3 - AR No. 2 - Recover Flash Steam

Oregon State University | Energy Efficiency Center

Flash Steam Recovery, style 2018 v1.0

Recommendation

Install a flash steam recovery tank to capture the boiler flash steam and preheat the feed water, rather than using boiler steam, reducing hog fuel use by 14.5%.

Annual Savings Summary

Source	*Quantity*	*Units*	*Cost Savings*
Hog Fuel	896	BDT	$17,929

Implementation Cost Summary

Description	*Cost*	*Payback (yrs)*
Implementation Cost	$8,549	0.5

Facility Background

The facility operates a hog fuel boiler as its primary source of steam and maintains a backup natural gas boiler to provide additional steam when the primary boiler cannot keep up with demand. The hog fuel boiler has an average firing rate of 25.5 MMBtu per hour, with an average steam supply rate of approximately 25,000 pounds per hour. Hog fuel is typically sold at a cost of $20/BDT and annual fuel use is approximately 9,547 BDT (bone-dry tons) of hog fuel, the total value of the fuel is approximately $190,940. The natural gas boiler's maximum steam supply is 12,700 pounds per hour, and the incremental cost of natural gas is $3.20/MMBtu. Steam pressure is maintained at 190 psig and temperature is assumed to be 384 °F for saturated steam at that pressure. During the assessment, analysts observed that flash steam from the condensate was vented directly to the atmosphere.

Opportunity Background

When condensate returns from the process, the pressure typically drops after the steam trap to atmospheric pressure. However, the condensate contains more energy than can be contained as liquid at reduced pressure. During this transition, excess energy turns a portion of the condensate into flash steam. Many facilities simply vent this flash steam to the atmosphere, losing the mass of steam and associated energy. Energy that is released in the flash steam could be used to pre-heat water to the boiler, lowering make-up energy usage. Recapturing the flash steam can also reduce make-up water and treatment costs, as well as reducing required blowdown. Energy recapture can be accomplished through direct injection of steam into the incoming water stream or a mixing tank, or through the use of a heat exchanger.

Proposal

Install a mixing tank to capture the condensate flash steam to pre-heat boiler makeup water. This will save $17,929 annually after an implementation cost of $8,549, resulting in a simple payback of 0.5 years.

Vendor Data

Analysts contacted Armstrong International in Three Rivers, MI, Cole Industrial in Lynnwood, WA, Penn Separator in Brookville, PA, and Spirax Sarco in Blythewood, SC, and received one quote from a vendor for a flash separator tank priced at $1,717. Related equipment is an additional $579 for a total of $2,296. This does not include labor estimates or site-specific piping.

Implementation

High-pressure condensate returning from the process is routed into a flash separator (Figure 3.2.1), which reduces pressure to the deaerator tank pressure. The deaerator is where dissolved oxygen and carbon dioxide are removed from boiler feedwater. The flash separator tank captures the flash steam at this lower pressure and routes it to low-pressure steam uses, such as wood block conditioning. Low-pressure steam can also be used to preheat boiler water [1].

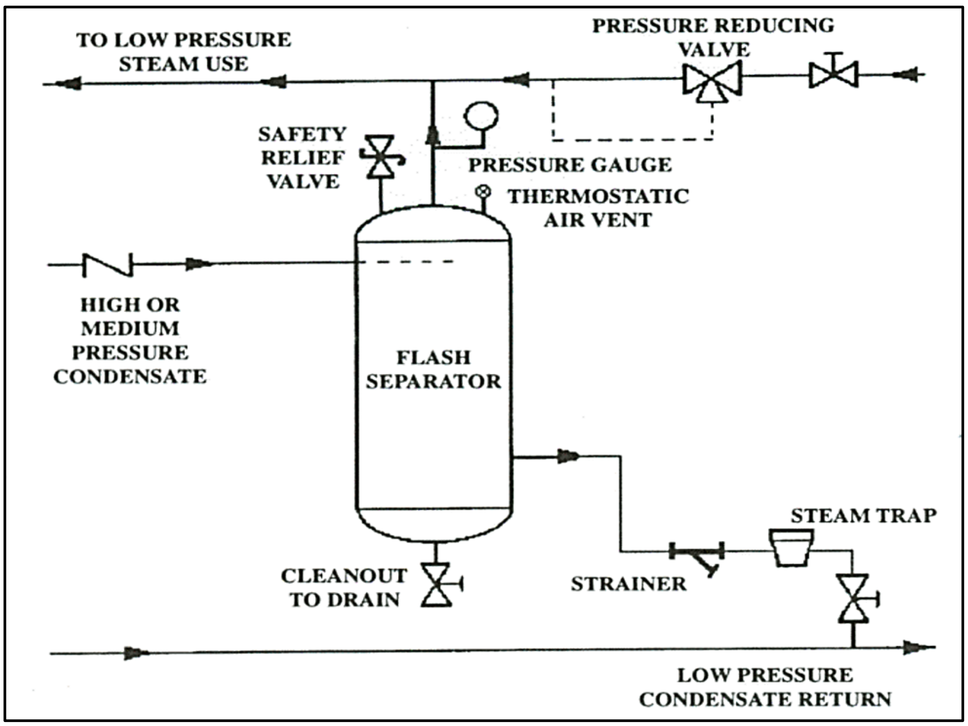

Figure 3.2.1: Schematic of a flash separation system. [1]

Incentives

This recommendation does not reduce utility consumption and will likely not qualify for typical incentives. This does not necessarily mean incentives are unavailable; custom incentives can sometimes be arranged.

Calculation Methodology

Data on typical steam production, steam temperature, condensate return volume, and feedwater temperature were collected on site. Annual steam production and makeup water were calculated from production data, which allowed analysts to calculate total energy use for the boiler. The available heating load is calculated based on the difference between the target temperature of water coming out of the boiler and temperature of water coming into the boiler. Available heating load is the quantity of heat needed to raise the water to its desired temperature. Available flash energy is the quantity of heat within the steam that is flashed based on the ratio of high and low-pressure condensate enthalpies. This ratio is a percentage of the condensate that is lost due to the flashing process. These data are included on the Data Preparation page, and available flash energy is calculated on the Analysis page. The available heat remaining in the low-pressure flash steam was calculated on the Analysis page. It is assumed that this heat has value for low-pressure steam applications, and analysts calculated savings based on the ratio of flash steam waste heat over total heat produced.

Next Steps

The next step in pursuing the savings outlined in this report is to confirm that estimates and calculations made in this report are accurate. Capturing flash steam can also reduce the treatment cost of make up water, therefore savings may be more than estimated in this report. Providing vendors with steam production and pressure will allow them to recommend an appropriately sized flash steam recovery tank.

Note

Analysts assumed the boiler is operating year-round at the steam production capacity stated in Data Preparation. Confirm annual steam production rates for a more accurate savings estimate.

References

[1] Penn Separator, "Condensate Handling and Flash Steam Recovery," *Literature Library by Penn Separator* . [Online]. Available: http://www.pennseparator.com/pdf/psc_flash_separators.pdf. [Accessed: 24 Apr 2018].

[2] R. B. Avery, P. L. Wilson, and J. W. Funck, *Fuelwood Characteristics of Northwestern Conifers and Hardwoods.* Research Bulletin 60. Corvallis, OR: Forest Research Laboratory, College of Forestry, Oregon State University, 1987, 21-22.

[3] M. Mossman, Ed., *RSMeans Mechanical Cost Data 2016* , 39th ed. RSMeans, 2015.

[4] "Properties of Saturated Steam - Imperial Units," *Engineering ToolBox,* (2003). [Online]. Available: https://www.engineeringtoolbox.com/saturated-steam-properties-d_273.html [Accessed 30 May 2018].

[5] "Water - Heat Capacity (Specific Heat)," *Engineering ToolBox,* (2004). [Online]. Available: https://engineeringtoolbox.com/specific-heat-capacity-water-d_660.html [Accessed 11 May 2018].

[6] "Water - Enthalpy (H) and Entropy (S)," *Engineering Toolbox,* (2009). [Online] Available: https://www.engineeringtoolbox.com/water-properties-d_1508.html [Accessed 20 May 2018].

[7] "Water - Heat of Vaporization," *Engineering Toolbox,* (2010). [Online]. Available: https://www.engineeringtoolbox.com/water-properties-d_1573.html [Accessed 30 May 2018].

