Thermodynamic Property Tables

Property Tables

- If you have 2 properties, you can find the others using the thermodynamic property tables.
- E.g. If you have pressure and temperature for steam, you can find it's specific volume, enthalpy, internal energy, and entropy.
- There are separate property tables for saturated mixtures, subcooled liquids, superheated vapors, and ideal gases.
- Thermodynamic property tables can be found in the back of your textbook or various places online.

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Interpolation

- Interpolation allows you to find values that are in between what the table provides
- The interpolation factor is consistent throughout the table for each individual state and is given by:

$$a = \frac{v - v_l}{v_h - v_l}$$

where *v* is the actual (given) property value, *vl* is the lower value on the chart, and *vh* is the higher value on the chart.

- E.g. If a subcooled liquid has a known pressure of 3.0 kPa, and a temperature of 27°C, but the only temperatures listed on the chart are 20°C and 30°C, then the interpolation factor is:

$$a = \frac{T - T_l}{T_h - T_l} = \frac{27 - 20}{30 - 20} = 0.7$$

- Other properties are found by:

$$v = v_l + a * (v_h - v_l)$$

$$u = u_l + a * (u_h - u_l)$$

$$h = h_l + a * (h_h - h_l)$$

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Saturated Property Tables

- Between a liquid and a vapor – contains both.
- Quality ($0 \leq x \leq 1$) determines properties.
- A quality of 0 is a saturated liquid.
- A quality of 1 is a saturated vapor.
- If given a temperature and a pressure, the quality is needed to determine its other properties.
- To determine whether or not a substance is a saturated mixture from the pressure and temperature, look at the pressure charts.
- If the temperature of the actual substance is higher than the saturated temperature, it's a superheated vapor.
- If it's lower, it's a subcooled liquid.
- If the two temperatures are equal, it is a saturated mixture.

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Temperature Tables

- Use the temperature table for when you are given the temperature of a saturated mixture
- Use the temperature and the quality to determine the other properties
- E.g. For steam at 70°C and a quality of 0.25, the specific volume is:

$$v = v_f + x * (v_g - v_f)$$

$$v = .00102 + .25 * (5.0395 - .00102)$$

$$v = 1.2606 \; m^3/kg$$

Temp	Pressure	volume (m^3/kg)		energy (kJ/kg)	
°C	MPa	vf	vg	uf	ug
0.01	0.00061	0.00100	205.99	0	2374.9
5	0.00087	0.00100	147.01	21.02	2381.8
10	0.00123	0.00100	106.30	42.02	2388.6
15	0.00171	0.00100	77.875	62.98	2395.5
20	0.00234	0.00100	57.757	83.91	2402.3
25	0.00317	0.00100	43.337	104.83	2409.1
30	0.00425	0.00100	32.878	125.73	2415.9
35	0.00563	0.00101	25.205	146.63	2422.7
40	0.00739	0.00101	19.515	167.53	2429.4
45	0.00960	0.00101	15.252	188.43	2436.1
50	0.01235	0.00101	12.027	209.33	2442.7
55	0.01576	0.00102	9.5643	230.24	2449.3
60	0.01995	0.00102	7.6672	251.16	2455.9
65	0.02504	0.00102	6.1935	272.09	2462.4
70	0.03120	0.00102	5.0395	293.03	2468.9
75	0.03860	0.00103	4.1289	313.99	2475.2
80	0.04741	0.00103	3.4052	334.96	2481.6
85	0.05787	0.00103	2.8258	355.95	2487.8
90	0.07018	0.00104	2.3591	376.97	2494.0
95	0.08461	0.00104	1.9806	398.00	2500.0
100	0.10142	0.00104	1.6718	419.06	2506.0
110	0.14338	0.00105	1.2093	461.26	2517.7
120	0.19867	0.00106	0.8912	503.60	2528.9
130	0.27028	0.00107	0.66800	546.09	2539.5

