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# THERMAL PROPERTIES OF SATURATED WATER AND STEAM

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ABSTRACT

The completion of new measurements of heat capacity and heat of vaporization of water in the range 0° to 100° C has contributed new data which affect the accepted values of the saturation properties of water and steam in the whole range up to the critical region. With these new data, it is now possible to compile the results of the entire series of measurements which have been carried out in this laboratory into a single table of smoothed values of the properties of saturated water and steam. The compilation presented supersedes the previous tabulations which have accompanied reports of the experimental measurements in this laboratory.

The properties of saturated steam and water included in the tables presented in this compilation are vapor pressure, specific volume, enthalpy, and entropy.

In the previous reports [1, 2, 3, 4][1], data obtained by calorimetric measurements have been given in several partial contributions, none of which has covered the entire range 0° to 374° C. It is the purpose of the present compilation to assemble these data into a thermodynamically consistent group, with the experimental irregularities smoothed out by the use of formulations. As far as possible, the formulas used, both empirical and theoretical, are indicated, and the experimental bases of the empirical formulas are also given. The units used are the same as those in the International Steam Tables [9].

It will be convenient to give the descriptions in two main parts, the first being for the range 0° to 100° C and the second from 100° to 374.15° C, since most of the reductions in the range 0° to 100° C have already been made in the report [4] on the experimental work, which is being published at this time. In that report an account is given of the measurements of the heat capacity and heat of vaporization of water, including the reduction of the data to give values of specific heat, enthalpy of both liquid and vapor, and specific volume of the vapor. The values in this range are taken directly from the report, making conversions to the units used in this tabulation.

[1] Figures in brackets indicate the literature references at the end of this paper.

From the theory [5] of calorimetry of a saturated fluid, the following relations are obtained, by which enthalpy, entropy, and specific volume are obtained from the calorimetric data.

$$H]_0^t=\alpha]_0^t+\beta]_0^t$$

$$H']_0^t=H]_0^t+L_t$$

$$\Phi]_0^t=\int_0^t\frac{1}{T}\frac{d\alpha dt}{dt}+\left[\frac{\beta}{T}\right]_0^t$$

$$\Phi']_0^t=\Phi]_0^t+\frac{L}{T}$$

$$\beta=uTdP/dt$$

$$\gamma=u'TdP/dt$$

In the above equations $H$ and $H'$ denote enthalpy; $\Phi$ and $\Phi'$ denote entropy; $u$ and $u'$ denote specific volume, in each case, respectively, of liquid and vapor; $L$ denotes heat of vaporization $(H'-H)$; $t$ is expressed in degrees centigrade, and $T$ in degrees Kelvin $(t+273.16\ ^\circ\text{C})$.

In order to calculate the values for entropy, $\Phi]_0^t$, from the relation given above, the empirical equation for $d\alpha/dt$ from the previous report [4] is used. This equation is

$$\frac{d\alpha}{dt}=4.1699+15.27t\ (10)^{-6}+0.0467\ (10)^{-0.036t},$$

where $d\alpha/dt$ is given in int.$j$/$g$-°$C$. After dividing the right member of this equation by $T$, the first two terms may be integrated directly in the evaluation of entropy. The third term could then have been integrated by numerical summation, but it was preferred to substitute for it a new empirical function which could be integrated directly. The integral $\{-1964.6\ (10)^{-(6+0.03755t)}\}$ of this new function was substituted for the term $\{0.0467\int_0^t\frac{1}{T}(10)^{-0.036t}\,dt\}$, and this was found to be equivalent to it well within the present requirements. By combining the calculated integrals of the three terms with the corresponding values of $\beta/T$, the values of $\Phi]_0^t$ were found for each of the 5° points from 0° to 100° $C$. By adding the corresponding values of $L/T$, the values of $\Phi']_0^t$ were found for the entropy of saturated vapor. These were converted to International Steam Table Calories per gram-degree centigrade for inclusion in table 2.

The values for specific volume of saturated liquid (0° to 100° C), given in table 2, were derived from the data of Chappuis [6], Thiessen [7], and Smith and Keyes [8], and are in agreement with the values adopted by the 1934 International Conference on Steam Tables [9].

The values of vapor pressure from 0° to 90° C, inclusive, given in table 2 were obtained by use of an unpublished formulation of the vapor-pressure data of the Reichsanstalt as reformulated by Harold T. Gerry and used by the International Steam Table Conference [9]

as a basis for definitive values. Dr. Gerry has very kindly given permission to quote the empirical equation

$$\log_{10}P = -3.142305\left\{\frac{10^3}{T}-\frac{10^3}{373.16}\right\}+8.2\log_{10}\left(\frac{373.16}{T}\right) -0.0024804(373.16-T)$$

in which $P$ is in standard atmospheres and $T$ is in degrees Kelvin. These values of $P$ were converted into kilograms per square centimeter by using the factor 1.033228.

