U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

GAS CALORIMETER TABLES

CIRCULAR C417

U. S. DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
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CIRCULAR OF THE NATIONAL BUREAU OF STANDARDS C417
[Supersedes Circular C65]

GAS CALORIMETER TABLES

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PREFACE

This Circular replaces an earlier Bureau publication, Circular 65, which has been widely used for 20 years as a laboratory handbook by those engaged in gas calorimetry. Data of the kind conveniently assembled in these tables must be used in every determination of heating value made with a flow calorimeter of the nonautomatic type. When the earlier Circular was prepared, nearly all fuel gases which were bought and sold could be classified into two groups, manufactured and natural gases, each with a fairly narrow range of properties, and the heating values of natural gases were only infrequently measured. For these reasons, the earlier publication was prepared primarily for convenient use with gas of only a limited range of compositions. This revised Circular gives equal consideration to gaseous fuels of all the varied types now used, and should contribute materially to convenience and accuracy in calorimetric work.

LYMAN J. BRIGGS, *Director.*

GAS CALORIMETER TABLES

ABSTRACT

This Circular contains condensed directions for operating a flow calorimeter for gases, with forms and directions for recording and computing results; tables of "reduction factors" for gas volumes, between 32 and 110° F and from 24 to 30.9 in. of mercury pressure; and tables of the corrections needed in calorimetric work. Blank forms are included to be filled in with data pertaining to local situations and individual laboratory instruments, so that the user may have all data needed in calorimetry conveniently arranged under one cover.

CONTENTS

I. INTRODUCTION

This Circular replaces Bureau Circular 65 of the same title, which was published in 1917. It contains concise operating directions for gas calorimeters of the usual water-flow or "Junkers" type and a set of correction tables. It may be regarded as a supplement to Circular 48 of the National Bureau of Standards entitled Standard Methods of Gas Testing.

It is assumed that the operator is familiar with the directions and necessary precautions for operating his calorimeter. The directions given here are very brief and are, for the most part, a summary of those stated and explained in Circular 48, and in Technologic Paper 36 on Industrial Gas Calorimetry. Both of these papers are now out of print but may be consulted in many libraries.

Because of the much more varied composition of the gases now in use than when any of the publications above referred to were issued, the method of tabulating some of the corrections has been changed. Instead of attempting to present two or three tables of humidity corrections to apply to all cases, data are given from which a table corresponding to local conditions can be easily prepared for use in an individual laboratory. Since the use of data presented in just this form has not been described previously, a longer discussion of the correction for humidity is given than would otherwise be appropriate.

The table of factors for reducing measured gas volumes to "standard conditions" (saturated with water vapor at 60° F and 30 inches of mercury pressure) has been recomputed to 4 decimal places instead of 3, and the table is extended to a wider range of temperatures and pressures. Requests for tables of wider range have been received several times in recent years. The publication of correction tables for gas volumes which give hundredths instead of tenths of a percent does not signify a belief that industrial calorimetric determinations can ordinarily be made accurate within 0.1 percent. The final uncertainty of a careful measurement of heating value is the algebraic sum of numerous uncertainties, none of which is ordinarily much greater than one part in one thousand, and since the errors may be cumulative, it seems desirable to eliminate one of the component sources of final uncertainty whenever it is possible to do so. It is possible to be certain of the fourth decimal place in the correction factors for the majority of measurements of gas for calorimetric purposes, which are made under conditions not too far from standard. The significance of more than the third decimal is doubtful in the factors near the limits of the table because of the variations of actual gas mixtures from the "ideal gas" laws. These deviations depend on the composition of the mixtures and cannot be generalized. The use of the fourth decimal does not contribute to the uncertainty of the result even in these cases, and it is carried throughout the table to avoid making an arbitrary choice of limits beyond which it is not significant.

The correction charts are arranged in a sequence convenient for use in connection with the forms proposed for recording calorimetric data, starting from the upper lefthand corner of the sheet and continuing in the normal order of applications of the corrections.

The larger forms for calorimetric test records and the three tests it calls for are recommended for use when practicable; but when numerous tests are taken daily, as for control purposes at the gas works, the small form may be preferred. The smaller form contains space for all the essential data but can be used for a single test only.

A summary of the procedure for recording and computing a test is included at the end of this Circular, from which the application of the blank forms and correction tables will be evident.

A considerable amount of interest has appeared recently in the expression of heating value of gas, not on the "standard" basis of saturation with water vapor at 60° F and 30 inches of mercury pressure, but on the basis of conditions actually existing at the time of measurement of the gas for sale or use. The method of recomputing the heating value to this basis is described.

II. SUMMARIZED OPERATING DIRECTIONS FOR FLOW CALORIMETERS

1. Purge gas lines from old gas and burn one burner from this time continuously throughout the period of test.
2. Observe temperature of laboratory.
3. Adjust the gas meter for temperature, level, position of index relative to drum, water level, saturation of water with gas.[1]
4. Test for gas leaks.

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[1] It was stated in Technologic Paper 36 of the Bureau of Standards, Industrial Gas Calorimetry (1914), that the initial lowering in the observed heating value resulting from the use of fresh water in the meter was of the order of 0.5 percent, and that the water had become saturated with gas, so far as calorimetric measurements are concerned, after the passage of 2 or 3 cubic feet of gas through the meter. Since T36 was published it has been found that with some gases the initial lowering in observed heating value resulting from the use of fresh water in the meter amounts to 1 percent or more, and that 10 to 20 cubic feet of gas must be passed through the meter to saturate the water. A lowering of the same order of magnitude in observed heating value resulted from allowing the meter to stand idle for several days, even though the water had been saturated previously. The magnitude of the effect of the water in the meter not being saturated with gas and the time required to saturate the water probably depend to a considerable extent on the composition of the gas.

5. Adjust temperature of water in supply tank.

6. Start flow of water through calorimeter and expel air from water circulation system.

7. Light gas, adjust rate of gas consumption,[2] adjust air mixer on burner, and insert burner into calorimeter.

8. Adjust water flow and see that the damper, if adjustable, is in proper position, as explained in footnote 2.

9. Allow time for establishment of a steady thermal state.

10. Prepare record sheet and make the preliminary observations of temperature and height of barometer, pressure and temperature of gas in meter, wet- and dry-bulb thermometer readings, temperature of products, and time of revolution of meter index.

11. Begin collection of condensate and record meter reading.

12. Take the first series of observations as follows: Make preliminary notation of water temperatures; shift water; observe series of water temperatures; shift water; make supplemental notation of water temperatures; and weigh the water.

13. Take the second (and later) series of observations.

14. Stop collection of condensate and record meter reading and amount of condensate.

15. Repeat the preliminary observations of operation 10.

16. Turn off gas and then turn off water.

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[2] The tables in this Circular have been computed for gas rates corresponding to 3,000 Btu per hour and 40 percent of excess air. With the calorimeters most widely used, rates of heat input between 2,500 and 3,500 Btu per hour have been found convenient and satisfactory for accurate measurements. If at these rates the flue damper is wide open, the excess air above that required for combustion may be over 100 percent. The excess air is reduced by closing the damper. A well-fitted damper with two ½-inch holes, when in the "closed" position, will allow about 40 percent of excess air to pass through the calorimeter when gas is burned at 3,000 Btu per hour. In some of the older calorimeters the holes in the damper were larger, and it was necessary, in order to reduce the excess air to 40 percent, to operate at rates up to 4,500 Btu per hour, but the need for this high rate could have been eliminated by providing a damper with smaller openings.

Gas analysis should be employed to determine a final adjustment of the gas rate and of the damper, such that about 40 percent more air than is required for combustion passes through the calorimeter.

The damper should then be fixed securely in position, and the rate in Btu per hour, called the "normal rate" in Circular 48, should be subsequently adhered to unless there is evidence of unsatisfactory conditions, such as incomplete combustion or inaccurate measurement of the gas with the meter used.

For testing gases of very low heating value, it is advantageous to use a smaller damper-opening and a rate of heat input considerably less than 3,000 Btu per hour, in order to avoid operating the usual calorimeter meter at rates above 10 cu ft per hour.

The adjustment of the gas rate when the orifice is of a size suitable for the gas under test may be made either by adjusting the pressure of the gas delivered to the burner or by throttling the flow at some point beyond the pressure regulator. When the same calorimeter must be used for testing gases of widely different heating values, it is necessary to change orifices and sometimes also to change the pressure radically, the highest pressures being employed with gases of the highest heating values.

III. TABLES AND OTHER DATA

Barometer certificate correction____
(To be entered by observer)

TABLE 1.—*Corrections for reductions of barometric heights to standard temperature (32° F)*

[In the table are given, for barometric heights of 24, 26, 28, and 30 inches, the amounts, in inches, to be subtracted from the observed readings of a mercurial barometer with brass scale (which is correct at 62° F), to reduce the heights, observed at various temperatures to inches of mercury at 32° F]

Temperature	Observed barometric height, inches—				Temperature	Observed barometric height, inches—			
	24. 0	26. 0	28. 0	30. 0		24. 0	26. 0	28. 0	30. 0
°F									
40	0. 03	0. 03	0. 03	0. 03	75	0. 10	0. 11	0. 12	0. 13
45	. 04	. 04	. 04	. 05	80	. 11	. 12	. 13	. 14
50	. 05	. 05	. 05	. 06	85	. 12	. 13	. 14	. 15
55	. 06	. 06	. 07	. 07					
60	. 07	. 07	. 08	. 09	90	. 13	. 14	. 16	. 17
					95	. 14	. 16	. 17	. 18
65	. 08	. 09	. 09	. 10	100	. 15	. 17	. 18	. 19
70	. 09	. 10	. 11	. 11	105	. 17	. 18	. 19	. 21
					110	. 18	. 19	. 20	. 22

TABLE 2.—*Equivalent pressures, inches water—inches mercury*

(1 inch of mercury=13.6 inches of water)

Water	1. 00	1. 50	2. 00	2. 50	3. 00	3. 50	4. 00	4. 50	5. 00	5. 50	6. 00
Mercury	0. 07	0. 11	0. 15	0. 18	0. 22	0. 26	0. 29	0. 33	0. 37	0. 40	0. 44

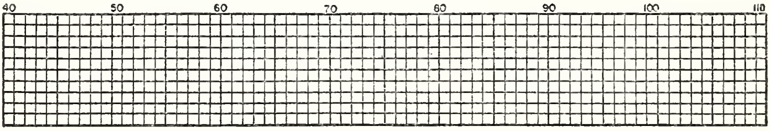

FIGURE 1.—*Scale correction. Meter thermometer No.* ______

TABLE 3.—*Correction factors for gas volume* [1]

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	24.0	24.1	24.2	24.3	24.4	24.5	24.6	24.7	24.8	24.9
32	0.8541	0.8577	0.8613	0.8648	0.8684	0.8720	0.8756	0.8792	0.8828	0.8863
33	.8520	.8556	.8592	.8628	.8664	.8699	.8735	.8771	.8807	.8843
34	.8501	.8537	.8572	.8608	.8644	.8679	.8715	.8751	.8786	.8822
35	.8480	.8516	.8552	.8587	.8623	.8659	.8694	.8730	.8765	.8801
36	.8461	.8496	.8532	.8567	.8603	.8639	.8674	.8710	.8745	.8781
37	.8440	.8476	.8511	.8547	.8582	.8618	.8653	.8689	.8724	.8760
38	.8421	.8456	.8491	.8527	.8562	.8598	.8633	.8669	.8704	.8739
39	.8401	.8436	.8471	.8507	.8542	.8577	.8613	.8648	.8684	.8719
40	.8380	.8415	.8451	.8486	.8521	.8556	.8592	.8627	.8662	.8698
41	.8360	.8395	.8430	.8465	.8501	.8536	.8571	.8606	.8641	.8677
42	.8340	.8375	.8410	.8445	.8480	.8515	.8551	.8586	.8621	.8656
43	.8319	.8354	.8389	.8424	.8460	.8495	.8530	.8565	.8600	.8635
44	.8299	.8334	.8369	.8404	.8439	.8474	.8509	.8544	.8579	.8614
45	.8279	.8313	.8348	.8383	.8418	.8453	.8488	.8523	.8558	.8593
46	.8258	.8293	.8328	.8363	.8398	.8433	.8468	.8502	.8537	.8572
47	.8238	.8272	.8307	.8342	.8377	.8412	.8446	.8481	.8516	.8551
48	.8217	.8252	.8287	.8321	.8356	.8391	.8426	.8460	.8495	.8530
49	.8196	.8231	.8266	.8300	.8335	.8370	.8404	.8439	.8474	.8508
50	.8176	.8210	.8245	.8280	.8314	.8349	.8383	.8418	.8453	.8487
51	.8155	.8189	.8224	.8258	.8293	.8328	.8362	.8397	.8431	.8466
52	.8134	.8169	.8203	.8238	.8272	.8307	.8341	.8376	.8410	.8445
53	.8113	.8147	.8182	.8216	.8251	.8285	.8319	.8354	.8388	.8423
54	.8092	.8127	.8161	.8195	.8230	.8264	.8298	.8333	.8367	.8401
55	.8072	.8106	.8140	.8174	.8209	.8243	.8277	.8311	.8346	.8380
56	.8050	.8084	.8119	.8153	.8187	.8221	.8255	.8289	.8324	.8358
57	.8029	.8063	.8097	.8132	.8166	.8200	.8234	.8268	.8302	.8336
58	.8008	.8042	.8076	.8110	.8144	.8178	.8212	.8246	.8280	.8314
59	.7986	.8020	.8054	.8088	.8122	.8156	.8190	.8224	.8258	.8292
60	.7965	.7998	.8032	.8066	.8100	.8134	.8168	.8202	.8236	.8270
61	.7943	.7977	.8011	.8045	.8079	.8112	.8146	.8180	.8214	.8248
62	.7921	.7955	.7989	.8022	.8056	.8090	.8124	.8158	.8191	.8225
63	.7899	.7933	.7967	.8000	.8034	.8068	.8102	.8135	.8169	.8203
64	.7877	.7911	.7944	.7978	.8012	.8045	.8079	.8113	.8146	.8180
65	.7855	.7889	.7922	.7956	.7990	.8023	.8057	.8090	.8124	.8158
66	.7833	.7866	.7900	.7933	.7967	.8000	.8034	.8067	.8101	.8134
67	.7810	.7844	.7877	.7911	.7944	.7978	.8011	.8045	.8078	.8112
68	.7787	.7821	.7854	.7887	.7921	.7954	.7988	.8021	.8055	.8088
69	.7765	.7798	.7832	.7865	.7898	.7932	.7965	.7998	.8032	.8065
70	.7742	.7775	.7808	.7841	.7875	.7908	.7941	.7975	.8008	.8041

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at t°; t=temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume*[1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	24. 0	24. 1	24. 2	24. 3	24. 4	24. 5	24. 6	24. 7	24. 8	24. 9
71	0. 7719	0. 7752	0. 7785	0. 7818	0. 7852	0. 7885	0. 7918	0. 7951	0. 7984	0. 8018
72	. 7696	. 7729	. 7762	. 7795	. 7828	. 7861	. 7894	. 7928	. 7961	. 7994
73	. 7672	. 7705	. 7738	. 7771	. 7804	. 7838	. 7871	. 7904	. 7937	. 7970
74	. 7648	. 7682	. 7715	. 7748	. 7781	. 7814	. 7847	. 7880	. 7913	. 7946
75	. 7625	. 7658	. 7691	. 7724	. 7757	. 7790	. 7823	. 7856	. 7889	. 7921
76	. 7600	. 7633	. 7666	. 7699	. 7732	. 7765	. 7798	. 7831	. 7864	. 7897
77	. 7577	. 7609	. 7642	. 7675	. 7708	. 7741	. 7774	. 7806	. 7839	. 7872
78	. 7552	. 7585	. 7618	. 7651	. 7684	. 7716	. 7749	. 7782	. 7815	. 7848
79	. 7528	. 7560	. 7593	. 7626	. 7659	. 7691	. 7724	. 7757	. 7790	. 7822
80	. 7503	. 7536	. 7568	. 7601	. 7634	. 7666	. 7699	. 7732	. 7764	. 7797
81	. 7478	. 7510	. 7543	. 7576	. 7608	. 7641	. 7673	. 7706	. 7739	. 7771
82	. 7452	. 7485	. 7518	. 7550	. 7583	. 7615	. 7648	. 7680	. 7713	. 7745
83	. 7427	. 7459	. 7492	. 7524	. 7557	. 7589	. 7622	. 7654	. 7687	. 7719
84	. 7401	. 7434	. 7466	. 7499	. 7531	. 7564	. 7596	. 7628	. 7661	. 7693
85	. 7375	. 7407	. 7440	. 7472	. 7505	. 7537	. 7569	. 7602	. 7634	. 7666
86	. 7349	. 7381	. 7414	. 7446	. 7478	. 7511	. 7543	. 7575	. 7608	. 7640
87	. 7322	. 7354	. 7387	. 7419	. 7451	. 7483	. 7516	. 7548	. 7580	. 7612
88	. 7296	. 7328	. 7360	. 7392	. 7424	. 7456	. 7489	. 7521	. 7553	. 7585
89	. 7269	. 7301	. 7333	. 7365	. 7397	. 7429	. 7461	. 7493	. 7526	. 7558
90	. 7241	. 7273	. 7305	. 7337	. 7370	. 7402	. 7434	. 7466	. 7498	. 7530
91	. 7213	. 7246	. 7278	. 7310	. 7342	. 7374	. 7406	. 7438	. 7470	. 7502
92	. 7186	. 7218	. 7250	. 7282	. 7314	. 7346	. 7378	. 7410	7441	. 7473
93	. 7157	. 7189	. 7221	. 7253	. 7285	. 7317	. 7349	. 7381	. 7413	. 7444
94	. 7129	. 7161	. 7193	. 7274	. 7256	. 7288	. 7320	. 7352	. 7384	. 7416
95	. 7100	. 7132	. 7164	. 7195	. 7227	. 7259	. 7291	. 7322	. 7354	. 7386
96	. 7071	. 7103	. 7135	. 7166	. 7198	. 7230	. 7261	. 7293	. 7325	. 7357
97	. 7041	. 7073	. 7105	. 7136	. 7168	. 7200	. 7231	. 7263	. 7295	. 7326
98	. 7012	. 7043	. 7075	. 7107	. 7138	. 7170	. 7201	. 7233	. 7265	. 7296
99	. 6981	. 7013	. 7044	. 7076	. 7107	. 7139	. 7170	. 7202	. 7234	. 7265
100	. 6951	. 6983	. 7014	. 7046	. 7077	. 7109	. 7140	. 7172	. 7203	. 7235
101	. 6920	. 6952	. 6983	. 7015	. 7046	. 7077	. 7109	. 7140	. 7172	. 7203
102	. 6889	. 6920	. 6951	. 6983	. 7014	. 7046	. 7077	. 7108	. 7140	. 7171
103	. 6857	. 6888	. 6920	. 6951	. 6982	. 7014	. 7045	. 7076	. 7108	. 7139
104	. 6825	. 6856	. 6887	. 6919	. 6950	. 6981	. 7012	. 7044	. 7075	. 7106
105	. 6792	. 6824	. 6855	. 6886	. 6917	. 6949	. 6980	. 7011	. 7042	. 7073
106	. 6760	. 6791	. 6822	. 6853	. 6884	. 6915	. 6947	. 6978	. 7009	. 7040
107	. 6726	. 6757	. 6788	. 6820	. 6851	. 6882	. 6913	. 6944	. 6975	. 7006
108	. 6693	. 6724	. 6755	. 6786	. 6817	. 6848	. 6879	. 6910	. 6941	. 6972
109	. 6659	. 6690	. 6721	. 6752	. 6783	. 6814	. 6845	. 6876	. 6907	. 6938
110	. 6624	. 6655	. 6686	. 6717	. 6748	. 6779	. 6809	. 6840	. 6871	. 6902

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[1] Formula used: Correction factor$=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$.

