close agreement of the results obtained for trials Nos. EDS-81 and 82, columns 19 and 20, Table D, both made on the same sample of imported peat bricks, again illustrates the ability of the operating staff to duplicate results with the "standard" test procedure used throughout.

General Discussion

Similarly as for the old (1925) series of tests previously reported on in Bureau of Mines Report No. 705, the trend of the efficiency values for these tests when considered as a whole in relation to fuel rank is downward as the rank lowers. In other words the high-rank, low-volatile, high-carbon fuels gave highest efficiencies; whereas the low-rank, high-volatile, low-carbon fuels gave the lowest efficiencies. Thus, and generally speaking, the efficiencies varied inversely with the volatile matter content of the different fuels and hence directly with their fixed carbon contents. Consequently less fuel was required to produce the same heating effect with the higher rank fuels than with the low-rank fuels.

The average thermal efficiency for the five individual tests made on the "standard" sample of American anthracite with a volatile matter content of 5 per cent was 65·8 per cent. For three tests on the same sample of Welsh anthracite with a volatile matter content of 8 per cent the average efficiency was 70·3 per cent. The increased efficiency for Welsh anthracite having a higher volatile content may be accounted for by its higher carbon content and calorific value. The efficiency obtained for the one test on French Indo-China anthracite with a volatile matter content of 4 per cent was very high in relation to American anthracite, 75·6 per cent. This is accounted for in this one test by the extremely high carbon content and the even control given during this test by the use of crushed firebrick on the grate as well as the grate seal provided by the natural tendency of the ash to form sheet clinker over the grate. For five tests on five different samples of by-product coke with less than 2 per cent of volatile matter the average efficiency was 72·4 per cent. The three tests on low-temperature coke with an average volatile matter content of 9 per cent gave an average efficiency of 70·0 per cent. The two tests on petroleum coke also with a volatile matter content of 9 per cent gave a like average efficiency of 71·1 per cent. Both of these efficiency values closely approximates that for the Welsh anthracite.

The efficiency values for the semi-bituminous, bituminous, and sub-bituminous coals varied from 50 to 60 per cent with two exceptions namely, trials Nos. DS-65 and DH-134, for which the values were below 50 per cent, and may be accounted for by the physical properties and behaviour of these two coals in the fire. The variation in values for semi-bituminous, bituminous, and sub-bituminous coals even when of the same rank are accounted for by varying ash contents and varying physical properties such as average size of lump, friability or tendency to crumble during handling and burning, and caking, swelling and clinkering tendencies during the combustion process. It can be appreciated, therefore, that the efficiency values for these coals would be more irregular and not so likely to grade as closely in rank as would the higher ranking and more uniform anthracite and coke fuels previously discussed.

The efficiency value obtained for Saskatchewan lignite was 48·6 per cent, whereas as previously mentioned the high value of 55·2 per cent for Ontario lignite is accounted for by the extreme dryness of the sample. Had Ontario lignite been in its state as mined, with approximately 45 per cent moisture content, the value would have been, in all probability, below 50 per cent.

The briquetted fuels gave varying efficiencies of from 66·7 per cent for briquettes made from anthracite fines to 54·0 per cent for peat bricks. Here again the efficiencies, in general, grade in accordance with the rank of fuel from which the briquettes are made.

Any reader who wishes to make a close study of the efficiency values for himself must not be too critical of minor contradictions in the general trend of the values unless he is prepared to weigh carefully all the supporting data in respect to physical and chemical properties and general burning characteristics of the various fuels concerned.

In the writers' opinion the efficiency values by themselves are not so good a criterion of fuel value for the lay reader as is item 40 *(e)*, Tables III, and A, B, C, and D (in pocket). This item gives the pounds of fuel used per therm (100,000 B.T.U.) of useful heat output, and is a direct measure of the quantity of fuel required to produce a specified heating result. This expression is translated, in item 40 *(f)*, into tonnage necessary to equal one ton of the "standard" American anthracite which is most important from an economic standpoint, since, knowing the prices of the various fuels concerned, comparisons of costs may easily be made between them. Therefore, the economic results to follow are given on a basis of these values rather than on a direct efficiency basis.

COMPARISON OF ECONOMIC RESULTS OF OLD AND NEW SERIES OF TESTS

In the interval between making the old and new series of tests a definite improvement in the average grade of American anthracite supplied to the Canadian market had been noted. This improvement in quality, as shown in an anthracite and coke analysis survey* made in the 1932-33 winter season, was the main factor prompting the retesting of American anthracite for the new series of tests. The sample used as a standard of comparison for the former tests averaged 14·5 per cent ash with a calorific value of 12,090 B.T.U. per pound as fired, whereas the "standard" sample used for the latter tests averaged 9·6 per cent ash with a corresponding higher calorific value of 13,190 B.T.U. Obviously, in any comparison between the two series of results due allowance should be made for the difference in grade between the two "standard" samples. For this reason Table IV, a reproduction of Table X, Bureau of Mines Report No. 705, is given with the addition of another column giving a recalculation of the equivalent tonnages corresponding to the ash content (9·6 per cent) and calorific value (13,190 B.T.U.) of the new "standard" sample.

*Anthracite and Coke Analysis Survey Conducted at the Fuel Research Laboratories, Paper I, "Investigations of Fuels and Fuel Testing 1932"—Bureau of Mines Report No. 737.

Table V, similarly to Table IV, gives the relative values of the fuels tested in the new series, compared with American anthracite, based on quantity of fuel fired to deliver 100,000 B.T.U. to the cooling water of the system. The column "equivalent tonnage to 10 tons of American anthracite", is a comparison of all the fuels with American anthracite, on a basis of heat delivery only. Although these results give merit ratings which are quite definite for the one factor commented upon, some care and discretion should be used in applying them inasmuch as other factors and fuel characteristics which the reader must interpret for himself from the data at his disposal should be taken into account before final decision is made regarding the best fuel value for a particular need. It must also be remembered that this comparison is based on tests made in a single type of furnace and might not apply to all types of furnaces, although it is reasonably safe to take the results as being relatively comparable for the more common types of furnaces used throughout Canada for domestic heating purposes.

TABLE III

Summarized Results of Comparative Burning Tests Made with Various Solid Fuels in a Domestic Hot-Water Boiler

Trial No.	Item No.		7	10(a)	10(b)	12(a)	16(b)	40(e)	40(f)	42(b)	44(e)	44(f)	45(a)	45(b)	46	47(a)	49(b)
	Fuel[1]		Combustion rate per cent of rated capacity, %	Fuel as fired				Fuel used		Refuse per cent of fuel used, %	Useful heat delivered		Flue gases		Excess air, %	Draught over fire, in. W.G.	Overall thermal efficiency, %
	No.	Kind		Moisture, %	Ash, %	Gross calorific value, B.T.U./lb.	Ash fusion temp., °F.	Per therm delivered to cooling water, lb.	To equal one ton American anthracite, tons		Per hour, B.T.U.	Per lb. fuel used, B.T.U.	Average temp., °F.	CO_2 content, %			
Part A.—Tests on Stove-size American Anthracite, for complete data *see* Table A (in pocket).																	
DS-49	3-34	American anthracite	55	3·1	8·8	13,230	2850	11·25	0·98	16·7	71,657	8,892	331	14·9	27	0·004	67·2
DS-50	3-34	" "	53	3·2	9·1	13,210	2860	11·48	1·00	17·5	67,729	8,711	307	13·5	41	0·012	65·9
DS-51	3-34	" "	50	3·1	9·5	13,260	2835	11·28	0·98	17·9	69,328	8,869	303	13·4	40	0·009	66·9
DS-61	3-34	" "	53	2·6	9·8	13,130	2810	11·66	1·01	19·6	67,913	8,574	310	12·4	50	0·013	65·3
DS-62	3-34	" "	49	2·4	10·6	13,130	2900	11·94	1·03	21·1	65,559	8,374	300	12·8	48	0·015	63·8
DS-X5[2]	3-34	" "	52	2·9	9·6	13,190	2850	11·52	1·00	18·6	68,437	8,684	310	13·4	41	0·010	65·8
EDS-53	3-34	" "	37	2·7	9·5	13,210	2840	13·34	1·16	26·4	49,341	7,495	210	13·3	39	0·003	56·7
EDS-54	3-34	" "	50	2·8	11·4	13,110	2840	12·11	1·05	21·4	66,258	8,256	286	12·4	51	0·009	63·0
EDS-55	3-34	" "	63	2·7	9·2	13,300	2860	11·57	1·00	18·8	82,784	8,646	337	11·9	54	0·027	65·0
EDS-56	3-34	" "	74	2·4	9·5	13,250	2855	11·34	0·98	17·7	97,428	8,820	390	11·9	54	0·021	66·5
EDS-57	3-34	" "	87	2·5	9·5	13,150	2840	10·94	0·95	14·9	114,990	9,141	436	13·6	30	0·040	69·5
EDS-58	3-34	" "	100	2·5	10·1	13,190	2855	10·91	0·95	13·9	132,241	9,170	495	13·5	34	0·046	69·5
EDS-60	3-34	" "	113	3·0	9·6	13,090	2830	10·97	0·95	12·7	149,295	9,116	525	13·8	33	0·053	69·6
EDS-63	3-34	" "	132	2·5	10·2	13,080	2840	11·20	0·97	13·6	174,476	8,930	605	14·1	34	0·072	68·3
Part B.—Tests on Anthracite Coals and Cokes, for complete data *see* Table B (in pocket).																	
DH-144	24-36	Welsh anthracite....	55	1·7	4·4	14,290	2340	9·54	0·83	4·7	70,122	10,479	348	10·9	67	0·016	73·3
EDH-145	24-36	" " ...	52	1·7	4·6	14,290	2330	10·37	0·90	16·2	69,236	9,644	321	12·3	48	0·024	67·5
EDH-146	24-36	" " ...	52	1·7	4·6	14,290	2330	10·00	0·87	11·8	68,281	10,011	317	13·1	41	0·015	70·1
EDH-149	2-37	Indo-China anthracite..............	53	3·8	5·0	13,160	2060	10·05	0·87	6·6	69,963	9,947	304	11·9	56	0·030	75·6
DH-131	17-36	By-product coke....	51	0·4	9·4	12,900	2760	11·72	1·02	10·9	68,600	8,531	308	9·7	87	0·037	66·1
DH-130	16-36	" "	51	0·2	9·2	12,850	2710	10·85	0·94	9·3	67,848	9,215	299	8·9	103	0·039	71·7
DS-89	1-35	" "	52	0·2	7·7	12,830	2510	10·74	0·93	9·3	68,470	9,310	302	11·4	56	0·013	72·6
DS-95	11-35	" "	54	1·2	9·9	12,500	2780	10·45	0·91	11·3	68,201	9,566	322	13·1	46	0·008	76·5
DS-96	12-35	" "	54	4·6	10·0	12,050	2780	11·10	0·96	11·5	68,776	9,005	312	13·2	45	0·012	74·7
EDS-94	27-31	Petroleum coke.....	52	1·4	0·5	15,210	2005	9·20	0·80	Nil.	68,008	10,867	303	11·2	63	0·019	71·4
EDS-93	27-31	" "	52	1·5	1·7	14,900	2000	9·49	0·84	2·4	69,228	10,542	303	14·0	30	0·008	70·8
DS-92	9-35	L.T. coke..........	53	3·1	8·6	12,840	2010	10·99	0·95	12·8	68,167	9,099	318	14·7	28	0·007	70·9
EDS-90	9-35	"	52	3·6	8·8	12,780	2090	11·21	0·97	12·3	68,330	8,924	313	13·7	33	0·011	69·8
EDS-91	10-35	"	52	3·6	10·6	12,510	1980	11·56	1·00	14·8	68,074	8,653	310	13·4	33	0·013	69·2

Part C.—Tests on American and Eastern Canada Coals, for complete data *see* Table C (in pocket).

DS-78	4-35	American—semi-bituminous..	52	0·7	9·2	14,190	2870	12·12	1·05	16·7	68,381	8,251	360	10·1	55	0·019	58·1
DH-132	15-36	" " ..	57	0·3	9·4	14,060	2280	13·70	1·19	27·1	70,359	7,300	373	10·6	65	0·018	51·9
DS-76	17-34	American bituminous..	51	1·6	8·2	13,900	2700	13·47	1·17	16·0	69,500	7,423	457	11·0	51	0·019	53·4
DS-75	16-34	" " ..	52	2·4	8·0	13,280	2045	14·36	1·25	12·9	69,019	6,963	484	12·7	30	0·008	52·4
DS-80	7-35	N.S. bituminous....	52	2·3	4·8	14,100	2015	14·18	1·23	15·0	70,064	7,050	450	12·3	32	0·012	50·0
DS-65	6-34	" "	47	1·3	11·0	13,540	2025	15·41	1·34	27·4	89,549	6,490	431	10·4	65	0·019	47·9
EDS-77	6-34	" "	52	1·2	11·4	13.250	2020	15·42	1·34	27·0	68,733	6,484	402	10·7	53	0·018	48·9
DS-71	12-34	" "	53	1·6	9·7	13,440	2170	13·78	1·20	14·5	68,601	7,259	426	11·0	51	0·019	54·0
DS-67	8-34	" "	51	3·9	11·4	12,530	2065	15·13	1·32	18·1	68,568	6,609	407	11·9	47	0·006	52·7
DS-69	10-34	" "	53	1·5	17·5	12,370	2440	13·93	1·21	22·7	70,436	7,181	412	11·5	47	0·007	58·1
DS-68	9-34	" "	52	1·4	17·9	12,320	2520	13·65	1·18	21·6	68,875	7,327	452	10·9	55	0·009	59·5
DS-66	7-34	" "	52	3·3	13·9	12,080	2000	15·43	i·34	21·1	71,060	6,480	441	12·8	32	0·006	53·6
DS-70	11-34	" "	54	2·4	15·1	11,880	2025	15·18	1·32	19·7	70,472	6,586	449	11·3	44	0·010	55·4
DH-200	2-38	" "	52	3·5	11·6	12,200	2580	14·43	1·25	17·9	69,953	6,929	452	11·5	48	0·020	56·8
DS-79	6-35	" "	53	5·8	11·4	11,300	2090	16·73	1·45	21·5	68,758	5,977	452	11·9	34	0·009	52·9
DH-201	3-38	" "	56	4·5	14·6	11,090	1970	16·78	1·46	22·2	70,583	5,961	413	9·8	62	0·017	53·8
DS-72	13-34	N.B. bituminous....	52	1·0	21·5	11,590	2040	14·82	1·29	23·1	72,630	6,748	454	9·2	74	0·028	58·2

Part D.—Tests on Western Canada Coals, Lignite, and Briquetted Fuels, for complete data *see* Table D (in pocket).

DS-73	14-34	B.C. bituminous....	51	2·3	11·8	12,800	2380	14·11	1·22	20·6	69.380	7,086	373	12·7	31	0·004	55·4
DS-74	15-34	" "	52	2·8	11·6	12,500	2170	14·25	1·24	16·6	68,793	7,017	475	13·4	26	0·005	56·1
DH-143	1A-37	Alberta bituminous	54	0·9	11·8	13,230	2300	13·53	1·17	24·1	68,851	7,393	382	10·5	68	0·024	55·9
DH-133	22-36	" " ..	57	0·8	13·2	12,970	2350	13·55	1·18	18·7	68,571	7,380	464	8·6	94	0·035	56·9
DS-97	13-35	" " ..	54	8·0	8·3	11,340	2240	16·22	1·41	19·9	68,534	6,165	384	11·3	56	0·022	54·4
DH-134	23-36	" " ..	49	5·5	14·8	11,315	2320	18·90	1·64	34·6	69,234	5,290	464	10·1	72	0·064	46·8
DH-135	21-36	" " ..	60	8·0	14·6	10,190	2200	17·84	1·55	23·6	68,550	5,605	378	10·2	69	0·035	55·0
DH-136	18-36	" " ..	52	7·0	18·4	9,730	2190	18·52	1·61	27·4	67,677	5,400	394	9·0	93	0·050	55·5
DH-138	28-36	" sub-bit.....	56	15·3	6·9	10,150	2040	16·83	1·46	10·8	69,922	5,942	383	12·1	47	0·014	58·5
DH-137	20-36	" "	60	16·4	6·7	10,130	2000	17·27	1·50	8·6	68,899	5,792	367	11·5	51	0·023	57·2
DH-139	19-36	Sask. lignite........	49	27·7	6·3	7,970	2200	25·84	2·24	9·5	66,375	3,870	389	6·3	161	0·034	48·6
DH-202	10-31	Ontario lignite......	53	19·2	6·5	8,350	2375	21·68	1·88	7·5	70,715	4,612	383	11·4	63	0·011	55·2
DS-64	5-34	Alberta briquettes..	55	0·6	9·8	14,050	2750	12·31	1·07	20·8	70,345	8,125	299	14·0	26	0·009	57·8
DS-98	14-35	American briquettes	52	0·9	9·8	13,650	2420	10·99	0·95	13·1	68,410	9,101	311	14·0	29	0·007	66·7
DH-198	1-38	Alberta briquettes..	53	0·8	12·3	13,660	2900+	11·83	1·03	13·2	70,268	8,453	372	12·9	39	0·013	61·9
DH-140	1-37	" " ..	54	0·7	12·1	13,500	2850+	12·17	1·06	15·4	71,313	8,217	358	12·6	38	0·013	60·9
DH-199	5-37	Sask. briquettes....	54	5·9	13·1	11,830	2050	13·62	1·18	15·5	70,370	7,340	349	13·8	35	0·010	62·0
EDS-81	4-34	Peat bricks.........	54	12·0	5·4	8,150	2245	22·73	1·97	5·6	70,765	4,399	331	13·2	35	0·010	54·0
EDS-82	4-34	"	53	5·4	5·7	8,140	2240	22·48	1·95	5·4	70,369	4,448	340	14·3	28	0·007	54·6

[1] Fuels are arranged in the same order in which they are tabulated in Tables A to D (in pocket).

[2] Trial No. DS-X5 gives the average results of the first five trials tabulated for American anthracite. These averaged results should be used for comparison with the other fuels.

TABLE IV**

Showing the Relative Values of the Various Fuels Tested (in the old series), Compared with American Anthracite and Based on Quantity of Fuel Fired per Therm (100,000 B.T.U.) delivered to the Cooling Water of the System

	Fuel	Pounds of fuel fired per therm (100,000 B.T.U.) delivered to the cooling water								Equivalent tonnage to 10 tons of American anthracite	Recalculated equivalent tonnage to 10 tons of 9·6 per cent ash and 13,190 B.T.U. American anthracite
		Values for each of the tests selected for charting and tabulation							Average value		
1	American anthracite	10·95	11·44	10·80	12·36	...	...	...	11·39	10·00	10·00
2	Welsh anthracite	9·60	9·78	9·48	9·35	9·57	...	...	9·56	8·39	9·16
3	Scotch semi-anthracite	9·44	9·57	9·68	10·24	...	...	...	9·73	8·54	9·32
4	Gas coke	11·45	11·20	10·93	10·82	10·96	11·36	11·76	11·21	9·84	10·74
6	By-product Coke No. 2	10·18	10·34	10·25	10·57	...	...	...	10·33	9·07	9·89
7	By-product Coke No. 3	*10·50	10·91	11·16	10·83	...	...	...	10·85	9·53	10·39
8	By-product Coke No. 4	*10·83	*10·23	*11·38	...	...	...	...	10·81	9·49	10·35
9	American smokeless, semi-bituminous No. 1	10·79	10·91	10·72	11·30	...	...	...	10·98	9·64	10·52
10	American smokeless, semi-bituminous No. 2	10·55	11·20	11·03	11·25	...	...	...	11·01	9·67	10·55
11	Alberta semi-bituminous	11·18	11·34	11·19	11·39	...	...	...	11·27	9·89	10·80
12	Alberta sub-bituminous No. 1	13·89	15·27	14·90	14·99	...	...	...	14·76	12·96	14·14
13	Alberta sub-bituminous No. 2	15·04	15·18	15·82	16·16	...	...	...	15·55	13·66	14·89
14	Alberta sub-bituminous No. 3	14·46	16·08	16·26	16·98	...	...	...	15·94	13·99	15·27
15	Alberta domestic No. 1	16·03	17·30	16·98	18·25	...	...	...	17·14	15·05	16·42
16	Alberta domestic No. 2	16·34	17·51	17·18	18·76	...	...	...	17·45	15·32	16·71
17	Alberta domestic No. 3	16·56	16·81	16·56	18·12	...	...	...	17·01	14·93	16·29
18	Alberta domestic No. 4	16·53	17·34	17·45	18·73	...	...	...	17·51	15·37	16·77
19	Alberta domestic No. 5	18·73	18·90	19·19	19·42	...	...	...	19·06	16·73	18·26
21	Air-dried, machine peat	*25·00	...	...	...	...	...	...	25·00	21·95	23·95

*Denotes tests of short duration. *See* page 28, paragraph 4 (Bureau of Mines Report No. 705) for explanation of short and long tests.