For the remaining portion of the table, 100° to 374.15° C, part of the calorimetric data from previous reports has been reformulated in order to make allowance for the small changes in values below 100° C shown by the latest results.

The enthalpy of saturated liquid was calculated, using the new formula for the $\alpha$ function in the range 100° to 374.15° C, as follows:

$$\alpha]_0^t = 0.48558+4.17144t-\{0.6058(t-130)^{3.1}-0.01812(t-200)^{3.64}\}10^{-6}$$

This equation gives values of $\alpha$ in international joules per gram. The values merge smoothly with the later more accurate experimental values, immediately below 100° C and are considered to be a good representation of the calorimetric data.

The values of the specific volume of saturated liquid, $u$, given in table 2, and used for computation of $\beta$ from 100° to 325 °C, were obtained from the results of Smith and Keyes [8]. From 330 to 374.15° C, the values of $\beta$ and corresponding values of $u$ were obtained from the calorimetric data of the previous report [3]. The values of $P$ and $dP/dt$ in the range 95° to 374.15° C are from the formula of Osborne and Meyers [10], based on recent measurements.

The values of $\gamma$ in the range 100° to 190° C were obtained by computation, using the formula given in a recent report [2]

$$\gamma = 2500.5-2.3233\ t-10^x,$$

where $x=5.1463-1540/T$, $t$ is in degrees centigrade, $T$ in degrees Kelvin, and $\gamma$ in international joules per gram. This formula represents an adjusted appraisal of all the measurements of heat of vaporization made in this laboratory in the range 0° to 220° C and merges smoothly with the values of $\gamma$ above 170° C, as deduced from formulations in a previous report [3]. From 195° to 374.15° C, inclusive, the values of L are directly obtained from the formulation of $L$ in the previous report [3]. Corresponding values of $\gamma$ in this range are in accord with the preferred values of $\beta$, as specified above.

The values of specific volume of saturated liquid, $u$, and of saturated vapor, $u'$, are consistent with values of $\beta$ and $\gamma$ through the thermodynamic relation, using the Clapeyron factor, $TdP/dt$.

For obtaining entropy in the range 100° to 374.15° C, use was made of the empirical formula for $\alpha$ given above and expressed in the differential form

$$\frac{d\alpha}{dt} = 4.1744-\{1.878(t-130)^{2.1}-0.066(t-200)^{2.64}\}10^{-6}.$$

For convenience in integrating the function $\frac{d\alpha}{Tdt}$, this function was

formulated, using values from the $d\alpha/dt$ equation to obtain a new explicit function of temperature of the form

$$\frac{d\alpha}{Tdt}=\frac{4.1744}{T}+10^{-7}\{-0.0607(t-130)^2+0.0105(t-200)^{2.29}\},$$

which, by integration, becomes

$$\int_{t_1}^{t}\frac{d\alpha}{Tdt}dt=9.605095\log_{10}\frac{T}{T_1}$$
$$+10^{-7}\left[-0.020233(t-130)^3+0.003192(t-200)^{3.29}\right]_{t_1}^{t}$$

In this equation, however, values of $(t-130)^3$ are to be used only above 130° C. By using the calculated values of this integral, the value of entropy at 100° C as the constant of integration, and values of $\beta/T$, the values of $\Phi]'_0$, entropy of saturated liquid at the temperature $t$, are determined. Values of $\Phi']'_0$, entropy of saturated vapor, are determined by the addition of $L/T$.

Tables 1 and 2 contain the numerical values obtained as described in the foregoing text. For conversion from international joules per gram to International Steam Table Calories per gram, the factor 1 int. j/g=0.238891 IT Cal/g has been used.

It may appear that the compilation of these properties of saturated water and steam as described here is quite a patchwork. Simplicity, rationality, or orderliness of formulas have as yet eluded the inspiration of this group and its colleagues. However much care has been taken to insure that the tabulated values are smooth functions of temperature and that the different groups of NBS calorimetric data have been fairly interpreted to give a consistent and congruent compilation, which now supersedes earlier ones issued from this laboratory

[1.] N. S. Osborne, H. F. Stimson, and E. F. Fiock, *A calorimetric determination of thermal properties of saturated water and steam from 0° to 270° C.* BS J. Research **5,** 411 (1930) RP209.