3 - AR No. 2 - Data Preparation

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Flash Steam Recovery, style 2018 v1.0

Available Heating Load Analysis

Operational Data

Hourly Steam Production	(m_S)	*25,000*	lbm/hr	**(N. 1)**
Operation hours	(t_{OH})	*7,488*	hrs	**(N. 1)**
Condensate Return Ratio	(C_R)	*40%*		**(N. 1)**
Make-up Water Use	(m_w)	*112,320,000*	lbm/yr	**(Eq. 1, N. 1)**
Steam Pressure	(P_{SC})	*190*	psig	**(N. 1)**
Feedwater Temperature	(T_i)	*210*	°F	**(N. 1)**
Steam Temperature	(T_{hw})	*384*	°F	**(N. 2)**
Hourly Boiler Energy	(E_B)	*25.5*	MMBtu/hr	**(Eq. 2)**
Boiler Efficiency	(η_B)	*71%*		**(N. 3)**
Total Hog Fuel Use (energy)	(E_H)	*190,789*	MMBtu/yr	**(Eq. 3, N. 1)**

Water Properties

Specific Heat of Water	(c_P)	*1.01*	Btu/lbm·°F	**(N. 4)**
Steam Enthalpy	(h_S)	*1,199*	Btu/lbm	**(N. 5)**
Feedwater Enthalpy	(h_F)	*180*	Btu/lbm	**(N. 5)**

Heating Load

Available Heating Load	(q_W)	*27,720*	MMBtu/yr	**(Eq. 4)**

Equations

Eq. 1) Makeup Water (m_W)

$$m_S \times t_{OH} \times (1 - C_R)$$

Eq. 2) Hourly Boiler Energy (E_B)

$$m_S \times (h_S - h_F) \times \frac{1MMBtu}{1{,}000{,}000Btu}$$

Eq. 3) Total Hog Fuel Usage (energy) (E_H)

$$E_B \times t_{OH}$$

Eq. 4) Available Heating Load (q_W)

$$\frac{(T_{hw} - T_i) \times c_P \times m_W}{\eta_B} \times \frac{1MMBtu}{1{,}000{,}000Btu}$$

Notes

N. 1) Based on production data provided by boiler operations personnel.

N. 2) Temperature of saturated steam at current steam pressure. [4]

N. 3) Boiler efficiency calculated internally based on data collected on site.

N. 4) Specific heat for feedwater temperature T_i [5].

N. 5) Enthalpy of saturated steam at P_{SC} [4] and condensate at T_i and atmospheric pressure [6].

3 - AR No. 2 - Analysis

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Flash Steam Recovery, style 2018 v1.0

Key Input Data

Operational Data

Condensate Return	(m_{RC})	*112,320,000*	lbm/yr	**(N. 6)**
Hog Fuel HHV	(HHV_H)	*20*	MMBtu/BDT	**(N. 7)**
Total Hog Fuel Usage (mass)	(m_H)	*9,539*	BDT/yr	**(Eq. 5)**

Incremental Energy Data

Hog Fuel Cost	(C_F)	*$20.00*	/BDT	**(N. 1)**
Incremental Steam Cost	(IC_H)	*$1.00*	/MMBtu	**(Eq. 6)**

Water Properties

Fraction of Condensate Flash Steam	($m_\%$)	*16.6%*		**(Eq. 7)**
Proposed Condensate Pressure	(P_{CP})	*6.0*	psig	**(N. 8)**
High Pressure Condensate Enthalpy	(H_{HP})	*358*	Btu/lbm	**(N. 9)**
Low Pressure Condensate Enthalpy	(H_{LP})	*198*	Btu/lbm	**(N. 9)**
Low Pressure Heat of Vaporization	(H_V)	*959*	Btu/lbm	**(N. 9)**

Energy Analysis

Current Conditions

Available Heating Load	(q_W)	*27,720*	MMBtu/yr	**(N. 6)**
Current Energy Consumption	(E_H)	*190,789*	MMBtu/yr	**(Eq. 3)**
Current Energy Cost	(C_C)	*$190,789*	/yr	**(Eq. 8)**

Proposed Conditions

Available Flash Energy	(q_F)	*17,929*	MMBtu/yr.	**(Eq. 9)**
Proposed Energy Consumption	(E_P)	*172,860*	MMBtu/yr	**(Eq. 10)**
Proposed Energy Cost	(C_P)	*$172,860*	/yr	**(Eq. 8)**

Energy Savings

Energy Savings	(E_S)	*17,929*	MMBtu/yr	**(N. 10)**
Fuel Savings	(F_S)	*896*	BDT/yr	**(Eq. 11)**
Cost Savings	(C_S)	*$17,929*	/year	**(N. 11)**

Equations

Eq. 5) Total Hog Fuel Usage (m_H)

$$\frac{E_H}{HHV_H}$$

Eq. 6) Incremental Steam Cost (IC_H)

$$\frac{C_F}{HHV_H}$$

Eq. 7) Condensate Flash Percent (m%)

$$\frac{H_{HP} - H_{LP}}{H_V}$$

Eq. 8) Energy Cost (C_C, C_P)

$$E_{H,P} \times IC_H$$

Eq. 9) Available Flash Energy (q_F)

$$H_V \times m_\% \times m_{RC} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu}$$

Eq. 10) Proposed Energy Consumption (E_P)

$$E_H - q_F$$

Eq. 11) Fuel savings (F_S)

$$\frac{E_S}{E_H} \times m_H$$

Notes

N. 6) Developed in Data Preparation on the previous page.

N. 7) Higher heating value of hog fuel based on assumption of primarily Douglas fir bark. Values taken from OSU Forest Research Lab Bulletin 60 [2].

N. 8) Pressure of deaerator tank, provided by boiler operations personnel.

N. 9) Condensate properties at P_{SC} and P_{CP} [4], [7].

N. 10) Energy savings is based on the minimum of the available heating load and flash steam energy values.

N. 11) Cost savings developed in Implementation on next page. Savings do not include reducing the make-up water purchased, reduced water treatment cost, or savings from make-up natural gas.

Implementation Cost Analysis

Material Costs

Flash Steam Recovery Tank	(C_{M1})	*$2,296*	/unit	**(N. 12)**
Pipe Cost (incl. labor)	(C_P)	*$105*	/ft	**(N. 13)**
Required Pipe Length	(L_P)	*50*	ft	**(N. 14)**
Total Pipe Costs	(C_{M2})	*$5,253*	/unit	**(Eq. 12)**

Labor Costs

Labor Rate	(R_L)	*$50*	/hr	**(N. 12)**
Labor Hours	(t_L)	*20*	hours	**(N. 12)**
Total Labor Cost	(C_{L1})	*$1,000*		**(Eq. 13)**

Economic Results

Annual Cost Savings	(C_S)	*$17,929*	/year	**(N. 11, Eq. 14)**
Implementation Cost	(C_I)	*$8,549*		**(Eq. 15)**
Simple Payback	(t_{PB})	*0.5*	years	**(Eq. 16)**

Equations

Eq. 12) Total Pipe Installation Costs (C_{M2})

$$C_P \times L_P$$

Eq. 13) Total Labor Cost (C_{L1})

$$t_L \times R_L$$

Eq. 14) Annual Cost Savings (C_S)

$$E_S \times IC_H$$

Eq. 15) Implementation Costs (C_I)

$$C_{M1} + C_{L1} + C_{M2}$$

Eq. 16) Simple Payback (t_{PB})

$$\frac{C_I}{C_S}$$

Notes

N. 12) Third party quote for a pressure-rated, 15,000 pound per hour flash steam recovery tank.

N. 13) Value from RSMeans 2016 based on 4" copper pipe plus 10% for insulation, including labor and materials [3].

N. 14) Length based on rough estimate of distance from flash vessel to deaerator.

DO NOT PRINT!