**Reproduction of Table X—Bureau of Mines Report No. 705.

TABLE V

Showing the Relative Values of the Various Fuels Tested (in the new series), Compared with American Anthracite and Based on Quantity of Fuel Fired per Therm (100,000 B.T.U.) delivered to the Cooling Water of the System

Fuel*		Pounds of fuel fired per therm (100,000 B.T.U.) delivered to the cooling water						Equivalent tonnage to 10 tons of 9·6 per cent ash and 13,190 B.T.U. American anthracite
No.	Kind	Values for each of the tests given in Tables A to D inclusive					Average value	
3–34	American anthracite	11·25	11·48	11·28	11·66	11·94	11·52	10·00
24–36	Welsh anthracite	9·54	10·37	10·00			9·97	8·65
2–37	French Indo-China anthracite	10·05					10·05	8·72
17–36	By-product coke	11·72					11·72	10·17
16–36	By-product coke	10·85					10·85	9·42
1–35	By-product coke	10·74					10·74	9·32
11–35	By-product coke	10·45					10·45	9·07
12–35	By-product coke	11·10					11·10	9·64
27–31	Petroleum coke	9·20	9·49				9·35	8·12
9–35	Low-temperature coke	10·99	11·21				11·10	9·64
10–35	Low-temperature coke	11·56					11·56	10·03
4–35	American semi-bituminous coal	12·12					12·12	10·52
15–36	American semi-bituminous coal	13·70					13·70	11·89
17–34	American bituminous coal	13·47					13·47	11·69
16–34	American bituminous coal	14·36					14·36	12·47
7–35	Nova Scotia bituminous coal	14·18					14·18	12.31
6–34	Nova Scotia bituminous coal	15·41	15·42				15·42	13·39
12–34	Nova Scotia bituminous coal	13·78					13·78	11·96
8–34	Nova Scotia bituminous coal	15·13					15·13	13·13
10–34	Nova Scotia bituminous coal	13·93					13·93	12·09
9–34	Nova Scotia bituminous coal	13·65					13·65	11·85
7–34	Nova Scotia bituminous coal	15·43					15·43	13·39
11–34	Nova Scotia bituminous coal	15·18					15·18	13·18
2–38	Nova Scotia bituminous coal	14·43					14·43	12·53
6–35	Nova Scotia bituminous coal	16·73					16·73	14·52
3–38	Nova Scotia bituminous coal	16·78					16·78	14·57
13–34	New Brunswick bituminous coal	14·82					14·82	12·86
14–34	British Columbia bituminous coal	14·11					14·11	12·25
15–34	British Columbia bituminous coal	14·25					14·25	12·37
1A–37	Alberta bituminous coal	13·53					13·53	11·74
22–36	Alberta bituminous coal	13·55					13·55	11·76
13–35	Alberta bituminous coal	16·22					16·22	14·08
23–36	Alberta bituminous coal	18·90					18·90	16·41
21–36	Alberta bituminous coal	17·84					17·84	15·49
18–36	Alberta bituminous coal	18·52					18·52	16·08
28–36	Alberta sub-bituminous coal	16·83					16·83	14·61
20–36	Alberta sub-bituminous coal	17·27					17·27	14·99
19–36	Saskatchewan lignite	25·84					25·84	22·43
10–31	Ontario lignite	21·68					21·68	18·82
5–34	Briquettes made from Alberta coal	12·31					12·31	10·69
14–35	Briquettes made from American anthracite	10·99					10·99	9·54
1–38	Briquettes made from Alberta coal	11·83					11·83	10·27
1–37	Briquettes made from Alberta coal	12·17					12·17	10·56
5–37	Briquettes made from Saskatchewan lignite	13·62					13·62	11·82
4–34	Imported peat bricks	22·73	22·48				22·61	19·63

*Fuels are arranged in the same order in which they are tabulated in Tables A to D (in pocket).

TITLE
Comparative tests of various fuels when burned in a domestic hot-water boiler, 1935-1938.

AUTHOR (Book)
BALTZER, Clarence Edwin.

DATE BORROWED

VOL/NO/YR (Periodical)

BORROWER: ______________________

Name ______________________

Div. ______________________

Phone ______________________

Room No. ______________________

MRB-132

TABLE A

Department of Mines and Resources

Bureau of Mines—Fuel Research Laboratories, Ottawa, Canada

Detailed Data and Results of Fourteen Comparative Burning Tests Made on a "Standard" Sample of American Anthracite in a Domestic Hot-Water Boiler

Item / Fuel	"Standard" Sample No. 3-34, American Anthracite, Stove Size													
Type of trial, etc.	Five 120-hour "Standard" Trials h					Average of five 120-hour "Standard" trials	Eight 24-hour "Efficiency" Trials h at Varying Rates of Combustion							
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Section "A", Items 1 to 20 inclusive—General														
1. Trial number	DS-49	DS-50	DS-51	DS-61	DS-62	DS-X5 a	EDS-53	EDS-54	EDS-55	EDS-56	EDS-57	EDS-58	EDS-60	EDS-63
2. Type of trial (S-Standard, O-Observation, E-Efficiency) h	S	S	S	S	S	S	E	E	E	E	E	E	E	E
3. Date of trial	10-15/9/34	17-22/9/34	24-29/9/34	19-24/11/34	26/11-1/12/34	10-9 to 1-12/34	22-23/10/34	23-24/10/34	24-25/10/34	25-26/10/34	26-27/10/34	27-28/10/34	16/17/11/34	5-6/12/34
4. Duration of trial, continuous total ... hrs.	120	120	120	120	120	120	24	24	24	24	24	24	24	24
5. Number of fire periods during 24-hour day	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6. Intervals between firings (24-hour day) ... hrs.	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10
7. Average rate of combustion, per cent of rated capacity of furnace ... %	55	53	50	53	49	52	37	50	63	74	87	100	113	132
8. Furnace: (a) Average rating, feet of water radiation ... sq. ft.	880	880	880	880	880	880	880	880	880	880	880	880	880	880
(b) Nominal grate area ... sq. ft.	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4
(c) Area of heating surface ... sq. ft.	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4
(d) Volume, grate to top of firepot ... cu. ft.	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4
Raw Fuel as Fired Unless Otherwise Specified														
9. Screen analysis: (Made on a representative portion of "bulk" sample received for test). (a) Through 18" on 12" round hole screen ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(b) " 12" " 10" " " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(c) " 10" " 8" " " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(d) " 8" " 6" " " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(e) " 6" " 4" " " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(f) " 4" " 3" " " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(g) " 3" " 2" " " ... %	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5	49·5
(h) " 2" " 1½" " " ... %	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0	42·0
(i) " 1½" " 1" " " ... %	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5	6·5
(j) " 1" " ¾" " " ... %	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5
(k) " ¾" " ½" " " ... %	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5
(l) " ½" " ⅜" " " ... %	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5
(m) " ⅜" " ¼" " " ... %	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3	0·3
(n) " ¼" ... %	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2	0·2
(o) Average size of lumps ... inches	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06	2·06
(p) "Size stability per cent" by shatter test on: (1) –6" (round hole screen) coal	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(2) 2" to 3" (round hole screen) size	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8	92·8
(3) 3" to 4" (" ") "	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(q) "Friability per cent" by tumbler test on: (1) 1" to 1½" (square hole screen) size	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8	29·8
10. Proximate analysis: (a) Moisture ... %	3·1	3·2	3·1	2·6	2·4	2·9	2·7	2·8	2·7	2·4	2·5	2·5	3·0	3·5
(b) Ash ... %	8·8	9·1	9·5	9·8	10·6	9·5	9·5	11·4	9·2	9·5	9·5	10·1	9·6	10·2
(c) Volatile matter ... %	5·0	5·1	4·9	5·2	5·2	5·1	5·1	5·1	5·3	5·0	5·5	5·3	5·4	5·5
(d) Fixed carbon (by difference) ... %	83·1	82·6	82·5	82·4	81·8	82·5	82·7	80·7	82·8	83·1	82·5	82·1	82·0	81·8
11. Ultimate analysis: (a) Carbon ... %	82·5	82·1	81·8	82·0	81·3	81·9	82·1	80·1	82·5	82·6	82·5	81·9	81·8	81·6
(b) Hydrogen ... %	2·9	2·9	2·9	2·8	2·8	2·9	2·8	2·8	2·9	2·8	2·8	2·8	2·9	2·8
(c) Ash ... %	8·8	9·1	9·5	9·8	10·6	9·6	9·5	11·4	9·2	9·5	9·5	10·1	9·6	10·2
(d) Sulphur ... %	0·9	1·0	0·9	0·9	0·9	0·9	1·0	0·8	0·8	0·8	0·8	0·7	0·9	0·9
(e) Nitrogen ... %	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9	0·9
(f) Oxygen (by difference) ... %	4·0	4·0	4·0	3·6	3·5	3·8	3·7	4·0	3·7	3·4	3·5	3·6	3·9	3·6
12. Calorific value: (a) As fired, gross value ... B.T.U./lb.	13,230	13,210	13,260	13,130	13,130	13,190	13,210	13,110	13,300	13,250	13,150	13,190	13,090	13,080
(b) Dry, gross value ... B.T.U./lb.	13,650	13,640	13,680	13,500	13,500	13,580	13,580	13,390	13,670	13,580	13,490	13,530	13,500	13,420
(c) Gas used for kindling (assumed) ... B.T.U./cu. ft.	500	500	500	500	500	500	500	500	500	500	500	500	500	500
13. Fuel ratio, fixed carbon/volatile matter	16·50	16·50	16·75	15·85	15·90	16·30	16·20	15·95	15·60	16·45	15·00	15·55	15·10	15·00
14. Carbon-hydrogen ratio	28·7	28·6	28·5	29·1	29·3	28·8	29·1	28·8	29·0	29·4	29·4	29·1	28·7	29·1
15. (a) Coking properties as judged by "coke button"	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking
(b) Swelling index = (Per cent swelling × 100) / (Per cent dry V.M. at 600°C.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(c) Caking index by "Gray" method	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16. Ash fusibility: (a) Initial deformation temperature ... °F.	2,780	2,780	2,760	2,680	2,735	2,745	2,775	2,770	2,785	2,780	2,750	2,750	2,720	2,720
(b) Softening point or fusion temperature ... °F.	2,850	2,860	2,835	2,810	2,900	2,850	2,840	2,840	2,860	2,855	2,840	2,855	2,830	2,840
(c) Fluid temperature or melting point ... °F.	2,910	2,905	2,900	2,900	2,900+	2,905	2,920	2,950	2,940	2,920	2,945	2,960	2,940	2,840+
17. Apparent specific gravity, as received in bulk	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47	1·47
18. Weight per cubic foot, as received in bulk ... lb.	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4	52·4
19. Volume per ton of 2,000 pounds, as received in bulk ... cu. ft.	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2	38·2
20. Grindability index by Hardgrove method	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5	28·5
Section "B", Items 21 to 35(c) inclusive—4-Day "Observation" Test														
21. Duration of "observation" trial ... hrs.	96	96	96	96	96	96	–	–	–	–	–	–	–	–
22. Fuel fired: (a) City gas used for kindling ... cu. ft.	100	100	100	101	100	100	–	–	–	–	–	–	–	–
(b) Fuel equivalent to gas used ... lb.	3·8	3·8	3·8	3·8	3·8	3·8	–	–	–	–	–	–	–	–
(c) Quantity during trial ... lb.	708	708	708	708	708	708	–	–	–	–	–	–	–	–
(d) Total, including gas equivalent ... lb.	711·8	711·8	711·8	711·8	711·8	711·8	–	–	–	–	–	–	–	–
23. Refuse removed: (a) Through fire-door during trial ... lb.	Nil	Nil	Nil	Nil	Nil	Nil	–	–	–	–	–	–	–	–
(b) From ash-pit during trial ... lb.	65·0	62·8	63·0	73·8	70·0	66·9	–	–	–	–	–	–	–	–
(c) Total, during trial ... lb.	65·0	62·8	63·0	73·8	70·0	66·9	–	–	–	–	–	–	–	–
(d) As dumped residual fire at end of trial ... lb.	71·3	70·3	82·3	86·8	92·5	80·6	–	–	–	–	–	–	–	–
Screen Examination of Refuse														
24. Clinker: (a) Removed through fire-door during trial ... lb.	Nil	Nil	Nil	Nil	Nil	–	–	–	–	–	–	–	–	–
(b) On 1" square mesh screen recovered from ash-pit refuse ... lb.	4	5½	5¾	3	2½	4¾	–	–	–	–	–	–	–	–
(c) " ½" " " " ... lb.	4½	4	3¾	5½	5	4½	–	–	–	–	–	–	–	–
(d) " 1" " " residual fire ... lb.	–	–	–	4	4¾	4½ b	–	–	–	–	–	–	–	–
(e) " ½" " " " ... lb.	–	–	–	1¾	1¾	1½ b	–	–	–	–	–	–	–	–
(f) Total—(over ½" screen size)—recovered ... lb.	–	–	–	14¼	14	14¾ b	–	–	–	–	–	–	–	–
25. Unburned combustible: (a) On 1" square mesh screen recovered from ash-pit refuse ... lb.	3¾	3¼	4	3½	4	3¾	–	–	–	–	–	–	–	–
(b) " ½" " " " ... lb.	7	6¼	7½	11½	10	8½	–	–	–	–	–	–	–	–
(c) " 1" " " residual fire ... lb.	–	–	–	42	47	44½ b	–	–	–	–	–	–	–	–
(d) " ½" " " " ... lb.	–	–	–	22½	21½	21⅛ b	–	–	–	–	–	–	–	–
(e) Total—(over ½" screen size)—recovered ... lb.	–	–	–	79	82½	80¾ b	–	–	–	–	–	–	–	–
26. Refuse—(through ½" screen size): (a) Recovered from ash-pit refuse ... lb.	46	44½	41½	50½	48½	46½	–	–	–	–	–	–	–	–
(b) " residual fire ... lb.	–	–	–	17	17½	17¼ b	–	–	–	–	–	–	–	–
(c) Total recovered ... lb.	–	–	–	67½	66	66¾ b	–	–	–	–	–	–	–	–
Estimated Corrections for Refuse, Dumped Residual Fire, Etc.														
27. Proximate analysis of refuse recovered during trial: (a) Ash c ... %	48·3	49·0	49·7	45·9	39·5	46·5	–	–	–	–	–	–	–	–
(b) Combustible c (by difference) ... %	51·7	51·0	50·3	54·1	60·5	53·5	–	–	–	–	–	–	–	–
28. Dumped residual fire: (a) Dry analysis, ash ... %	24·4	27·5	23·3	20·5 d	17·7 d	22·7	–	–	–	–	–	–	–	–
(b) " volatile matter ... %	2·0	1·7	1·1	1·4 d	1·4 d	1·5	–	–	–	–	–	–	–	–
(c) " fixed carbon (by difference) ... %	73·6	70·8	75·6	78·1 d	80·9 d	75·8	–	–	–	–	–	–	–	–
(d) Dry calorific value, gross ... B.T.U./lb.	10,660	10,150	10,800	11,130 d	11,540 d	10,860	–	–	–	–	–	–	–	–
(e) Sensible heat, total estimated ... B.T.U.	36,577	36,004	42,220	44,528	47,453	41,358	–	–	–	–	–	–	–	–
(f) " coal equivalent ... lb. (Items (e) and (f) based on items 23(d) plus 23(d).)	2·8	2·7	3·2	3·4	3·6	3·1	–	–	–	–	–	–	–	–
(g) Portion allocated to ash-pit loss ... lb.	27·8	32·1	27·8	25·4	22·0	27·0	–	–	–	–	–	–	–	–
(h) " not chargeable to test ... lb.	43·5	38·2	54·5	61·4	70·5	53·6	–	–	–	–	–	–	–	–
(i) Fuel equivalent of portion not chargeable ... lb.	42·1	36·7	52·2	58·9	67·1	51·4	–	–	–	–	–	–	–	–
29. Equivalent fuel used: (a) Total for trial, calculated ... lb.	663·9	672·4	656·4	649·5	641·1	657·3	–	–	–	–	–	–	–	–
(b) Per hour ... lb.	6·9	7·0	6·8	6·8	6·7	6·8	–	–	–	–	–	–	–	–
(c) Per square foot of grate surface per hour ... lb.	2·0	2·1	2·0	2·0	2·0	2·0	–	–	–	–	–	–	–	–
(d) " " heating " " ... lb.	0·21	0·22	0·21	0·21	0·21	0·21	–	–	–	–	–	–	–	–
(e) " therm e delivered to cooling water ... lb.	9·46	9·97	10·37	9·21	10·49	9·94	–	–	–	–	–	–	–	–
30. Total ash in fuel used, from fuel analysis ... lb.	58·6	61·1	62·3	63·6	67·9	62·7	–	–	–	–	–	–	–	–
31. Total refuse: (a) For test ... lb.	92·8	94·9	90·8	99·2	92·0	93·9	–	–	–	–	–	–	–	–
(b) Per cent of fuel used ... %	13·9	14·1	13·8	15·3	14·4	14·3	–	–	–	–	–	–	–	–
(c) " ton " " ... lb.	278	282	276	306	288	286	–	–	–	–	–	–	–	–
General Data														
32. Circulating water, average temperature: (a) Flow by thermograph ... °F.	137	136	139	122	119	131	–	–	–	–	–	–	–	–
(b) Return " ... °F.	110	100	112	91	90	102	–	–	–	–	–	–	–	–
33. Cooling water: (a) Average temperature, inlet, by thermograph ... °F.	64	60	69	43	45	56	–	–	–	–	–	–	–	–
(b) " " outlet " ... °F.	105	99	105	82	81	94	–	–	–	–	–	–	–	–
(c) " " difference ... °F.	41	39	36	39	36	38	–	–	–	–	–	–	–	–
(d) Total used during trial, corrected ... lb.	171,934	172,809	172,472	173,926	169,503	172,131	–	–	–	–	–	–	–	–
(e) Heat delivery per hour ... B.T.U.	73,430	70,228	64,677	70,405	63,676	68,501	–	–	–	–	–	–	–	–
(f) " " pound of fuel used ... B.T.U.	10,570	10,027	9,459	10,854	9,533	10,089	–	–	–	–	–	–	–	–
34. Flue gases: (a) Average temperature by recorder ... °F.	301	320	280	301	299	300	–	–	–	–	–	–	–	–
(b) " carbon dioxide content f ... %	13·2	13·4	13·5	14·0	13·9	13·6	–	–	–	–	–	–	–	–
35. Average: (a) Draught over fire, by recording gauge ... in. W.G.	0·007	0·016	0·008	0·008	0·007	0·009	–	–	–	–	–	–	–	–
(b) Room temperature, by thermograph ... °F.	67	63	70	70	67	67	–	–	–	–	–	–	–	–
(c) Outdoor temperature, by thermograph ... °F.	64	56	65	44	38	53	–	–	–	–	–	–	–	–
Section "C", Items 36 to 56(a) inclusive—One-Day "Efficiency" Test														
36. Duration of "efficiency" trial ... hrs.	24	24	24	24	24	24	24	24	24	24	24	24	24	24
37. Fuel fired: (a) City gas used for kindling ... cu. ft.	100	100	103	100	100	101	100	100	100	101	100	100	100	100
(b) Fuel equivalent to gas used ... lb.	3·8	3·8	3·9	3·8	3·8	3·8	3·8	3·8	3·8	3·8	3·8	3·8	3·8	3·8
(c) Quantity during trial ... lb.	247	247	247	247	247	247	215	260	305	335	380	425	470	509·5
(d) Total, including gas equivalent ... lb.	250·8	250·8	250·9	250·8	250·8	250·8	218·8	263·8	308·8	338·8	383·8	428·8	473·8	513·3
38. Refuse removed: (a) Through fire-door during trial ... lb.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
(b) From ash-pit " ... lb.	12·3	15·0	12·2	12·5	20·0	14·6	14	18·8	18·8	23	25	29·5	29	33·3
(c) Total, during trial ... lb.	12·3	15·0	12·2	12·5	20·0	14·6	14	18·8	18·8	23	25	29·5	29	33·3
(d) Dry analysis of total refuse recovered, ash ... %	48·3	49·0	49·7	45·9	39·5	46·5	31·2	40·6	45·3	51·7	64·5	64·4	68·6	71·3
(e) " " " combustible (by difference) ... %	51·7	51·0	50·3	54·1	60·5	53·5	68·8	59·4	54·7	48·3	35·5	35·6	31·4	28·7
(f) As dumped residual fire at end of trial ... lb.	74·5	89·0	82·0	84·5	82·3	80·9	88·3	94·3	104·5	98	101·5	103	102·3	69·3
39. Dumped residual fire: (a) Dry analysis, ash ... %	19·0	18·1	20·0	20·5	17·7	19·1	16·5	18·6	17·9	19·9	19·9	20·1	22·0	31·8
(b) " volatile matter ... %	1·5	1·8	1·4	1·4	1·4	1·5	2·2	1·4	1·3	1·1	0·9	0·9	0·7	0·6
(c) " fixed carbon (by difference) ... %	79·4	80·1	78·6	78·1	80·9	79·4	81·3	80·0	80·8	79·0	79·2	79·0	77·3	67·6
(d) " calorific value, gross ... B.T.U./lb.	11,530	11,600	11,440	11,130	11,540	11,466	11,570	11,345	11,330	11,080	11,060	10,960	10,730	9,040
(e) Sensible heat, total estimated ... B.T.U.	38,219	41,040	42,570	43,349	42,220	41,481	45,298	48,376	53,099	50,224	52,079	52,830	53,480	35,807
(f) " coal equivalent ... lb. (Items (e) and (f) based on items 38(c) plus 38(f).)	2·9	3·1	3·2	3·3	3·2	3·1	3·4	3·7	4·0	3·8	4·0	4·0	4·0	2·7
(g) Portion allocated to ash-pit loss ... lb.	18·8	17·6	21·2	24·7	19·6	20·4	27·6	22·3	24·5	23·8	18·9	18·6	21·1	27·7
(h) " not chargeable to test ... lb.	55·7	62·4	61·8	59·8	62·7	60·5	60·7	72·0	80·0	74·2	82·6	84·4	81·2	45·3
(i) Fuel equivalent of portion not chargeable ... lb.	54·5	61·1	60·1	57·4	59·7	58·6	57·4	67·5	75·0	69·9	77·9	75·7	76·3	41·7
40. Equivalent fuel used: (a) Total for trial, calculated ... lb.	193·4	189·6	187·6	190·1	187·9	189·1	156·0	192·6	220·8	265·1	301·9	346·1	393·0	468·9
(b) Per hour ... lb.	8·1	7·8	7·8	7·9	7·8	7·9	6·5	8·0	9·6	11·0	12·6	14·4	16·4	19·5
(c) " square foot of grate surface per hour ... lb.	2·4	2·3	2·3	2·4	2·3	2·3	1·9	2·4	2·8	3·3	3·7	4·2	4·8	5·7
(d) " " heating " " ... lb.	0·25	0·24	0·24	0·24	0·24	0·24	0·20	0·25	0·30	0·34	0·39	0·45	0·51	0·60
(e) " therm e delivered to cooling water ... lb.	11·25	11·48	11·28	11·06	11·94	11·52	13·34	12·11	11·57	11·34	10·94	10·91	10·97	11·20
(f) To equal one ton of stove size American anthracite g ... tons	0·98	1·00	0·98	1·01	1·03	1·00	1·16	1·05	1·00	0·98	0·95	0·95	0·95	0·97
41. Total ash in fuel used, from fuel analysis ... lb.	16·9	16·9	17·8	18·6	19·9	18·0	15·0	21·9	20·7	25·2	28·7	35·0	37·7	47·7
42. Total refuse: (a) For test ... lb.	32·1	32·6	33·5	37·2	39·6	35·0	41·6	41·1	43·3	48·8	44·9	45·1	50·1	63·8
(b) Per cent of fuel used ... %	16·7	17·5	17·9	19·6	21·1	18·6	26·4	21·4	18·8	17·7	14·9	13·9	12·7	13·6
(c) " ton " " ... lb.	334	350	358	392	422	371	528	428	376	354	298	278	254	272
43. Circulating water, average temperature: (a) Flow ... °F.	137	134	136	119	117	129	109	124	136	146	159	170	177	192
(b) Return ... °F.	111	108	111	92	91	103	86	97	106	114	124	133	136	149
44. Cooling water: (a) Average temperature, inlet ... °F.	65·9	65·2	65·6	45·0	44·1	57·1	52·5	53·3	53·5	53·6	53·5	52·2	44·1	41·9
(b) " " outlet ... °F.	106·0	102·8	104·5	83·2	81·2	95·5	80·0	90·5	100·0	102·3	118·0	126·9	127·6	139·3
(c) " " difference ... °F.	40·1	37·6	38·9	38·2	37·1	38·4	27·5	37·2	46·5	48·7	64·5	74·6	83·5	97·4
(d) Total used during trial, corrected ... lb.	42,887	43,230	43,328	42,608	42,410	42,794	43,064	42,747	42,727	42,247	42,787	42,544	42,911	42,992
(e) Heat delivery per hour ... B.T.U.	71,667	67,727	69,328	67,913	65,559	68,437	49,241	66,356	82,784	97,428	114,990	132,241	149,295	174,476
(f) " " pound of fuel used ... B.T.U.	8,892	8,711	8,869	8,574	8,374	8,684	7,495	8,256	8,646	8,820	9,141	9,170	9,116	8,930
45. Flue gases: (a) Average temperature ... °F.	331	307	303	310	300	310	210	286	337	390	438	495	525	605
(b) Dry volumetric analysis, carbon dioxide ... %	14·9	13·5	13·4	12·4	12·8	13·4	13·3	12·4	11·9	11·9	13·6	13·5	13·8	14·1
(c) " " oxygen ... %	4·6	6·2	6·2	7·1	6·9	6·2	6·0	7·2	7·5	7·5	6·0	5·5	5·3	5·4
(d) " " carbon monoxide ... %	0·2	0·2	0·1	0·4	0·4	0·3	0·7	0·3	0·2	0·1	0·2	0·2	0·2	0·1
(e) " " nitrogen (by difference) ... %	80·3	80·1	80·4	80·1	79·9	80·2	80·0	80·1	80·4	80·5	81·2	80·8	80·7	80·4
(f) " weight per pound of fuel used ... lb.	12·5	15·3	13·6	14·4	13·4	13·5	11·6	13·4	15·0	15·5	14·2	14·2	14·2	13·9
46. Excess air ... %	27	41	40	50	48	41	39	51	54	54	30	34	33	34
47. Draught average: (a) Over fire ... in. W.G.	0·004	0·012	0·009	0·013	0·013	0·010	0·003	0·009	0·027	0·021	0·040	0·046	0·053	0·072
(b) In flue ... in. W.G.	0·006	0·012	0·008	0·014	0·012	0·010	0·003	0·006	0·023	0·022	0·040	0·048	0·059	0·085
48. Average: (a) Room temperature ... °F.	69	70	66	69	65	68	65	69	68	70	68	60	70	64
(b) " relative humidity ... %	81	70	59	56	53	64	66	61	56	53	53	50	45	44
(c) Outdoor temperature ... °F.	67	67	58	42	40	55	51	54	49	52	42	33	38	22
(d) Barometric pressure ... in. Hg	30·029	29·903	29·886	29·953	29·713	29·897	29·747	30·046	29·926	29·581	29·55[5]	29·488	29·979	30·012
49. Efficiency: (a) Grate ... %	90·5	90·1	90·0	88·2	85·8	88·9	79·9	85·9	88·7	90·6	94·1	94·5	95·5	95·6
(b) Overall thermal ... %	67·2	65·9	66·9	65·3	63·8	65·8	56·7	63·0	65·0	66·5	69·5	69·5	69·6	68·3
Heat Account per Pound of Fuel Used in B.T.U. and per Cent														
50. Heat delivered to cooling water ... B.T.U.	8,892	8,711	8,869	8,574	8,374	8,684	7,495	8,256	8,646	8,820	9,141	9,170	9,116	8,930
51. Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... B.T.U.	305	302	303	292	292	299	281	289	306	301	308	316	329	328
52. Loss due to heat carried away in dry flue gases ... B.T.U.	786	768	774	833	756	783	404	698	968	1,190	1,261	1,482	1,551	1,805
53. " " unburned combustible matter in refuse ... B.T.U.	1,259	1,306	1,316	1,550	1,868	1,460	2,651	1,852	1,503	1,245	770	722	584	571
54. " " " carbon monoxide ... B.T.U.	99	108	55	226	211	140	325	162	121	64	114	114	113	56
55. " " radiation, errors, and unaccounted for ... B.T.U.	1,889	2,015	1,943	1,655	1,629	1,824	2,054	1,853	1,756	1,630	1,556	1,386	1,397	1,390
56. Total calorific value of 1 pound of fuel as fired, gross value ... B.T.U.	13,230	13,210	13,260	13,130	13,130	13,190	13,210	13,110	13,300	13,250	13,150	13,190	13,090	13,080
50. (a) Heat delivered to cooling water (same as item 49(b)) ... %	67·2	65·9	66·9	65·3	·3·8	65·8	56·7	63·0	65·0	66·5	69·5	69·5	69·6	68·3
51. (a) Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... %	2·3	2·3	2·3	2·2	2·2	2·3	2·1	2·2	2·3	2·3	2·3	2·4	2·5	2·5
52. (a) Loss due to heat carried away in dry flue gases ... %	5·9	5·8	5·8	6·4	5·8	5·9	3·1	5·3	7·3	9·0	9·6	11·2	11·8	13·8
53. (a) " " unburned combustible matter in refuse ... %	9·5	9·9	9·9	11·8	14·2	11·1	20·1	14·1	11·3	9·4	5·9	5·5	4·5	4·4
54. (a) " " " carbon monoxide ... %	0·8	0·8	0·4	1·7	1·6	1·1	2·5	1·3	0·9	0·5	0·9	0·9	0·9	0·4
55. (a) " " radiation, errors, and unaccounted for ... %	14·3	15·3	14·7	12·6	12·4	13·8	15·5	14·1	13·2	12·3	11·8	10·5	10·7	10·6
56. (a) Percentage, equivalent to total calorific value of 1 pound of fuel as fired, gross value ... %	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

