June 2024 ASHRAE Journal

The following pages contain supplementary information for the following articles in the June 2024 issue of *ASHRAE Journal*:

Net Positive Suction Head, Part 1
By David Sellers, P.E., Member ASHRAE

Online Figure 1 – Impeller Damaged by Cavitation (image courtesy Kelly Cramm).

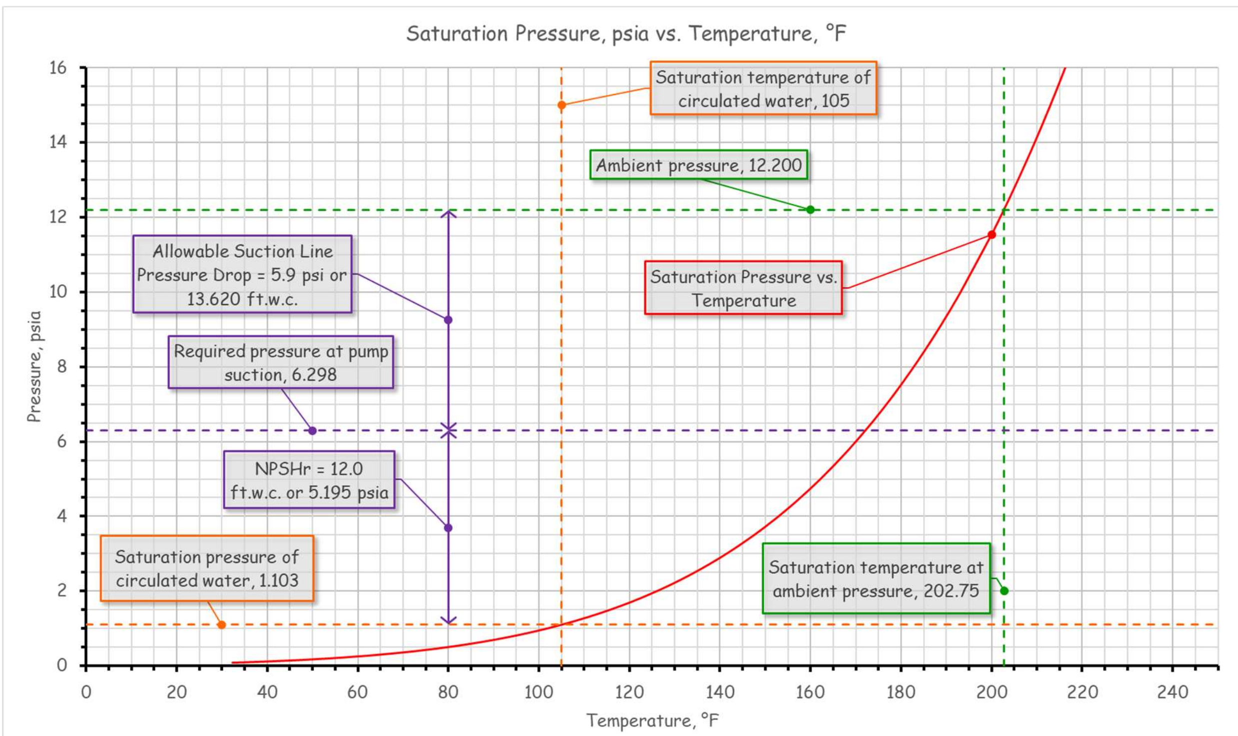
Properties of Water at Saturation
Data generated with REFPROP 9.1

