Gas Calorimeter Tables

National Bureau of Standards Circular 464

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UNITED STATES DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
E. U. Condon, *Director*

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By

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PREFACE

This Circular may be regarded as a revision of Circular 417, which, in turn, replaced an earlier publication, Circular 65. These two publications were widely used for approximately 30 years as laboratory handbooks by those engaged in gas calorimetry. Data of the kind assembled in these Circulars must be used in every determination of heating value with a water-flow calorimeter of the Junkers type.

When Circular 65 was prepared, nearly all fuel gases that 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, Circular 65 was prepared primarily for use with gases of only limited ranges of composition. Circular 417, on the other hand, gave equal consideration to practically all of the various types of gaseous fuels now in use.

The present Circular represents a revision of Circular 417 in the following respects:

Some minor errors in the data given in Circular 417 have been corrected, and where improved data have appeared since the publication of Circular 417, the new data are used in the present Circular.

There has been some change in notation, and in the method of deriving equations for the so-called humidity corrections. This was done in order to make the Circular as nearly as possible consistent in notation, and in method of presentation with ASTM Tentative Method of Test for Calorific Value of Gaseous Fuels by the Water Flow Calorimeter (ASTM Designation D 900–46 T), which has appeared since Circular 417. It is believed that these changes will reduce the confusion that might otherwise result from differences in notation and in methods of presentation in the two publications. The method of deriving the humidity correction in the present Circular and in ASTM Designation D 900–46 T is equivalent in principle to that used in Circular 417.

E. U. Condon, *Director.*

GAS CALORIMETER TABLES

By Ralph S. Jessup and Elmer R. Weaver

ABSTRACT

This Circular contains condensed directions for operating a gas calorimeter of the water-flow type, 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 correction factors needed in fuel-gas calorimetry. 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 the data needed in gas calorimetry conveniently arranged under one cover.

CONTENTS

I. INTRODUCTION

This Circular is a revision of Bureau Circular 417, which appeared in 1938, and which, in turn, replaced Circular 65, 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 fuel gases now in use than when Technologic Paper 36 and Circulars 48 and 65 were issued, the method of tabulating some of the corrections was changed in Circular 417 and in the present Circular. Instead of attempting to present two or three tables of humidity corrections to apply to all cases, data are given from which tables corresponding to local conditions can easily be prepared for use in an individual laboratory. As the use of data presented in just this form had not been described prior to the appearance of Circular 417, a longer discussion of the correction for humidity was given in that publication than would otherwise have been appropriate.

The discussion of the humidity correction in the present Circular is equivalent in principle to that given in Circular 417, but some changes have been made in notation, and the corrections are presented in terms of a function of relative humidity, rather than directly in terms of relative humidity itself as in Circular 417.

The table of factors for reducing gas volumes to standard conditions, which was recomputed to four decimal places for C417, is reproduced in this Circular without change. The publication of correction tables for gas volumes that 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 1 part in 1 thousand, but as 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 deviations 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 and tables 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 in. 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 WATER-FLOW GAS 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, saturation of water with gas,[1] water level.

4. Test for gas leaks.

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 so that the temperature rise of the water will be about 15° F, 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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[1] It was stated in Technologic Paper 36 of the National 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 cu ft 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 cu ft of gas must be passed through the meter to saturated 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 saturated the water probably depend to a considerable extent on the composition of the gas. The adjustment of the water level in the meter should be made after saturation of the water with gas. It has also been found that the use of rubber tubing in the gas line between the supply cock and the calorimeter burner will result in a considerable lowering in heating value, especially if the rubber tubing is new. For this reason it is recommended that flexible metal tubing be used in the gas line.

[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 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-in. 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 CHARTS

TABLE 1.—*Corrections for reduction of barometric heights to standard conditions* (32° F, 45° latitude, sea level)

(a) Barometer certificate correction ------------------------------------
(To be entered by observer.)

(b) *Temperature corrections.*—Corrections, in inches, to be subtracted from the observed readings of a mercurial barometer with a brass scale (which is correct at 62° F) to reduce the readings 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					*°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	90	.13	.14	.16	.17
60	.07	.07	.08	.09	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

(c) *Latitude corrections.*—Corrections, in inches, to be *subtracted* from the observed barometric height for latitudes below 45°, and *added* for latitudes above 45° to reduce the reading to inches of mercury at latitude 45°.

Latitude, degrees	Observed barometric height, inches—			
	24.0	26.0	28.0	30.0
25	0.04	0.04	0.05	0.05
30	.03	.03	.04	.04
35	.02	.02	.03	.03
40	.01	.01	.01	.01
50	0.01	0.01	0.01	0.01

(d) *Altitude corrections.*—The correction, in inches, to be *subtracted* from the observed barometric height to reduce the reading to inches of mercury at sea level can usually be neglected. It amounts to about 0.01 percent of the observed barometric height for each 1000 feet above sea level. For convenience the corrections (a), (b), (c), and (d) corresponding to a particular barometer, to local latitude, and average local barometric pressure can be combined to construct a single table of corrections.

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

[1 inch of mercury = 13.6 inches of water]

Water	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00
Mercury	.04	0.07	0.11	0.15	0.18	0.22	0.26	0.29

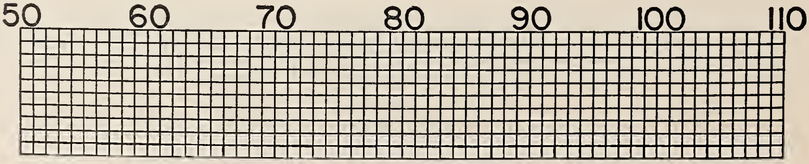

FIGURE 1.—*Certificate correction. Meter thermometer No.* ------.

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 $=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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 $=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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]

Temparature, °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	. 7651	. 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 $=\dfrac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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]

Temparature, °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	.8931	.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 $=\dfrac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p = total gas pressure; w_t = 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 $=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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 $=\dfrac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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 $=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p = total gas pressure; w_t = 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 $=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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: $\text{Correction factor} = \frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

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

TABLE 3. *Correction factor 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	. 9243	. 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: $\text{Correction factor}=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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	. 9972	. 9506	. 9539	. 9572	. 9605	. 9639	. 9672	. 9705

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[1] Formula used: Correction factor$=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p=total gas pressure; w_t=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	. 9624	. 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$=\frac{(p-w_t)(60+459.7)}{(t+459.8)(30-0.5217)}$

p=total gas pressure; w_t=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. 9227
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 $=\dfrac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

p = total gas pressure; w_t = 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 $=\frac{(p-w_t)(60+459.7)}{(t+459.7)(30-0.5218)}$

