U.S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

RESEARCH PAPER RP691

Part of Journal of Research of the National Bureau of Standards, vol. 13, July 1934

A FORMULA AND TABLES FOR THE PRESSURE OF SATURATED WATER VAPOR IN THE RANGE 0 TO 374 C

By Nathan S. Osborne and Cyril H. Meyers

ABSTRACT

Recent experimental determinations of the vapor pressure of water have enriched our knowledge of this property sufficiently to justify revision of the accepted values.

A formulation has been developed which by a single equation represents an adjusted composite appraisal of the available data; and defines concisely and explicitly the relation of saturation pressure to temperature between the freezing point and the critical region.

Graphical comparisons of the original data with the formula indicate the degree of accord, and the confidence which may be given to the adjusted values.

Comprehensive tables of pressures, derivatives, and boiling points, computed by use of the formula are given in several customary units for convenience in compiling complete tables of thermal properties of steam. A table of conversion factors is given.

CONTENTS

I. INTRODUCTION

Several determinations of the relation between the temperature and pressure of saturated water vapor have recently been made in the range between the normal boiling point and the critical region. These recent determinations have contributed substantially to the knowledge of this property of steam, and have prompted a study of the available data with the object of deducing a single definitive formula that will represent a composite adjusted appraisal and serve for the numerical calculation of explicit values.

The advantage of such an interpretation of the vapor pressure data is that it provides a simple and complete method of fixing reliable definitive values of the pressure and its derivative, and furnishes a basis for coordinating other thermodynamic data.

The resulting formula here presented makes no claim to rationality or apparent simplicity, as these qualities have as yet eluded the inspiration of the authors and their colleagues. On the other hand, careful consideration has been given to the selection of a type of function with sufficient adaptability to permit its adjustment to the general trend indicated by the data, without conforming too readily to fortuitous deviations of the data from the trend characteristic of this property of water. It is evident that much depends on the discernment of the seeker for such a formula. The final choice of the type and the degree of adjustment to the experimental points is more a matter of judgment than of rigid mathematical deduction. This is especially true in a case where groups of data from various experimental sources, and over different ranges of value are to be combined in a single correlation. Consideration was also given to suitability for numerical calculation of the pressure and its derivative.

The path of approach to this problem has been the modification of a simple form of equation, long recognized as an approximation to experimental fact, by the addition of successive correction terms, each modification permitting closer accord with the data. The numerous experimental steps in this process, many of which failed to meet the above requirements, are of no further interest, since the ultimate test made by comparing observed values with those calculated from these tentative formulas left no doubt of their relative fitness to represent both the individual values and the trend of the data.

II. THE FORMULA

The equation finally selected has the form

$$\log_{10}P = A + \frac{B}{T} + \frac{Cx}{T}(10^{Dx^2} - 1) + E(10^{Fy^{5/4}})$$

in which P = saturation pressure in international atmospheres

t = saturation temperature in degrees of the international temperature scale

$T = t + 273.16$

$x = T^2 - K$

$y = 374.11 - t$ (374.11 taken as critical temperature),

and the parameters have the values

$A = +5.4266514$

$B = -2005.1$

$C = +1.3869(10)^{-4}$

$D = +1.1965(10)^{-11}$

$K = +293{,}700$

$E = -0.0044$

$F = -0.0057148$

The derivative dP/dt is given by the equation

$$\frac{dP}{dt} = P\left[-\frac{B + Cx(10^{Dx^2} - 1)}{T^2} + 2C\{10^{Dx^2}(1 + 2Dx^2 \log_e 10) - 1\} - \frac{5}{4}EFy^{1/4}10^{Fy^{5/4}} \log_e 10\right] \log_e 10$$

A number of values of pressure and of the derivative, computed from this formula, are given in table 1.

As an aid in judging the accord of this expression for P with the experimental data and with other proposed formulas, a graph (fig. 1) has been prepared. Deviations ($P_{obs.}-P_{calc.}$) from the values calculated by the above formula are plotted as ordinates against temperature taken as abscissa. Since a uniform scale of coordinates over the entire range would exaggerate the relative importance of some of the deviations, the scale has been arbitrarily adjusted so as to facilitate their visual appraisal. Below 1 atmosphere the unit of deviation has been taken as 0.1 mm Hg. Between 1 and 10 atmospheres the unit is 0.001 atmosphere. Above 10 atmospheres the unit is one ten-thousandth of the pressure. Use of these units brings the scale of deviations to magnitudes comparable with the precision with which they can be measured. Appropriate changes of the scale of the abscissa avoid illusion where deviations in trend occur within a narrow range of temperature, as is the case near the critical region.

The data shown on the chart are taken from four sources, namely, the Physikalisch-Technische Reichsanstalt,[1] Egerton and Callendar,[2] the Bureau of Standards,[3] and the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology.[4] The classic data of the PTR between 0 and 100 C are still the chief experimental evidence in this range,[5] though published over 20 years ago, and their values between 100 C and the critical temperature were not approached in precision by other experimenters for nearly two decades. Since they were obtained, there have been many advances in experimental technic, and while the more recent data have in part confirmed the earlier results in the high range, they have also in part indicated the need of slight modifications.

III. DISCUSSION OF THE ACCORD OF PRESSURE VALUES-

A complete review of the experimental technic will not be under taken here, but it may be noted that the methods of the several groups differed in many important respects, and therefore the noteworthy accord shown in the results of the more recent determinations is especially reassuring as to their reliability. The data compared have all been reduced to the basis of the present international temperature scale.

In the range of temperature below 100 C, where the determinations made by several groups of experimenters of the Reichsanstalt constitute the chief source of experimental evidence, it appears that the spread of the individual results leaves considerable to discretion in the interpretation of the most probable trend of the pressure path. The present formula gives an interpretation differing somewhat from that of the Reichsanstalt Wärmetabellen and from those of the MIT

[1] Wärmetabellen, Friedr. Vieweg & Sohn, Braunschweig, 1919. Literature: K. Scheel and W. Heuse, Ann. d. Phys., vol. 29, 723, 1909, and vol. 31, 715, 1910 (pressures at less than 50 C); L. Holborn and F. Henning, ibid., vol. 26, 833, 1908 (pressures between 50 and 200 C); L. Holborn and A. Baumann, ibid., vol. 31, 945, 1910 (pressures above 200 C); F. Henning, ibid., vol. 22, 609, 1907 (comparison of older observations of saturation pressures).

[2] A. Egerton and G. S. Callendar, Phil. Trans. Roy. Soc. of London, series A, vol. 231, p. 147, 1932.

[3] B.S.Jour. Research, vol. 10 RP 523, p. 155, 1933.

[4] Leighton B. Smith, Frederick G. Keyes, and Harold T. Gerry, Proceedings American Academy of Arts and Sciences, vol. 69, no. 3, January 1934.

[5] The vapor pressure at the triple point (+0.01° C) has recently been determined by K. Prytz, Math Fys. Meddeleisen Danske Vidensk. Selskab, vol. 11, no. 2, p. 1, 1931.

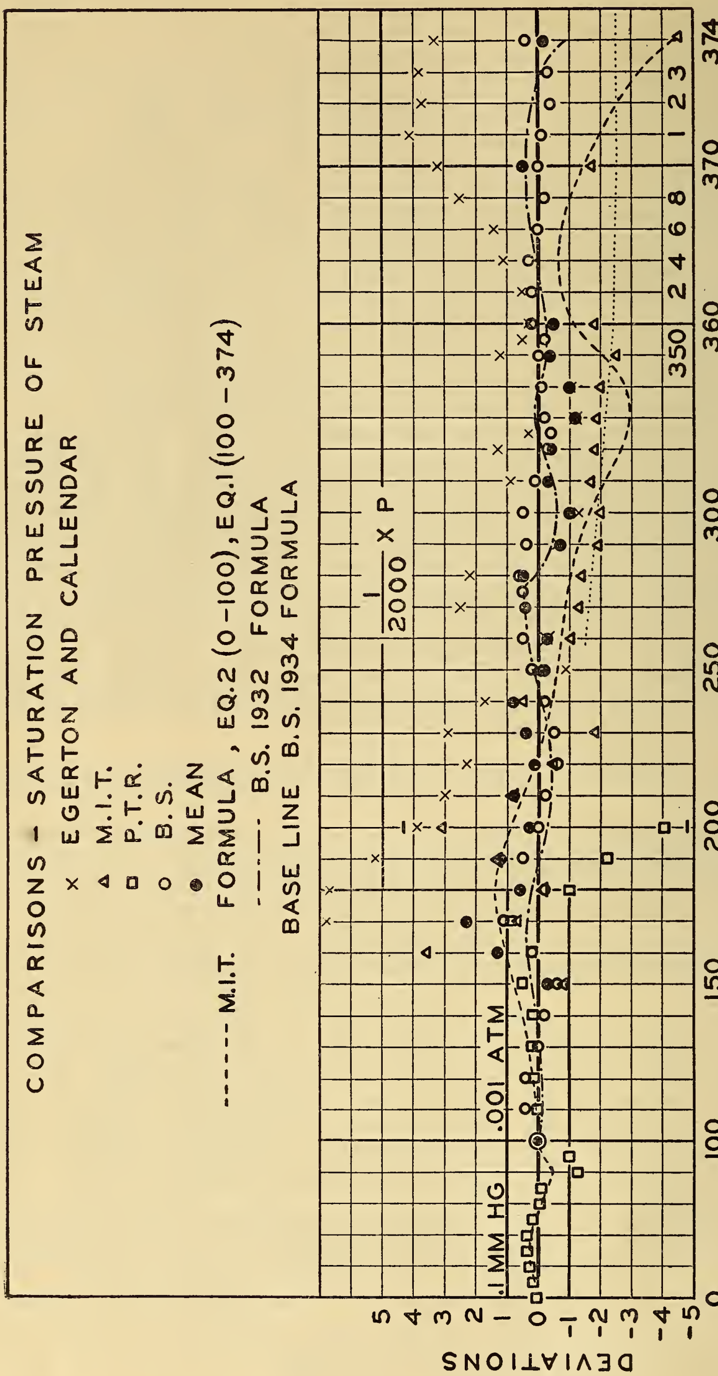
COMPARISONS – SATURATION PRESSURE OF STEAM
× EGERTON AND CALLENDAR
▵ M.I.T.
□ P.T.R.
○ B.S.
● MEAN
------ M.I.T. FORMULA, EQ.2 (0–100), EQ.1 (100–374)
-·-·- B.S. 1932 FORMULA
BASE LINE B.S. 1934 FORMULA
1/2000 × P
.001 ATM
.1 MM HG
TEMPERATURE DEGREES CENTIGRADE
DEVIATIONS

Figure 1

equations. In this range the degree of accord between the several interpretations and the experimental values is shown in the graph of deviations, figure 2.