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	25.0	25.1	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9
32	0. 8899	0. 8935	0. 8971	0. 9007	0. 9043	0. 9079	0. 9114	0. 9150	0. 9186	0. 9222
33	. 8878	. 8914	. 8950	. 8986	. 9021	. 9057	. 9093	. 9129	. 9165	. 9200
34	. 8858	. 8894	. 8929	. 8965	. 9001	. 9036	. 9072	. 9108	. 9144	. 9179
35	. 8837	. 8872	. 8908	. 8944	. 8979	. 9015	. 9051	. 9086	. 9122	. 9157
36	. 8816	. 8852	. 8888	. 8923	. 8959	. 8994	. 9030	. 9065	. 9101	. 9137
37	. 8795	. 8831	. 8866	. 8902	. 8937	. 8973	. 9008	. 9044	. 9079	. 9115
38	. 8775	. 8810	. 8846	. 8881	. 8917	. 8952	. 8987	. 9023	. 9058	. 9094
39	. 8754	. 8790	. 8825	. 8860	. 8896	. 8931	. 8966	. 9002	. 9037	. 9072
40	. 8733	. 8768	. 8803	. 8839	. 8874	. 8909	. 8945	. 8980	. 9015	. 9050
41	. 8712	. 8747	. 8782	. 8817	. 8853	. 8888	. 8923	. 8958	. 8993	. 9029
42	. 8691	. 8726	. 8761	. 8797	. 8832	. 8867	. 8902	. 8937	. 8972	. 9007
43	. 8670	. 8705	. 8740	. 8775	. 8810	. 8845	. 8880	. 8915	. 8950	. 8986
44	. 8649	. 8684	. 8719	. 8754	. 8789	. 8824	. 8859	. 8894	. 8929	. 8964
45	. 8628	. 8663	. 8698	. 8733	. 8768	. 8803	. 8837	. 8872	. 8907	. 8942
46	. 8607	. 8642	. 8677	. 8712	. 8746	. 8781	. 8816	. 8851	. 8886	. 8921
47	. 8586	. 8620	. 8655	. 8690	. 8725	. 8759	. 8794	. 8829	. 8864	. 8899
48	. 8564	. 8599	. 8634	. 8669	. 8703	. 8738	. 8773	. 8807	. 8842	. 8877
49	. 8543	. 8578	. 8612	. 8647	. 8682	. 8716	. 8751	. 8786	. 8820	. 8855
50	. 8522	. 8556	. 8591	. 8626	. 8660	. 8695	. 8729	. 8764	. 8799	. 8833
51	. 8500	. 8535	. 8569	. 8604	. 8638	. 8673	. 8707	. 8742	. 8776	. 8811
52	. 8479	. 8513	. 8548	. 8582	. 8617	. 8651	. 8686	. 8720	. 8755	. 8789
53	. 8457	. 8491	. 8526	. 8560	. 8594	. 8629	. 8663	. 8698	. 8732	. 8766
54	. 8436	. 8470	. 8504	. 8538	. 8573	. 8607	. 8641	. 8676	. 8710	. 8744
55	. 8414	. 8448	. 8483	. 8517	. 8551	. 8585	. 8620	. 8654	. 8688	. 8723
56	. 8392	. 8426	. 8460	. 8495	. 8529	. 8563	. 8597	. 8631	. 8666	. 8700
57	. 8370	. 8405	. 8439	. 8473	. 8507	. 8541	. 8575	. 8609	. 8643	. 8677
58	. 8348	. 8382	. 8416	. 8450	. 8484	. 8518	. 8552	. 8586	. 8621	. 8655
59	. 8326	. 8360	. 8394	. 8428	. 8462	. 8496	. 8530	. 8564	. 8598	. 8632
60	. 8304	. 8338	. 8372	. 8406	. 8439	. 8473	. 8507	. 8541	. 8575	. 8609
61	. 8282	. 8316	. 8349	. 8383	. 8417	. 8451	. 8485	. 8519	. 8553	. 8586
62	. 8259	. 8293	. 8327	. 8360	. 8394	. 8428	. 8462	. 8496	. 8529	. 8563
63	. 8237	. 8270	. 8304	. 8338	. 8371	. 8405	. 8439	. 8473	. 8506	. 8540
64	. 8214	. 8247	. 8281	. 8315	. 8348	. 8382	. 8416	. 8449	. 8483	. 8517
65	. 8191	. 8225	. 8258	. 8292	. 8326	. 8359	. 8393	. 8426	. 8460	. 8494
66	. 8168	. 8201	. 8235	. 8269	. 8302	. 8336	. 8369	. 8403	. 8436	. 8470
67	. 8145	. 8178	. 8212	. 8245	. 8279	. 8312	. 8346	. 8379	. 8413	. 8446
68	. 8121	. 8155	. 8188	. 8222	. 8255	. 8288	. 8322	. 8355	. 8389	. 8422
69	. 8098	. 8132	. 8165	. 8198	. 8232	. 8265	. 8298	. 8332	. 8365	. 8398
70	. 8074	. 8108	. 8141	. 8174	. 8208	. 8241	. 8274	. 8307	. 8341	. 8374

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P = total gas pressure; E = vapor pressure of water at t°; t = temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	25.0	25.1	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9
71	0.8051	0.8084	0.8117	0.8151	0.8184	0.8217	0.8250	0.8283	0.8317	0.8350
72	.8027	.8060	.8093	.8127	.8160	.8193	.8226	.8259	.8292	.8326
73	.8003	.8036	.8069	.8102	.8135	.8169	.8202	.8235	.8268	.8301
74	.7979	.8012	.8045	.8078	.8111	.8144	.8177	.8210	.8243	.8276
75	.7954	.7987	.8020	.8053	.8086	.8119	.8152	.8185	.8218	.8251
76	.7929	.7962	.7995	.8028	.8061	.8094	.8127	.8160	.8193	.8226
77	.7905	.7938	.7971	.8004	.8036	.8069	.8102	.8135	.8168	.8201
78	.7880	.7913	.7946	.7979	.8011	.8044	.8077	.8110	.8143	.8175
79	.7855	.7888	.7920	.7953	.7986	.8019	.8051	.8084	.8117	.8150
80	.7830	.7862	.7895	.7928	.7960	.7993	.8026	.8058	.8091	.8124
81	.7804	.7836	.7869	.7902	.7934	.7967	.7999	.8032	.8065	.8097
82	.7778	.7810	.7843	.7876	.7908	.7941	.7973	.8006	.8038	.8071
83	.7752	.7784	.7817	.7849	.7882	.7914	.7947	.7979	.8011	.8044
84	.7726	.7758	.7791	.7823	.7855	.7888	.7920	.7953	.7985	.8018
85	.7699	.7731	.7763	.7796	.7828	.7861	.7893	.7925	.7958	.7990
86	.7672	.7705	.7737	.7769	.7801	.7834	.7866	.7898	.7931	.7963
87	.7645	.7677	.7709	.7741	.7774	.7806	.7838	.7870	.7903	.7935
88	.7617	.7650	.7682	.7714	.7746	.7778	.7811	.7843	.7875	.7907
89	.7590	.7622	.7654	.7686	.7718	.7750	.7783	.7815	.7847	.7879
90	.7562	.7594	.7626	.7658	.7690	.7722	.7754	.7787	.7819	.7851
91	.7534	.7566	.7598	.7630	.7662	.7694	.7726	.7758	.7790	.7822
92	.7505	.7537	.7569	.7601	.7633	.7665	.7697	.7729	.7761	.7793
93	.7476	.7508	.7540	.7572	.7604	.7636	.7668	.7700	.7731	.7763
94	.7447	.7479	.7511	.7543	.7575	.7607	.7638	.7670	.7702	.7734
95	.7418	.7450	.7481	.7513	.7545	.7577	.7608	.7640	.7672	.7704
96	.7388	.7420	.7452	.7483	.7515	.7547	.7579	.7610	.7642	.7674
97	.7358	.7390	.7421	.7453	.7485	.7516	.7548	.7580	.7611	.7643
98	.7328	.7359	.7391	.7423	.7454	.7486	.7517	.7549	.7581	.7612
99	.7297	.7328	.7360	.7391	.7423	.7454	.7486	.7518	.7549	.7581
100	.7266	.7298	.7329	.7361	.7392	.7424	.7455	.7487	.7518	.7550
101	.7235	.7266	.7298	.7329	.7360	.7392	.7423	.7455	.7486	.7518
102	.7203	.7234	.7265	.7297	.7328	.7360	.7391	.7422	.7454	.7485
103	.7170	.7202	.7233	.7264	.7296	.7327	.7358	.7390	.7421	.7452
104	.7138	.7169	.7200	.7231	.7263	.7294	.7325	.7356	.7388	.7419
105	.7105	.7136	.7167	.7198	.7230	.7261	.7292	.7323	.7354	.7386
106	.7071	.7102	.7134	.7165	.7196	.7227	.7258	.7289	.7321	.7352
107	.7037	.7068	.7100	.7131	.7162	.7193	.7224	.7255	.7286	.7317
108	.7003	.7034	.7065	.7096	.7127	.7158	.7189	.7221	.7252	.7283
109	.6969	.7000	.7031	.7062	.7093	.7124	.7155	.7186	.7217	.7248
110	.6933	.6964	.6995	.7026	.7057	.7088	.7119	.7150	.7181	.7212

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[1] Formula used: Correction factor $=\dfrac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	26.0	26.1	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9
32	0.9258	0.9294	0.9330	0.9365	0.9401	0.9437	0.9473	0.9509	0.9545	0.9581
33	.9236	.9272	.9308	.9343	.9379	.9415	.9451	.9487	.9522	.9558
34	.9215	.9251	.9286	.9322	.9358	.9394	.9429	.9465	.9501	.9536
35	.9193	.9229	.9264	.9300	.9336	.9371	.9407	.9443	.9478	.9514
36	.9172	.9208	.9243	.9279	.9314	.9350	.9386	.9421	.9457	.9492
37	.9150	.9186	.9221	.9257	.9292	.9328	.9363	.9399	.9434	.9470
38	.9129	.9165	.9200	.9235	.9271	.9306	.9342	.9377	.9412	.9448
39	.9108	.9143	.9178	.9214	.9249	.9285	.9320	.9355	.9391	.9426
40	.9086	.9121	.9156	.9191	.9227	.9262	.9297	.9333	.9368	.9403
41	.9064	.9099	.9134	.9170	.9205	.9240	.9275	.9310	.9346	.9381
42	.9043	.9078	.9113	.9148	.9183	.9218	.9253	.9289	.9324	.9359
43	.9021	.9056	.9091	.9126	.9161	.9196	.9231	.9266	.9301	.9336
44	.8999	.9034	.9069	.9104	.9139	.9174	.9209	.9244	.9279	.9314
45	.8977	.9012	.9047	.9082	.9117	.9152	.9187	.9222	.9257	.9292
46	.8956	.8990	.9025	.9060	.9095	.9130	.9165	.9200	.9235	.9269
47	.8933	.8968	.9003	.9038	.9073	.9107	.9142	.9177	.9212	.9247
48	.8912	.8946	.8981	.9016	.9051	.9085	.9120	.9155	.9189	.9224
49	.8890	.8924	.8959	.8993	.9028	.9063	.9097	.9132	.9167	.9201
50	.8868	.8902	.8937	.8971	.9006	.9041	.9075	.9110	.9144	.9179
51	.8845	.8880	.8914	.8949	.8983	.9018	.9052	.9087	.9121	.9156
52	.8824	.8858	.8892	.8927	.8961	.8996	.9030	.9065	.9099	.9134
53	.8801	.8835	.8870	.8904	.8938	.8973	.9007	.9042	.9076	.9110
54	.8779	.8813	.8847	.8882	.8916	.8950	.8985	.9019	.9053	.9088
55	.8757	.8791	.8825	.8860	.8894	.8928	.8962	.8997	.9031	.9065
56	.8734	.8768	.8802	.8836	.8871	.8905	.8939	.8973	.9007	.9042
57	.8712	.8746	.8780	.8814	.8848	.8882	.8916	.8950	.8985	.9019
58	.8689	.8723	.8757	.8791	.8825	.8859	.8893	.8927	.8961	.8995
59	.8666	.8700	.8734	.8768	.8802	.8836	.8870	.8904	.8938	.8972
60	.8643	.8677	.8711	.8745	.8779	.8813	.8847	.8880	.8914	.8948
61	.8620	.8654	.8688	.8722	.8756	.8790	.8823	.8857	.8891	.8925
62	.8597	.8631	.8664	.8698	.8732	.8766	.8800	.8833	.8867	.8901
63	.8574	.8608	.8641	.8675	.8709	.8742	.8776	.8810	.8844	.8877
64	.8550	.8584	.8618	.8651	.8685	.8719	.8752	.8786	.8820	.8853
65	.8527	.8561	.8594	.8628	.8662	.8695	.8729	.8762	.8796	.8830
66	.8503	.8537	.8570	.8604	.8637	.8671	.8705	.8738	.8772	.8805
67	.8480	.8513	.8547	.8580	.8614	.8647	.8681	.8714	.8747	.8781
68	.8455	.8489	.8522	.8556	.8589	.8622	.8656	.8689	.8723	.8756
69	.8432	.8465	.8498	.8532	.8565	.8598	.8632	.8665	.8699	.8732
70	.8407	.8441	.8474	.8507	.8540	.8574	.8607	.8640	.8674	.8707

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at t°; t=temperature of gas (°F).

