

**UNIVERSITY OF BOLTON**  
**SCHOOL OF BUILT ENVIRONMENT &**  
**ENGINEERING**  
**BENG (HONS) MECHANICAL ENGINEERING**  
**SEMESTER 2 EXAMINATIONS 2009/2010**  
**ENGINEERING SYSTEMS 2**  
**MODULE NO: DMT2027**

Date: Tuesday, 1 June 2010

Time: 2.00 – 4.00 p.m.

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**INSTRUCTIONS TO CANDIDATES:**

There are SIX questions

Answer ANY FOUR questions

All questions carry equal marks

**CANDIDATES REQUIRE :**

Thermodynamic properties of fluids provided

Take density of water =  $1000 \text{ kg/m}^3$

Formula sheet provided

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- Q1 a) Oil of density  $860 \text{ kg/m}^3$  flows up a vertical pipe section of diameter 225mm. A manometer filled with fluid of density  $1075 \text{ kg/m}^3$  is used to measure the pressure drop across an orifice plate with a throat diameter of 75mm, as shown in Fig. Q1a.

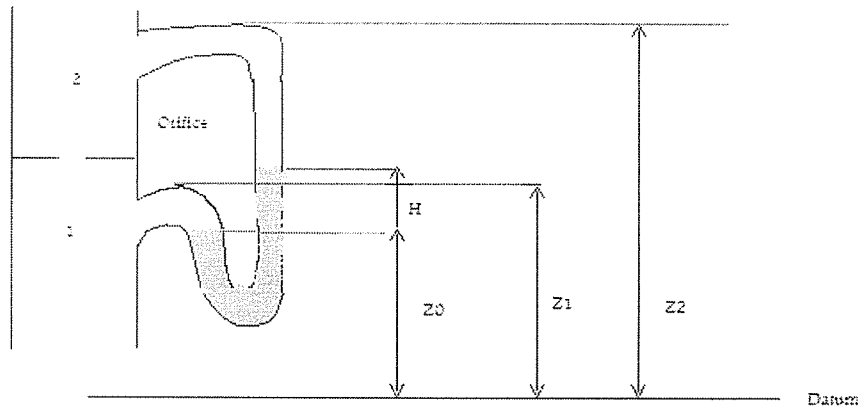


Fig. Q1a

Determine the flow rate of oil if the deflection of the manometer fluid is 0.5m of oil. Assume a discharge coefficient of 0.659 for the orifice.  
 (10 marks)

- b) Describe, with the aid of a diagram :
- (i) The arrangement of a venturi meter and explain its mode of action. (8 marks)
  - (ii) The construction and operation of a pitot static tube. (7 marks)

**Total 25 marks**

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- Q2 a) A pipeline is 15cm in diameter and is at an elevation of 100m at section A. At section B it is at an elevation of 107m and has a diameter of 30cm. When a discharge of 50  $\ell/s$  of water is passed through this pipe the pressure at Section A is observed to be 30 kPa and the energy loss in the pipe is 2m of water. Draw the system diagram and calculate the pressure at B when the flow is from A to B. (13 marks)
- b) A pipe bend has a cross-sectional area of  $0.01\text{m}^2$  at inlet and  $0.0025\text{m}^2$  at outlet. It bends  $90^\circ$  from its direction. The velocity of flow of water is 4m/s at inlet with a pressure of 100 kPa gauge. Draw the diagram and calculate the force acting parallel and perpendicular to the initial direction.

Take density of water =  $998\text{ kg/m}^3$  (12 marks)

**Total 25 marks**

- Q3 a) A piston-cylinder arrangement initially contains water at pressure 2MPa and temperature  $300^\circ\text{C}$ . During the piston movement, there is heat transfer to the water in such a way that the pressure in the cylinder remains constant.
- (i) Sketch the process on a p-v diagram indicating the relative position of the saturation curve. (2 marks)
- (ii) Find the work done per kilogram of water during the expansion. (5 marks)
- (iii) Find the heat transfer per kilogram of water during the expansion. (5 marks)
- b) The resistance to motion R for a sphere of diameter D moving at constant velocity V through a compressible fluid is dependent upon the density  $\rho$  and the bulk modulus K. The resistance is primarily due to the compression of the fluid in front of the sphere. Use the dimensional analysis Buckingham's pi theory to find the dimensionless relationship between these quantities. (13 marks)

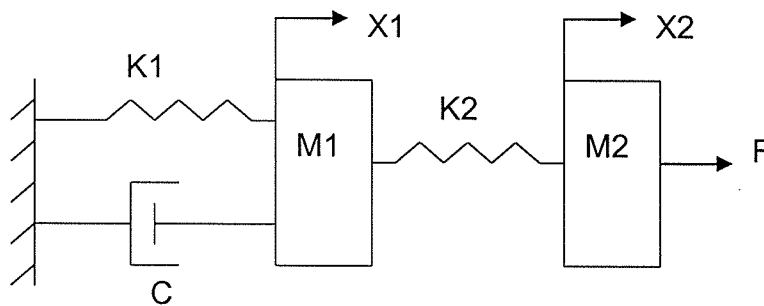
**Total 25 marks**

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- Q4 Figure Q4 shows a simplified industrial robotic system, where  
 $M1 = 8 \text{ Kg}$ ,  $K1 = 16 \text{ N/m}$ ,  $C = 3 \text{ Ns/m}$   
 $M2 = 2 \text{ Kg}$ ,  $K2 = 50 \text{ N/m}$
- (a) Develop the differential equations for the robotic system. (8 marks)
- (b) Use the Laplace transform to transfer the differential equations obtained from Q4(a) above. Assume that the system is subject to a unit step input and the initial conditions of the system are zeros (i.e. at time = 0,  $x$ ,  $\dot{x}$ ,  $\ddot{x}$  are all zeros). (4 marks)
- (c) Determine the transfer function  $G(s) = X1(s)/F(s)$  (13 marks)

**Total 25 marks**



**Figure Q4** A Simplified Industrial Robotic System

- Q5
- (a) Explain the term "Steady-State Error" and define the term "System Stability" with respect to a control system. (6 marks)
- (b) Steady-state error and stability are important design considerations when CNC machining. Figure Q5 gives a block diagram of a control system for CNC machining.
- (i) find the value of  $K$  so that there is 2% error in the steady state when a unit ramp input ( $\theta_i = 1/s^2$ ) is applied to the system. (7 marks)
- (ii) use the Routh-Hurwitz stability criterion to check the system's stability. (12 marks)

**Total 25 marks**

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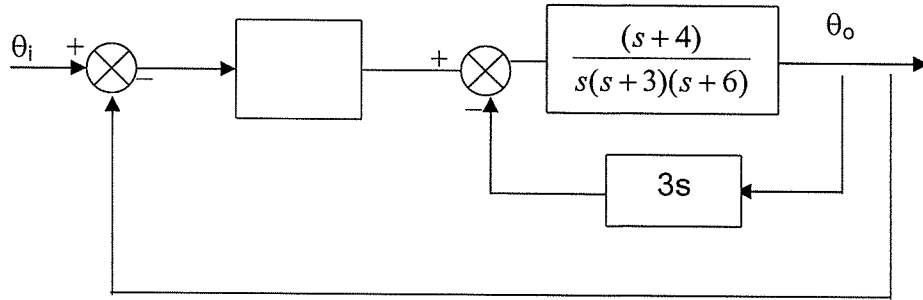


Figure Q5 A Control System for a Typical CNC Machine

Q6

- (a) Figure Q6(a) shows the output of a thermal system which is subjected to a step input.

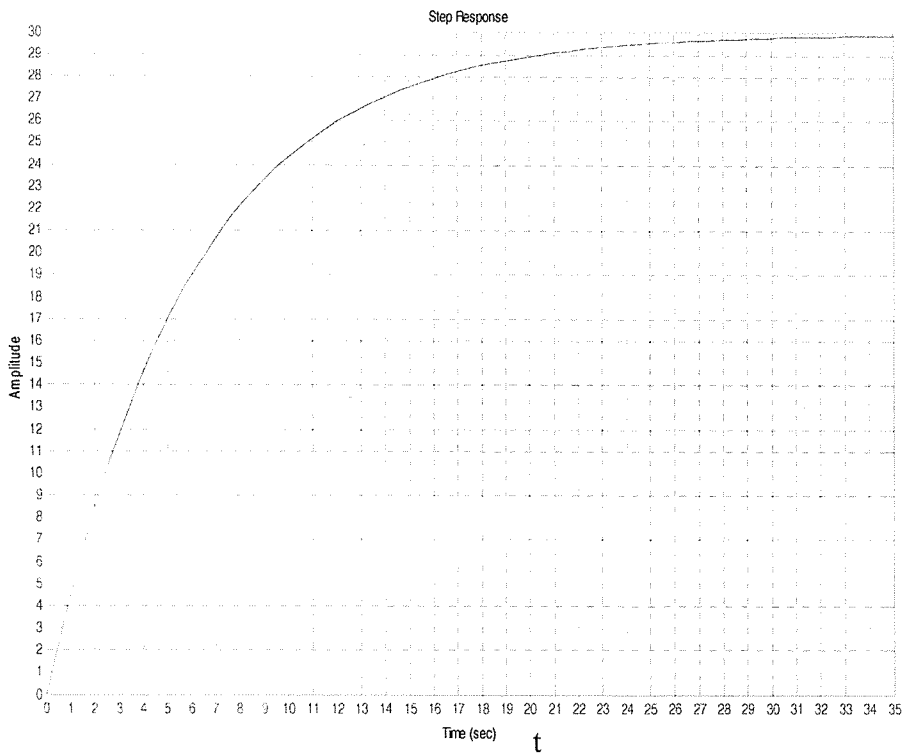


Figure Q6(a) The output of a thermal system

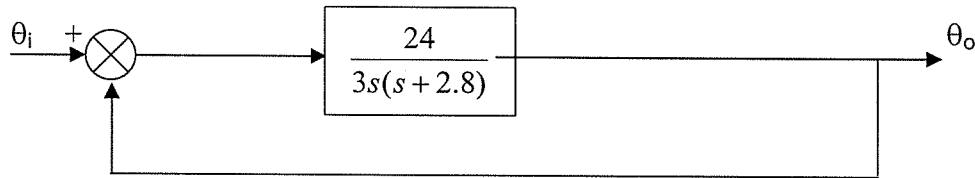
- (i) Specify the system performance by determining the time constant  $\tau$  and the final steady value  $G_{ss}$ . (3 marks)
- (ii) Determine the system's transfer function. (2 marks)

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(iii) Using the transfer function obtained (ii) above, if the step input is 50, what will be the time  $t$  taken for the output of the thermal system to reach 90% of its final value? (5 marks)

(b) Figure Q6(b) is a block diagram for a motorbike's suspension system.