By allowing a liberal tolerance to the experimental data in this region of low pressures and permitting the smoothing function to span deviations over considerable intervals, it is believed that a fairer appraisal of the true trend of the pressure curve has been obtained than would have been possible by a more rigorous adjustment. This opinion is supported by the result of a test in which experimental values of the latent heat of vaporization, the specific volumes, and the formulated vapor pressure relation were correlated by use of the Clapeyron equation. Without presenting the details of this test, it may be said that these thermodynamic data at the saturation limit in this region are in better accord with the present formula than with earlier appraisals of the pressure data.

A correlation of thermodynamic data over the entire range of the 2-phase boundary will be possible when the experimental results of the MIT program of specific volume measurements are available. The true correlation requires that temperatures be expressed on the thermodynamic scale of temperature. Therefore the actual correlation will involve such small errors as correspond to the deviation of the international scale of temperature from the true thermodynamic scale.

The Egerton and Callendar data used in the graph are their smoothed values at even temperatures except at 170, 180, and 200 C. In that range the values given by the series of measurements made in July and August 1932 have been used after a preliminary smoothing and reduction to even temperatures, since those experimenters have regarded these later measurements as more trustworthy than their earlier ones. They note that this group of their data shows a systematic deviation from the results of other observers, and they recognize the greater limitation on the accuracy of their method at the lower pressures. This deviation, although amounting to about 0.006 atmosphere from the general trend of the mean, is not serious. The effect of this departure is partly offset by the opposite though lesser deviation of the PTR values at 190 and 200 C.

The differences in trend in the extreme upper range among the Egerton and Callendar, the MIT, and the BS data are noteworthy, but perhaps not surprising when it is recalled that the properties of fluids tend to become more indeterminate as the critical region is approached.

Where there are, at the same point, values from three or more laboratories, mean values have been plotted in figure 1 in order to consider the formula with reference to the entire mass of experimental data, and thus appraise its fitness. In computing these mean values, less weight has been given to a determination consisting of but a single observation than to others, but otherwise all independent values have been regarded as of equal importance. The task of assigning to each determination a more precise estimate of relative accuracy is too difficult and delicate, and moreover proves unnecessary for the present purpose. It may be seen by inspection that the accord of these mean values with the formula, taken as a reference datum, is well within a reasonable tolerance, giving consideration to the magnitude of the deviations. No significant anomalies are indicated, there being no important systematic deviations of the mean values. The accord of the separate determinations is naturally less perfect, but not in so much as to leave serious doubt of the suitability of the formula as a tool for the adjustment and interpolation of the pressures, and for obtaining derivatives.

IV. DISCUSSION OF THE ACCORD OF DERIVATIVES

The derivatives, being removed one step further from the original data, are proportionately more susceptible to the influence of the appraisal of the data than are the pressures. It is obvious that too rigorous an adjustment of the smoothing function to the observed points may result in a false trend and exaggerated errors in the derivative. This may be appreciated by inspection of the graph, figure 3, which shows percentage deviations of the derivative, dP/dt, calculated from different interpretations of data.

While the deviations thus shown, particularly at the extremes of pressure, correspond to minor differences in actual pressure, they are of some consequence when the derivative is used as a factor for correlating thermodynamic data. It is also possible that the actual location of the saturation limit may have an appreciable effect on the extrapolation of superheat data to the saturation limit. It should be noted that the apparent discord shown in this graphical comparison is largely artificial, due to the wide latitude possible in the individual interpretations of the data.

For example, of several formulas tested in the present study, one which was adjusted to the same mean data, using a least square method of evaluating the constants, and giving careful consideration to relative weighting of the data, showed only moderate deviations from the pressure data but gave even greater discrepancies in the derivatives than any shown in figure 3. This equation was evidently of an unsuitable type, and like several others was discarded in favor of the one finally chosen.

As a further test of the actual accord of the data as distinguished from accord in their interpretation, it was found possible to adjust the constants in the formula so that with a change of only 1 in 4,000 of the derivative the values of pressure agreed with the MIT data to within 1 in 5,000 even in the extreme upper range. This adjustment is indicated by the fine dotted line on the pressure deviation graph, figure 1. A similar adjusted interpretation could be made for the Egerton and Callendar data. This confirms the conclusion that no serious discord actually exists among the data.

In the immediate vicinity of the critical point the experimental values are not as free from doubt as could be desired to establish the true course of the pressure curve. Greater refinements in the measurements may be necessary to decide this and permit a more reliable estimate of the limiting value of the derivative at the critical state. It may be pointed out that in the MIT formulation, the formula was fitted exactly to the experimental value at 374.11 C. The authors of that formulation express the opinion that this has not led to any distortion of the trend below 374.11 C. This conclusion seems open to question. It seems not improbable that this procedure which in effect assigns to this experimental point an infinite weight is partly responsible for the discordance between the derivatives of the two

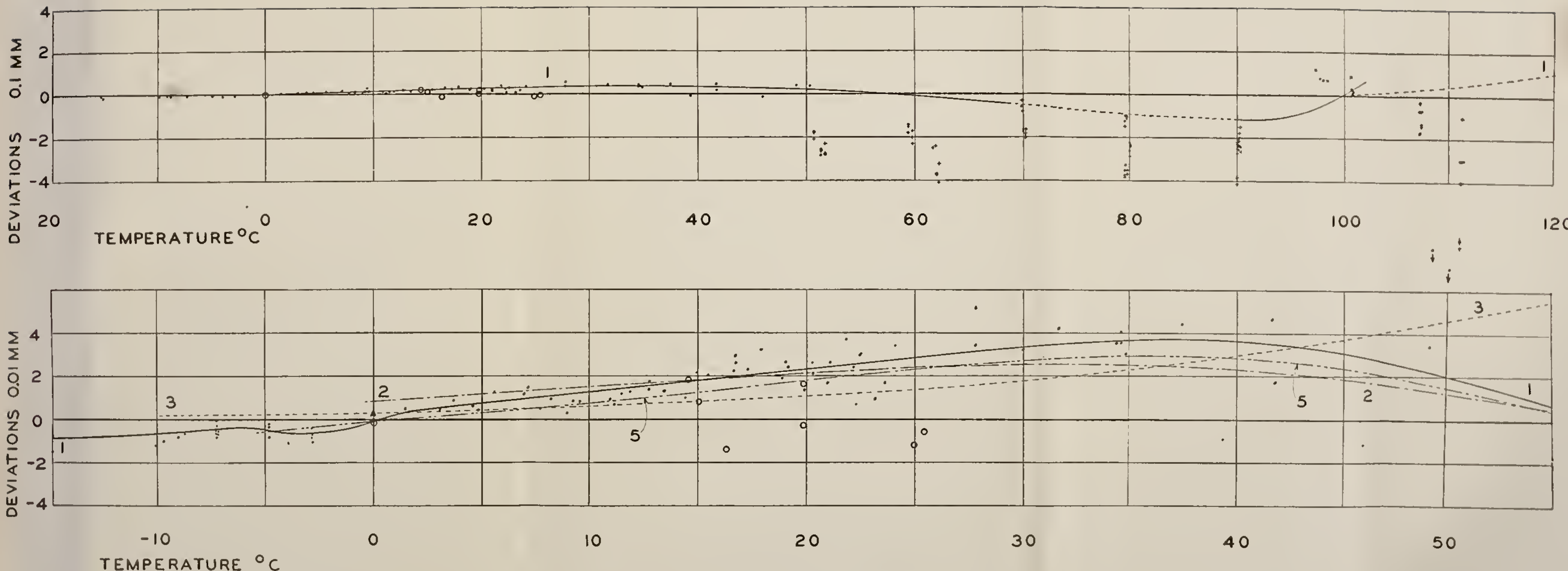

FIGURE 2.—*Vapor pressure—saturated steam: low-pressure range.*

Comparison of observed and adjusted values with B.S. formula as base line.

KEY

Observed points	*Adjusted values*
○ Thiesen and Scheel	1 ——— - - - Warmetabellen (broken where rounded to 1 mm)
+ Holborn and Henning	2 - —— - —— - MIT Eq. 2 } PTR data
• Scheel and Hense	5 —— - - —— - MIT Eq. 5 } PTR data
× Moser	3 - - - - - - - Curve of deviation of +.01° C.
△ Prytz	

60703—31 (Face p. 6)

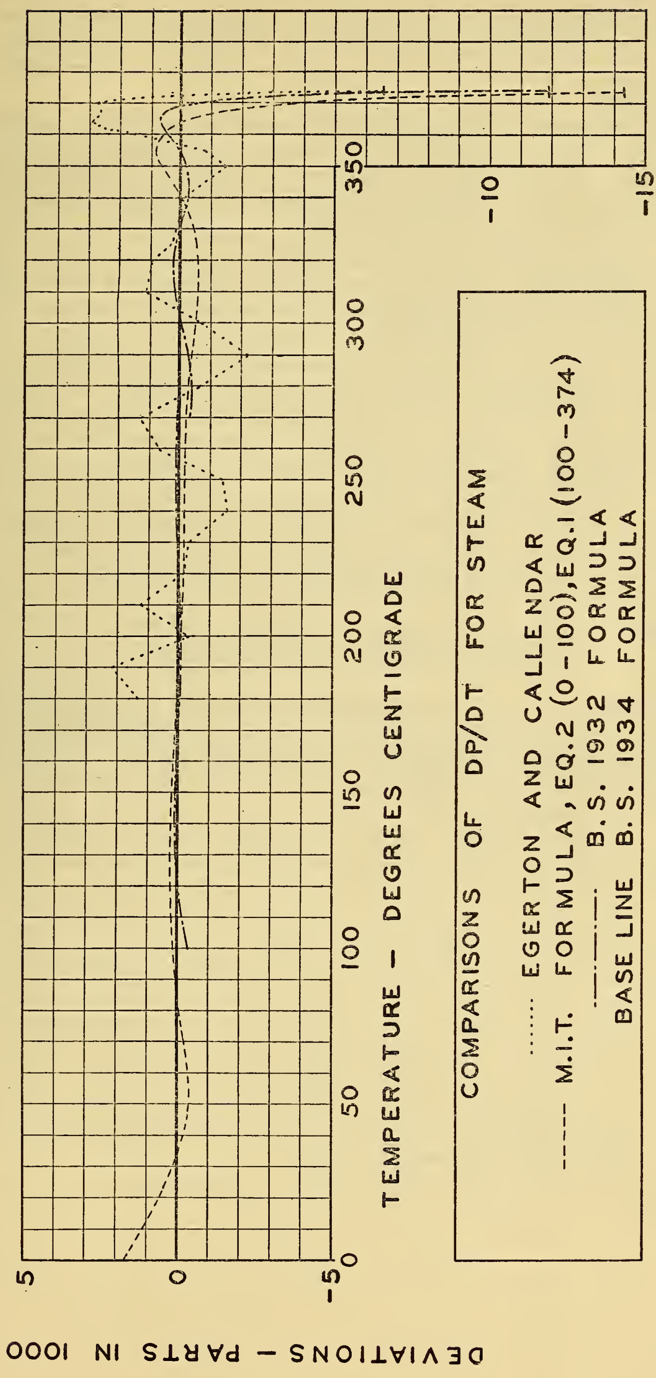
COMPARISONS OF DP/DT FOR STEAM
...... EGERTON AND CALLENDAR
---- M.I.T. FORMULA, EQ.2 (0-100), EQ.1 (100-374)
—·—·— B.S. 1932 FORMULA
BASE LINE B.S. 1934 FORMULA
TEMPERATURE — DEGREES CENTIGRADE
0
50
100
150
200
250
300
350
DEVIATIONS — PARTS IN 1000
5
0
-5
-10
-15

FIGURE 3

formulations. It appears that the present formula represents a fair appraisal of the existing data though it may require modification when more precise experimental evidence is available, establishing more definitely the true course of the pressure curve on approach to the critical region.