Saturated Steam Lookup (Press

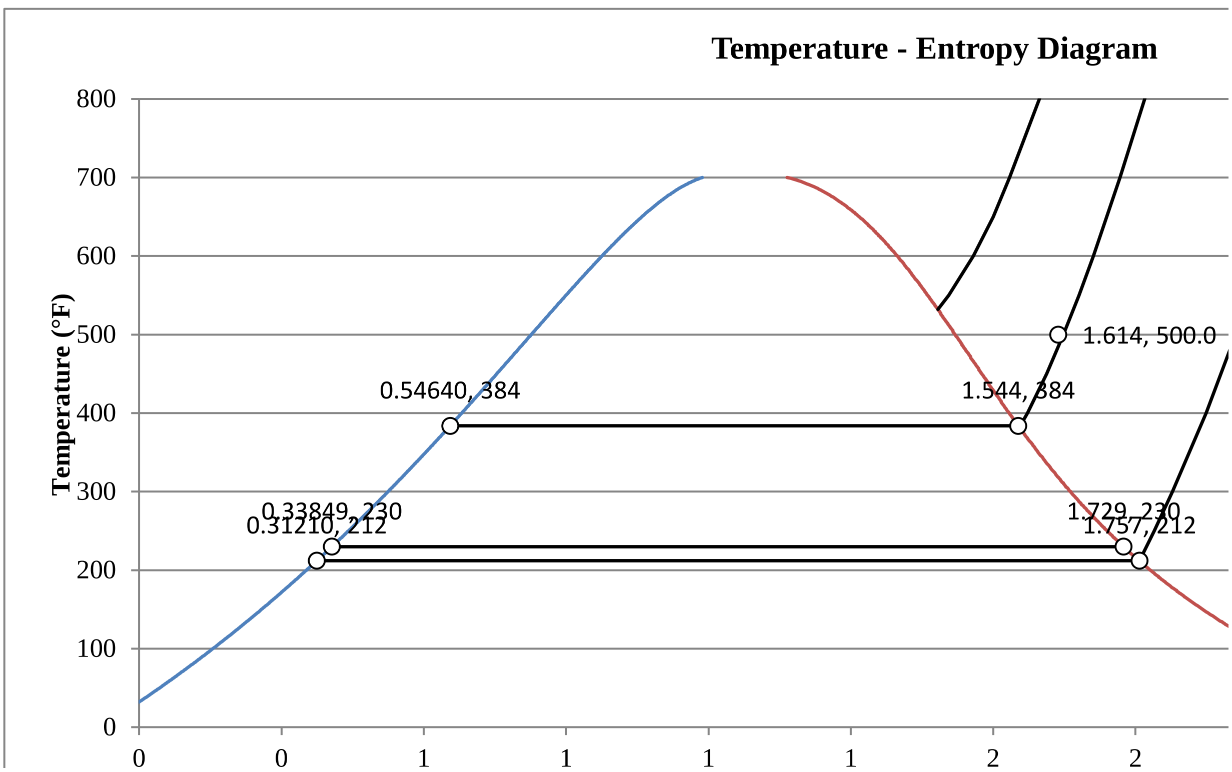
Gauge Pressure	Temperature	Specific Volume Sat. Liquid	Specific Volume Saturated Vapor	Enthalpy Saturated Liquid	Enthalpy Evaporated
(psig)	(°F)	(ft³/lb)	(ft³/lb)	(Btu/lb)	(Btu/lb)
0	212	0.01671	26.810	180.2	970.2
190	384	0.01841	2.237	357.7	841.6
6	230	0.01684	19.460	198.1	958.8

Saturated Steam Lookup (Temper

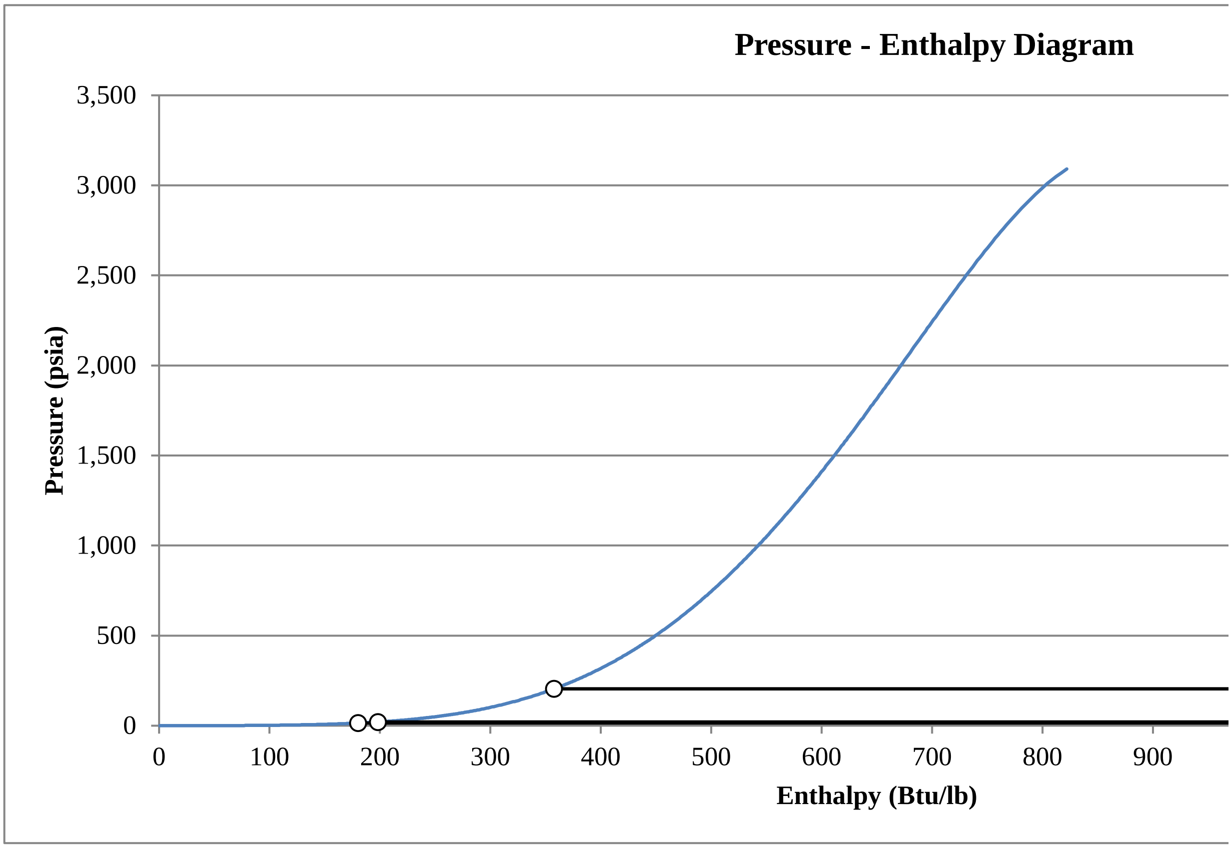
Temperature	Gauge Pressure	Specific Volume Sat. Liquid	Specific Volume Saturated Vapor	Enthalpy Saturated Liquid	Enthalpy Evaporated
(°F)	(psig)	(ft³/lb)	(ft³/lb)	(Btu/lb)	(Btu/lb)
212.0	0.0	0.01671	26.810	180.2	970.2
384.0	190.4	0.01841	2.233	357.9	841.5
534.0	900.0	0.02129	0.492	528.9	666.4

Superheated Steam Lookup

Gage Pressure	Temperature	Absolute Pressure	Specific Volume	Enthalpy	Entropy
(psig)	(°F)	(psia)	(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
200.0	500.0	214.7	2.554	1,266.8	1.614




Entropy (Btu/lb·°R)


Pressure - Enthalpy Diagram
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Pressure (psia)
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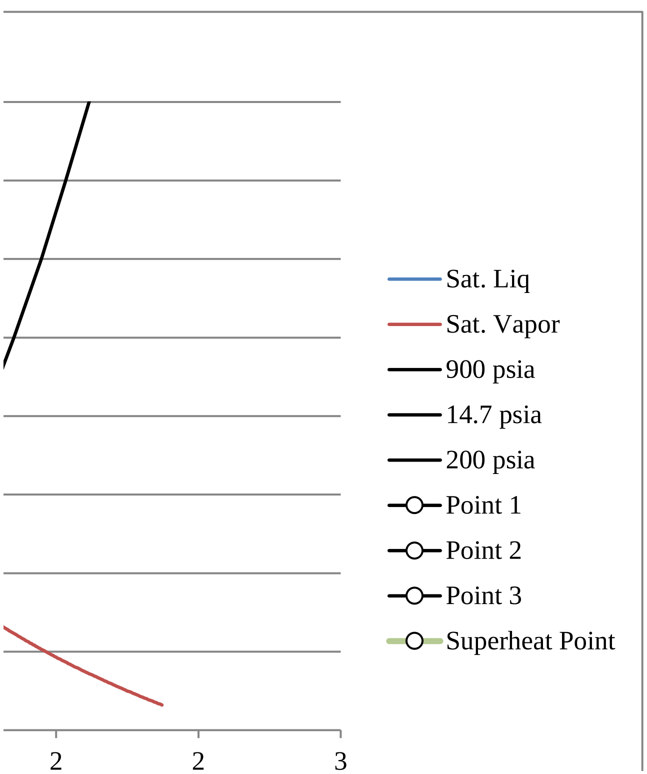
900
Enthalpy (Btu/lb)

ure)

	Entropy		Absolute Pressure
Saturated Vapor	Saturated Liquid	Saturated Vapor	
(Btu/lb)	**(Btu/lb·°R)**	**(Btu/lb·°R)**	**(psia)**
1,150.4	0.31210	1.757	14.7
1,199.3	0.54640	1.544	204.7
1,157.0	0.33849	1.729	20.7

rature)

