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TABLA A-1E

Masa molar, constante de gas y propiedades del punto crítico

Sustancia	Fórmula	Masa molar, M lbm/lbmol	Constante de gas, R		Propiedades del punto crítico		
			Btu/ lbm · R*	psia · ft ³ / lbm · R*	Temperatura, R	Presión, psia	Volumen, ft ³ /lbmol
Agua	H ₂ O	18.015	0.1102	0.5956	1164.8	3200	0.90
Aire	—	28.97	0.06855	0.3704	238.5	547	1.41
Alcohol etílico	C ₂ H ₅ OH	46.07	0.04311	0.2329	929.0	926	2.68
Alcohol metílico	CH ₃ OH	32.042	0.06198	0.3349	923.7	1154	1.89
Amoniaco	NH ₃	17.03	0.1166	0.6301	729.8	1636	1.16
Argón	Ar	39.948	0.04971	0.2686	272	705	1.20
Benceno	C ₆ H ₆	78.115	0.02542	0.1374	1012	714	4.17
Bromo	Br ₂	159.808	0.01243	0.06714	1052	1500	2.17
<i>n</i> -Butano	C ₄ H ₁₀	58.124	0.03417	0.1846	765.2	551	4.08
Cloro	Cl ₂	70.906	0.02801	0.1517	751	1120	1.99
Cloroformo	CHCl ₃	119.38	0.01664	0.08988	965.8	794	3.85
Cloruro metílico	CH ₃ Cl	50.488	0.03934	0.2125	749.3	968	2.29
Criptón	Kr	83.80	0.02370	0.1280	376.9	798	1.48
Diclorodifluorometano (R-12)	CCl ₂ F ₂	120.91	0.01643	0.08874	692.4	582	3.49
Diclorofluorometano (R-21)	CHCl ₂ F	102.92	0.01930	0.1043	813.0	749	3.16
Dióxido de carbono	CO ₂	44.01	0.04513	0.2438	547.5	1071	1.51
Dióxido de sulfuro	SO ₂	64.063	0.03100	1.1675	775.2	1143	1.95
Etano	C ₂ H ₆	30.020	0.06616	0.3574	549.8	708	2.37
Etileno	C ₂ H ₄	28.054	0.07079	0.3825	508.3	742	1.99
Helio	He	4.003	0.4961	2.6809	9.5	33.2	0.926
<i>n</i> -Hexano	C ₆ H ₁₄	86.178	0.02305	0.1245	914.2	439	5.89
Hidrógeno (normal)	H ₂	2.016	0.9851	5.3224	59.9	188.1	1.04
Metano	CH ₄	16.043	0.1238	0.6688	343.9	673	1.59
Monóxido de carbono	CO	28.011	0.07090	0.3831	240	507	1.49
Neón	Ne	20.183	0.09840	0.5316	80.1	395	0.668
Nitrógeno	N ₂	28.013	0.07090	0.3830	227.1	492	1.44
Óxido nitroso	N ₂ O	44.013	0.04512	0.2438	557.4	1054	1.54
Oxígeno	O ₂	31.999	0.06206	0.3353	278.6	736	1.25
Propano	C ₃ H ₈	44.097	0.04504	0.2433	665.9	617	3.20
Propileno	C ₃ H ₆	42.081	0.04719	0.2550	656.9	670	2.90
Tetracloruro de carbono	CCl ₄	153.82	0.01291	0.06976	1001.5	661	4.42
Tetrafluoroetano (R-134a)	CF ₃ CH ₂ F	102.03	0.01946	0.1052	673.6	588.7	3.19
Triclorofluorometano (R-11)	CCl ₃ F	137.37	0.01446	0.07811	848.1	635	3.97
Xenón	Xe	131.30	0.01513	0.08172	521.55	852	1.90

*Calculada de $R = R_u/M$, donde $R_u = 1.98588$ Btu/lbmol · R = 10.7316 psia · ft³/lbmol · R y M es la masa molar.Fuente: K. A. Kobe y R. E. Lynn, Jr., *Chemical Review* 52, 1953, pp. 117-236; y ASHRAE (Sociedad Americana de Ingenieros de Calefacción, Refrigeración y Acondicionamiento de Aire), *Handbook of Fundamentals*, Atlanta, Georgia, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., 1993, pp. 16.4 y 36.1.

TABLA A-2E

Calores específicos de gas ideal de varios gases comunes
a) A 80°F

Gas	Fórmula	Constante de gas, R Btu/lbm · R	c_p Btu/lbm · R	c_v Btu/lbm · R	k
Aire	—	0.06855	0.240	0.171	1.400
Argón	Ar	0.04971	0.1253	0.0756	1.667
Butano	C ₄ H ₁₀	0.03424	0.415	0.381	1.09
Dióxido de carbono	CO ₂	0.04513	0.203	0.158	1.285
Etano	C ₂ H ₆	0.06616	0.427	0.361	1.183
Etileno	C ₂ H ₄	0.07079	0.411	0.340	1.208
Helio	He	0.4961	1.25	0.753	1.667
Hidrógeno	H ₂	0.9851	3.43	2.44	1.404
Metano	CH ₄	0.1238	0.532	0.403	1.32
Monóxido de carbono	CO	0.07090	0.249	0.178	1.399
Neón	Ne	0.09840	0.246	0.1477	1.667
Nitrógeno	N ₂	0.07090	0.248	0.177	1.400
Octano	C ₈ H ₁₈	0.01742	0.409	0.392	1.044
Oxígeno	O ₂	0.06206	0.219	0.157	1.395
Propano	C ₃ H ₈	0.04504	0.407	0.362	1.124
Vapor	H ₂ O	0.1102	0.445	0.335	1.329

Fuente: Gordon J. Van Wylen y Richard E. Sonntag, *Fundamentals of Classical Thermodynamics*, versión inglés/SI, 3a. ed., Nueva York, John Wiley & Sons, 1986, p. 687, Tabla A.8E.

TABLA A-2E

Calores específicos de gas ideal de varios gases comunes (*continuación*)

b) A diversas temperaturas

Temp., °F	c_p Btu/lbm · R	c_v Btu/lbm · R	k	c_p Btu/lbm · R	c_v Btu/lbm · R	k	c_p Btu/lbm · R	c_v Btu/lbm · R	k
	<i>Aire</i>			<i>Dióxido de carbono, CO₂</i>			<i>Monóxido de carbono, CO</i>		
40	0.240	0.171	1.401	0.195	0.150	1.300	0.248	0.177	1.400
100	0.240	0.172	1.400	0.205	0.160	1.283	0.249	0.178	1.399
200	0.241	0.173	1.397	0.217	0.172	1.262	0.249	0.179	1.397
300	0.243	0.174	1.394	0.229	0.184	1.246	0.251	0.180	1.394
400	0.245	0.176	1.389	0.239	0.193	1.233	0.253	0.182	1.389
500	0.248	0.179	1.383	0.247	0.202	1.223	0.256	0.185	1.384
600	0.250	0.182	1.377	0.255	0.210	1.215	0.259	0.188	1.377
700	0.254	0.185	1.371	0.262	0.217	1.208	0.262	0.191	1.371
800	0.257	0.188	1.365	0.269	0.224	1.202	0.266	0.195	1.364
900	0.259	0.191	1.358	0.275	0.230	1.197	0.269	0.198	1.357
1000	0.263	0.195	1.353	0.280	0.235	1.192	0.273	0.202	1.351
1500	0.276	0.208	1.330	0.298	0.253	1.178	0.287	0.216	1.328
2000	0.286	0.217	1.312	0.312	0.267	1.169	0.297	0.226	1.314
	<i>Hidrógeno, H₂</i>			<i>Nitrógeno, N₂</i>			<i>Oxígeno, O₂</i>		
40	3.397	2.412	1.409	0.248	0.177	1.400	0.219	0.156	1.397
100	3.426	2.441	1.404	0.248	0.178	1.399	0.220	0.158	1.394
200	3.451	2.466	1.399	0.249	0.178	1.398	0.223	0.161	1.387
300	3.461	2.476	1.398	0.250	0.179	1.396	0.226	0.164	1.378
400	3.466	2.480	1.397	0.251	0.180	1.393	0.230	0.168	1.368
500	3.469	2.484	1.397	0.254	0.183	1.388	0.235	0.173	1.360
600	3.473	2.488	1.396	0.256	0.185	1.383	0.239	0.177	1.352
700	3.477	2.492	1.395	0.260	0.189	1.377	0.242	0.181	1.344
800	3.494	2.509	1.393	0.262	0.191	1.371	0.246	0.184	1.337
900	3.502	2.519	1.392	0.265	0.194	1.364	0.249	0.187	1.331
1000	3.513	2.528	1.390	0.269	0.198	1.359	0.252	0.190	1.326
1500	3.618	2.633	1.374	0.283	0.212	1.334	0.263	0.201	1.309
2000	3.758	2.773	1.355	0.293	0.222	1.319	0.270	0.208	1.298

