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ENGINEERING EXPERIMENT STATION

VOLUME 3 NUMBER 3

A REPORT OF STEAM BOILER TRIALS  
UNDER OPERATING CONDITIONS

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## INTRODUCTION.

Steam boiler trials may be divided broadly into two classes:

1. Tests under predetermined conditions, which are kept constant throughout, the purpose being to make a scientific study of the boiler performance under these conditions.

2. Tests performed under the every day operating conditions of the steam boiler plant.

**Acceptance Tests.**—These are made upon a new installation of boilers previous to their acceptance by the purchasers. They belong in class 1.

It is customary to include in a contract for steam boilers a number of clauses which carefully specify the minimum efficiency of combined boiler and grate when operating within a certain per cent of the rated power. Thus, it may be stated that, when burning bituminous mine run coal having a heating value of not less than 10,500 B. T. U. per pound, and operating between 80 and 120 per cent of the rated horsepower, the boiler shall absorb not less than 70 per cent of the calorific value of the coal.

In order to satisfy the purchaser that such a guarantee has been fulfilled, a boiler test must be made of not less than twelve hours duration. Commonly, the directions for the conduct of boiler trials comprised in the Standard Code of the American Society of Mechanical Engineers are followed. The boiler is fired up and operated for some time, in order to get the setting thoroughly heated up. Provision is made to dispose of surplus steam not needed in the operation of prime movers, so that the load, and all conditions, may be kept as nearly as possible constant. The firing is carefully supervised by the testing engineers representing the contractors and the purchasers. In some instances the coal is picked over and all slack and slaty coal thrown out. In short, every effort is made to get the best possible economy from the boiler on this test.

**Tests Under Operating Conditions.**—(Class 2). The conditions of every day service under which a boiler is operated are very different from those which obtain when an acceptance or similar test is run. Under every day operating conditions, the load on the boiler is likely to vary widely, from a very light load to a considerable overload, and sometimes these fluctuations follow each other rapidly. It is not practicable to maintain at all times the most advantageous test conditions.

The heating surfaces become coated with scale on one side and

soot on the other, with the effect of decreasing the rate of heat transmission from hot gasses on one side of the surface to water on the other. Brick work is liable to crack, permitting air leakage; and if this air becomes heated in the furnace, later passing off at the flue temperature, a loss of heat results. In addition to these reasons for a lower efficiency than can be obtained under special test conditions, mention should be made of what are called "stand-by" losses. An individual boiler in a plant may or may not be operated twenty-four hours a day. In the great majority of cases, the working day is much less than twenty-four hours. In electric lighting plants it may be a short period of a few hours carrying the plant over the peak load of the day. When a boiler is to be cut out the fire must be banked, an operation which takes a certain amount of coal. Furthermore, the boiler and setting begin at once to cool off, and the steam pressure falls. When the boiler is to be gotten under steam again, a considerable amount of coal must be burned to heat up the boiler and its setting before it can begin to produce steam. It is clear that coal thus burned during the stand-by period should be added to that burned while producing steam to get the total fuel cost. The proportion of this stand-by loss to the coal burned to evaporate water will depend upon the relative lengths of time the boiler is under steam and banked.

Let  $C$  = weight of coal burned to produce steam.

Let  $C'$  = coal burned during stand-by period.

Let  $W$  = total weight water evaporated.

Let  $w$  = pounds of water evaporated per pound of coal burned.

Then the number of pounds of water evaporated per pound is, properly

$$w = \frac{W}{C + C'}$$

If, however,  $C'$  is not considered, our expression would become

$$w = \frac{W}{C}$$

It is clear from the foregoing arguments, why the economy of a boiler, in pounds of feed water per pound of coal, based upon monthly records of coal burned and water fed to boiler, is bound to be much below the figure found by an acceptance or similar test.

The boiler tests which form the basis of this bulletin, the results of which are summarized in tables I, II, III and IV, were made from time to time by students, under the writer's direction in the course

of regular work in the Mechanical Laboratory at the University of Missouri. The boilers tested are located at the University heating and lighting plant, with the exception of the two tests of Table III, which were made on a Heine water tube boiler at the heating plant of the Horticultural Department.

The boiler equipment of the University heating and lighting plant consists of seven boilers, numbered consecutively, 1 to 7. Two of these, numbers 1 and 5, are Heine water tube boilers; the others are horizontal shell boilers of the return tubular type. Natural chimney draft is used for all. Boiler No. 1 is equipped with a rocking grate. The others have plain grates of the herring bone pattern. The tests herewith presented were made upon the two Heine boilers Nos. 1 and 5, return tubular boiler No. 7, and the Heine boiler before mentioned at the horticultural plant. The tests upon each boiler are comprised in a table, the short form of the A. S. M. E. Standard Code being followed. The heating surface, grate area, and rated power are given in each case.

In conducting these tests no effort was made to get an economy better than the ordinary daily performance. They represent ordinary operating conditions, but do not take into account stand-by losses.