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

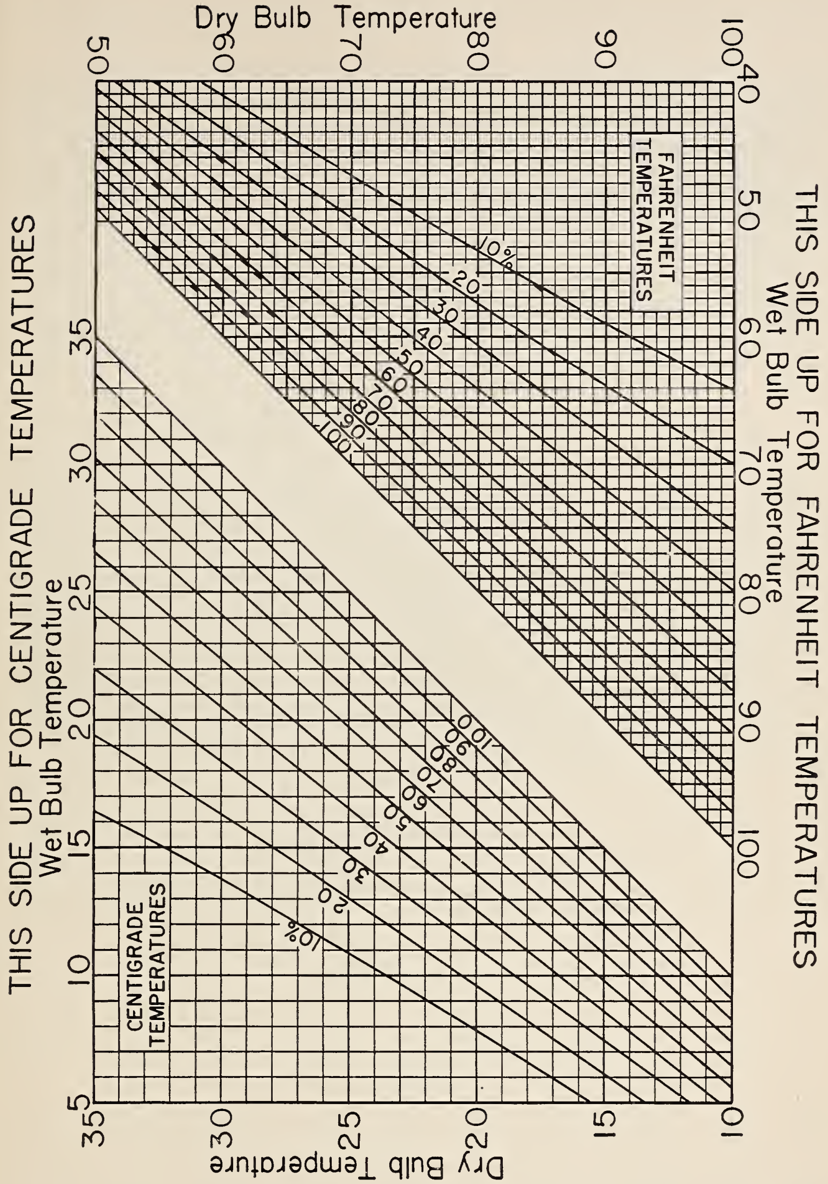

FIGURE 2.—*Chart giving values of the product f × (relative humidity) corresponding to wet- and dry-bulb temperatures from psychrometer with rapid ventilation.*

Calculated for a barometer height of 755 mm. At altitudes of 6,000 ft or over, the reduction in barometric pressure will cause an error of 5 percent or more 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 factor *F* (table 3) corresponding to the conditions of test differs from unity, multiply the tabulated values of seconds per revolution by *F*. If the heating value and the test conditions are 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 1 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----------------	----------------------	--------------------

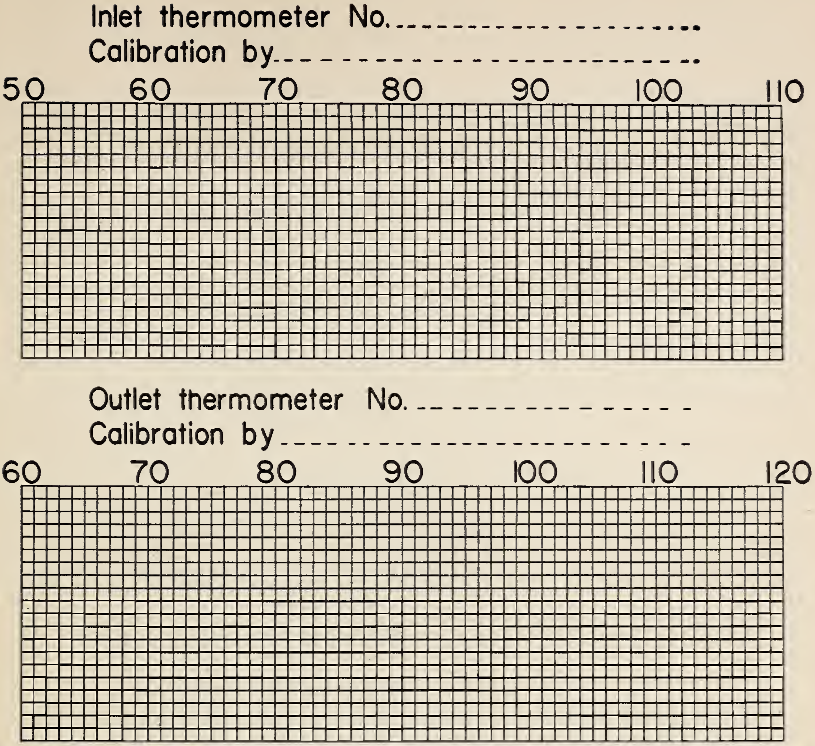

FIGURE 3.—*Certificate correction for calorimeter thermometers.*

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 in enlargement an 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 $=0.000085\times n(T-t)$
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 the difference between the temperatures of inlet-water and room. 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. As the discussion of corrections on exactly the basis proposed has not been given elsewhere in its entirety, 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. 30, where the preparation of a table of corrections for local use is illustrated.

In preparing the set of corrections it is assumed that the temperatures of inlet-water, entering gas and air, and effluent flue gases are all the same. We will let

W = weight of water (pounds) required to saturate a space of 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 [3]
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 the calorimeter per 1 cu ft of saturated gas [3]
h = relative humidity of air entering calorimeter, expressed as a fraction.