Nota: La unidad Btu/lbm · R es equivalente a Btu/lbm · °F.

Fuente: Kenneth Wark, *Thermodynamics*, 4a. ed., Nueva York, McGraw-Hill, 1983, p. 830, Tabla A.4. Publicada originalmente en *Tables of Thermal Properties of Gases*, NBS Circular 564, 1955.

TABLA A-2E

Calores específicos de gas ideal de varios gases comunes (*conclusión*)
c) Como una función de la temperatura

$$\bar{c}_p = a + bT + cT^2 + dT^3$$

(*T* in R, *c_p* en Btu/lbmol · R)

Sustancia	Fórmula	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	Rango de temp., R	% error	
							Máx.	Prom.
Acetileno	C ₂ H ₂	5.21	1.2227 × 10 ⁻²	-0.4812 × 10 ⁻⁵	0.7457 × 10 ⁻⁹	491-2700	1.46	0.59
Aire	—	6.713	0.02609 × 10 ⁻²	0.03540 × 10 ⁻⁵	-0.08052 × 10 ⁻⁹	491-3240	0.72	0.33
Amoniaco	NH ₃	6.5846	0.34028 × 10 ⁻²	0.073034 × 10 ⁻⁵	-0.27402 × 10 ⁻⁹	491-2700	0.91	0.36
Azufre	S ₂	6.499	0.2943 × 10 ⁻²	-0.1200 × 10 ⁻⁵	0.1632 × 10 ⁻⁹	491-3240	0.99	0.38
Benceno	C ₆ H ₆	-8.650	6.4322 × 10 ⁻²	-2.327 × 10 ⁻⁵	3.179 × 10 ⁻⁹	491-2700	0.34	0.20
<i>i</i> -Butano	C ₄ H ₁₀	-1.890	5.520 × 10 ⁻²	-1.696 × 10 ⁻⁵	2.044 × 10 ⁻⁹	491-2740	0.25	0.13
<i>n</i> -Butano	C ₄ H ₁₀	0.945	4.929 × 10 ⁻²	-1.352 × 10 ⁻⁵	1.433 × 10 ⁻⁹	491-2740	0.54	0.24
Cloruro de hidrógeno	HCl	7.244	-0.1011 × 10 ⁻²	0.09783 × 10 ⁻⁵	-0.1776 × 10 ⁻⁹	491-2740	0.22	0.08
Dióxido de azufre	SO ₂	6.157	0.7689 × 10 ⁻²	-0.2810 × 10 ⁻⁵	0.3527 × 10 ⁻⁹	491-3240	0.45	0.24
Dióxido de carbono	CO ₂	5.316	0.79361 × 10 ⁻²	-0.2581 × 10 ⁻⁵	0.3059 × 10 ⁻⁹	491-3240	0.67	0.22
Dióxido de nitrógeno	NO ₂	5.48	0.7583 × 10 ⁻²	-0.260 × 10 ⁻⁵	0.322 × 10 ⁻⁹	491-2700	0.46	0.18
Etano	C ₂ H ₆	1.648	2.291 × 10 ⁻²	-0.4722 × 10 ⁻⁵	0.2984 × 10 ⁻⁹	491-2740	0.83	0.28
Etanol	C ₂ H ₆ O	4.75	2.781 × 10 ⁻²	-0.7651 × 10 ⁻⁵	0.821 × 10 ⁻⁹	491-2700	0.40	0.22
Etileno	C ₂ H ₄	0.944	2.075 × 10 ⁻²	-0.6151 × 10 ⁻⁵	0.7326 × 10 ⁻⁹	491-2740	0.54	0.13
<i>n</i> -Hexano	C ₆ H ₁₄	1.657	7.328 × 10 ⁻²	-2.112 × 10 ⁻⁵	2.363 × 10 ⁻⁹	491-2740	0.72	0.20
Hidrógeno	H ₂	6.952	-0.02542 × 10 ⁻²	0.02952 × 10 ⁻⁵	-0.03565 × 10 ⁻⁹	491-3240	1.02	0.26
Metano	CH ₄	4.750	0.6666 × 10 ⁻²	0.09352 × 10 ⁻⁵	-0.4510 × 10 ⁻⁹	491-2740	1.33	0.57
Metanol	CH ₄ O	4.55	1.214 × 10 ⁻²	-0.0898 × 10 ⁻⁵	-0.329 × 10 ⁻⁹	491-1800	0.18	0.08
Monóxido de carbono	CO	6.726	0.02222 × 10 ⁻²	0.03960 × 10 ⁻⁵	-0.09100 × 10 ⁻⁹	491-3240	0.89	0.37
Nitrógeno	N ₂	6.903	-0.02085 × 10 ⁻²	0.05957 × 10 ⁻⁵	-0.1176 × 10 ⁻⁹	491-3240	0.59	0.34
Óxido nítrico	NO	7.008	-0.01247 × 10 ⁻²	0.07185 × 10 ⁻⁵	-0.1715 × 10 ⁻⁹	491-2700	0.97	0.36
Óxido nitroso	N ₂ O	5.758	0.7780 × 10 ⁻²	-0.2596 × 10 ⁻⁵	0.4331 × 10 ⁻⁹	491-2700	0.59	0.26
Oxígeno	O ₂	6.085	0.2017 × 10 ⁻²	-0.05275 × 10 ⁻⁵	0.05372 × 10 ⁻⁹	491-3240	1.19	0.28
<i>n</i> -Pentano	C ₅ H ₁₂	1.618	6.028 × 10 ⁻²	-1.656 × 10 ⁻⁵	1.732 × 10 ⁻⁹	491-2740	0.56	0.21
Propano	C ₃ H ₈	-0.966	4.044 × 10 ⁻²	-1.159 × 10 ⁻⁵	1.300 × 10 ⁻⁹	491-2740	0.40	0.12
Propileno	C ₃ H ₆	0.753	3.162 × 10 ⁻²	-0.8981 × 10 ⁻⁵	1.008 × 10 ⁻⁹	491-2740	0.73	0.17
Trióxido de azufre	SO ₃	3.918	1.935 × 10 ⁻²	-0.8256 × 10 ⁻⁵	1.328 × 10 ⁻⁹	491-2340	0.29	0.13
Vapor de agua	H ₂ O	7.700	0.02552 × 10 ⁻²	0.07781 × 10 ⁻⁵	-0.1472 × 10 ⁻⁹	491-3240	0.53	0.24

Fuente: *Chemical and Process Thermodynamics*, 3/E por Kyle, B. G., © 2000. Adaptada con permiso de Pearson Education, Inc., Upper Saddle River, Nueva Jersey.

