

TABLE 2. THERMODYNAMIC PROPERTIES OF MOIST AIR^a (STANDARD ATMOSPHERIC PRESSURE, 29.921 IN. Hg) (Concluded)

FAHR. TEMP. t (°F)	HUMIDITY RATIO W _g	VOLUME CU FT/LB DRY AIR			ENTHALPY BTU/LB DRY AIR			ENTROPY (°F) (LB DRY AIR)			CONDENSED WATER			FAHR. TEMP. t (°F)
		v _g	v _{sa}	v _a	h _a	h _{sa}	h _g	s _a	s _{sa}	s _g	Enthalpy Btu/Lb h _w	Entropy Btu/(Lb) s _w	Vap. Press in. Hg p _s	
175	0.5202	18.001	13.475	29.476	42.087	601.1	643.2	0.07756	1.005	1.083	143.02	0.2453	13.875	175
176	0.5510	16.020	14.074	30.476	42.528	627.1	669.4	0.07794	1.047	1.125	144.02	0.2456	13.917	176
177	0.5760	16.051	14.710	31.761	42.983	644.1	697.3	0.07832	1.091	1.169	145.02	0.2458	13.957	177
178	0.6016	16.076	15.388	33.462	43.450	661.1	725.3	0.07870	1.137	1.216	146.03	0.2460	14.000	178
179	0.6288	16.102	16.104	35.206	43.931	678.2	753.3	0.07908	1.187	1.266	147.03	0.2461	14.045	179
180	0.6578	16.127	16.870	36.997	44.426	695.2	781.8	0.07946	1.240	1.319	148.03	0.2463	14.093	180
181	0.6887	16.152	17.678	38.841	44.934	712.2	810.7	0.07984	1.296	1.376	149.03	0.2464	14.143	181
182	0.7218	16.177	18.526	40.741	45.454	733.9	840.7	0.08021	1.357	1.437	150.04	0.2465	14.195	182
183	0.7572	16.203	19.504	42.702	45.986	756.2	871.9	0.08059	1.421	1.502	151.04	0.2467	14.249	183
184	0.7953	16.228	20.613	44.828	46.531	779.2	903.5	0.08096	1.490	1.571	152.04	0.2468	14.305	184
185	0.8363	16.253	21.861	47.000	47.088	802.2	936.7	0.08134	1.565	1.646	153.05	0.2469	14.363	185
186	0.8803	16.278	23.275	48.780	47.666	826.2	971.7	0.08171	1.644	1.724	154.05	0.2470	14.423	186
187	0.9283	16.303	24.847	50.805	48.264	851.9	1009	0.08208	1.728	1.811	155.06	0.2471	14.485	187
188	0.9802	16.328	26.477	53.036	48.883	878.2	1049	0.08245	1.825	1.907	156.06	0.2472	14.549	188
189	1.037	16.354	28.264	55.516	49.523	905.2	1091	0.08283	1.928	2.011	157.06	0.2473	14.615	189
190	1.099	16.379	30.280	58.201	50.184	933.2	1135	0.08320	2.039	2.122	158.07	0.2474	14.683	190
191	1.166	16.405	32.535	61.145	50.866	962.2	1181	0.08357	2.161	2.245	159.07	0.2475	14.753	191
192	1.238	16.430	34.981	64.402	51.570	992.2	1229	0.08394	2.294	2.383	160.07	0.2476	14.825	192
193	1.316	16.456	37.636	67.985	52.296	1024	1279	0.08431	2.444	2.533	161.08	0.2477	14.899	193
194	1.416	16.480	40.581	71.841	53.044	1059	1331	0.08468	2.600	2.693	162.08	0.2478	14.975	194
195	1.519	16.506	43.785	76.001	53.814	1095	1385	0.08505	2.794	2.878	163.09	0.2479	15.053	195
196	1.635	16.531	47.285	80.416	54.604	1133	1441	0.08542	3.002	3.087	164.09	0.2480	15.133	196
197	1.767	16.556	51.042	85.077	55.416	1173	1500	0.08579	3.234	3.324	165.10	0.2481	15.215	197
198	1.917	16.581	55.074	90.007	56.249	1215	1561	0.08616	3.491	3.583	166.10	0.2482	15.299	198
199	2.085	16.602	59.310	95.274	57.104	1260	1624	0.08653	3.817	3.974	167.11	0.2483	15.385	199
200	2.295	16.622	63.810	100.912	57.981	1307	1689	0.08689	4.179	4.268	168.11	0.2484	15.473	200

Compiled by John A. Goff and S. Gratch.

Thermodynamics

vapor present. The probable reasons for this inaccuracy are due to the effect of:

1. Chemical solution of gas molecules in the water vapor.
2. The finite size of the molecules causing interference with the free passage of other molecules toward the boundaries of the system.
3. Intermolecular forces of attraction and repulsion.

Many attempts have been made to develop an equation of state which would predict the true states of real gases and vapors. The Van der Waal, Maxwell, and Beattie-Bridgman equations are probably the best known. Unfortunately, these expressions rapidly become much too complicated to be used in everyday calculations and, therefore, engineers find it more convenient to use tables of thermodynamic properties for specific working substances, as these can be prepared by physicists using the best laboratory equipment and all the refinements of mathematics.

Mechanical engineers have long been familiar with such tables for the properties of steam. Tables of the properties of moist air, as prepared by Goodenough and others, have been available for some time, but the latest and most precise of such tables are those which have resulted from a co-operative research agreement between the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *Towne Scientific School* of the *University of Pennsylvania*. These properties are published herein as Table 2, and are taken from a research report by Goff and Gratch.⁴ Table 2, which experimentally and mathematically takes into account deviations from perfect gas behavior, such as those listed above, makes the application of the Gibbs-Dalton Rule a less frequent necessity.

In Table 2 there are 15 columns of figures, each column being headed by a suitable symbol. In the following sub-paragraphs brief explanations are given of the data in Table 2 under the appropriate column headings.

t (°F) = Fahrenheit temperature defined in terms of absolute temperature T by the relation,

$$T = t + 459.69 \quad (24)$$

Absolute zero of temperature may be defined as the receiver temperature which will enable a Carnot Cycle engine to transform into work all the energy it receives in the form of heat.

W_g = humidity ratio at saturation. Saturation is the condition at which the vapor phase (moist air) may exist in equilibrium with a condensed phase (liquid or solid) at the given temperature and pressure (standard atmospheric pressure in the case of Table 2). At given values of temperature and pressure, the humidity ratio W can have any value from zero to W_g.

v_a = specific volume of dry air, cubic feet per pound.

v_{sa} = v_a - v_g, the difference between the volume of moist air at saturation, per pound of dry air, and the specific volume of the dry air itself, cubic feet per pound of dry air.

v_g = specific volume of moist air at saturation per pound of dry air, cubic feet per pound of dry air.

h_a = specific enthalpy of dry air, Btu per pound of dry air. The specific enthalpy of dry air has been assigned the value zero at 0 °F, standard atmospheric pressure. The energy unit Btu is related to the foot-pound by definition, as follows: 1 Btu = 778.3 ft-lb.

h_{sa} = h_a - h_g, the difference between the enthalpy of moist air at saturation, per pound of dry air, and the specific enthalpy of the dry air itself, Btu per pound of dry air.

h_g = enthalpy of moist air at saturation per pound of dry air, Btu per pound of dry air.

s_a = specific entropy of dry air, Btu per (pound) (Fahrenheit degree). It will be