The volume of saturated flue gases leaving the calorimeter per cubic foot of gas burned is determined by the damper opening and is independent of the relative humidity of the entering air. The volume of the entering air per cubic foot of gas burned would also be independent of relative humidity if the volume were measured under saturation conditions (or at any fixed relative humidity). In other words, for a given damper opening, and a given rate of combustion of gas in the calorimeter, $V_a = rV_c$ is a constant, independent of relative humidity. However, the actual volume of the air that enters the calorimeter per cubic foot of gas burned, if measured under the actual conditions under which it enters the calorimeter, is not independent of relative humidity, but, for a barometric pressure of 30 in., is given by

$$rV_c \times \frac{30 - w_t}{30 - hw_t},$$

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[3] It will be noted that V_c and V_a, as defined above, do not represent volumes of air measured under any particular conditions of temperature, pressure, and water vapor content. Instead, these quantities are dimensionless, being ratios of volumes of air to volumes of gas when both air and gas are measured under the same conditions.

where w_t represents the saturated vapor pressure of water at the temperature t. For convenience, let the ratio

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

Then for 1 cu ft of saturated gas burned in the calorimeter,

$fhWrV_c$ = weight of water in air actually entering calorimeter per cubic foot of gas, as measured

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

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

$(r-1)V_c$ = volume of excess air leaving the calorimeter per cubic foot of gas

$W(r-1)V_c+WV_p$ = weight of water vapor leaving calorimeter with flue gases, per cubic foot of gas as measured

W_c = weight of water produced by 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

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

from which it follows that

$$W_c-W_m=W(r-1)V_c-W-WfhrV_c+WV_p=$$
$$W[(r-1)V_c+V_p-1-fhrV_c].$$

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

$$L(W_c-W_m)=LW[(r-1)V_c+V_p-1-fhrV_c],$$

where L is the heat of vaporization (Btu/lb) of water at the temperature of measurement.

To obtain the correction to be added *after* the heat produced by combustion of gas has been expressed in terms of Btu per cubic foot *measured under standard conditions,* this number must be divided by F, the "correction factor for gas volumes", obtained from table 3. The final correction for humidity, C_h, to be added to the "observed heating value" is, therefore

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

The factor $[(r-1)\,V_c+V_p-1-fhrV_c]$ varies, of course, with the quantity of air that enters the calorimeter per cubic foot of gas burned, and with the composition of the gas. If an analysis of the gas is available, V_c and V_p can be computed readily from the data given in table 13. The value of r can also be determined accurately from analyses of the gas and of the flue gases. The value of the factor can therefore always be determined accurately with the aid of gas analysis.[4]

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 that enters the calorimeter.

If single values are assumed for r and for h, the values of the factor $[(r-1)V_c+V_p-1-fhrV_c]$, computed for the fuel gases in common use, are nearly proportional to their heating values. Hence, if the factor is divided by the heating value, the result is so nearly independent of the composition of the gas that an average figure for a given type of gas can be used satisfactorily without knowing the composition accurately. It is therefore convenient to define the quantity N by means of the equation

$$N=\frac{(r-1)V_c+V_p-1-fhrV_c}{H/100},$$

where H is the total heating value in Btu per standard cubic foot [5] of gas. The factor 100 is introduced here in order to avoid small fractional values of N. As the quantities in the numerator are all dimensionless ratios, the value of N is in standard cubic feet per 100 Btu of total heating value. If we let N_0 and N_1 denote the values of N for $fh=0$ and $fh=1$, respectively, then

$$N_0-N_1=\frac{rV_c}{H/100},$$

$$N=N_0-fh(N_0-N_1),$$

---

[4] It may be noted that a knowledge of the volume fractions of the various constituents of the gas is not necessary to determine V_c, V_p, and r. All that is required is an analysis of the flue gases to determine the volume fractions of oxygen and carbon dioxide, and a combustion analysis of the gas to determine the volume of oxygen consumed (O), the volume of carbon dioxide produced (CO_2), and the total contraction, (TC) all per unit volume of gas. Then

$$V_c=\frac{O}{0.2095}$$

$$V_p=1+V_c-TC.$$

To calculate r, let R_1 be the ratio of oxygen to carbon dioxide in the flue gases, and R_2 the ratio (O/CO_2) of oxygen consumed to carbon dioxide produced in combustion of the gas. Then

$$r=1+\frac{R_1}{R_2}.$$

[5] A standard cubic foot of gas is defined as the quantity of gas that will occupy a space of 1 cu ft when saturated with water vapor at 60° F and under a total pressure of 30 in. of mercury at 32° F and under standard gravity.

and the equation for the humidity correction becomes

$$C_h = \frac{H}{100}\,\frac{LW}{F}\,[N_0 - fh(N_0 - N_1)].$$

Here

$$F = \frac{(60+459.7)(p-w_t)}{(t+459.7)(30-w_{60})},$$

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

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

and within the limits of experimental error

$$C_h = \frac{30H}{100p}\,NLW\,\frac{(t+460)(30-w_{60})}{520(30-w_t)} = \frac{HSN}{100p} = \frac{HS}{100p}\,[N_0 - fh(N_0 - N_1)],$$

where

$$N = [N_0 - fh(N_0 - N_1)],$$

and

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

It will be seen that the above formula for C_h in terms of fh is somewhat simpler than the formulas given in Circular 417 for C_h in terms of h. It will also be seen that the quantities represented by N_0 and N_1, which are the limiting values of N for $fh=0$ and $fh=1$, respectively, are identical with the quantity Q as defined in Circular 417, for $h=0$ and $h=1$, respectively, but that N for any value of fh intermediate between 0 and 1 is not exactly the same as Q for the corresponding value of h.

If the gas rate and calorimeter damper are adjusted as indicated in footnote 2, about 40 percent more air than is theoretically required for complete combustion enters the calorimeter; that is, $r=1.40$. Table 6 gives values of N for various gases and for several values of fh, the value of r in all cases being assumed to be 1.40. In computing values of N for other than pure gases, approximate average values for the compositions of the mixtures were assumed.[6] Values of w_t, W, L, and S are given in table 7.

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

TABLE 6.—*Values of the factor, N, to be used in computing humidity corrections (see p. 25)*

$$N=\frac{0.40V_c+V_p-1-fh\times 1.40V_c}{H/100}$$

[Here H is the heating value of the gas in Btu per standard cubic foot, h is the relative humidity of the air, f is the factor defined on p. 24, V_c is the volume of air required for complete combustion of 1 volume of gas, and V_p is the volume of air-free products of combustion of 1 volume of gas]