TABLA A-3E

Propiedades de líquidos, sólidos y alimentos comunes

a) Líquidos

Sustancia	Datos de ebullición a 1 atm		Datos de congelación		Propiedades de líquido		
	Punto normal de ebullición, °F	Calor latente de vaporización, h_{fg} Btu/lbm	Punto de congelación, °F	Calor latente de fusión, h_{if} Btu/lbm	Temperatura, °F	Densidad, ρ lbm/ft ³	Calor específico, c_p Btu/lbm · R
Aceite (ligero)	—	—			77	56.8	0.430
Agua	212	970.1	32	143.5	32	62.4	1.01
					90	62.1	1.00
					150	61.2	1.00
					212	59.8	1.01
Alcohol etílico	173.5	368	-248.8	46.4	68	49.3	0.678
Amoniaco	-27.9	24.54	-107.9	138.6	-27.9	42.6	1.06
					0	41.3	1.083
					40	39.5	1.103
					80	37.5	1.135
Argón	-302.6	69.5	-308.7	12.0	-302.6	87.0	0.272
Benceno	176.4	169.4	41.9	54.2	68	54.9	0.411
<i>n</i> -Butano	31.1	165.6	-217.3	34.5	31.1	37.5	0.552
Dióxido de carbono	-109.2*	99.6 (a 32°F)	-69.8	—	32	57.8	0.583
Etanol	172.8	360.5	-173.6	46.9	77	48.9	0.588
Etilén glicol	388.6	344.0	12.6	77.9	68	69.2	0.678
Glicerina	355.8	419	66.0	86.3	68	78.7	0.554
Helio	-452.1	9.80	—	—	-452.1	9.13	5.45
Hidrógeno	-423.0	191.7	-434.5	25.6	-423.0	4.41	2.39
Isobutano	10.9	157.8	-255.5	45.5	10.9	37.1	0.545
Mercurio	674.1	126.7	-38.0	4.90	77	847	0.033
Metano	-258.7	219.6	296.0	25.1	-258.7	26.4	0.834
					-160	20.0	1.074
Metanol	148.1	473	-143.9	42.7	77	49.1	0.609
Nitrógeno	-320.4	85.4	-346.0	10.9	-320.4	50.5	0.492
					-260	38.2	0.643
Octano	256.6	131.7	-71.5	77.9	68	43.9	0.502
Oxígeno	-297.3	91.5	-361.8	5.9	-297.3	71.2	0.408
Petróleo	—	99-165			68	40.0	0.478
Propano	-43.7	184.0	-305.8	34.4	-43.7	36.3	0.538
					32	33.0	0.604
					100	29.4	0.673
Salmuera (20% de cloruro de sodio por masa)	219.0	—	0.7	—	68	71.8	0.743
Queroseno	399-559	108	-12.8	—	68	51.2	0.478
Refrigerante 134a	-15.0	93.3	-141.9	—	-40	88.5	0.283
					-15	86.0	0.294
					32	80.9	0.318
					90	73.6	0.348

*Temperatura de sublimación. (A presiones por debajo de la presión de punto triple de 75.1 psia, el dióxido de carbono existe como sólido o como gas. También, la temperatura de punto de congelamiento del dióxido de carbono es la temperatura de punto triple de -69.8°F.)

TABLA A-3E

Propiedades de líquidos, sólidos y alimentos comunes (*continuación*)

b) Sólidos (los valores son para temperatura ambiente, excepto que se indique otra cosa)

Sustancia	Densidad, ρ lbm/ft ³	Calor específico, c_p Btu/lbm · R	Sustancia	Densidad, ρ lbm/ft ³	Calor específico, c_p Btu/lbm · R
Metales			No metales		
Aceros dulces	489	0.119	Asfalto	132	0.220
Aluminio			Arcilla	62.4	0.220
-100°F		0.192	Arena	94.9	
32°F		0.212	Caucho (blando)	68.7	
100°F	170	0.218	Caucho (duro)	71.8	
200°F		0.224	Concreto	144	0.156
300°F		0.229	Diamante	151	0.147
400°F		0.235	Grafito	156	0.170
500°F		0.240	Granito	169	0.243
Bronce (76% Cu, 2% Zn, 2% Al)	517	0.0955	Hielo		
Cobre			-50°F		0.424
-60°F		0.0862	0°F		0.471
0°F		0.0893	20°F		0.491
100°F	555	0.0925	32°F	57.5	0.502
200°F		0.0938	Ladrillo común	120	0.189
390°F		0.0963	Ladrillo refractario (500 °C)	144	0.229
Hierro	490	0.107	Madera contrachapada (abeto Douglas)	34.0	
Latón amarillo (65% Cu, 35% Zn)	519	0.0955	Maderas duras (maple, encino, etc.)	45.0	
Magnesio	108	0.239	Maderas suaves (abeto, pino, etc.)	32.0	
Níquel	555	0.105	Mármol	162	0.210
Plata	655	0.056	Piedra	93.6	
Plomo	705	0.030	Piedra caliza	103	0.217
Tungsteno	1211	0.031	Vidrio para ventanas	169	0.191
			Vidrio pirex	139	0.200
			Yeso o tabla de yeso	50	0.260

c) Alimentos

Alimentos	Contenido de agua, % (masa)	Punto de congelación, °F	Calor específico, Btu/lbm · R		Calor latente de fusión Btu/lbm	Alimentos	Contenido de agua % (masa)	Punto de congelación, °F	Calor específico, Btu/lbm · R		Calor latente de fusión Btu/lbm
			Por encima del punto de congelación	Por debajo del punto de congelación					Por encima del punto de congelación	Por debajo del punto de congelación	
Brócoli	90	31	0.921	0.471	129	Mantequilla	16	—	—	0.249	23
Camarón	83	28	0.865	0.450	119	Manzanas	84	30	0.873	0.453	121
Carne de pollo	74	27	0.793	0.423	106	Maíz dulce	74	31	0.793	0.423	106
Carne de res	67	—	0.737	0.402	96	Naranjas	87	31	0.897	0.462	125
Cerezas	80	29	0.841	0.441	115	Papas	78	31	0.825	0.435	112
Espinaca	93	31	0.945	0.481	134	Pavo	64	—	0.713	0.393	92
Fresas	90	31	0.921	0.471	129	Plátanos	75	31	0.801	0.426	108
Helado	63	22	0.705	0.390	90	Queso suizo	39	14	0.513	0.318	56
Huevo entero	74	31	0.793	0.423	106	Salmón	64	28	0.713	0.393	92
Leche entera	88	31	0.905	0.465	126	Sandía	93	31	0.945	0.481	134
Lechuga	95	32	0.961	0.487	136	Tomates (maduros)	94	31	0.953	0.484	135

Fuente: Los valores han sido obtenidos de varios manuales y otras fuentes, o se han calculado. El contenido de agua y los datos de punto de congelación para alimentos provienen del ASHRAE, *Handbook of Fundamentals*, versión I-P, Atlanta, Georgia, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1993, Capítulo 30, Tabla 1. El punto de congelación es la temperatura a la que comienza la congelación para frutas y verduras, así como la temperatura promedio de congelación para otros alimentos.