**Figure Q6(b)** A Motorbike's Suspension System.

- (i) What is the suspension system's transfer function  $G(s) = \theta_o/\theta_i$ ? (3 marks)
- (ii) If a unit step input is applied into the suspension system, determine the system's percentage overshoot, rise time, settling time, peak time, natural frequency, damped frequency, and damping ratio. (12 marks)

**Total 25 marks**

**END OF QUESTIONS**

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**THERMOFLUIDS**

**Formulae Sheet**

$$P = F/A$$

$$\rho = m/v$$

$$m = \rho AV$$

$$P = P_g + P_{atm}$$

$$P = \rho gh$$

$$\text{Bulk Modulus } \beta = - \frac{dP}{dv/v}$$

$$\tau = \mu du/dy$$

$$h = \frac{4\sigma}{\rho g s d}$$

$$Z_1 + \frac{P_1}{\rho g} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{\rho g} + \frac{V_2^2}{2g}$$

$$V_1 = \sqrt{\frac{2g h \left( \frac{\rho_L}{\rho} - 1 \right)}{\left( \frac{a_1}{a_2} \right)^2 - 1}}$$

$$Q - W = \Delta U + \Delta PE + \Delta KE$$

$$W = \int P dV$$

$$P V^n = C$$

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$$W = \frac{P_1 V_1 - P_2 V_2}{n - 1}$$

$$W = P (v_2 - v_1)$$

$$W = PV \ln \left( \frac{V_2}{V_1} \right)$$

$$Q = C_d A \sqrt{2gh}$$

$$V_1 = C \sqrt{2g h_2 \left( \frac{\rho g_m}{\rho g} - 1 \right)}$$

$$\sum F = \frac{\Delta M}{\Delta t} = \Delta M$$

$$F = \rho QV$$

$$Re = VL \rho / \mu$$

$$dQ = du + dw$$

$$du = cu dT$$

$$dw = pdv$$

$$pv = mRT$$

$$h = h_f + xhf_g$$

$$s = s_f + xsf_g$$

$$v = x Vg$$

$$\dot{Q} - \dot{w} = \sum \dot{m}h$$

Blocks with feedback loop

$$G(s) = \frac{Go(s)}{1 + Go(s)H(s)} \text{ (for a negative feedback)}$$

$$G(s) = \frac{Go(s)}{1 - Go(s)H(s)} \text{ (for a positive feedback)}$$

Steady-State Errors

$$e_{ss} = \lim_{s \rightarrow 0} [s(1 - G_o(s))\theta_i(s)] \text{ (for an open-loop system)}$$

$$e_{ss} = \lim_{s \rightarrow 0} [s \frac{1}{1 + G_o(s)} \theta_i(s)] \text{ (for the closed-loop system with a unity feedback)}$$

$$e_{ss} = \lim_{s \rightarrow 0} [s \frac{1}{1 + \frac{G_1(s)}{1 + G_1(s)[H(s) - 1]}} \theta_i(s)] \text{ (if the feedback } H(s) \neq 1)$$

$$e_{ss} = \lim_{s \rightarrow 0} [-s \cdot \frac{G_2(s)}{1 + G_2(G_1(s) + 1)} \cdot \theta_d] \text{ (if the system subjects to a disturbance input)}$$

Laplace Transforms

A unit impulse function      1

A unit step function       $\frac{1}{s}$

A unit ramp function       $\frac{1}{s^2}$

First order Systems

$$\theta_o = G_{ss}(1 - e^{-t/\tau}) \text{ (for a unit step input)}$$

$$\theta_o = AG_{ss}(1 - e^{-t/\tau}) \text{ (for a step input with size } A)$$

Performance measures for second-order systems

$$\omega_d t_r = 1/2\pi$$

$$\omega_d t_p = \pi$$

$$\text{P.O.} = \exp\left(\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}\right) \times 100\%$$

$$t_s = \frac{4}{\zeta\omega_n}$$

$$\omega_d = \omega_n \sqrt{1-\zeta^2}$$

TABLE A-4

## Saturated water—Temperature table

Temp. °C T	Sat. press. kPa P <sub>sat</sub>	Specific volume m <sup>3</sup> /kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/(kg·K)		
		Sat. liquid v <sub>f</sub>	Sat. vapor v <sub>g</sub>	Sat. liquid u <sub>f</sub>	Evap. u <sub>fg</sub>	Sat. vapor u <sub>g</sub>	Sat. liquid h <sub>f</sub>	Evap. h <sub>fg</sub>	Sat. vapor h <sub>g</sub>	Sat. liquid s <sub>f</sub>	Evap. s <sub>fg</sub>	Sat. vapor s <sub>g</sub>
0.01	0.6113	0.001 000	206.14	0.00	2375.3	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	9.1562
5	0.8721	0.001 000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001 000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001 001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001 002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001 003	43.36	104.88	2304.9	2409.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5579
30	4.246	0.001 004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001 006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001 008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2559
45	9.593	0.001 010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001 012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0743
55	15.758	0.001 015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9902
60	19.940	0.001 017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9143
65	25.03	0.001 020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8458
70	31.19	0.001 023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7831
75	38.58	0.001 026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	7.7254
80	47.39	0.001 029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	7.6731
85	57.83	0.001 033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	7.6254
90	70.14	0.001 036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	7.5821
95	84.55	0.001 040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	7.5431
	<b>Sat. press. MPa P<sub>sat</sub></b>											
100	0.101 35	0.001 044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3
105	0.120 82	0.001 048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2
110	0.143 27	0.001 052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2
115	0.169 06	0.001 056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1
120	0.198 53	0.001 060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1
125	0.2321	0.001 065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0
130	0.2701	0.001 070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0
135	0.3130	0.001 075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9
140	0.3613	0.001 080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9
145	0.4154	0.001 085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8
150	0.4758	0.001 091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8
155	0.5431	0.001 096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.8
160	0.6178	0.001 102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.8
165	0.7005	0.001 108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.8
170	0.7917	0.001 114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.8
175	0.8920	0.001 121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.8
180	1.0021	0.001 127	0.194 05	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.8
185	1.1227	0.001 134	0.174 09	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.8
190	1.2544	0.001 141	0.156 54	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.8
195	1.3978	0.001 149	0.141 05	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.8
200	1.5538	0.001 157	0.127 36	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.8
205	1.7230	0.001 164	0.115 21	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.8
210	1.9062	0.001 173	0.104 41	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.8
215	2.104	0.001 181	0.094 79	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.8
220	2.318	0.001 190	0.086 19	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.8
225	2.548	0.001 199	0.078 49	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.8

TABLE A-4  
(Continued)

Temp. °C T	Sat. press. MPa P <sub>sat</sub>	Specific volume m <sup>3</sup> /kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/(kg·K)		
		Sat. liquid v <sub>f</sub>	Sat. vapor v <sub>g</sub>	Sat. liquid u <sub>f</sub>	Evap. u <sub>fg</sub>	Sat. vapor u <sub>g</sub>	Sat. liquid h <sub>f</sub>	Evap. h <sub>fg</sub>	Sat. vapor h <sub>g</sub>	Sat. liquid s <sub>f</sub>	Evap. s <sub>fg</sub>	Sat. vapor s <sub>g</sub>
230	2.795	0.001 209	0.071 58	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001 219	0.065 37	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001 229	0.059 76	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001 240	0.054 71	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083
250	3.973	0.001 251	0.050 13	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001 263	0.045 98	1104.28	1596.7	2600.9	1109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001 276	0.042 21	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001 289	0.038 77	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001 302	0.035 64	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001 317	0.032 79	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001 332	0.030 17	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001 348	0.027 77	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001 366	0.025 57	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001 384	0.023 54	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001 404	0.021 67	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001 425	0.019 948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001 447	0.018 350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230
315	10.547	0.001 472	0.016 867	1415.5	1121.1	2536.6	1431.0	1283.5	2714.5	3.3982	2.1821	5.5804
320	11.274	0.001 499	0.015 488	1444.6	1080.9	2525.5	1461.5	1238.6	2700.1	3.4480	2.0882	5.5362
330	12.845	0.001 561	0.012 996	1505.3	993.7	2498.9	1525.3	1140.6	2665.9	3.5507	1.8909	5.4417
340	14.586	0.001 638	0.010 797	1570.3	894.3	2464.6	1594.2	1027.9	2622.0	3.6594	1.6763	5.3357
350	16.513	0.001 740	0.008 813	1641.9	776.6	2418.4	1670.6	893.4	2563.9	3.7777	1.4335	5.2112
360	18.651	0.001 893	0.006 945	1725.2	626.3	2351.5	1760.5	720.3	2481.0	3.9147	1.1379	5.0526
370	21.03	0.002 213	0.004 925	1844.0	384.5	2228.5	1890.5	441.6	2332.1	4.1106	0.6865	4.7971
374.14	22.09	0.003 155	0.003 155	2029.6	0	2029.6	2099.3	0	2099.3	4.4298	0	4.4298

Source: Gordon J. Van Wylen and Richard E. Sonntag, *Fundamentals of Classical Thermodynamics*, English/SI Version, 3d ed., Wiley, New York, 1986, pp. 635–637, table A.1.1. Originally published in Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, *Steam Tables*, SI Units, Wiley, New York, 1978.

**TABLE A-5**  
Saturated water—Pressure table

Press. kPa <i>P</i>	Sat. Temp. °C <i>T<sub>sat</sub></i>	Specific volume m <sup>3</sup> /kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/(kg·K)		
		Sat. liquid <i>v<sub>f</sub></i>	Sat. vapor <i>v<sub>g</sub></i>	Sat. liquid <i>u<sub>f</sub></i>	Evap. <i>u<sub>fg</sub></i>	Sat. vapor <i>u<sub>g</sub></i>	Sat. liquid <i>h<sub>f</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. vapor <i>h<sub>g</sub></i>	Sat. liquid <i>s<sub>f</sub></i>	Evap. <i>s<sub>fg</sub></i>	Sat. vapor <i>s<sub>g</sub></i>
0.6113	0.01	0.001 000	206.14	0.00	2375.3	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	9.1562
1.0	6.98	0.001 000	129.21	29.30	2355.7	2385.0	29.30	2484.9	2514.2	0.1059	8.8697	8.9756
1.5	13.03	0.001 001	87.98	54.71	2338.6	2393.3	54.71	2470.6	2525.3	0.1957	8.6322	8.8279
2.0	17.50	0.001 001	67.00	73.48	2326.0	2399.5	73.48	2460.0	2533.5	0.2607	8.4629	8.7236
2.5	21.08	0.001 002	54.25	88.48	2315.9	2404.4	88.49	2451.6	2540.0	0.3120	8.3311	8.6431
3.0	24.08	0.001 003	45.67	101.04	2307.5	2408.5	101.05	2444.5	2545.5	0.3545	8.2231	8.5776
4.0	28.96	0.001 004	34.80	121.45	2293.7	2415.2	121.46	2432.9	2554.4	0.4226	8.0520	8.4746
5.0	32.88	0.001 005	28.19	137.81	2282.7	2420.5	137.82	2423.7	2561.5	0.4764	7.9187	8.3951
7.5	40.29	0.001 008	19.24	168.78	2261.7	2430.5	168.79	2406.0	2574.8	0.5764	7.6750	8.2514
10	45.81	0.001 010	14.67	191.82	2246.1	2437.9	191.83	2392.8	2584.7	0.6493	7.5009	8.1502
15	53.97	0.001 014	10.02	225.92	2222.8	2448.7	225.94	2373.1	2599.1	0.7549	7.2536	8.0085
20	60.06	0.001 017	7.649	251.38	2205.4	2456.7	251.40	2358.3	2609.7	0.8320	7.0766	7.9086
25	64.97	0.001 020	6.204	271.90	2191.2	2463.1	271.93	2346.3	2618.2	0.8931	6.9383	7.8314
30	69.10	0.001 022	5.229	289.20	2179.2	2468.4	289.23	2336.1	2625.3	0.9439	6.8247	7.7686
40	75.87	0.001 027	3.993	317.53	2159.5	2477.0	317.58	2319.2	2636.8	1.0259	6.6441	7.6700
50	81.33	0.001 030	3.240	340.44	2143.4	2483.9	340.49	2305.4	2645.9	1.0910	6.5029	7.5939
75	91.78	0.001 037	2.217	384.31	2112.4	2496.7	384.39	2278.6	2663.0	1.2130	6.2434	7.4564
<b>Press. MPa <i>P</i></b>												
0.100	99.63	0.001 043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001 048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001 053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2201
0.175	116.06	0.001 057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1689
0.200	120.23	0.001 061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1250
0.225	124.00	0.001 064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0867
0.250	127.44	0.001 067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0512
0.275	130.60	0.001 070	0.6573	548.59	1991.9	2540.5	548.89	2172.4	2721.3	1.6408	5.3801	7.0181
0.300	133.55	0.001 073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9863
0.325	136.30	0.001 076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9556
0.350	138.88	0.001 079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9261
0.375	141.32	0.001 081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.8976
0.40	143.63	0.001 084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8700
0.45	147.93	0.001 088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8247
0.50	151.86	0.001 093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.7800
0.55	155.48	0.001 097	0.3427	655.32	1909.2	2564.5	655.93	2097.0	2753.0	1.8973	4.8920	6.7359
0.60	158.85	0.001 101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.6920
0.65	162.01	0.001 104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.6481
0.70	164.97	0.001 108	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.6040
0.75	167.78	0.001 112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.5600
0.80	170.43	0.001 115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.5160
0.85	172.96	0.001 118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.4710
0.90	175.38	0.001 121	0.2150	741.83	1838.6	2580.5	742.83	2031.1	2773.9	2.0946	4.5280	6.4260
0.95	177.69	0.001 124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.3810
1.00	179.91	0.001 127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.3360
1.10	184.09	0.001 133	0.17753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.2700
1.20	187.99	0.001 139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.2040
1.30	191.64	0.001 144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.1380