[2.] E. F. Fiock and D. C. Ginnings, *Heat of vaporization of water at 50°, 70°, and 90°C.* BS J. Research **8,** 321 (1932) RP416.

[3] N. S. Osborne, H. F. Stimson, and D. C. Ginnings, *Calorimetric determination of the thermodynamic properties of saturated water in both the liquid and gaseous states from 100° to 374° C.* J. Research NBS **18,** 389 (1937) RP983.

[4] N. S. Osborne, H. F. Stimson, and D. C. Ginnings. *Measurements of heat capacity and heat of vaporization of water in the range 0° to 100°C.* J. Research NBS **23,** 197 (1939) RP1228.

[5] Nathan S. Osborne. *Calorimetry of a fluid.* BS J. Research **4,** 609 (1930) RP168.

[6] M. P. Chappuis, *Dilatation de l'eau. Travaux et Mémoires du Bureau International des Poids et Mesures* **13,** (1907).

[7] M. Thiesen, *Bestimmung der Ausdehnung des Wassers für Temperaturen zwischen 50° und 100°.* Wiss. Abhandl. physik.-tech. Reichsanstalt **4,** 1 (1904).

[8] Leighton B. Smith and Frederick G. Keyes, *The volumes of unit mass of liquid water and their correlation as a function of pressure and temperature.* Proc. Am. Acad. Arts Sci. **69,** 285 (1934).

[9] *The Third International Conference on Steam Tables.* Mech. Eng. **57,** 710 (1935).

[10] Nathan S. Osborne and Cyril H. Meyers, *A formula and tables for the pressure of saturated water vapor in the range 0° to 374°C.* J. Research NBS **13,** 1 (1934) RP691.

TABLE 1.—*Formulated data on saturated steam*

| Temperature | $\alpha]_0^t$ | $\beta$ | $\gamma$ | $H]_0^t$ | $H']_0^t$ | $L$ | $T\frac{dP}{dT}$ |
|---|---|---|---|---|---|---|---|
| °C | Int. j/g | Int. j/g | Int. j/g | Int. j/g | Int. j/g | Int. j/g | Int. j/cm³ |
| 100 | 417. 63 | 1. 41 | 2257. 71 | 419. 03 | 2675. 33 | 2256. 30 | 1. 3495 |
| 105 | 438. 49 | 1. 66 | 2244. 70 | 440. 13 | 2683. 17 | 2243. 04 | 1. 5815 |
| 110 | 459. 34 | 1. 94 | 2231. 54 | 461. 27 | 2690. 87 | 2229. 60 | 1. 8441 |
| 115 | 480. 20 | 2. 26 | 2218. 22 | 482. 45 | 2698. 41 | 2215. 96 | 2. 1402 |
| 120 | 501. 06 | 2. 62 | 2204. 75 | 503. 67 | 2705. 80 | 2202. 13 | 2. 4725 |
| 125 | 521. 92 | 3. 03 | 2191. 10 | 524. 93 | 2713. 00 | 2188. 07 | 2. 8440 |
| 130 | 542. 77 | 3. 48 | 2177. 26 | 546. 25 | 2720. 02 | 2173. 78 | 3. 2578 |
| 135 | 563. 63 | 3. 99 | 2163. 24 | 567. 61 | 2726. 86 | 2159. 25 | 3. 7170 |
| 140 | 584. 49 | 4. 56 | 2149. 00 | 589. 04 | 2733. 47 | 2144. 44 | 4. 2248 |
| 145 | 605. 34 | 5. 19 | 2134. 55 | 610. 52 | 2739. 88 | 2129. 36 | 4. 7847 |
| 150 | 626. 20 | 5. 89 | 2119. 87 | 632. 07 | 2746. 05 | 2113. 98 | 5. 3999 |
| 155 | 647. 05 | 6. 66 | 2104. 95 | 653. 69 | 2751. 98 | 2098. 29 | 6. 0740 |
| 160 | 667. 89 | 7. 51 | 2089. 78 | 675. 39 | 2757. 66 | 2082. 27 | 6. 8105 |
| 165 | 688. 74 | 8. 44 | 2074. 34 | 697. 16 | 2763. 06 | 2065. 90 | 7. 6129 |
| 170 | 709. 57 | 9. 46 | 2058. 63 | 719. 02 | 2768. 19 | 2049. 17 | 8. 4850 |
| 175 | 730. 41 | 10. 57 | 2042. 63 | 740. 96 | 2773. 02 | 2032. 06 | 9. 4305 |
| 180 | 751. 23 | 11. 79 | 2026. 34 | 763. 01 | 2777. 55 | 2014. 55 | 10. 453 |
| 185 | 772. 05 | 13. 11 | 2009. 73 | 785. 15 | 2781. 77 | 1996. 63 | 11. 557 |
| 190 | 792. 86 | 14. 55 | 1992. 80 | 807. 40 | 2785. 65 | 1978. 25 | 12. 745 |
| 195 | 813. 66 | 16. 11 | 1975. 53 | 829. 76 | 2789. 21 | 1959. 42 | 14. 023 |
| 200 | 834. 46 | 17. 80 | 1957. 88 | 852. 25 | 2792. 32 | 1940. 08 | 15. 393 |
| 205 | 855. 24 | 19. 63 | 1939. 85 | 874. 86 | 2795. 08 | 1920. 22 | 16. 860 |
| 210 | 876. 01 | 21. 61 | 1921. 45 | 897. 60 | 2797. 45 | 1899. 84 | 18. 429 |
| 215 | 896. 77 | 23. 74 | 1902. 65 | 920. 50 | 2799. 40 | 1878. 91 | 20. 102 |
| 220 | 917. 51 | 26. 04 | 1883. 45 | 943. 54 | 2800. 95 | 1857. 41 | 21. 885 |