The regular fireman fired the boiler in his customary manner. When the fire needed cleaning, he cleaned it, this operation usually taking place once or twice during the test. In case of the boilers with plain grates, most of the ash and refuse accumulates on the grate, and, in the process of cleaning, must be raked out through the door. This involves a considerable cooling of boiler and furnace, due to the admission of cold air, and a drop in the production of steam, disadvantages which are largely overcome by the use of a rocking grate, as in boiler No. 1. It was found in the tests on this boiler that nearly all the ash and refuse could be passed through by rocking the grate, though sometimes a few clinkers had to be raked out through the front door.

The method of starting and stopping was that defined in the Standard Code as the "Alternate Method." The procedure was as follows: The boiler being under steam, and the furnace and brick-work hot, the fire was burned low and cleaned. The pressure, temperatures, water level, and time of day were then noted, and the test was started. At the close the fire was burned low and cleaned, and the time of closing was considered to be the time when the operation of cleaning was concluded. An effort was made to have, as nearly as could be judged from observation, the same amount of coal on the grate at the close as at the beginning. The water level in the boiler and the steam pressure were made the same as at the start.

The per cent of  $\text{CO}_2$  in the flue gases was determined at frequent

intervals by means of an Orsat apparatus. The gas was drawn from a point in the flue between the boiler and damper, through a  $\frac{1}{4}$ -inch pipe, by means of an exhauster, and a sample was drawn off into the Orsat instrument from the side outlet of a tee in the gas line.

The feed water was weighed in two tanks mounted on scales in the usual manner, and discharged thence into a third tank from which the feed pump or injector used to feed the boiler took its supply.

At the end of each hour an hourly balance was determined of the quantity of coal burned and water fed to the boiler; the average pressures and temperatures for each hour were also computed. In connection with tables I and II the records of hourly quantities of five of the tests are graphically shown, Figs. 1 to 5. These indicate the variations in the boiler load that took place from hour to hour, as the demand for steam fluctuated.

It will be noted that the stand-by losses which occur when the boiler is cut out are not included in the tests. The final results indicate about what may be expected during the working period in the way of economy, in an ordinary plant of small size, equipped with boilers of from 125 to 250 horse-power, burning western bituminous coal, and hand fired by firemen of mediocre ability.

The efficiency of boiler and grate combined, item 31, ranges from 43 to 60 per cent. Disregarding tests No. 2, Table I, and No. 6, Table IV, the range of efficiency is 47 to 57 per cent. The average efficiencies for each boiler, including grate (item 31) are as follows:

Boiler No. 1,	Table I.....	46.1 per cent
“ “ “	Omitting Test No. 2.....	47.6 “ “
“ “ 5,	Table II.....	51. “ “
Hort. Boiler,	“ III.....	48.5 “ “
Boiler No. 7,	“ IV.....	54.7 “ “
“ “ “	Omitting Test No. 6.....	53.8 “ “

For the purpose of estimating the fuel expenditure for a given quantity of feed water delivered to a boiler, items 24 and 25 are of practical value to the owner and operator of a steam power plant who has not at hand the means of readily determining the per cent of moisture and ash in the coal, and hence cannot figure down to the basis of dry coal and of combustible, as in items 26 and 27. The maximum, minimum and average values of items 24 and 25 are arranged in the following summary. Also, to reduce the fuel cost to the basis of dollars and cents, another item (No. 33 of the short form) is added, assuming that the cost of coal delivered to the boiler room is \$2.50 per ton of 2,000 pounds.



	Boiler No. 1	Boiler No. 5	Hort. Boiler	Boiler No. 7
	1	1	1	
Item 24.—Water apparently evaporated under actual conditions per pound of coal as fired. Maximum values .....	5.38	6.04	5.77	5.92
Item 24.—Minimum value.....	5.08	5.47	5.36	5.07
Item 24.—Average of all.....	5.18	5.72	5.56	5.53
Item 25.—Equivalent exaporation from and at 212 deg. per lb. of coal as fired. Maximum values.....	5.74	6.50	6.30	6.98
Item 25.—Minimum values.....	5.32	6.07	5.78	5.86
Item 25.—Average of all.....	5.54	6.29	6.04	6.47
Item 33.—Cost of coal required for evaporating 1,000 pounds of water from and at 212 degrees, coal at \$2.50 per ton. Maximum value.....	\$.235	\$.206	\$.216	\$.213
Item 33.—Minimum value.....	.218	.192	.198	.179
Item 33.—Average of all.....	.225	.198	.207	.193

TABLE I.

DATA AND RESULTS OF EVAPORATIVE TESTS.

Name and location of boiler: Heine boiler No. 1, at U. of M. Heating and Lighting Plant.

Kind of fuel: Illinois coal.

Kind of furnace: Rocking grate, hand fired.

Method of starting and stopping: Alternate.