	Entropy		Absolute Pressure
Saturated Vapor	Saturated Liquid	Saturated Vapor	
(Btu/lb)	**(Btu/lb·°R)**	**(Btu/lb·°R)**	**(psia)**
1,150.4	0.31210	1.757	14.7
1,199.4	0.54660	1.544	205.1
1,195.4	0.73010	1.401	914.7



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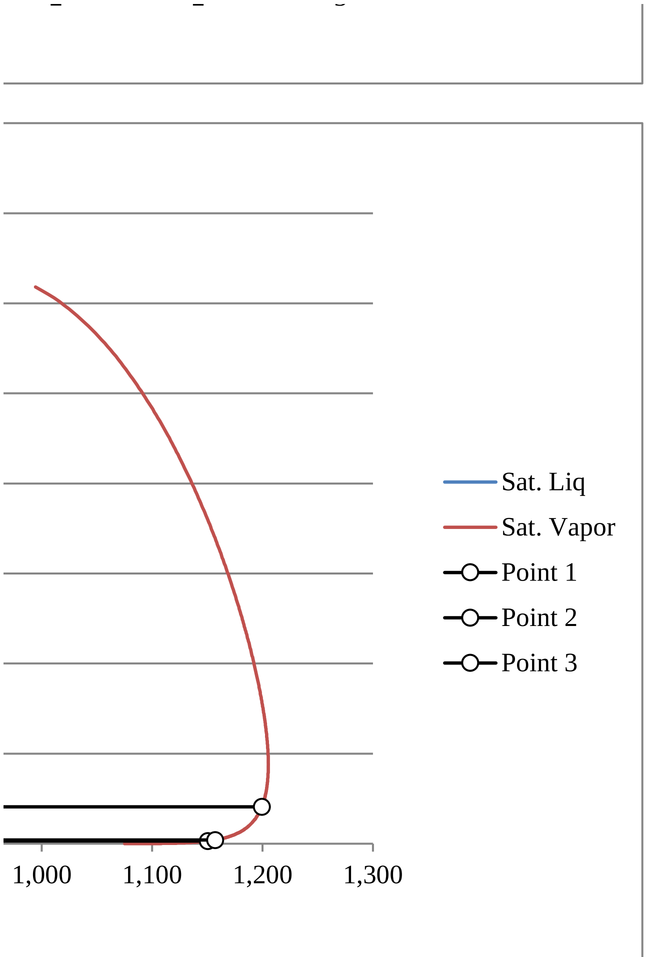

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979	994
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1,191	1,206
1,201	1,216
1,211	1,226
1,220	1,235
1,230	1,245
1,240	1,255
1,250	1,265
1,259	1,274
1,269	1,284
1,279	1,294
1,290	1,305
1,300	1,315
1,310	1,325
1,320	1,335
1,330	1,345
1,341	1,356
1,351	1,366
1,362	1,377
1,372	1,387
1,383	1,398
1,394	1,409
1,404	1,419
1,415	1,430
1,426	1,441
1,437	1,452
1,448	1,463
1,459	1,474
1,470	1,485
1,481	1,496
1,493	1,508
1,504	1,519
1,515	1,530
1,527	1,542
1,538	1,553
1,550	1,565
1,562	1,577
1,573	1,588
1,585	1,600
1,597	1,612
1,609	1,624
1,621	1,636

1,633	1,648
1,645	1,660
1,657	1,672
1,670	1,685
1,682	1,697
1,694	1,709
1,707	1,722
1,719	1,734
1,732	1,747
1,745	1,760
1,758	1,773
1,770	1,785
1,783	1,798
1,796	1,811
1,809	1,824
1,823	1,838
1,836	1,851
1,849	1,864
1,862	1,877
1,876	1,891
1,889	1,904
1,903	1,918
1,917	1,932
1,930	1,945
1,944	1,959
1,958	1,973
1,972	1,987
1,986	2,001
2,000	2,015
2,015	2,030
2,029	2,044
2,043	2,058
2,058	2,073
2,072	2,087
2,087	2,102
2,102	2,117
2,116	2,131
2,131	2,146
2,146	2,161
2,161	2,176
2,177	2,192
2,192	2,207
2,207	2,222
2,222	2,237
2,238	2,253

2,253	2,268
2,269	2,284
2,285	2,300
2,301	2,316
2,317	2,332
2,333	2,348
2,349	2,364
2,365	2,380
2,381	2,396
2,398	2,413
2,414	2,429
2,431	2,446
2,447	2,462
2,464	2,479
2,481	2,496
2,498	2,513
2,515	2,530
2,532	2,547
2,549	2,564
2,567	2,582
2,584	2,599
2,602	2,617
2,619	2,634
2,637	2,652
2,655	2,670
2,673	2,688
2,691	2,706
2,709	2,724
2,727	2,742
2,746	2,761
2,764	2,779
2,783	2,798
2,801	2,816
2,820	2,835
2,839	2,854
2,858	2,873
2,877	2,892
2,897	2,912
2,916	2,931
2,936	2,951
2,955	2,970
2,975	2,990
2,995	3,010
3,015	3,030
3,035	3,050

3,055	3,070
3,076	3,091

Saturated Properties of Steam					
(^{o}F)	(ft^3/lb)	(ft^3/lb)	(Btu/lb)	(Btu/lb)	(Btu/lb)
	Specific Volume		Enthalpy		
Temperature	Vf	Vg	hf	hfg	hg
32	0	3,302	0	1075.1	1075.0
33	0	3,178	1	1074.5	1075.5
34	0	3,059	2	1073.9	1075.9
35	0	2,945	3	1073.3	1076.4
36	0	2,836	4	1072.8	1076.8
37	0	2,732	5	1072.2	1077.2
38	0	2,632	6	1071.6	1077.7
39	0	2,536	7	1071.1	1078.1
40	0	2,443	8	1070.5	1078.5
41	0	2,355	9	1069.9	1079.0
42	0	2,270	10	1069.4	1079.4
43	0	2,189	11	1068.8	1079.9
44	0	2,111	12	1068.3	1080.3
45	0	2,036	13	1067.7	1080.7
46	0	1,964	14	1067.1	1081.2
47	0	1,895	15	1066.6	1081.6
48	0	1,828	16	1066.0	1082.1
49	0	1,764	17	1065.4	1082.5
50	0	1,703	18	1064.9	1082.9
51	0	1,644	19	1064.3	1083.4
52	0	1,588	20	1063.8	1083.8
53	0	1,533	21	1063.2	1084.2
54	0	1,481	22	1062.6	1084.7
55	0	1,431	23	1062.1	1085.1
56	0	1,382	24	1061.5	1085.6
57	0	1,336	25	1060.9	1086.0
58	0	1,291	26	1060.4	1086.4
59	0	1,248	27	1059.8	1086.9
60	0	1,206	28	1059.3	1087.3
61	0	1,166	29	1058.7	1087.7
62	0	1,128	30	1058.1	1088.2
63	0	1,091	31	1057.6	1088.6
64	0	1,055	32	1057.0	1089.0
65	0	1,021	33	1056.4	1089.5
66	0	988	34	1055.9	1089.9
67	0	956	35	1055.3	1090.4
68	0	926	36	1054.7	1090.8

69	0	896	37	1054.2	1091.2
70	0	867	38	1053.6	1091.7
71	0	840	39	1053.1	1092.1
72	0	814	40	1052.5	1092.5
73	0	788	41	1051.9	1093.0
74	0	763	42	1051.4	1093.4
75	0	740	43	1050.8	1093.8
76	0	717	44	1050.2	1094.3
77	0	695	45	1049.7	1094.7
78	0	673	46	1049.1	1095.1
79	0	653	47	1048.5	1095.6
80	0	633	48	1048.0	1096.0
81	0	614	49	1047.4	1096.4
82	0	595	50	1046.8	1096.9
83	0	577	51	1046.3	1097.3
84	0	560	52	1045.7	1097.7
85	0	543	53	1045.1	1098.2
86	0	527	54	1044.6	1098.6
87	0	511	55	1044.0	1099.0
88	0	496	56	1043.4	1099.5
89	0	482	57	1042.9	1099.9
90	0	468	58	1042.3	1100.3
91	0	454	59	1041.7	1100.8
92	0	441	60	1041.2	1101.2
93	0	428	61	1040.6	1101.6
94	0	416	62	1040.0	1102.1
95	0	404	63	1039.5	1102.5
96	0	393	64	1038.9	1102.9
97	0	381	65	1038.3	1103.3
98	0	371	66	1037.8	1103.8
99	0	360	67	1037.2	1104.2
100	0	350	68	1036.6	1104.6
101	0	340	69	1036.0	1105.1
102	0	331	70	1035.5	1105.5
103	0	322	71	1034.9	1105.9
104	0	313	72	1034.3	1106.4
105	0	304	73	1033.8	1106.8
106	0	296	74	1033.2	1107.2
107	0	288	75	1032.6	1107.6
108	0	280	76	1032.1	1108.1
109	0	273	77	1031.5	1108.5
110	0	265	78	1030.9	1108.9
111	0	258	79	1030.3	1109.3
112	0	251	80	1029.8	1109.8
113	0	245	81	1029.2	1110.2