Table 3.—*Correction factors for gas volume*[1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	26.0	26.1	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9
71	0.8383	0.8416	0.8450	0.8483	0.8516	0.8549	0.8582	0.8616	0.8649	0.8682
72	.8359	.8392	.8425	.8458	.8491	.8524	.8558	.8591	.8624	.8657
73	.8334	.8367	.8400	.8433	.8466	.8499	.8533	.8566	.8599	.8632
74	.8309	.8342	.8375	.8408	.8441	.8474	.8507	.8540	.8573	.8606
75	.8284	.8317	.8350	.8383	.8416	.8449	.8482	.8515	.8548	.8581
76	.8259	.8291	.8324	.8357	.8390	.8423	.8456	.8489	.8522	.8555
77	.8234	.8266	.8299	.8332	.8365	.8398	.8431	.8463	.8496	.8529
78	.8208	.8241	.8274	.8307	.8339	.8372	.8405	.8438	.8471	.8503
79	.8182	.8215	.8248	.8280	.8313	.8346	.8379	.8411	.8444	.8477
80	.8156	.8189	.8222	.8254	.8287	.8320	.8352	.8385	.8418	.8450
81	.8130	.8162	.8195	.8228	.8260	.8293	.8325	.8358	.8391	.8423
82	.8103	.8136	.8168	.8201	.8234	.8266	.8299	.8331	.8364	.8396
83	.8076	.8109	.8141	.8174	.8206	.8239	.8271	.8304	.8336	.8369
84	.8050	.8082	.8115	.8147	.8180	.8212	.8244	.8277	.8309	.8342
85	.8022	.8055	.8087	.8119	.8152	.8184	.8217	.8249	.8281	.8314
86	.7995	.8028	.8060	.8092	.8125	.8157	.8189	.8221	.8254	.8286
87	.7967	.7999	.8032	.8064	.8096	.8128	.8161	.8193	.8225	.8257
88	.7939	.7972	.8004	.8036	.8068	.8100	.8132	.8165	.8197	.8229
89	.7911	.7943	.7975	.8008	.8040	.8072	.8104	.8136	.8168	.8200
90	.7883	.7915	.7947	.7979	.8011	.8043	.8075	.8107	.8139	.8171
91	.7854	.7886	.7918	.7950	.7982	.8014	.8046	.8078	.8110	.8142
92	.7825	.7857	.7889	.7921	.7953	.7985	.8017	.8049	.8081	.8113
93	.7795	.7827	.7859	.7891	.7923	.7955	.7987	.8019	.8050	.8082
94	.7766	.7798	.7829	.7861	.7893	.7925	.7957	.7989	.8020	.8052
95	.7736	.7767	.7799	.7831	.7863	.7895	.7926	.7958	.7990	.8022
96	.7706	.7737	.7769	.7801	.7832	.7864	.7896	.7928	.7959	.7991
97	.7675	.7706	.7738	.7770	.7801	.7833	.7865	.7896	.7928	.7960
98	.7644	.7676	.7707	.7739	.7770	.7802	.7834	.7865	.7897	.7928
99	.7612	.7644	.7675	.7707	.7738	.7770	.7802	.7833	.7865	.7896
100	.7581	.7613	.7644	.7676	.7707	.7739	.7770	.7802	.7833	.7865
101	.7549	.7581	.7612	.7643	.7675	.7706	.7738	.7769	.7801	.7832
102	.7516	.7548	.7579	.7611	.7642	.7673	.7705	.7736	.7768	.7799
103	.7484	.7515	.7546	.7578	.7609	.7640	.7672	.7703	.7734	.7766
104	.7450	.7482	.7513	.7544	.7575	.7607	.7638	.7669	.7700	.7732
105	.7417	.7448	.7479	.7511	.7542	.7573	.7604	.7635	.7667	.7698
106	.7383	.7414	.7445	.7476	.7508	.7539	.7570	.7601	.7632	.7663
107	.7348	.7380	.7411	.7442	.7473	.7504	.7535	.7566	.7597	.7628
108	.7314	.7345	.7376	.7407	.7438	.7469	.7500	.7531	.7562	.7593
109	.7279	.7310	.7341	.7372	.7403	.7434	.7465	.7496	.7527	.7558
110	.7243	.7274	.7305	.7336	.7366	.7397	.7428	.7459	.7490	.7521

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at t°; t=temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume*[1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	27. 0	27. 1	27. 2	27. 3	27. 4	27. 5	27. 6	27. 7	27. 8	27. 9
32	0. 9616	0. 9652	0. 9688	0. 9724	0. 9760	0. 9796	0. 9832	0. 9867	0. 9903	0. 9939
33	. 9594	. 9630	. 9666	. 9701	. 9737	. 9773	. 9809	. 9844	. 9880	. 9916
34	. 9572	. 9608	. 9644	. 9679	. 9715	. 9751	. 9786	. 9822	. 9858	. 9894
35	. 9549	. 9585	. 9621	. 9656	. 9692	. 9728	. 9763	. 9799	. 9835	. 9870
36	. 9528	. 9563	. 9599	. 9634	. 9670	. 9706	. 9741	. 9777	. 9812	. 9848
37	. 9505	. 9541	. 9576	. 9612	. 9647	. 9683	. 9718	. 9754	. 9789	. 9825
38	. 9483	. 9519	. 9554	. 9590	. 9625	. 9660	. 9696	. 9731	. 9767	. 9802
39	. 9461	. 9497	. 9532	. 9567	. 9603	. 9638	. 9673	. 9709	. 9744	. 9780
40	. 9438	. 9474	. 9509	. 9544	. 9580	. 9615	. 9650	. 9685	. 9721	. 9756
41	. 9416	. 9451	. 9486	. 9522	. 9557	. 9592	. 9627	. 9662	. 9698	. 9733
42	. 9394	. 9429	. 9464	. 9499	. 9535	. 9570	. 9605	. 9640	. 9675	. 9710
43	. 9371	. 9406	. 9441	. 9477	. 9512	. 9547	. 9582	. 9617	. 9652	. 9687
44	. 9349	. 9384	. 9419	. 9454	. 9489	. 9524	. 9559	. 9594	. 9629	. 9664
45	. 9326	. 9361	. 9396	. 9431	. 9466	. 9501	. 9536	. 9571	. 9606	. 9641
46	. 9304	. 9339	. 9374	. 9409	. 9444	. 9479	. 9513	. 9548	. 9583	. 9618
47	. 9281	. 9316	. 9351	. 9386	. 9421	. 9455	. 9490	. 9525	. 9560	. 9595
48	. 9259	. 9294	. 9328	. 9363	. 9398	. 9433	. 9467	. 9502	. 9537	. 9571
49	. 9236	. 9271	. 9305	. 9340	. 9375	. 9409	. 9444	. 9479	. 9513	. 9548
50	. 9214	. 9248	. 9283	. 9317	. 9352	. 9387	. 9421	. 9456	. 9490	. 9525
51	. 9191	. 9225	. 9260	. 9294	. 9329	. 9363	. 9398	. 9432	. 9467	. 9501
52	. 9168	. 9203	. 9237	. 9271	. 9306	. 9340	. 9375	. 9409	. 9444	. 9478
53	. 9145	. 9179	. 9213	. 9248	. 9282	. 9317	. 9351	. 9385	. 9420	. 9454
54	. 9122	. 9156	. 9191	. 9225	. 9259	. 9294	. 9328	. 9362	. 9396	. 9431
55	. 9099	. 9134	. 9168	. 9202	. 9236	. 9271	. 9305	. 9339	. 9373	. 9408
56	. 9076	. 9110	. 9144	. 9178	. 9212	. 9247	. 9281	. 9315	. 9349	. 9383
57	. 9053	. 9087	. 9121	. 9155	. 9189	. 9223	. 9258	. 9292	. 9326	. 9360
58	. 9029	. 9063	. 9097	. 9131	. 9165	. 9199	. 9234	. 9268	. 9302	. 9336
59	. 9006	. 9040	. 9074	. 9108	. 9142	. 9176	. 9210	. 9244	. 9278	. 9312
60	. 8982	. 9016	. 9050	. 9084	. 9118	. 9152	. 9186	. 9220	. 9254	. 9288
61	. 8959	. 8993	. 9027	. 9060	. 9094	. 9128	. 9162	. 9196	. 9230	. 9264
62	. 8935	. 8969	. 9002	. 9036	. 9070	. 9104	. 9138	. 9171	. 9205	. 9239
63	. 8911	. 8945	. 8979	. 9012	. 9046	. 9080	. 9114	. 9147	. 9181	. 9215
64	. 8887	. 8921	. 8954	. 8988	. 9022	. 9055	. 9089	. 9123	. 9156	. 9190
65	. 8863	. 8897	. 8930	. 8964	. 8998	. 9031	. 9065	. 9098	. 9132	. 9166
66	. 8839	. 8872	. 8906	. 8939	. 8973	. 9006	. 9040	. 9073	. 9107	. 9141
67	. 8814	. 8848	. 8881	. 8915	. 8948	. 8982	. 9015	. 9049	. 9082	. 9116
68	. 8790	. 8823	. 8856	. 8890	. 8923	. 8957	. 8990	. 9023	. 9057	. 9090
69	. 8765	. 8799	. 8832	. 8865	. 8899	. 8932	. 8965	. 8999	. 9032	. 9065
70	. 8740	. 8773	. 8807	. 8840	. 8873	. 8906	. 8940	. 8973	. 9006	. 9040

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[1] Formula used: Correction factor $= \frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P = total gas pressure; E = vapor pressure of water at $t°$; t = temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume*[1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	27. 0	27. 1	27. 2	27. 3	27. 4	27. 5	27. 6	27. 7	27. 8	27. 9
71	0. 8715	0. 8749	0. 8782	0. 8815	0. 8848	0. 8881	0. 8915	0. 8948	0. 8981	0. 9014
72	. 8690	. 8723	. 8757	. 8790	. 8823	. 8856	. 8889	. 8922	. 8956	. 8989
73	. 8665	. 8698	. 8731	. 8764	. 8797	. 8830	. 8864	. 8897	. 8930	. 8963
74	. 8639	. 8673	. 8706	. 8739	. 8772	. 8805	. 8838	. 8871	. 8904	. 8937
75	. 8614	. 8647	. 8680	. 8713	. 8746	. 8779	. 8812	. 8845	. 8878	. 8911
76	. 8588	. 8621	. 8653	. 8686	. 8719	. 8752	. 8785	. 8818	. 8851	. 8884
77	. 8562	. 8595	. 8628	. 8661	. 8693	. 8726	. 8759	. 8792	. 8825	. 8858
78	. 8536	. 8569	. 8602	. 8634	. 8667	. 8700	. 8733	. 8766	. 8798	. 8831
79	. 8510	. 8542	. 8575	. 8608	. 8640	. 8673	. 8706	. 8739	. 8771	. 8804
80	. 8483	. 8516	. 8548	. 8581	. 8614	. 8646	. 8679	. 8712	. 8744	. 8777
81	. 8456	. 8488	. 8521	. 8554	. 8586	. 8619	. 8652	. 8684	. 8717	. 8749
82	. 8429	. 8461	. 8494	. 8526	. 8559	. 8592	. 8624	. 8657	. 8689	. 8722
83	. 8401	. 8434	. 8466	. 8499	. 8531	. 8564	. 8596	. 8629	. 8661	. 8694
84	. 8374	. 8407	. 8439	. 8471	. 8504	. 8536	. 8569	. 8601	. 8634	. 8666
85	. 8346	. 8378	. 8411	. 8443	. 8476	. 8508	. 8540	. 8573	. 8605	. 8637
86	. 8318	. 8351	. 8383	. 8415	. 8448	. 8480	. 8512	. 8545	. 8577	. 8609
87	. 8290	. 8322	. 8354	. 8386	. 8419	. 8451	. 8483	. 8515	. 8548	. 8580
88	. 8261	. 8293	. 8326	. 8358	. 8390	. 8422	. 8454	. 8487	. 8519	. 8551
89	. 8232	. 8265	. 8297	. 8329	. 8361	. 8393	. 8425	. 8457	. 8489	. 8522
90	. 8203	. 8236	. 8268	. 8300	. 8332	. 8364	. 8396	. 8428	. 8460	. 8492
91	. 8174	. 8206	. 8238	. 8270	. 8302	. 8334	. 8366	. 8398	. 8430	. 8462
92	. 8144	. 8176	. 8208	. 8240	. 8272	. 8304	. 8336	. 8368	. 8400	. 8432
93	. 8114	. 8146	. 8178	. 8210	. 8242	. 8274	. 8306	. 8338	. 8369	. 8401
94	. 8084	. 8116	. 8148	. 8180	. 8212	. 8243	. 8275	. 8307	. 8339	. 8371
95	. 8053	. 8085	. 8117	. 8149	. 8181	. 8212	. 8244	. 8276	. 8308	. 8339
96	. 8023	. 8055	. 8086	. 8118	. 8150	. 8181	. 8213	. 8245	. 8277	. 8308
97	. 7991	. 8023	. 8055	. 8086	. 8118	. 8150	. 8181	. 8213	. 8245	. 8276
98	. 7960	. 7992	. 8023	. 8055	. 8086	. 8118	. 8150	. 8181	. 8213	. 8245
99	. 7928	. 7959	. 7991	. 8022	. 8054	. 8086	. 8117	. 8149	. 8180	. 8212
100	. 7896	. 7928	. 7959	. 7991	. 8022	. 8054	. 8085	. 8117	. 8148	. 8180
101	. 7864	. 7895	. 7926	. 7958	. 7989	. 8021	. 8052	. 8084	. 8115	. 8147
102	. 7830	. 7862	. 7893	. 7924	. 7956	. 7987	. 8019	. 8050	. 8081	. 8113
103	. 7797	. 7828	. 7860	. 7891	. 7922	. 7954	. 7985	. 8016	. 8048	. 8079
104	. 7763	. 7794	. 7826	. 7857	. 7888	. 7919	. 7951	. 7982	. 8013	. 8045
105	. 7729	. 7760	. 7791	. 7823	. 7854	. 7885	. 7916	. 7948	. 7979	. 8010
106	. 7695	. 7726	. 7757	. 7788	. 7819	. 7850	. 7882	. 7913	. 7944	. 7975
107	. 7660	. 7691	. 7722	. 7753	. 7784	. 7815	. 7846	. 7877	. 7908	. 7940
108	. 7624	. 7655	. 7686	. 7717	. 7748	. 7780	. 7811	. 7842	. 7873	. 7904
109	. 7589	. 7620	. 7651	. 7682	. 7713	. 7744	. 7775	. 7806	. 7837	. 7868
110	. 7552	. 7583	. 7614	. 7645	. 7676	. 7707	. 7738	. 7769	. 7800	. 7831

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

Table 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F.]

Temperature, °F	Total gas pressure—Inches of mercury									
	28.0	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	28.9
32	0.9975	1.0011	1.0047	1.0083	1.0118	1.0154	1.0190	1.0226	1.0262	1.0298
33	.9952	0.9988	1.0023	1.0059	1.0095	1.0131	1.0166	1.0202	1.0238	1.0274
34	.9929	.9965	1.0001	1.0036	1.0072	1.0108	1.0143	1.0179	1.0215	1.0251
35	.9906	.9941	0.9977	1.0013	1.0048	1.0084	1.0120	1.0155	1.0191	1.0227
36	.9883	.9919	.9955	0.9990	1.0026	1.0061	1.0097	1.0132	1.0168	1.0204
37	.9860	.9896	.9931	.9967	1.0002	1.0038	1.0073	1.0109	1.0144	1.0180
38	.9838	.9873	.9908	.9944	0.9979	1.0015	1.0050	1.0086	1.0121	1.0156
39	.9815	.9850	.9886	.9921	.9956	0.9992	1.0027	1.0062	1.0098	1.0133
40	.9791	.9827	.9862	.9897	.9932	.9968	1.0003	1.0038	1.0074	1.0109
41	.9768	.9803	.9839	.9874	.9909	.9944	0.9979	1.0015	1.0050	1.0085
42	.9745	.9781	.9816	.9851	.9886	.9921	.9956	0.9991	1.0027	1.0062
43	.9722	.9757	.9792	.9827	.9862	.9897	.9932	.9968	1.0003	1.0038
44	.9699	.9734	.9769	.9804	.9839	.9874	.9909	.9944	0.9979	1.0014
45	.9676	.9711	.9746	.9781	.9816	.9850	.9885	.9920	.9955	0.9990
46	.9653	.9688	.9723	.9757	.9792	.9827	.9862	.9897	.9932	.9967
47	.9629	.9664	.9699	.9734	.9768	.9803	.9838	.9873	.9908	.9942
48	.9606	.9641	.9676	.9710	.9745	.9780	.9815	.9849	.9884	.9919
49	.9583	.9617	.9652	.9687	.9721	.9756	.9791	.9825	.9860	.9895
50	.9560	.9594	.9629	.9663	.9698	.9732	.9767	.9802	.9836	.9871
51	.9536	.9570	.9605	.9639	.9674	.9708	.9743	.9777	.9812	.9846
52	.9513	.9547	.9582	.9616	.9650	.9685	.9719	.9754	.9788	.9823
53	.9489	.9523	.9557	.9592	.9626	.9660	.9695	.9729	.9764	.9798
54	.9465	.9499	.9534	.9568	.9602	.9637	.9671	.9705	.9740	.9774
55	.9442	.9476	.9510	.9545	.9579	.9613	.9647	.9682	.9716	.9750
56	.9418	.9452	.9486	.9520	.9554	.9589	.9623	.9657	.9691	.9725
57	.9394	.9428	.9462	.9496	.9531	.9565	.9599	.9633	.9667	.9701
58	.9370	.9404	.9438	.9472	.9506	.9540	.9574	.9608	.9642	.9676
59	.9346	.9380	.9414	.9448	.9482	.9516	.9550	.9584	.9618	.9652
60	.9321	.9355	.9389	.9423	.9457	.9491	.9525	.9559	.9593	.9627
61	.9297	.9331	.9365	.9399	.9433	.9467	.9501	.9534	.9568	.9602
62	.9273	.9307	.9340	.9374	.9408	.9442	.9476	.9509	.9543	.9577
63	.9248	.9282	.9316	.9350	.9383	.9417	.9451	.9485	.9518	.9552
64	.9224	.9257	.9291	.9325	.9358	.9392	.9426	.9459	.9493	.9527
65	.9199	.9233	.9266	.9300	.9334	.9367	.9401	.9434	.9468	.9502
66	.9174	.9208	.9241	.9275	.9308	.9342	.9375	.9409	.9442	.9476
67	.9149	.9183	.9216	.9250	.9283	.9317	.9350	.9383	.9417	.9450
68	.9124	.9157	.9190	.9224	.9257	.9291	.9324	.9357	.9391	.9424
69	.9099	.9132	.9165	.9199	.9232	.9265	.9299	.9332	.9365	.9399
70	.9073	.9106	.9139	.9173	.9206	.9239	.9273	.9306	.9339	.9372

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[1] Formula used: Correction factor $=\dfrac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