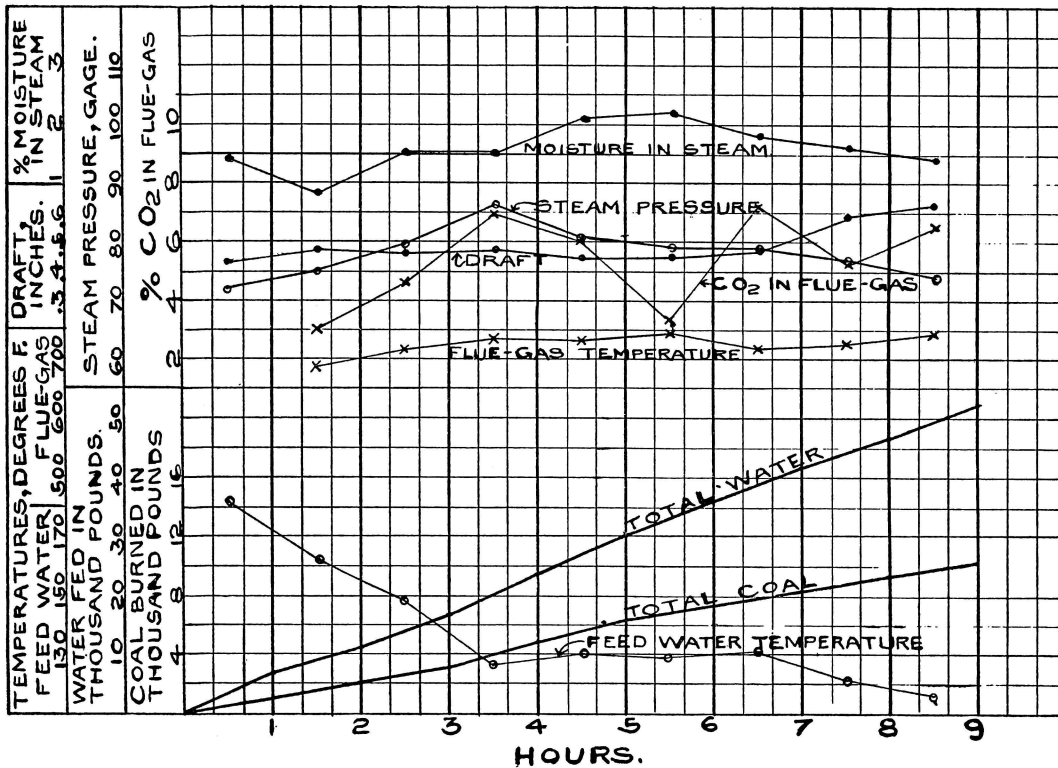
Grate surface: 40.5 square feet.

Water heating surface: 1399 square feet.

Total Quantities.	Test 1	Test 2	Test 3
1.—Date of trial.....	3/30, '12	4/13, '12	4/20, '12
2.—Duration of trial, hours.....	9	9.5	9.5
3.—Weight of coal as fired, pounds.....	10241	6200	6534
4.—Percentage of moisture in coal.....	9.52	8.32	6.98
5.—Total weight of dry coal consumed.....	9265	5685	6078
6.—Total ash and refuse, pounds.....	1588	685	838
7.—Percentage of ash and refuse in dry coal.....	17.15	12.3	13.7
8.—Total weight of water fed to the boiler, lbs..	52148	31482	35145
9.—Water actually evaporated, corrected for moisture in steam .....	51313	30850	34477
9a.—Factor of evaporation.....	1.110	1.069	1.087
10.—Equivalent water evaporated into dry steam from and at 212 degrees.....	56957	32980	37476
<b>Hourly Quantities.</b>			
11.—Dry coal consumed per hour, pounds.....	1029.5	599	639.7

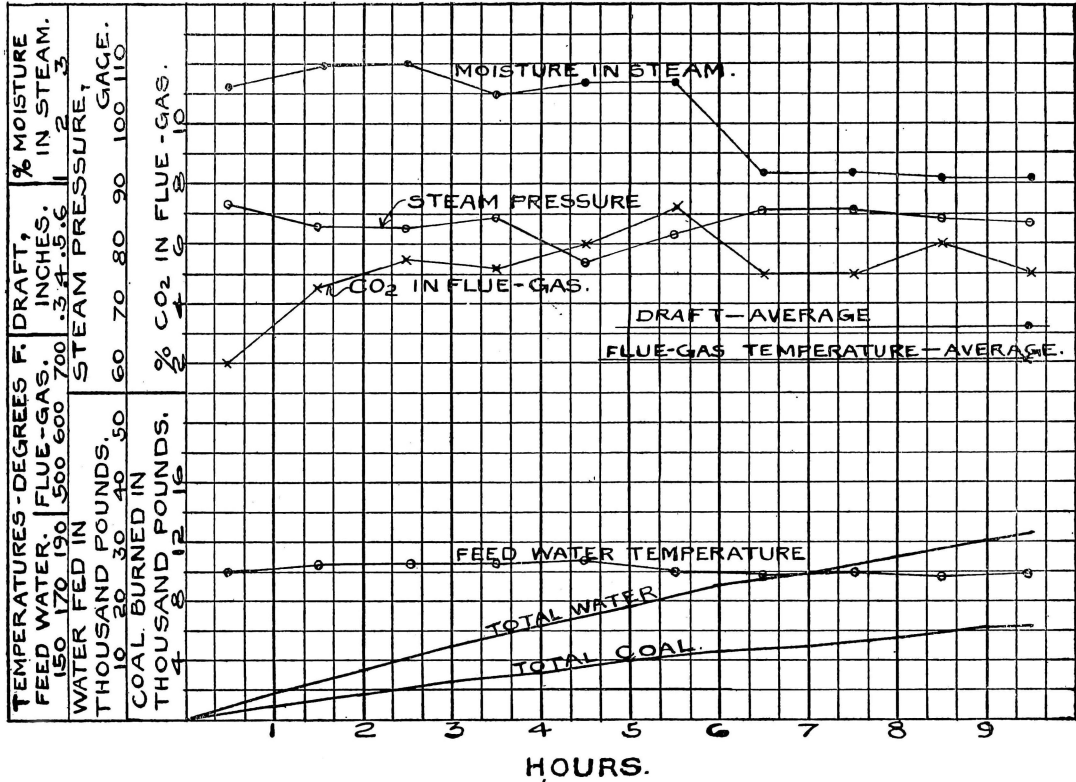
TABLE I.—Continued.