114	0	238	82	1028.6	1110.6
115	0	232	83	1028.0	1111.0
116	0	226	84	1027.5	1111.5
117	0	220	85	1026.9	1111.9
118	0	214	86	1026.3	1112.3
119	0	209	87	1025.7	1112.7
120	0	203	88	1025.2	1113.2
121	0	198	89	1024.6	1113.6
122	0	193	90	1024.0	1114.0
123	0	188	91	1023.4	1114.4
124	0	183	92	1022.9	1114.9
125	0	179	93	1022.3	1115.3
126	0	174	94	1021.7	1115.7
127	0	170	95	1021.1	1116.1
128	0	165	96	1020.6	1116.6
129	0	161	97	1020.0	1117.0
130	0	157	98	1019.4	1117.4
131	0	153	99	1018.8	1117.8
132	0	150	100	1018.2	1118.2
133	0	146	101	1017.7	1118.7
134	0	142	102	1017.1	1119.1
135	0	139	103	1016.5	1119.5
136	0	136	104	1015.9	1119.9
137	0	132	105	1015.3	1120.3
138	0	129	106	1014.8	1120.7
139	0	126	107	1014.2	1121.2
140	0	123	108	1013.6	1121.6
141	0	120	109	1013.0	1122.0
142	0	117	110	1012.4	1122.4
143	0	114	111	1011.9	1122.8
144	0	112	112	1011.3	1123.2
145	0	109	113	1010.7	1123.7
146	0	107	114	1010.1	1124.1
147	0	104	115	1009.5	1124.5
148	0	102	116	1008.9	1124.9
149	0	99	117	1008.3	1125.3
150	0	97	118	1007.8	1125.7
151	0	95	119	1007.2	1126.1
152	0	93	120	1006.6	1126.6
153	0	91	121	1006.0	1127.0
154	0	88	122	1005.4	1127.4
155	0	86	123	1004.8	1127.8
156	0	85	124	1004.2	1128.2
157	0	83	125	1003.6	1128.6
158	0	81	126	1003.1	1129.0

159	0	79	127	1002.5	1129.4
160	0	77	128	1001.9	1129.8
161	0	76	129	1001.3	1130.3
162	0	74	130	1000.7	1130.7
163	0	72	131	1000.1	1131.1
164	0	71	132	999.5	1131.5
165	0	69	133	998.9	1131.9
166	0	68	134	998.3	1132.3
167	0	66	135	997.7	1132.7
168	0	65	136	997.1	1133.1
169	0	63	137	996.5	1133.5
170	0	62	138	995.9	1133.9
171	0	61	139	995.3	1134.3
172	0	59	140	994.7	1134.7
173	0	58	141	994.1	1135.1
174	0	57	142	993.5	1135.5
175	0	56	143	992.9	1135.9
176	0	55	144	992.3	1136.3
177	0	53	145	991.7	1136.7
178	0	52	146	991.1	1137.1
179	0	51	147	990.5	1137.5
180	0	50	148	989.9	1137.9
181	0	49	149	989.3	1138.3
182	0	48	150	988.7	1138.7
183	0	47	151	988.1	1139.1
184	0	46	152	987.5	1139.5
185	0	45	153	986.9	1139.9
186	0	44	154	986.3	1140.3
187	0	44	155	985.7	1140.7
188	0	43	156	985.1	1141.1
189	0	42	157	984.5	1141.5
190	0	41	158	983.8	1141.9
191	0	40	159	983.2	1142.3
192	0	39	160	982.6	1142.7
193	0	39	161	982.0	1143.1
194	0	38	162	981.4	1143.4
195	0	37	163	980.8	1143.8
196	0	36	164	980.2	1144.2
197	0	36	165	979.5	1144.6
198	0	35	166	978.9	1145.0
199	0	34	167	978.3	1145.4
200	0	34	168	977.7	1145.8
201	0	33	169	977.1	1146.2
202	0	32	170	976.4	1146.5
203	0	32	171	975.8	1146.9

204	0	31	172	975.2	1147.3
205	0	31	173	974.6	1147.7
206	0	30	174	974.0	1148.1
207	0	29	175	973.3	1148.5
208	0	29	176	972.7	1148.8
209	0	28	177	972.1	1149.2
210	0	28	178	971.5	1149.6
211	0	27	179	970.8	1150.0
212	0	27	180	970.2	1150.4
213	0	26	181	969.6	1150.7
214	0	26	182	968.9	1151.1
215	0	25	183	968.3	1151.5
216	0	25	184	967.7	1151.9
217	0	24	185	967.0	1152.2
218	0	24	186	966.4	1152.6
219	0	24	187	965.8	1153.0
220	0	23	188	965.1	1153.4
221	0	23	189	964.5	1153.7
222	0	22	190	963.9	1154.1
223	0	22	191	963.2	1154.5
224	0	22	192	962.6	1154.8
225	0	21	193	961.9	1155.2
226	0	21	194	961.3	1155.6
227	0	20	195	960.6	1155.9
228	0	20	196	960.0	1156.3
229	0	20	197	959.4	1156.7
230	0	19	198	958.7	1157.0
231	0	19	199	958.1	1157.4
232	0	19	200	957.4	1157.8
233	0	18	201	956.8	1158.1
234	0	18	202	956.1	1158.5
235	0	18	203	955.5	1158.9
236	0	17	204	954.8	1159.2
237	0	17	205	954.1	1159.6
238	0	17	206	953.5	1159.9
239	0	17	208	952.8	1160.3
240	0	16	209	952.2	1160.6
241	0	16	210	951.5	1161.0
242	0	16	211	950.9	1161.4
243	0	16	212	950.2	1161.7
244	0	15	213	949.5	1162.1
245	0	15	214	948.9	1162.4
246	0	15	215	948.2	1162.8
247	0	15	216	947.5	1163.1
248	0	14	217	946.9	1163.5

249	0	14	218	946.2	1163.8
250	0	14	219	945.5	1164.2
251	0	14	220	944.9	1164.5
252	0	13	221	944.2	1164.8
253	0	13	222	943.5	1165.2
254	0	13	223	942.8	1165.5
255	0	13	224	942.2	1165.9
256	0	13	225	941.5	1166.2
257	0	12	226	940.8	1166.6
258	0	12	227	940.1	1166.9
259	0	12	228	939.5	1167.2
260	0	12	229	938.8	1167.6
261	0	12	230	938.1	1167.9
262	0	11	231	937.4	1168.2
263	0	11	232	936.7	1168.6
264	0	11	233	936.0	1168.9
265	0	11	234	935.3	1169.2
266	0	11	235	934.7	1169.6
267	0	11	236	934.0	1169.9
268	0	10	237	933.3	1170.2
269	0	10	238	932.6	1170.6
270	0	10	239	931.9	1170.9
271	0	10	240	931.2	1171.2
272	0	10	241	930.5	1171.5
273	0	10	242	929.8	1171.9
274	0	9	243	929.1	1172.2
275	0	9	244	928.4	1172.5
276	0	9	245	927.7	1172.8
277	0	9	246	927.0	1173.1
278	0	9	247	926.3	1173.5
279	0	9	248	925.6	1173.8
280	0	9	249	924.9	1174.1
281	0	9	250	924.2	1174.4
282	0	8	251	923.4	1174.7
283	0	8	252	922.7	1175.0
284	0	8	253	922.0	1175.3
285	0	8	254	921.3	1175.7
286	0	8	255	920.6	1176.0
287	0	8	256	919.9	1176.3
288	0	8	257	919.1	1176.6
289	0	8	259	918.4	1176.9
290	0	7	260	917.7	1177.2
291	0	7	261	917.0	1177.5
292	0	7	262	916.2	1177.8
293	0	7	263	915.5	1178.1