The formula is evidently unsuited for routine use such as engineering calculations. No such formula is needed in conjunction with adequate steam tables. The primary purpose is to furnish a suitable medium for formulating this property of steam in compiling steam tables. When once the formula has been used to compute tables of pressures and derivatives, at intervals of temperature small enough to permit accurate interpolation, these tables may be converted to other systems of units, and amplified to any desired extent without further reference to the formula. All such tables will be mutually consistent. They are suitable for use as actual working tables, and in addition provide a convenient reference medium for intercomparison of numerical values expressed in different systems of units. Comprehensive base tables of pressures and derivatives have been prepared in the systems of units commonly used in steam tables and are given in tables 2 to 6, inclusive. The formula is an independent but consistent means for expressing concisely the relation of saturation pressure to temperature. Definitive values of units and factors for converting pressures and energy quantities into different systems of units are given in table 7.

V. STEAM CONDENSATION TEMPERATURES FOR THERMOMETRIC CALIBRATION

The 100-degree fixed point of the international temperature scale is defined as the temperature of condensing water vapor under the pressure of one standard atmosphere. In actual practice, the usual procedure in thermometer calibration is to observe the thermometer reading in condensing water vapor at the prevailing atmospheric pressure, and to determine the actual temperature by observation of the pressure and use of the relation of vapor pressure to temperature. Even at sea level the temperature thus realized seldom equals the value of 100 degrees. At higher altitudes the temperature is often several degrees lower. Table 8 has been prepared to furnish a convenient means of determining by direct interpolation the temperature corresponding to an observed barometric pressure. The pressures must first be reduced to millimeters of mercury at 0 C and standard gravity (980.665 cm/sec ^{2}). A comparison of the values given by this table with those given by other similar tables and by other special formulas is shown on the graph, figure 4. The differences shown indicate the range of interpretations of the vapor pressure data as affecting the practical calibration of thermometers.

Note.—In tables 1 to 6, inclusive, all values of pressure below 0.01 C (32.018 F) are for vapor over subcooled liquid.

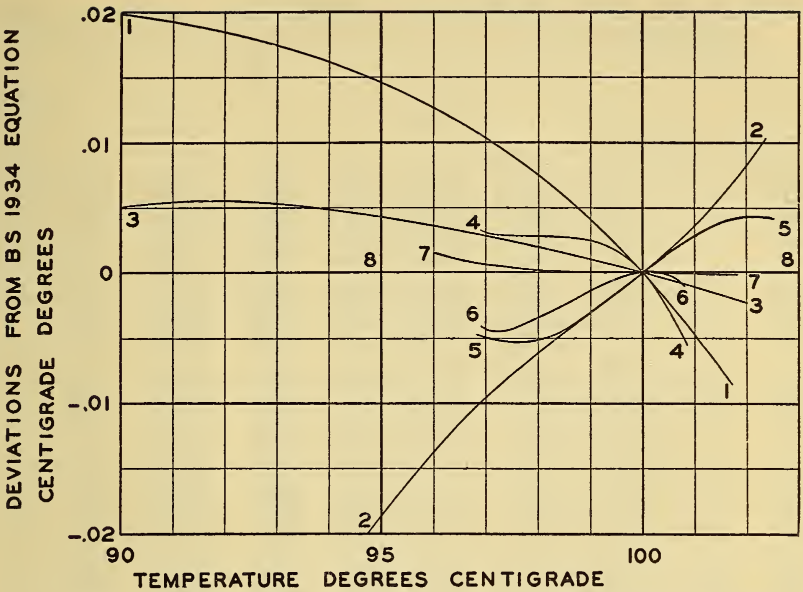

Figure 4.—*Steam condensation temperatures for thermometric calibration*

Comparison of various special equations and tables with B.S. 1934 formula as base line.

1. Guillaume (Broch-Reguault) Traite Pratique de Thermometrie de Precision, 1889.
2. Volet (Chappuis), Trav. Mem. Bur. Int. vol. 18, no. 4, 1930.
3. Wärmetabellen, 1919.
4. International Temperature Scale, Seventh General Conference of Weights and Measures, 1927.
5. Zmaczynski and Bonhoure, J. de Physique (ser. 7), vol. 1, p. 285, 1930.
6. Moser, Ann. d. Phys., vol. 14, p. 790, 1932.
7. Smith, Keyes and Gerry, Proc. Amer. Acad. Arts Sc., vol. 69, p. 137, 1934.
8. Holborn and Henning, Ann. d. Phys., vol. 26, p. 833, 1908 (same as base line within tolerance of rounded values given).

VI. TABLES OF SATURATION PRESSURES, SATURATION TEMPERATURES, AND CONVERSION FACTORS

TABLE 1.—*Saturation pressure of steam calculated from formula*

t	*P*	*dP/dt*	*t*	*P*	*dP/dt*
°*C*	*atm*	*atm/°C*	°*C*	*atm*	*atm/°C*
0	0.0060273	0.00043729	230	27.6130	0.50609
10	.012102	.00081027	240	33.0424	.58095
20	.023042	.00142704	250	39.2557	.66294
30	.041831	.0024015	260	46.3264	.75246
40	.072748	.0038796	270	54.3313	.84989
50	.121698	.0060412	280	63.3521	.95570
60	.196560	.0091004	290	73.4752	1.07045
70	.307520	.0133048	300	84.7931	1.19479
80	.467396	.0189322	310	97.4057	1.32954
90	.691923	.0262878	320	111.422	1.47572
100	1.00000	.035699	330	126.963	1.63483
110	1.41389	.047509	340	144.168	1.80896
120	1.95938	.062076	350	163.205	2.00197
130	2.66583	.079765	360	184.294	2.22115
140	3.56630	.100939	362	188.784	2.26932
150	4.69746	.125965	364	193.372	2.31938
160	6.09964	.155201	366	198.064	2.37165
170	7.81669	.188998	368	202.861	2.42656
180	9.89596	.227701	370	207.772	2.48495
190	12.3881	.271637	371	210.272	2.51588
200	15.3472	.321129	372	212.804	2.54858
210	18.8304	.376500	373	215.370	2.58412
220	22.8978	.438049	374	217.976	2.63069

TABLE 2.—*Pressure of saturated water vapor*

[1 standard atmosphere=1.033228 kg per sq cm—standard gravity=980.665 cm per sec per sec]