TABLA A-4E

Agua saturada. Tabla de temperaturas

Temp., T °F	Pres. sat., P_{sat} psia	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm			Entalpía, Btu/lbm			Entropía, Btu/lbm · R		
		Líquido, sat., v_f	Vapor, sat., v_g	Líquido, sat., u_f	Evaporación, u_{fg}	Vapor, sat., u_g	Líquido, sat., h_f	Evaporación, h_{fg}	Vapor, sat., h_g	Líquido, sat., s_f	Evaporación, s_{fg}	Vapor, sat., s_g
32.018	0.08871	0.01602	3299.9	0.000	1021.0	1021.0	0.000	1075.2	1075.2	0.00000	2.18672	2.1867
35	0.09998	0.01602	2945.7	3.004	1019.0	1022.0	3.004	1073.5	1076.5	0.00609	2.17011	2.1762
40	0.12173	0.01602	2443.6	8.032	1015.6	1023.7	8.032	1070.7	1078.7	0.01620	2.14271	2.1589
45	0.14756	0.01602	2035.8	13.05	1012.2	1025.3	13.05	1067.8	1080.9	0.02620	2.11587	2.1421
50	0.17812	0.01602	1703.1	18.07	1008.9	1026.9	18.07	1065.0	1083.1	0.03609	2.08956	2.1256
55	0.21413	0.01603	1430.4	23.07	1005.5	1028.6	23.07	1062.2	1085.3	0.04586	2.06377	2.1096
60	0.25638	0.01604	1206.1	28.08	1002.1	1030.2	28.08	1059.4	1087.4	0.05554	2.03847	2.0940
65	0.30578	0.01604	1020.8	33.08	998.76	1031.8	33.08	1056.5	1089.6	0.06511	2.01366	2.0788
70	0.36334	0.01605	867.18	38.08	995.39	1033.5	38.08	1053.7	1091.8	0.07459	1.98931	2.0639
75	0.43016	0.01606	739.27	43.07	992.02	1035.1	43.07	1050.9	1093.9	0.08398	1.96541	2.0494
80	0.50745	0.01607	632.41	48.06	988.65	1036.7	48.07	1048.0	1096.1	0.09328	1.94196	2.0352
85	0.59659	0.01609	542.80	53.06	985.28	1038.3	53.06	1045.2	1098.3	0.10248	1.91892	2.0214
90	0.69904	0.01610	467.40	58.05	981.90	1040.0	58.05	1042.4	1100.4	0.11161	1.89630	2.0079
95	0.81643	0.01612	403.74	63.04	978.52	1041.6	63.04	1039.5	1102.6	0.12065	1.87408	1.9947
100	0.95052	0.01613	349.83	68.03	975.14	1043.2	68.03	1036.7	1104.7	0.12961	1.85225	1.9819
110	1.2767	0.01617	264.96	78.01	968.36	1046.4	78.02	1031.0	1109.0	0.14728	1.80970	1.9570
120	1.6951	0.01620	202.94	88.00	961.56	1049.6	88.00	1025.2	1113.2	0.16466	1.76856	1.9332
130	2.2260	0.01625	157.09	97.99	954.73	1052.7	97.99	1019.4	1117.4	0.18174	1.72877	1.9105
140	2.8931	0.01629	122.81	107.98	947.87	1055.9	107.99	1013.6	1121.6	0.19855	1.69024	1.8888
150	3.7234	0.01634	96.929	117.98	940.98	1059.0	117.99	1007.8	1125.7	0.21508	1.65291	1.8680
160	4.7474	0.01639	77.185	127.98	934.05	1062.0	128.00	1001.8	1129.8	0.23136	1.61670	1.8481
170	5.9999	0.01645	61.982	138.00	927.08	1065.1	138.02	995.88	1133.9	0.24739	1.58155	1.8289
180	7.5197	0.01651	50.172	148.02	920.06	1068.1	148.04	989.85	1137.9	0.26318	1.54741	1.8106
190	9.3497	0.01657	40.920	158.05	912.99	1071.0	158.08	983.76	1141.8	0.27874	1.51421	1.7930
200	11.538	0.01663	33.613	168.10	905.87	1074.0	168.13	977.60	1145.7	0.29409	1.48191	1.7760
210	14.136	0.01670	27.798	178.15	898.68	1076.8	178.20	971.35	1149.5	0.30922	1.45046	1.7597
212	14.709	0.01671	26.782	180.16	897.24	1077.4	180.21	970.09	1150.3	0.31222	1.44427	1.7565
220	17.201	0.01677	23.136	188.22	891.43	1079.6	188.28	965.02	1153.3	0.32414	1.41980	1.7439
230	20.795	0.01684	19.374	198.31	884.10	1082.4	198.37	958.59	1157.0	0.33887	1.38989	1.7288
240	24.985	0.01692	16.316	208.41	876.70	1085.1	208.49	952.06	1160.5	0.35342	1.36069	1.7141
250	29.844	0.01700	13.816	218.54	869.21	1087.7	218.63	945.41	1164.0	0.36779	1.33216	1.6999
260	35.447	0.01708	11.760	228.68	861.62	1090.3	228.79	938.65	1167.4	0.38198	1.30425	1.6862
270	41.877	0.01717	10.059	238.85	853.94	1092.8	238.98	931.76	1170.7	0.39601	1.27694	1.6730
280	49.222	0.01726	8.6439	249.04	846.16	1095.2	249.20	924.74	1173.9	0.40989	1.25018	1.6601
290	57.573	0.01735	7.4607	259.26	838.27	1097.5	259.45	917.57	1177.0	0.42361	1.22393	1.6475
300	67.028	0.01745	6.4663	269.51	830.25	1099.8	269.73	910.24	1180.0	0.43720	1.19818	1.6354
310	77.691	0.01755	5.6266	279.79	822.11	1101.9	280.05	902.75	1182.8	0.45065	1.17289	1.6235
320	89.667	0.01765	4.9144	290.11	813.84	1104.0	290.40	895.09	1185.5	0.46396	1.14802	1.6120
330	103.07	0.01776	4.3076	300.46	805.43	1105.9	300.80	887.25	1188.1	0.47716	1.12355	1.6007
340	118.02	0.01787	3.7885	310.85	796.87	1107.7	311.24	879.22	1190.5	0.49024	1.09945	1.5897
350	134.63	0.01799	3.3425	321.29	788.16	1109.4	321.73	870.98	1192.7	0.50321	1.07570	1.5789
360	153.03	0.01811	2.9580	331.76	779.28	1111.0	332.28	862.53	1194.8	0.51607	1.05227	1.5683
370	173.36	0.01823	2.6252	342.29	770.23	1112.5	342.88	853.86	1196.7	0.52884	1.02914	1.5580
380	195.74	0.01836	2.3361	352.87	761.00	1113.9	353.53	844.96	1198.5	0.54152	1.00628	1.5478
390	220.33	0.01850	2.0842	363.50	751.58	1115.1	364.25	835.81	1200.1	0.55411	0.98366	1.5378

TABLA A-4E

Agua saturada. Tabla de temperaturas (*conclusión*)