Gas	Total heating value, Btu per standard cubic foot	*fh*										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Hydrogen	319.3	0.57	0.47	0.37	0.26	0.16	0.05	−0.05	−0.16	−0.26	−0.37	−0.47
Carbon monoxide	316.0	.90	.80	.69	.58	.48	.37	+.27	+.16	+.05	−.05	−.16
Methane	996.9	1.14	1.01	.87	.74	.60	.47	.34	.20	.07	−.07	−.20
Ethane	1,758	1.20	1.06	.93	.80	.66	.53	.39	.26	.13	−.01	−.14
Propane	2,529	1.22	1.09	.96	.82	.69	.55	.42	.28	.15	+.01	−.12
Butane	3,333	1.24	1.11	.97	.84	70	.57	.43	30	.16	.03	−.11
Ethylene	1,586	1.14	1.02	.89	.76	.64	.51	.38	.25	.13	.00	−.13
Propylene	2,342	1.20	1.07	.94	.81	.68	.54	.41	.28	.15	.02	−.11
Acetylene	1,462	1.05	0.93	.82	.70	.59	.47	.36	.24	.13	.01	−.10
Benzene	3,687	1.29	1.16	1.02	.88	.75	.61	.48	.34	.20	.07	−.07
Butane-air and propane-air	3,000	1.24	1.10	0.97	.84	.70	.56	.43	.30	.16	.02	−.11
	1,500	1.20	1.07	.94	.81	.68	.54	.41	.28	.15	.02	−.11
	1,000	1.15	1.02	.90	.77	.65	.52	.39	.27	.14	.02	−.11
	800	1.11	0.99	.87	.74	.62	.50	.38	.26	.13	.01	−.11
	700	1.09	.97	.85	.73	.61	.49	.37	.25	.13	.01	−.11
	600	1.05	.93	.82	.70	.59	47	.35	.24	.12	.01	−.11
	500	1.00	.89	.78	.67	.56	.44	.33	.22	.11	.00	−.11
Water gas	1,000	1.11	.98	.85	.72	.59	.46	.33	.20	.07	−.06	−.19
	800	1.08	.95	.82	.70	.57	.44	.31	.18	.06	−.07	−.20
	700	1.05	.92	.80	.68	.55	.42	.30	.18	.05	−.08	−.20
	600	1.02	.90	.77	.65	.53	.40	.28	.16	.04	−.09	−.21
	500	0.96	.84	.72	.60	.48	.36	.25	.13	.01	−.11	−.23
	400	.88	.76	.65	.54	.42	.30	.19	.08	−.04	−.16	−.27
	300	.73	.62	.52	.41	.31	.20	.09	−.01	−.12	−.22	−.33
Coal, coke oven, oil, and refinery	2,000	1.22	1.08	.95	.82	.68	.54	.41	+.28	+.14	.00	−.13
	1,500	1.20	1.07	.93	.80	.66	.53	.40	.26	.13	−.01	−.14
	1,100	1.14	1.01	.88	.75	.62	.49	.36	.23	.10	−.03	−.17
	900	1.10	0.97	.84	.71	.58	.45	.32	.19	.06	−.07	−.20
	800	1.07	.94	.81	.69	.56	.43	.30	.17	.05	−.08	−.21
	700	1.03	.90	.78	.65	.53	.40	.27	.15	.02	−.10	−.23
	600	0.98	.86	.73	.61	.48	.36	.24	.11	−.01	−.14	−.26
	500	.92	.80	.68	.56	.44	.32	.19	.07	−.05	−.17	−.29
Natural	1,300	1.18	1.04	.91	.78	.64	.50	.37	.24	+.10	−.04	−.17
	1,100	1.16	1.03	.89	.76	.62	.49	.36	.22	.09	−.05	−.18
	[a] 900	1.14	1.01	.87	.74	.60	.47	.34	.20	.07	−.07	−.20

[a] Or lower.

A great majority of determinations of heating value are made in connection with the periodic testing of gaseous fuels that vary only moderately in composition. The approximate heating value of the gas 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

$$C_h=\frac{HSN}{100p}=\frac{HS}{100p}\,[N_0+fh(N_0-N_1)],$$

and single values of N_0 and N_1 may be chosen, depending upon the

TABLE 7. *Values of the factor S and related quantities*

S is used to compute the humidity correction from the equation

$$C_h=\frac{HNS}{p}.$$

It is defined by means of the relation

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

in which t is the dry-bulb temperature 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 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 & Sons, New York, N. Y., 1936.)

t	w_t	$W\times 1{,}000$	L	S	t	w_t	$W\times 1{,}000$	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					

character of the gas in question. A single table of corrections to take the place of the above equation can, therefore, be prepared for local use.

For mixtures of two or more gases of the types covered in table 6, the value of N corresponding to any value of fh can be computed from the corresponding values of N and H for the constituent gases by means of the relation

$$N=\frac{N_aH_aX_a+N_bH_bX_b+\ .\ .\ .}{H_aX_a+H_bX_b+\ .\ .\ .},$$

where X_a, X_b, . . . are the volume fractions; H_a, H_b, . . . are the heating values; and N_a, N_b, . . . are the values of N for the constituents a, b, . . ., respectively, of the mixture.

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 the heat lost from the calorimeter to the surroundings, for the effect of buoyancy of the air on the observed weight of water, and for the change in heating value with temperature. The preparation of the combined table will be illustrated, after these additional corrections have been discussed.

The corrections, C_s for the heat capacity of water, C_b for buoyancy, and C_t for reducing heating values determined at different temperatures to a common temperature (60° F) all depend on temperature. 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 conditions under which the calorimeter is operated. This correction, C_e, may be taken without appreciable error as 0.2 percent of the total heating value of the gas for water-flow calorimeters of the type commonly used in this country, when operated with inlet-water at room temperature, and when otherwise adjusted and operated as recommended in this circular. Values for the above corrections are given in table 8.

TABLE 8.—*Minor corrections (C_m) to be added to observed heating value*

[Values of C_s for variation in the heat capacity of water, C_b for the buoyancy of the air, C_e for heat loss from the calorimeter when inlet-water is at room temperature, and C_t for change in heating value with temperature are given. The values of C_s and C_e are for a temperature rise of 15° F and a gas rate of 3,000 Btu per hour. The values of C_b are for a barometric pressure of 30 in. of mercury. The tabulated values of C_t apply for calculating total heating values of all fuel gases in the range 300 to 3,000 Btu, except blue water gas, for which half the tabulated values should be used. The values of C_t for net heating values are negligible]

Room temperature	Corrections, percentage of total heating value						Correction, Btu/cu ft, for calculating—	
	C_b	C_s	C_e	C_t	$(C_b+C_s+C_e+C_t)$	$(C_b+C_s+C_e)$	Total heating value $C_m=\frac{H}{100}(C_b+C_s+C_e+C_t)$	Net heating value $C_m=\frac{H}{100}(C_b+C_s+C_e)$
°*F*								
40	+0.11	+0.22	+0.20	−0.10	+0.43	+0.53		
45	.11	.11	.20	−.07	.35	.42		
50	.11	.03	.20	−.05	.29	.34		
55	.11	−.04	.20	−.02	.25	.27		
60	.11	−.09	.20	+.00	.22	.22		
65	.11	−.12	.20	.02	.21	.19		
70	.11	−.15	.20	.05	.21	.16		
75	.11	−.16	.20	.07	.22	.15		
80	.10	−.17	.20	.10	.23	.13		
85	.10	−.18	.20	.12	.24	.12		
90	.10	−.18	.20	.15	.27	.12		
95	.10	−.17	.20	.17	.30	.13		
100	.10	−.16	.20	.20	.34	.14		
105	.10	−.15	.20	.22	.37	.15		
110	.10	−.14	.20	.25	.41	.16		

The values of C_b given in table 8 were calculated for a barometric pressure of 30 in. of mercury. If the barometric pressure, B, differs significantly from 30 in., the tabulated values of C_b should be multiplied by $B/30$.