a The data given for Trial No. DS-X5 are the averaged results obtained for five repeat tests, all of which very closely approximated each other in value.

b Average of two tests only; totals, therefore, are not necessarily exact.

c As the normal refuse recovered during first four days of trial was not available for chemical analysis after having been screened, the values reported for items 27(a) and (b) are assumed to be the same as the values reported for items 38(d) and (e) in the "efficiency" part of the trial.

d For Trials No. DS-61-62 only, the dumpings recovered at conclusion of the first four days of trial were not available for chemical analysis after having been screened, therefore, the values reported for items 28(a), (b), (c), and (d) are assumed to be the same as the values reported for items 39(a), (b), (c), and (d) in the "efficiency" part of the trial.

e Therm=100,000 B.T.U. Due to the assumed analysis (*see* notes **c** and **d**, the values reported for item 29 (e) are approximate only, for exact values *see* item 40(e).

f Values determined by continuously operated CO_2 recorder.

g Based on the average value obtained for item 40(e) trial No. DS-X5.

h For an explanation of the terms "standard" trial, "observation" trial, and "efficiency" trial *see* page 3.

TABLE B

Department of Mines and Resources

Bureau of Mines—Fuel Research Laboratories, Ottawa, Canada

Detailed Data and Results of Fourteen Burning Tests Made on Various Anthracite Coals and Cokes in Comparison with a "Standard" Sample of American Anthracite in a Domestic Hot-Water Boiler