Temp *t*	Pressure *p*	Derivative *dp/dt*	*p*	*dp/dt*	Temp *t*	*p*	*dp/dt*	*p*	*dp/dt*
°C	*std atm*	*atm/°C*	*kg/cm²*	*kg/cm² °C*	*°C*	*std atm*	*atm/°C*	*kg/cm² °C*	*kg/cm² °C*
−5	0.004162	0.0003146	0.004300	0.0003251	55	0.15531	0.007444	0.16047	0.007691
−4	.004487	.0003364	.004637	.0003476	56	.16291	.007754	.16832	.008012
−3	.004835	.0003595	.004996	.0003715	57	.17082	.008074	.17650	.008343
−2	.005207	.0003840	.005380	.0003968	58	.17906	.008405	.18501	.008685
−1	.005604	.0004099	.005790	.0004235	59	.18764	.008747	.19387	.009038
0	.006027	.0004373	.006228	.0004518	60	.19656	.009100	.20309	.009403
+1	.006479	.0004662	.006694	.0004817	61	.20584	.009465	.21268	.009780
2	.006960	.0004968	.007192	.0005134	62	.21549	.009841	.22265	.010168
3	.007473	.0005292	.007722	.0005467	63	.22553	.010229	.23302	.010569
4	.008019	.0005633	.008286	.0005820	64	.23596	.010630	.24380	.010983
5	.008600	.0005993	.008886	.0006192	65	.24679	.011043	.25499	.011410
6	.009218	.0006372	.009525	.0006584	66	.25805	.011468	.26662	.011850
7	.009875	.0006772	.010204	.0006997	67	.26973	.011907	.27870	.012303
8	.010574	.0007193	.010925	.0007432	68	.28186	.012359	.29123	.012770
9	.011315	.0007636	.011691	.0007890	69	.29446	.012825	.30424	.013251
10	.012102	.0008103	.012504	.0008372	70	.30752	.013305	.31774	.013747
11	.012936	.0008593	.013366	.0008879	71	.32107	.013799	.33174	.014257
12	.013821	.0009109	.014280	.0009412	72	.33512	.014307	.34626	.014782
13	.014759	.0009651	.015249	.0009972	73	.34969	.014830	.36131	.015323
14	.015752	.0010220	.016276	.0010560	74	.36479	.015368	.37691	.015879
15	.016804	.0010818	.017362	.0011177	75	.38043	.015922	.39307	.016451
16	.017917	.0011445	.018512	.0011825	76	.39664	.016492	.40982	.017039
17	.019094	.0012102	.019728	.0012504	77	.41342	.017077	.42716	.017644
18	.020338	.0012792	.021014	.0013217	78	.43080	.017679	.44511	.018266
19	.021653	.0013514	.022373	.0013963	79	.44878	.018297	.46370	.018905
20	.023042	.0014270	.023808	.0014745	80	.46740	.018932	.48293	.019561
21	.024508	.0015063	.025323	.0015563	81	.48665	.019585	.50282	.020236
22	.026056	.0015891	.026922	.0016419	82	.50657	.020255	.52340	.020928
23	.027688	.0016758	.028608	.0017315	83	.52717	.020943	.54469	.021639
24	.029409	.0017665	.030386	.0018252	84	.54846	.021649	.56668	.022368
25	.031222	.0018612	.032260	.0019231	85	.57047	.022374	.58943	.023117
26	.033133	.0019602	.034234	.0020253	86	.59322	.023118	.61293	.023886
27	.035144	.0020636	.036312	.0021322	87	.61672	.023881	.63721	.024674
28	.037261	.0021715	.038500	.0022436	88	.64099	.024663	.66229	.025483
29	.039489	.0022841	.040801	.0023600	89	.66605	.025465	.68818	.026312
30	.041831	.0024015	.043221	.0024813	90	.69192	.026288	.71491	.027161
31	.044293	.0025240	.045765	.0026079	91	.71863	.027131	.74251	.028032
32	.046881	.0026516	.048439	.0027397	92	.74619	.027995	.77098	.028925
33	.049599	.0027846	.051247	.0028771	93	.77463	.028880	.80037	.029840
34	.052452	.0029230	.054195	.0030201	94	.80396	.029786	.83067	.030776
35	.055446	.0030672	.057288	.0031691	95	.83421	.030715	.86192	.031736
36	.058588	.0032172	.060535	.0033241	96	.86540	.031666	.89416	.032718
37	.061883	.0033733	.063939	.0034854	97	.89755	.032639	.92737	.033724
38	.065337	.0035356	.067508	.0036531	98	.93068	.033636	.96161	.034753
39	.068956	.0037043	.071247	.0038274	99	.96482	.034655	.99688	.035807
40	.072748	.0038796	.075165	.0040085	100	1.00000	.035699	1.03323	.036885
41	.076718	.0040618	.079267	.0041967	101	1.0362	.036766	1.0707	.037988
42	.080873	.0042509	.083560	.0043921	102	1.0735	.037858	1.1092	.039115
43	.085222	.0044472	.088054	.0045950	103	1.1120	.038974	1.1489	.040269
44	.089770	.0046510	.092753	.0048055	104	1.1515	.040115	1.1898	.041448
45	.094526	.0048624	.097667	.005024	105	1.1922	.041282	1.2318	.042654
46	.099497	.005082	.10280	.005250	106	1.2341	.042474	1.2751	.043886
47	.10469	.005309	.10817	.005485	107	1.2772	.043693	1.3196	.045145
48	.11012	.005544	.11378	.005729	108	1.3215	.044938	1.3654	.046431
49	.11578	.005788	.11963	.005981	109	1.3670	.046210	1.4125	.047746
50	.12170	.006041	.12574	.006242	110	1.4139	.047509	1.4609	.049088
51	.12787	.006303	.13212	.006513	111	1.4621	.048836	1.5106	.05046
52	.13431	.006574	.13877	.006792	112	1.5116	.05019	1.5618	.05186
53	.14102	.006854	.14571	.007082	113	1.5624	.05157	1.6144	.05329
54	.14802	.007144	.15294	.007381	114	1.6147	.05299	1.6684	.05475

TABLE 2.—*Pressure of saturated water vapor*—Continued

[1 standard atmosphere=1.033228 kg per sq cm—standard gravity=980.665 cm per sec per sec]

Temp *t*	Pressure *p*	Derivative *dp/dt*	*p*	*dp/dt*	Temp *t*	*p*	*dp/dt*	*p*	*dp/dt*
°*C*	*std atm*	*atm/°C*	*kg/cm²*	*kg/cm² °C*	°*C*	*std atm*	*atm/°C*	*kg/cm² °C*	*kg/cm² °C*
115	1.6684	0.05443	1.7239	0.05623	180	9.8960	0.22770	10.225	0.23527
116	1.7236	.05590	1.7809	.05775	181	10.126	.23185	10.462	.23956
117	1.7802	.05740	1.8394	.05930	182	10.360	.23606	10.703	.24390
118	1.8384	.05893	1.8995	.06088	183	10.598	.24032	10.950	.24830
119	1.8981	.06049	1.9612	.06250	184	10.840	.24463	11.201	.25276
120	1.9594	.06208	2.0245	.06414	185	11.087	.24899	11.456	.25727
121	2.0223	.06370	2.0895	.06582	186	11.338	.25341	11.715	.26183
122	2.0868	.06535	2.1561	.06752	187	11.594	.25789	11.979	.26646
123	2.1530	.06704	2.2245	.06927	188	11.854	.26242	12.248	.27113
124	2.2209	.06876	2.2947	.07104	189	12.119	.26700	12.522	.27587
125	2.2905	.07051	2.3666	.07285	190	12.388	.27164	12.800	.28066
126	2.3619	.07229	2.4404	.07469	191	12.662	.27633	13.083	.28551
127	2.4351	.07411	2.5160	.07657	192	12.941	.28108	13.371	.29042
128	2.5101	.07596	2.5935	.07848	193	13.224	.28589	13.664	.29539
129	2.5870	.07784	2.6730	.08043	194	13.513	.29075	13.962	.30041
130	2.6658	.07976	2.7544	.08242	195	13.806	.29567	14.265	.30549
131	2.7466	.08172	2.8378	.08443	196	14.104	.30065	14.573	.31064
132	2.8293	.08371	2.9233	.08649	197	14.407	.30568	14.886	.31584
133	2.9140	.08574	3.0108	.08858	198	14.715	.31077	15.204	.32110
134	3.0008	.08780	3.1005	.09071	199	15.029	.31592	15.528	.32642
135	3.0896	.08989	3.1923	.09288	200	15.347	.32113	15.857	.33180
136	3.1806	.09203	3.2863	.09509	201	15.671	.32640	16.192	.33724
137	3.2737	.09420	3.3824	.09733	202	16.000	.33173	16.532	.34275
138	3.3690	.09641	3.4809	.09961	203	16.334	.33711	16.877	.34831
139	3.4665	.09866	3.5817	.10193	204	16.674	.34256	17.228	.35394
140	3.5663	.10094	3.6848	.10429	205	17.020	.34806	17.585	.35963
141	3.6684	.10326	3.7903	.10669	206	17.370	.35363	17.948	.36538
142	3.7728	.10562	3.8982	.10913	207	17.727	.35925	18.316	.37119
143	3.8797	.10803	4.0086	.11162	208	18.089	.36494	18.690	.37707
144	3.9889	.11047	4.1214	.11414	209	18.457	.37069	19.070	.38301
145	4.1006	.11295	4.2369	.11670	210	18.830	.37650	19.456	.38901
146	4.2148	.11547	4.3549	.11930	211	19.210	.38237	19.848	.39508
147	4.3316	.11803	4.4755	.12195	212	19.595	.38830	20.246	.40121
148	4.4509	.12064	4.5988	.12464	213	19.986	.39430	20.651	.40740
149	4.5728	.12328	4.7248	.12738	214	20.384	.40036	21.061	.41366
150	4.6975	.12596	4.8535	.13015	215	20.787	.40648	21.477	.41999
151	4.8248	.12869	4.9851	.13297	216	21.197	.41267	21.901	.42638
152	4.9549	.13146	5.1195	.13583	217	21.613	.41892	22.331	.43284
153	5.0877	.13428	5.2568	.13874	218	22.035	.42523	22.767	.43936
154	5.2234	.13713	5.3970	.14169	219	22.463	.43161	23.209	.44595
155	5.3620	.14004	5.5402	.14469	220	22.898	.43805	23.659	.45260
156	5.5035	.14298	5.6864	.14773	221	23.339	.44456	24.115	.45933
157	5.6480	.14597	5.8357	.15082	222	23.787	.45113	24.577	.46612
158	5.7955	.14900	5.9880	.15395	223	24.241	.45777	25.047	.47298
159	5.9460	.15208	6.1436	.15713	224	24.702	.46447	25.523	.47990
160	6.0996	.15520	6.3023	.16036	225	25.170	.47124	26.007	.48690
161	6.2564	.15837	6.4643	.16363	226	25.645	.47807	26.497	.49396
162	6.4164	.16158	6.6296	.16695	227	26.126	.48498	26.995	.5011
163	6.5796	.16485	6.7982	.17032	228	26.615	.49195	27.499	.5083
164	6.7461	.16815	6.9703	.17374	229	27.110	.49898	28.011	.5156
165	6.9159	.17151	7.1457	.17721	230	27.613	.5061	28.531	.5229
166	7.0891	.17491	7.3247	.18072	231	28.123	.5133	29.057	.5303
167	7.2658	.17836	7.5072	.18429	232	28.640	.5205	29.591	.5378
168	7.4459	.18186	7.6933	.18790	233	29.164	.5278	30.133	.5454
169	7.6295	.18540	7.8830	.19156	234	29.695	.5352	30.682	.5530
170	7.8167	.18900	8.0764	.19528	235	30.234	.5426	31.239	.5607
171	8.0075	.19264	8.2736	.19904	236	30.780	.5502	31.803	.5685
172	8.2020	.19634	8.4745	.20286	237	31.334	.5578	32.376	.5763
173	8.4002	.20008	8.6793	.20673	238	31.895	.5654	32.955	.5842
174	8.6022	.20387	8.8880	.21065	239	32.465	.5732	33.544	.5922
175	8.8080	.20772	9.1006	.21462	240	33.042	.5810	34.140	.6003
176	9.0176	.21161	9.3172	.21864	241	33.627	.5888	34.745	.6084
177	9.2312	.21556	9.5379	.22272	242	34.220	.5968	35.357	.6166
178	9.4487	.21955	9.7627	.22685	243	34.821	.6048	35.978	.6249
179	9.6703	.22360	9.9916	.23103	244	35.430	.6129	36.607	.6332

TABLE 2.—*Pressure of saturated water vapor*—Continued

[1 standard atmosphere=1.033228 kg per sq cm—standard gravity=980.665 cm per sec per sec]