Table 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	28.0	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	28.9
71	0.9048	0.9081	0.9114	0.9147	0.9180	0.9214	0.9247	0.9280	0.9313	0.9346
72	.9022	.9055	.9088	.9121	.9154	.9188	.9221	.9254	.9287	.9320
73	.8996	.9029	.9062	.9095	.9128	.9161	.9194	.9228	.9261	.9294
74	.8970	.9003	.9036	.9069	.9102	.9135	.9168	.9201	.9234	.9267
75	.8944	.8977	.9010	.9043	.9076	.9108	.9141	.9174	.9207	.9240
76	.8917	.8950	.8983	.9015	.9048	.9081	.9114	.9147	.9180	.9213
77	.8890	.8923	.8956	.8989	.9022	.9055	.9088	.9120	.9153	.9186
78	.8864	.8897	.8930	.8962	.8995	.9028	.9061	.9094	.9126	.9159
79	.8837	.8870	.8902	.8935	.8968	.9000	.9033	.9066	.9099	.9131
80	.8810	.8842	.8875	.8908	.8940	.8973	.9006	.9038	.9071	.9104
81	.8782	.8815	.8847	.8880	.8912	.8945	.8978	.9010	.9043	.9075
82	.8754	.8787	.8819	.8852	.8884	.8917	.8950	.8982	.9015	.9047
83	.8726	.8759	.8791	.8824	.8856	.8889	.8921	.8954	.8986	.9019
84	.8698	.8731	.8763	.8796	.8828	.8861	.8893	.8925	.8958	.8990
85	.8670	.8702	.8734	.8767	.8799	.8832	.8864	.8896	.8929	.8961
86	.8641	.8674	.8706	.8738	.8771	.8803	.8835	.8868	.8900	.8932
87	.8612	.8644	.8677	.8709	.8741	.8773	.8806	.8838	.8870	.8902
88	.8583	.8615	.8648	.8680	.8712	.8744	.8776	.8808	.8841	.8873
89	.8554	.8586	.8618	.8650	.8682	.8714	.8746	.8779	.8811	.8843
90	.8524	.8556	.8588	.8620	.8652	.8685	.8717	.8749	.8781	.8813
91	.8494	.8526	.8558	.8590	.8622	.8654	.8686	.8718	.8750	.8782
92	.8464	.8496	.8528	.8560	.8592	.8624	.8656	.8688	.8720	.8752
93	.8433	.8465	.8497	.8529	.8561	.8593	.8625	.8656	.8688	.8720
94	.8403	.8434	.8466	.8498	.8530	.8562	.8594	.8625	.8657	.8689
95	.8371	.8403	.8435	.8467	.8498	.8530	.8562	.8594	.8626	.8657
96	.8340	.8372	.8404	.8435	.8467	.8499	.8530	.8562	.8594	.8626
97	.8308	.8340	.8371	.8403	.8435	.8466	.8498	.8530	.8561	.8593
98	.8276	.8308	.8339	.8371	.8403	.8434	.8466	.8497	.8529	.8561
99	.8243	.8275	.8306	.8338	.8370	.8401	.8433	.8464	.8496	.8527
100	.8211	.8243	.8274	.8306	.8337	.8369	.8400	.8432	.8463	.8495
101	.8178	.8209	.8241	.8272	.8304	.8335	.8367	.8398	.8430	.8461
102	.8144	.8176	.8207	.8238	.8270	.8301	.8333	.8364	.8395	.8427
103	.8110	.8142	.8173	.8204	.8236	.8267	.8298	.8330	.8361	.8392
104	.8076	.8107	.8138	.8170	.8201	.8232	.8263	.8295	.8326	.8357
105	.8041	.8072	.8104	.8135	.8166	.8197	.8229	.8260	.8291	.8322
106	.8006	.8037	.8069	.8100	.8131	.8162	.8193	.8224	.8256	.8287
107	.7971	.8002	.8033	.8064	.8095	.8126	.8157	.8188	.8220	.8251
108	.7935	.7966	.7997	.8028	.8059	.8090	.8121	.8152	.8183	.8214
109	.7899	.7930	.7961	.7992	.8023	.8054	.8085	.8116	.8147	.8178
110	.7862	.7893	.7924	.7954	.7985	.8016	.8047	.8078	.8109	.8140

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[1] Formula used: Correction factor$=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	29.0	29.1	29.2	29.3	29.4	29.5	29.6	29.7	29.8	29.9
32	1. 0334	1. 0369	1. 0405	1. 0441	1. 0477	1. 0513	1. 0549	1. 0585	1. 0620	1. 0656
33	1. 0310	1. 0345	1. 0381	1. 0417	1. 0453	1. 0488	1. 0524	1. 0560	1. 0596	1. 0632
34	1. 0286	1. 0322	1. 0358	1. 0393	1. 0429	1. 0465	1 0501	1. 0536	1. 0572	1. 0608
35	1. 0262	1. 0298	1. 0333	1. 0369	1. 0405	1. 0440	1. 0476	1. 0512	1. 0547	1. 0583
36	1. 0239	1. 0275	1. 0310	1. 0346	1. 0381	1. 0417	1. 0453	1. 0488	1. 0524	1. 0559
37	1. 0215	1. 0251	1. 0286	1. 0322	1. 0357	1. 0393	1. 0428	1. 0464	1. 0499	1. 0535
38	1. 0192	1. 0227	1. 0263	1. 0298	1. 0333	1. 0369	1. 0404	1. 0440	1. 0475	1. 0511
39	1. 0168	1. 0204	1. 0239	1. 0274	1. 0310	1. 0345	1. 0381	1. 0416	1. 0451	1. 0487
40	1. 0144	1. 0179	1. 0215	1. 0250	1. 0285	1. 0320	1. 0356	1. 0391	1. 0426	1. 0462
41	1. 0120	1. 0155	1. 0191	1. 0226	1. 0261	1. 0296	1. 0331	1. 0367	1. 0402	1. 0437
42	1. 0097	1. 0132	1. 0167	1. 0202	1. 0237	1. 0272	1. 0308	1. 0343	1. 0378	1. 0413
43	1. 0073	1. 0108	1. 0143	1. 0178	1. 0213	1. 0248	1. 0283	1. 0318	1. 0353	1. 0388
44	1. 0049	1. 0084	1. 0119	1. 0154	1. 0189	1. 0224	1. 0259	1. 0294	1. 0329	1. 0364
45	1. 0025	1. 0060	1. 0095	1. 0130	1. 0165	1. 0200	1. 0235	1. 0270	1. 0305	1. 0339
46	1. 0001	1. 0036	1. 0071	1. 0106	1. 0141	1. 0176	1. 0211	1. 0246	1. 0280	1. 0315
47	0. 9977	1. 0012	1. 0047	1. 0082	1. 0116	1. 0151	1. 0186	1. 0221	1. 0256	1. 0290
48	. 9953	0. 9988	1. 0023	1. 0058	1. 0092	1. 0127	1. 0162	1. 0196	1. 0231	1. 0266
49	. 9929	. 9964	0. 9998	1. 0033	1. 0068	1. 0102	1. 0137	1. 0172	1. 0206	1. 0241
50	. 9905	. 9940	. 9975	1. 0009	1. 0044	1. 0078	1. 0113	1. 0148	1. 0182	1. 0217
51	. 9881	. 9915	. 9950	0. 9984	1. 0019	1. 0054	1. 0088	1. 0123	1. 0157	1. 0192
52	. 9857	. 9892	. 9926	. 9961	0. 9995	1. 0029	1. 0064	1. 0098	1. 0133	1. 0167
53	. 9832	. 9867	. 9901	. 9936	. 9970	1. 0004	1. 0039	1. 0073	1. 0107	1. 0142
54	. 9808	. 9843	. 9877	. 9911	. 9946	0. 9980	1. 0014	1. 0049	1. 0083	1. 0117
55	. 9784	. 9819	. 9853	. 9887	. 9921	. 9956	0. 9990	1. 0024	1. 0058	1. 0093
56	. 9759	. 9794	. 9828	. 9862	. 9896	. 9930	. 9965	0. 9999	1. 0033	1. 0067
57	. 9735	. 9769	. 9803	. 9838	. 9872	. 9906	. 9940	. 9974	1. 0008	1. 0042
58	. 9710	. 9744	. 9778	. 9812	. 9846	. 9881	. 9915	. 9949	0. 9983	1. 0017
59	. 9686	. 9720	. 9754	. 9788	. 9822	. 9856	. 9890	. 9924	. 9958	0. 9992
60	. 9661	. 9695	. 9729	. 9762	. 9796	. 9830	. 9864	. 9898	. 9932	. 9966
61	. 9636	. 9670	. 9704	. 9738	. 9772	. 9805	. 9839	. 9873	. 9907	. 9941
62	. 9611	. 9644	. 9678	. 9712	. 9746	. 9780	. 9813	. 9847	. 9881	. 9915
63	. 9586	. 9619	. 9653	. 9687	. 9721	. 9754	. 9788	. 9822	. 9856	. 9889
64	. 9560	. 9594	. 9628	. 9661	. 9695	. 9729	. 9762	. 9796	. 9830	. 9863
65	. 9535	. 9569	. 9602	. 9636	. 9670	. 9703	. 9737	. 9770	. 9804	. 9838
66	. 9509	. 9543	. 9576	. 9610	. 9644	. 9677	. 9711	. 9744	. 9778	. 9811
67	. 9494	. 9517	. 9551	. 9584	. 9618	. 9651	. 9685	. 9718	. 9752	. 9785
68	. 9458	. 9491	. 9524	. 9558	. 9591	. 9625	. 9658	. 9692	. 9725	. 9758
69	. 9432	. 9465	. 9499	. 9532	. 9566	. 9599	. 9632	. 9666	. 9699	. 9732
70	. 9406	. 9439	. 9472	. 9506	. 9539	. 9572	. 9605	. 9639	. 9672	. 9705

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

Table 3.—*Correction factors for gas volume*[1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	29.0	29.1	29.2	29.3	29.4	29.5	29.6	29.7	29.8	29.9
71	0.9380	0.9413	0.9446	0.9479	0.9513	0.9546	0.9579	0.9612	0.9645	0.9679
72	.9353	.9387	.9420	.9453	.9486	.9519	.9552	.9586	.9619	.9652
73	.9327	.9360	.9393	.9426	.9459	.9492	.9525	.9559	.9592	.9625
74	.9300	.9333	.9366	.9399	.9432	.9465	.9498	.9531	.9564	.9597
75	.9273	.9306	.9339	.9372	.9405	.9438	.9471	.9504	.9537	.9570
76	.9246	.9279	.9312	.9345	.9377	.9410	.9443	.9476	.9509	.9542
77	.9219	.9252	.9285	.9318	.9350	.9383	.9416	.9449	.9482	.9515
78	.9192	.9225	.9257	.9290	.9323	.9356	.9389	.9421	.9454	.9487
79	.9164	.9197	.9230	.9262	.9295	.9328	.9361	.9393	.9426	.9459
80	.9136	.9169	.9202	.9234	.9267	.9300	.9332	.9365	.9398	.9430
81	.9108	.9141	.9173	.9206	.9238	.9271	.9304	.9336	.9369	.9401
82	.9080	.9112	.9145	.9177	.9210	.9242	.9275	.9308	.9340	.9373
83	.9051	.9083	.9116	.9148	.9181	.9213	.9246	.9278	.9311	.9343
84	.9023	.9055	.9088	.9120	.9152	.9185	.9217	.9250	.9282	.9315
85	.8993	.9026	.9058	.9090	.9123	.9155	.9188	.9220	.9252	.9285
86	.8965	.8997	.9029	.9061	.9094	.9126	.9158	.9191	.9223	.9255
87	.8935	.8967	.8999	.9031	.9064	.9096	.9128	.9160	.9193	.9225
88	.8905	.8937	.8969	.9002	.9034	.9066	.9098	.9130	.9163	.9195
89	.8875	.8907	.8939	.8971	.9004	.9036	.9068	.9100	.9132	.9164
90	.8845	.8877	.8909	.8941	.8973	.9005	.9037	.9069	.9101	.9134
91	.8814	.8846	.8878	.8910	.8942	.8974	.9006	.9038	.9070	.9102
92	.8784	.8816	.8848	.8879	.8911	.8943	.8975	.9007	.9039	.9071
93	.8752	.8784	.8816	.8848	.8880	.8912	.8944	.8975	.9007	.9039
94	.8721	.8753	.8785	.8816	.8848	.8880	.8912	.8944	.8976	.9008
95	.8689	.8721	.8753	.8784	.8816	.8848	.8880	.8912	.8943	.8975
96	.8657	.8689	.8721	.8753	.8784	.8816	.8848	.8879	.8911	.8943
97	.8625	.8656	.8688	.8720	.8751	.8783	.8815	.8846	.8878	.8910
98	.8592	.8624	.8655	.8687	.8719	.8750	.8782	.8814	.8845	.8877
99	.8559	.8590	.8622	.8653	.8685	.8717	.8748	.8780	.8811	.8843
100	.8526	.8558	.8589	.8621	.8652	.8684	.8715	.8747	.8778	.8810
101	.8492	.8524	.8555	.8587	.8618	.8650	.8681	.8713	.8744	.8775
102	.8458	.8489	.8521	.8552	.8584	.8615	.8646	.8678	.8709	.8741
103	.8424	.8455	.8486	.8518	.8549	.8580	.8612	.8643	.8674	.8706
104	.8389	.8420	.8451	.8482	.8514	.8545	.8576	.8607	.8639	.8670
105	.8353	.8385	.8416	.8447	.8478	.8510	.8541	.8572	.8603	.8634
106	.8318	.8349	.8380	.8411	.8443	.8474	.8505	.8536	.8567	.8598
107	.8282	.8313	.8344	.8375	.8406	.8437	.8468	.8500	.8531	.8562
108	.8245	.8276	.8307	.8339	.8370	.8401	.8432	.8463	.8494	.8525
109	.8209	.8240	.8271	.8302	.8333	.8364	.8395	.8426	.8457	.8488
110	.8171	.8202	.8233	.8264	.8295	.8326	.8357	.8388	.8419	.8450

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[1] Formula used: Correction factor $=\dfrac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$

P = total gas pressure; E = vapor pressure of water at $t°$; t = temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	30. 0	30. 1	30. 2	30. 3	30. 4	30. 5	30. 6	30. 7	30. 8	30. 9
32	1. 0692	1. 0728	1. 0764	1. 0800	1. 0836	1. 0871	1. 0907	1. 0943	1. 0979	1. 1015
33	1. 0667	1. 0703	1. 0739	1. 0775	1. 0811	1. 0846	1. 0882	1. 0918	1. 0954	1. 0989
34	1. 0643	1. 0679	1. 0715	1. 0751	1. 0786	1. 0822	1. 0858	1. 0893	1. 0929	1. 0965
35	1. 0619	1. 0654	1. 0690	1. 0725	1. 0761	1. 0797	1. 0832	1. 0868	1. 0904	1. 0939
36	1. 0595	1. 0630	1. 0666	1. 0702	1. 0737	1. 0773	1. 0808	1. 0844	1. 0879	1. 0915
37	1. 0570	1. 0606	1. 0641	1. 0676	1. 0712	1. 0747	1. 0783	1. 0818	1. 0854	1. 0889
38	1. 0546	1. 0581	1. 0617	1. 0652	1. 0688	1. 0723	1. 0759	1. 0794	1. 0829	1. 0865
39	1. 0522	1. 0557	1. 0593	1. 0628	1. 0663	1. 0699	1. 0734	1. 0769	1. 0805	1. 0840
40	1. 0497	1. 0532	1. 0567	1. 0603	1. 0638	1. 0673	1. 0709	1. 0744	1. 0779	1. 0814
41	1. 0472	1. 0508	1. 0543	1. 0578	1. 0613	1. 0648	1. 0684	1. 0719	1. 0754	1. 0789
42	1. 0448	1. 0483	1. 0518	1. 0554	1. 0589	1. 0624	1. 0659	1. 0694	1. 0729	1. 0764
43	1. 0423	1. 0459	1. 0494	1. 0529	1. 0564	1. 0599	1. 0634	1. 0669	1. 0704	1. 0739
44	1. 0399	1. 0434	1. 0469	1. 0504	1. 0539	1. 0574	1. 0609	1. 0644	1. 0679	1. 0714
45	1. 0374	1. 0409	1. 0444	1. 0479	1. 0514	1. 0549	1. 0584	1. 0619	1. 0654	1. 0689
46	1 0350	1. 0385	1. 0420	1. 0455	1. 0490	1. 0524	1. 0559	1. 0594	1. 0629	1. 0664
47	1. 0325	1. 0360	1. 0395	1. 0430	1. 0464	1. 0499	1. 0534	1. 0569	1. 0604	1. 0638
48	1. 0301	1. 0335	1. 0370	1. 0405	1. 0440	1. 0474	1. 0509	1. 0544	1. 0578	1. 0613
49	1. 0276	1. 0310	1. 0345	1. 0380	1. 0414	1. 0449	1. 0484	1. 0518	1. 0553	1. 0588
50	1. 0251	1. 0286	1. 0320	1. 0355	1. 0390	1. 0424	1. 0459	1. 0493	1. 0528	1. 0563
51	1. 0226	1. 0261	1. 0295	1. 0330	1. 0364	1. 0399	1. 0433	1. 0468	1. 0502	1. 0537
52	1. 0202	1. 0236	1. 0271	1. 0305	1. 0340	1. 0374	1. 0408	1. 0443	1. 0477	1. 0512
53	1. 0176	1. 0211	1. 0245	1. 0279	1. 0314	1. 0348	1. 0383	1. 0417	1. 0451	1. 0486
54	1. 0151	1. 0186	1. 0220	1. 0254	1. 0289	1. 0323	1. 0357	1. 0392	1. 0426	1. 0460
55	1. 0127	1. 0161	1. 0195	1. 0230	1. 0264	1. 0298	1. 0332	1. 0367	1. 0401	1. 0435
56	1. 0101	1. 0135	1. 0170	1. 0204	1. 0238	1. 0272	1. 0306	1. 0341	1. 0375	1. 0409
57	1. 0076	1. 0111	1. 0145	1. 0179	1. 0213	1. 0247	1. 0281	1. 0315	1. 0349	1. 0384
58	1. 0051	1. 0085	1. 0119	1. 0153	1. 0187	1. 0221	1. 0255	1. 0289	1. 0323	1. 0357
59	1. 0026	1. 0060	1. 0094	1. 0128	1. 0162	1. 0196	1. 0230	1. 0264	1. 0298	1. 0332
60	1. 0000	1. 0034	1. 0068	1. 0102	1. 0136	1. 0170	1. 0203	1. 0237	1. 0271	1. 0305
61	0. 9975	1. 0009	1. 0042	1. 0076	1. 0110	1. 0144	1. 0178	1. 0212	1. 0246	1. 0279
62	. 9949	0. 9982	1. 0016	1. 0050	1. 0084	1. 0118	1. 0151	1. 0185	1. 0219	1. 0253
63	. 9923	. 9957	0. 9990	1. 0024	1. 0058	1. 0092	1. 0125	1. 0159	1. 0193	1. 0227
64	. 9897	. 9931	. 9964	0. 9998	1. 0032	1. 0065	1. 0099	1. 0133	1. 0166	1. 0200
65	. 9871	. 9905	. 9938	. 9972	1. 0006	1. 0039	1. 0073	1. 0106	1. 0140	1. 0174
66	. 9845	. 9878	. 9912	. 9945	0. 9979	1. 0012	1. 0046	1. 0080	1. 0113	1. 0147
67	. 9819	. 9852	. 9886	. 9919	. 9953	0. 9986	1. 0019	1. 0053	1. 0086	1. 0120
68	. 9792	. 9825	. 9859	. 9892	. 9925	. 9959	0. 9992	1. 0026	1. 0059	1. 0092
69	. 9766	. 9799	. 9832	. 9866	. 9899	. 9932	. 9966	0. 9999	1. 0032	1. 0066
70	. 9739	. 9772	. 9805	. 9838	. 9872	. 9905	. 9938	. 9972	1. 0005	1. 0038

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[1] Formula used: Correction factor $=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$.