TABLE A-5  
(Continued)

Press. MPa <i>P</i>	Sat. temp. °C <i>T<sub>sat</sub></i>	Specific volume m <sup>3</sup> /kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/(kg·K)		
		Sat. liquid <i>v<sub>f</sub></i>	Sat. vapor <i>v<sub>g</sub></i>	Sat. liquid <i>u<sub>f</sub></i>	Evap. <i>u<sub>fg</sub></i>	Sat. vapor <i>u<sub>g</sub></i>	Sat. liquid <i>h<sub>f</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. vapor <i>h<sub>g</sub></i>	Sat. liquid <i>s<sub>f</sub></i>	Evap. <i>s<sub>fg</sub></i>	Sat. vapor <i>s<sub>g</sub></i>
1.40	195.07	0.001 149	0.140 84	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001 154	0.131 77	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001 166	0.113 49	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001 177	0.099 63	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001 187	0.088 75	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001 197	0.079 98	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001 217	0.066 68	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001 235	0.057 07	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001 252	0.049 78	1082.31	1520.0	2602.3	1087.31	1714.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001 286	0.039 44	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001 319	0.032 44	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001 351	0.027 37	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001 384	0.023 52	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001 418	0.020 48	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001 452	0.018 026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141
11	318.15	0.001 489	0.015 987	1433.7	1096.0	2529.8	1450.1	1255.5	2705.6	3.4295	2.1233	5.5527
12	324.75	0.001 527	0.014 263	1473.0	1040.7	2513.7	1491.3	1193.6	2684.9	3.4962	1.9962	5.4924
13	330.93	0.001 567	0.012 780	1511.1	985.0	2496.1	1531.5	1130.7	2662.2	3.5606	1.8718	5.4323
14	336.75	0.001 611	0.011 485	1548.6	928.2	2476.8	1571.1	1066.5	2637.6	3.6232	1.7485	5.3717
15	342.24	0.001 658	0.010 337	1585.6	869.8	2455.5	1610.5	1000.0	2610.5	3.6848	1.6249	5.3098
16	347.44	0.001 711	0.009 306	1622.7	809.0	2431.7	1650.1	930.6	2580.6	3.7461	1.4994	5.2455
17	352.37	0.001 770	0.008 364	1660.2	744.8	2405.0	1690.3	856.9	2547.2	3.8079	1.3698	5.1777
18	357.06	0.001 840	0.007 489	1698.9	675.4	2374.3	1732.0	777.1	2509.1	3.8715	1.2329	5.1044
19	361.54	0.001 924	0.006 657	1739.9	598.1	2338.1	1776.5	688.0	2464.5	3.9388	1.0839	5.0228
20	365.81	0.002 036	0.005 834	1785.6	507.5	2293.0	1826.3	583.4	2409.7	4.0139	0.9130	4.9269
21	369.89	0.002 207	0.004 952	1842.1	388.5	2230.6	1888.4	446.2	2334.6	4.1075	0.6938	4.8013
22	373.80	0.002 742	0.003 568	1961.9	125.2	2087.1	2022.2	143.4	2165.6	4.3110	0.2216	4.5327
22.09	374.14	0.003 155	0.003 155	2029.6	0	2029.6	2099.3	0	2099.3	4.4298	0	4.4298

Source: Gordon J. Van Wylen and Richard E. Sonntag, *Fundamentals of Classical Thermodynamics*, English/SI Version, 3d ed., Wiley, New York, 1986, pp. 638–640, table A.1.2. Originally published in Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, *Steam Tables*, SI Units, Wiley, New York, 1978.

**TABLE A-6**  
Superheated water

<i>T</i> °C	<i>v</i> m <sup>3</sup> /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/(kg·K)	<i>v</i> m <sup>3</sup> /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/(kg·K)	<i>v</i> m <sup>3</sup> /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/(kg·K)
<i>P</i> = 0.01 MPa (45.81°C)				<i>P</i> = 0.05 MPa (81.33°C)				<i>P</i> = 0.10 MPa (99.63°C)				
Sat.	14.674	2437.9	2584.7	8.1502	3.240	2483.9	2645.9	7.5939	1.6940	2506.1	2675.5	7.3594
50	14.869	2443.9	2592.6	8.1749								
100	17.196	2515.5	2687.5	8.4479	3.418	2511.6	2682.5	7.6947	1.6958	2506.7	2676.2	7.3614
150	19.512	2587.9	2783.0	8.6882	3.889	2585.6	2780.1	7.9401	1.9364	2582.8	2776.4	7.6134
200	21.825	2661.3	2879.5	8.9038	4.356	2659.9	2877.7	8.1580	2.172	2658.1	2875.3	7.8343
250	24.136	2736.0	2977.3	9.1002	4.820	2735.0	2976.0	8.3556	2.406	2733.7	2974.3	8.0333
300	26.445	2812.1	3076.5	9.2813	5.284	2811.3	3075.5	8.5373	2.639	2810.4	3074.3	8.2158
400	31.063	2968.9	3279.6	9.6077	6.209	2968.5	3278.9	8.8642	3.103	2967.9	3278.2	8.5435
500	35.679	3132.3	3489.1	9.8978	7.134	3132.0	3488.7	9.1546	3.565	3131.6	3488.1	8.8342
600	40.295	3302.5	3705.4	10.1608	8.057	3302.2	3705.1	9.4178	4.028	3301.9	3704.4	9.0976
700	44.911	3479.6	3928.7	10.4028	8.981	3479.4	3928.5	9.6599	4.490	3479.2	3928.2	9.3398
800	49.526	3663.8	4159.0	10.6281	9.904	3663.6	4158.9	9.8852	4.952	3663.5	4158.6	9.5652
900	54.141	3855.0	4396.4	10.8396	10.828	3854.9	4396.3	10.0967	5.414	3854.8	4396.1	9.7767
1000	58.757	4053.0	4640.6	11.0393	11.751	4052.9	4640.5	10.2964	5.875	4052.8	4640.3	9.9764
1100	63.372	4257.5	4891.2	11.2287	12.674	4257.4	4891.1	10.4859	6.337	4257.3	4891.0	10.1659
1200	67.987	4467.9	5147.8	11.4091	13.597	4467.8	5147.7	10.6662	6.799	4467.7	5147.6	10.3463
1300	72.602	4683.7	5409.7	11.5811	14.521	4683.6	5409.6	10.8382	7.260	4683.5	5409.5	10.5183
<i>P</i> = 0.20 MPa (120.23°C)				<i>P</i> = 0.30 MPa (133.55°C)				<i>P</i> = 0.40 MPa (143.63°C)				
Sat.	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2372	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.6563	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780
<i>P</i> = 0.50 MPa (151.86°C)				<i>P</i> = 0.60 MPa (158.85°C)				<i>P</i> = 0.80 MPa (170.43°C)				
Sat.	0.3749	2561.2	2748.7	6.8213	0.3157	2567.4	2756.8	6.7600	0.2404	2576.8	2769.1	6.6628
200	0.4249	2642.9	2855.4	7.0592	0.3520	2638.9	2850.1	6.9665	0.2608	2630.6	2839.3	6.8158
250	0.4744	2723.5	2960.7	7.2709	0.3938	2720.9	2957.2	7.1816	0.2931	2715.5	2950.0	7.0384
300	0.5226	2802.9	3064.2	7.4599	0.4344	2801.0	3061.6	7.3724	0.3241	2797.2	3056.5	7.2328
350	0.5701	2882.6	3167.7	7.6329	0.4742	2881.2	3165.7	7.5464	0.3544	2878.2	3161.7	7.4089
400	0.6173	2963.2	3271.9	7.7938	0.5137	2962.1	3270.3	7.7079	0.3843	2959.7	3267.1	7.5716
500	0.7109	3128.4	3483.9	8.0873	0.5920	3127.6	3482.8	8.0021	0.4433	3126.0	3480.6	7.8673
600	0.8041	3299.6	3701.7	7.3522	0.6697	3299.1	3700.9	8.2674	0.5018	3297.9	3699.4	8.1333
700	0.8969	3477.5	3925.9	8.5952	0.7472	3477.0	3925.3	8.5107	0.5601	3476.2	3924.2	8.3770
800	0.9896	3662.1	4156.9	8.8211	0.8245	3661.8	4156.5	8.7367	0.6181	3661.1	4155.6	8.6033
900	1.0822	3853.6	4394.7	9.0329	0.9017	3853.4	4394.4	8.9486	0.6761	3852.8	4393.7	8.8153
1000	1.1747	4051.8	4639.1	9.2328	0.9788	4051.5	4638.8	9.1485	0.7340	4051.0	4638.2	9.0153
1100	1.2672	4256.3	4889.9	9.4224	1.0559	4256.1	4889.6	9.3381	0.7919	4255.6	4889.1	9.2050
1200	1.3596	4466.8	5146.6	9.6029	1.1330	4466.5	5146.3	9.5185	0.8497	4466.1	5145.9	9.3855
1300	1.4521	4682.5	5408.6	9.7749	1.2101	4682.3	5408.3	9.6906	0.9076	4681.8	5407.9	9.5575