Temp *t*	Pressure *p*	Derivative *dp/dt*	*p*	*dp/dt*	Temp *t*	*p*	*dp/dt*	*p*	*dp/dt*
°C	*std atm*	*atm/°C*	*kg/cm²*	*kg/cm² °C*	*°C*	*std atm*	*atm/°C*	*kg/cm² °C*	*kg/cm² °C*
245	36.047	0.6210	37.244	0.6417	310	97.406	1.3295	100.64	1.3737
246	36.672	.6293	37.890	.6502	311	98.742	1.3436	102.02	1.3883
247	37.305	.6376	38.545	.6588	312	100.09	1.3578	103.42	1.4029
248	37.947	.6460	39.208	.6674	313	101.46	1.3721	104.83	1.4177
249	38.597	.6544	39.880	.6762	314	102.84	1.3866	106.25	1.4326
250	39.256	.6629	40.560	.6850	315	104.23	1.4011	107.69	1.4477
251	39.923	.6716	41.250	.6939	316	105.64	1.4158	109.15	1.4628
252	40.599	.6802	41.948	.7028	317	107.06	1.4306	110.62	1.4781
253	41.284	.6890	42.655	.7119	318	108.50	1.4455	112.11	1.4935
254	41.977	.6978	43.372	.7210	319	109.95	1.4606	113.61	1.5091
255	42.679	.7067	44.097	.7302	320	111.42	1.4757	115.12	1.5248
256	43.390	.7157	44.832	.7395	321	112.91	1.4910	116.66	1.5406
257	44.111	.7248	45.576	.7489	322	114.40	1.5064	118.21	1.5565
258	44.840	.7339	46.330	.7583	323	115.92	1.5220	119.77	1.5726
259	45.579	.7432	47.093	.7679	324	117.45	1.5377	121.35	1.5888
260	46.326	.7525	47.866	.7775	325	118.99	1.5535	122.95	1.6052
261	47.083	.7618	48.648	.7872	326	120.56	1.5695	124.56	1.6217
262	47.850	.7713	49.440	.7969	327	122.13	1.5856	126.19	1.6383
263	48.626	.7808	50.242	.8068	328	123.73	1.6019	127.84	1.6551
264	49.412	.7905	51.054	.8167	329	125.34	1.6183	129.50	1.6720
265	50.207	.8002	51.875	.8267	330	126.96	1.6348	131.18	1.6891
266	51.012	.8099	52.707	.8369	331	128.61	1.6515	132.88	1.7064
267	51.827	.8198	53.549	.8470	332	130.27	1.6683	134.59	1.7238
268	52.652	.8298	54.401	.8573	333	131.94	1.6853	136.33	1.7413
269	53.486	.8398	55.264	.8677	334	133.64	1.7025	138.08	1.7591
270	54.331	.8499	56.137	.8781	335	135.35	1.7198	139.85	1.7770
271	55.187	.8601	57.020	.8887	336	137.08	1.7373	141.63	1.7950
272	56.052	.8704	57.914	.8993	337	138.82	1.7550	143.44	1.8133
273	56.927	.8807	58.819	.9100	338	140.59	1.7728	145.26	1.8317
274	57.813	.8912	59.734	.9208	339	142.37	1.7908	147.10	1.8503
275	58.710	.9017	60.660	.9317	340	144.17	1.8090	148.96	1.8691
276	59.616	.9123	61.597	.9427	341	145.99	1.8273	150.84	1.8880
277	60.534	.9230	62.546	.9537	342	147.82	1.8459	152.73	1.9072
278	61.463	.9338	63.505	.9649	343	149.68	1.8646	154.65	1.9266
279	62.402	.9447	64.475	.9761	344	151.55	1.8836	156.59	1.9462
280	63.352	.9557	65.457	.9875	345	153.45	1.9028	158.54	1.9660
281	64.313	.9668	66.450	.9989	346	155.36	1.9222	160.52	1.9860
282	65.286	.9779	67.455	1.0104	347	157.29	1.9418	162.52	2.0063
283	66.269	.9892	68.471	1.0220	348	159.24	1.9616	164.53	2.0268
284	67.264	1.0005	69.499	1.0337	349	161.21	1.9817	166.57	2.0475
285	68.270	1.0119	70.539	1.0455	350	163.20	2.0020	168.63	2.0685
286	69.288	1.0234	71.590	1.0574	351	165.22	2.0225	170.71	2.0897
287	70.317	1.0350	72.654	1.0694	352	167.25	2.0434	172.81	2.1113
288	71.358	1.0468	73.729	1.0815	353	169.30	2.0645	174.93	2.1331
289	72.411	1.0586	74.817	1.0937	354	171.38	2.0859	177.07	2.1552
290	73.475	1.0704	75.917	1.1060	355	173.48	2.1076	179.24	2.1776
291	74.552	1.0824	77.029	1.1184	356	175.59	2.1296	181.43	2.2004
292	75.640	1.0945	78.153	1.1309	357	177.74	2.1519	183.64	2.2234
293	76.741	1.1067	79.291	1.1435	358	179.90	2.1746	185.88	2.2469
294	77.854	1.1190	80.441	1.1562	359	182.08	2.1977	188.13	2.2707
295	78.979	1.1314	81.603	1.1690	360	184.29	2.2212	190.42	2.2950
296	80.116	1.1439	82.779	1.1819	361	186.53	2.2450	192.72	2.3196
297	81.266	1.1564	83.967	1.1949	362	188.78	2.2693	195.06	2.3447
298	82.429	1.1691	85.168	1.2080	363	191.07	2.2941	197.41	2.3703
299	83.605	1.1819	86.383	1.2212	364	193.37	2.3194	199.80	2.3964
300	84.793	1.1948	87.611	1.2345	365	195.70	2.3452	202.21	2.4232
301	85.994	1.2078	88.852	1.2479	366	198.06	2.3716	204.64	2.4505
302	87.209	1.2209	90.106	1.2614	367	200.45	2.3987	207.11	2.4784
303	88.436	1.2341	91.375	1.2751	368	202.86	2.4266	209.60	2.5072
304	89.677	1.2474	92.657	1.2888	369	205.30	2.4553	212.12	2.5368
305	90.931	1.2608	93.952	1.3027	370	207.77	2.4850	214.68	2.5675
306	92.198	1.2743	95.262	1.3167	371	210.27	2.5159	217.26	2.5995
307	93.480	1.2880	96.586	1.3308	372	212.80	2.5486	219.88	2.6333
308	94.774	1.3017	97.924	1.3450	373	215.37	2.5841	222.53	2.6700
309	96.083	1.3156	99.276	1.3593	374	217.98	2.6307	225.22	2.7181

TABLE 3.—*Pressure of saturated water vapor in pounds per square inch*

Fahrenheit temperature—Standard Gravity=32.174 ft/sec²

t °F	0	1	2	3	4	5	6	7	8	9	t °F
20	.05388	.05622	.05865	.06117	.06378	.06650	.06932	.07224	.07528	.07842	20
30	.08169	.08507	.08858	.09221	.09598	.09988	.10392	.10811	.11245	.11693	30
40	.12158	.12639	.13137	.13652	.14184	.14735	.15305	.15895	.16504	.17134	40
50	.17784	.18457	.19152	.19869	.20611	.21376	.22167	.22983	.23825	.24695	50
60	.25592	.26518	.27473	.28458	.29474	.30521	.31601	.32715	.33863	.35046	60
70	.36264	.37520	.38814	.40146	.41518	.42931	.44386	.45884	.47426	.49013	70
80	.50645	.52326	.54054	.55832	.57661	.59541	.61475	.63463	.65507	.67608	80
90	.69767	.71985	.74265	.76607	.79013	.81484	.84022	.86628	.89303	.92050	90
100	.94870	.97765	1.0073	1.0378	1.0691	1.1012	1.1341	1.1679	1.2025	1.2380	100
110	1.2744	1.3117	1.3499	1.3892	1.4294	1.4705	1.5127	1.5560	1.6003	1.6456	110
120	1.6921	1.7397	1.7885	1.8384	1.8895	1.9418	1.9953	2.0501	2.1062	2.1636	120
130	2.2224	2.2825	2.3439	2.4068	2.4711	2.5369	2.6042	2.6729	2.7433	2.8152	130
140	2.8886	2.9638	3.0405	3.1190	3.1992	3.2811	3.3648	3.4503	3.5377	3.6269	140
150	3.7180	3.8110	3.9060	4.0030	4.1021	4.2032	4.3064	4.4118	4.5193	4.6290	150
160	4.7410	4.8553	4.9719	5.0908	5.2121	5.3359	5.4621	5.5908	5.7221	5.8559	160
170	5.9925	6.1316	6.2735	6.4181	6.5654	6.7156	6.8688	7.0249	7.1839	7.3459	170
180	7.5110	7.6791	7.8504	8.0250	8.2027	8.3837	8.5680	8.7558	8.9469	9.1415	180
190	9.3397	9.5414	9.7467	9.9558	10.168	10.385	10.605	10.830	11.058	11.290	190
200	11.526	11.766	12.011	12.260	12.512	12.770	13.031	13.297	13.568	13.843	200
210	14.123	14.407	14.696	14.990	15.289	15.592	15.901	16.214	16.533	16.857	210
220	17.186	17.520	17.860	18.205	18.556	18.912	19.274	19.641	20.015	20.394	220
230	20.779	21.170	21.566	21.969	22.378	22.794	23.216	23.644	24.078	24.519	230
240	24.967	25.421	25.882	26.350	26.825	27.307	27.796	28.292	28.795	29.305	240
250	29.823	30.349	30.881	31.422	31.970	32.526	33.090	33.661	34.241	34.829	250
260	35.425	36.029	36.642	37.262	37.892	38.530	39.177	39.833	40.497	41.171	260
270	41.853	42.545	43.246	43.956	44.676	45.405	46.144	46.892	47.650	48.418	270
280	49.196	49.984	50.783	51.591	52.410	53.240	54.080	54.930	55.791	56.664	280
290	57.547	58.441	59.346	60.262	61.190	62.130	63.081	64.043	65.017	66.003	290
300	67.002	68.012	69.034	70.068	71.115	72.175	73.247	74.332	75.429	76.540	300
310	77.664	78.800	79.950	81.113	82.290	83.481	84.685	85.903	87.134	88.380	310
320	89.640	90.915	92.203	93.506	94.824	96.157	97.504	98.866	100.24	101.64	320
330	103.04	104.47	105.91	107.36	108.83	110.32	111.82	113.34	114.87	116.42	330
340	117.99	119.58	121.18	122.80	124.43	126.08	127.75	129.44	131.15	132.87	340
350	134.61	136.37	138.14	139.94	141.75	143.58	145.43	147.30	149.19	151.09	350
360	153.02	154.96	156.93	158.91	160.91	162.94	164.98	167.04	169.13	171.23	360
370	173.35	175.50	177.66	179.85	182.06	184.28	186.53	188.80	191.10	193.41	370
380	195.75	198.11	200.49	202.89	205.32	207.76	210.23	212.73	215.24	217.78	380
390	220.35	222.93	225.54	228.18	230.83	233.52	236.22	238.95	241.71	244.49	390
400	247.29	250.12	252.97	255.85	258.76	261.69	264.65	267.63	270.64	273.67	400
410	276.73	279.82	282.93	286.07	289.24	292.44	295.66	298.91	302.18	305.49	410
420	308.82	312.18	315.57	318.99	322.43	325.91	329.41	332.94	336.51	340.10	420
430	343.72	347.37	351.05	354.76	358.50	362.27	366.07	369.90	373.77	377.66	430
440	381.59	385.54	389.53	393.55	397.60	401.68	405.80	409.95	414.13	418.34	440
450	422.59	426.87	431.18	435.53	439.91	444.32	448.77	453.25	457.77	462.32	450
460	466.90	471.52	476.18	480.86	485.59	490.35	495.15	499.98	504.85	509.75	460
470	514.70	519.67	524.69	529.74	534.83	539.96	545.12	550.32	555.56	560.84	470
480	566.16	571.51	576.90	582.33	587.81	593.32	598.87	604.46	610.08	615.75	480
490	621.46	627.21	633.00	638.84	644.71	650.62	656.58	662.57	668.61	674.69	490
500	680.81	686.98	693.18	699.43	705.73	712.06	718.44	724.87	731.33	737.84	500
510	744.40	751.00	757.64	764.33	771.06	777.84	784.67	791.54	798.45	805.42	510
520	812.43	819.48	826.58	833.73	840.92	848.17	855.46	862.80	870.18	877.61	520
530	885.10	892.63	900.21	907.84	915.52	923.24	931.02	938.85	946.73	954.66	530
540	962.64	970.67	978.75	986.88	995.06	1003.3	1011.6	1019.9	1028.3	1036.8	540
550	1045.3	1053.8	1062.4	1071.1	1079.8	1088.6	1097.4	1106.3	1115.2	1124.2	550
560	1133.2	1142.3	1151.5	1160.7	1169.9	1179.3	1188.6	1198.1	1207.6	1217.1	560
570	1226.7	1236.4	1246.1	1255.9	1265.7	1275.6	1285.6	1295.6	1305.7	1315.9	570
580	1326.1	1336.3	1346.6	1357.0	1367.5	1378.0	1388.6	1399.2	1409.9	1420.7	580
590	1431.5	1442.4	1453.3	1464.3	1475.4	1486.5	1497.8	1509.0	1520.4	1531.8	590
600	1543.3	1554.8	1566.4	1578.1	1589.8	1601.6	1613.5	1625.4	1637.5	1649.5	600
610	1661.7	1673.9	1686.2	1698.6	1711.0	1723.5	1736.1	1748.7	1761.4	1774.2	610
620	1787.1	1800.0	1813.1	1826.1	1839.3	1852.5	1865.8	1879.2	1892.8	1906.2	620
630	1919.8	1933.5	1947.3	1961.1	1975.1	1989.1	2003.2	2017.3	2031.5	2045.9	630
640	2060.3	2074.8	2089.3	2104.0	2118.7	2133.5	2148.4	2163.4	2178.4	2193.6	640
650	2208.8	2224.1	2239.5	2255.0	2270.6	2286.3	2302.0	2317.9	2333.8	2349.8	650
660	2366.0	2382.2	2398.5	2414.8	2431.3	2447.9	2464.6	2481.4	2498.2	2515.2	660
670	2532.2	2549.4	2566.6	2584.0	2601.5	2619.0	2636.7	2654.5	2672.3	2690.3	670
680	2708.4	2726.5	2744.9	2763.3	2781.8	2800.4	2819.2	2838.0	2857.0	2876.1	680
690	2895.3	2914.6	2934.1	2953.6	2973.3	2993.2	3013.1	3033.2	3053.4	3073.8	690
700	3094.3	3114.9	3135.7	3156.7	3177.8	3199.1	------	------	------	------	700