Items / Fuel															
Kind	"Standard" Sample	Anthracite Coals				Cokes									
Sample No.	3-34	24-36			2-37	17-36	16-36	1-35	11-35	12-35	27-31		9-35		10-35
Name or area	American Anthracite	Welsh h			French Indo-China h	By-product Coke, Western Ontario		By-product Coke, Quebec	By-product Coke, Eastern Ontario		Petroleum Coke h		Low-temperature Coke from Nova Scotia Coal		
Size, etc.	Stove	Cobbles			Stove	Range	Nut	Stove	Stove	Nut	Plus ½-in. h lump		Washed lump		Unwashed lump
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		50-lb. clinker on grate	75-lb. broken firebrick on grate		50-lb. broken firebrick on grate						Perforated plate on grate	50-lb. broken firebrick on grate			
Section "A", Items 1 to 20 inclusive—General															
1. Trial number	DS-X5 a	DH-144	EDH-145	EDH-146	EDH-149	DH-151	DH-150	DS-89	DS-85	DS-66	EDS-94	EDS-93	DS-92	EDS-90	EDS-91
2. Type of trial (S-Standard, O-Observation, E-Efficiency)	S	S	E	E	E	S	S	S	S	S	E	E	S	E	E
3. Date of trial	10-9 to 1-12/34	14-19/6/37	29-30/6/37	30-6 to 1-7/37	26-31/7/37	18-29/1/37	11-31/1/37	9-11/9/35	14-19/6/35	29-10 to 2-11/35	10-11/10/35	8-9/10/35	30-9 to 5-10/35	24-25/5/35	26-27/5/35
4. Duration of trial, continuous total ... hrs.	120	120	24	24	120	120	120	120	120	120	24	24	120	24	24
5. Number of fire periods during 24-hour day	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6. Intervals between firings (24-hour day) ... hrs.	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10
7. Average rate of combustion, per cent of rated capacity of furnace ... %	52	55	52	52	53	51	51	52	54	54	52	52	53	52	52
8. Furnace:															
(a) Average rating, feet of water radiation ... sq. ft.	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880
(b) Nominal grate area ... sq. ft.	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4
(c) Area of heating surface ... sq. ft.	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4
(d) Volume, grate to top of firepot ... cu. ft.	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4
Raw Fuel as Fired Unless Otherwise Specified															
9. Screen analysis: (Made on a representative portion of "bulk" sample received for test):															
(a) Through 18" on 12" round hole screen ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(b) " 12" " 10" " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(c) " 10" " 8" " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(d) " 8" " 6" " ... %	–	–	–	–	–	–	–	0·0	–	–	–	–	–	–	–
(e) " 6" " 4" " ... %	–	10·0	10·0	10·0	–	–	–	0·0	1·0	–	89·1	80·1	6·0	6·0	11·4
(f) " 4" " 3" " ... %	–	34·9	34·9	34·9	6·5	–	–	46·3	32·4	12·4	4·0	4·0	49·6	49·6	48·1
(g) " 3" " 2" " ... %	49·5	36·5	36·5	36·5	40·0	–	11·4	46·0	38·3	59·7	2·7	2·7	33·1	33·1	28·2
(h) " 2" " 1½" " ... %	42·0	9·9	9·9	9·9	42·1	–	47·2	5·9	23·4	23·0	3·2	3·2	5·1	5·1	4·2
(i) " 1½" " 1" " ... %	6·5	4·3	4·3	4·3	5·6	20·5	37·4	0·6	3·2	2·7	4·9	4·9	2·4	2·4	2·9
(j) " 1" " ¾" " ... %	0·5	1·0	1·0	1·0	2·3	66·9	1·9	0·3	0·7	0·7	2·2	2·2	0·6	0·6	0·6
(k) " ¾" " ½" " ... %	0·4	0·7	0·7	0·7	1·2	9·6	0·4	0·4 g	0·2 g	0·3 g	0·6	0·6	0·5	0·5	0·6
(l) " ½" " ⅜" " ... %	0·5	0·6	0·6	0·6	0·5	0·6	0·2	0·1 g	0·1 g	0·1 g	0·3 g	0·3 g	0·4 g	0·4 g	0·4 g
(m) " ⅜" " ¼" " ... %	0·3	0·6	0·6	0·6	0·6	0·2	0·2	0·7 g	0·7 g	1·8 g	0·3 g	0·3 g	0·4 g	0·4 g	0·4 g
(n) " ¼" " 0" " ... %	0·2	1·4	1·4	1·4	1·0	2·2	0·9	–	–	–	1·7 g	1·7 g	2·0 g	2·0 g	3·6 g
(o) Average size of lumps ... inches	2·06	3·88	3·88	3·88	2·88	0·91	1·00	2·05	1·84	1·21	5·49	5·49	3·00	3·00	3·09
(p) "Size stability per cent" by shatter test on:															
(1) ...–4" (round hole screen) coal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(2) 2" to 3" (round hole screen) size	–	85·3	85·3	85·3	–	–	–	–	–	–	–	–	–	–	–
(3) 3" to 4" (" " ") "	92·8	81·6	81·6	81·6	–	–	–	–	–	–	–	–	–	–	–
(q) "Friability per cent" by tumbler test on: (1) 1" to 1½" (square hole screen) size	29·8	30·1	30·1	30·1	–	–	–	–	–	–	52·9	52·9	41·5	41·5	41·5
10. Proximate analysis:															
(a) Moisture ... %	2·9	1·7	1·7	1·7	3·8	0·4	0·2	0·2	1·2	4·6	1·1	1·5	3·1	3·6	3·5
(b) Ash ... %	9·5	4·4	4·6	4·6	5·0	9·4	9·2	7·7	9·9	10·0	0·5	1·7	8·6	8·8	10·6
(c) Volatile matter ... %	5·1	6·7	8·1	8·1	3·9	0·6	1·0	2·1	1·1	1·1	9·3	9·4	9·6	9·2	9·9
(d) Fixed carbon (by difference) ... %	82·5	87·2	85·6	85·6	87·3	89·6	89·6	90·0	87·8	84·3	89·1	87·4	78·7	78·4	76·0
11. Ultimate analysis:															
(a) Carbon ... %	81·0	87·6	87·5	87·5	87·1	87·5	87·8	89·6	85·8	83·0	90·0	88·5	79·7	79·1	78·8
(b) Hydrogen ... %	2·9	3·3	3·3	3·3	2·0	0·8	0·8	0·4	0·7	0·9	3·8	3·8	2·7	2·7	2·5
(c) Ash ... %	9·6	4·4	4·6	4·6	5·0	9·4	9·2	7·7	9·9	10·0	0·5	1·7	8·6	8·8	10·6
(d) Sulphur ... %	0·9	0·9	0·8	0·8	0·9	0·7	0·7	0·9	0·7	0·6	1·6	1·7	2·1	2·4	2·3
(e) Nitrogen ... %	0·9	1·1	1·1	1·1	0·6	1·1	0·9	1·0	1·3	1·0	1·5	1·5	1·5	1·5	1·4
(f) Oxygen (by difference) ... %	3·8	2·7	2·7	2·7	4·4	0·5	0·6	0·4	1·6	4·5	2·6	2·8	5·4	5·8	4·4
12. Calorific value:															
(a) As fired, gross value ... B.T.U./lb.	13,190	14,290	14,290	14,290	13,160	12,900	12,850	12,830	12,500	12,050	15,210	14,900	12,840	12,780	12,510
(b) Dry, gross value ... B.T.U./lb.	13,580	14,540	14,540	14,540	13,680	12,950	12,880	12,850	12,640	12,630	15,410	15,140	13,250	13,260	12,990
(c) Gas used for kindling (assumed) ... B.T.U./cu. ft.	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
13. Fuel ratio, fixed carbon/volatile matter	16·20	13·01	10·57	10·57	–	–	–	–	–	–	9·90	9·30	–	–	–
14. Carbon-hydrogen ratio	28·8	26·5	26·5	26·5	–	–	–	–	–	–	23·9	23·7	–	–	–
15. (a) Coking properties as judged by "coke button"	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	–	–	–	–	–	–	–	–	–	–
(b) Swelling index = Per cent swelling × 100 / Per cent dry V.M. at 60°C.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(c) Coking index by "Gray" method	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16. Ash fusibility:															
(a) Initial deformation temperature ... °F.	2,745	2,140	2,175	2,175	1,950	2,600	2,450	2,425	2,670	2,480	1,950	1,900	1,920	2,020	1,960
(b) Softening point or fusion temperature ... °F.	2,839	2,340	2,330	2,330	2,060	2,760	2,710	2,550	2,780	2,780	2,005	2,000	2,040	2,090	1,980
(c) Fluid temperature or melting point ... °F.	2,905	2,500	2,550	2,550	2,485	2,890	2,890	2,650	2,960	2,870	2,050	2,050	2,150	2,230	2,120
17. Apparent specific gravity, as received in bulk	1·47	1·42	1·42	1·42	1·60	0·99	0·99	0·89	1·05	1·05	0·71 i, 0·82 i	0·71 i, 0·82 i	0·88	0·88	0·87
18. Weight per cubic foot, as received in bulk ... lb.	52·4	48·7	48·7	48·7	55·7	27·8	26·4	26·1	32·0	35·8	24·8	24·8	26·4	26·4	27·3
19. Volume per ton of 2,000 pounds, as received in bulk ... cu. ft.	38·2	41·1	41·1	41·1	35·9	71·9	75·8	76·6	62·5	55·9	80·6	80·6	75·8	75·8	73·3
20. Grindability index by Hardgrove method	28·5	50·0	50·0	50·0	–	–	–	–	–	–	–	–	–	–	–
Section "B", Items 21 to 35(c) inclusive—4-Day "Observation" Test															
21. Duration of "observation" trial ... hrs.	96	96	–	–	–	95	96	96	96	96	–	–	96	–	–
22. Fuel fired:															
(a) City gas used for kindling ... cu. ft.	100	200	–	–	–	100	100	100	100	100	–	–	100	–	–
(b) Fuel equivalent to gas used ... lb.	3·8	7·0	–	–	–	3·9	3·9	3·9	4·0	4·1	–	–	3·9	–	–
(c) Quantity during trial ... lb.	708	691	–	–	–	713	708	761	773	798	–	–	755	–	–
(d) Total, including gas equivalent ... lb.	711·8	698·0	–	–	–	716·9	711·9	764·9	777·0	802·1	–	–	758·9	–	–
23. Refuse removed:															
(a) Through fire-door during trial ... lb.	Nil	Nil	–	–	–	Nil	Nil	Nil	Nil	Nil	–	–	½	–	–
(b) From ash-pit during trial ... lb.	66·9	15·5	–	–	–	47·8	46·8	41¾	67¼	66	–	–	45½	–	–
(c) Total, during trial ... lb.	66·9	15·5	–	–	–	47·8	46·8	41¾	67¼	66	–	–	46	–	–
(d) As dumped residual fire at end of trial ... lb.	80·6	106·8	–	–	–	65·5	63·5	73¼	80½	81	–	–	85½	–	–
Screen Examination of Refuse															
24. Clinker:															
(a) Removed through fire-door during trial ... lb.	Nil	Nil	–	–	–	Nil	Nil	Nil	Nil	Nil	–	–	½	–	–
(b) On 1" square mesh screen recovered from ash-pit refuse ... lb.	4¼	1	–	–	–	2½	3½	2½	4	2½	–	–	1	–	–
(c) " ½" " " " " " ... lb.	4¼	1½	–	–	–	2¼	4½	2½	4	2½	–	–	1	–	–
(d) " 1" " " " residual fire ... lb.	4½ b	3½	–	–	–	7½	2	1¼	1½	2½	–	–	5½	–	–
(e) " ½" " " " " " ... lb.	1½ b	–	–	–	–	2½	2½	1½	1¼	2½	–	–	2½	–	–
(f) Total—(over ½" screen size)—recovered ... lb.	14½ b	6½	–	–	–	17	11½	8	9	14	–	–	10	–	–
25. Unburned combustible:															
(a) On 1" square mesh screen recovered from ash-pit refuse ... lb.	3½	0	–	–	–	Nil	3½	1½	8	3½	–	–	¼	–	–
(b) " ½" " " " " " ... lb.	8	½	–	–	–	½	2½	2½	4½	5	–	–	3	–	–
(c) " 1" " " " residual fire ... lb.	44½ b	40	–	–	–	Nil	39	51	56½	32½	–	–	36½	–	–
(d) " ½" " " " " " ... lb.	21½ b	24½	–	–	–	44	5	3	8	33½	–	–	16½	–	–
(e) Total—(over ½" screen size)—recovered ... lb.	80½ b	64½	–	–	–	50	53	58½	77½	74½	–	–	56½	–	–
26. Refuse—(through ½" screen size):															
(a) Recovered from ash-pit refuse ... lb.	46½ b	12½	–	–	–	35½	38½	34½	49½	47½	–	–	41	–	–
(b) " " residual fire ... lb.	17½ b	38½	–	–	–	11	10½	11¾	12	10½	–	–	22½	–	–
(c) Total recovered ... lb.	66½ b	51½	–	–	–	46½	48½	46	61½	58½	–	–	63½	–	–
Estimated Corrections for Refuse, Dumped Residual Fire, Etc.															
27. Proximate analysis of refuse recovered during trial:															
(a) Ash c ... %	46·5	40·5	–	–	–	78·7	84·1	70·4	73·6	83·3	–	–	62·3	–	–
(b) Combustible c (by difference) ... %	53·5	59·5	–	–	–	21·3	15·9	29·6	26·4	16·7	–	–	37·7	–	–
28. Dumped residual fire:															
(a) Dry analysis, ash d ... %	22·7	6·9	–	–	–	23·3	18·4	16·7	19·4	22·9	–	–	17·6	–	–
(b) " volatile matter d ... %	1·5	2·1	–	–	–	1·8	1·0	1·2	1·0	0·9	–	–	4·6	–	–
(c) " fixed carbon d (by difference) ... %	75·8	91·0	–	–	–	74·9	80·6	82·1	79·6	76·2	–	–	77·8	–	–
(d) Dry calorific value, gross d ... B.T.U./lb.	10,860	12,829	–	–	–	9,550	10,970	11,660	11,250	10,690	–	–	11,660	–	–
(e) Sensible heat, total estimated ... B.T.U.	41,368	80,438	–	–	–	33,602	32,576	36,038	41,297	41,553	–	–	42,964	–	–
(f) " coal equivalent ... lb.	3·1	5·6	–	–	–	2·6	2·5	2·8	3·3	3·4	–	–	3·3	–	–
(Items (e) and (f) based on items 23(a) plus 23(d).)															
(g) Portion allocated to ash-pit loss ... lb.	27·0	7·1	–	–	–	13·1	7·8	10·1	11·8	13·8	–	–	13·6	–	–
(h) " not chargeable to test ... lb.	53·6	99·7	–	–	–	52·4	55·7	60·2	68·7	67·2	–	–	70·2	–	–
(i) Fuel equivalent of portion not chargeable ... lb.	51·4	91·8	–	–	–	45·8	52·9	60·6	69·0	69·2	–	–	70·5	–	–
29. Equivalent fuel used:															
(a) Total for trial, calculated ... lb.	657·3	600·6	–	–	–	668·5	656·5	701·5	704·7	729·5	–	–	685·1	–	–
(b) Per hour ... lb.	6·8	6·3	–	–	–	7·0	6·8	7·3	7·3	7·6	–	–	7·1	–	–
(c) Per square foot of grate surface per hour ... lb.	2·0	1·8	–	–	–	2·0	2·0	2·1	2·2	2·2	–	–	2·1	–	–
(d) " " heating " ... lb.	0·21	0·19	–	–	–	0·21	0·21	0·23	0·22	0·23	–	–	0·22	–	–
(e) " therm e delivered to cooling water ... lb.	9·94	8·46	–	–	–	10·30	9·79	10·74	10·27	10·62	–	–	10·17	–	–
30. Total ash in fuel used, from fuel analysis ... lb.	62·7	26·4	–	–	–	62·7	60·3	53·9	69·7	72·9	–	–	58·9	–	–
31. Total refuse:															
(a) For test ... lb.	93·9	22·6	–	–	–	60·9	57·6	51·4	79·3	79·8	–	–	59·9	–	–
(b) Per cent of fuel used ... %	14·3	3·8	–	–	–	9·1	8·8	7·3	11·3	10·9	–	–	8·8	–	–
(c) " ton " " ... lb.	286	76	–	–	–	182	176	146	226	218	–	–	176	–	–
General Data															
32. Circulating water, average temperature:															
(a) Flow by thermograph ... °F.	131	133	–	–	–	115	114	136	130	130	–	–	130	–	–
(b) Return " ... °F.	102	104	–	–	–	82	80	108	101	100	–	–	102	–	–
33. Cooling water:															
(a) Average temperature, inlet by thermograph ... °F.	56	–	–	–	–	–	–	68	–	–	–	–	–	–	–
(b) " " outlet " ... °F.	94	–	–	–	–	–	–	106	–	–	–	–	–	–	–
(c) " " difference ... °F.	38	41	–	–	–	38	39	38	40	40	–	–	39	–	–
(d) Total used during trial, corrected ... lb.	172,121	173,230	–	–	–	170,757	171,889	171,877	171,492	171,783	–	–	172,794	–	–
(e) Heat delivery per hour ... B.T.U.	68,501	73,984	–	–	–	67,591	69,830	68,035	71,455	71,576	–	–	70,198	–	–
(f) " " pound of fuel used ... B.T.U.	10,089	11,826	–	–	–	9,706	10,211	9,311	9,734	9,419	–	–	9,856	–	–
34. Flue gases:															
(a) Average temperature by recorder ... °F.	300	335	–	–	–	320	312	312	327	320	–	–	337	–	–
(b) " carbon dioxide content f ... %	13·6	10·1	–	–	–	9·9	8·5	12·1	12·6	13·6	–	–	12·0	–	–
35. Average:															
(a) Draught over fire by recording gauge ... in. W.G.	0·009	0·023	–	–	–	0·030	0·032	0·015	0·018	0·011	–	–	0·022	–	–
(b) Room temperature, by thermograph ... °F.	67	74	–	–	–	72	71	65	72	76	–	–	65	–	–
(c) Outdoor temperature, by thermograph ... °F.	53	64	–	–	–	22	31	59	51	56	–	–	47	–	–
Section "C", Items 36 to 56 (a) inclusive—One-Day "Efficiency" Test															
36. Duration of "efficiency" trial ... hrs.	24	24	24	24	120	24	24	24	24	24	24	24	24	24	24
37. Fuel fired:															
(a) City gas used for kindling ... cu. ft.	101	200	200	200	300	102	100	100	100	100	100	287	100	100	100
(b) Fuel equivalent to gas used ... lb.	3·8	7·0	7·0	7·0	11·4	4·0	3·9	3·9	4·0	4·1	3·3	9·6	3·9	3·9	4·0
(c) Quantity during trial ... lb.	247	232	232	232	970	243	235	244	237	237	206	191	229	220	225
(d) Total, including gas equivalent ... lb.	250·8	239·0	239·0	239·0	981·4	247·0	238·9	247·9	241·0	241·1	209·3	200·6	232·9	223·9	229·0
38. Refuse removed:															
(a) Through fire-door during trial ... lb.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
(b) From ash-pit " ... lb.	14·6	1·8	1·0	1·3	9·0	6·3	7·8	5·0	7·8	10·0	0 j	2·8	13	12·5	15·5
(c) Total, during trial ... lb.	14·6	1·8	1·0	1·3	9·0	6·3	7·8	5·0	7·8	10·0	0	2·8	13	12·5	15·5
(d) Dry analysis of total refuse recovered, ash ... %	46·5	40·5	21·1	24·3	65·5	78·7	84·1	70·4	73·6	83·3	–	6·9	62·3	62·7	60·4
(e) " " " " " combustible (by difference) ... %	53·5	59·5	78·9	75·7	34·5	21·3	15·9	29·6	26·4	16·7	–	93·1	37·7	37·3	39·6
(f) As dumped residual fire at end of trial ... lb.	80·9	85·5	90·0	90·5	171·5	73	70·5	79·0	77·8	64·5	60 j	43·0	60·3	47·5	49·8
39. Dumped residual fire:															
(a) Dry analysis, ash ... %	19·1	6·9	9·5	8·5	21·5	23·3	18·4	16·7	19·4	22·9	1·3	1·9	17·6	20·3	23·1
(b) " " volatile matter ... %	1·5	2·1	2·7	3·1	2·3	1·8	1·0	1·2	1·0	0·9	4·0	2·5	4·6	4·6	4·6
(c) " " fixed carbon (by difference) ... %	79·4	91·0	87·8	88·4	76·2	74·9	80·6	82·1	79·6	76·2	94·7	95·6	77·8	75·1	72·3
(d) " calorific value, gross ... B.T.U./lb.	11,466	12,829	13,010	13,100	11,220	9,550	10,970	11,660	11,250	10,690	14,350	14,040	11,660	11,350	10,990
(e) Sensible heat, total estimated ... B.T.U.	41,481	69,512	84,645	84,902	113,630	37,449	36,167	40,527	39,911	33,089	30,780	47,581	30,934	24,368	25,547
(f) " coal equivalent ... lb.	3·1	4·9	5·9	5·9	8·6	2·9	2·8	3·2	3·2	2·7	2·0	3·2	2·4	1·9	2·0
(Items (e) and (f) based on items 38(a) plus 38(f).)															
(g) Portion allocated to ash-pit loss ... lb.	20·4	5·7	26·7	17·9	46·4	14·6	8·7	11·3	11·4	11·0	0	0·8	9·8	9·9	12·2
(h) " not chargeable to test ... lb.	60·5	79·8	63·3	72·6	125·1	58·4	61·8	67·7	66·4	53·5	60	42·2	50·5	37·6	37·6
(i) Fuel equivalent of portion not chargeable ... lb.	58·6	73·5	60·8	69·4	128·8	51·1	59·4	68·2	66·7	55·1	57·1	39·8	50·7	38·1	38·2
40. Equivalent fuel used:															
(a) Total for trial, calculated ... lb.	189·1	160·6	172·3	163·7	844·0	193·0	176·7	176·5	171·1	183·3	150·2	157·6	179·8	183·9	188·8
(b) Per hour ... lb.	7·9	6·7	7·2	6·8	7·0	8·0	7·4	7·4	7·1	7·6	6·3	6·6	7·5	7·7	7·9
(c) " square foot of grate surface per hour ... lb.	2·3	2·0	2·1	2·0	2·1	2·4	2·2	2·2	2·1	2·2	1·8	1·9	2·2	2·3	2·3
(d) " " " heating " " ... lb.	0·24	0·21	0·22	0·21	0·22	0·25	0·23	0·23	0·22	0·24	0·19	0·20	0·23	0·24	0·24
(e) " therm e delivered to cooling water ... lb.	11·52	9·54	10·37	10·00	10·05	11·72	10·85	10·74	10·45	11·10	9·20	9·49	10·99	11·21	11·56
(f) To equal one ton of stove-size American anthracite ... tons	1·00	0·83	0·90	0·87	0·87	1·02	0·94	0·93	0·91	0·96	0·80	0·84	0·95	0·97	1·00
41. Total ash in fuel used, from fuel analysis ... lb.	18·0	7·0	7·9	7·5	42·1	18·0	16·2	13·5	16·9	18·2	0·7	2·6	15·3	16·0	19·8
42. Total refuse:															
(a) For test ... lb.	35·0	7·5	27·7	19·2	55·4	20·9	16·5	16·3	19·2	21·0	0	3·6	22·8	22·4	27·7
(b) Per cent of fuel used ... %	18·6	4·7	16·2	11·8	6·6	10·9	9·3	9·3	11·3	11·5	0	2·4	12·8	12·3	14·8
(c) " ton " " ... lb.	371	94	324	236	132	218	186	186	226	230	0	48	256	246	296
43. Circulating water, average temperature:															
(a) Flow ... °F.	129	132	135	134	139	114	112	130	124	125	124	126	126	129	129
(b) Return ... °F.	103	105	109	108	113	86	85	104	98	99	98	99	99	103	103
44. Cooling water:															
(a) Average temperature, inlet ... °F.	57·1	67·4	70·7	70·8	75·6	38·0	38·2	65·2	54·4	53·5	55·3	55·4	57·3	62·9	63·1
(b) " " outlet ... °F.	95·5	106·4	110·1	109·0	114·5	76·9	75·8	103·2	92·1	91·7	93·2	94·1	95·7	101·1	101·3
(c) " " difference ... °F.	38·4	39·0	39·4	38·2	38·9	38·9	37·6	38·0	37·7	38·2	37·9	38·7	38·4	38·2	38·2
(d) Total used during trial, corrected ... lb.	42,794	43,152	42,174	42,899	215,823	42,324	43,307	43,244	43,417	43,210	43,066	42,932	42,604	42,930	42,769
(e) Heat delivery per hour ... B.T.U.	68,437	70,122	69,236	68,281	69,963	68,600	67,848	68,470	68,201	68,776	68,008	69,228	68,167	68,330	68,074
(f) " " pound of fuel used ... B.T.U.	8,684	10,479	9,644	10,011	9,947	8,531	9,215	9,310	9,566	9,005	10,867	10,542	9,099	8,924	8,653
45. Flue gases:															
(a) Average temperature ... °F.	310	348	321	317	304	308	299	302	322	312	303	303	318	313	310
(b) Dry volumetric analysis, carbon dioxide ... %	13·4	10·9	12·3	13·1	11·9	9·7	8·9	11·4	13·1	13·2	11·2	14·0	14·7	13·7	13·4
(c) " " " oxygen ... %	6·2	8·6	7·0	6·2	7·7	9·9	10·8	7·7	6·7	6·6	8·3	5·0	4·7	5·3	5·4
(d) " " " carbon monoxide ... %	0·3	0·0	0·0	0·0	0·1	0·2	0·1	0·6	0·3	0·2	0·1	0·4	0·2	0·1	0·2
(e) " " " nitrogen (by difference) ... %	80·2	80·5	80·7	80·7	80·3	80·2	80·2	80·3	79·9	80·0	80·4	80·6	80·4	80·9	81·0
(f) " weight per pound of fuel used ... lb.	13·5	19·5	15·3	15·2	17·8	21·5	23·8	18·2	15·6	15·3	20·0	15·2	12·8	13·7	13·6
46. Excess air ... %	41	67	48	41	56	87	103	56	46	45	63	30	28	33	33
47. Draught average:															
(a) Over fire ... in. W.G.	0·010	0·016	0·024	0·015	0·030	0·037	0·039	0·013	0·008	0·012	0·019	0·008	0·007	0·011	0·013
(b) In flue ... in. W.G.	0·010	0·017	0·020	0·008	0·026	0·037	0·037	0·010	0·008	0·011	0·019	0·008	0·008	0·011	0·011
48. Average:															
(a) Room temperature ... °F.	68	72	72	70	77	69	70	61	68	74	69	66	66	67	70
(b) " relative humidity ... %	64	64	55	64	69	28	31	49	41	49	45	36	40	52	64
(c) Outdoor temperature ... °F.	55	58	60	60	65	21	15	51	53	53	54	44	42	53	61
(d) Barometric pressure ... in. Hg	29·897	29·923	29·485	29·618	29·818	29·828	29·944	30·106	29·738	30·094	29·921	30·169	29·703	30·014	29·834
49. Efficiency:															
(a) Grate ... %	88·9	97·1	87·0	90·9	97·5	97·4	98·3	96·9	96·5	97·7	100·0 j	97·8	94·5	94·8	93·1
(b) Overall thermal ... %	65·8	73·3	67·5	70·1	75·6	66·1	71·7	72·6	76·5	74·7	71·4	70·8	70·9	69·8	69·2
Heat Account per Pound of Fuel Used in B.T.U. and per Cent															
50. Heat delivered to cooling water ... B.T.U.	8,684	10,479	9,644	10,011	9,947	8,531	9,215	9,310	9,566	9,005	10,867	10,542	9,099	8,924	8,653
51. Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... B.T.U.	299	328	345	345	207	83	83	42	73	94	395	396	283	283	261
52. Loss due to heat carried away in dry flue gases ... B.T.U.	783	1,292	914	901	970	1,233	1,308	1,053	951	874	1,123	865	774	809	783
53. " " unburned combustible matter in refuse ... B.T.U.	1,480	411	1,864	1,305	332	339	218	381	437	281	0 j	324	704	671	857
54. " " " carbon monoxide ... B.T.U.	140	Nil	Nil	Nil	72	17	10	441	188	121	81	243	102	55	109
55. " " radiation, errors, and unaccounted for ... B.T.U.	1,824	1,780	1,523	1,728	1,632	2,697	2,016	1,600	1,285	1,675	2,744	2,530	1,878	2,038	1,847
56. Total calorific value of 1 pound of fuel as fired, gross value ... B.T.U.	13,190	14,290	14,290	14,290	13,160	12,900	12,850	12,830	12,500	12,050	15,210	14,900	12,840	12,780	12,510
50. (a) Heat delivered to cooling water (same as item 49(b)) ... %	65·8	73·3	67·5	70·1	75·6	66·1	71·7	72·6	76·5	74·7	71·4	70·8	70·9	69·8	69·2
51. (a) Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... %	2·3	2·3	2·4	2·4	1·6	0·7	0·6	0·3	0·6	0·8	2·6	2·6	2·2	2·2	2·1
52. (a) Loss due to heat carried away in dry flue gases ... %	5·9	9·0	6·4	6·3	7·4	9·6	10·2	8·2	7·6	7·3	7·4	5·8	6·0	6·3	6·2
53. (a) " " unburned combustible matter in refuse ... %	11·1	2·9	13·0	9·1	2·5	2·6	1·7	3·0	3·5	2·3	0·0 j	2·2	5·5	5·3	6·8
54. (a) " " " carbon monoxide ... %	1·1	Nil	Nil	Nil	0·5	0·1	0·1	3·4	1·5	1·0	0·5	1·6	0·8	0·4	0·9
55. (a) " " radiation, errors, and unaccounted for ... %	13·8	12·5	10·7	12·1	12·4	20·9	15·7	12·5	10·3	13·9	18·1	17·0	14·6	16·0	14·8
56. (a) Percentage, equivalent to total calorific value of 1 pound of fuel as fired, gross value ... %	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

a The data given for trial No. DS-X5 are the averaged results obtained for five repeat tests, all of which very closely approximated each other in value. (*See* Table A).

b Average of two tests only; totals, therefore, are not necessarily exact. (*See* Table A).

c As the normal refuse recovered during first four days of trial was not available for chemical analysis after having been screened, the values reported for items 27(*a*) and (*b*) are assumed to be the same as the values reported for items 38(*d*) and (*e*) in the "efficiency" part of the trial.

d Excepting trial No. DS-X5 (*see* Table A), the dumpings recovered at conclusion of the first four days of trial were not available for chemical analysis after having been screened, therefore, the values reported for items 28(*a*), (*b*), (*c*), and (*d*) are assumed to be the same as the values reported for items 39(*a*), (*b*), (*c*), and (*d*) in the "efficiency" part of the trial.

e Therm = 100,000 B.T.U. Due to the assumed analysis (*see* notes **c** and **d**), the values reported for item 29(*e*) are approximate only, for exact values see item 40(*e*).

f Value for trial No. DS-X5 only, determined by continuously operated CO_2 recorder (*see* Table A), remaining values determined by hand-operated Orsat making one determination per hour from 9 a.m. to 11 p.m. daily, night determinations (11 p.m. to 9 a.m.) not made except for trials prefixed with letters DH for which one determination was made nightly on a composite sample taken from 11 p.m. to 9 a.m.

g The ¼- and ⅜-inch screens used for trials so marked **g** (sub-items (*l*), (*m*), and (*n*) of item 9) had square mesh openings.

h Due to the low ash content and peculiar nature of the Welsh and French Indo-China anthracites and petroleum coke the furnace grate had to be modified in order to obtain consistent results comparable with the other fuels. This modification consisted of, placing a known quantity and quality of broken clinker on grate as for trial No. DH-144; placing a known quantity of inert broken firebrick, 1½ to 2½ inch in size, on grate as for trials EDH-145-146-149 and EDS-93; placing a perforated metal plate over grate as for trial No. EDS-94. *See* page 15 for explanation.

i Apparent specific gravity −8"+½" lump 0·71; apparent gravity −2"+½" lump 0·82.

j Due to the nature of grate used for trial No. EDS-94 a very small (almost negligible) amount of normal ash-pit refuse which was practically pure carbon was recovered. This quantity was added to the dumped residual fire, thus giving a grate efficiency of 100% (item 49(*a*)) and no combustible loss (heat balance items 53 and 53(*a*)).