Click here to jump to interpolators — Click here to jump to atmospheric

Temperature. °F	Pressure psia	Pressure psig	Liquid Density, lb_m/ft^3	Vapor Density, lb_m/ft^3	Liquid Enthalpy, Btu/lb_m	Latent Heat of Vaporization, Btu/lb_m	Vapor Enthalpy, Btu/lb_m	Liquid Entropy, Btu/lb_m-°R	Vapor Entropy, Btu/lb_m-°R
32.375	0.09	-14.619	62.416	0.00030724	0.36037	1,075.7	1,076.1	0.00073212	2.1869
35.005	0.10	-14.609	62.421	0.00033957	3.01100	1,074.2	1,077.2	0.00610460	2.1777
37.411	0.11	-14.599	62.423	0.00037174	5.43390	1,072.9	1,078.3	0.01099100	2.1693
39.632	0.12	-14.589	62.423	0.00040374	7.66730	1,071.6	1,079.3	0.01547400	2.1616
50.280	0.18	-14.529	62.406	0.00059309	18.35900	1,065.5	1,083.9	0.03666100	2.1262
60.392	0.26	-14.449	62.362	0.00084023	28.48900	1,059.8	1,088.3	0.05633100	2.0942
70.532	0.37	-14.339	62.294	0.00117320	38.63200	1,054.1	1,092.7	0.07564700	2.0638
80.747	0.52	-14.189	62.206	0.00161820	48.84300	1,048.4	1,097.2	0.09472200	2.0345
90.044	0.70	-14.009	62.110	0.00214230	58.13200	1,043.1	1,101.2	0.11176000	2.0092
99.982	0.95	-13.759	61.992	0.00285710	68.06100	1,037.3	1,105.4	0.12966000	1.9833
110.890	1.31	-13.399	61.845	0.00386670	78.96100	1,031.1	1,110.1	0.14895000	1.9562
120.320	1.71	-12.999	61.705	0.00496840	88.37900	1,025.7	1,114.1	0.16532000	1.9338
129.730	2.21	-12.499	61.554	0.00632290	97.79000	1,020.3	1,118.1	0.18141000	1.9124
140.230	2.91	-11.799	61.373	0.00818710	108.29000	1,014.1	1,122.4	0.19906000	1.8896
150.930	3.81	-10.899	61.175	0.01054200	119.00000	1,007.9	1,126.9	0.21676000	1.8674
160.550	4.81	-9.899	60.987	0.01311700	128.64000	1,002.2	1,130.8	0.23241000	1.8483
170.070	6.01	-8.699	60.792	0.01616000	138.18000	996.5	1,134.7	0.24768000	1.8301
179.940	7.51	-7.199	60.580	0.01990900	148.08000	990.5	1,138.6	0.26327000	1.8119
189.800	9.31	-5.399	60.358	0.02434300	157.99000	984.5	1,142.5	0.27863000	1.7945
200.000	11.54	-3.171	60.120	0.02975400	168.24000	978.3	1,146.5	0.29429000	1.7772
201.000	11.78	-2.931	60.096	0.03033300	169.25000	977.7	1,146.9	0.29581000	1.7755
202.000	12.02	-2.686	60.072	0.03092200	170.26000	977.0	1,147.3	0.29733000	1.7739
203.000	12.27	-2.438	60.048	0.03152000	171.26000	976.3	1,147.6	0.29885000	1.7722
204.000	12.52	-2.185	60.024	0.03212800	172.27000	975.7	1,148.0	0.30037000	1.7706
205.000	12.78	-1.927	60.000	0.03274500	173.28000	975.1	1,148.4	0.30188000	1.7690
206.000	13.04	-1.665	59.976	0.03337200	174.28000	974.5	1,148.8	0.30340000	1.7673
207.000	13.31	-1.399	59.951	0.03400900	175.29000	973.9	1,149.2	0.30491000	1.7657
208.000	13.58	-1.128	59.927	0.03465500	176.30000	973.2	1,149.5	0.30642000	1.7641
209.000	13.86	-0.853	59.902	0.03531200	177.31000	972.6	1,149.9	0.30792000	1.7625
210.000	14.14	-0.573	59.877	0.03597800	178.31000	972.0	1,150.3	0.30943000	1.7609
211.000	14.42	-0.289	59.853	0.03665500	179.32000	971.4	1,150.7	0.31093000	1.7593
212.000	14.71	0.000	59.828	0.03734300	180.33000	970.8	1,151.1	0.31243000	1.7577
220.000	17.20	2.492	59.626	0.04322800	188.40000	965.7	1,154.1	0.32436000	1.7451
227.920	20.00	5.291	59.421	0.04977400	196.40000	960.6	1,157.0	0.33605000	1.7331
250.300	30.00	15.291	58.812	0.07274100	219.08000	945.8	1,164.9	0.36847000	1.7007
267.220	40.00	25.291	58.324	0.09523900	236.30000	934.3	1,170.6	0.39240000	1.6777
280.990	50.00	35.291	57.909	0.11741000	250.38000	924.6	1,175.0	0.41153000	1.6599
292.680	60.00	45.291	57.545	0.13935000	262.38000	916.2	1,178.6	0.42757000	1.6454