**TABLE A-6**  
(Continued)

$T$ °C	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)
<b><math>P = 1.00 \text{ MPa (179.91}^\circ\text{C)}</math></b>				<b><math>P = 1.20 \text{ MPa (187.99}^\circ\text{C)}</math></b>				<b><math>P = 1.40 \text{ MPa (195.07}^\circ\text{C)}</math></b>				
Sat.	0.194 44	2583.6	2778.1	6.5865	0.163 33	2588.8	2784.8	6.5233	0.140 84	2592.8	2790.0	6.4693
200	0.2060	2621.9	2827.9	6.6940	0.169 30	2612.8	2815.9	6.5898	0.143 02	2603.1	2803.3	6.4975
250	0.2327	2709.9	2942.6	6.9247	0.192 34	2704.2	2935.0	6.8294	0.163 50	2698.3	2927.2	6.7467
300	0.2579	2793.2	3051.2	7.1229	0.2138	2789.2	3045.8	7.0317	0.182 28	2785.2	3040.4	6.9534
350	0.2825	2875.2	3157.7	7.3011	0.2345	2872.2	3153.6	7.2121	0.2003	2869.2	3149.5	7.1360
400	0.3066	2957.3	3263.9	7.4651	0.2548	2954.9	3260.7	7.3774	0.2178	2952.5	3257.5	7.3026
500	0.3541	3124.4	3478.5	7.7622	0.2946	3122.8	3476.3	7.6759	0.2521	3121.1	3474.1	7.6027
600	0.4011	3296.8	3697.9	8.0290	0.3339	3295.6	3696.3	7.9435	0.2860	3294.4	3694.8	7.8710
700	0.4478	3475.3	3923.1	8.2731	0.3729	3474.4	3922.0	8.1881	0.3195	3473.6	3920.8	8.1160
800	0.4943	3660.4	4154.7	8.4996	0.4118	3659.7	4153.8	8.4148	0.3528	3659.0	4153.0	8.3431
900	0.5407	3852.2	4392.9	8.7118	0.4505	3851.6	4392.2	8.6272	0.3861	3851.1	4391.5	8.5556
1000	0.5871	4050.5	4637.6	8.9119	0.4892	4050.0	4637.0	8.8274	0.4192	4049.5	4636.4	8.7559
1100	0.6335	4255.1	4888.6	9.1017	0.5278	4254.6	4888.0	9.0172	0.4524	4254.1	4887.5	8.9457
1200	0.6798	4465.6	5145.4	9.2822	0.5665	4465.1	5144.9	9.1977	0.4855	4464.7	5144.4	9.1262
1300	0.7261	4681.3	5407.4	9.4543	0.6051	4680.9	5407.0	9.3698	0.5186	4680.4	5406.5	9.2984
<b><math>P = 1.60 \text{ MPa (201.41}^\circ\text{C)}</math></b>				<b><math>P = 1.80 \text{ MPa (207.15}^\circ\text{C)}</math></b>				<b><math>P = 2.00 \text{ MPa (212.42}^\circ\text{C)}</math></b>				
Sat.	0.123 80	2596.0	2794.0	6.4218	0.110 42	2598.4	2797.1	6.3794	0.099 63	2600.3	2799.5	6.3409
225	0.132 87	2644.7	2857.3	6.5518	0.116 73	2636.6	2846.7	6.4808	0.103 77	2628.3	2835.8	6.4147
250	0.141 84	2692.3	2919.2	6.6732	0.124 97	2686.0	2911.0	6.6066	0.111 44	2679.6	2902.5	6.5453
300	0.158 62	2781.1	3034.8	6.8844	0.140 21	2776.9	3029.2	6.8226	0.125 47	2772.6	3023.5	6.7664
350	0.174 56	2866.1	3145.4	7.0694	0.154 57	2863.0	3141.2	7.0100	0.138 57	2859.8	3137.0	6.9563
400	0.190 05	2950.1	3254.2	7.2374	0.168 47	2947.7	3250.9	7.1794	0.151 20	2945.2	3247.6	7.1271
500	0.2203	3119.5	3472.0	7.5390	0.195 50	3117.9	3469.8	7.4825	0.175 68	3116.2	3467.6	7.4317
600	0.2500	3293.3	3693.2	7.8080	0.2220	3292.1	3691.7	7.7523	0.199 60	3290.9	3690.1	7.7024
700	0.2794	3472.7	3919.7	8.0535	0.2482	3471.8	3918.5	7.9983	0.2232	3470.9	3917.4	7.9487
800	0.3086	3658.3	4152.1	8.2808	0.2742	3657.6	4151.2	8.2258	0.2467	3657.0	4150.3	8.1765
900	0.3377	3850.5	4390.8	8.4935	0.3001	3849.9	4390.1	8.4386	0.2700	3849.3	4389.4	8.3895
1000	0.3668	4049.0	4635.8	8.6938	0.3260	4048.5	4635.2	8.6391	0.2933	4048.0	4634.6	8.5901
1100	0.3958	4253.7	4887.0	8.8837	0.3518	4253.2	4886.4	8.8290	0.3166	4252.7	4885.9	8.7800
1200	0.4248	4464.2	5143.9	9.0643	0.3776	4463.7	5143.4	9.0096	0.3398	4463.3	5142.9	8.9607
1300	0.4538	4679.9	5406.0	9.2364	0.4034	4679.5	5405.6	9.1818	0.3631	4679.0	5405.1	9.1329
<b><math>P = 2.50 \text{ MPa (223.99}^\circ\text{C)}</math></b>				<b><math>P = 3.00 \text{ MPa (233.90}^\circ\text{C)}</math></b>				<b><math>P = 3.50 \text{ MPa (242.60}^\circ\text{C)}</math></b>				
Sat.	0.079 98	2603.1	2803.1	6.2575	0.066 68	2604.1	2804.2	6.1869	0.057 07	2603.7	2803.4	6.1253
225	0.080 27	2605.6	2806.3	6.2639	0.070 58	2644.0	2855.8	6.2872	0.058 72	2623.7	2829.2	6.1749
250	0.087 00	2662.6	2880.1	6.4085	0.081 14	2750.1	2993.5	6.5390	0.068 42	2738.0	2977.5	6.4461
300	0.098 90	2761.6	3008.8	6.6438	0.090 53	2843.7	3115.3	6.7428	0.076 78	2835.3	3104.0	6.6579
350	0.109 76	2851.9	3126.3	6.8403	0.099 36	2932.8	3230.9	6.9212	0.084 53	2926.4	3222.3	6.8405
400	0.120 10	2939.1	3239.3	7.0148	0.107 87	3020.4	3344.0	7.0834	0.091 96	3015.3	3337.2	7.0052
450	0.130 14	3025.5	3350.8	7.1746	0.116 19	3108.0	3456.5	7.2338	0.099 18	3103.0	3450.9	7.1572
500	0.139 93	3112.1	3462.1	7.3234	0.124 43	3195.0	3568.0	7.3842	0.106 40	3190.0	3564.0	7.3076
600	0.159 30	3288.0	3686.3	7.5960	0.148 38	3466.5	3911.7	7.7571	0.126 99	3464.3	3908.8	7.6837
700	0.178 32	3465.3	4148.2	8.0720	0.164 14	3653.5	4145.9	7.9862	0.140 56	3651.8	4143.7	7.9134
800	0.197 16	3655.3	4387.6	8.2853	0.179 80	3846.5	4385.9	8.1999	0.154 02	3845.0	4384.1	8.1276
900	0.215 90	3847.9	4633.1	8.4861	0.195 41	4045.4	4631.6	8.4009	0.167 43	4044.1	4630.1	8.3288
1000	0.2346	4046.7	4884.6	8.6762	0.210 98	4250.3	4883.3	8.5912	0.180 80	4249.2	4881.9	8.5192
1100	0.2532	4251.5	5141.7	8.8569	0.226 52	4460.9	5140.5	8.7720	0.194 15	4459.8	5139.3	8.7000
1200	0.2718	4462.1	5404.0	9.0291	0.242 06	4676.6	5402.8	8.9442	0.207 49	4675.5	5401.7	8.8723

TABLE A-6  
(Continued)

T °C	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m <sup>3</sup> /kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
Sat.	0.049 78	2602.3	2801.4	6.0701	0.044 06	2600.1	2798.3	6.0198	0.039 44	2597.1	2794.3	5.91
275	0.054 57	2667.9	2886.2	6.2285	0.047 30	2650.3	2863.2	6.1401	0.041 41	2631.3	2838.3	6.01
300	0.058 84	2725.3	2960.7	6.3615	0.051 35	2712.0	2943.1	6.2828	0.045 32	2698.0	2924.5	6.20
350	0.066 45	2826.7	3092.5	6.5821	0.058 40	2817.8	3080.6	6.5131	0.051 94	2808.7	3068.4	6.41
400	0.073 41	2919.9	3213.6	6.7690	0.064 75	2913.3	3204.7	6.7047	0.057 81	2906.6	3195.7	6.61
450	0.080 02	3010.2	3330.3	6.9363	0.070 74	3005.0	3323.3	6.8746	0.063 30	2999.7	3316.2	6.81
500	0.086 43	3099.5	3445.3	7.0901	0.076 51	3095.3	3439.6	7.0301	0.068 57	3091.0	3433.8	6.91
600	0.098 85	3279.1	3674.4	7.3688	0.087 65	3276.0	3670.5	7.3110	0.078 69	3273.0	3666.5	7.21
700	0.110 95	3462.1	3905.9	7.6198	0.098 47	3459.9	3903.0	7.5631	0.088 49	3457.6	3900.1	7.51
800	0.122 87	3650.0	4141.5	7.8502	0.109 11	3648.3	4139.3	7.7942	0.098 11	3646.6	4137.1	7.71
900	0.134 69	3843.6	4382.3	8.0647	0.119 65	3842.2	4380.6	8.0091	0.107 62	3840.7	4378.8	7.91
1000	0.146 45	4042.9	4628.7	8.2662	0.130 13	4041.6	4627.2	8.2108	0.117 07	4040.4	4625.7	8.11
1100	0.158 17	4248.0	4880.6	8.4567	0.140 56	4246.8	4879.3	8.4015	0.126 48	4245.6	4878.0	8.31
1200	0.169 87	4458.6	5138.1	8.6376	0.150 98	4457.5	5136.9	8.5825	0.135 87	4456.3	5135.7	8.51
1300	0.181 56	4674.3	5400.5	8.8100	0.161 39	4673.1	5399.4	8.7549	0.145 26	4672.0	5398.2	8.71
	P = 6.0 MPa (275.64°C)				P = 7.0 MPa (285.88°C)				P = 8.0 MPa (295.06°C)			
Sat.	0.032 44	2589.7	2784.3	5.8892	0.027 37	2580.5	2772.1	5.8133	0.023 52	2569.8	2758.0	5.71
300	0.036 16	2667.2	2884.2	6.0674	0.029 47	2632.2	2838.4	5.9305	0.024 26	2590.9	2785.0	5.71
350	0.042 23	2789.6	3043.0	6.3335	0.035 24	2769.4	3016.0	6.2283	0.029 95	2747.7	2987.3	6.11
400	0.047 39	2892.9	3177.2	6.5408	0.039 93	2878.6	3158.1	6.4478	0.034 32	2863.8	3138.3	6.31
450	0.052 14	2988.9	3301.8	6.7193	0.044 16	2978.0	3287.1	6.6327	0.038 17	2966.7	3272.0	6.51
500	0.056 65	3082.2	3422.2	6.8803	0.048 14	3073.4	3410.3	6.7975	0.041 75	3064.3	3398.3	6.71
550	0.061 01	3174.6	3540.6	7.0288	0.051 95	3167.2	3530.9	6.9486	0.045 16	3159.8	3521.0	6.91
600	0.065 25	3266.9	3658.4	7.1677	0.055 65	3260.7	3650.3	7.0894	0.048 45	3254.4	3642.0	7.11
700	0.073 52	3453.1	3894.2	7.4234	0.062 83	3448.5	3888.3	7.3476	0.054 81	3443.9	3882.4	7.31
800	0.081 60	3643.1	4132.7	7.6566	0.069 81	3639.5	4128.2	7.5822	0.060 97	3636.0	4123.8	7.51
900	0.089 58	3837.8	4375.3	7.8727	0.076 69	3835.0	4371.8	7.7991	0.067 02	3832.1	4368.3	7.71
1000	0.097 49	4037.8	4622.7	8.0751	0.083 50	4035.3	4619.8	8.0020	0.073 01	4032.8	4616.9	7.91
1100	0.105 36	4243.3	4875.4	8.2661	0.090 27	4240.9	4872.8	8.1933	0.078 96	4238.6	4870.3	8.11
1200	0.113 21	4454.0	5133.3	8.4474	0.097 03	4451.7	5130.9	8.3747	0.084 89	4449.5	5128.5	8.31
1300	0.121 06	4669.6	5396.0	8.6199	0.103 77	4667.3	5393.7	8.5475	0.090 80	4665.0	5391.5	8.51
	P = 9.0 MPa (303.40°C)				P = 10.0 MPa (311.06°C)				P = 12.5 MPa (327.89°C)			
Sat.	0.020 48	2557.8	2742.1	5.6772	0.018 026	2544.4	2724.7	5.6141	0.013 495	2505.1	2673.8	5.51
325	0.023 27	2646.6	2856.0	5.8712	0.019 861	2610.4	2809.1	5.7568	0.016 126	2624.6	2826.2	5.51
350	0.025 80	2724.4	2956.6	6.0361	0.022 42	2699.2	2923.4	5.9443	0.020 00	2789.3	3039.3	6.01
400	0.029 93	2848.4	3117.8	6.2854	0.026 41	2832.4	3096.5	6.2120	0.022 99	2912.5	3199.8	6.21
450	0.033 50	2955.2	3256.6	6.4844	0.029 75	2943.4	3240.9	6.4190	0.022 99	2912.5	3199.8	6.21
500	0.036 77	3055.2	3386.1	6.6576	0.032 79	3045.8	3373.7	6.5966	0.025 60	3021.7	3341.8	6.51
550	0.039 87	3152.2	3511.0	6.8142	0.035 64	3144.6	3500.9	6.7561	0.028 01	3125.0	3475.2	6.81
600	0.042 85	3248.1	3633.7	6.9589	0.038 37	3241.7	3625.3	6.9029	0.030 29	3225.4	3604.0	6.91
650	0.045 74	3343.6	3755.3	7.0943	0.041 01	3338.2	3748.2	7.0398	0.032 48	3324.4	3730.4	7.01
700	0.048 57	3439.3	3876.5	7.2221	0.043 58	3434.7	3870.5	7.1687	0.034 60	3422.9	3855.3	7.11
800	0.054 09	3632.5	4119.3	7.4596	0.048 59	3628.9	4114.8	7.4077	0.038 69	3620.0	4103.6	7.41
900	0.059 50	3829.2	4364.8	7.6783	0.053 49	3826.3	4361.2	7.6272	0.042 67	3819.1	4352.5	7.61
1000	0.064 85	4030.3	4614.0	7.8821	0.058 32	4027.8	4611.0	7.8315	0.046 58	4021.6	4603.8	7.81
1100	0.070 16	4236.3	4867.7	8.0740	0.063 12	4234.0	4865.1	8.0237	0.050 45	4228.2	4858.8	8.01
1200	0.075 44	4447.2	5126.2	8.2556	0.067 89	4444.9	5123.8	8.2055	0.054 30	4439.3	5118.0	8.21
1300	0.080 72	4662.7	5389.2	8.4284	0.072 65	4460.5	5387.0	8.3783	0.058 13	4654.8	5381.4	8.41