TABLE C

DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES—FUEL RESEARCH LABORATORIES, OTTAWA, CANADA

Detailed Data and Results of Seventeen Burning Tests Made on Various American and Eastern Canada Coals in Comparison with a "Standard" Sample of American Anthracite in a Domestic Hot-Water Boiler

Item / Fuel	"Standard" Sample	American Coals: Semi-bituminous		American Coals: Bituminous		Eastern Canada Coals: Bituminous												
Sample No.	3-34	4-35	15-36	17-34	16-34	7-35	6-34		12-34	8-34	10-34	9-34	7-34	11-34	2-38	6-35	3-38	13-34
Name of area	American Anthracite	Fulton seam, Pennsylvania	Pocahontas No. 4 seam, W. Virginia	Upper Freeport seam, Pennsylvania	Pittsburgh No. 8 seam, Ohio	Sydney area, Nova Scotia	Sydney area, Nova Scotia		Springhill area, Nova Scotia	Sydney area, Nova Scotia	Pictou area, Nova Scotia	Pictou area, Nova Scotia	Sydney area, Nova Scotia	Joggins area, Nova Scotia	Pictou area, Nova Scotia	Inverness area, Nova Scotia	Inverness area, Nova Scotia	Minto area, New Brunswick
Size, etc.	Stove	Lump	Egg	Egg	Lump	Lump	Lump		Lump	Lump	Lump	Lump	Lump	Lump	Screened lump	Lump	Lump	Lump
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SECTION "A", ITEMS 1 TO 20 INCLUSIVE—GENERAL																		
1. Trial number	DS-X5 a	DS-78	DH-132	DS-76	DS-75	DS-80	DS-65	EDS-77 h	DS-71	DS-67	DS-69	DS-68	DS-66	DS-70	DH-200	DS-79	DH-201	DS-72
2. Type of trial (S-Standard, O-Observation, E-Efficiency)	S	S	S	S	S	S	S	E	S	S	S	S	S	S	S	S	S	S
3. Date of trial	10-9 to 1-12/34	29-4 to 4-5/35	25-30/1/37	8-13/4/35	1-6/4/35	10-15/6/35	7-12/1/35	24-25/4/35	25-2 to 2-3/35	21-26/1/35	11-16/2/35	28-1 to 2-2/35	14-19/1/35	18-23/2/35	3-8/10/38	27-5 to 1-6/35	17-22/10/38	4-9/3/35
4. Duration of trial, continuous total ... hrs.	120	120	120	120	120	120	120	24	120	120	120	120	120	120	120	120	120	120
5. Number of fire periods during 24-hour day	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6. Intervals between firings (24-hour day) ... hrs.	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10
7. Average rate of combustion, per cent of rated capacity of furnace ... %	52	52	57	51	52	52	47	52	53	51	53	52	52	54	52	53	55	52
8. Furnace: (a) Average rating, feet of water radiation ... sq. ft.	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880
(b) Nominal grate area ... sq. ft.	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4
(c) Area of heating surface ... sq. ft.	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4
(d) Volume, grate to top of firepot ... cu. ft.	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4
RAW FUEL AS FIRED UNLESS OTHERWISE SPECIFIED																		
9. Screen analysis: (Made on a representative portion of "bulk" sample received for test). (a) Through 18" on 12" round hole screen ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(b) " 12" " 10" " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5·6	–	–	–
(c) " 10" " 8" " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6·4	–	2·7	–
(d) " 8" " 6" " ... %	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10·9	–	9·6	–
(e) " 6" " 4" " ... %	–	0·0	–	1·5	18·5	8·8	6·7	6·7	17·6	8·0	11·3	20·3	9·4	7·7	21·3	7·0	7·7	3·3
(f) " 4" " 3" " ... %	–	0·0	12·0	13·7	17·3	6·3	7·2	7·2	5·6	5·6	4·5	13·1	8·5	6·5	12·2	8·1	12·7	5·2
(g) " 3" " 2" " ... %	49·5	26·3	60·1	36·5	29·8	11·0	15·8	15·8	11·3	9·6	10·6	16·8	16·7	10·4	13·2	16·4	23·6	15·4
(h) " 2" " 1½" " ... %	42·0	22·8	18·6	24·9	14·8	10·7	12·7	12·7	12·7	7·7	13·3	11·4	13·8	10·7	7·3	13·0	16·9	16·8
(i) " 1½" " 1" " ... %	6·5	18·9	3·6	11·3	11·5	21·0	12·1	12·1	21·4	12·9	24·0	10·8	17·9	17·7	8·2	18·0	14·3	21·2
(j) " 1" " ¾" " ... %	0·5	5·4	0·7	3·0	3·2	10·9	6·9	6·9	7·6	13·5	12·6	5·9	10·0	13·5	3·8	10·8	3·7	12·7
(k) " ¾" " ½" " ... %	0·5	4·7	0·7	2·5	1·8	10·2	8·3	8·3	6·4	18·4	8·5	6·2	7·0	10·5	3·6	9·5	3·0	10·0
(l) " ½" " ⅜" " ... %	0·5	5·3 g	0·7	1·8 g	1·0 g	7·6 g	8·8 g	8·8 g	5·4 g	11·1 g	5·1 g	5·2 g	5·5 g	8·0 g	3·2	6·1 g	2·4	5·8 g
(m) " ⅜" " ¼" " ... %	0·3	5·5 g	0·7	1·5 g	0·7 g	5·6 g	7·9 g	7·9 g	4·4 g	6·0 g	3·6 g	4·1 g	4·3 g	6·2 g	1·7	4·2 g	1·2	3·8 g
(n) " ¼" ... %	0·2	11·1 g	2·9	3·3 g	1·4 g	7·9 g	13·6 g	13·6 g	7·6 g	7·2 g	6·5 g	6·2 g	6·9 g	8·8 g	2·6	6·9 g	2·2	5·8 g
(o) Average size of lumps ... inches	2·06	1·42	2·31	2·10	2·73	1·60	1·55	1·55	2·00	1·44	1·72	2·36	1·83	1·53	4·08	1·70	2·87	1·51
(p) "Size stability per cent" by shatter test on: (1) –4" (round hole screen) coal	–	76·0	–	85·5	88·0	93·5	93·0	93·0	89·0	86·0	94·0	95·0	89·0	90·5	95·0	89·5	88·2	92·0
(2) 2" to 3" (round hole screen) size	92·8	62·0	78·5	79·5	84·0	77·0	72·0	72·0	76·0	69·0	84·5	84·5	75·5	69·0	80·4	73·0	77·6	76·0
(3) 3" to 4" "	–	–	72·0	79·5	77·0	–	70·5	70·5	72·5	60·5	82·0	79·5	63·0	60·5	77·6	68·0	73·6	69·5
(q) "Friability per cent" by tumbler test on: (1) 1" to 1½" (square hole screen) size	29·8	71·5	57·9	48·2	36·3	44·3	59·0	59·0	54·3	54·4	46·2	47·6	47·4	58·0	29·1	44·8	26·6	49·5
10. Proximate analysis: (a) Moisture ... %	2·9	0·7	0·3	1·6	2·4	2·3	1·3	1·2	1·6	3·9	1·5	1·4	3·3	2·4	3·5	5·8	4·5	1·0
(b) Ash ... %	9·5	9·2	9·4	8·2	8·6	4·8	11·0	11·4	9·7	11·4	17·5	17·9	13·9	15·1	11·6	11·4	14·6	21·5
(c) Volatile matter ... %	5·1	15·9	15·8	32·0	40·7	39·0	31·4	31·9	31·0	32·6	25·3	27·6	34·7	36·3	30·5	37·7	34·0	30·1
(d) Fixed carbon (by difference) ... %	82·5	74·2	74·5	58·2	48·9	53·9	56·3	55·5	57·7	52·1	55·7	53·1	48·1	46·2	54·4	45·1	46·9	47·4
11. Ultimate analysis: (a) Carbon ... %	81·9	81·3	82·2	78·0	72·6	78·5	74·3	73·1	78·1	67·9	69·6	69·0	66·7	65·5	71·1	63·8	62·6	62·9
(b) Hydrogen ... %	2·9	4·4	4·2	5·0	5·4	5·8	4·9	4·9	5·0	4·8	4·5	4·6	5·0	4·8	4·9	5·3	5·0	4·1
(c) Ash ... %	9·6	9·2	9·4	8·2	8·0	4·8	11·0	11·4	9·7	11·4	17·5	17·9	13·9	15·1	11·6	11·4	14·6	21·5
(d) Sulphur ... %	0·9	1·4	0·7	1·2	3·7	2·1	4·9	5·8	1·6	5·2	1·2	0·7	6·5	6·4	1·1	7·0	7·5	8·0
(e) Nitrogen ... %	0·9	1·3	1·2	1·5	1·4	1·7	1·3	1·3	2·0	1·3	1·8	2·0	1·3	1·9	1·9	1·2	1·4	0·8
(f) Oxygen (by difference) ... %	3·8	2·4	2·3	6·1	8·9	7·1	3·6	3·1	5·6	9·4	5·4	4·9	6·6	6·3	9·4	11·3	8·9	2·7
12. Calorific value: (a) As fired, gross value ... B.T.U./lb.	13,190	14,190	14,060	13,900	13,280	14,100	13,540	13,250	13,440	12,530	12,370	12,320	12,080	11,880	12,200	11,300	11,090	11,590
(b) Dry, gross value ... B.T.U./lb.	13,580	14,280	14,100	14,130	13,610	14,430	13,710	13,420	13,660	13,040	12,560	12,500	12,500	12,170	12,640	12,000	11,620	11,710
(c) Gas used for kindling (assumed) ... B.T.U./cu. ft.	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
13. Fuel ratio, fixed carbon/volatile matter	16·30	4·65	4·70	1·80	1·20	1·40	1·80	1·75	1·85	1·60	2·20	1·90	1·40	1·25	1·78	1·20	1·38	1·60
14. Carbon-hydrogen ratio	28·8	18·5	19·4	15·4	13·5	13·5	15·0	15·1	15·2	14·2	15·5	15·1	13·2	13·8	14·5	12·1	12·5	15·2
15. (a) Caking properties as judged by "coke button"	Non-caking	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Fair to good	Good	Poor	Poor	Poor	Good
(b) Swelling index = (Per cent swelling × 100) / (Per cent dry V.M. at 600°C.)	–	2,240	450	430	224	156	566	566	1,008	56	85	0	173	137	−180	−222	−210	516
(c) Caking index by "Gray" method	–	52	40	69	52	58	57	–	62	54	43	47	48	55	12	11	24	52
16. Ash fusibility: (a) Initial deformation temperature ... °F.	2,745	2,740	2,150	2,610	1,900	1,925	1,940	1,920	2,050	1,945	2,280	2,280	1,865	1,930	2,400	1,990	1,880	1,950
(b) Softening point or fusion temperature ... °F.	2,850	2,870	2,280	2,700	2,045	2,015	2,025	2,020	2,170	2,065	2,440	2,520	2,000	2,025	2,580	2,090	1,970	2,040
(c) Fluid temperature or melting point ... °F.	2,905	2,870	2,320	2,800	2,400	2,350	2,080	2,120	2,350	2,200	2,530	2,575	2,050	2,085	2,630	2,220	2,060	2,160
17. Apparent specific gravity, as received in bulk	1·47	1·35	1·36	1·31	1·33	1·29	1·36	1·36	1·35	1·34	1·40	1·36	1·40	1·42	1·38	1·40	1·44	1·47
18. Weight per cubic foot, as received in bulk ... lb.	52·4	50·5	46·7	45·6	46·8	47·4	53·2	53·2	49·5	50·2	50·8	50·6	51·4	53·6	47·5	52·6	54·9	53·5
19. Volume per ton of 2,000 pounds, as received in bulk ... cu. ft.	38·2	39·6	42·8	43·9	42·7	42·2	37·6	37·6	40·4	39·8	39·4	39·5	38·9	37·3	42·1	38·0	36·4	37·4
20. Grindability index by Hardgrove method	28·5	97·5	94·4	75·0	67·3	65·5	76·6	76·6	81·7	72·4	79·7	74·9	70·0	73·6	59·8	58·8	59·6	70·1
SECTION "B", ITEMS 21 TO 35(c) INCLUSIVE—4-DAY "OBSERVATION" TEST																		
21. Duration of "observation" trial ... hrs.	96	96	96	96	96	96	96	–	96	96	96	96	96	96	96	96	96	96
22. Fuel fired: (a) City gas used for kindling ... cu. ft.	100	100	100	100	100	100	100	–	100	100	100	100	100	100	100	100	100	100
(b) Fuel equivalent to gas used ... lb.	3·8	3·5	3·6	3·6	3·8	3·5	3·7	–	3·7	4·0	4·0	4·1	4·1	4·2	4·1	4·4	4·5	4·3
(c) Quantity during trial ... lb.	708	782	781	833	855	878	826	–	893	918	914	904	908	992	878	1,046	1,051	951
(d) Total, including gas equivalent ... lb.	711·8	785·5	784·6	836·6	858·8	881·5	829·7	–	896·7	922·0	918·0	908·1	912·1	996·2	882·1	1,050·4	1,055·5	955·3
23. Refuse removed: (a) Through fire-door during trial ... lb.	Nil	Nil	2·5	Nil	Nil	Nil	Nil	–	Nil	Nil	2	Nil	Nil	Nil	6	6·8	30·3	Nil
(b) From ash-pit during trial ... lb.	66·9	81·3	53·8	70	72·8	79	131·8	–	100·5	94	134	138	97·8	138	89·5	85	90·5	155
(c) Total, during trial ... lb.	66·9	81·3	56·3	70	72·8	79	131·8	–	100·5	94	136	138	97·8	138	95·5	91·8	120·8	155
(d) As dumped residual fire at end of trial ... lb.	80·6	100·3	108·5	91	62·3	78·5	69	–	71	78	92·5	87·8	77·5	76·3	75·3	85·3	80·3	107·5
SCREEN EXAMINATION OF REFUSE																		
24. Clinker: (a) Removed through fire-door during trial ... lb.	Nil	Nil	2¼	Nil	Nil	Nil	Nil	–	Nil	Nil	2	Nil	Nil	Nil	6	6¾	30½	Nil
(b) On 1" square mesh screen recovered from ash-pit refuse ... lb.	4⅛	¾	¾	2	2¼	1¼	3¼	–	2¼	1¾	4½	3¾	3	3¼	3	2	1¾	5¼
(c) " ½" " " " " ... lb.	4¾	3	2	3½	3½	2¼	4½	–	5¼	6	12½	10½	8¼	12½	7¼	5	10	19¼
(d) " 1" " " " residual fire ... lb.	4⅜ b	0	9¼	2	2½	1	2¼	–	4½	4¾	9¼	2¼	15¼	16	5¼	11½	15¼	22¾
(e) " ½" " " " " ... lb.	1⅝ b	¾	3	1¼	1½	1¼	¾	–	2¼	1¾	4	1¾	1¼	3¾	3¼	6	6¼	4¼
(f) Total—(over ½" screen size)—recovered ... lb.	14⅞ b	4½	17¼	8¾	9¾	5¾	10¾	–	14¼	14¼	32¼	18¼	27¾	35½	24¾	31¼	63¾	51½
25. Unburned combustible: (a) On 1" square mesh screen recovered from ash-pit refuse ... lb.	3⅜	4½	½	2½	3½	2	8	–	4	2¼	4½	3½	¾	1¾	2	¾	¼	1
(b) " ½" " " " " ... lb.	8½	7½	5	8	8	15¼	19	–	12½	10¾	11	9¼	5¼	12¾	7	5¼	4½	7¼
(c) " 1" " " " residual fire ... lb.	44½ b	54	51	51¾	32¼	35½	36	–	36¼	41	46¾	59½	30½	24	23¾	18¾	18¼	39¾
(d) " ½" " " " " ... lb.	21⅞ b	16½	17¼	15	11¾	18¾	13¾	–	13	16¼	15¼	9	14	13½	15	15½	17¼	16
(e) Total—(over ½" screen size)—recovered ... lb.	80¾ b	82½	73¾	77¼	55½	71½	76¾	–	65¾	70¼	77½	81¼	50½	52	47¾	40¼	40¼	64
26. Refuse—(through ½" screen size): (a) Recovered from ash-pit refuse ... lb.	46½	65½	45½	54	55¼	57¾	97¼	–	76½	73¾	101¾	110¾	79¾	107½	70¼	71¾	74	121¼
(b) " residual fire ... lb.	17¼ b	29	28	21	14¼	22¼	16½	–	14¾	14¾	17	15	17¾	19¼	28	33¾	22¾	25¼
(c) Total recovered ... lb.	63¾ b	94½	73½	75	69½	80	113¾	–	91¼	88½	118¾	125¾	97½	126¾	98¼	105½	96¾	146½
ESTIMATED CORRECTIONS FOR REFUSE, DUMPED RESIDUAL FIRE, ETC.																		
27. Proximate analysis of refuse recovered during trial: (a) Ash c ... %	46·5	49·4	35·4	51·5	53·7	32·9	32·7	–	56·2	47·5	75·7	72·3	67·3	69·8	71·1	55·7	66·9	77·5
(b) Combustible c (by difference) ... %	53·5	50·6	64·6	48·5	46·3	67·1	67·3	–	43·8	52·5	24·3	27·7	32·7	30·2	28·9	44·3	33·1	22·5
28. Dumped residual fire: (a) Dry analysis, ash d ... %	22·7	16·1	21·8	19·7	18·4	12·5	25·3	–	21·0	23·7	37·9	29·4	39·8	31·2	38·1	34·6	43·0	43·9
(b) " volatile matter d ... %	1·5	2·9	3·8	4·1	10·8	6·5	5·9	–	3·2	7·3	3·2	3·2	6·6	13·3	3·5	8·0	7·3	5·8
(c) " fixed carbon d (by difference) ... %	75·8	81·0	74·4	76·2	70·8	81·0	68·8	–	75·8	69·0	58·9	67·4	53·6	55·5	58·4	57·4	49·7	50·3
(d) Dry calorific value, gross d ... B.T.U./lb.	10,860	11,900	11,320	11,320	11,490	12,650	10,620	–	11,290	10,930	8,840	9,870	8,530	10,110	8,430	9,350	7,950	8,100
(e) Sensible heat, total estimated ... B.T.U.	41,368	51,428	55,661	46,683	31,934	40,271	35,397	–	36,423	40,014	47,453	45,041	39,758	39,116	41,707	43,759	56,738	55,148
(f) " coal equivalent ... lb.	3·1	3·6	4·0	3·4	2·4	2·9	2·6	–	2·7	3·2	3·8	3·7	3·3	3·3	3·4	3·9	5·1	4·8
(Items (e) and (f) based on items 23(a) plus 23(d)). (g) Portion allocated to ash-pit loss ... lb.	27·0	17·2	51·5	23·9	14·0	21·3	45·3	–	17·0	25·9	32·2	18·2	37·2	22·1	33·3	44·0	43·1	42·8
(h) " not chargeable to test ... lb.	53·6	83·1	57·0	67·1	48·3	57·2	23·7	–	54·0	52·1	60·3	69·6	40·3	54·1	42·0	41·3	37·2	64·7
(i) Fuel equivalent of portion not chargeable ... lb.	51·4	75·4	53·1	62·3	47·0	55·8	32·1	–	51·7	52·5	57·1	57·9	40·5	56·6	41·3	45·9	39·6	63·1
29. Equivalent fuel used: (a) Total for trial, calculated ... lb.	657·3	706·5	727·5	770·9	809·4	822·8	805·0	–	842·3	866·3	857·1	846·5	868·3	936·3	833·3	1,000·6	1,010·8	887·4
(b) Per hour ... lb.	6·8	7·4	7·6	8·0	8·4	8·6	8·4	–	8·8	9·0	8·9	8·8	9·0	9·8	8·7	10·4	10·5	9·2
(c) Per square foot of grate surface per hour ... lb.	2·0	2·2	2·2	2·4	2·5	2·5	2·5	–	2·6	2·7	2·6	2·6	2·7	2·9	2·6	3·1	3·1	2·7
(d) " " heating " ... lb.	0·21	0·23	0·23	0·25	0·26	0·26	0·26	–	0·27	0·28	0·28	0·27	0·28	0·30	0·27	0·32	0·33	0·29
(e) " therm e delivered to cooling water ... lb.	9·94	10·83	10·11	11·90	12·32	12·55	13·79	–	12·34	13·31	12·70	12·20	13·30	13·77	12·59	14·89	14·06	13·70
30. Total ash in fuel used, from fuel analysis ... lb.	62·7	65·0	68·4	63·2	64·6	39·5	88·4	–	81·6	98·7	150·0	151·5	120·6	141·2	97·1	114·0	147·7	190·0
31. Total refuse: (a) For test ... lb.	93·9	98·5	107·8	93·9	86·8	100·3	177·1	–	117·5	119·9	168·2	156·2	135·0	160·1	128·8	135·8	163·9	197·8
(b) Per cent of fuel used ... %	14·3	13·9	14·8	12·2	10·7	12·2	22·0	–	14·0	13·9	19·6	18·5	15·6	17·1	15·4	13·6	16·2	22·3
(c) " ton " ... lb.	286	278	296	244	214	244	440	–	280	278	392	370	312	342	308	272	324	446
GENERAL DATA																		
32. Circulating water, average temperature: (a) Flow by thermograph ... °F.	131	119	119	117	116	135	116	–	118	118	119	121	118	117	131	132	135	117
(b) Return ... °F.	102	88	86	82	80	109	82	–	84	85	83	87	86	82	99	102	102	82
33. Cooling water: (a) Average temperature, inlet by thermograph ... °F.	56	48	–	40	38	65	42	–	38	39	38	38	37	38	–	58	–	39
(b) " outlet ... °F.	94	86	–	77	76	103	76	–	78	77	77	77	75	78	–	97	–	77
(c) " difference ... °F.	38	38	42	37	38	38	34	–	40	38	39	39	38	40	38	39	43	38
(d) Total used during trial, corrected ... lb.	172,121	171,682	171,341	175,025	172,954	172,479	171,690	–	170,593	171,298	173,069	170,782	171,852	169,946	174,146	172,369	167,146	170,414
(e) Heat delivery per hour ... B.T.U.	68,501	67,957	74,962	67,458	68,461	68,273	60,807	–	71,080	67,805	70,317	69,384	68,025	70,811	68,933	70,025	74,867	67,456
(f) " pound of fuel used ... B.T.U.	10,089	9,234	9,892	8,400	8,120	7,966	7,252	–	8,101	7,514	7,876	8,197	7,521	7,260	7,941	6,718	7,110	7,297
34. Flue gases: (a) Average temperature by recorder ... °F.	300	350	373	436	438	410	351	–	415	401	385	418	387	423	395	416	420	445
(b) " carbon dioxide content f ... %	13·6	11·2	9·8	11·2	12·1	12·0	11·5	–	11·6	11·8	12·2	12·7	12·5	11·6	11·3	12·5	11·6	9·4
35. Average: (a) Draught over fire by recording gauge ... in. W.G.	0·009	0·030	0·025	0·022	0·015	0·013	0·014	–	0·021	0·023	0·020	0·014	0·023	0·023	0·013	0·010	0·013	0·035
(b) Room temperature, by thermograph ... °F.	67	64	71	74	70	73	68	–	74	66	78	68	64	70	66	74	67	76
(c) Outdoor temperature, by thermograph ... °F.	53	43	12	47	35	68	30	–	7	3	16	−7	4	16	45	68	50	19
SECTION "C", ITEMS 36 TO 56(a) INCLUSIVE—ONE-DAY "EFFICIENCY" TEST																		
36. Duration of "efficiency" trial ... hrs.	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
37. Fuel fired: (a) City gas used for kindling ... cu. ft.	101	100	100	100	100	100	100	100	100	102	100	101	100	100	100	100	100	100
(b) Fuel equivalent to gas used ... lb.	3·8	3·5	3·6	3·6	3·8	3·5	3·7	3·8	3·7	4·1	4·0	4·1	4·1	4·2	4·1	4·4	4·5	4·3
(c) Quantity during trial ... lb.	247	263	279	282	290	282	279	300	277	292	292	296	287	318	288	319	323	309
(d) Total, including gas equivalent ... lb.	250·8	266·5	282·6	285·6	293·8	285·5	282·7	303·8	280·7	296·1	296·0	300·1	291·1	322·2	292·1	323·4	327·5	313·3
38. Refuse removed: (a) Through fire-door during trial ... lb.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
(b) From ash-pit ... lb.	14·6	18·5	16·3	13·8	14·8	14·5	23·3	46·3	15·8	22·8	21·3	28·8	31·3	26·3	6·0	17·5	19·8	25·0
(c) Total, during trial ... lb.	14·6	18·5	16·3	13·8	14·8	14·5	23·3	46·3	15·8	22·8	21·3	28·8	31·3	26·3	6·0	17·5	19·8	25·0
(d) Dry analysis of total refuse recovered, ash ... %	46·5	49·4	35·4	51·5	53·7	32·9	32·7	38·0	56·2	47·5	75·7	72·3	67·3	69·8	71·1	65·7	66·9	77·5
(e) " " " " combustible (by difference) ... %	53·5	50·6	64·6	48·5	46·3	67·1	67·3	62·0	43·8	52·5	24·3	27·7	32·7	30·2	28·9	44·3	33·1	22·5
(f) As dumped residual fire at end of trial ... lb.	80·9	85·8	97·5	84·3	70·5	66·8	71·3	70·5	70·3	66·0	92·0	95·8	49·5	83·3	84·3	81·0	80·3	87·0
39. Dumped residual fire: (a) Dry analysis, ash ... %	19·1	16·1	21·8	19·7	18·4	12·5	25·3	19·9	21·0	23·7	37·9	29·4	39·8	31·2	38·1	34·6	43·0	43·9
(b) " volatile matter ... %	1·5	2·9	3·8	4·1	10·8	6·5	5·9	7·6	3·2	7·3	3·2	3·2	6·6	13·3	3·5	8·0	7·3	5·8
(c) " fixed carbon (by difference) ... %	79·4	81·0	74·4	76·2	70·8	81·0	68·8	72·7	75·8	69·0	58·9	67·4	53·6	55·5	58·4	97·4	49·7	50·3
(d) " calorific value, gross ... B.T.U./lb.	11,466	11,900	11,320	11,320	11,490	12,650	10,620	11,600	11,290	10,930	8,840	9,870	8,530	10,110	8,430	9,350	7,950	8,100
(e) Sensible heat, total estimated ... B.T.U.	41,481	44,015	50,018	43,246	36,167	34,268	36,577	36,167	36,064	33,858	47,196	49,145	25,394	42,733	43,246	41,553	41,194	44,631
(f) " coal equivalent ... lb.	3·1	3·1	3·6	3·1	2·7	2·4	2·7	2·7	2·7	2·7	3·8	4·0	2·1	3·6	3·5	3·7	3·7	3·9
(Items (e) and (f) based on items 38(f) plus 38(f)). (g) Portion allocated to ash-pit loss ... lb.	20·4	14·7	46·3	22·1	15·8	21·1	46·8	22·2	16·9	21·0	32·0	19·8	23·8	24·2	37·2	41·8	43·1	34·6
(h) " not chargeable to test ... lb.	60·5	71·1	51·2	62·2	54·7	45·7	24·5	48·3	53·4	44·1	60·0	76·0	25·7	59·1	47·1	39·2	37·2	52·4
(i) Fuel equivalent of portion not chargeable ... lb.	58·6	64·5	47·7	57·8	53·2	44·6	22·8	46·7	51·2	44·4	56·8	70·5	25·8	61·8	46·3	43·6	39·6	51·1
40. Equivalent fuel used: (a) Total for trial, calculated ... lb.	189·1	198·9	231·3	224·7	237·9	238·5	257·2	254·4	226·8	249·0	235·4	225·6	263·2	256·8	242·3	276·1	284·2	258·3
(b) Per hour ... lb.	7·9	8·3	9·6	9·4	9·9	9·9	10·7	10·6	9·5	10·4	9·8	9·4	11·0	10·7	10·1	11·5	11·8	10·8
(c) " square foot of grate surface per hour ... lb.	2·3	2·4	2·8	2·8	2·9	2·9	3·2	3·1	2·8	3·1	2·9	2·8	3·2	3·1	3·0	3·4	3·5	3·2
(d) " " " heating " ... lb.	0·24	0·26	0·30	0·29	0·31	0·31	0·33	0·33	0·29	0·32	0·30	0·29	0·34	0·33	0·31	0·35	0·37	0·33
(e) " therm e delivered to cooling water ... lb.	11·52	12·12	13·70	13·47	14·36	14·18	15·41	15·42	13·78	15·13	13·93	13·05	15·43	15·18	14·43	16·73	16·78	14·82
(f) To equal one ton of stove-size American anthracite ... tons	1·00	1·05	1·19	1·17	1·25	1·23	1·34	1·34	1·20	1·32	1·21	1·18	1·34	1·32	1·25	1·45	1·46	1·29
41. Total ash in fuel used, from fuel analysis ... lb.	18·0	18·3	21·7	18·4	18·9	11·4	28·2	28·9	21·9	28·2	41·2	40·5	36·3	38·7	28·0	31·4	41·4	55·4
42. Total refuse: (a) For test ... lb.	35·0	33·2	62·6	35·9	30·6	35·6	70·1	68·5	32·7	44·7	53·3	48·6	55·1	50·5	43·2	59·3	62·9	59·6
(b) Per cent of fuel used ... %	18·6	16·7	27·1	16·0	12·9	15·0	27·4	27·0	14·5	18·1	22·7	21·6	21·1	19·7	17·9	21·5	22·2	23·1
(c) " ton " ... lb.	371	334	542	320	258	300	548	540	290	362	454	432	422	394	358	430	444	462
43. Circulating water, average temperature: (a) Flow ... °F.	129	118	115	113	111	136	116	117	112	116	112	115	117	113	128	129	128	115
(b) Return ... °F.	103	90	86	84	83	109	87	89	83	87	83	87	89	83	100	103	101	86
44. Cooling water: (a) Average temperature, inlet ... °F.	57·1	48·4	38·5	38·3	37·9	65·0	37·6	43·4	37·7	37·4	38·6	38·0	37·5	37·7	59·1	59·7	58·2	37·6
(b) " " outlet ... °F.	95·5	86·4	77·9	76·6	76·3	103·5	76·7	81·8	76·2	75·8	77·3	76·7	77·3	77·4	97·7	97·9	97·5	77·6
(c) " " difference ... °F.	38·4	38·0	39·4	38·3	38·4	38·5	39·1	38·4	38·5	38·4	38·7	38·7	39·8	39·7	38·6	38·2	39·3	40·0
(d) Total used during trial, corrected ... lb.	42,794	43,188	42,858	43,551	43,137	43,676	42,690	42,958	42,764	42,855	43,681	42,713	42,850	42,603	43,494	43,199	43,104	43,578
(e) Heat delivery per hour ... B.T.U.	68,437	68,381	70,359	69,500	69,019	70,084	69,540	68,733	68,601	68,568	70,436	68,875	71,060	70,472	69,953	68,758	70,583	72,630
(f) " " pound of fuel used ... B.T.U.	8,684	8,251	7,300	7,423	6,963	7,050	6,490	6,484	7,259	6,609	7,181	7,327	6,480	6,586	6,929	5,977	5,961	6,748
45. Flue gases: (a) Average temperature ... °F.	310	360	373	457	484	450	431	402	426	407	412	452	441	449	452	452	413	454
(b) Dry volumetric analysis, carbon dioxide ... %	13·4	10·1	10·6	11·0	12·7	12·3	10·4	10·7	11·0	11·9	11·5	10·9	12·8	11·3	11·5	11·9	9·8	9·2
(c) " " " oxygen ... %	6·2	7·7	8·5	7·3	5·0	5·3	8·5	7·5	7·3	6·9	6·9	7·7	5·2	6·7	7·0	5·5	8·3	9·2
(d) " " " carbon monoxide ... %	0·3	0·4	0·1	0·2	0·4	0·3	0·2	0·1	0·3	0·3	0·5	0·2	0·5	0·1	0·3	0·5	0·3	0·2
(e) " " " nitrogen (by difference) ... %	80·2	81·8	80·8	81·5	81·9	82·1	80·9	81·7	81·2	80·9	81·1	81·2	81·5	81·9	81·2	82·1	81·6	81·4
(f) " weight per pound of fuel used ... lb.	13·5	17·3	15·1	15·7	12·8	13·4	13·2	13·0	15·2	12·0	13·4	14·0	11·3	13·1	14·0	11·0	13·6	15·3
46. Excess air ... %	41	55	65	51	30	32	65	53	51	47	47	55	32	44	48	34	62	74
47. Draught average: (a) Over fire ... in. W.G.	0·010	0·019	0·018	0·019	0·008	0·012	0·019	0·018	0·019	0·006	0·007	0·009	0·006	0·010	0·020	0·009	0·017	0·028
(b) In flue ... in. W.G.	0·010	0·017	0·019	0·022	0·017	0·010	0·044	0·025	0·040	0·033	0·019	0·025	0·033	0·033	0·015	0·017	0·013	0·084
48. Average: (a) Room temperature ... °F.	68	63	74	67	67	64	65	68	71	64	77	72	64	70	69	68	65	69
(b) " relative humidity ... %	64	35	26	36	31	63	32	29	32	34	43	43	29	33	37	48	37	33
(c) Outdoor temperature ... °F.	55	39	22	34	32	57	7	52	16	−8	30	14	0	0	43	61	38	11
(d) Barometric pressure ... in. Hg	29·897	30·121	30·411	29·844	30·043	29·599	29·760	29·904	29·846	29·854	29·428	30·021	30·350	30·184	30·23	29·935	29·65	30·500
49. Efficiency: (a) Grate ... %	88·9	91·3	81·9	91·8	93·4	89·4	80·1	81·5	93·1	88·9	93·5	92·9	91·7	92·7	93·8	87·7	90·3	93·4
(b) Overall thermal ... %	65·8	58·1	51·9	53·4	52·4	50·0	47·9	48·9	54·0	52·7	58·1	59·5	53·6	55·4	56·8	52·9	53·8	58·2
HEAT ACCOUNT PER POUND OF FUEL USED IN B.T.U. AND PER CENT																		
50. Heat delivered to cooling water ... B.T.U.	8,684	8,251	7,300	7,423	6,963	7,050	6,490	6,484	7,259	6,609	7,181	7,327	6,480	6,586	6,929	5,977	5,961	6,748
51. Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... B.T.U.	299	471	448	554	604	642	538	531	545	523	486	506	552	529	541	585	545	453
52. Loss due to heat carried away in dry flue gases ... B.T.U.	783	1,233	1,084	1,470	1,281	1,241	1,159	1,042	1,295	988	1,077	1,313	1,022	1,192	1,287	1,014	1,136	1,414
53. " " unburned combustible matter in refuse ... B.T.U.	1,460	1,236	2,553	1,134	874	1,469	2,688	2,448	926	1,384	804	872	1,007	869	754	1,393	1,073	759
54. " " carbon monoxide ... B.T.U.	140	282	17	127	206	167	107	53	308	146	271	117	228	53	170	222	167	125
55. " " radiation, errors, and unaccounted for ... B.T.U.	1,824	2,717	2,658	3,192	3,352	3,531	2,558	2,692	3,107	2,880	2,551	2,185	2,791	2,651	2,519	2,109	2,208	2,091
56. Total calorific value of 1 pound of fuel as fired, gross value ... B.T.U.	13,190	14,190	14,060	13,900	13,280	14,100	13,540	13,250	13,440	12,530	12,370	12,320	12,080	11,880	12,200	11,300	11,090	11,590
50. (a) Heat delivered to cooling water (same as item 49(b)) ... %	65·8	58·1	51·9	53·4	52·4	50·0	47·9	48·9	54·0	52·7	58·1	59·5	53·6	55·4	56·8	52·9	53·8	58·2
51. (a) Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... %	2·3	3·3	3·2	4·0	4·6	4·6	4·0	4·0	4·1	4·2	3·9	4·1	4·6	4·5	4·4	5·2	4·9	3·9
52. (a) Loss due to heat carried away in dry flue gases ... %	5·9	8·7	7·7	10·6	9·6	8·8	8·6	7·9	9·6	7·9	8·7	10·7	8·5	10·0	10·6	9·0	10·2	12·2
53. (a) " " unburned combustible matter in refuse ... %	11·1	8·7	18·2	8·1	6·6	10·4	19·8	18·5	6·9	11·0	6·5	7·1	8·3	7·3	6·2	12·3	9·7	6·5
54. (a) " " carbon monoxide ... %	1·1	2·0	0·1	0·9	1·6	1·2	0·8	0·4	2·3	1·2	2·2	0·9	1·9	0·5	1·4	2·0	1·5	1·1
55. (a) " " radiation, errors, and unaccounted for ... %	13·8	19·2	18·9	23·0	25·2	25·0	18·9	20·3	23·1	23·0	20·6	17·7	23·1	22·3	20·6	18·6	19·9	18·1
56. (a) Percentage, equivalent to total calorific value of 1 pound of fuel as fired, gross value ... %	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100 0	100·0	100·0

a The data given for trial No. DS-X5 are the averaged results obtained for five repeat tests, all of which very closely approximated each other in value. (*See* Table A).

b Average of two tests only; totals, therefore, are not necessarily exact. (*See* Table A).

c As the normal refuse recovered during first four days of trial was not available for chemical analysis after having been screened, the values reported for items 27(*a*) and (*b*) are assumed to be the same as the values reported for items 38(*d*) and (*e*) in the "efficiency" part of the trial.

d Excepting trial No. DS-X5 (*see* Table A), the dumpings recovered at conclusion of the first four days of trial were not available for chemical analysis after having been screened, therefore, the values reported for items 28(*a*), (*b*), (*c*), and (*d*) are assumed to be the same as the values reported for items 39(*a*), (*b*), (*c*), and (*d*) in the "efficiency" part of the trial.

e Therm = 100,000 B.T.U. Due to the assumed analysis (*see* notes c and d), the values reported for item 29(*e*) are approximate only, for exact value see items 40(*e*)

f Value for trial No. DS-X5 only, determined by continuously operated CO_2 recorder (*see* Table A), remaining values determined by hand-operated Orsat making one determination per hour from 9 a.m. to 11 p.m. daily, night determinations (11 p.m. to 9 a.m.) not made except for trials prefixed with letters DH for which one determination was made nightly on a composite sample taken from 11 p.m. to 9 a.m.

g The ½- and ⅜-inch screens used for trials so marked g (sub-items (*l*), (*m*), and (*n*) of item 9) had square mesh openings.