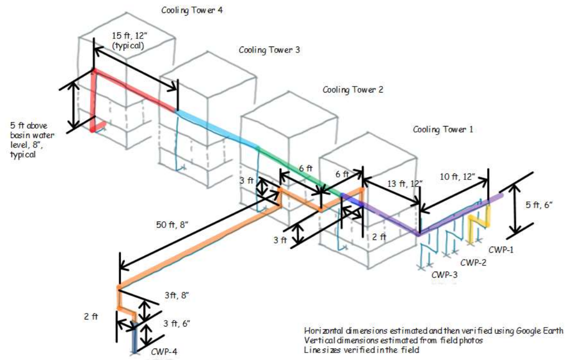
Online Figure 2 – A Steam Table (visit http://tinyurl.com/SteamTableAndCharts for a copy).

Online Figure 3 – A Compound Gage.



Online Figure 4 – The impact of higher altitudes and hotter condenser water.

Run to CWP-1 - 3, Three Chillers Running at Design Flow		
Segment	Loss, ft.w.c.	Cumulative Loss, ft.w.c.
Cold Basin	0.00	0.00
Red Segment 1	7.88	7.88
Red Segment 2	0.25	8.13
Blue Segment	0.49	8.62
Green Segment	1.10	9.72
Dark Blue Segment	0.69	10.42
Purple Segment	3.09	13.50
Yellow Segment	8.31	21.81
Total	21.81	ft.w.c.
	9.44	psi
	19.22	in hg



Online Figure 5 – Suction Line Pressure Drop Projection

Celebrating Sadi
By Andy Pearson, Ph.D., C.Eng., Fellow ASHRAE

French Revolutionary Calendar

The French Revolutionary Calendar, current when Sadi Carnot was born, comprises four seasons of three months each. The French names and their translation are shown below, together with a satirical version published in the British press at the time poking fun at this innovation.

Season	Month	Meaning	Satirical Form	Period from
Autumn	Vendémiaire	Vintage	Wheezy	22 September
	Brumaire	Misty	Sneezy	22 October
	Frimaire	Frosty	Freezy	21 November
Winter	Nivôse	Snowy	Slippy	21 December
	Pluviôse	Rainy	Drippy	20 January
	Ventôse	Windy	Nippy	19 February
Spring	Germinal	Germination	Showery	21 March
	Floréal	Flowery	Flowery	20 April
	Prairial	Meadow	Bowery	20 May
Summer	Messidor	Harvest	Hoppy	19 June
	Thermidor	Summer heat	Croppy	19 July
	Fructidor	Fruit	Poppy	18 August

Carnot's Axioms – Quotations from the Reflections

The production of motive power is then due in steam-engines not to an actual consumption of caloric, but to its transportation from a warm body to a cold body, that is, to its re-establishment of equilibrium.

Wherever there exists a difference of temperature, motive-power can be produced.

The maximum of motive power resulting from the employment of steam is also the maximum of motive power realizable by any means whatever.

The motive power of heat depends on the quantity of caloric used, and on what may be termed, on what in fact we will call, the height of its fall, that is to say, the difference of temperature of the bodies between which the exchange of caloric is made.