294	0	7	264	914.8	1178.4
295	0	7	265	914.1	1178.7
296	0	7	266	913.3	1179.0
297	0	7	267	912.6	1179.3
298	0	7	268	911.8	1179.6
299	0	7	269	911.1	1179.9
300	0	6	270	910.4	1180.2
301	0	6	271	909.6	1180.4
302	0	6	272	908.9	1180.7
303	0	6	273	908.1	1181.0
304	0	6	274	907.4	1181.3
305	0	6	275	906.7	1181.6
306	0	6	276	905.9	1181.9
307	0	6	277	905.2	1182.2
308	0	6	278	904.4	1182.4
309	0	6	279	903.6	1182.7
310	0	6	280	902.9	1183.0
311	0	6	281	902.1	1183.3
312	0	5	282	901.4	1183.6
313	0	5	283	900.6	1183.8
314	0	5	284	899.8	1184.1
315	0	5	285	899.1	1184.4
316	0	5	286	898.3	1184.6
317	0	5	287	897.5	1184.9
318	0	5	288	896.8	1185.2
319	0	5	289	896.0	1185.4
320	0	5	291	895.2	1185.7
321	0	5	292	894.5	1186.0
322	0	5	293	893.7	1186.2
323	0	5	294	892.9	1186.5
324	0	5	295	892.1	1186.8
325	0	5	296	891.3	1187.0
326	0	5	297	890.6	1187.3
327	0	4	298	889.8	1187.5
328	0	4	299	889.0	1187.8
329	0	4	300	888.2	1188.0
330	0	4	301	887.4	1188.3
331	0	4	302	886.6	1188.5
332	0	4	303	885.8	1188.8
333	0	4	304	885.0	1189.0
334	0	4	305	884.2	1189.3
335	0	4	306	883.4	1189.5
336	0	4	307	882.6	1189.7
337	0	4	308	881.8	1190.0
338	0	4	309	881.0	1190.2

339	0	4	310	880.2	1190.5
340	0	4	311	879.4	1190.7
341	0	4	312	878.6	1190.9
342	0	4	313	877.7	1191.2
343	0	4	315	876.9	1191.4
344	0	4	316	876.1	1191.6
345	0	4	317	875.3	1191.8
346	0	4	318	874.5	1192.1
347	0	3	319	873.6	1192.3
348	0	3	320	872.8	1192.5
349	0	3	321	872.0	1192.7
350	0	3	322	871.1	1193.0
351	0	3	323	870.3	1193.2
352	0	3	324	869.5	1193.4
353	0	3	325	868.6	1193.6
354	0	3	326	867.8	1193.8
355	0	3	327	866.9	1194.0
356	0	3	328	866.1	1194.2
357	0	3	329	865.3	1194.4
358	0	3	330	864.4	1194.6
359	0	3	331	863.6	1194.9
360	0	3	332	862.7	1195.1
361	0	3	333	861.8	1195.3
362	0	3	335	861.0	1195.5
363	0	3	336	860.1	1195.7
364	0	3	337	859.3	1195.8
365	0	3	338	858.4	1196.0
366	0	3	339	857.5	1196.2
367	0	3	340	856.7	1196.4
368	0	3	341	855.8	1196.6
369	0	3	342	854.9	1196.8
370	0	3	343	854.0	1197.0
371	0	3	344	853.2	1197.2
372	0	3	345	852.3	1197.3
373	0	3	346	851.4	1197.5
374	0	3	347	850.5	1197.7
375	0	2	348	849.6	1197.9
376	0	2	349	848.7	1198.1
377	0	2	350	847.8	1198.2
378	0	2	352	846.9	1198.4
379	0	2	353	846.0	1198.6
380	0	2	354	845.1	1198.7
381	0	2	355	844.2	1198.9
382	0	2	356	843.3	1199.1
383	0	2	357	842.4	1199.2

384	0	2	358	841.5	1199.4
385	0	2	359	840.6	1199.5
386	0	2	360	839.7	1199.7
387	0	2	361	838.7	1199.8
388	0	2	362	837.8	1200.0
389	0	2	363	836.9	1200.1
390	0	2	364	836.0	1200.3
391	0	2	365	835.0	1200.4
392	0	2	367	834.1	1200.6
393	0	2	368	833.2	1200.7
394	0	2	369	832.2	1200.9
395	0	2	370	831.3	1201.0
396	0	2	371	830.4	1201.1
397	0	2	372	829.4	1201.3
398	0	2	373	828.5	1201.4
399	0	2	374	827.5	1201.5
400	0	2	375	826.6	1201.6
401	0	2	376	825.6	1201.8
402	0	2	377	824.6	1201.9
403	0	2	378	823.7	1202.0
404	0	2	379	822.7	1202.1
405	0	2	381	821.8	1202.3
406	0	2	382	820.8	1202.4
407	0	2	383	819.8	1202.5
408	0	2	384	818.8	1202.6
409	0	2	385	817.9	1202.7
410	0	2	386	816.9	1202.8
411	0	2	387	815.9	1202.9
412	0	2	388	814.9	1203.0
413	0	2	389	813.9	1203.1
414	0	2	390	812.9	1203.2
415	0	2	391	811.9	1203.3
416	0	2	393	810.9	1203.4
417	0	2	394	809.9	1203.5
418	0	2	395	808.9	1203.6
419	0	2	396	807.9	1203.7
420	0	2	397	806.9	1203.7
421	0	1	398	805.9	1203.8
422	0	1	399	804.9	1203.9
423	0	1	400	803.8	1204.0
424	0	1	401	802.8	1204.1
425	0	1	402	801.8	1204.1
426	0	1	403	800.8	1204.2
427	0	1	405	799.7	1204.3
428	0	1	406	798.7	1204.3

429	0	1	407	797.7	1204.4
430	0	1	408	796.6	1204.5
431	0	1	409	795.6	1204.5
432	0	1	410	794.5	1204.6
433	0	1	411	793.5	1204.6
434	0	1	412	792.4	1204.7
435	0	1	413	791.4	1204.7
436	0	1	415	790.3	1204.8
437	0	1	416	789.2	1204.8
438	0	1	417	788.2	1204.9
439	0	1	418	787.1	1204.9
440	0	1	419	786.0	1204.9
441	0	1	420	784.9	1205.0
442	0	1	421	783.8	1205.0
443	0	1	422	782.8	1205.0
444	0	1	423	781.7	1205.1
445	0	1	425	780.6	1205.1
446	0	1	426	779.5	1205.1
447	0	1	427	778.4	1205.1
448	0	1	428	777.3	1205.1
449	0	1	429	776.2	1205.2
450	0	1	430	775.1	1205.2
451	0	1	431	773.9	1205.2
452	0	1	432	772.8	1205.2
453	0	1	434	771.7	1205.2
454	0	1	435	770.6	1205.2
455	0	1	436	769.5	1205.2
456	0	1	437	768.3	1205.2
457	0	1	438	767.2	1205.2
458	0	1	439	766.0	1205.2
459	0	1	440	764.9	1205.2
460	0	1	441	763.8	1205.1
461	0	1	443	762.6	1205.1
462	0	1	444	761.4	1205.1
463	0	1	445	760.3	1205.1
464	0	1	446	759.1	1205.1
465	0	1	447	758.0	1205.0
466	0	1	448	756.8	1205.0
467	0	1	449	755.6	1205.0
468	0	1	451	754.4	1204.9
469	0	1	452	753.3	1204.9
470	0	1	453	752.1	1204.8
471	0	1	454	750.9	1204.8
472	0	1	455	749.7	1204.8
473	0	1	456	748.5	1204.7

474	0	1	457	747.3	1204.6
475	0	1	459	746.1	1204.6
476	0	1	460	744.9	1204.5
477	0	1	461	743.6	1204.5
478	0	1	462	742.4	1204.4
479	0	1	463	741.2	1204.3
480	0	1	464	740.0	1204.3
481	0	1	465	738.7	1204.2
482	0	1	467	737.5	1204.1
483	0	1	468	736.3	1204.0
484	0	1	469	735.0	1203.9
485	0	1	470	733.8	1203.9
486	0	1	471	732.5	1203.8
487	0	1	472	731.3	1203.7
488	0	1	474	730.0	1203.6
489	0	1	475	728.7	1203.5
490	0	1	476	727.5	1203.4
491	0	1	477	726.2	1203.3
492	0	1	478	724.9	1203.2
493	0	1	479	723.6	1203.0
494	0	1	481	722.3	1202.9
495	0	1	482	721.0	1202.8
496	0	1	483	719.7	1202.7
497	0	1	484	718.4	1202.6
498	0	1	485	717.1	1202.4
499	0	1	487	715.8	1202.3
500	0	1	488	714.5	1202.2
501	0	1	489	713.1	1202.0
502	0	1	490	711.8	1201.9
503	0	1	491	710.5	1201.7
504	0	1	492	709.1	1201.6
505	0	1	494	707.8	1201.4
506	0	1	495	706.5	1201.3
507	0	1	496	705.1	1201.1
508	0	1	497	703.7	1201.0
509	0	1	498	702.4	1200.8
510	0	1	500	701.0	1200.6
511	0	1	501	699.6	1200.4
512	0	1	502	698.2	1200.3
513	0	1	503	696.9	1200.1
514	0	1	504	695.5	1199.9
515	0	1	506	694.1	1199.7
516	0	1	507	692.7	1199.5
517	0	1	508	691.3	1199.3
518	0	1	509	689.8	1199.1