TABLE A-6  
(Continued)

T °C	P = 15.0 MPa (342.24°C)				P = 17.5 MPa (354.75°C)				P = 20.0 MPa (365.81°C)			
	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
Sat.	0.010 337	2455.5	2610.5	5.3098	0.007 920	2390.2	2528.8	5.1419	0.005 834	2293.0	2409.7	4.926
350	0.011 470	2520.4	2692.4	5.4421	0.012 447	2685.0	2902.9	5.7213	0.009 942	2619.3	2818.1	5.554
400	0.015 649	2740.7	2975.5	5.8811	0.015 174	2844.2	3109.7	6.0184	0.012 695	2806.2	3060.1	5.901
450	0.018 445	2879.5	3156.2	6.1404	0.017 358	2970.3	3274.1	6.2383	0.014 768	2942.9	3238.2	6.140
500	0.020 80	2996.6	3308.6	6.3443	0.019 288	3083.9	3421.4	6.4230	0.016 555	3062.4	3393.5	6.334
550	0.022 93	3104.7	3448.6	6.5199	0.021 06	3191.5	3560.1	6.5866	0.018 178	3174.0	3537.6	6.504
600	0.024 91	3208.6	3582.3	6.6776	0.022 74	3296.0	3693.9	6.7357	0.019 693	3281.4	3675.3	6.658
650	0.026 80	3310.3	3712.3	6.8224	0.024 34	3398.7	3824.6	6.8736	0.021 13	3386.4	3809.0	6.799
700	0.028 61	3410.9	3840.1	6.9572	0.027 38	3601.8	4081.1	7.1244	0.023 85	3592.7	4069.7	7.054
800	0.032 10	3610.9	4092.4	7.2040	0.030 31	3804.7	4335.1	7.3507	0.026 45	3797.5	4326.4	7.283
900	0.035 46	3811.9	4343.8	7.4279	0.033 16	4009.3	4589.5	7.5589	0.028 97	4003.1	4582.5	7.492
1000	0.038 75	4015.4	4596.6	7.6348	0.035 97	4216.9	4846.4	7.7531	0.031 45	4211.3	4840.2	7.687
1100	0.042 00	4222.6	4852.6	7.8283	0.038 76	4428.3	5106.6	7.9360	0.033 91	4422.8	5101.0	7.870
1200	0.045 23	4433.8	5112.3	8.0108	0.041 54	4643.5	5370.5	8.1093	0.036 36	4638.0	5365.1	8.044
1300	0.048 45	4649.1	5376.0	8.1840								
	P = 25.0 MPa				P = 30.0 MPa				P = 35.0 MPa			
375	0.001 973 1	1798.7	1848.0	4.0320	0.001 789 2	1737.8	1791.5	3.9305	0.001 700 3	1702.9	1762.4	3.8722
400	0.006 004	2430.1	2580.2	5.1418	0.002 790	2067.4	2151.1	4.4728	0.002 100	1914.1	1987.6	4.2126
425	0.007 881	2609.2	2806.3	5.4723	0.005 303	2455.1	2614.2	5.1504	0.003 428	2253.4	2373.4	4.7747
450	0.009 162	2720.7	2949.7	5.6744	0.006 735	2619.3	2821.4	5.4424	0.004 961	2498.7	2672.4	5.1962
500	0.011 123	2884.3	3162.4	5.9592	0.008 678	2820.7	3081.1	5.7905	0.006 927	2751.9	2994.4	5.628
550	0.012 724	3017.5	3335.6	6.1765	0.010 168	2970.3	3275.4	6.0342	0.008 345	2921.0	3213.0	5.9025
600	0.014 137	3137.9	3491.4	6.3602	0.011 446	3100.5	3443.9	6.2331	0.009 527	3062.0	3395.5	6.1179
650	0.015 433	3251.6	3637.4	6.5229	0.012 596	3221.0	3598.9	6.4058	0.010 575	3189.8	3559.9	6.3010
700	0.016 646	3361.3	3777.5	6.6707	0.013 661	3335.8	3745.6	6.5606	0.011 533	3309.8	3713.5	6.4631
800	0.018 912	3574.3	4047.1	6.9345	0.015 623	3555.5	4024.2	6.8332	0.013 278	3536.7	4001.5	6.7450
900	0.021 045	3783.0	4309.1	7.1680	0.017 448	3768.5	4291.9	7.0718	0.014 883	3754.0	4274.9	6.9386
1000	0.023 10	3990.9	4568.5	7.3802	0.019 196	3978.8	4554.7	7.2867	0.016 410	3966.7	4541.1	7.2064
1100	0.025 12	4200.2	4828.2	7.5765	0.020 903	4189.2	4816.3	7.4845	0.017 895	4178.3	4804.6	7.4037
1200	0.027 11	4412.0	5089.9	7.7605	0.022 589	4401.3	5079.0	7.6692	0.019 360	4390.7	5068.3	7.5910
1300	0.029 10	4626.9	5354.4	7.9342	0.024 266	4616.0	5344.0	7.8432	0.020 815	4605.1	5333.6	7.7653
	P = 40.0 MPa				P = 50.0 MPa				P = 60.0 MPa			
375	0.001 640 7	1677.1	1742.8	3.8290	0.001 559 4	1638.6	1716.6	3.7639	0.001 502 8	1609.4	1699.5	3.7141
400	0.001 907 7	1854.6	1930.9	4.1135	0.001 730 9	1788.1	1874.6	4.0031	0.001 633 5	1745.4	1843.4	3.9318
425	0.002 532	2096.9	2198.1	4.5029	0.002 007	1959.7	2060.0	4.2734	0.001 816 5	1892.7	2001.7	4.1626
450	0.003 693	2365.1	2512.8	4.9459	0.002 486	2159.6	2284.0	4.5884	0.002 085	2053.9	2179.0	4.4121
500	0.005 622	2678.4	2903.3	5.4700	0.003 892	2525.5	2720.1	5.1726	0.002 956	2390.6	2567.9	4.9321
550	0.006 984	2869.7	3149.1	5.7785	0.005 118	2763.6	3019.5	5.5485	0.003 956	2658.8	2896.2	5.3441
600	0.008 094	3022.6	3346.4	6.0114	0.006 112	2942.0	3247.6	5.8178	0.004 834	2861.1	3151.2	5.6452
650	0.009 063	3158.0	3520.6	6.2054	0.006 966	3093.5	3441.8	6.0342	0.005 595	3028.8	3364.5	5.8829
700	0.009 941	3283.6	3681.2	6.3750	0.007 727	3230.5	3616.8	6.2189	0.006 272	3177.2	3553.5	6.0824
800	0.011 523	3517.8	3978.7	6.6662	0.009 076	3479.8	3933.6	6.5290	0.007 459	3441.5	3889.1	6.4109
900	0.012 962	3739.4	4257.9	6.9150	0.010 283	3710.3	4224.4	6.7882	0.008 508	3681.0	4191.5	6.6805
1000	0.014 324	3954.6	4527.6	7.1356	0.011 411	3930.5	4501.1	7.0146	0.009 480	3906.4	4475.2	6.9127
1100	0.015 642	4167.4	4793.1	7.3364	0.012 496	4145.7	4770.5	7.2184	0.010 409	4124.1	4748.6	7.1195
1200	0.016 940	4380.1	5057.7	7.5224	0.013 561	4359.1	5037.2	7.4058	0.011 317	4338.2	5017.2	7.3083
1300	0.018 229	4594.3	5323.5	7.6969	0.014 616	4572.8	5303.6	7.5808	0.012 215	4551.4	5284.3	7.4837

Source: Gordon J. Van Wylen and Richard E. Sonntag, *Fundamentals of Classical Thermodynamics*, English/SI Version, 3d ed., Wiley New York, 1986, pp. 641-648, table A.1.3. Originally published in Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, *Steam Tables*, SI Units, Wiley, New York, 1978.