12.—Dry coal per sq. ft. grate surface per hour....	25.42	14.8	15.8
13.—Water evaporated per hour corrected for quality of steam .....	5700	3250	3629
14.—Equivalent evaporation per hour from and at 212 degrees .....	6329	3470	3944
15.—Equivalent evaporation per hour from at at 212 deg. per sq. ft. of water heating furnace..	4.52	2.48	2.82
<b>Average Pressure and Temperatures.</b>			
16.—Steam pressure by gage.....	78.5	83.3	85.11
17.—Temperature of feed water, deg. F.....	138.5	181	163
18.—Temperature of escaping gas.....	726	705	702
19.—Force of draft between damper and boiler, inches of water.....	.49	.22	.24
20.—Percentage of moisture in steam.....	1.6	2.0	1.9
<b>Horse-Power.</b>			
21.—Horse-power developed .....	183	100.7	114
22.—Builder's rated horse-power.....	150	150	150
23.—Percentage of rated power developed.....	122	66	76
<b>Economic Results.</b>			
24.—Water apparently evaporated under actual conditions per pound of coal as fired.....	5.09	5.08	5.38
25.—Equivalent evaporation from and at 212 degrees per pound of coal as fired.....	5.56	5.32	5.74
26.—Equivalent evaporation from and at 212 degrees per pound of dry coal.....	6.15	5.80	6.17
27.—Equivalent evaporation from and at 212 degrees per pound of combustible.....	7.43	6.59	7.13
<b>Efficiency.</b>			
28.—Calorific value of the dry coal per pound, B. T. U. ....	12750	12940	12360
29.—Calorific value of the combustible per pound, B. T. U. ....	14390	14760	14750
30.—Efficiency of boiler based on combustible....	50.1	43.15	47.0
31.—Efficiency of boiler, including grate, based on dry coal .....	46.8	43.25	48.4



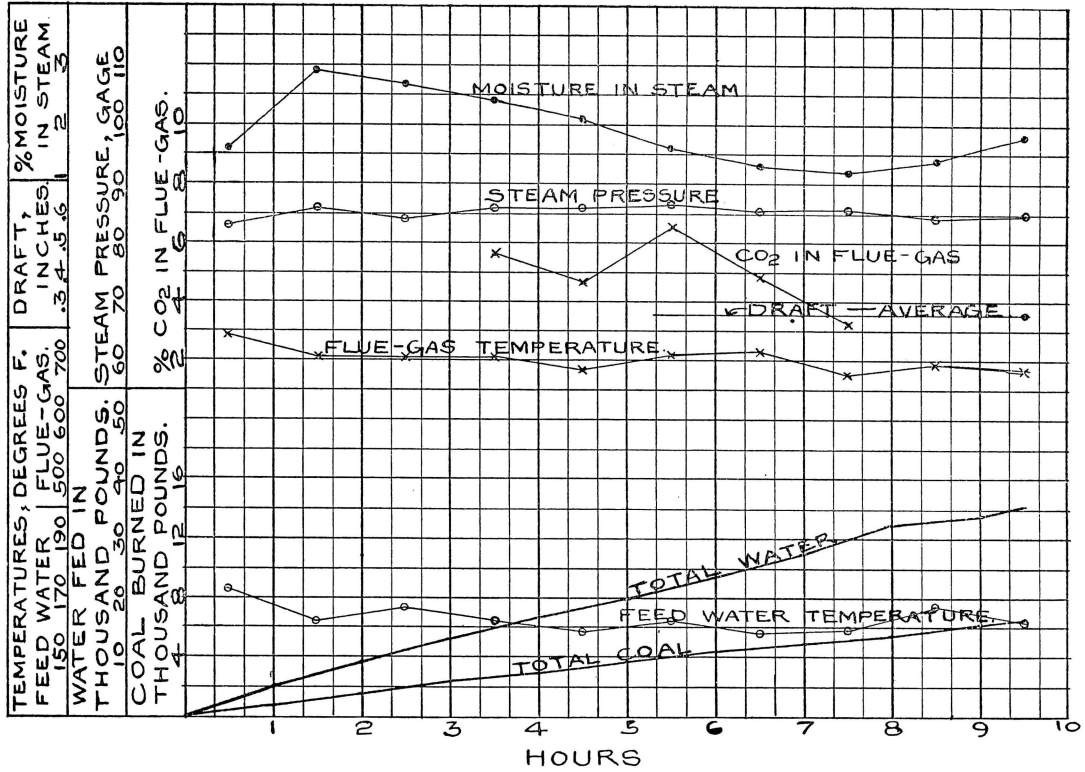
HEINE BOILER No.1 - TEST No.1

FIG. 1



HEINE BOILER No.1-TEST No.2

FIG.2



HEINE BOILER, No. 1 — TEST No. 3

FIG. 3

TABLE II.