P=total gas pressure; E=vapor pressure of water at $t°$; t=temperature of gas (°F).

TABLE 3.—*Correction factors for gas volume* [1]—Continued

[Multiply observed volume of saturated gas by factor to reduce to volume of saturated gas at 60° F and under a pressure of 30 inches of mercury at 32° F]

Temperature, °F	Total gas pressure—Inches of mercury									
	30. 0	30. 1	30. 2	30. 3	30. 4	30. 5	30. 6	30. 7	30. 8	30. 9
71	0. 9712	0. 9745	0. 9778	0. 9812	0. 9845	0. 9878	0. 9911	0. 9944	0. 9978	1. 0011
72	. 9685	. 9718	. 9751	. 9784	. 9818	. 9851	. 9884	. 9917	. 9950	0. 9983
73	. 9658	. 9691	. 9724	. 9757	. 9790	. 9823	. 9856	. 9889	. 9923	. 9956
74	. 9630	. 9664	. 9697	. 9730	. 9763	. 9796	. 9829	. 9862	. 9895	. 9928
75	. 9603	. 9636	. 9669	. 9702	. 9735	. 9768	. 9801	. 9834	. 9867	. 9900
76	. 9575	. 9608	. 9641	. 9674	. 9707	. 9739	. 9772	. 9805	. 9838	. 9871
77	. 9547	. 9580	. 9613	. 9646	. 9679	. 9712	. 9745	. 9777	. 9810	. 9843
78	. 9520	. 9553	. 9585	. 9618	. 9651	. 9684	. 9716	. 9749	. 9782	. 9815
79	. 9491	. 9524	. 9557	. 9590	. 9622	. 9655	. 9688	. 9721	. 9753	. 9786
80	. 9463	. 9496	. 9528	. 9561	. 9594	. 9626	. 9659	. 9692	. 9724	. 9757
81	. 9434	. 9467	. 9499	. 9532	. 9564	. 9597	. 9630	. 9662	. 9695	. 9728
82	. 9405	. 9438	. 9470	. 9503	. 9535	. 9568	. 9600	. 9633	. 9666	. 9698
83	. 9376	. 9408	. 9441	. 9473	. 9506	. 9538	. 9571	. 9603	. 9636	. 9668
84	. 9347	. 9379	. 9412	. 9444	. 9477	. 9509	. 9542	. 9574	. 9606	. 9639
85	. 9317	. 9349	. 9382	. 9414	. 9447	. 9479	. 9511	. 9544	. 9576	. 9608
86	. 9288	. 9320	. 9352	. 9385	. 9417	. 9449	. 9481	. 9514	. 9546	. 9578
87	. 9257	. 9289	. 9322	. 9354	. 9386	. 9418	. 9451	. 9483	. 9515	. 9547
88	. 9227	. 9259	. 9291	. 9324	. 9356	. 9388	. 9420	. 9452	. 9484	. 9517
89	. 9196	. 9228	. 9261	. 9293	. 9325	. 9357	. 9389	. 9421	. 9453	. 9485
90	. 9166	. 9198	. 9230	. 9262	. 9294	. 9326	. 9358	. 9390	. 9422	. 9454
91	. 9134	. 9166	. 9198	. 9230	. 9262	. 9294	. 9326	. 9358	. 9390	. 9422
92	. 9103	. 9135	. 9167	. 9199	. 9231	. 9263	. 9295	. 9327	. 9359	. 9391
93	. 9071	. 9103	. 9135	. 9167	. 9199	. 9231	. 9263	. 9294	. 9326	. 9358
94	. 9039	. 9071	. 9103	. 9135	. 9167	. 9199	. 9230	. 9262	. 9294	. 9326
95	. 9007	. 9039	. 9070	. 9102	. 9134	. 9166	. 9198	. 9229	. 9261	. 9293
96	. 8975	. 9006	. 9038	. 9070	. 9102	. 9133	. 9165	. 9197	. 9228	. 9260
97	. 8941	. 8973	. 9005	. 9036	. 9068	. 9100	. 9131	. 9163	. 9195	. 9226
98	. 8908	. 8940	. 8972	. 9003	. 9035	. 9066	. 9098	. 9130	. 9161	. 9193
99	. 8874	. 8906	. 8937	. 8969	. 9001	. 9032	. 9064	. 9095	. 9127	. 9158
100	. 8841	. 8873	. 8904	. 8936	. 8967	. 8999	. 9030	. 9062	. 9093	. 9125
101	. 8807	. 8838	. 8870	. 8901	. 8933	. 8964	. 8996	. 9027	. 9058	. 9090
102	. 8772	. 8803	. 8835	. 8866	. 8897	. 8929	. 8960	. 8992	. 9023	. 9054
103	. 8737	. 8768	. 8800	. 8831	. 8862	. 8894	. 8925	. 8956	. 8988	. 9019
104	. 8701	. 8733	. 8764	. 8795	. 8826	. 8858	. 8889	. 8920	. 8951	. 8983
105	. 8666	. 8697	. 8728	. 8759	. 8791	. 8822	. 8853	. 8884	. 8915	. 8947
106	. 8630	. 8661	. 8692	. 8723	. 8754	. 8785	. 8817	. 8848	. 8879	. 8910
107	. 8593	. 8624	. 8655	. 8686	. 8717	. 8748	. 8780	. 8811	. 8842	. 8873
108	. 8556	. 8587	. 8618	. 8649	. 8680	. 8711	. 8742	. 8773	. 8804	. 8835
109	. 8519	. 8550	. 8581	. 8612	. 8643	. 8674	. 8705	. 8736	. 8767	. 8798
110	. 8481	. 8511	. 8542	. 8573	. 8604	. 8635	. 8666	. 8697	. 8728	. 8759

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[1] Formula used: Correction factor$=\frac{(P-E)(60+459.7)}{(t+459.7)(30-0.5217)}$.

P=total gas pressure; E=vapor pressure of water at t°; t=temperature of gas (°F).

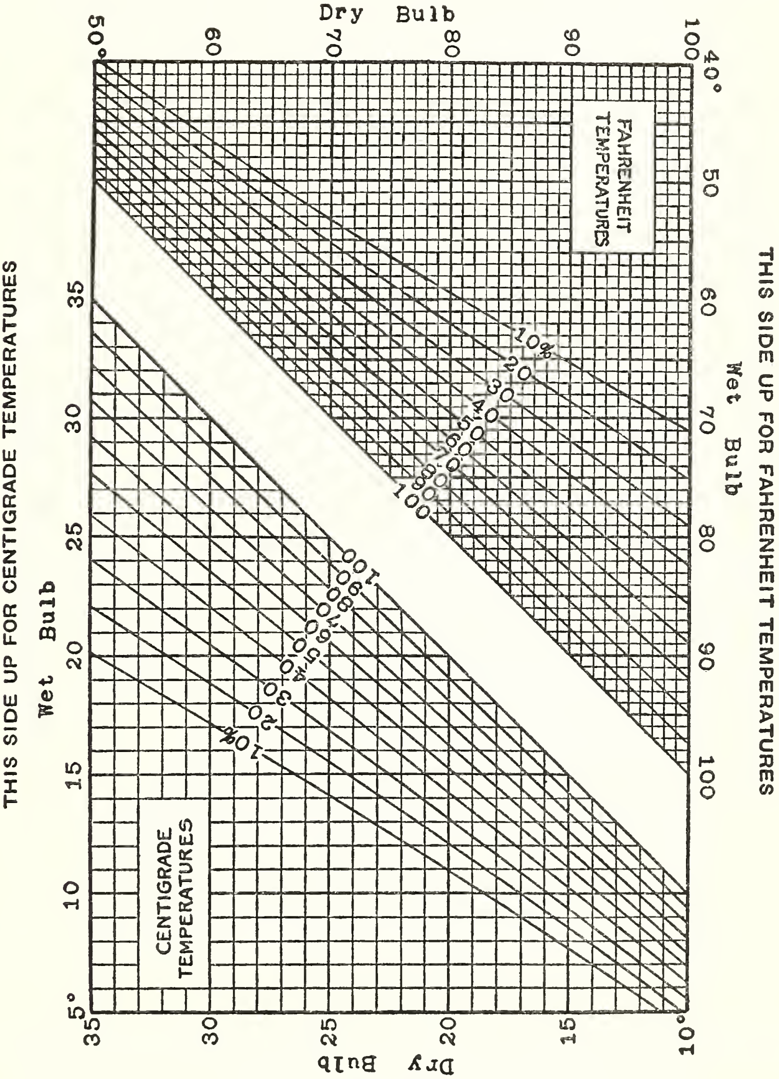


FIGURE 2.—*Relative humidity from wet- and dry-bulb thermometer readings in still air.*

Calculated for a barometer height of 755 mm. At altitudes of 6,000 feet or over the reduction in barometric pressure will cause an error of 5 percent or over at very low humidities.

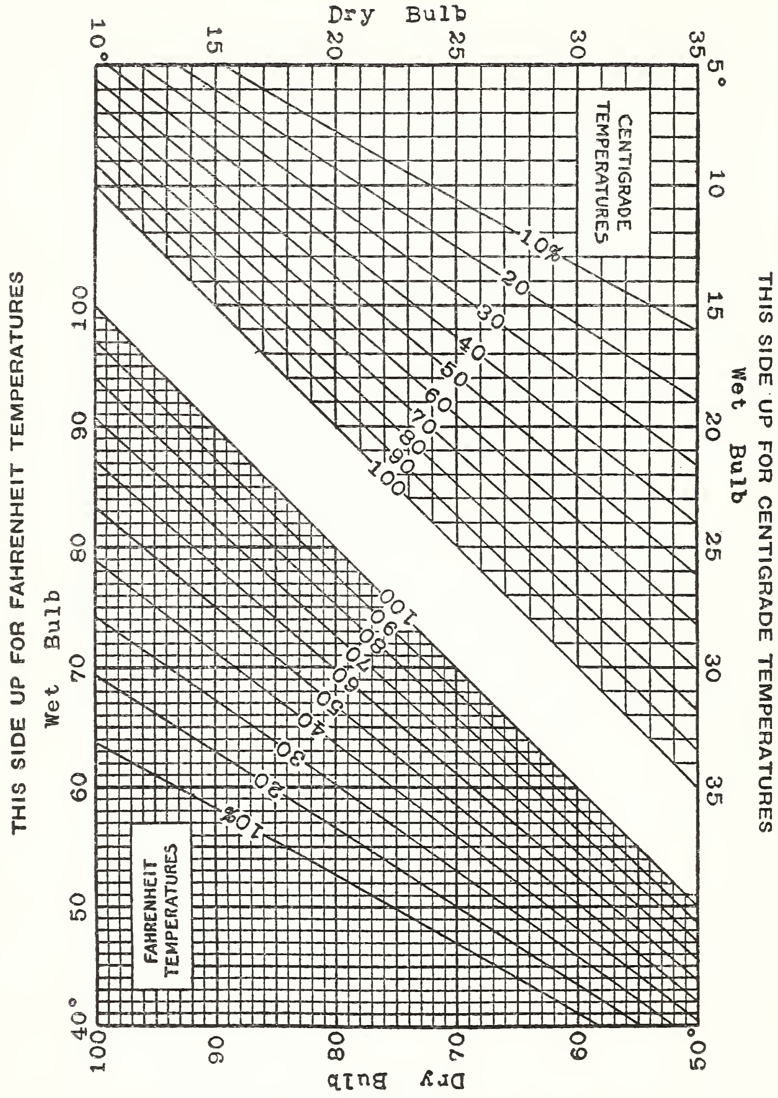


FIGURE 3.—*Relative humidity from wet- and dry-bulb thermometer readings for psychrometer with rapid ventilation.*

Calculated for a barometer height of 755 mm. At altitudes of 6,000 feet or over the reduction in barometric pressure will cause an error of 5 percent or over at very low humidities.

TABLE 4.—*Seconds per revolution of a 0.1 cubic foot meter corresponding to 3,000 Btu per hour*

[The time in seconds, for 1 revolution of the index, which corresponds to 3,000 Btu per hour is given in this table. If a different rate, *R*, in Btu per hour is employed, the time shown should be multiplied by 3,000/*R*. If the heating value is approximately constant, it is recommended that, for convenience, the time corresponding to 5 percent more and 5 percent less than the specified rate for a gas of the anticipated heating value be entered in the blanks provided for the purpose, at the bottom of the table, and that the gas rate be adjusted so that the meter makes one revolution between the limits indicated. Gas of heating value lower than 300 Btu and preferably lower than 400 Btu per cubic foot should be measured with a larger meter because of the effect of the speed of the meter on the accuracy of the measurement.]

Anticipated heating value	Seconds per revolution	Anticipated heating value	Seconds per revolution	Anticipated heating value	Seconds per revolution
Btu/cu ft		Btu/cu ft		Btu/cu ft	
300	36	750	90	1,200	144
350	42	800	96	1,300	156
400	48	850	102	1,400	168
450	54	900	108	1,500	180
500	60	950	114	1,750	210
550	66	1,000	120	2,000	240
600	72	1,050	126	2,500	300
650	78	1,100	132	3,000	360
700	84	1,150	138	3,500	420

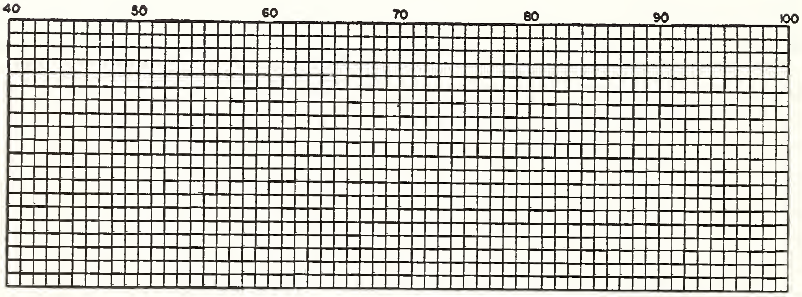
Seconds per revolution for local conditions

Gas	Maximum	Minimum
*A*________________	____________________	____________________
*B*________________	____________________	____________________
*C*________________	____________________	____________________

THERMOMETER CORRECTIONS

Inlet thermometer No. ________________________

Calibration by ______________________________



Outlet thermometer No. _____________________

Calibration by _____________________________

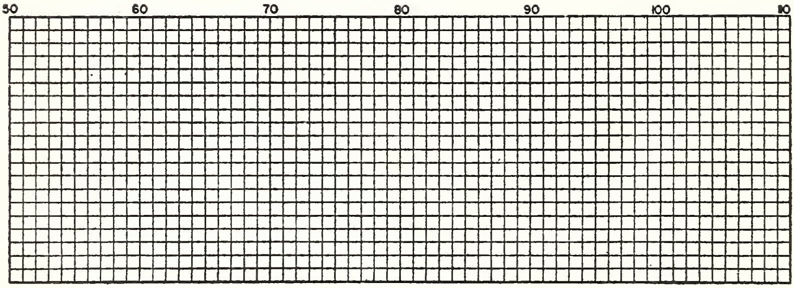


FIGURE 4.—*Certificate correction for thermometers.*

TABLE 5.—*Emergent stem corrections to readings of outlet-water thermometers for different immersions of thermometers in calorimeter*[1]

[Table is applicable when temperature of inlet water is approximately equal to room temperature, but is not applicable if the emergent portion of the stem includes an enlargement in the capillary]

Immersion	Temperature rise of water, °F	Temperature of room (°F)					
		50	60	70	80	90	100
Thermometer immersed to 30° F	10	+0.02	+0.03	+0.04	+0.05	+0.05	+0.06
	15	+.04	+.05	+.06	+.07	+.09	+.10
	20	+.06	+.07	+.09	+.11	+.13	+.15
Thermometer immersed to 40° F	10	+.01	+.02	+.03	+.03	+.04	+.05
	15	+.03	+.04	+.05	+.06	+.08	+.09
	20	+.04	+.05	+.07	+.09	+.11	+.12
Thermometer immersed to 50° F	10	+.01	+.01	+.02	+.03	+.04	+.05
	15	+.02	+.03	+.04	+.05	+.07	+.08
	20	+.02	+.04	+.06	+.07	+.09	+.11
Thermometer immersed to 60° F	10	+.00	+.01	+.02	+.02	+.03	+.04
	15	+.00	+.01	+.03	+.04	+.05	+.06
	20	+.00	+.02	+.04	+.05	+.07	+.09

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[1] Correction $= 0.000086 \times n\,(T-t)$
where n = number of degrees emergent from the bath
T = temperature of the bulb
t = mean temperature of the emergent stem.