TABLE A-7  
Compressed liquid water

$T$ °C	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)
$P = 5 \text{ MPa (263.99°C)}$				$P = 10 \text{ MPa (311.06°C)}$				$P = 15 \text{ MPa (342.24°C)}$				
Sat.	0.001 285 9	1147.8	1154.2	2.9202	0.001 452 4	1393.0	1407.6	3.3596	0.001 658 1	1585.6	1610.5	3.684
0	0.000 997 7	0.04	5.04	0.0001	0.000 995 2	0.09	10.04	0.0002	0.000 992 8	0.15	15.05	0.000
20	0.000 999 5	83.65	88.65	0.2956	0.000 997 2	83.36	93.33	0.2945	0.000 995 0	83.06	97.99	0.293
40	0.001 005 6	166.95	171.97	0.5705	0.001 003 4	166.35	176.38	0.5686	0.001 001 3	165.76	180.78	0.566
60	0.001 014 9	250.23	255.30	0.8285	0.001 012 7	249.36	259.49	0.8258	0.001 010 5	248.51	263.67	0.823
80	0.001 026 8	333.72	338.85	1.0720	0.001 024 5	332.59	342.83	1.0688	0.001 022 2	331.48	346.81	1.065
100	0.001 041 0	417.52	422.72	1.3030	0.001 038 5	416.12	426.50	1.2992	0.001 036 1	414.74	430.28	1.295
120	0.001 057 6	501.80	507.09	1.5233	0.001 054 9	500.08	510.64	1.5189	0.001 052 2	498.40	514.19	1.514
140	0.001 076 8	586.76	592.15	1.7343	0.001 073 7	584.68	595.42	1.7292	0.001 070 7	582.66	598.72	1.724
160	0.001 098 8	672.62	678.12	1.9375	0.001 095 3	670.13	681.08	1.9317	0.001 091 8	667.71	684.09	1.928
180	0.001 124 0	759.63	765.25	2.1341	0.001 119 9	756.65	767.84	2.1275	0.001 115 9	753.76	770.50	2.121
200	0.001 153 0	848.1	853.9	2.3255	0.001 148 0	844.5	856.0	2.3178	0.001 143 3	841.0	858.2	2.310
220	0.001 186 6	938.4	944.4	2.5128	0.001 180 5	934.1	945.9	2.5039	0.001 174 8	929.9	947.5	2.495
240	0.001 226 4	1031.4	1037.5	2.6979	0.001 218 7	1026.0	1038.1	2.6872	0.001 211 4	1020.8	1039.0	2.677
260	0.001 274 9	1127.9	1134.3	2.8830	0.001 264 5	1121.1	1133.7	2.8699	0.001 255 0	1114.6	1133.4	2.857
280					0.001 321 6	1220.9	1234.1	3.0548	0.001 308 4	1212.5	1232.1	3.035
300					0.001 397 2	1328.4	1342.3	3.2469	0.001 377 0	1316.6	1337.3	3.220
320									0.001 472 4	1431.1	1453.2	3.424
340									0.001 631 1	1567.5	1591.9	3.654
$P = 20 \text{ MPa (365.81°C)}$				$P = 30 \text{ MPa}$				$P = 50 \text{ MPa}$				
Sat.	0.002 036	1785.6	1826.3	4.0139	0.000 985 6	0.25	29.82	0.0001	0.000 976 6	0.20	49.03	0.000
0	0.000 990 4	0.19	20.01	0.0004	0.000 988 6	82.17	111.84	0.2899	0.000 980 4	81.00	130.02	0.284
20	0.000 992 8	82.77	102.62	0.2923	0.000 995 1	164.04	193.89	0.5607	0.000 987 2	161.86	211.21	0.558
40	0.000 999 2	165.17	185.16	0.5646	0.001 004 2	246.06	276.19	0.8154	0.000 996 2	242.98	292.79	0.808
60	0.001 008 4	247.68	267.85	0.8206	0.001 015 6	328.30	358.77	1.0561	0.001 007 3	324.34	374.70	1.044
80	0.001 019 9	330.40	350.80	1.0624	0.001 029 0	410.78	441.66	1.2844	0.001 020 1	405.88	456.89	1.270
100	0.001 033 7	413.39	434.06	1.2917	0.001 044 5	493.59	524.93	1.5018	0.001 034 8	487.65	539.39	1.480
120	0.001 049 6	496.76	517.76	1.5102	0.001 062 1	576.88	608.75	1.7098	0.001 051 5	569.77	622.35	1.690
140	0.001 067 8	580.69	602.04	1.7193	0.001 082 1	660.82	693.28	1.9096	0.001 070 3	652.41	705.92	1.880
160	0.001 088 5	665.35	687.12	1.9204	0.001 104 7	745.59	778.73	2.1024	0.001 091 2	735.69	790.25	2.070
180	0.001 112 0	750.95	773.20	2.1147	0.001 130 2	831.4	865.3	2.2893	0.001 114 6	819.7	875.5	2.260
200	0.001 138 8	837.7	860.5	2.3031	0.001 159 0	918.3	953.1	2.4711	0.001 140 8	904.7	961.7	2.440
220	0.001 169 5	925.9	949.3	2.4870	0.001 192 0	1006.9	1042.6	2.6490	0.001 170 2	990.7	1049.2	2.610
240	0.001 204 6	1016.0	1040.0	2.6674	0.001 230 3	1097.4	1134.3	2.8243	0.001 203 4	1078.1	1138.2	2.780
260	0.001 246 2	1108.6	1133.5	2.8459	0.001 275 5	1190.7	1229.0	2.9986	0.001 241 5	1167.2	1229.3	2.950
280	0.001 296 5	1204.7	1230.6	3.0248	0.001 330 4	1287.9	1327.8	3.1741	0.001 286 0	1258.7	1323.0	3.120
300	0.001 359 6	1306.1	1333.3	3.2071	0.001 399 7	1390.7	1432.7	3.3539	0.001 338 8	1353.3	1420.2	3.280
320	0.001 443 7	1415.7	1444.6	3.3979	0.001 492 0	1501.7	1546.5	3.5426	0.001 403 2	1452.0	1522.1	3.450
340	0.001 568 4	1539.7	1571.0	3.6075	0.001 626 5	1626.6	1675.4	3.7494	0.001 483 8	1556.0	1630.2	3.620
360	0.001 822 6	1702.8	1739.3	3.8772	0.001 869 1	1781.4	1837.5	4.0012	0.001 588 4	1667.2	1746.6	3.810

Source: Gordon J. Van Wylen and Richard E. Sonntag, *Fundamentals of Classical Thermodynamics*, English/SI Version, 3d ed., New York, 1986, pp. 649–650, table A.1.4. Originally published in Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and John Moore, *Steam Tables*, SI Units, Wiley, New York, 1978.

**TABLE A-17**  
Ideal-gas properties of air

$T$ K	$h$ kJ/kg	$P_r$	$u$ kJ/kg	$u_r$	$s^\circ$ kJ/(kg·K)	$T$ K	$h$ kJ/kg	$P_r$	$u$ kJ/kg	$u_r$	$s^\circ$ kJ/(kg·K)
200	199.97	0.3363	142.56	1707.	1.295 59	580	586.04	14.38	419.55	115.7	2.37
210	209.97	0.3987	149.69	1512.	1.344 44	590	596.52	15.31	427.15	110.6	2.39
220	219.97	0.4690	156.82	1346.	1.391 05	600	607.02	16.28	434.78	105.8	2.40
230	230.02	0.5477	164.00	1205.	1.435 57	610	617.53	17.30	442.42	101.2	2.42
240	240.02	0.6355	171.13	1084.	1.478 24	620	628.07	18.36	450.09	96.92	2.44
250	250.05	0.7329	178.28	979.	1.519 17	630	638.63	19.84	457.78	92.84	2.46
260	260.09	0.8405	185.45	887.8	1.558 48	640	649.22	20.64	465.50	88.99	2.47
270	270.11	0.9590	192.60	808.0	1.596 34	650	659.84	21.86	473.25	85.34	2.49
280	280.13	1.0889	199.75	738.0	1.632 79	660	670.47	23.13	481.01	81.89	2.50
285	285.14	1.1584	203.33	706.1	1.650 55	670	681.14	24.46	488.81	78.61	2.52
290	290.16	1.2311	206.91	676.1	1.668 02	680	691.82	25.85	496.62	75.50	2.54
295	295.17	1.3068	210.49	647.9	1.685 15	690	702.52	27.29	504.45	72.56	2.55
300	300.19	1.3860	214.07	621.2	1.702 03	700	713.27	28.80	512.33	69.76	2.57
305	305.22	1.4686	217.67	596.0	1.718 65	710	724.04	30.38	520.23	67.07	2.58
310	310.24	1.5546	221.25	572.3	1.734 98	720	734.82	32.02	528.14	64.53	2.60
315	315.27	1.6442	224.85	549.8	1.751 06	730	745.62	33.72	536.07	62.13	2.61
320	320.29	1.7375	228.42	528.6	1.766 90	740	756.44	35.50	544.02	59.82	2.63
325	325.31	1.8345	232.02	508.4	1.782 49	750	767.29	37.35	551.99	57.63	2.64
330	330.34	1.9352	235.61	489.4	1.797 83	760	778.18	39.27	560.01	55.54	2.66
340	340.42	2.149	242.82	454.1	1.827 90	780	800.03	43.35	576.12	51.64	2.69
350	350.49	2.379	250.02	422.2	1.857 08	800	821.95	47.75	592.30	48.08	2.71
360	360.58	2.626	257.24	393.4	1.885 43	820	843.98	52.59	608.59	44.84	2.74
370	370.67	2.892	264.46	367.2	1.913 13	840	866.08	57.60	624.95	41.85	2.77
380	380.77	3.176	271.69	343.4	1.940 01	860	888.27	63.09	641.40	39.12	2.79
390	390.88	3.481	278.93	321.5	1.966 33	880	910.56	68.98	657.95	36.61	2.82
400	400.98	3.806	286.16	301.6	1.991 94	900	932.93	75.29	674.58	34.31	2.84
410	411.12	4.153	293.43	283.3	2.016 99	920	955.38	82.05	691.28	32.18	2.87
420	421.26	4.522	300.69	266.6	2.041 42	940	977.92	89.28	708.08	30.22	2.89
430	431.43	4.915	307.99	251.1	2.065 33	960	1000.55	97.00	725.02	28.40	2.92
440	441.61	5.332	315.30	236.8	2.088 70	980	1023.25	105.2	741.98	26.73	2.94
450	451.80	5.775	322.62	223.6	2.111 61	1000	1046.04	114.0	758.94	25.17	2.96
460	462.02	6.245	329.97	211.4	2.134 07	1020	1068.89	123.4	776.10	23.72	2.98
470	472.24	6.742	337.32	200.1	2.156 04	1040	1091.85	133.3	793.36	22.39	3.01
480	482.49	7.268	344.70	189.5	2.177 60	1060	1114.86	143.9	810.62	21.14	3.03
490	492.74	7.824	352.08	179.7	2.198 76	1080	1137.89	155.2	827.88	19.98	3.05
500	503.02	8.411	359.49	170.6	2.219 52	1100	1161.07	167.1	845.33	18.896	3.07
510	513.32	9.031	366.92	162.1	2.239 93	1120	1184.28	179.7	862.79	17.886	3.09
520	523.63	9.684	374.36	154.1	2.259 97	1140	1207.57	193.1	880.35	16.946	3.11
530	533.98	10.37	381.84	146.7	2.279 67	1160	1230.92	207.2	897.91	16.064	3.13
540	544.35	11.10	389.34	139.7	2.299 06	1180	1254.34	222.2	915.57	15.241	3.15
550	554.74	11.86	396.86	133.1	2.318 09	1200	1277.79	238.0	933.33	14.470	3.17
560	565.17	12.66	404.42	127.0	2.336 85	1220	1301.31	254.7	951.09	13.747	3.19
570	575.59	13.50	411.97	121.2	2.355 31	1240	1324.93	272.3	968.95	13.069	3.21