## DATA AND RESULTS OF EVAPORATIVE TESTS.

Name and location of boiler: Heine boiler No. 5, U. of M. Heating and Lighting Plant.

Kind of fuel: Illinois coal.

Kind of furnace: Plain grate, hand fired.

Method of starting and stopping: Alternate.

Grate surface: 47 square feet.

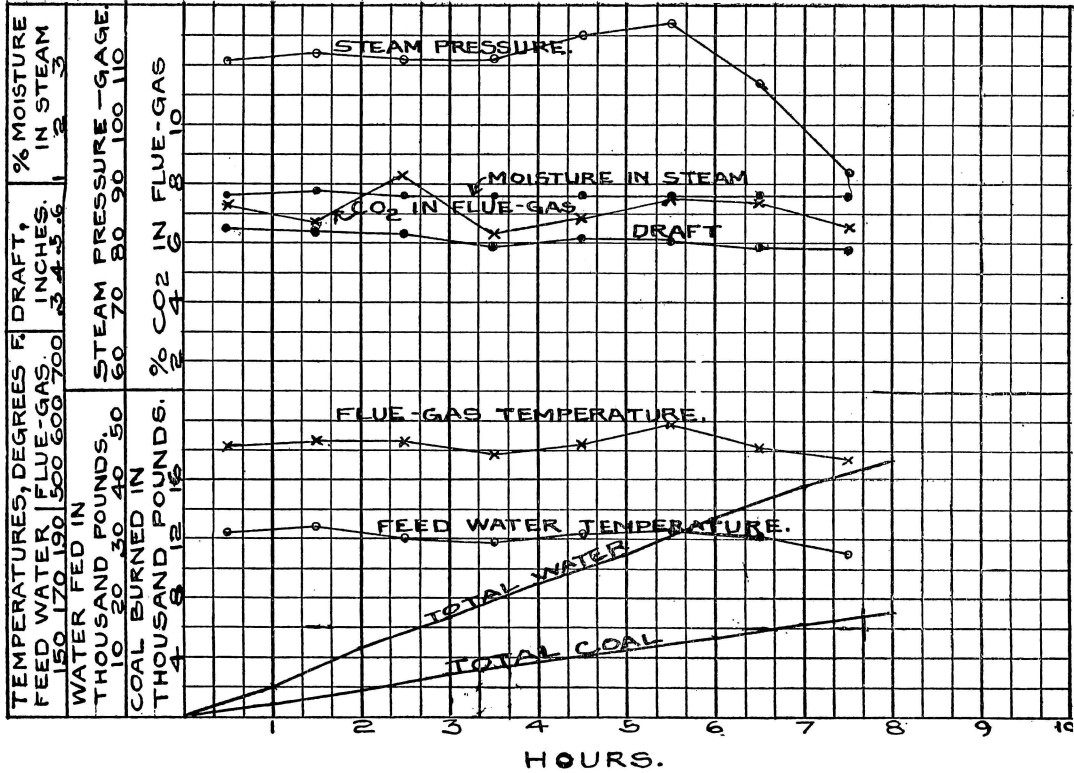
Water heating surface: 2232 square feet

Total Quantities	Test 1	Test 2	Test 3	Test 4	Test 5
1.—Date of trial.....	5/5, '09	5/6, '09	5/9, '10	4/27, '12	5/4, '12
2.—Duration of trial, hours....	8	8	8	8	10
3.—Weight of coal as fired, lbs.	7429	8121	9682	7183	9727
4.—Percentage of moisture in coal .....	7.4	11.0	9.6	5.97	7.84
5.—Total weight of dry coal consumed .....	6879	7227	8752	6754	8965
6.—Total ash and refuse, lbs...	1143	816	1564	966.5	1199
7.—Percentage of ash and refuse in dry coal.....	16.65	11.3	17.9	14.3	13.4
8.—Total weight of water fed to the boiler, pounds.....	43912	45202	53000	43390	54504
9.—Water actually evaporated, corrected for moisture in steam .....	43692	44730	52310	43043	53926
9a.—Factor of evaporation.....	1.107	1.130	1.121	1.061	1.138
10.—Equivalent water evaporated into dry steam from and at 212 degrees.....	48367	50545	58640	45670	61368
<b>Hourly Quantities.</b>					
11.—Dry coal consumed per hour, pounds .....	859	903	1094	844	896.5
12.—Dry coal per sq. ft. grate surface per hour, pounds..	18.26	19.22	23.2	18.0	19.06
13.—Water evaporated per hour, corrected for quality of steam .....	5461	5591	6540	5380	5392
14.—Equivalent evaporation per hour from and at 212 deg.	6046	6318	7330	5709	6137
15.—Equivalent evaporation per hour from and at 212 deg. per sq. ft. of water heating surface .....	2.70	2.82	3.28	2.40	2.74
<b>Average Pressures and Temperatures.</b>					
16.—Steam pressure by gage....	84	92.5	95.8	109.5	108.7
17.—Temperature of feed water,					