TABLE 4.—*Derivative of the pressure of saturated water vapor (dp/dt) in pounds per square inch per degree Fahrenheit*

t °F	0	1	2	3	4	5	6	7	8	9	t °F
20	.002294	2383	2474	2569	2666	2767	2871	2979	3090	3204	20
30	.003322	3444	3570	3700	3834	3972	4114	4260	4411	4567	30
40	.004727	4893	5063	5238	5418	5604	5794	5991	6193	6401	40
50	.006615	6836	7062	7294	7534	7779	8032	8292	8558	8832	50
60	.009114	9402	9699	10004	10316	10637	10966	11304	11651	12007	60
70	.012372	12746	13129	13522	13925	14338	14762	15196	15640	16096	70
80	.016563	17040	17530	18031	18544	19069	19607	20157	20721	21297	80
90	.021886	22490	23107	23737	24382	25042	25717	26406	27110	27831	90
100	.028567	29319	30087	30873	31675	32494	33331	34185	35058	35948	100
110	.036857	37785	38732	39699	40685	41691	42719	43766	44834	45924	110
120	.047035	48168	49323	50501	51702	52926	54173	55445	56740	58060	120
130	.05941	.06078	.06217	.06359	.06504	.06652	.06802	.06955	.07110	.07269	130
140	.07430	.07593	.07760	.07931	.08104	.08280	.08460	.08642	.08827	.09016	140
150	.09208	.09403	.09601	.09803	.10008	.10216	.10428	.10644	.10863	.11085	150
160	.11311	.11541	.11775	.12012	.12253	.12498	.12747	.13000	.13256	.13517	160
170	.13782	.14050	.14324	.14600	.14882	.15167	.15457	.15752	.16050	.16353	170
180	.16661	.16973	.17289	.17611	.17937	.18267	.18602	.18943	.19288	.19638	180
190	.19993	.20353	.20717	.21088	.21462	.21843	.22228	.22619	.23015	.23417	190
200	.23824	.24236	.24654	.25077	.25506	.25941	.26381	.26828	.27279	.27737	200
210	.28201	.28670	.29146	.29628	.30116	.30609	.31109	.31616	.32128	.32648	210
220	.33173	.33704	.34243	.34787	.35339	.35897	.36462	.37034	.37612	.38197	220
230	.38789	.39388	.39994	.40607	.41227	.41854	.42489	.43130	.43780	.44435	230
240	.45100	.45771	.46450	.47136	.47830	.48532	.49240	.49958	.50682	.51415	240
250	.5216	.5290	.5366	.5443	.5520	.5598	.5677	.5757	.5837	.5919	250
260	.6001	.6084	.6168	.6253	.6338	.6425	.6512	.6601	.6690	.6780	260
270	.6871	.6963	.7056	.7149	.7244	.7339	.7436	.7533	.7631	.7731	270
280	.7831	.7932	.8034	.8137	.8241	.8346	.8452	.8559	.8667	.8776	280
290	.8886	.8997	.9109	.9222	.9336	.9450	.9567	.9684	.9802	.9921	290
300	1.0041	1.0162	1.0284	1.0408	1.0532	1.0658	1.0784	1.0912	1.1040	1.1170	300
310	1.1301	1.1433	1.1566	1.1700	1.1836	1.1972	1.2110	1.2248	1.2388	1.2529	310
320	1.2671	1.2815	1.2959	1.3105	1.3251	1.3399	1.3548	1.3699	1.3850	1.4003	320
330	1.4157	1.4312	1.4468	1.4625	1.4784	1.4944	1.5105	1.5267	1.5431	1.5596	330
340	1.5762	1.5929	1.6097	1.6267	1.6438	1.6610	1.6784	1.6959	1.7135	1.7312	340
350	1.7491	1.7671	1.7852	1.8035	1.8219	1.8404	1.8590	1.8778	1.8968	1.9158	350
360	1.9350	1.9543	1.9738	1.9933	2.0130	2.0329	2.0529	2.0730	2.0933	2.1137	360
370	2.1342	2.1549	2.1757	2.1967	2.2178	2.2390	2.2604	2.2819	2.3036	2.3254	370
380	2.3473	2.3694	2.3916	2.4140	2.4365	2.4592	2.4820	2.5049	2.5280	2.5513	380
390	2.5746	2.5982	2.6219	2.6457	2.6697	2.6938	2.7181	2.7425	2.7671	2.7918	390
400	2.8167	2.8417	2.8669	2.8923	2.9178	2.9434	2.9692	2.9951	3.0212	3.0475	400
410	3.0739	3.1005	3.1272	3.1541	3.1811	3.2083	3.2357	3.2632	3.2909	3.3187	410
420	3.3467	3.3748	3.4032	3.4316	3.4603	3.4891	3.5180	3.5472	3.5764	3.6059	420
430	3.6355	3.6653	3.6952	3.7253	3.7556	3.7860	3.8166	3.8474	3.8784	3.9095	430
440	3.9408	3.9722	4.0038	4.0356	4.0675	4.0997	4.1320	4.1644	4.1971	4.2299	440
450	4.2629	4.2960	4.3294	4.3629	4.3966	4.4304	4.4645	4.4987	4.5331	4.5676	450
460	4.6024	4.6373	4.6724	4.7077	4.7431	4.7788	4.8146	4.8506	4.8868	4.9231	460
470	4.9597	4.9964	5.0333	5.0704	5.1077	5.1451	5.1828	5.2206	5.2586	5.2968	470
480	5.335	5.374	5.413	5.452	5.491	5.530	5.570	5.609	5.649	5.689	480
490	5.730	5.770	5.811	5.852	5.893	5.934	5.976	6.017	6.059	6.101	490
500	6.143	6.186	6.229	6.271	6.314	6.358	6.401	6.445	6.489	6.533	500
510	6.577	6.622	6.666	6.711	6.756	6.802	6.847	6.893	6.939	6.985	510
520	7.032	7.078	7.125	7.172	7.219	7.266	7.314	7.362	7.410	7.458	520
530	7.507	7.556	7.605	7.654	7.703	7.753	7.803	7.853	7.903	7.954	530
540	8.004	8.056	8.107	8.158	8.210	8.262	8.314	8.366	8.419	8.472	540
550	8.525	8.578	8.632	8.686	8.740	8.794	8.848	8.903	8.958	9.014	550
560	9.069	9.125	9.181	9.237	9.294	9.350	9.407	9.465	9.522	9.580	560
570	9.638	9.696	9.755	9.814	9.873	9.932	9.992	10.052	10.112	10.172	570
580	10.233	10.294	10.355	10.416	10.478	10.540	10.603	10.665	10.728	10.792	580
590	10.855	10.919	10.983	11.047	11.112	11.177	11.242	11.307	11.373	11.439	590
600	11.506	11.573	11.640	11.707	11.775	11.843	11.911	11.980	12.048	12.118	600
610	12.187	12.257	12.328	12.398	12.469	12.540	12.612	12.684	12.756	12.829	610
620	12.902	12.975	13.049	13.123	13.197	13.272	13.347	13.423	13.500	13.575	620
630	13.652	13.729	13.806	13.884	13.963	14.041	14.120	14.200	14.280	14.360	630
640	14.441	14.523	14.604	14.687	14.769	14.853	14.936	15.020	15.105	15.190	640
650	15.275	15.361	15.448	15.535	15.623	15.711	15.800	15.889	15.979	16.070	650
660	16.161	16.252	16.345	16.438	16.532	16.626	16.721	16.817	16.913	17.011	660
670	17.109	17.207	17.307	17.407	17.508	17.610	17.713	17.817	17.922	18.028	670
680	18.134	18.242	18.351	18.461	18.572	18.685	18.799	18.913	19.030	19.147	680
690	19.267	19.388	19.510	19.634	19.761	19.889	20.019	20.152	20.288	20.427	690
700	20.570	20.717	20.869	21.030	21.205	21.418	------	------	------	------	700