TABLE 1.—*Formulated data on saturated steam*—Continued

| Temperature | $a]_0^t$ | $\beta$ | $\gamma$ | $H]_0^t$ | $H']_0^t$ | $L$ | $T\frac{dP}{dT}$ |
|---|---|---|---|---|---|---|---|
| °C | Int. j/g | Int. j/g | Int. j/g | Int. j/g | Int. j/g | Int. j/g | Int. j/cm³ |
| 225 | 938. 24 | 28. 52 | 1863. 82 | 966. 75 | 2802. 05 | 1835. 30 | 23. 782 |
| 230 | 958. 96 | 31. 18 | 1843. 76 | 990. 13 | 2802. 71 | 1812. 58 | 25. 797 |
| 235 | 979. 66 | 34. 04 | 1823. 24 | 1013. 70 | 2802. 89 | 1789. 20 | 27. 935 |
| 240 | 1000. 35 | 37. 12 | 1802. 24 | 1037. 46 | 2802. 58 | 1765. 12 | 30. 201 |
| 245 | 1021. 03 | 40. 42 | 1780. 75 | 1061. 43 | 2801. 76 | 1740. 33 | 32. 599 |
| 250 | 1041. 68 | 43. 96 | 1758. 73 | 1085. 63 | 2800. 40 | 1714. 77 | 35. 136 |
| 255 | 1062. 32 | 47. 76 | 1736. 16 | 1110. 08 | 2798. 47 | 1688. 40 | 37. 815 |
| 260 | 1082. 95 | 51. 84 | 1713. 01 | 1134. 78 | 2795 95 | 1661. 17 | 40. 642 |
| 265 | 1103. 55 | 56. 21 | 1689. 24 | 1159. 76 | 2792. 78 | 1633. 03 | 43. 624 |
| 270 | 1124. 14 | 60. 90 | 1664. 81 | 1185. 04 | 2788. 94 | 1603. 91 | 46. 765 |
| 275 | 1144. 72 | 65. 94 | 1639. 68 | 1210. 64 | 2784. 38 | 1573. 75 | 50. 074 |
| 280 | 1165. 27 | 71. 34 | 1613. 81 | 1236. 60 | 2779. 07 | 1542. 47 | 53. 556 |
| 285 | 1185. 80 | 77. 15 | 1587. 12 | 1262. 94 | 2772. 91 | 1509. 97 | 57. 219 |
| 290 | 1206. 32 | 83. 39 | 1559. 55 | 1289. 70 | 2765. 85 | 1476. 16 | 61. 071 |
| 295 | 1226. 81 | 90. 12 | 1531. 03 | 1316. 92 | 2757. 83 | 1440. 91 | 65. 120 |
| 300 | 1247. 29 | 97. 37 | 1501. 45 | 1344. 65 | 2748. 73 | 1404. 08 | 69. 375 |
| 305 | 1267. 75 | 105. 21 | 1470. 70 | 1372. 94 | 2738. 43 | 1365. 49 | 73. 846 |
| 310 | 1288. 18 | 113. 69 | 1438. 60 | 1401. 86 | 2726. 77 | 1324. 91 | 78. 545 |