The values of C_t given in table 8 apply to all fuel gases in the range 300 to 3,000 Btu except blue water gas. For blue water gas one-half of the tabulated values of C_t should be used. The correction C_t for net heating values is negligible.

The last two columns left blank in table 8 are to be obtained by multiplying the sums $(C_b+C_s+C_e+C_t)$ and $(C_b+C_s+C_e)$, by the local total heating value in hundreds of Btu, $H/100$. The numbers, C_m, thus obtained are the aggregates of the minor corrections in Btu per cubic foot, to be added to the observed heating values in computing total and net heating values. As already suggested, it is convenient to prepare a single table of the combined corrections for humidity, heat capacity of water, buoyancy, heat loss, and change in heating value with temperature, to be added to the observed heating value to obtain the total heating value.

V. PREPARATION OF A CORRECTION TABLE FOR LOCAL USE

The preparation of a table of corrections for local use will be illustrated for the case where the average local barometric pressure is 28 in. of mercury, and the gas to be tested is a mixture of 550 Btu carburetted water gas and 1,110 Btu natural gas, the heating value of the mixture being 700 Btu per standard cubic foot. Let X_1 and X_2 denote the volume fractions of the carburetted water gas and the natural gas, respectively, in the mixture. Then

$$X_1+X_2=1,$$

and because the heating value of the mixture is 700 Btu per cu ft,

$$550X_1+1,100X_2=700.$$

By solving those two equations, there are obtained the values

$$X_1=0.727$$
$$X_2=0.273.$$

The values of N_0 and N_1 for the two constituent gases, from table 6, and the corresponding values for the mixed gas, calculated by means of the equation given on p. 28, are found to be as follows:

Gas	N_0	N_1
550 Btu carburetted water	0. 99	−0. 22
1,100 Btu natural	1. 16	−. 18
700 Btu mixture	1. 06	−. 20

The calculation of the combined correction, C_c, for the mixed gas is illustrated in table 9. Each step in the preparation of the local table from the data in tables 6 to 8 is clearly shown, and the combined correction is indicated by boldfaced type. When this correction 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 10) is given to be filled out for local use.

TABLE 9. *Combined corrections (C_c) for illustrative local conditions*

[It is assumed that the gas is a mixture of 550 Btu carburatted water gas and 1100 Btu natural gas, the heating value of the mixture being 700 Btu. It is also assumed that the local barometric pressure is 28 inches of mercury. Then the combined correction:

$$C_c=\frac{(H/100)\ NS}{p}+(H/100)(C_b+C_s+C_e+C_t)\text{ becomes }C_c=\frac{7.00\ NS}{28}+7.00\ (C_m).$$

H is the anticipated total heating value of the mixture in Btu and p is the average local barometric pressure in inches of mercury. The values of S were taken from table 7 and the values of N were calculated as described in the text, using data taken from table 6. Values of C_m were taken from table 8.]

		Values of *fh*	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
		Values of *N*	1.06	0.94	0.81	0.68	0.56	0.43	0.30	0.18	0.05	−0.08	−0.20
Combustion air temperature (dry-bulb)	*S*	Corrections	Btu per standard cubic foot										
°F													
40	13	7.00 *NS*/28	3.4	3.1	2.6	2.2	1.8	1.4	1.0	0.6	0.2	−0.3	−0.7
		7.00 (C_m)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	+3.0	+3.0
		C_c	**6.4**	**6.1**	**5.6**	**5.2**	**4.8**	**4.4**	**4.0**	**3.6**	**3.2**	**2.7**	**2.3**
45	15	7.00 *NS*/28	4.0	3.5	3.0	2.6	2.1	1.6	1.1	0.7	0.2	−0.3	−0.8
		7.00 (C_m)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	+2.5
		C_c	**6.5**	**6.0**	**5.5**	**5.1**	**4.6**	**4.1**	**3.6**	**3.2**	**2.7**	**2.2**	**1.7**
50	18	7.00 *NS*/28	4.8	4.2	3.6	3.1	2.5	1.9	1.4	0.8	0.2	−0.4	−0.9
		7.00 (C_m	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	+2.0	+2.0
		C_c	**6.8**	**6.2**	**5.6**	**5.1**	**4.5**	**3.9**	**3.4**	**2.8**	**2.2**	**1.6**	**1.1**
55	22	7.00 *NS*/ 8	5.8	5.2	4.5	3.7	3.1	2.4	1.7	1.0	0.3	−0.4	−1.1
		7.00 (C_m)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	+1.6	+1.6
		C_c	**7.4**	**6.8**	**6.1**	**5.3**	**4.7**	**4.0**	**3.3**	**2.6**	**1.9**	**1.2**	**0.5**
60	26	7.00 *NS*/28	6.9	6.1	5.3	4.4	3.6	2.8	2.0	1.2	0.3	−0.5	−1.3
		7.00 (C_m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	+1.5	+1.5
		C_c	**8.4**	**7.6**	**6.8**	**5.9**	**5.1**	**4.3**	**3.5**	**2.7**	**1.8**	**1.0**	**0.2**
65	31	7.00 *NS*/28	8.2	7.3	6.3	5.3	4.3	3.3	2.3	1.4	0.4	−0.6	−1.6
		7.00 (C_m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	+1.5	+1.5
		C_c	**9.7**	**8.8**	**7.8**	**6.8**	**5.8**	**4.8**	**3.8**	**2.9**	**1.9**	**0.9**	**−0.1**
70	37	7.00 *NS*/28	9.8	8.7	7.5	6.3	5.2	4.0	2.8	1.7	0.5	−0.7	−1.9
		7.00 (C_m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	+1.5	+1.5
		C_c	**11.3**	**10.2**	**9.0**	**7.8**	**6.7**	**5.5**	**4.3**	**3.2**	**2.0**	**0.8**	**−0.4**
75	44	7.00 *NS*/28	11.7	10.3	8.9	7.5	6.2	4.7	3.3	2.0	0.6	−0.9	−2.2
		7.00 (C_m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	+1.5	+1.5
		C_c	**13.2**	**11.8**	**10.4**	**9.0**	**7.7**	**6.2**	**4.8**	**3.5**	**2.1**	**0.6**	**−0.7**
80	53	7.00 *NS*/28	14.0	12.5	10.7	9.0	7.4	5.7	4.0	2.4	0.7	−1.1	−2.7
		7.00 (C_m)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	+1.6	+1.6
		C_c	**15.6**	**14.1**	**12.3**	**10.6**	**9.0**	**7.3**	**5.6**	**4.0**	**2.3**	**0.5**	**−1.1**

TABLE 9. *Combined corrections (C_c) for illustrative local conditions*—Con.