519	0	1	511	688.4	1198.9
520	0	1	512	687.0	1198.7
521	0	1	513	685.6	1198.5
522	0	1	514	684.1	1198.3
523	0	1	515	682.7	1198.1
524	0	1	517	681.3	1197.8
525	0	1	518	679.8	1197.6
526	0	1	519	678.3	1197.4
527	0	1	520	676.9	1197.1
528	0	1	522	675.4	1196.9
529	0	1	523	673.9	1196.7
530	0	1	524	672.4	1196.4
531	0	1	525	671.0	1196.2
532	0	1	526	669.5	1195.9
533	0	0	528	668.0	1195.6
534	0	0	529	666.4	1195.4
535	0	0	530	664.9	1195.1
536	0	0	531	663.4	1194.8
537	0	0	533	661.9	1194.6
538	0	0	534	660.4	1194.3
539	0	0	535	658.8	1194.0
540	0	0	536	657.3	1193.7
541	0	0	538	655.7	1193.4
542	0	0	539	654.2	1193.1
543	0	0	540	652.6	1192.8
544	0	0	542	651.0	1192.5
545	0	0	543	649.4	1192.2
546	0	0	544	647.8	1191.8
547	0	0	545	646.3	1191.5
548	0	0	547	644.7	1191.2
549	0	0	548	643.0	1190.9
550	0	0	549	641.4	1190.5
551	0	0	550	639.8	1190.2
552	0	0	552	638.2	1189.8
553	0	0	553	636.5	1189.5
554	0	0	554	634.9	1189.1
555	0	0	556	633.2	1188.8
556	0	0	557	631.6	1188.4
557	0	0	558	629.9	1188.0
558	0	0	559	628.2	1187.6
559	0	0	561	626.6	1187.3
560	0	0	562	624.9	1186.9
561	0	0	563	623.2	1186.5
562	0	0	565	621.5	1186.1
563	0	0	566	619.7	1185.7

564	0	0	567	618.0	1185.2
565	0	0	569	616.3	1184.8
566	0	0	570	614.5	1184.4
567	0	0	571	612.8	1184.0
568	0	0	573	611.0	1183.5
569	0	0	574	609.3	1183.1
570	0	0	575	607.5	1182.7
571	0	0	577	605.7	1182.2
572	0	0	578	603.9	1181.8
573	0	0	579	602.1	1181.3
574	0	0	581	600.3	1180.8
575	0	0	582	598.5	1180.3
576	0	0	583	596.7	1179.9
577	0	0	585	594.8	1179.4
578	0	0	586	593.0	1178.9
579	0	0	587	591.1	1178.4
580	0	0	589	589.2	1177.9
581	0	0	590	587.4	1177.4
582	0	0	591	585.5	1176.8
583	0	0	593	583.6	1176.3
584	0	0	594	581.7	1175.8
585	0	0	596	579.8	1175.2
586	0	0	597	577.8	1174.7
587	0	0	598	575.9	1174.1
588	0	0	600	573.9	1173.6
589	0	0	601	572.0	1173.0
590	0	0	602	570.0	1172.4
591	0	0	604	568.0	1171.8
592	0	0	605	566.0	1171.2
593	0	0	607	564.0	1170.6
594	0	0	608	562.0	1170.0
595	0	0	610	560.0	1169.4
596	0	0	611	557.9	1168.8
597	0	0	612	555.9	1168.2
598	0	0	614	553.8	1167.5
599	0	0	615	551.7	1166.9
600	0	0	617	549.6	1166.2
601	0	0	618	547.5	1165.6
602	0	0	620	545.4	1164.9
603	0	0	621	543.3	1164.2
604	0	0	622	541.2	1163.5
605	0	0	624	539.0	1162.8
606	0	0	625	536.8	1162.1
607	0	0	627	534.7	1161.4
608	0	0	628	532.5	1160.7

609	0	0	630	530.2	1159.9
610	0	0	631	528.0	1159.2
611	0	0	633	525.8	1158.4
612	0	0	634	523.5	1157.7
613	0	0	636	521.3	1156.9
614	0	0	637	519.0	1156.1
615	0	0	639	516.7	1155.3
616	0	0	640	514.4	1154.5
617	0	0	642	512.0	1153.7
618	0	0	643	509.7	1152.9
619	0	0	645	507.3	1152.1
620	0	0	646	504.9	1151.2
621	0	0	648	502.5	1150.3
622	0	0	649	500.1	1149.5
623	0	0	651	497.7	1148.6
624	0	0	653	495.2	1147.7
625	0	0	654	492.7	1146.8
626	0	0	656	490.3	1145.9
627	0	0	657	487.7	1144.9
628	0	0	659	485.2	1144.0
629	0	0	660	482.7	1143.0
630	0	0	662	480.1	1142.1
631	0	0	664	477.5	1141.1
632	0	0	665	474.9	1140.1
633	0	0	667	472.3	1139.1
634	0	0	669	469.6	1138.1
635	0	0	670	466.9	1137.0
636	0	0	672	464.2	1136.0
637	0	0	673	461.5	1134.9
638	0	0	675	458.8	1133.8
639	0	0	677	456.0	1132.7
640	0	0	678	453.2	1131.6
641	0	0	680	450.4	1130.5
642	0	0	682	447.5	1129.3
643	0	0	684	444.7	1128.2
644	0	0	685	441.8	1127.0
645	0	0	687	438.8	1125.8
646	0	0	689	435.9	1124.6
647	0	0	690	432.9	1123.3
648	0	0	692	429.9	1122.1
649	0	0	694	426.8	1120.8
650	0	0	696	423.7	1119.5
651	0	0	698	420.6	1118.2
652	0	0	699	417.5	1116.8
653	0	0	701	414.3	1115.5

654	0	0	703	411.1	1114.1
655	0	0	705	407.8	1112.7
656	0	0	707	404.5	1111.2
657	0	0	709	401.2	1109.8
658	0	0	711	397.8	1108.3
659	0	0	712	394.4	1106.8
660	0	0	714	391.0	1105.3
661	0	0	716	387.5	1103.7
662	0	0	718	383.9	1102.1
663	0	0	720	380.4	1100.5
664	0	0	722	376.7	1098.8
665	0	0	724	373.0	1097.1
666	0	0	726	369.3	1095.4
667	0	0	728	365.5	1093.7
668	0	0	730	361.6	1091.9
669	0	0	732	357.7	1090.1
670	0	0	734	353.8	1088.2
671	0	0	737	349.7	1086.3
672	0	0	739	345.6	1084.4
673	0	0	741	341.5	1082.4
674	0	0	743	337.2	1080.4
675	0	0	745	332.9	1078.3
676	0	0	748	328.5	1076.1
677	0	0	750	324.0	1074.0
678	0	0	752	319.4	1071.7
679	0	0	755	314.8	1069.4
680	0	0	757	310.0	1067.1
681	0	0	760	305.1	1064.7
682	0	0	762	300.1	1062.2
683	0	0	765	295.0	1059.6
684	0	0	767	289.8	1057.0
685	0	0	770	284.4	1054.3
686	0	0	773	278.9	1051.4
687	0	0	775	273.2	1048.5
688	0	0	778	267.4	1045.5
689	0	0	781	261.4	1042.4
690	0	0	784	255.1	1039.1
691	0	0	787	248.6	1035.7
692	0	0	790	241.9	1032.2
693	0	0	794	234.9	1028.4
694	0	0	797	227.5	1024.5
695	0	0	801	219.8	1020.3
696	0	0	804	211.6	1015.9
697	0	0	808	203.0	1011.2
698	0	0	812	193.7	1006.1

699	0	0	817	183.6	1000.5
700	0	0	822	172.5	994.3

(Btu/lb·°R)	(Btu/lb·°R)
Entropy	
Sf	**Sg**
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Superheated

(psia)	(psig)	(°F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
1	-14	102
		150
		200
		250
		300
		400
		500
		600
		700
		800
		900
		1,000

(psia)	(psig)	(°F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
5	-10	162
		200
		250
		300
		400
		500
		600
		700
		800
		900
		1,000