h Trial No. EDS-77 is a repeat test on trial No. DS-65, and was made in order to check up on the low efficiency figure obtained for the latter trial. As the results for these two trials closely approximate each other in value it may safely be assumed that the results for trial No. DS-65 are not in error, and are, therefore, representative of the fuel tested

TABLE D

Department of Mines and Resources

Bureau of Mines—Fuel Research Laboratories, Ottawa, Canada

Detailed Data and Results of Nineteen Burning Tests Made on Various Western Canada Coals, Lignite, and Briquetted Fuels in Comparison with a "Standard" Sample of American Anthracite in a Domestic Hot-Water Boiler

Item \ Fuel																				
Kind	"Standard" Sample	Western Canada Coals: Bituminous—(Caking and Non-caking)								Western Canada Coals: Sub-bituminous		Lignite		Briquetted Fuels: Made by Various Processes						
Sample No.	3-34	14-34	15-34	1A-37	22-36	13-35	23-36	21-36	18-36	28-36	20-36	19-36	10-31	5-34	14-35	1-38	1-37	5-37	4-34	
Name or area	American Anthracite	Telkwa area, British Columbia	Nanaimo area, British Columbia	Mountain Park area, Alberta		Saunders area, Alberta	Prairie Creek area, Alberta	Coalspur area, Alberta	Coalspur area, Alberta	Drumheller area, Alberta		Estevan area, Saskatchewan	Northern Ontario	Bituminous fines, Cascade area, Alberta	Anthracite fines, Lykens Valley, Pa.	Bituminous fines, Nordegg area, Alberta		Lignite fines, Estevan area, Saskatchewan	Imported Peat Bricks	
Size, etc.	Stove	Lump	Lump	Lump	Lump	Lump	Mine-run	Lump	Lump	Egg	Lump	Lump	Forked lump							
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Section "A", Items 1 to 20 inclusive—General																				
1. Trial number	DS-X5 a	DS-73	DS-74	DH-143	DH-133	DS-97	DH-134	DH-135	DH-136	DH-138	DH-137	DH-139	DH-202	DS-64	DS-98	DH-198	DH-140	DH-199	EDS-81	EDS-82
2. Type of trial (S-Standard, O-Observation, E-Efficiency)	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	E	E
3. Date of trial	10-9 to 1-12/34	18-23/3/35	25-30/3/35	7-12/6/37	1-6/2/37	4-9/11/35	8-13/2/37	15-20/2/37	22-27/2/37	8-13/3/37	1-6/3/37	15-20/3/37	24-29/10/38	17-22/12/34	18-23/11/35	19-24/9/38	31-5 to 5-6/37	26/9 to 1/10/38	8-9/5/35	10-11/5/35
4. Duration of trial, continuous total ... hrs.	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	24	24
5. Number of fire periods during 24-hour day	3	3	3	3	3	3	3	3	3	3	3	6	6	3	3	3	3	3	6	6
6. Intervals between firings (24-hour day) ... hrs.	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	4½; 4½; 2½; 2½; 5 & 5	4½; 4½; 2½; 2½; 5 & 5	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	9, 5, and 10	4½; 4½; 2½; 2½; 5 & 5	4½; 4½; 2½; 2½; 5 & 5
7. Average rate of combustion, per cent of rated capacity of furnace	52	51	52	54	57	54	49	60	52	56	60	49	53	55	52	53	54	54	54	53
8. Furnace: (a) Average rating, feet of water radiation ... sq. ft.	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880
(b) Nominal grate area ... sq. ft.	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4	3·4
(c) Area of heating surface ... sq. ft.	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4	32·4
(d) Volume, grate to top of firepot ... cu. ft.	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4	5·4
Raw Fuel as Fired Unless Otherwise Specified																				
9. Screen analysis: (Made on a representative portion of "bulk" sample received for test). (a) Through 18" on 12" round hole screen ... %	–	–	–	–	–	–	–	9·7	–	–	23·0	24·1	–	–	–	–	–	–	Size of average brick: 7·3" × 3·2" × 1·6"; volume = 37·4 cu. in. weight = 1·66 lb.	
(b) " 12" " 10" "	–	–	–	–	6·2	–	–	12·7	–	–	13·3	22·7	1·8	–	–	–	–	–		
(c) " 10" " 8" "	–	–	–	–	12·0	–	1·9	14·5	0·6	–	15·0	15·9	2·5	–	–	–	–	–		
(d) " 8" " 6" "	–	–	–	–	18·6	–	3·2	16·4	7·9	–	25·1	20·0	3·0	–	–	–	–	–		
(e) " 6" " 4" "	–	61·7	26·5	42·9	29·3	23·9	2·6	18·9	32·8	–	15·6	7·1	14·7	–	–	–	–	–		
(f) " 4" " 3" "	–	15·6	15·2	12·6	12·8	14·5	2·8	9·0	15·3	10·7	1·8	2·0	13·7	–	–	–	–	–		
(g) " 3" " 2" "	49·5	12·6	20·1	17·4	7·5	17·4	5·9	8·0	18·2	25·8	1·8	2·8	23·7	100·0	100·0	–	–	100·0		
(h) " 2" " 1½" "	42·0	3·5	10·4	10·1	2·5	8·7	5·2	3·5	8·7	20·0	0·9	1·0	11·7	–	–	100·0	100·0	–		
(i) " 1½" " 1" "	6·5	2·0	9·2	17·0	2·1	10·8	11·4	2·2	6·9	23·8	1·0	1·1	11·7	–	–	–	–	–		
(j) " 1" " ¾" "	0·5	0·7	4·7	–	1·0	7·6	9·0	1·1	2·1	10·4	0·5	0·6	4·9	–	–	–	–	–		
(k) " ¾" " ½" "	0·5	0·6	4·3	–	1·5	8·8	12·4	1·1	2·0	4·3	0·5	0·7	3·9	–	–	–	–	–		
(l) " ½" " ¼" "	0·5	0·6 g	3·1 g	–	1·5	4·5 g	16·3	1·1	1·9	2·5	0·6	0·8	3·1	–	–	–	–	–		
(m) " ¼" " ⅛" "	0·3	0·6 g	2·4 g	–	1·7	1·9 g	11·4	0·7	1·3	1·0	0·4	0·5	1·8	–	–	–	–	–		
(n) " ⅛" " 0" "	0·2	2·1 g	4·1 g	–	3·3	1·9 g	17·9	1·1	2·3	1·5	0·5	0·7	3·5	–	–	–	–	–		
(o) Average size of lumps ... inches	2·06	6·43	3·01	3·41	5·26	2·81	1·25	6·88	3·52	1·80	8·95	9·48	2·88	2·50	2·25	1·75	1·75	2·25		
(p) "Size stability per cent" by shatter test on: (1) 4"-6" (round hole screen) coal	–	92·0	88·0	–	–	88·0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(2) 2" to 3" (round hole screen) size	92·8	87·5	80·0	79·6	84·8	78·5	73·9	78·4	82·1	66·8	76·3	82·0	–	–	97·8	–	–	–	–	–
(3) 3" to 4" (" " ") "	–	85·5	78·0	81·3	79·7	76·5	72·2	74·5	74·6	62·3	70·2	74·4	–	–	–	–	–	–	–	–
(q) "Friability per cent" by tumbler test on: (1) 1" to 1½" (square hole screen) size	29·8	36·2	48·3	43·4	48·5	53·6	41·1	34·6	44·4	38·8	29·2	30·4	–	–	94·8	–	–	–	15·1	15·1
10. Proximate analysis: (a) Moisture ... %	2·9	2·3	2·8	0·9	0·8	8·0	5·5	8·0	7·0	15·3	16·4	27·7	19·2	0·6	0·9	0·8	0·7	5·9	12·0	11·4
(b) Ash ... %	9·5	11·8	11·6	11·8	13·2	8·3	14·8	14·6	18·4	6·9	6·7	6·3	6·5	9·8	9·8	12·3	12·1	13·1	5·4	5·7
(c) Volatile matter ... %	5·1	28·2	39·3	22·8	27·6	34·1	33·8	33·3	32·2	31·3	30·9	27·9	37·3	18·6	12·0	19·7	18·6	17·0	56·8	57·5
(d) Fixed carbon (by difference) ... %	82·5	57·7	46·3	64·5	58·4	49·6	45·9	44·1	42·4	46·5	46·0	38·1	37·0	71·0	77·3	67·2	68·6	64·0	25·8	25·4
11. Ultimate analysis: (a) Carbon ... %	81·9	74·3	69·9	77·3	75·3	66·3	64·8	59·8	58·2	59·6	58·7	48·4	52·6	81·1	81·9	78·4	79·2	73·2	48·4	48·5
(b) Hydrogen ... %	2·9	4·6	5·2	4·6	4·6	4·9	5·2	4·7	4·6	5·8	5·9	6·4	5·5	4·4	3·6	4·5	4·6	3·2	5·9	5·9
(c) Ash ... %	9·6	11·8	11·6	11·8	13·2	8·3	14·8	14·6	18·4	6·9	6·7	6·3	6·5	9·8	9·8	12·3	12·1	13·1	5·4	5·7
(d) Sulphur ... %	0·9	0·8	1·1	0·3	0·3	0·3	0·3	0·2	0·3	0·8	0·8	0·4	0·5	0·9	0·7	0·7	0·7	0·7	0·4	0·4
(e) Nitrogen ... %	0·9	1·2	1·4	1·1	1·1	1·0	1·4	0·7	0·8	1·1	1·2	0·8	0·5	1·6	1·0	1·0	1·1	1·1	1·7	1·7
(f) Oxygen (by difference) ... %	3·8	7·3	10·8	4·9	5·5	19·2	13·5	20·0	17·7	25·8	26·7	37·7	34·4	2·2	3·0	3·1	2·3	8·7	38·2	37·8
12. Calorific value: (a) As fired, gross value ... B.T.U./lb.	13,190	12,800	12,500	13,230	12,970	11,340	11,315	10,190	9,730	10,150	10,130	7,970	8,350	14,050	13,650	13,660	13,500	11,830	8,150	8,140
(b) Dry, gross value ... B.T.U./lb.	13,580	13,110	12,860	13,350	13,075	12,330	11,980	11,090	10,470	12,000	12,110	11,030	10,340	14,140	13,780	13,760	13,600	12,570	9,250	9,190
(c) Gas used for kindling (assumed) ... B.T.U./cu. ft.	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
13. Fuel ratio, fixed carbon/volatile matter	16·30	2·05	1·20	2·85	2·10	1·45	1·40	1·35	1·30	1·50	1·50	0·73	0·99	3·85	6·44	3·41	–	3·76	0·45	0·44
14. Carbon-hydrogen ratio	28·8	16·2	13·4	17·0	16·4	13·4	12·5	12·6	12·7	10·3	9·9	7·6	9·6	18·4	23·0	17·4	–	22·9	8·2	8·2
15. (a) Caking properties as judged by "coke button"	Non-caking	Poor	Fair	Fair to good	Good	Slightly agglom.	Poor to fair	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Non-caking	Agglomerate	Non-caking	Poor	Poor to fair	Agglomerate	Non-caking	Non-caking
(b) Swelling index = (Per cent swelling × 100) / (Per cent dry V.M. at 600°C.)	–	–297	–230	–233	329	Nil	–18	–	–	–	–	–	–	–	–	–	–	–	–	–
(c) Caking index by "Gray" method	–	17	13	29	53	Nil	3	–	–	–	–	–	–	–	–	–	–	–	–	–
16. Ash fusibility: (a) Initial deformation temperature ... °F.	2,745	2,270	2,110	2,200	2,240	2,190	2,250	2,100	2,000	1,940	1,925	2,120	2,305	2,630	2,100	2,900	2,850+	1,990	2,200	2,190
(b) Softening point or fusion temperature ... °F.	2,850	2,380	2,170	2,300	2,350	2,240	2,320	2,200	2,190	2,040	2,000	2,200	2,375	2,750	2,420	2,900+	2,850+	2,050	2,245	2,240
(c) Fluid temperature or melting point ... °F.	2,905	2,500	2,230	2,375	2,440	2,270	2,410	2,300	2,300	2,070	2,190	2,280	2,395	2,850	2,540	2,900+	2,850+	2,120	2,270	2,270
17. Apparent specific gravity, as received in bulk	1·47	1·39	1·35	1·40	1·38	1·35	1·40	1·31	1·47	1·34	1·33	1·29	1·14	1·24	1·25	1·20	1·22	1·20	1·25	1·25
18. Weight per cubic foot, as received in bulk ... lb.	52·4	47·6	51·9	52·8	46·2	49·5	55·8	49·7	49·9	47·5	46·7	40·5	33·2	42·5	43·6	43·4	44·2	41·1	70·0	70·0
19. Volume per ton of 2,000 pounds, as received in bulk ... cu. ft.	38·2	42·0	38·5	–	43·3	40·4	35·8	40·2	40·1	42·1	42·8	49·4	60·2	47·1	45·9	46·1	45·2	48·7	28·6	28·6
20. Grindability index by "Hardgrove" method	28·5	70·8	75·0	84·7	73·6	61·6	52·8	45·0	55·2	39·2	39·3	53·5	–	–	–	–	–	–	–	–
Section "B", Items 21 to 35(c) Inclusive—4-Day "Observation" Test																				
21. Duration of "observation" trial ... hrs.	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	–	–
22. Fuel fired: (a) City gas used for kindling ... cu. ft.	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–	–
(b) Fuel equivalent to gas used ... lb.	3·8	3·9	4·0	3·8	3·9	4·4	4·4	4·9	5·1	4·9	4·9	6·3	6·0	3·6	3·7	3·7	3·7	4·2	–	–
(c) Quantity during trial ... lb.	708	911	938	862	838	995	963	1,144	1,184	1,146	1,196	1,575	1,414	796	768	744	744	932	–	–
(d) Total, including gas equivalent ... lb.	711·8	914·9	942·0	865·8	841·9	999·4	967·4	1,148·9	1,189·1	1,150·9	1,200·9	1,581·3	1,420·0	799·6	771·7	747·7	747·7	936·2	–	–
23. Refuse removed: (a) Through fire-door during trial ... lb.	Nil	Nil	8	Nil	1·0	4	9·5	19·5	5·0	15·3	13·3	Nil	Nil	Nil	1·7	Nil	Nil	Nil	–	–
(b) From ash-pit during trial ... lb.	66·9	113·5	128·3	94·3	58·0	106·3	147·8	104·8	215·8	55·5	36·8	106·5	69	104	89·8	81	77·8	56·3	–	–
(c) Total, during trial ... lb.	66·9	113·5	136·3	94·3	59·0	110·3	157·3	124·3	220·8	70·8	50·1	106·5	69	104	91·5	81	77·8	56·3	–	–
(d) As dumped residual fire at end of trial ... lb.	80·6	109·8	53·3	99·2	79·3	67·5	110·5	100·5	126·3	95·0	83·5	69·0	76·3	104	114·3	44·3	61·2	127·5	–	–
Screen Examination of Refuse																				
24. Clinker: (a) Removed through fire-door during trial ... lb.	Nil	Nil	8	Nil	1	4	9½	19½	5	15¼	13¼	Nil	Nil	Nil	1¾	Nil	Nil	Nil	–	–
(b) On 1" square mesh screen recovered from ash-pit refuse ... lb.	4⅛	¾	2¼	2¾	½	1	2	½	3½	1¼	¼	0	Nil	⅛	¼	1½	½	¼	–	–
(c) " ½" " " " " "	4⅞	3½	6½	5¼	2	2¼	8¾	3	11	4	1	0	Nil	1¼	1¾	3¼	1½	1½	–	–
(d) " ¼" " " " " residual fire ... lb.	4⅜ b	3¾	5½	11¾	6	4¼	6	3¼	12½	6	4	4¾	Nil	½	2¼	1¼	½	15½	–	–
(e) " ⅛" " " " "	1⅝ b	1½	1¼	4¾	3½	2	4½	3¼	8¾	7¼	2	1¼	Nil	⅜	2	1	1	3¾	–	–
(f) Total—(over ⅛" screen size)—recovered ... lb.	14⅞ b	9½	23½	25	13	13½	30¾	29½	40¾	33¾	21¼	6	Nil	2⅜	8	7¼	3½	21	–	–
25. Unburned combustible: (a) On 1" square mesh screen recovered from ash-pit refuse ... lb.	3⅝	5	3¼	2¼	1	½	¼	Nil	½	Nil	Nil	Nil	Nil	6⅝	½	3½	5¾	1	–	–
(b) " ½" " " " " "	8⅓	16¾	12¾	8	3¼	9¾	7½	2¾	6¾	1	1	¼	3	12¼	2½	5½	6¼	1	–	–
(c) " ¼" " " " " residual fire ... lb.	44½ b	57¼	17	43½	33	8¾	7½	11½	15¼	4½	12¾	½	11	77	55	24	31½	68	–	–
(d) " ⅛" " " " "	21⅞ b	19½	13	11	10¾	15¼	14½	17¼	17	17	17¾	1½	24¼	9¼	9½	5¼	9	9¾	–	–
(e) Total—(over ⅛" screen size)—recovered ... lb.	80¾ b	98½	46	64¾	48	34¼	29½	31½	39½	22½	31½	2¼	38¼	105⅛	67½	38¼	52½	79¾	–	–
26. Refuse—(through ⅛" screen size): (a) Recovered from ash-pit refuse ... lb.	46¼	87½	103¼	75½	51¼	92¾	129¼	98½	194	49¼	34¼	105	66	83¾	84¾	67¼	63¾	52¼	–	–
(b) " " residual fire ... lb.	17½ b	28¼	16½	28¼	26	37¼	78¼	65¼	72¾	60¼	46½	60½	41	17¼	45½	12½	19¼	30½	–	–
(c) Total recovered ... lb.	66¾ b	115¾	120	103¾	77¼	130	207½	163¾	266¾	109½	80¾	165½	107	101	130¼	79¾	83	83	–	–
Estimated Corrections for Refuse, Dumped Residual Fire, Etc.																				
27. Proximate analysis of refuse recovered during trial: (a) Ash c ... %	46·5	50·7	63·3	61·1	64·1	37·8	48·9	73·0	65·0	63·0	76·7	54·3	78·1	41·4	64·2	82·7	84·3	84·2	–	–
(b) Combustible c (by difference) ... %	53·5	49·3	36·7	38·9	35·9	62·2	51·1	27·0	35·0	37·0	23·3	45·7	21·9	58·6	35·8	17·3	15·7	15·8	–	–
28. Dumped residual fire: (a) Dry analysis, ash d ... %	22·7	22·1	23·4	33·5	31·1	19·8	45·9	46·2	45·4	23·5	21·2	23·4	29·3	13·6	18·3	30·0	34·2	26·6	–	–
(b) " volatile matter d ... %	1·5	3·7	8·5	6·7	3·5	11·0	10·1	10·6	8·0	5·8	3·1	10·5	8·2	2·3	2·7	3·0	1·1	6·9	–	–
(c) " fixed carbon d (by difference) ... %	75·8	74·2	68·1	59·8	65·4	69·2	44·0	43·2	46·6	70·7	75·7	66·1	62·5	84·1	79·0	67·0	64·7	66·5	–	–
(d) Dry calorific value, gross d ... B.T.U./lb.	10,860	11,160	11,060	9,130	9,700	10,990	7,620	7,100	7,650	10,940	11,480	10,670	10,480	12,220	11,530	9,410	9,170	10,970	–	–
(e) Sensible heat, total estimated ... B.T.U.	41,368	56,302	27,317	50,890	40,681	34,628	56,087	51,557	64,792	48,735	42,836	35,397	39,142	53,352	58,636	22,700	31,396	65,408	–	–
(f) " coal equivalent ... lb. (Items (e) and (f) based on items 23(d) plus 28(f))	3·1	4·4	2·2	3·8	3·1	3·1	5·0	5·1	6·7	4·8	4·2	4·4	4·7	3·8	4·3	1·7	2·3	5·5	–	–