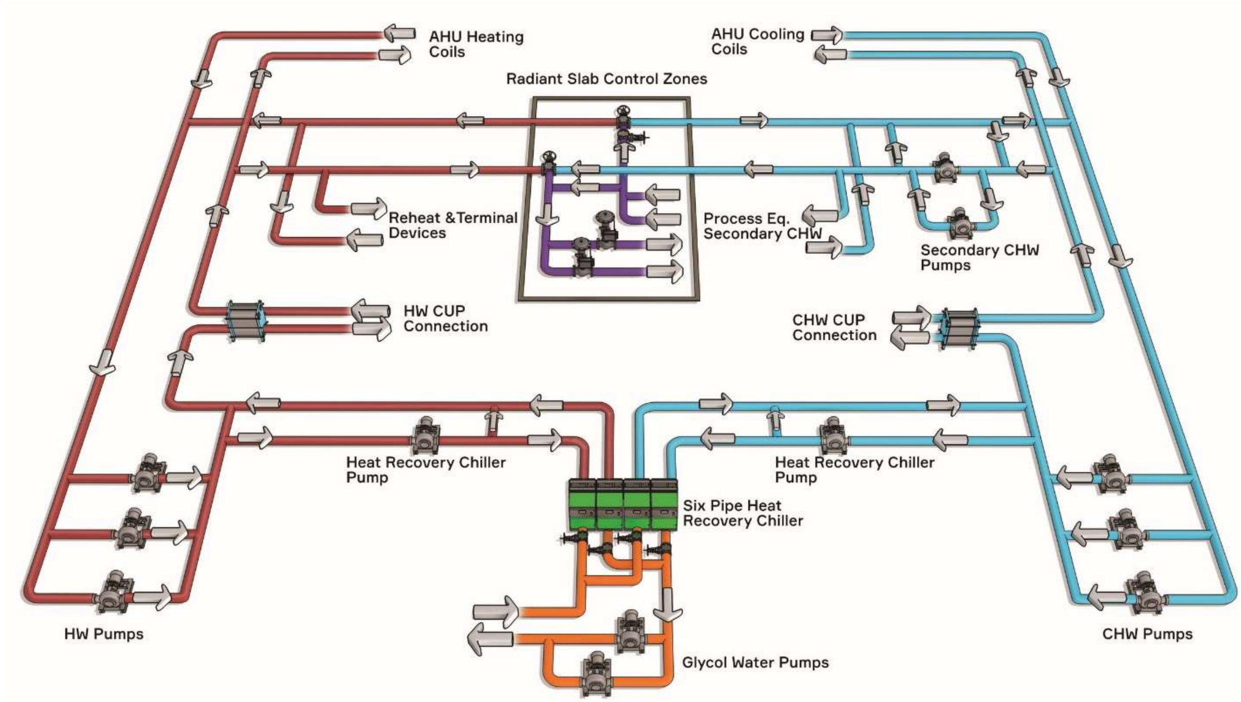
The motive power of heat is independent of the agents employed to realize it; its quantity is fixed solely by the temperatures of the bodies between which is effected, finally, the transfer of the caloric.

When a gas passes without change of temperature from one definite volume and pressure to another volume and another pressure equally definite, the quantity of caloric absorbed or relinquished is always the same, whatever may be the nature of the gas chosen as the subject of the experiment.

The difference between specific heat under constant pressure and specific heat under constant volume is the same for all gases.

When a gas varies in volume without change of temperature, the quantities of heat absorbed or liberated by this gas are in arithmetical progression, if the increments or decrements of volume are found to be in geometrical progression.

Balancing Occupant Comfort with Research Innovation
By Robin Graves, P.E., Member ASHRAE



Online Figure 1. The interconnected heating hot water (HW), geothermal glycol water, chilled water (CHW), and radiant slab control zones of the geothermal system. Air-handling unit (AHU) components and central utility plant (CUP) connections are also shown.