Temp., T °F	Pres. sat., P_{sat} psia	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm			Entalpía, Btu/lbm			Entropía, Btu/lbm · R		
		Líqu. sat., v_f	Vapor sat., v_g	Líqu. sat., u_f	Evap., u_{fg}	Vapor sat., u_g	Líqu. sat., h_f	Evap., h_{fg}	Vapor sat., h_g	Líqu. sat., s_f	Evap., s_{fg}	Vapor sat., s_g
400	247.26	0.01864	1.8639	374.19	741.97	1116.2	375.04	826.39	1201.4	0.56663	0.96127	1.5279
410	276.69	0.01878	1.6706	384.94	732.14	1117.1	385.90	816.71	1202.6	0.57907	0.93908	1.5182
420	308.76	0.01894	1.5006	395.76	722.08	1117.8	396.84	806.74	1203.6	0.59145	0.91707	1.5085
430	343.64	0.01910	1.3505	406.65	711.80	1118.4	407.86	796.46	1204.3	0.60377	0.89522	1.4990
440	381.49	0.01926	1.2178	417.61	701.26	1118.9	418.97	785.87	1204.8	0.61603	0.87349	1.4895
450	422.47	0.01944	1.0999	428.66	690.47	1119.1	430.18	774.94	1205.1	0.62826	0.85187	1.4801
460	466.75	0.01962	0.99510	439.79	679.39	1119.2	441.48	763.65	1205.1	0.64044	0.83033	1.4708
470	514.52	0.01981	0.90158	451.01	668.02	1119.0	452.90	751.98	1204.9	0.65260	0.80885	1.4615
480	565.96	0.02001	0.81794	462.34	656.34	1118.7	464.43	739.91	1204.3	0.66474	0.78739	1.4521
490	621.24	0.02022	0.74296	473.77	644.32	1118.1	476.09	727.40	1203.5	0.67686	0.76594	1.4428
500	680.56	0.02044	0.67558	485.32	631.94	1117.3	487.89	714.44	1202.3	0.68899	0.74445	1.4334
510	744.11	0.02067	0.61489	496.99	619.17	1116.2	499.84	700.99	1200.8	0.70112	0.72290	1.4240
520	812.11	0.02092	0.56009	508.80	605.99	1114.8	511.94	687.01	1199.0	0.71327	0.70126	1.4145
530	884.74	0.02118	0.51051	520.76	592.35	1113.1	524.23	672.47	1196.7	0.72546	0.67947	1.4049
540	962.24	0.02146	0.46553	532.88	578.23	1111.1	536.70	657.31	1194.0	0.73770	0.65751	1.3952
550	1044.8	0.02176	0.42465	545.18	563.58	1108.8	549.39	641.47	1190.9	0.75000	0.63532	1.3853
560	1132.7	0.02207	0.38740	557.68	548.33	1106.0	562.31	624.91	1187.2	0.76238	0.61284	1.3752
570	1226.2	0.02242	0.35339	570.40	532.45	1102.8	575.49	607.55	1183.0	0.77486	0.59003	1.3649
580	1325.5	0.02279	0.32225	583.37	515.84	1099.2	588.95	589.29	1178.2	0.78748	0.56679	1.3543
590	1430.8	0.02319	0.29367	596.61	498.43	1095.0	602.75	570.04	1172.8	0.80026	0.54306	1.3433
600	1542.5	0.02362	0.26737	610.18	480.10	1090.3	616.92	549.67	1166.6	0.81323	0.51871	1.3319
610	1660.9	0.02411	0.24309	624.11	460.73	1084.8	631.52	528.03	1159.5	0.82645	0.49363	1.3201
620	1786.2	0.02464	0.22061	638.47	440.14	1078.6	646.62	504.92	1151.5	0.83998	0.46765	1.3076
630	1918.9	0.02524	0.19972	653.35	418.12	1071.5	662.32	480.07	1142.4	0.85389	0.44056	1.2944
640	2059.3	0.02593	0.18019	668.86	394.36	1063.2	678.74	453.14	1131.9	0.86828	0.41206	1.2803
650	2207.8	0.02673	0.16184	685.16	368.44	1053.6	696.08	423.65	1119.7	0.88332	0.38177	1.2651
660	2364.9	0.02767	0.14444	702.48	339.74	1042.2	714.59	390.84	1105.4	0.89922	0.34906	1.2483
670	2531.2	0.02884	0.12774	721.23	307.22	1028.5	734.74	353.54	1088.3	0.91636	0.31296	1.2293
680	2707.3	0.03035	0.11134	742.11	269.00	1011.1	757.32	309.57	1066.9	0.93541	0.27163	1.2070
690	2894.1	0.03255	0.09451	766.81	220.77	987.6	784.24	253.96	1038.2	0.95797	0.22089	1.1789
700	3093.0	0.03670	0.07482	801.75	146.50	948.3	822.76	168.32	991.1	0.99023	0.14514	1.1354
705.10	3200.1	0.04975	0.04975	866.61	0	866.6	896.07	0	896.1	1.05257	0	1.0526

Fuente: Las tablas A-4E a A-8E fueron generadas utilizando el programa para resolver ecuaciones de ingeniería (EES) desarrollado por S. A. Klein y F. L. Alvarado. La rutina utilizada en los cálculos es la altamente precisa Steam_IAPWS, que incorpora la Formulación 1995 para las Propiedades Termodinámicas de la Sustancia Agua Ordinaria para Uso Científico y General, editada por The International Association for the Properties of Water and Steam (IAPWS). Esta formulación reemplaza a la de 1984 de Haar, Gallagher y Kell (NBS/NRC Steam Tables, Hemisphere Publishing Co., 1984), la cual está también disponible en EES como la rutina STEAM. La nueva formulación se basa en las correlaciones de Saul y Wagner (J. Phys. Chem. Ref. Data, 16, 893, 1987) con modificaciones para ajustarla a la Escala Internacional de Temperaturas de 1990. Las modificaciones están descritas por Wagner y Pruss (J. Phys. Chem. Ref. Data, 22, 783, 1993). Las propiedades del hielo están basadas en Hyland y Wexler, "Formulations for the Thermodynamic Properties of the Saturated Phases of H₂O from 173.15 K a 473.15 K", *ASHRAE Trans.*, Part 2A, Paper 2793, 1983.