(g) Portion allocated to ash-pit loss ... lb.	27·0	28·4	11·9	43·4	27·8	25·3	100·5	53·4	71·5	26·6	16·0	22·2	23·2	12·2	17·7	11·1	18·7	23·0	–	–
(h) " not chargeable to test ... lb.	53·6	81·4	41·4	55·8	51·5	42·2	10·0	47·1	54·8	68·4	67·5	46·8	53·1	91·8	96·6	33·2	42·5	104·5	–	–
(i) Fuel equivalent of portion not chargeable ... lb.	51·4	80·1	42·1	51·0	48·5	46·4	10·5	51·4	63·3	88·6	89·3	74·7	86·7	83·3	90·0	28·6	38·5	113·7	–	–
29. Equivalent fuel used: (a) Total for trial, calculated ... lb.	657·3	830·4	897·7	811·0	790·3	949·9	951·9	1,092·4	1,119·1	1,057·5	1,107·4	1,502·2	1,328·6	712·5	677·4	717·4	706·9	817·0	–	–
(b) Per hour ... lb.	6·8	8·7	9·4	8·4	8·2	9·9	9·9	11·4	11·7	11·0	11·5	15·6	13·8	7·4	7·1	7·5	7·4	8·5	–	–
(c) " square foot of grate surface per hour ... lb.	2·0	2·5	2·8	2·5	2·4	2·9	2·9	3·3	3·4	3·2	3·4	4·6	4·1	2·2	2·1	2·2	2·2	2·5	–	–
(d) " " " heating " ... lb.	0·21	0·27	0·29	0·26	0·25	0·31	0·31	0·35	0·36	0·34	0·36	0·48	0·43	0·23	0·22	0·23	0·23	0·26	–	–
(e) " therm e delivered to cooling water ... lb.	9·94	13·05	13·68	11·81	10·86	13·77	15·45	14·44	17·11	14·97	14·65	24·14	20·06	10·12	10·31	10·59	10·25	11·68	–	–
30. Total ash in fuel used, from fuel analysis ... lb.	62·7	98·0	103·9	95·7	104·2	78·7	141·0	159·5	206·2	73·0	74·1	94·5	86·3	69·8	66·4	88·0	85·4	107·2	–	–
31. Total refuse: (a) For test ... lb.	93·9	141·9	148·2	137·7	86·8	135·6	257·8	177·7	292·3	97·4	66·1	128·7	92·2	116·2	109·3	92·1	96·5	79·3	–	–
(b) Per cent of fuel used ... %	14·3	17·1	16·5	17·0	11·0	14·3	27·1	16·3	26·1	9·2	6·0	8·6	6·9	16·3	16·1	12·9	13·7	9·7	–	–
(c) " ton " " ... lb.	286	342	330	340	220	286	542	326	522	184	120	172	138	326	322	258	174	194	–	–
General Data																				
32. Circulating water, average temperature: (a) Flow by thermograph ... °F.	131	114	115	133	119	131	112	123	115	120	123	114	113	113	123	136	129	136	–	–
(b) Return " ... °F.	102	78	80	105	84	101	78	88	81	86	89	82	97	80	92	103	100	103	–	–
33. Cooling water: (a) Average temperature, inlet by thermograph ... °F.	56	37	38	–	–	–	–	–	–	–	–	–	–	39	–	–	–	–	–	–
(b) " " outlet " ... °F.	94	74	76	–	–	–	–	–	–	–	–	–	–	80	–	–	–	–	–	–
(c) " " difference ... °F.	38	37	38	40	42	40	36	44	38	41	44	36	39	41	38·5	39	40	41	–	–
(d) Total used during trial, corrected ... lb.	172,121	172,036	172,700	171,605	173,224	172,412	171,121	171,928	172,169	172,295	171,814	172,857	169,821	171,744	170,725	173,759	172,386	170,549	–	–
(e) Heat delivery per hour ... B.T.U.	68,501	66,306	68,360	71,502	75,786	71,838	64,170	78,800	68,150	73,584	78,748	64,821	68,990	73,349	68,468	70,590	71,828	72,839	–	–
(f) " " pound of fuel used ... B.T.U.	10,089	7,665	7,310	8,464	9,206	7,260	6,472	6,925	5,846	6,680	6,827	4,142	4,985	9,883	9,703	9,446	9,754	8,559	–	–
34. Flue gases: (a) Average temperature by recorder ... °F.	300	337	381	390	467	382	424	410	362	380	380	372	393	297	314	350	350	362	–	–
(b) " carbon dioxide content f ... %	13·6	11·8	13·6	8·9	10·1	12·7	9·3	10·1	7·7	10·9	10·6	6·6	10·4	12·3	13·4	10·5	10·2	11·4	–	–
35. Average: (a) Draught over fire, by recording gauge ... in. W.G.	0·009	0·016	0·010	0·040	0·038	0·024	0·030	0·043	0·043	0·017	0·026	0·045	0·013	0·009	0·027	0·025	0·028	0·008	–	–
(b) Room temperature, by thermograph ... °F.	67	71	69	74	68	77	72	74	72	74	74	74	69	68	69	64	72	68	–	–
(c) Outdoor temperature, by thermograph ... °F.	53	33	31	64	8	49	19	16	25	10	24	26	45	15	37	54	66	53	–	–
Section "C", Items 36 to 56(a) Inclusive—One-Day "Efficiency" Test																				
36. Duration of "efficiency" trial ... hrs.	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
37. Fuel fired: (a) City gas used for kindling ... cu. ft.	101	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	110	50	50
(b) Fuel equivalent to gas used ... lb.	3·8	3·9	4·0	3·8	3·9	4·4	4·4	4·9	5·1	4·9	4·9	6·3	6·0	3·6	3·7	3·7	3·7	4·6	3·1	3·1
(c) Quantity during trial ... lb.	247	289	302	272	279	315	324	346	356	359	359	440	414	259	252	247	254	293	446	446
(d) Total, including gas equivalent ... lb.	250·8	292·9	306·0	275·8	282·9	319·4	328·4	350·9	361·1	363·9	363·9	446·3	420·0	262·6	255·7	250·7	257·7	297·6	449·1	449·1
38. Refuse removed: (a) Through fire-door during trial ... lb.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1·0	1·5	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
(b) From ash-pit " ... lb.	14·6	28·8	20·0	12·3	9·5	26	16·0	14·0	19·5	7·0	11·0	29·0	14	35·3	9·5	7·5	9·3	22·3	12·5	13·3
(c) Total, during trial ... lb.	14·6	28·8	20·0	12·3	9·5	26	16·0	15·0	21·0	7·0	11·0	29·0	14	35·3	9·5	7·5	9·3	22·3	12·5	13·3
(d) Dry analysis of total refuse recovered, ash ... %	46·5	50·7	63·3	61·1	64·1	37·8	48·9	73·0	65·0	63·0	76·7	54·3	78·1	41·4	64·2	82·7	84·3	84·2	87·1	86·5
(e) " " " " " combustible (by difference) ... %	53·5	49·3	36·7	38·9	35·9	62·2	51·1	27·0	35·0	37·0	23·3	45·7	21·9	58·6	35·8	17·3	15·7	15·8	12·9	13·5
(f) As dumped residual fire at end of trial ... lb.	80·9	75·3	85·0	94·7	92·0	71·8	101·8	102·3	109·0	83·0	70·0	30·3	43·5	65·5	91·3	74·8	74	72·3	45·3	47·0
39. Dumped residual fire: (a) Dry analysis, ash ... %	19·1	22·1	23·4	33·5	31·1	19·8	45·9	46·2	45·4	23·5	21·2	23·4	29·3	13·6	18·3	30·0	34·2	26·6	22·8	18·5
(b) " " volatile matter ... %	1·5	3·7	8·5	6·7	3·5	11·0	10·1	10·6	8·0	5·8	3·1	10·5	8·2	2·3	2·7	3·0	1·1	6·9	9·6	8·7
(c) " " fixed carbon (by difference) ... %	79·4	74·2	68·1	59·8	65·4	69·2	44·0	43·2	46·6	70·7	75·7	66·1	62·5	84·1	79·0	67·0	64·7	66·5	67·6	72·8
(d) " calorific value, gross ... B.T.U./lb.	11,466	11,160	11,060	9,130	9,700	10,990	7,620	7,100	7,650	10,940	11,480	10,670	10,480	12,220	11,530	9,410	9,170	10,970	11,200	11,790
(e) Sensible heat, total estimated ... B.T.U.	41,481	38,629	43,605	48,581	47,196	36,833	52,223	52,480	55,917	42,579	35,910	15,544	22,316	33,602	46,837	38,372	37,962	37,090	23,239	24,111
(f) " coal equivalent ... lb. (Items (e) and (f) based on items 38(a) plus 38(f)).	3·1	3·0	3·5	3·7	3·6	3·2	4·6	5·2	5·7	4·2	3·5	2·0	2·7	2·4	3·4	2·8	2·8	3·1	2·9	3·0
(g) Portion allocated to ash-pit loss ... lb.	20·4	19·5	19·0	41·5	32·2	26·9	92·6	54·4	61·7	23·3	13·4	9·8	13·2	7·7	14·1	18·7	22·6	13·1	9·3	7·1
(h) " not chargeable to test ... lb.	60·5	55·8	66·0	53·2	59·8	44·9	9·2	47·9	47·3	59·7	56·6	20·5	30·2	57·8	77·2	56·1	51·4	59·2	36·0	39·9
(i) Fuel equivalent of portion not chargeable ... lb.	58·6	54·9	67·2	48·6	56·3	49·4	9·7	52·2	54·6	77·3	74·9	32·7	49·3	52·4	71·9	48·4	46·6	64·4	60·1	66·4
40. Equivalent fuel used: (a) Total for trial, calculated ... lb.	189·1	235·0	235·3	223·5	223·0	266·8	314·1	293·5	300·8	282·4	285·5	411·6	368·0	207·8	180·4	199·5	208·3	230·1	386·1	379·7
(b) Per hour ... lb.	7·9	9·8	9·8	9·3	9·3	11·1	13·1	12·2	12·5	11·8	11·9	17·2	15·3	8·7	7·5	8·3	8·7	9·6	16·1	15·8
(c) " square foot of grate surface per hour ... lb.	2·3	2·9	2·9	2·7	2·7	3·3	3·8	3·6	3·7	3·5	3·5	5·0	4·5	2·5	2·2	2·4	2·6	2·8	4·7	4·7
(d) " " " heating " ... lb.	0·24	0·30	0·30	0·29	0·29	0·34	0·40	0·38	0·39	0·36	0·57	0·53	0·47	0·27	0·23	0·26	0·27	0·30	0·50	0·49
(e) " therm e delivered to cooling water ... lb.	11·52	14·11	14·25	13·53	13·55	16·22	18·90	17·84	18·52	16·83	17·27	25·84	21·68	12·31	10·99	11·83	12·17	13·62	22·73	22·48
(f) To equal one ton of stove-size American anthracite ... tons	1·00	1·22	1·24	1·17	1·18	1·41	1·64	1·55	1·61	1·46	1·50	2·24	1·88	1·07	0·95	1·03	1·06	1·18	1·97	1·95
41. Total ash in fuel used, from fuel analysis ... lb.	18·0	27·6	27·2	26·4	29·4	22·0	46·5	42·9	55·5	19·4	19·0	25·7	23·7	20·2	17·6	24·4	25·1	29·9	20·8	21·6
42. Total refuse: (a) For test ... lb.	35·0	48·3	39·0	53·8	41·7	52·9	108·6	69·4	82·7	30·3	24·4	38·8	27·2	43·0	23·6	26·2	31·9	35·4	21·8	20·4
(b) Per cent of fuel used ... %	18·6	20·6	16·6	24·1	18·7	19·9	34·6	23·6	27·4	10·8	8·6	9·5	7·5	20·8	13·1	13·2	15·4	15·5	5·6	5·4
(c) " ton " " ... lb.	371	412	332	482	374	398	692	472	548	216	172	190	150	416	262	264	308	310	112	108
43. Circulating water, average temperature: (a) Flow ... °F.	129	110	111	129	113	124	114	113	113	115	114	111	126	112	120	131	129	129	121	121
(b) Return ... °F.	103	82	83	103	85	98	86	85	85	87	86	84	99	83	93	104	102	101	93	94
44. Cooling water: (a) Average temperature, inlet ... °F.	57·1	38·2	37·5	66·0	38·1	52·2	38·7	38·1	38·2	38·2	38·5	38·4	55·1	38·4	45·2	63·1	62·9	61·3	49·3	50·2
(b) " " outlet ... °F.	95·5	76·3	75·7	104·4	76·4	90·4	77·6	76·5	76·1	77·0	76·9	75·4	95·4	77·8	83·5	101·9	102·5	101·1	88·6	89·3
(c) " " difference ... °F.	38·4	38·1	38·2	38·4	38·3	38·2	38·9	38·4	37·9	38·8	38·4	37·0	40·3	39·4	38·3	38·8	39·6	39·8	39·3	39·1
(d) Total used during trial, corrected ... lb.	42,794	43,704	43,221	43,032	42,969	43,058	42,715	42,844	42,856	43,251	43,062	43,054	42,113	42,850	42,868	43,465	43,220	42,434	43,215	43,193
(e) Heat delivery per hour ... B.T.U.	68,437	69,380	68,793	68,851	68,571	68,534	69,234	68,550	67,677	69,922	68,899	66,375	70,715	70,345	68,410	70,268	71,313	70,370	70,765	70,369
(f) " " pound of fuel used ... B.T.U.	8,684	7,086	7,017	7,393	7,380	6,165	5,290	5,605	5,400	5,942	5,792	3,870	4,612	8,125	9,101	8,453	8,217	7,340	4,399	4,448
45. Flue gases: (a) Average temperature ... °F.	310	373	475	382	464	384	464	378	394	383	367	389	383	299	311	372	358	349	331	340
(b) Dry volumetric analysis, carbon dioxide ... %	13·4	12·7	13·4	10·5	8·6	11·3	10·1	10·2	9·0	12·1	11·3	6·3	11·4	14·0	14·0	12·9	12·6	13·8	13·2	14·3
(c) " " " oxygen ... %	6·2	5·2	4·5	8·7	10·4	7·7	9·0	8·8	10·3	6·9	7·3	13·2	8·2	4·4	4·8	6·0	6·0	5·5	5·6	4·7
(d) " " " carbon monoxide ... %	0·3	0·4	0·5	0·1	0·2	0·2	0·1	0·2	0·1	0·1	0·2	0·0	0·4	0·5	0·2	0·2	0·2	0·2	0·4	0·7
(e) " " " nitrogen (by difference) ... %	80·2	81·7	81·6	80·7	80·8	80·8	80·8	80·8	80·6	80·9	81·2	80·5	80·0	81·1	81·0	80·9	81·2	80·5	80·8	80·3
(f) " weight per pound of fuel used ... lb.	13·5	12·3	11·6	16·0	19·3	11·8	11·5	12·8	13·3	11·5	12·4	17·2	11·2	12·0	13·8	14·7	15·1	12·8	8·9	8·1
46. Excess air ... %	41	31	26	68	94	56	72	69	93	47	51	161	63	26	29	39	38	35	35	28
47. Draught average: (a) Over fire ... in. W.G.	0·010	0·004	0·005	0·024	0·035	0·022	0·064	0·033	0·050	0·014	0·023	0·034	0·011	0·009	0·007	0·013	0·013	0·010	0·010	0·007
(b) In flue ... in. W.G.	0·010	0·005	0·016	0·022	0·032	0·018	0·046	0·031	0·052	0·014	0·023	0·057	0·010	0·005	0·004	0·009	0·013	0·010	0·010	0·010
48. Average: (a) Room temperature ... °F.	68	71	67	73	69	70	75	71	71	72	72	76	69	69	65	74	69	69	67	71
(b) " relative humidity ... %	64	36	33	51	28	37	28	33	28	18	28	27	41	29	27	57	58	43	39	39
(c) Outdoor temperature ... °F.	55	35	33	64	12	34	34	27	21	18	16	33	40	7	24	59	63	47	56	55
(d) Barometric pressure ... in. Hg	29·897	30·045	29·716	29·978	29·851	30·001	29·803	30·174	29·704	30·121	29·736	29·701	30·00	30·067	30·147	29·68	29·736	29·87	30·100	29·736
49. Efficiency: (a) Grate ... %	88·9	88·4	92·9	89·7	92·4	84·0	77·2	90·8	85·6	94·3	97·1	92·0	97·1	87·3	95·0	97·6	97·4	97·0	98·7	98·7
(b) Overall thermal ... %	65·8	55·4	56·1	55·9	56·9	54·4	46·8	55·0	55·5	58·5	57·2	48·6	55·2	57·8	66·7	61·9	60·9	62·0	54·0	54·6
Heat Account Per Pound of Fuel Used in B.T.U. and Per Cent																				
50. Heat delivered to cooling water ... B.T.U.	8,684	7,086	7,017	7,393	7,380	6,165	5,290	5,605	5,400	5,942	5,792	3,870	4,612	8,125	9,101	8,453	8,217	7,340	4,399	4,448
51. Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... B.T.U.	299	491	580	492	510	526	574	503	496	622	628	685	698	457	377	479	489	339	622	622
52. Loss due to heat carried away in dry flue gases ... B.T.U.	783	892	1,136	1,187	1,830	889	1,074	943	1,031	858	878	1,292	844	662	815	1,051	1,047	860	564	523
53. " " unburned combustible matter in refuse ... B.T.U.	1,460	1,485	890	1,368	981	1,809	2,578	931	1,402	581	292	636	238	1,781	685	333	353	357	106	106
54. " " " carbon monoxide ... B.T.U.	140	199	233	65	158	95	47	104	54	46	100	0	175	241	110	118	122	103	142	226
55. " " radiation, errors, and unaccounted for ... B.T.U.	1,824	2,647	2,644	2,725	2,111	1,856	1,752	2,104	1,347	2,101	2,440	1,487	1,783	2,784	2,562	3,226	3,272	2,831	2,317	2,215
56. Total calorific value of 1 pound of fuel as fired, gross value ... B.T.U.	13,190	12,800	12,500	13,230	12,970	11,340	11,315	10,190	9,730	10,150	10,130	7,970	8,350	14,050	13,650	13,660	13,500	11,830	8,150	8,140
50. (a) Heat delivered to cooling water (same as item 49(b)) ... B.T.U.	65·8	55·4	56·1	55·9	56·9	54·4	46·8	55·0	55·5	58·5	57·2	48·6	55·2	57·8	66·7	61·9	60·9	62·0	54·0	54·6
51. (a) Loss due to steam formed from moisture in fuel and that formed by burning hydrogen in dry fuel ... %	2·3	3·8	4·6	3·7	3·9	4·6	5·1	4·9	5·1	6·1	6·2	8·6	8·4	3·3	2·8	3·5	3·6	2·9	7·6	7·7
52. (a) Loss due to heat carried away in dry flue gases ... %	5·9	7·0	9·1	9·0	14·1	7·8	9·5	9·3	10·6	8·5	8·6	16·2	10·1	4·7	6·0	7·7	7·8	7·3	6·9	6·4
53. (a) " " unburned combustible matter in refuse ... %	11·1	11·6	7·1	10·3	7·6	16·0	22·8	9·1	14·4	5·7	2·9	8·0	2·8	12·7	5·0	2·4	2·6	3·0	1·3	1·3
54. (a) " " " carbon monoxide ... %	1·1	1·5	1·9	0·5	1·2	0·8	0·4	1·0	0·6	0·5	1·0	0·0	2·1	1·7	0·8	0·9	0·9	0·9	1·8	2·8
55. (a) " " radiation, errors, and unaccounted for ... %	13·8	20·7	21·2	20·6	16·3	16·4	15·4	20·7	13·8	20·7	24·1	18·6	21·4	19·8	18·7	23·6	24·2	23·9	28·4	27·2
56. (a) Percentage, equivalent to total calorific value of 1 pound of fuel as fired, gross value ... %	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