64092—34——2

TABLE 5.—*Pressure of saturated water vapor*

Pounds per square inch—Fahrenheit temperature—Standard gravity=32.174 ft/sec²

lb/in.²	°F	lb/in.²	°F	lb/in.²	°F	lb/in.²	°F
0.10	35.030	5.4	165.510	37	262.579	97	325.627
.12	39.663	5.5	166.297	38	264.170	98	326.365
.14	43.657	5.6	167.071	39	265.728	99	327.097
.16	47.175	5.8	168.585	40	267.253	100	327.823
.18	50.324	6.0	170.054	41	268.748	101	328.544
.20	53.179	6.2	171.484	42	270.213	102	329.260
.22	55.792	6.4	172.876	43	271.651	103	329.969
.24	58.203	6.5	173.559	44	273.061	104	330.673
.25	59.343	6.6	174.232	45	274.446	105	331.371
.26	60.444	6.8	175.553	46	275.807	106	332.064
.28	62.539	7.0	176.842	47	277.143	107	332.753
.30	64.506	7.2	178.100	48	278.457	108	333.436
.32	66.361	7.4	179.330	49	279.749	109	334.114
.34	68.117	7.5	179.934	50	281.020	110	334.787
.35	68.962	7.6	180.532	51	282.270	111	335.455
.36	69.786	7.8	181.708	52	283.501	112	336.118
.38	71.375	8.0	182.858	53	284.712	113	336.778
.40	72.892	8.2	183.985	54	285.906	114	337.431
.42	74.344	8.4	185.089	55	287.082	115	338.082
.44	75.737	8.5	185.633	56	288.240	116	338.727
.45	76.414	8.6	186.172	57	289.382	117	339.368
.46	77.076	8.8	187.233	58	290.509	118	340.004
.48	78.365	9.0	188.275	59	291.620	119	340.636
.50	79.608	9.2	189.297	60	292.715	120	341.265
.55	82.536	9.4	190.301	61	293.796	121	341.889
.60	85.240	9.5	190.796	62	294.862	122	342.509
.65	87.755	9.6	191.287	63	295.916	123	343.125
.70	90.106	9.8	192.256	64	296.955	124	343.736
.75	92.317	10.0	193.209	65	297.982	125	344.344
.80	94.403	10.5	195.524	66	298.997	126	344.949
.85	96.378	11.0	197.748	67	299.998	127	345.549
.90	98.256	11.5	199.890	68	300.989	128	346.146
.95	100.045	12.0	201.956	69	301.967	129	346.739
1.00	101.755	12.5	203.951	70	302.934	130	347.329
1.10	104.964	13.0	205.881	71	303.890	131	347.915
1.2	107.930	13.5	207.751	72	304.836	132	348.497
1.3	110.689	14.0	209.564	73	305.771	133	349.076
1.4	113.272	14.5	211.323	74	306.695	134	349.651
1.5	115.701	15.0	213.034	75	307.610	135	350.223
1.6	117.994	16.0	216.319	76	308.515	136	350.792
1.7	120.167	17	219.437	77	309.411	137	351.358
1.8	122.233	18	222.407	78	310.297	138	351.920
1.9	124.203	19	225.244	79	311.175	139	352.479
2.0	126.086	20	227.961	80	312.043	140	353.034
2.2	129.622	21	230.568	81	312.903	141	353.587
2.4	132.893	22	233.075	82	313.755	142	354.137
2.6	135.939	23	235.491	83	314.598	143	354.684
2.8	138.791	24	237.821	84	315.433	144	355.227
3.0	141.475	25	240.073	85	316.260	145	355.768
3.2	144.010	26	242.253	86	317.080	146	356.305
3.4	146.414	27	244.364	87	317.891	147	356.840
3.6	148.701	28	246.413	88	318.696	148	357.372
3.8	150.883	29	248.403	89	319.493	149	357.901
4.0	152.969	30	250.338	90	320.283	150	358.428
4.2	154.969	31	252.221	91	321.067	151	358.952
4.4	156.889	32	254.054	92	321.843	152	359.472
4.6	158.737	33	255.842	93	322.613	153	359.991
4.8	160.519	34	257.586	94	323.376	154	360.506
5.0	162.238	35	259.289	95	324.133	155	361.019
5.2	163.901	36	260.953	96	324.883	156	361.529

TABLE 5.—*Pressure of saturated water vapor*—Continued

lb/in.^{2}	°F	lb/in.^{2}	°F	lb/in.^{2}	°F	lb/in.^{2}	°F
157	362. 037	275	409. 436	650	494. 896	1500	596. 199
158	362. 542	280	411. 059	660	496. 572	1520	597. 967
159	363. 045	285	412. 659	670	498. 229	1540	599. 717
160	363. 545	290	414. 239	680	499. 868	1560	601. 449
161	364. 043	295	415. 797	690	501. 488	1580	603. 165
162	364. 538	300	417. 334	700	503. 090	1600	604. 863
163	365. 031	305	418. 853	710	504. 675	1620	606. 545
164	365. 522	310	420. 352	720	506. 243	1640	608. 211
165	366. 010	315	421. 832	730	507. 794	1660	609. 861
166	366. 496	320	423. 295	740	509. 330	1680	611. 496
167	366. 980	325	424. 739	750	510. 849	1700	613. 115
168	367. 461	330	426. 167	760	512. 353	1720	614. 720
169	367. 940	335	427. 578	770	513. 842	1740	616. 310
170	368. 417	340	428. 973	780	515. 317	1760	617. 886
171	368. 892	345	430. 352	790	516. 777	1780	619. 448
172	369. 364	350	431. 716	800	518. 223	1800	620. 996
173	369. 834	355	433. 065	810	519. 655	1820	622. 531
174	370. 303	360	434. 399	820	521. 074	1840	624. 053
175	370. 769	365	435. 719	830	522. 479	1860	625. 561
176	371. 233	370	437. 025	840	523. 872	1880	627. 057
177	371. 695	375	438. 317	850	525. 252	1900	628. 540
178	372. 155	380	439. 596	860	526. 620	1920	630. 011
179	372. 613	385	440. 863	870	527. 976	1940	631. 470
180	373. 069	390	442. 117	880	529. 320	1960	632. 917
181	373. 523	395	443. 359	890	530. 652	1980	634. 353
182	373. 975	400	444. 588	900	531. 973	2000	635. 776
183	374. 425	405	445. 806	910	533. 282	2050	639. 287
184	374. 873	410	447. 012	920	534. 581	2100	642. 730
185	375. 319	415	448. 207	930	535. 869	2150	646. 107
186	375. 764	420	449. 391	940	537. 147	2200	649. 422
187	376. 206	425	450. 564	950	538. 413	2250	652. 676
188	376. 647	430	451. 727	960	539. 670	2300	655. 871
189	377. 085	435	452. 879	970	540. 917	2350	659. 010
190	377. 522	440	454. 021	980	542. 154	2400	662. 094
191	377. 957	445	455. 153	990	543. 382	2450	665. 125
192	378. 391	450	456. 276	1000	544. 600	2500	668. 105
193	378. 822	455	457. 388	1020	547. 007	2550	671. 035
194	379. 252	460	458. 492	1040	549. 381	2600	673. 916
195	379. 680	465	459. 586	1060	551. 720	2650	676. 750
196	380. 107	470	460. 672	1080	554. 024	2700	679. 537
197	380. 532	475	461. 748	1100	556. 296	2750	682. 279
198	380. 955	480	462. 816	1120	558. 536	2800	684. 977
199	381. 376	485	463. 875	1140	560. 747	2850	687. 632
200	381. 796	490	464. 926	1160	562. 927	2900	690. 245
202	382. 630	495	465. 969	1180	565. 079	2950	692. 815
204	383. 458	500	467. 004	1200	567. 204	3000	695. 344
205	383. 870	510	469. 050	1220	569. 300	3050	697. 832
210	385. 906	520	471. 065	1240	571. 372	3100	700. 278
215	387. 903	530	473. 051	1260	573. 417	3150	702. 683
220	389. 865	540	475. 009	1280	575. 438	3200	705. 044
225	391. 793	550	476. 939	1300	577. 434		
230	393. 687	560	478. 842	1320	579. 407		
235	395. 549	570	480. 719	1340	581. 357		
240	397. 381	580	482. 571	1360	583. 285		
245	398. 184	590	484. 399	1380	585. 191		
250	400. 958	600	486. 203	1400	587. 076		
255	402. 704	610	487. 985	1420	588. 940		
260	404. 425	620	489. 744	1440	590. 784		
265	406. 119	630	491. 482	1460	592. 608		
270	407. 789	640	493. 199	1480	594. 413		