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Temperature Tables

- If given temperature and another property, find the quality by reversing the process.
- E.g. For steam at 70°C and a specific energy of 1000kJ/kg:

$$x = \frac{u - u_f}{u_g - u_f}$$

$$x = \frac{1000 - 293.03}{2468.9 - 293.03}$$

$$x = 0.325$$

- The pressure for any saturated mixture is the pressure at that temperature

Temp	Pressure	volume (m^3/kg)		energy (kJ/kg)	
°C	MPa	vf	vg	uf	ug
0.01	0.00061	0.00100	205.99	0	2374.9
5	0.00087	0.00100	147.01	21.02	2381.8
10	0.00123	0.00100	106.30	42.02	2388.6
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130	0.27028	0.00107	0.66800	546.09	2539.5

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Pressure Tables

- Use the pressure table for when you are given the pressure of a saturated mixture
- Like the temperature table, use the pressure and the quality to determine the other properties
- E.g. For R134a at 300kPa and a quality of 0.25, the specific volume is:

$$v = v_f + x * (v_g - v_f)$$

$$v = .0007737 + .25 * (.0677 - .0007737)$$

$$v = .0175 \ m^3/kg$$

R134a - TetraFlouroEthane Saturation Properties -

Pressure	Temp	volume (m^3/kg)		enthalpy (	
kPa	°C	vf	vg	hf	hfg
60	-36.9	0.0007098	0.3112	3.9	
80	-31.1	0.0007185	0.2376	11.3	
100	-26.4	0.0007259	0.1926	17.3	
120	-22.3	0.0007324	0.1621	22.5	
140	-18.8	0.0007383	0.1402	27.1	
160	-15.6	0.0007437	0.1235	31.2	
180	-12.7	0.0007487	0.1104	35.0	
200	-10.1	0.0007534	0.0999	38.5	
220	-7.6	0.0007578	0.0912	41.7	
240	-5.4	0.0007620	0.0839	44.7	
260	-3.2	0.0007661	0.0777	47.5	
280	-1.2	0.0007699	0.0724	50.2	
300	0.7	0.0007737	0.0677	52.8	
320	2.5	0.0007773	0.0636	55.2	
340	4.2	0.0007808	0.0600	57.5	
360	5.8	0.0007842	0.0567	59.8	
400	8.9	0.0007907	0.0512	64.0	
500	15.7	0.0008060	0.0411	73.4	
600	21.6	0.0008200	0.0343	81.5	
700	26.7	0.0008332	0.0294	88.8	
800	31.3	0.0008459	0.0256	95.5	
900	35.5	0.0008581	0.0227	101.6	
1000	39.4	0.0008701	0.0203	107.4	

Superheated Gas Tables

- Used for temperatures higher than the saturation temperature at a given pressure.
- Any two properties allow you to find all other properties at that state.
- E.g. For superheated R744 at 100° and h=558 kJ/kg, the pressure is:

$$a = \frac{h - h_l}{h_h - h_l}$$

$$a = \frac{558 - 554.73}{560.97 - 554.73} = 0.524$$

$$P = P_l + a * (P_h - P_l)$$

$$P = 3.0 + .524 * (2.0 - 3.0)$$

$$P = 2.48\ MPa$$

Carbon Dioxide Refrigerant (R744) - Superheated

P = 3.0 MPa (-5.55°C)

Temp	volume	enthalpy	entropy
°C	v(m^3/kg)	h(kJ/kg)	s(kJ/kg.K)
Sat.	0.012207	433.61	1.8754
0	0.012931	442.22	1.9072
10	0.014082	455.98	1.9567
20	0.015116	468.46	2.0001
30	0.016074	480.20	2.0395
40	0.01698	491.46	2.0760
50	0.017847	502.39	2.1104
60	0.018683	513.09	2.1430
70	0.019495	523.64	2.1742
80	0.020287	534.07	2.2041
90	0.021063	544.42	2.2330
100	0.021824	554.73	2.2610
110	0.022574	565.00	2.2882
120	0.023313	575.26	2.3146
130	0.024043	585.51	2.3404
140	0.024766	595.77	2.3655
150	0.025481	606.05	2.3901
160	0.026191	616.35	2.4142
170	0.026895	626.67	2.4377