a The data given for trial No. DS-X5 are the averaged results obtained for five repeat tests, all of which very closely approximated each other in value. (*See* Table A).

b Average of two tests only, totals therefore are not necessarily exact. (*See* Table A).

c As the normal refuse recovered during first four days of trial was not available for chemical analysis after having been screened, the values reported for items 27(*a*) and (*b*) are assumed to be the same as the values reported for items 38(*d*) and (*e*) in the "efficiency" part of the trial.

d Excepting trial No. DS-X5 (*see* Table A), the dumpings recovered at conclusion of the first four days of trial were not available for chemical analysis after having been screened, therefore, the values reported for items 28(*a*), (*b*), (*c*), and (*d*) are assumed to be the same as the values reported for items 39(*a*), (*b*), (*c*), and (*d*) in the "efficiency" part of the trial.

e Therm = 100,000 B.T.U. Due to the assumed analysis (*see* notes **c** and **d**), the values reported for item 29(*e*) are approximate only, for exact values see item 40(*e*).

f Value for trial No. DS-X5 only, determined by continuously operated CO_2 recorder (*see* Table A), remaining values determined by hand-operated Orsat making one determination per hour from 9 a.m. to 11 p.m. daily, night determinations (11 p.m. to 9 a.m.) not made except for trials prefixed with letters DH for which one determination was made nightly on a composite sample taken from 11 p.m. to 9 a.m.

g The ½- and ⅛-inch screens used for trials so marked **g** (sub-items (*l*), (*m*), and (*n*) of item 9) had square mesh openings.