Combustion air temperature (dry-bulb)	S	Corrections	Btu per standard cubic foot										
85	62	7.00 $NS/28$	16.4	14.6	12.6	10.5	8.7	6.7	4.7	2.8	0.8	−1.2	−3.1
		7.00 (C_m)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	+1.7	+1.7
		C_c	**18.1**	**16.3**	**14.3**	**12.2**	**10.4**	**8.4**	**6.4**	**4.5**	**2.5**	**0.5**	**−1.4**
90	73	7.00 $NS/28$	19.3	17.2	14.8	12.4	10.2	7.8	5.5	3.3	0.9	−1.4	−3.7
		7.00 (C_m)	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	+1.9	+1.9
		C_c	**21.2**	**19.1**	**16.7**	**14.3**	**12.1**	**9.7**	**7.4**	**5.2**	**2.8**	**0.5**	**−1.8**
95	86	7.00 $NS/28$	22.8	20.2	17.4	14.6	12.0	9.3	6.5	3.9	1.1	−1.7	−4.3
		7.00 (C_m)	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	+2.1	+2.1
		C_c	**24.9**	**22.3**	**19.5**	**16.7**	**14.1**	**11.4**	**8.6**	**6.0**	**3.2**	**0.4**	**−2.2**
100	100	7.00 $NS/28$	26.5	23.5	20.3	17.0	14.0	10.8	7.5	4.5	1.3	−2.0	−5.0
		7.00 (C_m)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	+2.4	+2.4
		C_c	**28.9**	**25.9**	**22.7**	**19.4**	**16.4**	**13.2**	**9.9**	**6.9**	**3.7**	**0.4**	**−2.6**
105	117	7.00 $NS/28$	31.0	27.5	23.7	19.9	16.4	12.6	8.8	5.3	1.5	−2.3	−5.9
		7.00 (C_m)	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	+2.6	+2.6
		C_c	**33.6**	**30.1**	**26.3**	**22.5**	**19.0**	**15.2**	**11.4**	**7.9**	**4.1**	**0.3**	**−3.3**
110	138	7.00 $NS/28$	36.6	32.4	27.9	23.5	19.3	14.8	10.4	6.2	1.7	−2.8	−6.9
		7.00 (C_m)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	+2.9	+2.9
		C_c	**39.5**	**35.3**	**30.8**	**26.4**	**22.2**	**17.7**	**13.3**	**9.1**	**4.6**	**0.1**	**−4.0**

Table 10. *Combined correction to be applied to observed heating value to obtain total hearing value under local conditions*

Type of gas ________________________________. Approximate total heating value __________ Btu.

Average barometric pressure __________________ inches of mercury.

fh ___________		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
N ___________												
Dry-bulb temperature	*S*	Combined correction, C_c, Btu per cubic foot										
°*F*												
40	13											
45	15											
50	18											
55	22											
60	26											
65	31											
70	37											
75	44											
80	53											
85	62											
90	73											
95	86											
100	100											
105	117											
110	138											

Fractions of a Btu are of doubtful significance in any of the corrections; but to avoid the 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 corrections can then be rounded 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, given in the last column of table 8 and a correction for the latent heat of the condensed water collected are the only ones 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 corrections obtained from table 11 must be used in calculating total and net heating values.

TABLE 11. *Corrections for difference between inlet-water temperature and room temperature*

Mean of inlet-water and room temperatures	Correction in percentage of total heating value per degree		Correction in Btu per degree for local conditions	
	For calculating total heating values	For calculating net heating values	For calculating total heating values	For calculating net heating values
°*F*				
40	0.094	0.074	----------	----------
45	.102	.079	----------	----------
50	.110	.083	----------	----------
55	.119	.087	----------	----------
60	.128	.090	----------	----------
65	.136	.092	----------	----------
70	.146	.094	----------	----------
75	.155	.095	----------	----------
80	.167	.097	----------	----------
85	.180	.098	----------	----------
90	.194	.099	----------	----------
95	.209	.099	----------	----------
100	.228	.100	----------	----------
105	.249	.101	----------	----------
110	.273	.101	----------	----------

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

In table 11 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 values given are in percent of total heating value, and must be multiplied by the approximate value of $H/100$ for 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 inlet-water is warmer than the room; subtracted if inlet-water is colder. The table is based on an assumed gas rate of 3,000 Btu of total heating value per hour. If a materially different rate is used, subtract from the figures in the table 0.01 percent per deg. F for each 300 Btu per hour above 3,000.

The values given in table 11 include corrections for the effects of (a) the change in specific heat of water with temperature, (b) the heat lost by "radiation" from the surface of the calorimeter, (c) the sensible heat of the flue gases, (d) the sensible heat of the condensed water, and (e) the heat of vaporization of the water in the flue gases. The net effect of the factors listed above is practically independent of barometric pressure and relative humidity. It depends to some extent upon the composition of the gas, but if the difference between the temperatures of inlet-water and room is kept within 2 or 3 deg the magnitude of the correction will be so small that its variation with gas composition can be neglected, and the single value given in table 11 for each temperature can be used without appreciable error for all fuel gases. It should be noted that the values given in table 11 are tabulated as a function of the *mean* of the temperatures of inlet-water and room.

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. As the conditions of measurement for the calorimetric test 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 in. 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 12, 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 that 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

TABLE 12.—*Vapor pressure and heat of vaporization of water* (*ice below 32° F*)

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

Temperature	Vapor pressure	Heat of vaporization, *r*	Temperature	Vapor pressure	Heat of vaporization, *r*
°*F*	*in.* Hg	*Btu/ml*	°*F*	*in.* Hg	*Btu/ml*
−40	0.004	--------	+55	0.436	2.34
−30	.007	--------	60	.522	2.34
−20	.013	--------	65	.622	2.33
−10	.022	--------	70	.739	2.32
0	.038	--------	75	.875	2.31
+5	.049	--------	80	1.032	2.31
10	.063	--------	85	1.213	2.30
15	.081	--------	90	1.422	2.29
20	.103	--------	95	1.660	2.28
25	.130	--------	100	1.933	2.27
30	.164	--------	105	2.243	2.26
35	.204	--------	110	2.596	2.25
40	.248	2.36	--------	--------	--------
45	.300	2.36	--------	--------	--------
50	.363	2.35	--------	--------	--------

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 that give the quantity of gas measured in terms of cubic feet at 60° F and 30 in. of mercury pressure, but without taking account of any change that 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

$$\frac{(P-D)(60+460)}{(30-0.5218)(t+460)}=17.640\,\frac{P-D}{t+460}.$$

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

$$\frac{\left(P-\frac{DP}{p}\right)(60+460)}{(30-0.5218)(t+460)}=17.640\ \frac{P(p-D)}{p(t+460)}.$$

Again, the product multiplied by the number of cubic feet registered gives the total heat of combusiton 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.—*Heating value, "air requirement," and products of combustion of important constituents of fuel gases*

[Heating values of gases from hydrogen to acetylene are based on values of heat of combustion per mole selected by F. D. Rossini, et. al, and corrections for deviations from the ideal gas laws selected for the most part by C. S. Cragoe. Values for benzene, pentane, hexane, and decane were computed from values of heat of combustion per mole as though they were ideal gases. Actually these substances are liquids at 60° F and 30 in. of Hg and the deviations of their vapors from the ideal gas laws, which are large, depend on the other gases present as well as on their own concentrations. The tabulated values of heat of combustion differ from those given in C417 for several reasons, including (1) the use in the present table of a different Btu—, defined as the heat required to raise the temperature of 1-pound mass of pure water from 58.5° to 59.5° F, (2) the use of new data on the heats of combustion of many of the gases, particularly benzene and the olefins, and (3) new values for the deviation of ethylene and propane from the ideal gas law. In calculating the volumes of air required for combustion, and of CO_2 and N_2 in the products of combination corrections were made for the deviations from the ideal gas laws for the combustible gases and for air, CO_2 and N_2, except in the case of the gases from benzene to decane, for which the volumes were calculated on the basis of the ideal gas laws. The heating values given are in all cases referred to 60° F.]