Differential correction

Date	Difference (°F)

Meter calibration

Date	One revolution equals—
	Cubic feet
	Cubic feet
	Cubic feet
	Cubic feet
	Cubic feet

IV. CORRECTIONS FOR HUMIDITY, SPECIFIC HEAT OF WATER, BUOYANCY, AND HEAT LOSS

Because the fuel gases now used are much more varied in composition than at the time Bureau Circulars 48 and 65 were prepared, a change has been made in the presentation of data needed to make corrections of observed heating value for humidity, specific heat of water, the effect of buoyancy of the air on the observed weight of water, heat loss, and difference between inlet-water temperature and room temperature. Instead of attempting to supply tables from which these corrections can be entered directly on the test record, data are given from which tables for direct use corresponding to local conditions of gas supply can be prepared. Since the discussion of corrections on exactly the basis proposed is not elsewhere available, it is given here in some detail. If the reader is interested only in the magnitude of the corrections to be made, not in the reasons for them, he may turn directly to the next heading, p. 32, where the preparation of a table of corrections for local use is illustrated.

In preparing the set of corrections, it was assumed that the temperatures of inlet water, entering gas and air, and products of combustion are all the same. We will let

W=weight of water (pounds) required to saturate 1 cu ft.
V_c=volume of air (cubic feet) required to burn 1 cu ft of gas, air and gas measured under the same conditions.
WV_c=weight of water in saturated air required to burn 1 cu ft of saturated gas.
$V_a=rV_c$=volume of air, reduced to saturated condition, entering calorimeter per 1 cu ft of gas.
h=relative humidity of air entering calorimeter.

The volume of saturated products of combustion leaving the calorimeter is determined by the damper opening and is independent of the relative humidity of the entering air. But because it is not saturated, the volume of air entering the calorimeter is not independent of the relative humidity, hence the actual volume of air which enters the calorimeter is

$$rV_c \times \frac{(30-w_t)}{(30-hw_t)}$$

where w_t represents the saturated vapor pressure of water at temperature t.

For convenience, let the ratio

$$\frac{30-w_t}{30-hw_t}=f.$$

Then

$fhWrV_c$=weight of water in air actually entering calorimeter.

$W(1+fhrV_c)$=weight of water in air and gas entering calorimeter.

V_p=volume of air-free products of combustion of 1 cu ft of gas, both measured saturated at same temperature and pressure.

WV_p=weight of water in air-free products from 1 cu ft of gas.

$(r-1)V_c$=volume of excess air leaving the calorimeter.

$W(r-1)V_c+WV_p$=weight of water vapor leaving the calorimeter with products of combustion.

W_c=weight of water produced from combustion of 1 cu ft of gas as measured.

W_m=weight of water condensed and measured per 1 cu ft of gas as measured.

A steady thermal condition requires that

$$W_c+W(1+fhrV_c)=W_m+W(r-1)V_c+WV_p.$$

$$\begin{aligned}W_c-W_m&=W(r-1)V_c-W-WfhrV_c+WV_p\\&=W[(r-fhr-1)V_c+V_p-1].\end{aligned}$$

The correction in Btu to be added to the observed heating value of 1 cu ft of gas *as measured* to obtain the total heating value of 1 cu ft of gas *as measured* is

$$LW[(r-fhr-1)V_c+V_p-1],$$

where L is the heat of vaporization of water at the temperature of measurement.

To obtain the correction to be added *after* the heating value of the gas has been reduced to standard conditions, this number must be divided by F, the "correction factor for gas volumes." The final correction for humidity, C_h, to be added to the "observed heating value" is, therefore,

$$C_h=\frac{LW}{F}\times[(r-fhr-1)V_c+V_p-1].$$

The factor $(r-fhr-1)V_c+V_p-1$ varies, of course, with the quantity of air which enters the calorimeter and with the composition of the gas. If an analysis has been made of the gas, V_c and V_p can be computed readily. The data needed are given in table 14. The value of r can also be determined accurately by an analysis of the products of combustion. The value of the factor can, therefore, always be determined accurately with the aid of gas analysis.

However, gas analysis requires more time, greater skill, and more equipment than the importance of making this correction alone usually justifies; and it is consequently desirable to make general approximations with regard to both the composition of the gas and the quantity of air which enters the calorimeter.

If single values are assumed for r and for h, the values of the factor $(r-fhr-1)V_c+V_p-1$, computed for the fuel gases in common use, are nearly proportional to their heating values. Hence, if the factor is divided by heating value, the result is so nearly independent of composition that an average figure for gases of a given type may be used satisfactorily without knowing the composition accurately.

The factor f introduces only a minor correction in the volume of air which enters the calorimeter, but, because it changes with both humidity and temperature, it greatly complicates the tabulation of values for the larger expression, which does not vary with temperature. It is, therefore, desirable to write

$$\frac{1}{H}[(r-fhr-1)V_c+V_p-1]$$

$$=\frac{1}{H}[(r-hr-1)V_c+V_p-1]+\frac{V_c}{H}(hr-fhr)$$
$$=Q+q.$$

The second term, $q=\frac{V_c}{H}(hr-fhr)$ is so small that any variation in the value of V_c/H is entirely negligible. Negligible, also, is the effect of variations of pressure on the product $\frac{LW}{F}\times Hq$. For tabulating, it will be convenient to let

$$\frac{LW}{F}\times q=Y.$$

If the gas rate and the outlet damper are adjusted as indicated in footnote 2, page 3, about 40 percent more air than is required for complete combustion enters the calorimeter; that is, $r=1.40$. Table 6 gives values for

$$Q=\frac{1}{H}[(r-hr-1)V_c+V_p-1]$$

for various gases and several relative humidities, the value of r in all cases being assumed to be 1.40. In computing values of Q for other than pure gases, approximate average values for the compositions of the mixtures were assumed.[3]

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[3] The formula from which Q is derived applies only when enough water is formed during combustion to saturate the products. This is not the case with gas containing too large a percentage of carbon monoxide. Values for Q are given for carbon monoxide because it is usually present in mixtures which do supply enough water for saturation.

TABLE 6.—*Values of the factor, Q, to be used in computing humidity corrections (see p. 27)*

$$Q=\frac{1}{H}[(1.40-1.40\,h-1)\,V_c+V_p-1]$$

[Here H is the heating value of the gas in thousands of Btu per cu ft, h is the relative humidity of the air, V_c is the volume of air required for complete combustion of one volume of gas, and V_p the volume of air-free products.]

Gas	Relative humidity, *h*										
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Hydrogen	5.8	4.8	3.7	2.7	1.6	0.6	−0.5	−1.6	−2.6	−3.7	−4.7
Carbon monoxide	9.0	8.0	6.9	5.9	4.8	3.7	2.7	1.6	0.5	−.7	−1.8
Methane	10.4	9.2	8.0	6.7	5.5	4.2	3.0	1.7	.5	−.8	−2.0
Ethane	11.9	10.6	9.2	7.9	6.6	5.2	3.9	2.6	1.2	−.1	−1.4
Propane	12.0	10.7	9.4	8.1	6.7	5.4	4.1	2.8	1.5	.1	−1.2
Butane	12.0	10.7	9.4	8.1	6.8	5.5	4.2	2.9	1.6	.3	−1.1
Ethylene	11.5	10.2	8.9	7.7	6.4	5.1	3.8	2.6	1.3	.0	−1.3
Propylene	11.8	10.5	9.2	7.9	6.7	5.4	4.1	2.8	1.5	.2	−1.1
Acetylene	10.4	9.2	8.1	7.0	5.8	4.7	3.5	2.4	1.3	.1	−1.0
Benzene	12.9	11.5	10.2	8.8	7.5	6.1	4.7	3.4	2.0	.7	−0.7
Average "Illuminants"	12.1	10.8	9.5	8.2	6.9	5.6	4.3	3.0	1.7	.4	−1.0
Producer gas	8.2	7.2	6.1	5.1	4.0	2.9	1.9	0.8	−0.3	−1.3	−2.4
Water gas:											
"Blue"	7.6	6.5	5.4	4.3	3.3	2.2	1.1	.0	−1.0	−2.1	−3.2
500 Btu	9.7	8.5	7.3	6.1	4.9	3.7	2.5	1.3	0.1	−1.1	−2.3
600 Btu	10.7	9.5	8.2	7.0	5.7	4.5	3.2	2.0	.7	−0.5	−1.8
700 Btu	11.8	10.4	9.1	7.8	6.5	5.2	3.9	2.6	1.3	.0	−1.3
Coal gas, oil gas below 800 Btu	9.1	7.9	6.7	5.5	4.3	3.1	1.9	0.7	−0.5	−1.6	−2.8
Oil refinery gas above 1,200 Btu	12.0	10.7	9.4	8.0	6.7	5.4	4.1	2.8	1.4	0.1	−1.2
Mixed natural and manufactured gas:											
Below 700 Btu	9.3	8.1	6.9	5.8	4.6	3.4	2.2	1.1	−0.1	−1.3	−2.5
Above 700 Btu	10.1	8.9	7.7	6.5	5.2	4.0	2.8	1.6	.3	−0.9	−2.1
Natural gas:											
Below 1,200 Btu	10.7	9.5	8.2	6.9	5.7	4.4	3.2	1.9	.6	−.6	−1.9
Above 1,200 Btu [1]	11.9	10.6	9.2	7.9	6.6	5.2	3.9	2.6	1.2	−.1	−1.4

[1] Includes liquefied petroleum gases and their mixtures with air or inert, and gasoline-air mixtures.

Table 7 gives values for Y for a variety of temperatures and relative humidities. The correction for humidity, C_h, has now been simplified to

$$C_h=H\frac{LW}{F}Q+HY$$

in which the values of Q and Y can be read from tables; but it is desirable to simplify the expression still further. Both L and W are determined by temperature. The correction factor for gas volumes, F, is determined in part by temperature and in part by pressure, but the latter is usually so nearly constant in any laboratory that the effect of its variations on the correction may be ignored. It will, therefore, be a simplification to separate the effect of pressure from the effects of temperature and to combine the latter. The factor, F, represents the expression,

$$F=\frac{(60+460)\times(p-w_t)}{(t+460)(30-w_{60})},$$

in which t is the temperature of the gas in degrees Fahrenheit and p is the total pressure on the gas when measured, w_{60} is the vapor pressure of water at 60° F and w_t is the vapor pressure of water at temperature t. A nearly equivalent expression would be

$$F\ (\text{approx.}) = \frac{520 \times (30 - w_t) \times p}{(t+460) \times (30 - w_{60}) \times 30}$$

and, within the limit of experimental error,

$$\begin{aligned} C_h &= \frac{30\ H}{p} \times Q \times LW \times \frac{(t+460)\ (30-w_{60})}{520\ (30-w_t)} + HY \\ &= \frac{HQS}{p} + HY \end{aligned}$$

in which

$$S = \frac{30\ LW\ (t+460)\ (30-w_{60})}{520\ (30-w_t)}.$$

Table 7.—*Values of Y*

[Y is the minor correction to be added to observed heating values to correct for the fact that a greater quantity of air generally enters the calorimeter than would be the case if the air were saturated with water vapor.

$$Y = \frac{LWV_c hr}{HF}\ (1-f)$$

where L is the heat of vaporization of water, W is the weight of saturated water vapor per cubic foot; V_c is the number of cubic feet of air required to burn 1 cu ft of gas; h is the relative humidity; H is the heating value of gas in thousands of Btu per cubic foot; F is the conversion factor for reducing gas volumes to 60° F and 30 in. of mercury; r is the ratio (assumed 1.40) of air (reduced to saturated condition) which enters the calorimeter to the air required to burn the gas; and f is the ratio of the volume of air which actually enters the calorimeter to the volume which would enter it if saturated with water vapor.]

Dry-bulb temperature	Relative humidity, h										
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
°F	Btu per 1,000 Btu of observed heating value										
55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0
65	.0	.0	.0	.1	.1	.1	.1	.1	.0	.0	.0
70	.0	.0	.1	.1	.1	.1	.1	.1	.1	.0	.0
75	.0	.0	.1	.1	.1	.1	.1	.1	.1	.0	.0
80	.0	.1	.1	.2	.2	.2	.2	.2	.1	.0	.0
85	.0	.1	.2	.2	.2	.3	.2	.2	.2	.1	.0
90	.0	.1	.2	.3	.3	.3	.3	.3	.2	.1	.0
95	.0	.2	.3	.4	.5	.5	.5	.4	.3	.1	.0
100	.0	.2	.4	.5	.6	.6	.6	.5	.4	.2	.0
105	.0	.3	.6	.7	.8	.9	.8	.7	.6	.2	.0
110	.0	.4	.8	1.0	1.1	1.2	1.1	1.0	.7	.3	.0

Values of w_t, W, L, and S are given in table 8.

A great majority of determinations of heating value are made in connection with the periodic testing of gas mixtures which vary only moderately in composition. The approximate heating value of the mixtures is known in advance, and the pressure at which the gas is measured depends mainly on altitude and is nearly constant. Constant values for both H and p corresponding to local conditions may, therefore, usually be inserted in the equation $C_h = HQS/p + HY$ and a single value of Q for each humidity may be chosen, depending on the character of the gas in question. A single table of corrections to take the place of Q, S, and Y and their coefficients can, therefore, be made up readily for local use.

Table 8.—*Values of the factor S and related quantities*

[S is used to compute the humidity correction from the equation

$$C_h = \frac{HQS}{p} + HY$$

$$S = \frac{30\,LW\,(t+460)\,(30-w_{60})}{520\,(30-w_t)}$$

in which t is the temperature of the dry-bulb thermometer in degrees Fahrenheit; L is the latent heat of vaporization of water in Btu per pound; W is the weight of saturated water vapor per cubic foot; w_t is the vapor pressure of water at temperature t, in inches of mercury; and w_{60} is the vapor pressure of water at 60° F. The data are from Keenan and Keyes, Thermodynamic Properties of Steam (John Wiley and Sons, New York, N. Y., 1936).]

t	w_t	W ×1,000	L	S	t	w_t	W ×1,000	L	S
40	0.25	0.41	1.071	13	80	1.03	1.58	1,049	52
45	.30	.50	1,068	15	85	1.21	1.84	1,046	62
50	.36	.59	1,066	18	90	1.42	2.13	1,043	72
55	.44	.70	1,063	22	95	1.66	2.47	1,040	86
60	.52	.83	1,060	26	100	1.93	2.85	1,037	100
65	.62	.98	1,057	31	105	2.24	3.28	1,034	117
70	.74	1.15	1,054	37	110	2.60	3.77	1,032	138
75	.88	1.35	1,052	44					

With the corrections for humidity, in the table made for local use, may be combined the additional small corrections for the different heat capacities of water at different temperatures, for heat lost from the calorimeter to the surroundings, and for the effect of the buoyancy of air on the observed weight of water. The preparation of the combined table will be illustrated after these additional corrections have been discussed.

At ordinary laboratory temperatures, above 70° F, the sum of the corrections for the heat capacity of water and for heat lost is of nearly the same magnitude as the correction for buoyancy, but of opposite sign. Consequently, it would make little difference at these temperatures if all three corrections were ignored. Under exceptional conditions, the temperature of the room may be considerably less than 60° F; the three corrections are then of the same sign and may not be negligible. Since it is very easy to incorporate them into the table for local use, there is no good reason for omitting them.

The correction, C_s, for the heat capacity or specific heat of water, and the correction, C_b, for buoyancy, both depend on temperature and are given in table 9. The correction for heat lost from the calorimeter, sometimes referred to as a correction for radiation and sometimes as an efficiency correction, is a characteristic of the construction of the calorimeter employed, and to some extent of the rate at which the gas is burned. This correction, C_e, usually amounts to 0.1 or 0.2 of 1 percent in calorimeters of the type commonly used in America, when adjusted as recommended in this Circular; it may be assumed without appreciable error, to be 1.5 Btu per 1,000 Btu produced by combustion. If the loss of heat per 1,000 Btu is known for the individual calorimeter, the amount should be entered in the spaces in the table under C_e. Otherwise, use 1.5 Btu. The last column, left blank, is obtained by multiplying the sum of the corrections by the local heating value in thousands of Btu.