TABLA A-5E

Agua saturada. Tabla de presiones

Pres., <i>P</i> psia	Temp. sat., <i>T</i> _{sat} °F	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm			Entalpía, Btu/lbm			Entropía, Btu/lbm · R		
		Líqu. sat., <i>v</i> _f	Vapor sat., <i>v</i> _g	Líqu. sat., <i>u</i> _f	Evap., <i>u</i> _{fg}	Vapor sat., <i>u</i> _g	Líqu. sat., <i>h</i> _f	Evap., <i>h</i> _{fg}	Vapor sat., <i>h</i> _g	Líqu. sat., <i>s</i> _f	Evap., <i>s</i> _{fg}	Vapor sat., <i>s</i> _g
1	101.69	0.01614	333.49	69.72	973.99	1043.7	69.72	1035.7	1105.4	0.13262	1.84495	1.9776
2	126.02	0.01623	173.71	94.02	957.45	1051.5	94.02	1021.7	1115.8	0.17499	1.74444	1.9194
3	141.41	0.01630	118.70	109.39	946.90	1056.3	109.40	1012.8	1122.2	0.20090	1.68489	1.8858
4	152.91	0.01636	90.629	120.89	938.97	1059.9	120.90	1006.0	1126.9	0.21985	1.64225	1.8621
5	162.18	0.01641	73.525	130.17	932.53	1062.7	130.18	1000.5	1130.7	0.23488	1.60894	1.8438
6	170.00	0.01645	61.982	138.00	927.08	1065.1	138.02	995.88	1133.9	0.24739	1.58155	1.8289
8	182.81	0.01652	47.347	150.83	918.08	1068.9	150.86	988.15	1139.0	0.26757	1.53800	1.8056
10	193.16	0.01659	38.425	161.22	910.75	1072.0	161.25	981.82	1143.1	0.28362	1.50391	1.7875
14.696	211.95	0.01671	26.805	180.12	897.27	1077.4	180.16	970.12	1150.3	0.31215	1.44441	1.7566
15	212.99	0.01672	26.297	181.16	896.52	1077.7	181.21	969.47	1150.7	0.31370	1.44441	1.7549
20	227.92	0.01683	20.093	196.21	885.63	1081.8	196.27	959.93	1156.2	0.33582	1.39606	1.7319
25	240.03	0.01692	16.307	208.45	876.67	1085.1	208.52	952.03	1160.6	0.35347	1.36060	1.7141
30	250.30	0.01700	13.749	218.84	868.98	1087.8	218.93	945.21	1164.1	0.36821	1.33132	1.6995
35	259.25	0.01708	11.901	227.92	862.19	1090.1	228.03	939.16	1167.2	0.38093	1.30632	1.6872
40	267.22	0.01715	10.501	236.02	856.09	1092.1	236.14	933.69	1169.8	0.39213	1.28448	1.6766
45	274.41	0.01721	9.4028	243.34	850.52	1093.9	243.49	928.68	1172.2	0.40216	1.26506	1.6672
50	280.99	0.01727	8.5175	250.05	845.39	1095.4	250.21	924.03	1174.2	0.41125	1.24756	1.6588
55	287.05	0.01732	7.7882	256.25	840.61	1096.9	256.42	919.70	1176.1	0.41958	1.23162	1.6512
60	292.69	0.01738	7.1766	262.01	836.13	1098.1	262.20	915.61	1177.8	0.42728	1.21697	1.6442
65	297.95	0.01743	6.6560	267.41	831.90	1099.3	267.62	911.75	1179.4	0.43443	1.20341	1.6378
70	302.91	0.01748	6.2075	272.50	827.90	1100.4	272.72	908.08	1180.8	0.44112	1.19078	1.6319
75	307.59	0.01752	5.8167	277.31	824.09	1101.4	277.55	904.58	1182.1	0.44741	1.17895	1.6264
80	312.02	0.01757	5.4733	281.87	820.45	1102.3	282.13	901.22	1183.4	0.45335	1.16783	1.6212
85	316.24	0.01761	5.1689	286.22	816.97	1103.2	286.50	898.00	1184.5	0.45897	1.15732	1.6163
90	320.26	0.01765	4.8972	290.38	813.62	1104.0	290.67	894.89	1185.6	0.46431	1.14737	1.6117
95	324.11	0.01770	4.6532	294.36	810.40	1104.8	294.67	891.89	1186.6	0.46941	1.13791	1.6073
100	327.81	0.01774	4.4327	298.19	807.29	1105.5	298.51	888.99	1187.5	0.47427	1.12888	1.6032
110	334.77	0.01781	4.0410	305.41	801.37	1106.8	305.78	883.44	1189.2	0.48341	1.11201	1.5954
120	341.25	0.01789	3.7289	312.16	795.79	1107.9	312.55	878.20	1190.8	0.49187	1.09646	1.5883
130	347.32	0.01796	3.4557	318.48	790.51	1109.0	318.92	873.21	1192.1	0.49974	1.08204	1.5818
140	353.03	0.01802	3.2202	324.45	785.49	1109.9	324.92	868.45	1193.4	0.50711	1.06858	1.5757
150	358.42	0.01809	3.0150	330.11	780.69	1110.8	330.61	863.88	1194.5	0.51405	1.05595	1.5700
160	363.54	0.01815	2.8347	335.49	776.10	1111.6	336.02	859.49	1195.5	0.52061	1.04405	1.5647
170	368.41	0.01821	2.6749	340.62	771.68	1112.3	341.19	855.25	1196.4	0.52682	1.03279	1.5596
180	373.07	0.01827	2.5322	345.53	767.42	1113.0	346.14	851.16	1197.3	0.53274	1.02210	1.5548
190	377.52	0.01833	2.4040	350.24	763.31	1113.6	350.89	847.19	1198.1	0.53839	1.01191	1.5503
200	381.80	0.01839	2.2882	354.78	759.32	1114.1	355.46	843.33	1198.8	0.54379	1.00219	1.5460
250	400.97	0.01865	1.8440	375.23	741.02	1116.3	376.09	825.47	1201.6	0.56784	0.95912	1.5270
300	417.35	0.01890	1.5435	392.89	724.77	1117.7	393.94	809.41	1203.3	0.58818	0.92289	1.5111
350	431.74	0.01912	1.3263	408.55	709.98	1118.5	409.79	794.65	1204.4	0.60590	0.89143	1.4973
400	444.62	0.01934	1.1617	422.70	696.31	1119.0	424.13	780.87	1205.0	0.62168	0.86350	1.4852
450	456.31	0.01955	1.0324	435.67	683.52	1119.2	437.30	767.86	1205.2	0.63595	0.83828	1.4742
500	467.04	0.01975	0.92819	447.68	671.42	1119.1	449.51	755.48	1205.0	0.64900	0.81521	1.4642
550	476.97	0.01995	0.84228	458.90	659.91	1118.8	460.93	743.60	1204.5	0.66107	0.79388	1.4550
600	486.24	0.02014	0.77020	469.46	648.88	1118.3	471.70	732.15	1203.9	0.67231	0.77400	1.4463

TABLA A-5E

Agua saturada. Tabla de presiones (*conclusión*)

Pres., <i>P</i> psia	Temp. sat., <i>T</i> _{sat} °F	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm			Entalpía, Btu/lbm			Entropía, Btu/lbm · R		
		Líqu. sat., <i>v</i> _f	Vapor sat., <i>v</i> _g	Líqu. sat., <i>u</i> _f	Evap., <i>u</i> _{fg}	Vapor sat., <i>u</i> _g	Líqu. sat., <i>h</i> _f	Evap., <i>h</i> _{fg}	Vapor sat., <i>h</i> _g	Líqu. sat., <i>s</i> _f	Evap., <i>s</i> _{fg}	Vapor sat., <i>s</i> _g
700	503.13	0.02051	0.65589	488.96	627.98	1116.9	491.62	710.29	1201.9	0.69279	0.73771	1.4305
800	518.27	0.02087	0.56920	506.74	608.30	1115.0	509.83	689.48	1199.3	0.71117	0.70502	1.4162
900	532.02	0.02124	0.50107	523.19	589.54	1112.7	526.73	669.46	1196.2	0.72793	0.67505	1.4030
1000	544.65	0.02159	0.44604	538.58	571.49	1110.1	542.57	650.03	1192.6	0.74341	0.64722	1.3906
1200	567.26	0.02232	0.36241	566.89	536.87	1103.8	571.85	612.39	1184.2	0.77143	0.59632	1.3677
1400	587.14	0.02307	0.30161	592.79	503.50	1096.3	598.76	575.66	1174.4	0.79658	0.54991	1.3465
1600	604.93	0.02386	0.25516	616.99	470.69	1087.7	624.06	539.18	1163.2	0.81972	0.50645	1.3262
1800	621.07	0.02470	0.21831	640.03	437.86	1077.9	648.26	502.35	1150.6	0.84144	0.46482	1.3063
2000	635.85	0.02563	0.18815	662.33	404.46	1066.8	671.82	464.60	1136.4	0.86224	0.42409	1.2863
2500	668.17	0.02860	0.13076	717.67	313.53	1031.2	730.90	360.79	1091.7	0.91311	0.31988	1.2330
3000	695.41	0.03433	0.08460	783.39	186.41	969.8	802.45	214.32	1016.8	0.97321	0.18554	1.1587
3200.1	705.10	0.04975	0.04975	866.61	0	866.6	896.07	0	896.1	1.05257	0	1.0526