| 315 | 1308. 60 | 122. 91 | 1405. 08 | 1431. 49 | 2713. 67 | 1282. 18 | 83. 484 |
| 320 | 1329. 00 | 132. 94 | 1370. 18 | 1461. 93 | 2699. 16 | 1237. 24 | 88. 677 |
| 325 | 1349. 37 | 143. 93 | 1333. 67 | 1493. 29 | 2683. 03 | 1189. 74 | 94. 14 |
| 330 | 1369. 73 | 156. 00 | 1295. 29 | 1525. 71 | 2665. 00 | 1139. 29 | 99. 89 |
| 335 | 1390. 06 | 169. 39 | 1254. 67 | 1559. 44 | 2644. 72 | 1085. 28 | 105. 96 |
| 340 | 1410. 37 | 184. 22 | 1211. 22 | 1594. 58 | 2621. 58 | 1027. 00 | 112. 37 |
| 345 | 1430. 67 | 200. 89 | 1164. 27 | 1631. 54 | 2594. 92 | 963. 38 | 119. 16 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 350 | 1450. 94 | 219. 99 | 1112. 84 | 1670. 92 | 2563. 77 | 892. 85 | 126. 38 |
| 355 | 1471. 19 | 242. 41 | 1055. 39 | 1713. 59 | 2526. 57 | 812. 98 | 134. 12 |
| 360 | 1491. 42 | 269. 81 | 989. 23 | 1761. 22 | 2480. 64 | 719. 42 | 142. 47 |
| 365 | 1511. 63 | 305. 62 | 908. 87 | 1817. 24 | 2420. 49 | 603. 25 | 151. 62 |
| 366 | 1515. 67 | 314. 42 | 890. 12 | 1830. 08 | 2405. 78 | 575. 70 | 153. 57 |
| 367 | 1519. 70 | 324. 04 | 870. 08 | 1843. 73 | 2389. 77 | 546. 04 | 155. 56 |
| 368 | 1523. 74 | 334. 66 | 848. 46 | 1858. 39 | 2372. 19 | 513. 80 | 157. 61 |
| 369 | 1527. 78 | 346. 58 | 824. 82 | 1874. 35 | 2352. 59 | 478. 24 | 159. 73 |
| 370 | 1531. 81 | 360. 24 | 798. 54 | 1892. 04 | 2330. 34 | 438. 30 | 161. 91 |
| 371 | 1535. 85 | 376. 40 | 768. 50 | 1912. 24 | 2304. 34 | 392. 10 | 164. 18 |
| 372 | 1539. 88 | 396. 59 | 732. 63 | 1936. 46 | 2272. 50 | 336. 04 | 166. 57 |
| 373 | 1543. 92 | 424. 66 | 685. 64 | 1968. 57 | 2229. 55 | 260. 98 | 169. 16 |
| 374 | 1547. 95 | 483. 49 | 598. 10 | 2031. 43 | 2146. 04 | 114. 61 | 172. 5 |
| 374.15 | 1548. 55 | 535. 1 | 535. 1 | 2083. 6 | 2083. 6 | 0. 00 | 173. 1 |