TABLE 6.—*Pressure of saturated water vapor*

Kilograms per square centimeter—Centigrade temperature

[Standard gravity, 980.665 cm/sec²]

kg/cm²	°C	kg/cm²	°C	kg/cm²	°C	kg/cm²	°C	kg/cm²	°C
------	------	1.00	99.087	9.0	174.529	45	256.227	110	316.580
0.0075	2.590	1.10	101.764	9.2	175.461	46	257.564	112	317.929
.0100	6.707	1.20	104.247	9.4	176.377	47	258.879	114	319.260
.0125	9.996	1.30	106.564	9.6	177.278	48	260.173	116	320.573
.0150	12.749	1.40	108.739	9.8	178.164	49	261.446	118	321.868
.0175	15.123	1.5	110.789	10.0	179.036	50	262.700	120	323.146
.0200	17.217	1.6	112.730	10.5	181.158	51	263.934	122	324.408
.0225	19.091	1.7	114.573	11.0	183.201	52	265.151	124	325.653
.0250	20.791	1.8	116.330	11.5	185.172	53	266.349	126	326.883
.0275	22.349	1.9	118.009	12.0	187.078	54	267.531	128	328.098
.030	23.788	2.0	119.617	12.5	188.922	55	268.695	130	329.298
.035	26.375	2.1	121.160	13.0	190.709	56	269.844	132	330.483
.040	28.658	2.2	122.645	13.5	192.443	57	270.977	134	331.654
.045	30.705	2.3	124.075	14.0	194.128	58	272.096	136	332.812
.050	32.562	2.4	125.456	14.5	195.766	59	273.199	138	333.956
.055	34.265	2.5	126.791	15.0	197.360	60	274.288	140	335.087
.060	35.839	2.6	128.082	15.5	198.914	61	275.364	142	336.205
.065	37.302	2.7	129.335	16.0	200.429	62	276.426	144	337.311
.070	38.672	2.8	130.550	16.5	201.907	63	277.475	146	338.404
.075	39.959	2.9	131.730	17.0	203.351	64	278.512	148	339.486
.080	41.174	3.0	132.878	17.5	204.763	65	279.535	150	340.556
.085	42.326	3.1	133.995	18.0	206.143	66	280.547	152	341.614
.090	43.420	3.2	135.083	18.5	207.494	67	281.549	154	342.661
.095	44.463	3.3	136.144	19.0	208.817	68	282.538	156	343.697
.100	45.460	3.4	137.180	19.5	210.113	69	283.516	158	344.723
.11	47.331	3.5	138.192	20.0	211.383	70	284.483	160	345.738
.12	49.062	3.6	139.180	20.5	212.629	71	285.440	162	346.742
.13	50.673	3.7	140.146	21.0	213.852	72	286.387	164	347.737
.14	52.181	3.8	141.091	21.5	215.053	73	287.323	166	348.721
.15	53.599	3.9	142.017	22.0	216.232	74	288.250	168	349.696
.16	54.939	4.0	142.923	22.5	217.390	75	289.167	170	350.661
.17	56.209	4.1	143.812	23.0	218.529	76	290.075	172	351.617
.18	57.416	4.2	144.684	23.5	219.649	77	290.974	174	352.563
.19	58.568	4.3	145.538	24.0	220.750	78	291.864	176	353.501
.20	59.669	4.4	146.377	24.5	221.834	79	292.745	178	354.429
.21	60.724	4.5	147.201	25.0	222.901	80	293.618	180	355.348
.22	61.738	4.6	148.010	25.5	223.951	81	294.483	182	356.259
.23	62.713	4.7	148.805	26.0	224.986	82	295.339	184	357.161
.24	63.652	4.8	149.587	26.5	226.006	83	296.187	186	358.055
.25	64.559	4.9	150.356	27.0	227.011	84	297.028	188	358.941
.26	65.435	5.0	151.112	27.5	228.001	85	297.861	190	359.818
.28	67.106	5.2	152.589	28.0	228.978	86	298.686	192	360.687
.30	68.678	5.4	154.021	28.5	229.942	87	299.504	194	361.548
.32	70.164	5.6	155.412	29.0	230.892	88	300.315	196	362.401
.34	71.573	5.8	156.763	29.5	231.830	89	301.119	198	363.247
.35	72.252	6.0	158.078	30	232.756	90	301.916	200	364.084
.36	72.914	6.2	159.358	31	234.573	91	302.706	202	364.914
.38	74.194	6.4	160.605	32	236.345	92	303.489	204	365.737
.40	75.418	6.6	161.822	33	238.075	93	304.266	206	366.552
.45	78.267	6.8	163.010	34	239.766	94	305.036	208	367.359
.50	80.860	7.0	164.171	35	241.419	95	305.801	210	368.159
.55	83.245	7.2	165.305	36	243.035	96	306.559	212	368.951
.60	85.454	7.4	166.415	37	244.618	97	307.311	214	369.737
.65	87.514	7.6	167.501	38	246.169	98	308.057	216	370.514
.70	89.446	7.8	168.565	39	247.688	99	308.797	218	371.285
.75	91.266	8.0	169.607	40	249.178	100	309.531	220	372.048
.80	92.988	8.2	170.629	41	250.640	102	310.983	222	372.803
.85	94.622	8.4	171.631	42	252.074	104	312.413	224	373.550
.90	96.178	8.6	172.615	43	253.483	106	313.822	225	373.920
.95	97.663	8.8	173.581	44	254.867	108	315.211	---	-------

TABLE 7.—*Conversion factors*

Definitive Values

1 standard atmosphere = 760 mm mercury column (density 13.5951 g/cm^3, gravity 980.665 cm/sec^2).
1 meter = 39.37 inches.
1 pound = 453.59243 grams.
1,000 calories = 1/860 international kilowatt hour (definition of International Steam Conference, London 1929).
1 international electrical watt = 1.0003 absolute watts (rounded experimental value as of 1934).
1 Btu = 252.00 cal (definition evolved by usage and based on relations between mass units and thermometric scales).

PRESSURE CONVERSION FACTORS

Atm		kg/cm^2		bar		mm Hg		lb/in.^{2}
1	=	1. 03323	=	1. 01325	=	760.	=	14. 6960
. 967841	=	1	=	. 980665	=	735. 559	=	14. 2234
. 986923	=	1. 01972	=	1	=	750. 062	=	14. 5038
1. 31579	=	1. 35951	=	1. 33322	=	1000	=	19. 3369
. 680457	=	. 703067	=	. 689473	=	517. 147	=	10

ENERGY CONVERSION FACTORS

Absolute joule	international electrical		Heat		Pressure×volume			
j	*int. j*	*int. whr*	*cal*	*Btu*	$\frac{\text{lb}}{\text{in.}^2}$–ft^3	$\frac{\text{kg}}{\text{cm}^2}$–m^3	atm–dm^3	ft–lb
10, 000 =	9, 997 =	2. 7769 =	2, 388. 2 =	9. 4770 =	51. 2195 =	0. 101972 =	98. 6923 =	7, 375. 61
10, 003 =	10, 000 =	2. 7778 =	2, 388. 9 =	9. 4799 =	51. 235 =	. 10200 =	98. 722 =	7, 377. 8
36, 011 =	36, 000 =	10 =	8, 600 =	34. 128 =	184. 45 =	. 36721 =	355. 40 =	26, 560
41, 873 =	41, 860 =	11. 628 =	10, 000 =	39. 683 =	214. 47 =	. 42699 =	413. 25 =	30, 884
10, 552 =	10, 549 =	2. 9302 =	2, 520. 0 =	10 =	54. 046 =	. 10760 =	104. 14 =	7, 782. 6
195, 238 =	195, 180 =	54. 217 =	46, 626 =	1, 850. 3 =	1, 000 =	1. 9909 =	1, 926. 85 =	144, 000
98, 066. 5 =	98, 037 =	27. 233 =	23, 420 =	92. 938 =	502. 292 =	1 =	967. 841 =	72, 330. 0
10, 132. 5 =	10, 129 =	2. 8137 =	2, 419. 8 =	9. 6026 =	51. 8982 =	. 103323 =	100 =	7, 473. 33
13, 558. 2 =	13, 554 =	3. 7650 =	3, 237. 9 =	12. 849 =	69. 4444 =	. 138255 =	133. 809 =	10, 000

TABLE 8.—(*Thermometric*) *Condensation temperature of steam*

[Star (*) indicates change in integer]

P	Pressure in mm mercury (standard)										P
	0	1	2	3	4	5	6	7	8	9	
	Temperature in degrees of international scale										
500	88.678	0.730	0.782	0.834	0.886	0.938	0.990	*0.042	*0.093	*0.144	500
510	89.196	.247	.298	.350	.401	.452	.502	.553	.604	.655	510
520	.705	.756	.806	.856	.907	.957	*.007	*.057	*.107	*.157	520
530	90.206	.256	.306	.355	.405	.454	.503	.553	.602	.651	530
540	.700	.749	.798	.846	.895	.944	.992	*.041	*.089	*.138	540
550	91.186	.234	.282	.330	.378	.426	.474	.521	.569	.617	550
560	.664	.712	.759	.806	.854	.901	.948	.995	*.042	*.089	560
570	92.136	.182	.229	.276	.322	.369	.415	.462	.508	.554	570
580	.600	.646	.692	.738	.784	.830	.876	.922	.967	*.013	580
590	93.058	.104	.149	.195	.240	.285	.330	.375	.420	.465	590
600	.5100	.5548	.5996	.6443	.6889	.7335	.7780	.8224	.8668	.9112	600
610	.9554	.9996	*.0438	*.0879	*.1319	*.1759	*.2198	*.2636	*.3074	*.3511	610
620	94.3948	.4384	.4820	.5255	.5689	.6123	.6556	.6989	.7421	.7852	620
630	.8283	.8713	.9143	.9572	*.0001	*.0429	*.0857	*.1284	*.1710	*.2136	630
640	95.2562	.2987	.3411	.3834	.4257	.4680	.5102	.5523	.5944	.6365	640
650	95.6785	.7204	.7623	.8041	.8459	.8876	.9293	.9709	*.0125	*.0539	650
660	96.0954	.1368	.1782	.2195	.2607	.3019	.3431	.3842	.4252	.4662	660
670	.5072	.5480	.5889	.6297	.6704	.7111	.7517	.7923	.8329	.8734	670
680	.9138	.9542	.9946	*.0349	*.0751	*.1153	*.1555	*.1956	*.2356	*.2756	680
690	97.3156	.3555	.3954	.4352	.4749	.5146	.5543	.5939	.6335	.6730	690
700	.7125	.7519	.7913	.8307	.8700	.9092	.9484	.9876	*.0267	*.0657	700
710	98.1048	.1437	.1827	.2216	.2604	.2992	.3379	.3766	.4153	.4539	710
720	.4925	.5310	.5695	.6079	.6463	.6846	.7229	.7612	.7994	.8376	720
730	.8757	.9138	.9519	.9899	*.0278	*.0657	*.1036	*.1414	*.1792	*.2170	730
740	99.2547	.2924	.3300	.3675	.4051	.4426	.4800	.5174	.5548	.5921	740
750	.6294	.6667	.7039	.7410	.7781	.8152	.8523	.8893	.9262	.9631	750
760	100.0000	.0368	.0736	.1104	.1471	.1838	.2204	.2570	.2936	.3301	760
770	.3666	.4030	.4394	.4758	.5121	.5484	.5846	.6208	.6570	.6932	770
780	.7293	.7653	.8013	.8373	.8733	.9092	.9450	.9808	*.0166	*.0524	780
790	101.0881	.1238	.1594	.1950	.2306	.2661	.3016	.3371	.3725	.4079	790
	0	1	2	3	4	5	6	7	8	9	

WASHINGTON, March 30, 1934.