The number, C_m, in the last column of table 9 is the aggregate of the minor corrections to be added to the observed heating value in computing both the net and the total heating values. As already suggested, it is convenient to prepare a single table of the combined corrections for humidity, heat capacity of water, buoyancy, and heat lost, to be added to the observed heating value to obtain the total heating value under local conditions.

TABLE 9.—*Minor corrections (C_m) to be added to observed heating value*

[Values of C_S for variation of heat capacity of water and C_b for buoyancy of air are given. The value of C_S is based on an assumed increase of temperature of 15° F in the calorimeter. Values of C_e for the individual calorimeter should be used, if known. Otherwise, use 1.5 Btu per 1,000 Btu liberated. H is the approximate heating value of the gas in thousands of Btu.]

Dry-bulb temperature	Correction (Btu per 1000 Btu liberated)				Sum of minor corrections $C_m=H\ (C_b+C_S+C_e)$
	C_b	C_S	C_b+C_S	C_e	
°F					Btu
40	1.1	2.8	3.9		
45	1.1	1.5	2.6		
50	1.1	0.4	1.5		
55	1.1	−.6	0.6		
60	1.1	−1.4	−.3		
65	1.1	−2.0	−.9		
70	1.1	−2.5	−1.4		
75	1.1	−2.6	−1.6		
80	1.0	−2.7	−1.7		
85	1.0	−2.7	−1.7		
90	1.0	−2.6	−1.6		
95	1.0	−2.5	−1.5		
100	1.0	−2.3	−1.3		
105	1.0	−2.1	−1.1		
110	1.0	−2.0	−1.0		

V. PREPARATION OF A CORRECTION TABLE FOR LOCAL USE

Table 10 is presented as an example of the preparation of a table of this kind for local use. It represents the correction to be applied in the case of a mixed coal and water gas of 800 Btu per cubic foot in a locality where the average barometric pressure is 28 inches of mercury. Each step in the preparation of the local table from the data in tables 6 to 9 is clearly shown, and the combined correction is indicated by bold-faced type. When this is added to the observed heating value the total heating value is obtained in a single operation, if the inlet water is at the temperature indicated by the dry-bulb thermometer, which should be located where it will indicate the temperature of the air entering the calorimeter. A skeleton table (table 11) is given to be filled out for local use.

Fractions of a Btu are of doubtful significance in any of the corrections; but to avoid the possible accumulation of a significant error by dropping them, it is suggested that the first decimal be retained in making up tables of combined correction factors until the final figure for entry in the table is found. The correction can then be rounded off to the nearest Btu, if desired. In case the net heating value is to be determined, the correction for humidity is not involved, and the correction, C_m, from table 9 is the only one to be used if the inlet water is at the temperature indicated by the dry-bulb thermometer. If it is at a different temperature, the additional correction shown in table 12 is necessary.

TABLE 10.—*"Combined correction" for illustrative local conditions*

[It is assumed that the gas is a mixture of natural and manufactured gas of 800 Btu per cubic foot and that the local barometric pressure is 28 in. of mercury. Then the combined correction

$$C_c=\frac{HQS}{1000\,P}+\frac{HY}{1000}+\frac{H(C_b+C_s+C_e)}{1000},$$

becomes

$$C_c=\frac{0.800\,QS}{28}+0.800\,Y+0.800\,(C_b+C_s+C_e).$$

H is the local heating value and *P* is the average local barometric pressure. Values of *Q* are those given in table 6 for "mixed natural and manufactured gas above 700 Btu"; values of *S* are taken from table 8; values of *Y* from table 7; and values of C_b+C_s from table 9. C_s is assumed to be 1.5 Btu per 1,000 Btu of observed heating value.]

Relative humidity→			0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Values of *Q* for 800 Btu mixed gas→			10.1	8.9	7.7	6.5	5.2	4.0	2.8	1.6	0.3	−0.9	−2.1
Dry-bulb temperature	*S*	Corrections↓	Btu per cubic foot										
°F													
40	13	$0.800\,QS/28$	3.8	3.3	2.9	2.4	1.9	1.5	1.0	0.6	0.1	−0.3	−0.8
		$.800\,Y$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	0.0	.0	.0
		$.800\,(C_b+C_s+C_e)$	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
		C_c	**8.1**	**7.6**	**7.2**	**6.7**	**6.2**	**5.8**	**5.3**	**4.9**	**4.4**	**4.0**	**3.5**
45	15	$0.800\,QS/28$	4.3	3.8	3.3	2.8	2.2	1.7	1.2	0.7	0.1	−0.4	−0.9
		$.800\,Y$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	0.0	.0	.0
		$.800\,(C_b+C_s-C_e$	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
		C_c	**7.6**	**7.1**	**6.6**	**6.1**	**5.5**	**5.0**	**4.5**	**4.0**	**3.4**	**2.9**	**2.4**

TABLE 10.—*"Combined correction" for illustrative local conditions*—Continued

Relative humidity⟶			0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Values of Q for 800 Btu mixed gas⟶			10.1	8.9	7.7	6.5	5.2	4.0	2.8	1.6	0.3	−0.9	−2.1
Dry-bulb temperature	S	Corrections↓	Btu per cubic foot										
°F													
50	18	0.800 $QS/28$	5.2	4.6	4.0	3.3	2.7	2.1	1.4	0.8	0.2	−0.5	−1.1
		.800 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	.0	0.0
		.800 $(C_b+C_s+C_e)$	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		C_c	**7.6**	**7.0**	**6.4**	**5.7**	**5.1**	**4.5**	**3.8**	**3.2**	**2.6**	**1.9**	**1.3**
55	22	0.800 $QS/28$	6.3	5.6	4.8	4.1	3.3	2.5	1.8	1.0	0.2	−0.6	−1.3
		.800 Y	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.0	.0	0.0
		.800 $(C_b+C_s+C_e)$	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
		C_c	**8.0**	**7.3**	**6.5**	**5.8**	**5.0**	**4.2**	**3.5**	**2.7**	**1.9**	**1.1**	**0.4**
60	26	0.800 $QS/28$	7.5	6.6	5.7	4.8	3.9	3.0	2.1	1.2	0.2	−0.7	−1.6
		.800 Y	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	.0	.0	0.0
		.800 $(C_b+C_s+C_e)$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		C_c	**8.5**	**7.6**	**6.7**	**5.8**	**4.9**	**4.1**	**3.1**	**2.2**	**1.2**	**0.3**	**−0.6**
65	31	0.800 $QS/28$	8.9	7.9	6.8	5.8	4.6	3.5	2.5	1.4	0.3	−0.8	−1.9
		.800 Y	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	.0	.0	0.0
		.800 $(C_b+C_s+C_e)$	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
		C_c	**9.4**	**8.4**	**7.3**	**6.4**	**5.2**	**4.1**	**3.1**	**2.0**	**.8**	**−.3**	**−1.4**
70	37	0.800 $QS/28$	10.7	9.4	8.1	6.9	5.5	4.2	3.0	1.7	0.3	−1.0	−2.2
		.800 Y	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	.1	0.0	0.0
		.800 $(C_b+C_s+C_e)$	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
		C_c	**10.8**	**9.5**	**8.3**	**7.1**	**5.7**	**4.4**	**3.2**	**1.9**	**.5**	**−.9**	**−2.1**
75	44	0.800 $QS/23$	12.6	11.1	9.7	8.2	6.5	5.0	3.5	2.0	0.4	−1.1	−2.6
		.800 Y	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	.1	0.0	0.0
		.800 $(C_b+C_s+C_e)$	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1
		C_c	**12.5**	**11.0**	**9.7**	**8.2**	**6.5**	**5.0**	**3.5**	**2.0**	**.4**	**−1.2**	**−2.7**
80	52	0.800 $QS/28$	15.0	13.2	11.4	9.7	7.7	5.9	4.2	2.4	0.4	−1.3	−3.1
		.800 Y	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	.1	0.0	0.0
		.800 $(C_b+C_s+C_e)$	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2
		C_c	**14.8**	**13.1**	**11.3**	**9.7**	**7.7**	**5.9**	**4.2**	**2.4**	**.3**	**−1.5**	**−3.3**
85	62	0.800 $QS/28$	17.8	15.8	13.6	11.5	9.2	7.1	5.0	2.8	0.5	−1.6	−3.7
		.800 Y	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2	.2	0.1	0.0
		.800 $(C_b+C_s+C_e)$	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2	−.2
		C_c	**17.6**	**15.7**	**13.6**	**11.5**	**9.2**	**7.1**	**5.0**	**2.8**	**.5**	**−1.7**	**−3.9**
90	72	0.800 $QS/28$	20.8	18.3	15.8	13.4	10.7	8.2	5.8	3.3	0.6	−1.9	−4.3
		.800 Y	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2	.2	0.1	0.0
		.800 $(C_b+C_s+C_e)$	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1	−.1
		C_c	**20.7**	**18.3**	**15.9**	**13.5**	**10.8**	**8.3**	**5.9**	**3.4**	**0.7**	**−1.9**	**−4.4**
95	86	0.800 $QS/28$	24.8	21.9	18.9	16.0	12.8	9.8	6.9	3.9	0.7	−2.2	−5.2
		.800 Y	0.0	0.2	0.2	0.3	0.4	0.4	0.4	0.3	.2	0.1	0.0
		.800 $(C_b+C_s+C_e)$	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
		C_c	**24.8**	**22.1**	**19.1**	**16.3**	**13.2**	**10.2**	**7.3**	**4.2**	**0.9**	**−2.1**	**−5.2**
100	100	0.800 $QS/28$	28.9	25.4	22.0	18.6	14.9	11.4	8.0	4.6	0.9	−2.6	−6.0
		.800 Y	0.0	0.2	0.3	0.4	0.5	0.5	0.5	0.4	.3	0.2	0.0
		.800 $(C_b+C_s+C_e)$	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
		C_c	**29.1**	**25.8**	**22.5**	**19.2**	**15.6**	**12.1**	**8.7**	**5.2**	**1.4**	**−2.2**	**−5.8**
105	117	0.800 $QS/28$	33.8	29.8	25.7	21.7	17.4	13.4	9.4	5.3	1.0	−3.0	−7.0
		.800 Y	0.0	0.2	0.5	0.6	0.6	0.7	0.6	0.6	0.5	0.2	0.0
		.800 $(C_b+C_s+C_e)$	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
		C_c	**34.1**	**30.3**	**26.5**	**22.6**	**18.3**	**14.4**	**10.3**	**6.2**	**1.8**	**−2.5**	**−6.7**
110	138	0.800 $QS/28$	39.8	35.1	30.4	25.6	20.5	15.8	11.0	6.3	1.2	−3.5	−8.3
		.800 Y	0.0	0.3	0.6	0.8	0.9	1.0	0.9	0.8	0.6	0.2	0.0
		.800 $C_b+C_s+C_e)$	.4	.4	.4	.4	.4	0.4	.4	.4	.4	.4	.4
		C_c	**40.2**	**35.8**	**31.4**	**26.8**	**21.8**	**17.2**	**12.3**	**7.5**	**2.2**	**−2.9**	**−7.9**

TABLE 11.—*Combined corrections to be applied to observed heating value to obtain total heating value under local conditions*

Type of gas ________________________________ Approximate heating value ________________ Average barometric pressure ________________]

Relative humidity →		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Q →											
Dry-bulb temperature	S	Combined correction, C_c, BTU per cu ft									
°F											
40	13										
45	15										
50	18										
55	22										
60	26										
65	31										
70	37										
75	44										
80	52										
85	62										
90	72										
95	86										
100	100										
105	117										
110	138										

VI. CORRECTIONS FOR DIFFERENCE BETWEEN INLET-WATER TEMPERATURE AND ROOM TEMPERATURE

In table 12 are given the data from which to determine the amounts by which the total and net heating values, calculated from the observed heating value as if the inlet water had been at room temperature, must be corrected on account of any difference in temperature between inlet water and room. The numbers in the table are to be multiplied by the approximate heating value of the gas to obtain the correction in Btu per degree difference in temperature. For convenience, blanks for this product are left in the table, to be filled in for local use. The correction is added if the inlet water is warmer than the room; subtracted if the inlet water is colder. In calculating the observed heating value, the stem corrections to both the inlet- and outlet-water thermometers must be taken into account when the inlet-water temperature differs much from room temperature. The table is based on an assumed gas rate of 3,000 Btu per hour. If a materially different rate is used, subtract from the figures in the table 0.05 Btu for each 300 Btu per hour above 3,000.

The table includes corrections for (a) the change in the specific heat of water; (b) the heat lost by "radiation" from the calorimeter; (c) the heat in the products of combustion, including water vapor; (d) the heat in the condensed water; and (e) the heat of vaporization of the water carried by the flue gas. In computing the values in the table, an "average" gas, consisting of equal parts of average 550 Btu water gas and average 1,100 Btu natural gas, was assumed. The second decimal may be uncertain for gases of other compositions, the negligible deviation resulting mainly from differences in the ratio of carbon to hydrogen in the fuel.

TABLE 12.—*Corrections for difference between inlet-water temperature and room temperature*

Dry-bulb temperature	Corrections in Btu per 1° F per 1,000 Btu of total heating value		Corrections in Btu per 1° F for local conditions	
	For calculating total heating value	For calculating net heating value	For calculating total heating value	For calculating net heating value
°F				
40	0.78	0.58		
45	.85	.61		
50	.93	.65		
55	1.04	.70		
60	1.15	.75		
65	1.26	.79		
70	1.36	.82		
75	1.46	.83		
80	1.58	.84		
85	1.71	.85		
90	1.85	.85		
95	2.01	.85		
100	2.19	.85		
105	2.42	.85		
110	2.67	.85		

VII. CORRECTION OF HEATING VALUE TO BASIS OF MEASUREMENT FOR USE

It is sometimes desired to determine the heating value of gas as measured for sale or use rather than on the basis of "standard" conditions. Since the conditions of measurement in the calorimeter meter are not, in general, exactly those existing at the time of measurement for use, it is most convenient to compute the heating value of the gas saturated at 60° F and 30 inches of mercury in the usual way and to multiply the result by a factor determined by the observed conditions of pressure, temperature, and humidity at the time of measurement for use. In general, it is incorrect to assume that dry gas introduced into a low-pressure distributing system will maintain its original condition of humidity until metered, and the humidity of the gas as well as the temperature should always be determined at the place at which the gas is measured.

The amount of water vapor in the gas can usually be determined best by the use of a dew-point apparatus. The partial pressure of water vapor in the gas corresponding to the mean of the temperatures at which dew appears and disappears, can be read from table 13, which shows the vapor pressure of water in inches of mercury at various temperatures.

Three cases will be considered. In the first and second it is assumed that the gas has been measured by displacement meters of the diaphragm, rotary, or proportional types which give readings directly in cubic feet of gas under the conditions of pressure, temperature, and humidity actually existing in the meter. In the first case it is assumed that the dew point of the gas has been determined at the pressure existing in the meter; in the second case that the dew point has been observed after the gas has expanded to a lower pressure. In the third case it is assumed that the gas is measured by an orifice meter or some other type of "inferential" meter. Such meters do not, in general, give data directly in cubic feet, but the volume metered must be calculated from observations of other physical quantities. It is customary to use formulas which give the quantity of gas measured in terms of cubic feet at 60° F and 30 inches of mercury pressure, but without taking account of any change which would occur in the percentage of water vapor in the gas if brought to saturation at 60° F. For this class of meters, corrections for temperature and pressure have already been made when the volume of gas is first expressed in cubic feet, and only the correction for humidity remains.

In each of the factors which follow, P represents the total pressure (barometric plus gage) of the gas in the meter in inches of mercury; t represents its temperature in °F; p represents the total pressure, which may or may not differ from P, of the gas in which the dew point is taken; and D represents the vapor pressure of water at the observed dew point.

Case 1.—The heating value of the gas at its temperature, pressure, and humidity in the meter is to be determined, and the dew point of the gas has been observed at the meter pressure.

Multiply the heating value under standard conditions, determined in the usual way, by the factor,

$$\frac{(P-D)\ (60+460)}{(30-0.5217)\ (t+460)}=17.640\ \frac{P-D}{t+460}.$$

The product multiplied by the number of cubic feet registered by the meter will give the total heat of combustion of the gas measured.

Case 2.—The heating value of the gas under the conditions in the meter is to be determined as in *case 1*, but the dew point has been observed in gas expanded to pressure p.

Multiply the heating value under standard conditions by the factor

$$\frac{\left(P-\frac{DP}{p}\right)(60+460)}{(30-0.5217)\ (t+460)}=17.640\ \frac{P\ (p-D)}{p\ (t+460)}.$$

Again, the product multiplied by the number of cubic feet registered gives the total heat of combustion of the gas measured.

Case 3.—The volume of gas metered has been reduced as though it were dry to the volume it would occupy if dry under otherwise standard conditions, and the dew point was measured at pressure p. The heating value at standard temperature and pressure is to be determined as though no water were added or removed. (The amount of water contained may be sufficient to condense at 60° F, but the problem is to be treated as though it remained in vapor form.)

Multiply the heating value under standard conditions by the factor

$$1.018\ \frac{p-D}{p}.$$

The product, multiplied by the number of cubic feet at standard temperature and pressure, gives the total heat of combustion of the gas measured.