Gas	Heating value at 60° F				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		CO_2	N_2
	Btu/cu ft	*Btu/cu ft*	*Btu/cu ft*	*Btu/cu ft*	*cu ft*	*cu ft*	*cu ft*
Hydrogen, H_2	319.3	269.7	324.9	274.5	2.38	----------	1.88
Carbon monoxide, CO	316.0	316.0	321.6	321.6	2.39	1.00	1.89
Methane, CH_4	996.9	897.6	1,014.6	913.5	9.56	1.00	7.56
Ethane, C_2H_6	1,758	1,608	1.789	1,636	16.84	2.01	13.31
Propane, C_2H_3	2.529	2,327	2,573	2,368	24.31	3.04	19.22
Normal butane, C_4H_{10}	3,333	3,076	3.392	3,131	32.13	4.12	25.40
Isobutane, C_4H_{10}	3,304	3,049	3,363	3.103	31.93	4.10	25.24
Ethylene, C_2H_4	1,586	1,487	1,614	1,513	14.40	2.00	11.38
Propylene, C_3H_6	2,342	2,189	2,383	2,228	21.86	3.04	17.28
Acetylene, C_2H_2	1,462	1,412	1,488	1,437	12.00	2.00	9.49
Benzene, C_6H_6	3,687	3,538	3.752	3,601	35.79	6.00	28.29
Pentane, C_5H_{12}	3,951	3,654	4,021	3,718	38.20	5.00	30.20
Hexane, C_6H_{14}	4.687	4,340	4.770	4,417	45.37	6.00	35.86
Decane, $C_{10}H_{22}$	7.631	7,086	7,766	7,211	74.02	10.00	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	2.8 to 3.5	14.6 to 17.8

VIII. RECORDS AND COMPUTATIONS

1. Enter from page 4 the *certificate correction* and the *temperature latitude, and altitude corrections* to the barometer.[7] 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 enter on the record the value *of the product fh* corresponding to the recorded *dry-bulb* and *wet-bulb* thermometer readings of the psychrometer.

6. Enter the *rate* in *Btu per hour* corresponding to the *time* in seconds *of 1 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 figure 3, page 21, 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 21 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 22 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. If the temperatures of inlet-water and room differ, enter on the record the emergent stem correction to the average readings of the inlet-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

$$\text{Stem correction} = Kn(T^\circ - t^\circ),$$

---

[7] The corrections for latitude and altitude for local conditions, if significant, may be combined with the certificate correction.

where

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 21, 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. Correct the weight of *water collected*, W, 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 22 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 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 33 the *combined corrections* for atmospheric humidity, specific heat of water, buoyancy, and heat lost from the calorimeter. Table 10 on page 33 has been left blank for the convenient entry of corrections corresponding to local conditions. Directions for ascertaining these corrections are given on page 30.

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 34 are given the data from which to determine the amounts by which the total and the 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 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 0.162 percent per 1 deg difference, i. e., the value is too high by $4\times0.162=0.648$ percent. Similarly, the net heating value is too high by $4\times0.096=0.384$ percent.

19. Enter from table 11, page 34, 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,* and by *10 times the meter calibration factor* to find the volume of the gas under standard conditions (i. e., 60° F, 30 in. 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 in. of pressure. Enter on the record the average, A, of the two values found as above from the two tests for condensed water collected.

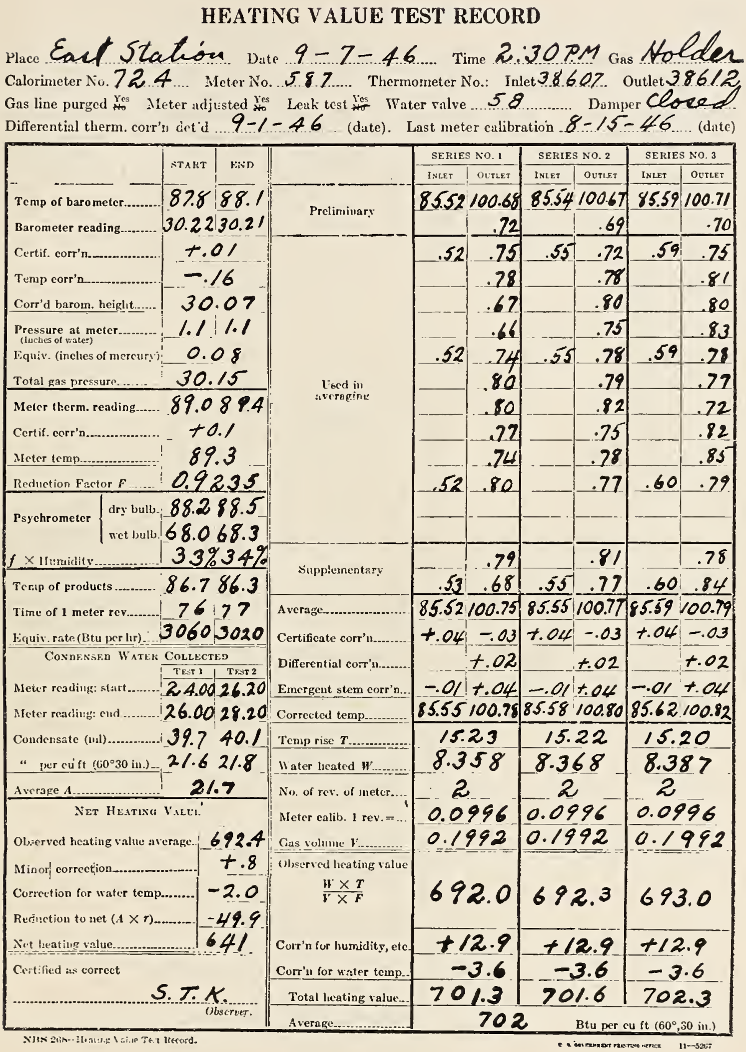
(b) Enter on the record the *average* of the *observed heating values.*

(c) Enter on the record the minor correction for specific heat, buoyancy, and heat loss from table 8 page 29. (The correction C_t and the correction for atmospheric humidity are not included.)