TABLE A-17  
(Continued)

$T$ K	$h$ kJ/kg	$P_r$	$u$ kJ/kg	$v_r$	$s^\circ$ kJ/(kg·K)	$T$ K	$h$ kJ/kg	$P_r$	$u$ kJ/kg	$v_r$	$s^\circ$ kJ/(kg·K)
1260	1348.55	290.8	986.90	12.435	3.236 38	1600	1757.57	791.2	1298.30	5.804	3.523 6
1280	1372.24	310.4	1004.76	11.835	3.255 10	1620	1782.00	834.1	1316.96	5.574	3.538 7
1300	1395.97	330.9	1022.82	11.275	3.273 45	1640	1806.46	878.9	1335.72	5.355	3.553 8
1320	1419.76	352.5	1040.88	10.747	3.291 60	1660	1830.96	925.6	1354.48	5.147	3.568 9
1340	1443.60	375.3	1058.94	10.247	3.309 59	1680	1855.50	974.2	1373.24	4.949	3.583 9
1360	1467.49	399.1	1077.10	9.780	3.327 24	1700	1880.1	1025	1392.7	4.761	3.5979
1380	1491.44	424.2	1095.26	9.337	3.344 74	1750	1941.6	1161	1439.8	4.328	3.6336
1400	1515.42	450.5	1113.52	8.919	3.362 00	1800	2003.3	1310	1487.2	3.944	3.6684
1420	1539.44	478.0	1131.77	8.526	3.379 01	1850	2065.3	1475	1534.9	3.601	3.7023
1440	1563.51	506.9	1150.13	8.153	3.395 86	1900	2127.4	1655	1582.6	3.295	3.7354
1460	1587.63	537.1	1168.49	7.801	3.412 47	1950	2189.7	1852	1630.6	3.022	3.7677
1480	1611.79	568.8	1186.95	7.468	3.428 92	2000	2252.1	2068	1678.7	2.776	3.7994
1500	1635.97	601.9	1205.41	7.152	3.445 16	2050	2314.6	2303	1726.8	2.555	3.8303
1520	1660.23	636.5	1223.87	6.854	3.461 20	2100	2377.4	2559	1775.3	2.356	3.8605
1540	1684.51	672.8	1242.43	6.569	3.477 12	2150	2440.3	2837	1823.8	2.175	3.8901
1560	1708.82	710.5	1260.99	6.301	3.492 76	2200	2503.2	3138	1872.4	2.012	3.9191
1580	1733.17	750.0	1279.65	6.046	3.508 29	2250	2566.4	3464	1921.3	1.864	3.9474

Source: Kenneth Wark, *Thermodynamics*, 4th ed., McGraw-Hill, New York, 1983, pp. 785-786, table A-5M. Originally published in J. Keenan and J. Kays, *Gas Tables*, Wiley, New York, 1948.

**TABLE A-11**  
Saturated refrigerant-12—Temperature table

Temp. °C <i>T</i>	Sat. press. MPa <i>P<sub>sat</sub></i>	Specific volume m <sup>3</sup> /kg		Internal energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/(kg·K)	
		Sat. liquid <i>v<sub>f</sub></i>	Sat. vapor <i>v<sub>g</sub></i>	Sat. liquid <i>u<sub>f</sub></i>	Sat. vapor <i>u<sub>g</sub></i>	Sat. liquid <i>h<sub>f</sub></i>	Evap. <i>h<sub>fg</sub></i>	Sat. vapor <i>h<sub>g</sub></i>	Sat. liquid <i>s<sub>f</sub></i>	Sat. vap <i>s<sub>g</sub></i>
-40	0.06417	0.0006 595	0.241 91	-0.04	154.07	0	169.59	169.59	0	0.72
-35	0.08071	0.0006 656	0.195 40	4.37	156.13	4.42	167.48	171.90	0.0187	0.72
-30	0.10041	0.0006 720	0.159 38	8.79	158.20	8.86	165.33	174.20	0.0371	0.71
-28	0.10927	0.0006 746	0.147 28	10.58	159.02	10.65	164.46	175.11	0.0444	0.71
-26	0.11872	0.0006 773	0.136 28	12.35	159.84	12.43	163.59	176.02	0.0517	0.71
-25	0.12368	0.0006 786	0.131 17	13.25	160.26	13.33	163.15	176.48	0.0552	0.71
-24	0.12880	0.0006 800	0.126 28	14.13	160.67	14.22	162.71	176.93	0.0589	0.71
-22	0.13953	0.0006 827	0.117 17	15.92	161.48	16.02	161.82	177.83	0.0660	0.71
-20	0.15093	0.0006 855	0.108 85	17.72	162.31	17.82	160.92	178.74	0.0731	0.70
-18	0.16304	0.0006 883	0.101 24	19.51	163.12	19.62	160.01	179.63	0.0802	0.70
-15	0.18260	0.0006 926	0.091 02	22.20	164.35	22.33	158.64	180.97	0.0906	0.70
-10	0.21912	0.0007 000	0.076 65	26.72	166.39	26.87	156.31	183.19	0.1080	0.70
-5	0.26096	0.0007 078	0.064 96	31.27	168.42	31.45	153.93	185.37	0.1251	0.69
0	0.30861	0.0007 159	0.055 39	35.83	170.44	36.05	151.48	187.53	0.1420	0.69
4	0.35124	0.0007 227	0.048 95	39.51	172.04	39.76	149.47	189.23	0.1553	0.69
8	0.39815	0.0007 297	0.043 40	43.21	173.63	43.50	147.41	190.91	0.1686	0.69
12	0.44962	0.0007 370	0.038 60	46.93	175.20	47.26	145.30	192.56	0.1817	0.69
16	0.50591	0.0007 446	0.034 42	50.67	176.78	51.05	143.14	194.19	0.1948	0.68
20	0.56729	0.0007 525	0.030 78	54.44	178.32	54.87	140.91	195.78	0.2078	0.68
24	0.63405	0.0007 607	0.027 59	58.25	179.85	58.73	138.61	197.34	0.2207	0.68
26	0.66954	0.0007 650	0.026 14	60.17	180.61	60.68	137.44	198.11	0.2271	0.68
28	0.70648	0.0007 694	0.024 78	62.09	181.36	62.63	136.24	198.87	0.2335	0.68
30	0.74490	0.0007 739	0.023 51	64.01	182.11	64.59	135.03	199.62	0.2400	0.68
32	0.78485	0.0007 785	0.022 31	65.96	182.85	66.57	133.79	200.36	0.2463	0.68
34	0.82636	0.0007 832	0.021 18	67.90	183.59	68.55	132.53	201.09	0.2527	0.68
36	0.86948	0.0007 880	0.020 12	69.86	184.31	70.55	131.25	201.80	0.2591	0.68
38	0.91423	0.0007 929	0.019 12	71.84	185.03	72.56	129.94	202.51	0.2655	0.68
40	0.96065	0.0007 980	0.018 17	73.82	185.74	74.59	128.61	203.20	0.2718	0.68
42	1.0086	0.0008 033	0.017 28	75.82	186.45	76.63	127.25	203.88	0.2782	0.68
44	1.0587	0.0008 086	0.016 44	77.82	187.13	78.68	125.87	204.54	0.2845	0.68
48	1.1639	0.0008 199	0.014 88	81.88	188.51	82.83	123.00	205.83	0.2973	0.68
52	1.2766	0.0008 318	0.013 49	86.00	189.83	87.06	119.99	207.05	0.3101	0.67
56	1.3972	0.0008 445	0.012 24	90.18	191.10	91.36	116.84	208.20	0.3229	0.67
60	1.5259	0.0008 581	0.011 11	94.43	192.31	95.74	113.52	209.26	0.3358	0.67
112	4.1155	0.0017 92	0.001 79	175.98	175.98	183.35	0	183.35	0.5687	0.56

Source: Adapted from Kenneth Wark, *Thermodynamics*, 4th ed., McGraw-Hill, New York, 1983, pp. 807–808, table A-16M. Original published by E. I. du Pont de Nemours & Company, Inc., 1969.

**TABLE A-13**  
Superheated refrigerant-12

Temp. °C	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)
	<b>0.060 MPa (<math>T_{sat} = -41.42^\circ\text{C}</math>)</b>				<b>0.10 MPa (<math>T_{sat} = -30.10^\circ\text{C}</math>)</b>			
Sat.	0.257 5	153.49	168.94	0.7290	0.160 0	158.15	174.15	0.717
-40	0.259 3	154.16	169.72	0.7324	0.167 7	163.22	179.99	0.740
-20	0.283 8	163.91	180.94	0.7785	0.182 7	173.50	191.77	0.785
0	0.307 9	174.05	192.52	0.8225	0.190 0	178.77	197.77	0.807
10	0.319 8	179.26	198.45	0.8439	0.197 3	184.12	203.85	0.828
20	0.331 7	184.57	204.47	0.8647	0.204 5	189.57	210.02	0.848
30	0.343 5	189.96	210.57	0.8852	0.211 7	195.09	216.26	0.869
40	0.355 2	195.46	216.77	0.9053	0.218 8	200.70	222.58	0.888
50	0.367 0	201.02	223.04	0.9251	0.226 0	206.38	228.98	0.908
60	0.378 7	206.69	229.41	0.9444	0.240 1	218.00	242.01	0.946
80	0.402 0	218.25	242.37	0.9822				
	<b>0.14 MPa (<math>T_{sat} = -21.91^\circ\text{C}</math>)</b>				<b>0.18 MPa (<math>T_{sat} = -15.38^\circ\text{C}</math>)</b>			
Sat.	0.116 8	161.52	177.87	0.7102	0.092 2	164.20	180.80	0.705
-20	0.117 9	162.50	179.01	0.7147	0.092 5	164.39	181.03	0.718
-10	0.123 5	167.69	184.97	0.7378	0.099 1	172.37	190.21	0.740
0	0.128 9	172.94	190.99	0.7602	0.103 4	177.77	196.38	0.763
10	0.134 3	178.28	197.08	0.7821	0.107 6	183.23	202.60	0.784
20	0.139 7	183.67	203.23	0.8035	0.111 8	188.77	208.89	0.806
30	0.144 9	189.17	209.46	0.8243	0.116 0	194.35	215.23	0.828
40	0.150 2	194.72	215.75	0.8447	0.120 1	200.02	221.64	0.849
50	0.155 3	200.38	222.12	0.8648	0.124 1	205.78	228.12	0.870
60	0.160 5	206.08	228.55	0.8844	0.132 2	217.47	241.27	0.900
80	0.170 7	217.74	241.64	0.9225	0.140 2	229.45	254.69	0.940
100	0.180 9	229.67	255.00	0.9593				
	<b>0.20 MPa (<math>T_{sat} = -12.53^\circ\text{C}</math>)</b>				<b>0.24 MPa (<math>T_{sat} = -7.42^\circ\text{C}</math>)</b>			
Sat.	0.083 5	165.37	182.07	0.7035	0.070 3	167.45	184.32	0.700
0	0.088 6	172.08	189.08	0.7325	0.072 9	171.49	188.99	0.711
10	0.092 6	177.50	196.02	0.7548	0.076 3	176.98	195.29	0.740
20	0.096 4	183.00	202.28	0.7766	0.079 6	182.53	201.63	0.763
30	0.100 2	188.56	208.60	0.7978	0.082 8	188.14	208.01	0.784
40	0.104 0	194.17	214.97	0.8184	0.086 0	193.80	214.44	0.806
50	0.107 7	199.86	221.40	0.8387	0.089 2	199.51	220.92	0.828
60	0.111 4	205.62	227.90	0.8585	0.092 3	205.31	227.46	0.849
80	0.118 7	217.35	241.09	0.8969	0.098 5	217.07	240.71	0.880
100	0.125 9	229.35	254.53	0.9339	0.104 5	229.12	254.20	0.920
120	0.133 1	241.59	268.21	0.9696	0.110 5	241.41	267.93	0.950