TABLE 2.—*Properties of saturated steam*

| Temperature (° C) | Vapor pressure | Enthalpy | | | Specific volume | | Entropy | | Temperature |
|---|---|---|---|---|---|---|---|---|---|
| | | Liquid | Vaporization | Vapor | Liquid | Vapor | Liquid | Vapor | |
| | *kg/cm²* | *IT Cal/g* | *IT Cal/g* | *IT Cal/g* | *cm³/g* | *cm³/g* | *IT Cal/g-°C* | *IT Cal/g-°C* | *° C* |
| 0 | 0. 006228 | 0. 000 | 597. 3 | 597. 3 | 1. 00021 | 206288 | 0. 0000 | 2. 1865 | 0 |
| 5 | . 008891 | 5. 028 | 594. 5 | 599. 5 | 1. 00008 | 147150 | . 0182 | 2. 1554 | 5 |
| 10 | . 012513 | 10. 040 | 591. 7 | 601. 7 | 1. 00035 | 106422 | . 0361 | 2. 1256 | 10 |
| 15 | . 017377 | 15. 043 | 588. 9 | 603. 9 | 1. 00095 | 77973 | . 0536 | 2. 0972 | 15 |
| 20 | . 023829 | 20. 040 | 586. 0 | 606. 1 | 1. 00184 | 57836 | . 0708 | 2. 0699 | 20 |
| 25 | . 032287 | 25. 033 | 583. 2 | 608. 3 | 1. 00301 | 43401 | . 0877 | 2. 0438 | 25 |
| 30 | . 043254 | 30. 024 | 580. 4 | 610. 4 | 1. 00442 | 32929 | . 1043 | 2. 0188 | 30 |
| 35 | . 057326 | 35. 015 | 577. 6 | 612. 6 | 1. 00605 | 25245 | . 1206 | 1. 9948 | 35 |
| 40 | . 075204 | 40. 006 | 574. 7 | 614. 7 | 1. 00789 | 19546 | . 1367 | 1. 9719 | 40 |
| 45 | . 097707 | 44. 997 | 571. 8 | 616. 8 | 1. 00993 | 15275 | . 1525 | 1. 9499 | 45 |
| 50 | . 12578 | 49. 990 | 569. 0 | 619. 0 | 1. 0121 | 12045 | . 1681 | 1. 9287 | 50 |
| 55 | . 16050 | 54. 984 | 566. 1 | 621. 1 | 1. 0145 | 9578 | . 1834 | 1. 9084 | 55 |
| 60 | . 20312 | 59. 981 | 563. 2 | 623. 2 | 1. 0171 | 7677. 6 | . 1985 | 1. 8889 | 60 |
| 65 | . 25501 | 64. 981 | 560. 2 | 625. 2 | 1. 0199 | 6201. 4 | . 2134 | 1. 8701 | 65 |
| 70 | . 31775 | 69. 984 | 557. 3 | 627. 3 | 1. 0228 | 5045. 3 | . 2281 | 1. 8521 | 70 |
| 75 | . 39307 | 74. 991 | 554. 3 | 629. 3 | 1. 0258 | 4133. 2 | . 2426 | 1. 8347 | 75 |
| 80 | . 48292 | 80. 002 | 551. 3 | 631. 3 | 1. 0290 | 3408. 3 | . 2568 | 1. 8180 | 80 |
| 85 | . 58943 | 85. 018 | 548. 3 | 633. 3 | 1. 0324 | 2828. 2 | . 2709 | 1. 8018 | 85 |
| 90 | . 71491 | 90. 039 | 545. 2 | 635. 3 | 1. 0359 | 2360. 9 | . 2848 | 1. 7862 | 90 |
| 95 | . 86192 | 95. 067 | 542. 1 | 637. 2 | 1. 0396 | 1982. 1 | . 2986 | 1. 7712 | 95 |
| 100 | 1. 03323 | 100. 102 | 539. 0 | 639. 1 | 1. 0435 | 1673. 0 | . 3122 | 1. 7566 | 100 |
| 105 | 1. 2318 | 105. 14 | 535. 8 | 641. 0 | 1. 0474 | 1419. 4 | . 3256 | 1. 7426 | 105 |
| 110 | 1. 4609 | 110. 19 | 532. 6 | 642. 8 | 1. 0515 | 1210. 1 | . 3388 | 1. 7289 | 110 |
| 115 | 1. 7239 | 115. 25 | 529. 4 | 644. 6 | 1. 0558 | 1036. 5 | . 3519 | 1. 7157 | 115 |
| 120 | 2. 0245 | 120. 32 | 526. 1 | 646. 4 | 1. 0603 | 891. 71 | . 3649 | 1. 7029 | 120 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 125 | 2. 3666 | 125. 40 | 522. 7 | 648. 1 | 1. 0649 | 770. 43 | . 3777 | 1. 6905 | 125 |
| 130 | 2. 7544 | 130. 49 | 519. 3 | 649. 8 | 1. 0697 | 668. 32 | . 3904 | 1. 6784 | 130 |
| 135 | 3. 1923 | 135. 60 | 515. 8 | 651. 4 | 1. 0747 | 582. 00 | . 4029 | 1. 6667 | 135 |