(psia)	(psig)	(°F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
10	-5	193
		200
		250
		300
		400
		500
		600
		700
		800

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		900
		1,000
		1,100

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
15	0	212
		250
		300
		400
		500
		600
		700
		800
		900
		1,000
		1,100

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
20	5	228
		250
		300
		350
		400
		500
		600
		700
		800
		900
		1,000
		1,100

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
40	25	267
		300
		350
		400
		500
		600
		700
		800
		900
		1,000

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		1,100

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
60	45	293
		300
		350
		400
		500
		600
		700
		800
		900
		1,000
		1,100
		1,200

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
80	65	312
		350
		400
		500
		600
		700
		800
		900
		1,000
		1,100
		1,200

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
100	85	328
		350
		400
		450
		500
		600
		700
		800
		900
		1,000
		1,100
		1,200

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(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
120	105	341
		350
		400
		450
		500
		600
		700
		800
		900
		1,000
		1,100
		1,200

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
140	125	353
		400
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
160	145	364
		400
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200

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(psia)	**(psig)**	**(^oF)**
Abs. Pressure	**Gauge Pressure**	**Temperature**
180	165	373
		400
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200

(psia)	**(psig)**	**(^oF)**
Abs. Pressure	**Gauge Pressure**	**Temperature**
200	185	382
		400
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200

(psia)	**(psig)**	**(^oF)**
Abs. Pressure	**Gauge Pressure**	**Temperature**
250	235	401
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300

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(psia)	(psig)	(°F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
300	285	417
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300

(psia)	(psig)	(°F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
350	335	432
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300

(psia)	(psig)	(°F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
400	385	445
		450
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300

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(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
450	435	456
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300
		1,400

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
500	485	467
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300
		1,400

(psia)	(psig)	(^{o}F)
Abs. Pressure	**Gauge Pressure**	**Temperature**
600	585	486
		500
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300
		1,400

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(psia)	(psig)	(^oF)
Abs. Pressure	**Gauge Pressure**	**Temperature**
700	685	503
		550
		600
		700
		800
		900
		1,000
		1,100
		1,200
		1,300
		1,400

(psia)	(psig)	(^oF)
Abs. Pressure	**Gauge Pressure**	**Temperature**
800	785	518
		550
		600
		650
		700
		800
		900
		1,000
		1,100
		1,200
		1,300
		1,400

(psia)	(psig)	(^oF)
Abs. Pressure	**Gauge Pressure**	**Temperature**
900	885	532
		550
		600
		650
		700
		800
		900
		1,000
		1,100
		1,200
		1,300
		1,400

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Water Vapor Properties

(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
334	1,105	2
363	1,127	2
393	1,150	2
422	1,173	2
452	1,195	2
512	1,242	2
572	1,288	2
631	1,336	2
691	1,384	2
750	1,434	2
810	1,484	2
870	1,535	2

(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
74	1,131	2
78	1,148	2
84	1,171	2
90	1,195	2
102	1,241	2
114	1,288	2
126	1,336	2
138	1,384	2
150	1,434	2
162	1,484	2
174	1,535	2

(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
38	1,143	2
39	1,146	2
42	1,170	2
45	1,194	2
51	1,240	2
57	1,288	2
63	1,335	2
69	1,384	2
75	1,433	2

Table Index

(psia)
Superheat Pressure
1
5
10
15
20
40
60
80
100
120
140
160
180
200
250
300
350
400
450
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1,000
1,200
1,400
1,600
1,800
2,000
2,500
3,000
3,500
4,000
4,400
4,800

81	1,484	2
87	1,535	2
93	1,587	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
27	1,150	2
28	1,169	2
31	1,193	2
35	1,240	2
39	1,287	2
43	1,335	2
47	1,384	2
51	1,433	2
55	1,483	2
59	1,535	2
63	1,587	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
20	1,156	2
21	1,167	2
22	1,191	2
24	1,215	2
25	1,239	2
28	1,287	2
31	1,335	2
34	1,383	2
37	1,433	2
40	1,483	2
43	1,534	2
46	1,586	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
11	1,170	2
11	1,187	2
12	1,212	2
13	1,236	2
14	1,285	2
16	1,333	2
17	1,382	2
19	1,432	2
20	1,483	2
22	1,534	2

23	1,586	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
7	1,178	2
7	1,182	2
8	1,208	2
8	1,233	2
9	1,283	2
10	1,332	2
11	1,381	2
12	1,431	2
13	1,482	2
14	1,533	2
15	1,586	2
16	1,639	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
5	1,184	2
6	1,204	2
6	1,230	2
7	1,281	2
8	1,330	2
9	1,380	2
9	1,430	2
10	1,481	2
11	1,533	2
12	1,585	2
12	1,638	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
4	1,188	2
5	1,200	2
5	1,227	2
5	1,253	2
6	1,279	2
6	1,329	2
7	1,379	2
7	1,430	2
8	1,481	2
9	1,532	2
9	1,585	2
10	1,638	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
4	1,191	2
4	1,196	2
4	1,224	2
4	1,251	2
5	1,277	2
5	1,328	2
6	1,378	2
6	1,429	2
7	1,480	2
7	1,532	2
8	1,584	2
8	1,637	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
3	1,194	2
3	1,221	2
4	1,248	2
4	1,275	2
4	1,301	2
4	1,326	2
5	1,377	2
5	1,428	2
6	1,479	2
6	1,531	2
7	1,584	2
7	1,637	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
3	1,196	2
3	1,218	2
3	1,246	2
3	1,273	2
4	1,299	2
4	1,325	2
4	1,376	2
5	1,427	2
5	1,478	2
5	1,530	2
6	1,583	2
6	1,637	2

(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
3	1,198	2
3	1,214	2
3	1,243	2
3	1,271	2
3	1,297	2
3	1,323	2
4	1,375	2
4	1,426	2
4	1,478	2
5	1,530	2
5	1,583	2
5	1,636	2

(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
2	1,199	2
2	1,211	2
3	1,240	2
3	1,268	2
3	1,295	2
3	1,322	2
3	1,374	2
4	1,425	2
4	1,477	2
4	1,529	2
5	1,582	2
5	1,636	2

(ft³/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
2	1,202	2
2	1,233	2
2	1,263	2
2	1,291	2
2	1,318	2
3	1,371	2
3	1,423	2
3	1,475	2
3	1,528	2
4	1,581	2
4	1,635	2
4	1,689	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
2	1,204	2
2	1,226	2
2	1,257	2
2	1,286	2
2	1,314	2
2	1,368	2
2	1,421	2
3	1,474	2
3	1,526	2
3	1,580	2
3	1,634	2
3	1,689	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,205	1
1	1,218	2
1	1,251	2
2	1,282	2
2	1,310	2
2	1,365	2
2	1,419	2
2	1,472	2
2	1,525	2
3	1,579	2
3	1,633	2
3	1,688	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,205	1
1	1,209	1
1	1,245	2
1	1,277	2
1	1,306	2
2	1,362	2
2	1,417	2
2	1,470	2
2	1,524	2
2	1,577	2
2	1,632	2
3	1,687	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,205	1
1	1,238	2
1	1,271	2
1	1,302	2
1	1,359	2
2	1,414	2
2	1,468	2
2	1,522	2
2	1,576	2
2	1,631	2
2	1,686	2
2	1,742	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,205	1
1	1,231	1
1	1,266	2
1	1,298	2
1	1,357	2
1	1,412	2
2	1,467	2
2	1,521	2
2	1,575	2
2	1,630	2
2	1,685	2
2	1,741	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,204	1
1	1,216	1
1	1,255	1
1	1,289	2
1	1,350	2
1	1,408	2
1	1,463	2
1	1,518	2
2	1,573	2
2	1,628	2
2	1,683	2
2	1,739	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,202	1
1	1,243	1
1	1,280	2
1	1,344	2
1	1,403	2
1	1,459	2
1	1,515	2
1	1,570	2
1	1,626	2
1	1,681	2
2	1,738	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,199	1
1	1,230	1
1	1,270	1
1	1,305	2
1	1,338	2
1	1,398	2
1	1,456	2
1	1,512	2
1	1,568	2
1	1,624	2
1	1,680	2
1	1,736	2

(ft^3/lb)	(Btu/lb)	(Btu/lb·°R)
Specific Volume Saturated Vapor	**Enthalpy**	**Entropy**
1	1,196	1
1	1,215	1
1	1,260	1
1	1,297	2
1	1,331	2
1	1,393	2
1	1,452	2
1	1,509	2
1	1,565	2
1	1,621	2
1	1,678	2
1	1,735	2