(d) From table 11 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 standard cubic foot* of the gas, entered opposite A in the record, by the appropriate value of the latent heat of vaporization of water, r, from table 12 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 East Station Date 9-7-46 Time 2:30 PM Gas Holder
Calorimeter No. 724 Meter No. 587 Thermometer No.: Inlet 38607 Outlet 38612
Gas line purged Yes ~~No~~ Meter adjusted Yes ~~No~~ Leak test Yes ~~No~~ Water valve 58 Damper Closed
Differential therm. corr'n det'd 9-1-46 (date). Last meter calibration 8-15-46 (date)

	START	END
Temp of barometer	87.8	88.1
Barometer reading	30.22	30.21
Certif. corr'n	+.01	
Temp corr'n	-.16	
Corr'd barom. height	30.07	
Pressure at meter (Inches of water)	1.1	1.1
Equiv. (inches of mercury)	0.08	
Total gas pressure	30.15	
Meter therm. reading	89.0	89.4
Certif. corr'n	+0.1	
Meter temp	89.3	
Reduction Factor *F*	0.9235	
Psychrometer dry bulb	88.2	88.5
Psychrometer wet bulb	68.0	68.3
f × Humidity	33%	34%
Temp of products	86.7	86.3
Time of 1 meter rev	76	77
Equiv. rate (Btu per hr)	3060	3020
CONDENSED WATER COLLECTED	TEST 1	TEST 2
Meter reading: start	24.00	26.20
Meter reading: end	26.00	28.20
Condensate (ml)	39.7	40.1
" per cu ft (60°30 in.)	21.6	21.8
Average *A*	21.7	
NET HEATING VALUE		
Observed heating value average	692.4	
Minor correction	+.8	
Correction for water temp	-2.0	
Reduction to net (*A* × *r*)	-49.9	
Net heating value	641	

Certified as correct

S. T. K.
Observer.

	SERIES NO. 1		SERIES NO. 2		SERIES NO. 3	
	INLET	OUTLET	INLET	OUTLET	INLET	OUTLET
Preliminary	85.52	100.68	85.54	100.67	85.59	100.71
		.72		.69		.70
Used in averaging	.52	.75	.55	.72	.59	.75
		.78		.78		.81
		.67		.80		.80
		.66		.75		.83
	.52	.74	.55	.78	.59	.78
		.80		.79		.77
		.80		.82		.72
		.77		.75		.82
		.74		.78		.85
	.52	.80		.77	.60	.79
Supplementary		.79		.81		.78
	.53	.68	.55	.77	.60	.84
Average	85.52	100.75	85.55	100.77	85.59	100.79
Certificate corr'n	+.04	-.03	+.04	-.03	+.04	-.03
Differential corr'n		+.02		+.02		+.02
Emergent stem corr'n	-.01	+.04	-.01	+.04	-.01	+.04
Corrected temp	85.55	100.78	85.58	100.80	85.62	100.82
Temp rise *T*	15.23		15.22		15.20	
Water heated *W*	8.358		8.368		8.387	
No. of rev. of meter	2		2		2	
Meter calib. 1 rev. =	0.0996		0.0996		0.0996	
Gas volume *V*	0.1992		0.1992		0.1992	
Observed heating value $\frac{W \times T}{V \times F}$	692.0		692.3		693.0	
Corr'n for humidity, etc.	+12.9		+12.9		+12.9	
Corr'n for water temp.	-3.6		-3.6		-3.6	
Total heating value	701.3		701.6		702.3	
Average	702		Btu per cu ft (60°,30 in.)			

NBS 268—Heating Value Test Record.

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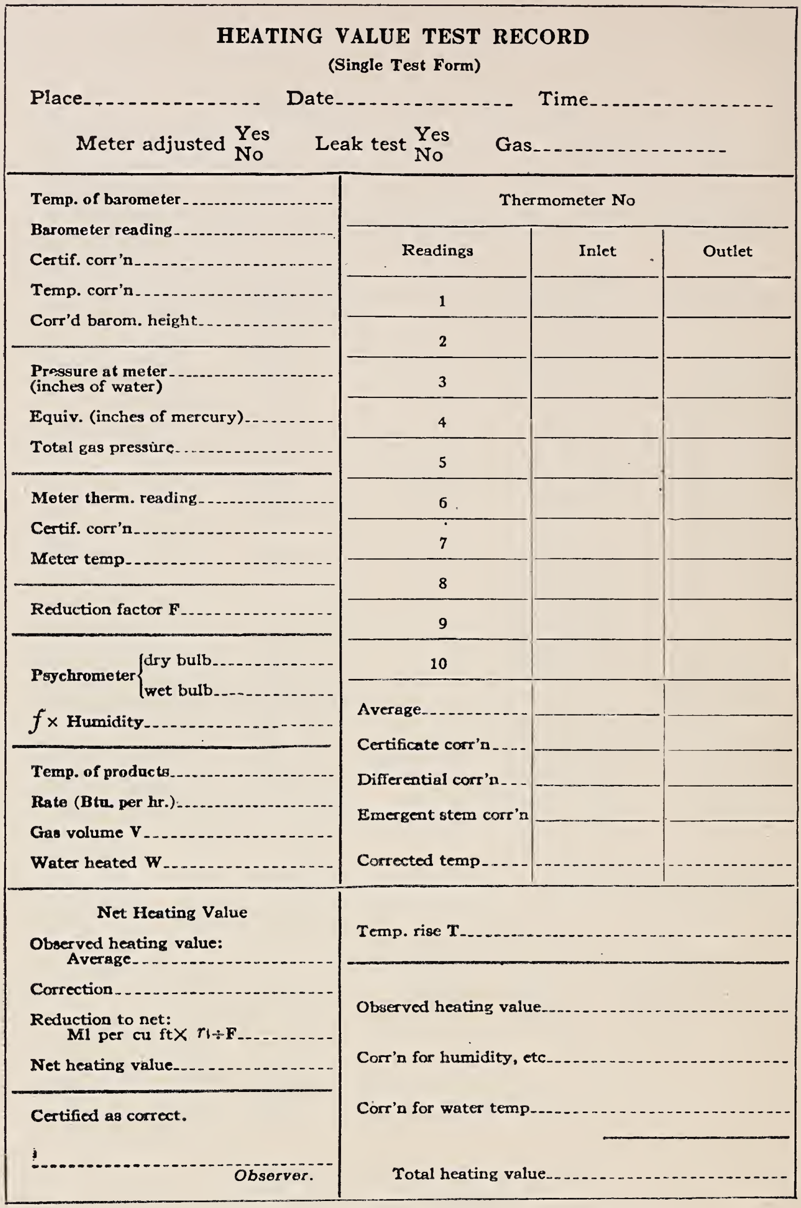
FIGURE 4. *Form for calorimetric record.*

(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________________

f × 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× $n \div$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 5. *Form for calorimetric record of single test.*

WASHINGTON, June 11, 1947.