| 140 | 3. 6848 | 140. 72 | 512. 3 | 653. 0 | 1. 0798 | 508. 66 | . 4154 | 1. 6553 | 140 |
| 145 | 4. 2369 | 145. 85 | 508. 7 | 654. 5 | 1. 0851 | 446. 12 | . 4277 | 1. 6442 | 145 |
| 150 | 4. 8535 | 151. 00 | 505. 0 | 656. 0 | 1. 0906 | 392. 57 | . 4399 | 1. 6333 | 150 |
| 155 | 5. 5402 | 156. 16 | 501. 3 | 657. 4 | 1. 0962 | 346. 55 | . 4520 | 1. 6227 | 155 |
| 160 | 6. 3023 | 161. 34 | 497. 4 | 658. 8 | 1. 1021 | 306. 85 | . 4640 | 1. 6124 | 160 |
| 165 | 7. 1457 | 166. 55 | 493. 5 | 660. 1 | 1. 1081 | 272. 48 | . 4759 | 1. 6022 | 165 |
| 170 | 8. 0764 | 171. 77 | 489. 5 | 661. 3 | 1. 1144 | 242. 62 | . 4877 | 1. 5923 | 170 |
| 175 | 9. 1006 | 177. 01 | 485. 4 | 662. 4 | 1. 1208 | 216. 60 | . 4994 | 1. 5825 | 175 |
| 180 | 10. 225 | 182. 28 | 481. 3 | 663. 5 | 1. 1275 | 193. 85 | . 5110 | 1. 5730 | 180 |
| 185 | 11. 456 | 187. 57 | 477. 0 | 664. 5 | 1. 1344 | 173. 90 | . 5225 | 1. 5636 | 185 |
| 190 | 12. 800 | 192. 88 | 472. 6 | 665. 5 | 1. 1415 | 156. 35 | . 5340 | 1. 5543 | 190 |
| 195 | 14. 265 | 198. 23 | 468. 1 | 666. 3 | 1. 1489 | 140. 88 | . 5454 | 1. 5452 | 195 |
| 200 | 15. 857 | 203. 59 | 463. 5 | 667. 1 | 1. 1565 | 127. 19 | . 5567 | 1. 5362 | 200 |
| 205 | 17. 585 | 209. 00 | 458. 7 | 667. 7 | 1. 1644 | 115. 05 | . 5679 | 1. 5273 | 205 |
| 210 | 19. 456 | 214. 43 | 453. 9 | 668. 3 | 1. 1726 | 104. 265 | . 5791 | 1. 5185 | 210 |
| 215 | 21. 478 | 219. 90 | 448. 9 | 668. 8 | 1. 1812 | 94. 650 | . 5903 | 1. 5098 | 215 |
| 220 | 23. 659 | 225. 40 | 443. 7 | 669. 1 | 1. 1900 | 86. 062 | . 6014 | 1. 5011 | 220 |
| 225 | 26. 007 | 230. 95 | 438. 4 | 669. 4 | 1. 1992 | 78. 372 | . 6124 | 1. 4925 | 225 |
| 230 | 28. 531 | 236. 53 | 433. 0 | 669. 5 | 1. 2087 | 71. 472 | . 6234 | 1. 4840 | 230 |
| 235 | 31. 239 | 242. 16 | 427. 4 | 669. 6 | 1. 2187 | 65. 267 | . 6344 | 1. 4756 | 235 |
| 240 | 34. 140 | 247. 84 | 421. 7 | 669. 5 | 1. 2291 | 59. 674 | . 6454 | 1. 4671 | 240 |
| 245 | 37. 244 | 253. 57 | 415. 8 | 669. 3 | 1. 2399 | 54. 625 | . 6563 | 1. 4587 | 245 |
| 250 | 40. 560 | 259. 35 | 409. 6 | 669. 0 | 1. 2512 | 50. 056 | . 6672 | 1. 4503 | 250 |
| 255 | 44. 097 | 265. 19 | 403. 3 | 668. 5 | 1. 2631 | 45. 912 | . 6782 | 1. 4418 | 255 |
| 260 | 47. 866 | 271. 09 | 396. 8 | 667. 9 | 1. 2755 | 42. 149 | . 6891 | 1. 4334 | 260 |
| 265 | 51. 875 | 277. 06 | 390. 1 | 667. 2 | 1. 2886 | 38. 723 | . 7000 | 1. 4249 | 265 |
| 270 | 56. 137 | 283. 09 | 383. 2 | 666. 3 | 1. 3023 | 35. 599 | . 7109 | 1. 4163 | 270 |
| 275 | 60. 660 | 289. 21 | 376. 0 | 665. 2 | 1. 3168 | 32. 745 | . 7219 | 1. 4077 | 275 |
| 280 | 65. 457 | 295. 41 | 368. 5 | 663. 9 | 1. 3321 | 30. 133 | . 7328 | 1. 3990 | 280 |
| 285 | 70. 539 | 301. 70 | 360. 7 | 662. 4 | 1. 3483 | 27. 738 | . 7439 | 1. 3902 | 285 |
| 290 | 75. 917 | 308. 10 | 352. 6 | 660. 7 | 1. 3655 | 25 537 | . 7550 | 1. 3812 | 290 |
| 295 | 81. 603 | 314. 60 | 344. 2 | 658. 8 | 1. 3839 | 23. 511 | . 7662 | 1. 3720 | 295 |