TABLA A-6E

Vapor de agua sobrecalentado

<i>T</i> °F	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R
<i>P</i> = 1.0 psia (101.69°F)*				<i>P</i> = 5.0 psia (162.18°F)				<i>P</i> = 10 psia (193.16°F)				
Sat.†	333.49	1043.7	1105.4	1.9776	73.525	1062.7	1130.7	1.8438	38.425	1072.0	1143.1	1.7875
200	392.53	1077.5	1150.1	2.0509	78.153	1076.2	1148.5	1.8716	38.849	1074.5	1146.4	1.7926
240	416.44	1091.2	1168.3	2.0777	83.009	1090.3	1167.1	1.8989	41.326	1089.1	1165.5	1.8207
280	440.33	1105.0	1186.5	2.1030	87.838	1104.3	1185.6	1.9246	43.774	1103.4	1184.4	1.8469
320	464.20	1118.9	1204.8	2.1271	92.650	1118.4	1204.1	1.9490	46.205	1117.6	1203.1	1.8716
360	488.07	1132.9	1223.3	2.1502	97.452	1132.5	1222.6	1.9722	48.624	1131.9	1221.8	1.8950
400	511.92	1147.1	1241.8	2.1722	102.25	1146.7	1241.3	1.9944	51.035	1146.2	1240.6	1.9174
440	535.77	1161.3	1260.4	2.1934	107.03	1160.9	1260.0	2.0156	53.441	1160.5	1259.4	1.9388
500	571.54	1182.8	1288.6	2.2237	114.21	1182.6	1288.2	2.0461	57.041	1182.2	1287.8	1.9693
600	631.14	1219.4	1336.2	2.2709	126.15	1219.2	1335.9	2.0933	63.029	1219.0	1335.6	2.0167
700	690.73	1256.8	1384.6	2.3146	138.09	1256.7	1384.4	2.1371	69.007	1256.5	1384.2	2.0605
800	750.31	1295.1	1433.9	2.3553	150.02	1294.9	1433.7	2.1778	74.980	1294.8	1433.5	2.1013
1000	869.47	1374.2	1535.1	2.4299	173.86	1374.2	1535.0	2.2524	86.913	1374.1	1534.9	2.1760
1200	988.62	1457.1	1640.0	2.4972	197.70	1457.0	1640.0	2.3198	98.840	1457.0	1639.9	2.2433
1400	1107.8	1543.7	1748.7	2.5590	221.54	1543.7	1748.7	2.3816	110.762	1543.6	1748.6	2.3052
<i>P</i> = 15 psia (212.99°F)				<i>P</i> = 20 psia (227.92°F)				<i>P</i> = 40 psia (267.22°F)				
Sat.	26.297	1077.7	1150.7	1.7549	20.093	1081.8	1156.2	1.7319	10.501	1092.1	1169.8	1.6766
240	27.429	1087.8	1163.9	1.7742	20.478	1086.5	1162.3	1.7406				
280	29.085	1102.4	1183.2	1.8010	21.739	1101.4	1181.9	1.7679	10.713	1097.3	1176.6	1.6858
320	30.722	1116.9	1202.2	1.8260	22.980	1116.1	1201.2	1.7933	11.363	1112.9	1197.1	1.7128
360	32.348	1131.3	1221.1	1.8496	24.209	1130.7	1220.2	1.8171	11.999	1128.1	1216.9	1.7376
400	33.965	1145.7	1239.9	1.8721	25.429	1145.1	1239.3	1.8398	12.625	1143.1	1236.5	1.7610
440	35.576	1160.1	1258.8	1.8936	26.644	1159.7	1258.3	1.8614	13.244	1157.9	1256.0	1.7831
500	37.986	1181.9	1287.3	1.9243	28.458	1181.6	1286.9	1.8922	14.165	1180.2	1285.0	1.8143
600	41.988	1218.7	1335.3	1.9718	31.467	1218.5	1334.9	1.9398	15.686	1217.5	1333.6	1.8625
700	45.981	1256.3	1383.9	2.0156	34.467	1256.1	1383.7	1.9837	17.197	1255.3	1382.6	1.9067
800	49.967	1294.6	1433.3	2.0565	37.461	1294.5	1433.1	2.0247	18.702	1293.9	1432.3	1.9478
1000	57.930	1374.0	1534.8	2.1312	43.438	1373.8	1534.6	2.0994	21.700	1373.4	1534.1	2.0227
1200	65.885	1456.9	1639.8	2.1986	49.407	1456.8	1639.7	2.1668	24.691	1456.5	1639.3	2.0902
1400	73.836	1543.6	1748.5	2.2604	55.373	1543.5	1748.4	2.2287	27.678	1543.3	1748.1	2.1522
1600	81.784	1634.0	1861.0	2.3178	61.335	1633.9	1860.9	2.2861	30.662	1633.7	1860.7	2.2096
<i>P</i> = 60 psia (292.69°F)				<i>P</i> = 80 psia (312.02°F)				<i>P</i> = 100 psia (327.81°F)				
Sat.	7.1766	1098.1	1177.8	1.6442	5.4733	1102.3	1183.4	1.6212	4.4327	1105.5	1187.5	1.6032
320	7.4863	1109.6	1192.7	1.6636	5.5440	1105.9	1187.9	1.6271				
360	7.9259	1125.5	1213.5	1.6897	5.8876	1122.7	1209.9	1.6545	4.6628	1119.8	1206.1	1.6263
400	8.3548	1140.9	1233.7	1.7138	6.2187	1138.7	1230.8	1.6794	4.9359	1136.4	1227.8	1.6521
440	8.7766	1156.1	1253.6	1.7364	6.5420	1154.3	1251.2	1.7026	5.2006	1152.4	1248.7	1.6759
500	9.4005	1178.8	1283.1	1.7682	7.0177	1177.3	1281.2	1.7350	5.5876	1175.9	1279.3	1.7088
600	10.4256	1216.5	1332.2	1.8168	7.7951	1215.4	1330.8	1.7841	6.2167	1214.4	1329.4	1.7586
700	11.4401	1254.5	1381.6	1.8613	8.5616	1253.8	1380.5	1.8289	6.8344	1253.0	1379.5	1.8037
800	12.4484	1293.3	1431.5	1.9026	9.3218	1292.6	1430.6	1.8704	7.4457	1292.0	1429.8	1.8453
1000	14.4543	1373.0	1533.5	1.9777	10.8313	1372.6	1532.9	1.9457	8.6575	1372.2	1532.4	1.9208
1200	16.4525	1456.2	1638.9	2.0454	12.3331	1455.9	1638.5	2.0135	9.8615	1455.6	1638.1	1.9887
1400	18.4464	1543.0	1747.8	2.1073	13.8306	1542.8	1747.5	2.0755	11.0612	1542.6	1747.2	2.0508
1600	20.438	1633.5	1860.5	2.1648	15.3257	1633.3	1860.2	2.1330	12.2584	1633.2	1860.0	2.1083
1800	22.428	1727.6	1976.6	2.2187	16.8192	1727.5	1976.5	2.1869	13.4541	1727.3	1976.3	2.1622
2000	24.417	1825.2	2096.3	2.2694	18.3117	1825.0	2096.1	2.2376	14.6487	1824.9	2096.0	2.2130

* La temperatura entre paréntesis es la temperatura de saturación a la presión especificada.

† Propiedades del vapor saturado a la presión especificada.