TABLE A-  
Saturated refrigerant-12-Pressure ta

Press. MPa	Sat. Temp. °C $T_{sat}$	Specific volume m <sup>3</sup> /kg		Internal energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/(kg·K)	
		Sat. liquid $v_f$	Sat. vapor $v_g$	Sat. liquid $u_f$	Sat. vapor $u_g$	Sat. liquid $h_f$	Evap. $h_{fg}$	Sat. vapor $h_g$	Sat. liquid $s_f$	Sat vap $s_g$
0.06	-41.42	0.000 657 8	0.2575	-1.29	153.49	-1.25	170.19	168.94	-0.0054	0.71
0.10	-30.10	0.000 671 9	0.1600	8.71	158.15	8.78	165.37	174.15	0.0368	0.71
0.12	-25.74	0.000 677 6	0.1349	12.58	159.95	12.66	163.48	176.14	0.0526	0.71
0.14	-21.91	0.000 682 8	0.1168	15.99	161.52	16.09	161.78	177.87	0.0663	0.71
0.16	-18.49	0.000 687 6	0.1031	19.07	162.91	19.18	160.23	179.41	0.0784	0.71
0.18	-15.38	0.000 692 1	0.092 25	21.86	164.19	21.98	158.82	180.80	0.0893	0.71
0.20	-12.53	0.000 696 2	0.083 54	24.43	165.36	24.57	157.50	182.07	0.0992	0.71
0.24	-7.42	0.000 704 0	0.070 33	29.06	167.44	29.23	155.09	184.32	0.1168	0.71
0.28	-2.93	0.000 711 1	0.060 76	33.15	169.26	33.35	152.92	186.27	0.1321	0.61
0.32	1.11	0.000 717 7	0.053 51	36.85	170.88	37.08	150.92	188.00	0.1457	0.61
0.40	8.15	0.000 729 9	0.043 21	43.35	173.69	43.64	147.33	190.97	0.1691	0.61
0.50	15.60	0.000 743 8	0.034 82	50.30	176.61	50.67	143.35	194.02	0.1935	0.61
0.60	22.00	0.000 756 6	0.029 13	56.35	179.09	56.80	139.77	196.57	0.2142	0.61
0.70	27.65	0.000 768 6	0.025 01	61.75	181.23	62.29	136.45	198.74	0.2324	0.61
0.80	32.74	0.000 780 2	0.021 88	66.68	183.13	67.30	133.33	200.63	0.2487	0.61
0.90	37.37	0.000 791 4	0.019 42	71.22	184.81	71.93	130.36	202.29	0.2634	0.61
1.0	41.64	0.000 802 3	0.017 44	75.46	186.32	76.26	127.50	203.76	0.2770	0.61
1.2	49.31	0.000 823 7	0.014 41	83.22	188.95	84.21	122.03	206.24	0.3015	0.61
1.4	56.09	0.000 844 8	0.012 22	90.28	191.11	91.46	116.76	208.22	0.3232	0.61
1.6	62.19	0.000 866 0	0.010 54	96.80	192.95	98.19	111.62	209.81	0.3329	0.61

Source: Adapted from Kenneth Wark, *Thermodynamics*, 4th ed., McGraw-Hill, New York, 1983, p. 809. table A-17M. Originally published by E. I. du Pont de Nemours & Company, Inc., 1969.

TABLE A-1  
(Continued)

Temp. °C	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)
<b>0.28 MPa (<math>T_{sat} = -2.93^{\circ}\text{C}</math>)</b>					<b>0.32 MPa (<math>T_{sat} = 1.11^{\circ}\text{C}</math>)</b>			
Sat.	0.060 76	169.26	186.27	0.6980	0.053 51	170.88	188.00	0.6960
0	0.061 66	170.89	188.15	0.7049				
10	0.064 64	176.45	194.55	0.7279	0.055 90	175.90	193.79	0.7167
20	0.067 55	182.06	200.97	0.7502	0.058 52	181.57	200.30	0.7393
30	0.070 40	187.71	207.42	0.7718	0.061 06	187.28	206.82	0.7612
40	0.073 19	193.42	213.91	0.7928	0.063 55	193.02	213.36	0.7824
50	0.075 94	199.18	220.44	0.8134	0.066 00	198.82	219.94	0.8031
60	0.078 65	205.00	227.02	0.8334	0.068 41	204.68	226.57	0.8233
80	0.083 99	216.82	240.34	0.8722	0.073 14	216.55	239.96	0.8623
100	0.089 24	228.29	253.88	0.9095	0.077 78	228.66	253.55	0.8997
120	0.094 43	241.21	267.65	0.9455	0.082 36	241.00	267.36	0.9358
<b>0.40 MPa (<math>T_{sat} = 8.15^{\circ}\text{C}</math>)</b>					<b>0.50 MPa (<math>T_{sat} = 15.60^{\circ}\text{C}</math>)</b>			
Sat.	0.043 21	173.69	190.97	0.6928	0.034 82	176.61	194.02	0.6899
10	0.043 63	174.76	192.21	0.6972				
20	0.045 84	180.57	198.91	0.7204	0.035 65	179.26	197.08	0.7004
30	0.047 97	186.39	205.58	0.7428	0.037 46	185.23	203.96	0.7235
40	0.050 05	192.23	212.25	0.7645	0.039 22	191.20	210.81	0.7457
50	0.052 07	198.11	218.94	0.7855	0.040 91	197.19	217.64	0.7672
60	0.054 06	204.03	225.65	0.8060	0.042 57	203.20	224.48	0.7881
80	0.057 91	216.03	239.19	0.8454	0.045 78	215.32	238.21	0.8281
100	0.061 73	228.20	252.89	0.8831	0.048 89	227.61	252.05	0.8662
120	0.065 46	240.61	266.79	0.9194	0.051 93	240.10	266.06	0.9028
140	0.069 13	253.23	280.88	0.9544	0.054 92	252.77	280.23	0.9379
<b>0.60 MPa (<math>T_{sat} = 22.00^{\circ}\text{C}</math>)</b>					<b>0.70 MPa (<math>T_{sat} = 27.65^{\circ}\text{C}</math>)</b>			
Sat.	0.029 13	179.09	196.57	0.6878	0.025 01	181.23	198.74	0.6860
30	0.030 42	184.01	202.26	0.7068	0.025 35	182.72	200.46	0.6917
40	0.031 97	190.13	209.31	0.7297	0.026 76	189.00	207.73	0.7153
50	0.033 45	196.23	216.30	0.7516	0.028 10	195.23	214.90	0.7378
60	0.034 89	202.34	223.27	0.7729	0.029 39	201.45	222.02	0.7595
80	0.037 65	214.61	237.20	0.8135	0.031 84	213.88	236.17	0.8008
100	0.040 32	227.01	251.20	0.8520	0.034 19	226.40	250.33	0.8398
120	0.042 91	239.57	265.32	0.8889	0.036 46	239.05	264.57	0.8769
140	0.045 45	252.31	279.58	0.9243	0.038 67	251.85	278.92	0.9125
160	0.047 94	265.25	294.01	0.9584	0.040 85	264.83	293.42	0.9468

TABLE A-13

(Continued)

Temp. °C	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)	$v$ m <sup>3</sup> /kg	$u$ kJ/kg	$h$ kJ/kg	$s$ kJ/(kg·K)
<b>0.80 MPa (<math>T_{sat} = 32.74^\circ\text{C}</math>)</b>					<b>0.90 MPa (<math>T_{sat} = 37.37^\circ\text{C}</math>)</b>			
Sat.	0.021 88	183.13	200.63	0.6845	0.019 42	184.81	202.29	0.6832
40	0.022 83	187.81	206.07	0.7021	0.019 74	186.55	204.32	0.6897
50	0.024 07	194.19	213.45	0.7253	0.020 91	193.10	211.92	0.7136
60	0.025 25	200.52	220.72	0.7474	0.022 01	199.56	219.37	0.7361
80	0.027 48	213.13	235.11	0.7894	0.024 07	212.37	234.03	0.7790
100	0.029 59	225.77	249.44	0.8289	0.026 01	225.13	248.54	0.8190
120	0.031 62	238.51	263.81	0.8664	0.027 85	237.97	263.03	0.8566
140	0.033 59	251.39	278.26	0.9022	0.029 64	250.90	277.58	0.8937
160	0.035 52	264.41	292.83	0.9367	0.031 38	263.99	292.23	0.9277
180	0.037 42	277.60	307.54	0.9699	0.033 09	277.23	307.01	0.9600
<b>1.0 MPa (<math>T_{sat} = 41.64^\circ\text{C}</math>)</b>					<b>1.2 MPa (<math>T_{sat} = 49.31^\circ\text{C}</math>)</b>			
Sat.	0.017 44	186.32	203.76	0.6820	0.014 41	188.95	206.24	0.6790
50	0.018 37	191.95	210.32	0.7026	0.014 48	189.43	206.81	0.6811
60	0.019 41	198.56	217.97	0.7259	0.015 46	196.41	214.96	0.7060
80	0.021 34	211.57	232.91	0.7695	0.017 22	209.91	230.57	0.7520
100	0.023 13	224.48	247.61	0.8100	0.018 81	223.13	245.70	0.7930
120	0.024 84	237.41	262.25	0.8482	0.020 30	236.27	260.53	0.8320
140	0.026 47	250.43	276.90	0.8845	0.021 72	249.45	275.51	0.8690
160	0.028 07	263.56	291.63	0.9193	0.023 09	263.70	290.41	0.9040
180	0.029 63	276.84	306.47	0.9528	0.024 43	276.05	305.37	0.9380
200	0.031 16	290.26	321.42	0.9851	0.025 74	289.55	320.44	0.9710
<b>1.4 MPa (<math>T_{sat} = 56.09^\circ\text{C}</math>)</b>					<b>1.6 MPa (<math>T_{sat} = 62.19^\circ\text{C}</math>)</b>			
Sat.	0.012 22	191.11	208.22	0.6778	0.010 54	192.95	209.81	0.6750
60	0.012 58	194.00	211.61	0.6881				
80	0.014 25	208.11	228.06	0.7360	0.011 98	206.17	225.34	0.7200
100	0.015 71	221.70	243.69	0.7791	0.013 37	220.19	241.58	0.7600
120	0.017 05	235.09	258.96	0.8189	0.014 61	233.84	257.22	0.8000
140	0.018 32	248.43	274.08	0.8564	0.015 77	247.38	272.61	0.8400
160	0.019 54	261.80	289.16	0.8921	0.016 86	260.90	287.88	0.8800
180	0.020 71	275.27	304.26	0.9262	0.017 92	274.47	303.14	0.9100
200	0.021 86	288.84	319.44	0.9589	0.018 95	288.11	318.43	0.9400
220	0.022 99	302.51	334.70	0.9905	0.019 96	301.84	333.78	0.9800

Source: Adapted from Kenneth Wark, *Thermodynamics*, 4th ed., McGraw-Hill, New York, 1983, pp. 810–812, table A-18M. Or published by E. I. du Pont de Nemours & Company, Inc., 1969.