TABLE 2.—*Properties of saturated steam*—Continued

| Temperature | Vapor pressure | Enthalpy | | | Specific volume | | Entropy | | Temperature |
|---|---|---|---|---|---|---|---|---|---|
| | | Liquid | Vaporization | Vapor | Liquid | Vapor | Liquid | Vapor | |
| °C | kg/cm² | ITCal/g | ITCal/g | ITCal/g | cm³/g | cm³/g | ITCal/g-°C | ITCal/g-°C | °C |
| 300 | 87. 611 | 321. 22 | 335. 4 | 656. 6 | 1. 4036 | 21. 643 | 0. 7774 | 1. 3626 | 300 |
| 305 | 93. 952 | 327. 98 | 326. 2 | 654. 2 | 1. 4247 | 19. 916 | . 7888 | 1. 3530 | 305 |
| 310 | 100. 64 | 334. 89 | 316. 5 | 651. 4 | 1. 4475 | 18. 316 | . 8003 | 1. 3431 | 310 |
| 315 | 107. 69 | 341. 97 | 306. 3 | 648. 3 | 1. 4722 | 16. 831 | . 8120 | 1. 3328 | 315 |
| 320 | 115. 12 | 349. 24 | 295. 6 | 644. 8 | 1. 4992 | 15. 451 | . 8239 | 1. 3221 | 320 |
| 325 | 122. 95 | 356. 73 | 284. 2 | 641. 0 | 1. 5289 | 14. 167 | . 8360 | 1. 3111 | 325 |
| 330 | 131. 18 | 364. 48 | 272. 2 | 636. 6 | 1. 562 | 12. 967 | . 8484 | 1. 2996 | 330 |
| 335 | 139. 85 | 372. 54 | 259. 3 | 631. 8 | 1. 599 | 11. 841 | . 8612 | 1. 2875 | 335 |
| 340 | 148. 96 | 380. 93 | 245. 3 | 626. 3 | 1. 639 | 10. 779 | . 8743 | 1. 2745 | 340 |
| 345 | 158. 54 | 389. 76 | 230. 1 | 619. 9 | 1. 686 | 9. 771 | . 8881 | 1. 2604 | 345 |
| 350 | 168. 63 | 399. 17 | 213. 3 | 612. 5 | 1. 741 | 8. 805 | . 9025 | 1. 2448 | 350 |
| 355 | 179. 24 | 409. 36 | 194. 2 | 603. 6 | 1. 807 | 7. 869 | . 9181 | 1. 2273 | 355 |
| 360 | 190. 42 | 420. 74 | 171. 9 | 592. 6 | 1. 894 | 6. 943 | . 9354 | 1. 2069 | 360 |
| 365 | 202. 21 | 434. 12 | 144. 1 | 578. 2 | 2. 016 | 5. 995 | . 9556 | 1. 1814 | 365 |
| 366 | 204. 64 | 437. 19 | 137. 5 | 574. 7 | 2. 048 | 5. 796 | . 9602 | 1. 1754 | 366 |
| 367 | 207. 11 | 440. 45 | 130. 4 | 570. 9 | 2. 083 | 5. 593 | . 9652 | 1. 1689 | 367 |
| 368 | 209. 60 | 443. 95 | 122. 7 | 566. 7 | 2. 123 | 5. 383 | . 9704 | 1. 1619 | 368 |
| 369 | 212. 12 | 447. 77 | 114. 2 | 562. 0 | 2. 170 | 5. 164 | . 9762 | 1. 1541 | 369 |
| 370 | 214. 68 | 452. 0 | 104. 7 | 556. 7 | 2. 225 | 4. 932 | . 9825 | 1. 1453 | 370 |
| 371 | 217. 26 | 456. 8 | 93. 7 | 550. 5 | 2. 293 | 4. 681 | . 9898 | 1. 1352 | 371 |
| 372 | 219. 88 | 462. 6 | 80. 3 | 542. 9 | 2. 38 | 4. 40 | . 9986 | 1. 1230 | 372 |
| 373 | 222. 53 | 470. 3 | 62. 4 | 532. 6 | 2. 51 | 4. 05 | 1. 0102 | 1. 1067 | 373 |
| 374 | 225. 22 | 485. 3 | 27. 4 | 512. 7 | 2. 80 | 3. 47 | 1. 0332 | 1. 0755 | 374 |
| 374.15 | 225. 65 | 498. | 0. 0 | 498. | 3. 1 | 3. 1 | 1. 0524 | 1. 0524 | 374. 15 |

WASHINGTON, April 28, 1939.