TABLE II.—Continued.

deg. F. ....	144	123	132	192	117
18.—Temperature of escaping gas.	515	512	609	563	637
19.—Force of draft between damper and boiler, inches of water .....	.42	.54	.67	.54	.57
20.—Percentage of moisture in steam .....	.49	1.05	1.30	.80	1.06
<b>Horse-Power.</b>					
21.—Horse-power developed ....	175	184	212	165	178
22.—Builder's rated horse-power.	250	250	250	250	250
23.—Percentage or rated power developed .....	70	73.6	84.8	66	71
<b>Economic Results.</b>					
24.—Water apparently evaporated under actual conditions per pound of coal as fired....	5.92	5.57	5.47	6.04	5.6
25.—Equivalent exaporation from and at 212 deg. per pound of coal as fired.....	6.50	6.23	6.07	6.35	6.28
26.—Equivalent evaporation from and at 212 deg. per pound of dry coal.....	7.04	7.00	6.70	6.76	6.84
27.—Equivalent evaporation from and at 212 deg. per pound of combustible .....	8.43	7.89	8.17	7.88	7.90
<b>Efficiency.</b>					
28.—Calorific value of dry coal per pound, B. T. U.....	13970	*13900	12520	12413	12616
29.—Calorific value of the combustible per pound.....	14700	.....	14570	14000	14450
30.—Efficiency of boiler based on combustible .....	55.6	.....	54.5	54.6	53.1
31.—Efficiency of boiler, including grate, based on dry coal..	48.9	48.8	52.0	52.8	52.6

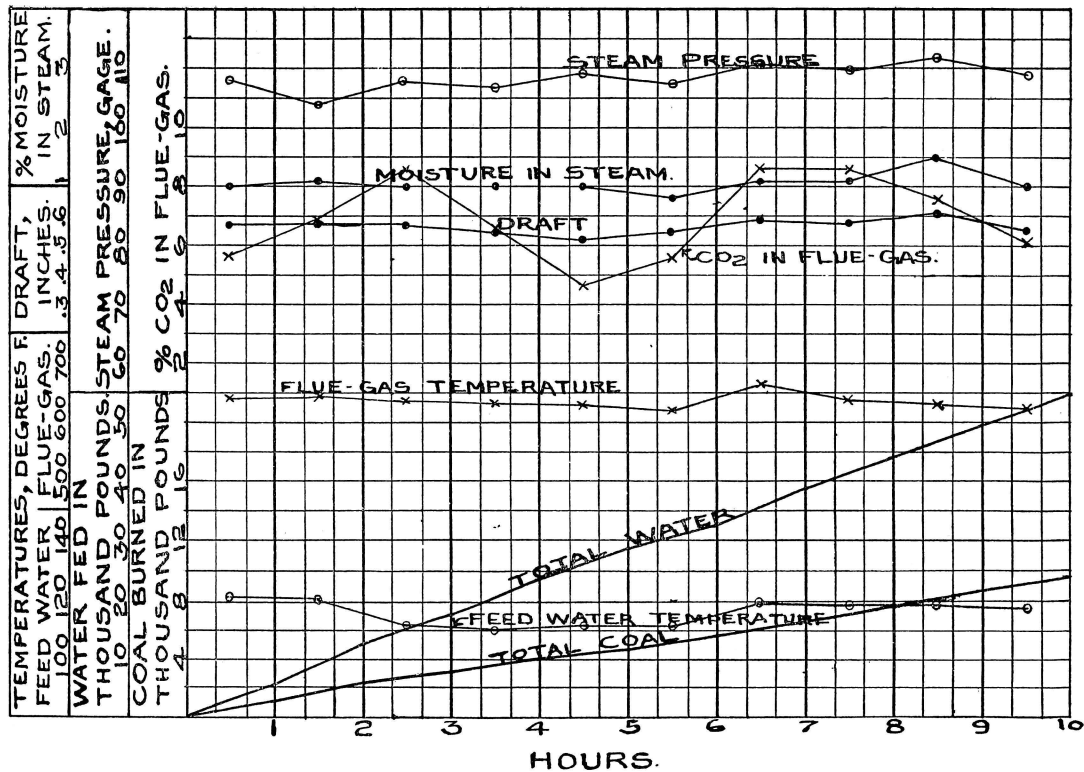
\*Assumed.



HEINE BOILER No. 5 - TEST No. 4

FIG. 4.





HEINE BOILER No.5 - TEST No.5.

FIG. 5.