TABLE 13.—*Vapor pressure of water (ice below 32° F)*

[Data from Thermodynamic Properties of Steam, by Keenan and Keyes]

Temperature	Vapor pressure (in. of Hg)	Temperature	Vapor pressure (in. of Hg)
°F		°F	
−40	0.004	45	0.300
−30	.007	50	.363
−20	.013	55	.436
−10	.022	60	.522
0	.038	65	.622
5	.049	70	.739
10	.063	75	.875
15	.081	80	1.032
20	.103	85	1.213
25	.130	90	1.422
30	.164	95	1.660
35	.204	100	1.933
40	.248	105	2.243

TABLE 14.—*Heating value, "air requirement," and products of combustion of important constituents of fuel gases*

[Heating values of gases reported from hydrogen to acetylene are based on values of heat of combustion per mole selected by F. D. Rossini and corrections for deviation from the ideal gas laws by C. S. Cragoe, July 1, 1937. Values for benzene, pentane, hexane, and decane are computed from values of heat of combustion per mole, selected by Rossini, as though they were ideal gases. Actually, the pure substances are liquids at 60° F, 30 in. of Hg and the deviation of their vapors from ideal gas laws, which are large, depend on the other gases present as well as on their own concentration. The estimation of the extent of this deviation must be made in each individual case if the amount of vapor present and the purpose for which the data are to be used appear to justify a correction. Decane is included as representative of the vapor of average motor gasoline. The range of values reported for "illuminants" is that within which the constituents of ordinary coal gas and water gas reported under this term usually fall. Illuminants may have considerably lower or very much higher heating values than those listed. The volumes of air required for combustion and the products formed correspond to complete chemical reactions and the ideal gas laws without correction.]

Gas	Heating value				Volume of air required to burn 1 cu ft	Volume of products of combustion		
	Gas saturated at 60° F, 30 in. of Hg		Gas dry at 60° F, 30 in. of Hg					
	Total	Net	Total	Net		H_2O	CO_2	N_2
	Btu/cu ft	Btu/cu ft	Btu/cu ft	Btu/cu ft	cu ft	cu ft	cu ft	cu ft
Hydrogen, H_2	319.4	269.9	325.0	274.6	2.39	1	0	1.89
Carbon monoxide, CO	316.1	316.1	321.7	321.7	2.39	0	1	1.89
Methane, CH_4	997.4	898.1	1,015.0	914.0	9.55	2	1	7.55
Ethane, C_2H_6	1,759	1,609	1,790	1,637	16.71	3	2	13.21
Propane, C_3H_8	2,528	2,326	2,572	2,366	23.87	4	3	18.87
Normal butane, C_4H_{10}	3,336	3,079	3,393	3,132	31.03	5	4	24.53
Isobutane. C_4H_{10}	3,307	3,052	3,364	3,105	31.03	5	4	24.53
Ethylene, C_2H_4	1,587	1,487	1,615	1,514	14.32	2	2	11.32
Propylene, C_3H_6	2,339	2,188	2,380	2,226	21.48	3	3	16.98
Acetylene, C_2H_2	1,465	1,415	1,491	1,440	11.93	1	2	9.43
Benzene, C_6H_6	3,693	3,544	3,758	3,607	35.79	3	6	28.29
Pentane, C_5H_{12}	3,953	3,656	4,023	3,720	38.20	6	5	30.20
Hexane, C_6H_{14}	4,688	4,341	4,771	4,418	45.37	7	6	35.86
Decane, $C_{10}H_{22}$	7,628	7,081	7,763	7,210	74.02	11	10	58.52
"Illuminants"	2,000 to 2,400	1,875 to 2,275	2,000 to 2,450	1,900 to 2,300	18.5 to 22.5	2.2 to 2.4	2.8 to 3.5	14.6 to 17.8

VIII. RECORDS AND COMPUTATIONS

1. Enter from page 4 the *certificate correction* and the *temperature correction* to the barometer. The corrections thus entered are added to (or subtracted from) the *barometer readings* to find the *corrected barometric height*, the *average* obtained from the barometer readings being entered on the record.

2. Enter the *equivalent, in inches of mercury,* of the pressure at meter inlet, and add this to the *corrected barometric height* to find the *total gas pressure.*

3. Enter from page 4 the *scale correction* to meter thermometer; and calculate the corrected *meter temperature;* only the average calculated from the readings of the meter thermometer is entered on the record.

4. From table 3 enter the *reduction factor, F,* corresponding to the *total gas pressure* and the *meter temperature.*

5. From figure 2 or figure 3 enter on the record the relative atmospheric *humidity* (to the nearest 5 percent) corresponding to the recorded *dry-bulb* and *wet-bulb* thermometer readings of the type of psychrometer employed.

6. Enter the *rate* in *Btu per hour* corresponding to the *time* in seconds *of one revolution* of the meter index and the anticipated heating value.

7. Average separately, for each series, the *readings of the inlet and of the outlet water thermometers,* omitting the *preliminary* and *supplementary* readings, and enter these *averages* on the record.

8. Enter from page 22 the *certificate corrections* corresponding to the average readings of the inlet and outlet water thermometers.

From the thermometer-calibration certificate, the points may be plotted on page 22 and the points connected by lines to give the correction for any intermediate reading. The same scale should be used for both thermometers, if possible, in order to avoid confusion in use. Should another thermometer be substituted, a new set of corrections can be pasted over the old one.

9. Enter from page 24 the *differential correction* to the reading of the outlet-water thermometer.

This correction, determined as described on page 58 of Circular 48, is applied in order to correct for any relative change that may have occurred in the thermometers since the determination of their certificate corrections.

10. Enter on the record the *emergent stem correction* to the average readings of the outlet-water thermometer.

Correction for emergent stem of thermometer.—If the mercury thread of a thermometer is not at the same temperature as the bulb, the emergent stem correction may be too large to be neglected. The correction for emergent stem may be computed from the formula:

$$\text{Stem correction} = K \times n\ (T^\circ - t^\circ).$$

K=factor for relative expansion of mercury in glass; 0.00015 to 0.00016 for centigrade thermometers, 0.000083 to 0.000089 for Fahrenheit thermometers, at ordinary temperatures, depending upon the glass of which the stem is made. For ordinary calorimetric thermometers graduated on the Fahrenheit scale, the value K=0.000085 may be used.
n=number of degrees emergent from the bath.
T=temperature of the bulb.
t=mean temperature of the emergent stem.

Table 5, page 23, shows emergent-stem corrections for four depths of immersion. If a thermometer with any other immersion point is used, the data can be calculated from the formula given. The mean temperature of the emergent stem of the outlet thermometer is slightly above room temperature, and some allowance was made for this in the table shown.

11. Enter on the record the *corrected temperature* of the inlet and of the outlet water for each series by applying the several corrections to the averages of the readings of the inlet and outlet water thermometers.

12. Subtract the corrected temperature of the inlet water from the corrected temperature of the outlet water for each series, and enter this "*temperature rise*," T, on the record.

13. The weight of *water collected*, W, is corrected if calibration has shown any error in the weights used.

14. Opposite *number of revolutions of meter* enter on the record the number of revolutions made by the meter index during the time the effluent water for each series was being collected.

15. Enter from page 24 the meter calibration constant, viz, the number of *cubic feet corresponding to one revolution* of the meter.

16. Enter on the record the *gas volume*, V, which is the product of the number of revolutions of the meter and the meter calibration constant.

17. Calculate and enter on the record for each series the observed heating value found from the following equation:

$$\text{Observed heating value}=\frac{\text{Water heated }(W)\times\text{temperature rise }(T)}{\text{Gas volume }(V)\times\text{reduction factor }(F)}$$

18. Enter from page 34 the combined corrections for atmospheric humidity, specific heat of water, buoyancy, and heat lost from the calorimeter. Table 11 on page 34 has been left blank for the convenient entry of corrections corresponding to local conditions. Directions for ascertaining these corrections are given on page 32.

If the inlet water is not at room temperature, another correction (to be added if the water is warmer and subtracted if colder than the room) is necessary.

On page 35 are given the data from which to determine the amounts by which the total and the net heating values, calcuated from the observed heating value as if the inlet water had been at room temperature, must be corrected on account of difference between inlet-water and room temperatures. For example, if the room temperature were 80° F and the inlet-water temperature were 76° F, the total heating value, calculated in the usual way, is too high by 1.58 Btu per 1,000 Btu per 1° difference, i. e., the value is too high by $4\times1.58=6.32$ Btu per 1,000 Btu. Similarly, the net heating value is too high by $4\times0.84=3.36$ Btu per 1,000 Btu.

19. Enter from table 12, page 35, the correction for difference between room temperature and the temperature of the water entering the calorimeter.

20. Calculate the *total heating values* by applying to the *observed heating values* the *corrections indicated.* The *average* of the *total heating values* found from all the series is then entered on the record.

21. If it is desired to find the *net heating value*, proceed as follows:

(a) Subtract the *meter reading at the start* from the *meter reading at end* of *collection of condensate.* This difference gives approximately the number of cubic feet of gas (measured at *meter temperature* and under a pressure equal to that entered above as the *total gas pressure*) burned during the collection of the recorded *condensate* (*ml*). Multiply this difference, as found above, by the *factor, F,* to find the volume of the gas under standard conditions (i. e., 60° F, 30 inches of pressure), and divide the *condensate* (*ml*) collected by this product and enter the resulting quotient on the record as the *condensate per cubic foot* of gas measured at 60° F and 30 inches of pressure. Enter on the record the average, *A*, of the two values found as above from the two tests for condensed water collected.

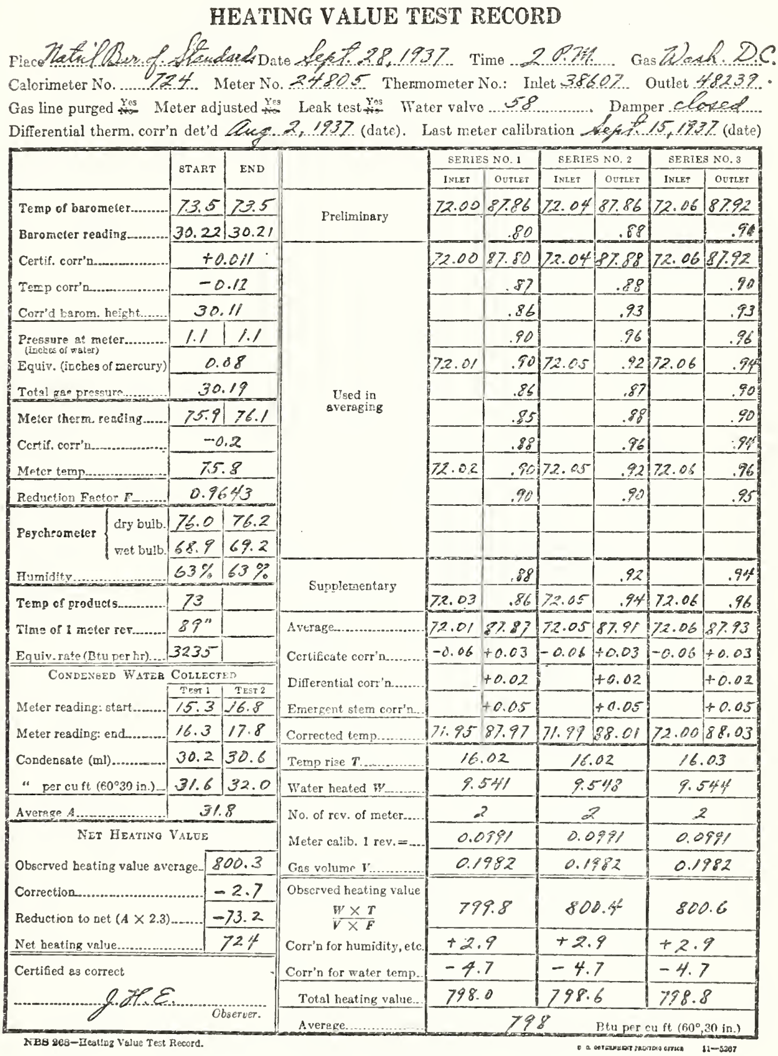
(b) Enter on the record the *average* of the *observed heating values.*

(c) Enter on the record the combined correction for specific heat, buoyancy, and heat loss from table 9, page 31. (The correction for atmospheric humidity is not included.)

(d) Enter on the record the correction for difference between the temperature of the room and the water entering the calorimeter.

(e) Multiply the *condensate per cubic foot* of the gas (measured at 60° F and 30 inches), entered opposite *A* in the record, by 2.3 and enter the product thus found as the *reduction to net.*

(f) To the *observed heating value* add the *corrections* indicated and subtract the number derived as explained above, representing the *reduction to net,* and enter the result as the *net heating value.*



HEATING VALUE TEST RECORD

Place Nat'l Bur. of Standards Date Sept. 28, 1937 Time 2 P.M. Gas Wash. D.C.

Calorimeter No. 724 Meter No. 24805 Thermometer No.: Inlet 38607 Outlet 48239

Gas line purged Yes ~~No~~ Meter adjusted Yes ~~No~~ Leak test Yes ~~No~~ Water valve 58 Damper closed

Differential therm. corr'n det'd Aug. 2, 1937 (date). Last meter calibration Sept. 15, 1937 (date)

	START	END
Temp of barometer	73.5	73.5
Barometer reading	30.22	30.21
Certif. corr'n	+0.011	
Temp corr'n	−0.12	
Corr'd barom. height	30.11	
Pressure at meter (inches of water)	1.1	1.1
Equiv. (inches of mercury)	0.08	
Total gas pressure	30.19	
Meter therm. reading	75.9	76.1
Certif. corr'n	−0.2	
Meter temp	75.8	
Reduction Factor F	0.9643	
Psychrometer dry bulb	76.0	76.2
Psychrometer wet bulb	68.9	69.2
Humidity	63%	63%
Temp of products	73	
Time of 1 meter rev	89"	
Equiv. rate (Btu per hr)	3235	

CONDENSED WATER COLLECTED	TEST 1	TEST 2
Meter reading: start	15.3	16.8
Meter reading: end	16.3	17.8
Condensate (ml)	30.2	30.6
" per cu ft (60°30 in.)	31.6	32.0
Average A	31.8	

NET HEATING VALUE	
Observed heating value average	800.3
Correction	−2.7
Reduction to net (A × 2.3)	−73.2
Net heating value	724

Certified as correct

J. H. E.
Observer.

	SERIES NO. 1 INLET	SERIES NO. 1 OUTLET	SERIES NO. 2 INLET	SERIES NO. 2 OUTLET	SERIES NO. 3 INLET	SERIES NO. 3 OUTLET
Preliminary	72.00	87.86	72.04	87.86	72.06	87.92
		.80		.88		.96
Used in averaging	72.00	87.80	72.04	87.88	72.06	87.92
		.87		.88		.90
		.86		.93		.93
		.90		.96		.96
	72.01	.90	72.05	.92	72.06	.94
		.86		.87		.90
		.85		.88		.90
		.88		.96		.94
	72.02	.90	72.05	.92	72.06	.96
		.90		.90		.95
Supplementary		.88		.92		.94
	72.03	.86	72.05	.94	72.06	.96
Average	72.01	87.87	72.05	87.91	72.06	87.93
Certificate corr'n	−0.06	+0.03	−0.06	+0.03	−0.06	+0.03
Differential corr'n		+0.02		+0.02		+0.02
Emergent stem corr'n		+0.05		+0.05		+0.05
Corrected temp	71.95	87.97	71.99	88.01	72.00	88.03
Temp rise T	16.02		16.02		16.03	
Water heated W	9.541		9.548		9.544	
No. of rev. of meter	2		2		2	
Meter calib. 1 rev. =	0.0991		0.0991		0.0991	
Gas volume V	0.1982		0.1982		0.1982	
Observed heating value $\frac{W \times T}{V \times F}$	799.8		800.4		800.6	
Corr'n for humidity, etc.	+2.9		+2.9		+2.9	
Corr'n for water temp.	−4.7		−4.7		−4.7	
Total heating value	798.0		798.6		798.8	
Average	798 Btu per cu ft (60°,30 in.)					

NBS 268—Heating Value Test Record.

U. S. GOVERNMENT PRINTING OFFICE 11—5267

FIGURE 5.—*Form for calorimetric record.*

(The trim dimensions of this form, as used by the Bureau, are 8 by 10½ inches.)

HEATING VALUE TEST RECORD

(Single Test Form)

Place________________ Date________________ Time________________

Meter adjusted Yes No Leak test Yes No Gas__________________

Temp. of barometer__________________
Barometer reading__________________
Certif. corr'n__________________
Temp. corr'n__________________
Corr'd barom. height__________________

Pressure at meter__________________
(inches of water)
Equiv. (inches of mercury)__________
Total gas pressure__________________

Meter therm. reading__________________
Certif. corr'n__________________
Meter temp__________________

Reduction factor F__________________

Psychrometer {dry bulb______________ / wet bulb______________}
Humidity__________________

Temp. of products__________________
Rate (Btu. per hr.)__________________
Gas volume V__________________
Water heated W__________________

Thermometer No.

Readings	Inlet	Outlet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average____________		
Certificate corr'n____		
Differential corr'n___		
Emergent stem corr'n		
Corrected temp_____	____________	____________

Net Heating Value

Observed heating value:
Average______________________
Correction______________________
Reduction to net:
Ml per cu ft×2.3÷F__________
Net heating value__________________

Certified as correct.

____
Observer.

Temp. rise T______________________________

Observed heating value__________________________
Corr'n for humidity, etc__________________________
Corr'n for water temp__________________________
Total heating value__________________________

FIGURE 6.—*Heating value test record.*

WASHINGTON, August 3, 1937.

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