P = 2.0 MPa (-19.5°C)

Temp	volume	enthalpy	entropy
°C	v(m^3/kg)	h(kJ/kg)	s(kJ/kg.K)
Sat.	0.019033	436.85	1.9461
-10	0.020507	448.58	1.9915
0	0.021926	460.00	2.0341
10	0.023257	470.84	2.0731
20	0.024526	481.32	2.1095
30	0.025748	491.57	2.1438
40	0.026934	501.65	2.1766
50	0.028091	511.63	2.2079
60	0.029224	521.54	2.2381
70	0.030337	531.41	2.2673
80	0.031434	541.26	2.2956
90	0.032516	551.11	2.3231
100	0.033586	560.97	2.3499
110	0.034646	570.85	2.3760
120	0.035696	580.76	2.4015
130	0.036738	590.69	2.4265
140	0.037773	600.66	2.4509
150	0.038802	610.68	2.4749
160	0.039825	620.73	2.4984
170	0.040842	630.84	2.5214

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Subcooled Liquid Tables

- Used for temperatures lower than the saturation temperature at a given pressure
- Any two properties allow you to find all other properties at that state.
- E.g. For subcooled water at 240°C and u=1027 KJ/kg, the pressure is:

$$a = \frac{u - u_l}{u_h - u_l}$$

$$a = \frac{1027 - 1026.1}{1031.6 - 1026.1} = 0.164$$

$$P = P_l + a * (P_h - P_l)$$

$$P = 10.0 + .164 * (5.0 - 10.0)$$

$$P = 9.18\ MPa$$

Compressed Liquid Water Properties - (5 MPa

	P = 5 MPa				P = 10 MPa			
Temp	density	energy	enthalpy	entropy	density	energy	enthalpy	entropy
°C	kg/m^3	u(kJ/kg)	h(kJ/kg)	s(kJ/kg.K)	kg/m^3	u(kJ/kg)	h(kJ/kg)	s(kJ/kg.K)
20	1000.4	83.6	88.6	0.2954	1002.7	83.3	93.3	0.2944
40	994.4	166.9	172.0	0.5705	996.5	166.3	176.4	0.5685
60	985.3	250.3	255.4	0.8287	987.5	249.4	259.5	0.8260
80	974.0	333.8	339.0	1.0723	976.2	332.7	342.9	1.0691
100	960.6	417.6	422.9	1.3034	962.9	416.2	426.6	1.2996
120	945.5	501.9	507.2	1.5236	947.9	500.2	510.7	1.5191
140	928.6	586.8	592.2	1.7344	931.3	584.7	595.5	1.7293
160	910.1	672.6	678.0	1.9374	913.0	670.1	681.0	1.9315
180	889.7	759.5	765.1	2.1338	892.9	756.5	767.7	2.1271
200	867.3	847.9	853.7	2.3251	870.9	844.3	855.8	2.3174
220	842.6	938.4	944.3	2.5127	846.8	934.0	945.8	2.5037
240	815.1	1031.6	1037.7	2.6983	820.2	1026.1	1038.3	2.6876
260	784.0	1128.5	1134.9	2.8841	790.3	1121.6	1134.3	2.8710

References

Fundamentals of Engineering Thermodynamics, Moran and Shapiro, Ch.3

Thermodynamics – Theory http://ecourses.ou.edu/cgi-bin/ebook.cgi?doc=&topic=th&chap_sec=02.3&page=theory

Steam Tables – Thermodynamics http://www.engineersedge.com/thermodynamics/steam_tables.htm

Guide to Using the Two-Phase Property Tables http://abata.sdsmt.edu/pdf_files/ME211/Guide%20to%20Using%20the%20Two%20Phase%20Property%20Tables.pdf

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