**TABLE III.**  
**DATA AND RESULTS OF EVAPORATIVE TESTS.**

**Name and location of boiler:** Heine boiler at Horticultural heating plant.  
**Kind of fuel:** Illinois coal.  
**Kind of furnace:** Plain grate, hand fired.  
**Method of starting and stopping:** Alternate.  
**Grate surface:** 25 square feet.  
**Water heating surface:** 1217 square feet.

Total Quantities.	Test 1	Test 2
1.—Date of trial.....	2/19, '10	2/22, '10
2.—Duration of trial, hours.....	9	10
3.—Weight of coal, as fired, pounds.....	4647	5100
4.—Percentage of moisture in coal.....	7.9	7.9
5.—Total weight of dry coal consumed.....	4280	4700
6.—Total ash and refuse, pounds.....	1068	1031
7.—Percentage of ash and refuse in dry coal.....	24.9	21.9
8.—Total weight of water fed to the boiler, pounds.....	26769	27355
9.—Water actually evaporated, corrected for moisture in steam .....	26582	27000
9a.—Factor of evaporation.....	1.096	1.090
10.—Equivalent water evaporated into dry steam from and at 212 degrees .....	29181	29421
<b>Hourly Quantities.</b>		
11.—Dry coal consumed per hour, pounds.....	475	470
12.—Dry coal per square foot grate surface per hour.....	19.0	18.8
13.—Water evaporated per hour, corrected for quality of steam .....	2955	2700
14.—Equivalent evaporation per hour from and at 212 deg...	3242	2942
15.—Equivalent evaporation per hour from and at 212 deg. per square foot of water heating surface.....	2.64	2.43
<b>Average Pressures and Temperatures</b>		
16.—Steam pressure by gage.....	44	65.3
17.—Temperature of feed water, deg. F.....	144	156
18.—Temperature of escaping gas.....	574	646
19.—Force of draft between damper and boiler, inches of water .....	.34	.38
20.—Percentage of moisture in steam.....	.70	1.3
<b>Horse-Power.</b>		
21.—Horse-power developed .....	94	84
22.—Builder's rated horse-power.....	130	130
23.—Percentage of rated power developed.....	72.5	64.8
<b>Economic Results.</b>		
24.—Water apparently evaporated under actual conditions per pound of coal as fired.....	5.77	5.36

TABLE III.—Continued.

25.—Equivalent evaporation from and at 212 deg. per pound of coal as fired.....	6.30	5.78
26.—Equivalent evaporation from and at 212 deg. per pound of dry coal .....	6.82	6.26
27.—Equivalent evaporation from and at 212 deg. per pound of combustible .....	9.06	8.03
<b>Efficiency.</b>		
28.—Calorific value of dry coal per pound, B. T. U.....	13184	12880
29.—Calorific value of combustible per pound.....	.....	.....
30.—Efficiency of boiler based on combustible.....	.....	.....
31.—Efficiency of boiler, including grate, based on dry coal..	50.0	47.1

TABLE IV.

## DATA AND RESULTS OF EVAPORATIVE TESTS.

Name and location of boiler: Return tubular, No. 7, U. of M. heating and lighting plant.

Kind of fuel: Illinois coal.

Kind of furnace: Plain grate, hand fired.

Method of starting and stopping: Alternate.

Grate surface: 25.3 square feet.

Water heating surface: 1239 square feet.

Total Quantities.	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
1.—Date of trial.....	2/11, '11	2/25, '11	3/11, '11	4/1, '11	4/8, '11	4/22, '11
2.—Duration of trial, hours.....	10	9	10.23	10.06	10	10
3.—Weight of coal as fired, pounds.....	7957	8446	7658	8125	7379	7640
4.—Percentage of moisture in coal.....	9.0	12.0	8.4	9.4	8.9	9.5
5.—Total weight of dry coal consumed.....	7240	7430	7015	7360	6720	6914
6.—Total ash and refuse, pounds.....	1120	1348	1135	1128	1093	1157
7.—Percentage of ash and refuse in dry coal.....	15.5	18.1	16.2	15.3	16.2	16.8
8.—Total weight of water fed to the boiler, pounds.....	46506	42866	42313	44706	43673	40950
9.—Water actually exaporated, corrected for moisture in steam..	45395	42350	42059	44350	43200	40377
9a.—Factor of evaporation.....	1.188	1.170	1.164	1.191	1.193	1.192
10.—Equivalent water evaporated into dry steam from and at 212 degrees .....	53923	49549	48956	52820	51537	48129
<b>Hourly Quantities.</b>						
11.—Dry coal consumed per hour, pounds.....	724	825	685	731	672	691
12.—Dry coal per sq. ft. grate surface per hour.....	28.5	32.5	27.1	28.8	26.6	27.2
13.—Water evaporated per hour, corrected for quality of steam..	4539	4705	4110	4408	4320	4038
14.—Equivalent evaporation per hour from and at 212 degrees....	5392	5506	4785	5250	5154	4813
15.—Equivalent evaporation per hour from and at 212 deg. per sq. ft. of water heating surface.....	4.35	4.44	3.86	4.23	4.16	3.88

TABLE IV.—Continued.

<b>Average pressures and Temperatures.</b>						
16.—Steam pressure by gage.....	93.6	90.4	96.7	94.8	92.2	96.7
17.—Temperature of feed water, deg. F.....	67	83	90	64	62	63
18.—Temperature of escaping gas.....	560	547	522	472	521	485
19.—Force of draft between damper and boiler, inches of water..	.73	.50	.46	.54	.53	.56
20.—Percentage of moisture in steam.....	2.4	1.2	.6	.8	1.1	1.4
<b>Horse-Power.</b>						
21.—Horse-power developed .....	156	160	139	152	150	140
22.—Builder's rated horse-power.....	150	150	150	150	150	150
23.—Percentage of rated power developed.....	104	106.6	92.6	101.3	100	93.3
<b>Economic Results.</b>						
24.—Water apparently evaporated under actual conditions per pound of coal as fired.....	5.84	5.07	5.52	5.50	5.90	5.36
25.—Equivalent evaporation from and at 212 deg, per pound of coal as fired.....	6.77	5.86	6.39	6.51	6.98	6.30
26.—Equivalent evaporation from and at 212 deg. per pound of dry coal .....	7.44	6.67	6.97	7.18	7.67	6.97
27.—Equivalent evaporation from and at 212 deg. per pound of combustion .....	8.81	8.16	8.32	8.47	9.16	8.38
<b>Efficiency.</b>						
28.—Calorific value of dry coal per pound, B. T. U.....	12840	13190	12800	*13000	*13000	11380
29.—Calorific value of the combustible per pound.....	14600	14800	14350	15100	14750	14070
30.—Efficiency of boiler based on combustible.....	58.5	53.5	56.2	54.3	60.2	58.0
31.—Efficiency of boiler including grate, based on dry coal.....	56.2	49.1	52.8	53.7	57.2	59.6

\*Assumed.

It will be noted that the boiler efficiencies in these tests are somewhat lower than those commonly found in similar boilers under test conditions. At the Louisiana Purchase Exposition in 1904 a large number of tests were made at the coal testing plant that was operated for the purpose of investigating the qualities of the various coals and lignites of the United States, the results of which are found in the published "Report on the Operations of the Coal Testing Plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, 1904." Heine Saftey boilers of 210 horse-power rated capacity were used. The grates were plain, the furnace hand fired and the draft natural. For purposes of comparison, the results of tests Nos. 18, 19, 38, 48, 50, 73, in which series Illinois coal was burned, are summarized, together with the tests of Table II, Heine boiler No. 5, in Table No. V, which follows. The data of the St. Louis tests are taken from the Report, p. 961. It will be noted that the economic results, items 26 and 27, from Table No. II, are about 9 per cent less in amount than the corresponding figures for the St. Louis tests; while the two efficiencies, items 30 and 31, are respectively 10 and 14 per cent lower.

**TABLE V.**

A comparison of Economic Results and Efficiencies between Heine boiler No. 5, Table II, and tests made at the Louisiana Purchase Exposition, St. Louis. Illinois coal used in both series.

		<b>Economic Results.</b>				<b>Efficiency (per cent).</b>				
		<b>Test Number.</b>	<b>Water apparently evaporated under actual conditions per pound of coal as fired.</b>	<b>Equivalent evaporation from and at 212 deg. per pound of coal as fired.</b>	<b>Equivalent evaporation from and at 212 deg. per pound of dry coal.</b>	<b>Equivalent evaporation from and at 212 deg. per pound of Combustible.</b>	<b>Caloric value of dry coal per pound, B. T. U.</b>	<b>Caloric value of the combustible per pound, B. T. U.</b>	<b>Efficiency of boiler based on combustible.</b>	<b>Efficiency of boiler including grate, based on dry coal.</b>
<b>St. Louis Tests.</b>		24	25	26	27	28	29	30	31	
	18	5.54	6.51	7.21	8.76	11,855	14,252	59.36	58.73	
	19	6.09	7.16	8.00	8.92	12,569	14,159	60.83	61.47	
	38	6.19	7.35	8.04	9.53	12,857	14,712	62.42	60.39	
	48	5.39	6.38	7.37	8.61	12,427	14,323	58.05	57.27	
	50	5.34	6.36	7.27	8.44	12,439	14,319	56.92	56.35	
	73	5.32	6.43	7.40	8.75	11,594	13,992	60.39	61.64	
	<b>Average</b>	5.56	6.70	7.55	8.84	12,293	14,293	59.66	59.31	
<b>Table No. II.</b>	1	5.92	6.50	7.04	8.43	13,970	14,700	55.60	48.90	
	2	5.57	6.23	7.00	7.89	13,900	.....	.....	48.80	
	3	5.47	6.07	6.71	8.17	12,520	14,570	54.50	52.00	
	4	6.04	6.35	6.76	7.88	12,413	14,000	54.60	52.80	
	5	5.60	6.28	6.84	7.90	12,616	14,450	53.10	52.60	
		<b>Average</b>	5.72	6.28	6.87	8.05	13,084	14,430	53.56	51.02









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