TABLA A-6E

Vapor de agua sobrecalentado (*continuación*)

<i>T</i> °F	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R
<i>P</i> = 120 psia (341.25°F)				<i>P</i> = 140 psia (353.03°F)				<i>P</i> = 160 psia (363.54°F)				
Sat.	3.7289	1107.9	1190.8	1.5883	3.2202	1109.9	1193.4	1.5757	2.8347	1111.6	1195.5	1.5647
360	3.8446	1116.7	1202.1	1.6023	3.2584	1113.4	1197.8	1.5811				
400	4.0799	1134.0	1224.6	1.6292	3.4676	1131.5	1221.4	1.6092	3.0076	1129.0	1218.0	1.5914
450	4.3613	1154.5	1251.4	1.6594	3.7147	1152.6	1248.9	1.6403	3.2293	1150.7	1246.3	1.6234
500	4.6340	1174.4	1277.3	1.6872	3.9525	1172.9	1275.3	1.6686	3.4412	1171.4	1273.2	1.6522
550	4.9010	1193.9	1302.8	1.7131	4.1845	1192.7	1301.1	1.6948	3.6469	1191.4	1299.4	1.6788
600	5.1642	1213.4	1328.0	1.7375	4.4124	1212.3	1326.6	1.7195	3.8484	1211.3	1325.2	1.7037
700	5.6829	1252.2	1378.4	1.7829	4.8604	1251.4	1377.3	1.7652	4.2434	1250.6	1376.3	1.7498
800	6.1950	1291.4	1429.0	1.8247	5.3017	1290.8	1428.1	1.8072	4.6316	1290.2	1427.3	1.7920
1000	7.2083	1371.7	1531.8	1.9005	6.1732	1371.3	1531.3	1.8832	5.3968	1370.9	1530.7	1.8682
1200	8.2137	1455.3	1637.7	1.9684	7.0367	1455.0	1637.3	1.9512	6.1540	1454.7	1636.9	1.9363
1400	9.2149	1542.3	1746.9	2.0305	7.8961	1542.1	1746.6	2.0134	6.9070	1541.8	1746.3	1.9986
1600	10.2135	1633.0	1859.8	2.0881	8.7529	1632.8	1859.5	2.0711	7.6574	1632.6	1859.3	2.0563
1800	11.2106	1727.2	1976.1	2.1420	9.6082	1727.0	1975.9	2.1250	8.4063	1726.9	1975.7	2.1102
2000	12.2067	1824.8	2095.8	2.1928	10.4624	1824.6	2095.7	2.1758	9.1542	1824.5	2095.5	2.1610
<i>P</i> = 180 psia (373.07°F)				<i>P</i> = 200 psia (381.80°F)				<i>P</i> = 225 psia (391.80°F)				
Sat.	2.5322	1113.0	1197.3	1.5548	2.2882	1114.1	1198.8	1.5460	2.0423	1115.3	1200.3	1.5360
400	2.6490	1126.3	1214.5	1.5752	2.3615	1123.5	1210.9	1.5602	2.0728	1119.7	1206.0	1.5427
450	2.8514	1148.7	1243.7	1.6082	2.5488	1146.7	1241.0	1.5943	2.2457	1144.1	1237.6	1.5783
500	3.0433	1169.8	1271.2	1.6376	2.7247	1168.2	1269.0	1.6243	2.4059	1166.2	1266.3	1.6091
550	3.2286	1190.2	1297.7	1.6646	2.8939	1188.9	1296.0	1.6516	2.5590	1187.2	1293.8	1.6370
600	3.4097	1210.2	1323.8	1.6897	3.0586	1209.1	1322.3	1.6771	2.7075	1207.7	1320.5	1.6628
700	3.7635	1249.8	1375.2	1.7361	3.3796	1249.0	1374.1	1.7238	2.9956	1248.0	1372.7	1.7099
800	4.1104	1289.5	1426.5	1.7785	3.6934	1288.9	1425.6	1.7664	3.2765	1288.1	1424.5	1.7528
900	4.4531	1329.7	1478.0	1.8179	4.0031	1329.2	1477.3	1.8059	3.5530	1328.5	1476.5	1.7925
1000	4.7929	1370.5	1530.1	1.8549	4.3099	1370.1	1529.6	1.8430	3.8268	1369.5	1528.9	1.8296
1200	5.4674	1454.3	1636.5	1.9231	4.9182	1454.0	1636.1	1.9113	4.3689	1453.6	1635.6	1.8981
1400	6.1377	1541.6	1746.0	1.9855	5.5222	1541.4	1745.7	1.9737	4.9068	1541.1	1745.4	1.9606
1600	6.8054	1632.4	1859.1	2.0432	6.1238	1632.2	1858.8	2.0315	5.4422	1632.0	1858.6	2.0184
1800	7.4716	1726.7	1975.6	2.0971	6.7238	1726.5	1975.4	2.0855	5.9760	1726.4	1975.2	2.0724
2000	8.1367	1824.4	2095.4	2.1479	7.3227	1824.3	2095.3	2.1363	6.5087	1824.1	2095.1	2.1232
<i>P</i> = 250 psia (400.97°F)				<i>P</i> = 275 psia (409.45°F)				<i>P</i> = 300 psia (417.35°F)				
Sat.	1.8440	1116.3	1201.6	1.5270	1.6806	1117.0	1202.6	1.5187	1.5435	1117.7	1203.3	1.5111
450	2.0027	1141.3	1234.0	1.5636	1.8034	1138.5	1230.3	1.5499	1.6369	1135.6	1226.4	1.5369
500	2.1506	1164.1	1263.6	1.5953	1.9415	1162.0	1260.8	1.5825	1.7670	1159.8	1257.9	1.5706
550	2.2910	1185.6	1291.5	1.6237	2.0715	1183.9	1289.3	1.6115	1.8885	1182.1	1287.0	1.6001
600	2.4264	1206.3	1318.6	1.6499	2.1964	1204.9	1316.7	1.6380	2.0046	1203.5	1314.8	1.6270
650	2.5586	1226.8	1345.1	1.6743	2.3179	1225.6	1343.5	1.6627	2.1172	1224.4	1341.9	1.6520
700	2.6883	1247.0	1371.4	1.6974	2.4369	1246.0	1370.0	1.6860	2.2273	1244.9	1368.6	1.6755
800	2.9429	1287.3	1423.5	1.7406	2.6699	1286.5	1422.4	1.7294	2.4424	1285.7	1421.3	1.7192
900	3.1930	1327.9	1475.6	1.7804	2.8984	1327.3	1474.8	1.7694	2.6529	1326.6	1473.9	1.7593
1000	3.4403	1369.0	1528.2	1.8177	3.1241	1368.5	1527.4	1.8068	2.8605	1367.9	1526.7	1.7968
1200	3.9295	1453.3	1635.0	1.8863	3.5700	1452.9	1634.5	1.8755	3.2704	1452.5	1634.0	1.8657
1400	4.4144	1540.8	1745.0	1.9488	4.0116	1540.5	1744.6	1.9381	3.6759	1540.2	1744.2	1.9284
1600	4.8969	1631.7	1858.3	2.0066	4.4507	1631.5	1858.0	1.9960	4.0789	1631.3	1857.7	1.9863
1800	5.3777	1726.2	1974.9	2.0607	4.8882	1726.0	1974.7	2.0501	4.4803	1725.8	1974.5	2.0404
2000	5.8575	1823.9	2094.9	2.1116	5.3247	1823.8	2094.7	2.1010	4.8807	1823.6	2094.6	2.0913

TABLA A-6E

Vapor de agua sobrecalentado (*continuación*)

<i>T</i> °F	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R
<i>P</i> = 350 psia (431.74°F)				<i>P</i> = 400 psia (444.62°F)				<i>P</i> = 450 psia (456.31°F)				
Sat.	1.3263	1118.5	1204.4	1.4973	1.1617	1119.0	1205.0	1.4852	1.0324	1119.2	1205.2	1.4742
450	1.3739	1129.3	1218.3	1.5128	1.1747	1122.5	1209.4	1.4901				
500	1.4921	1155.2	1251.9	1.5487	1.2851	1150.4	1245.6	1.5288	1.1233	1145.4	1238.9	1.5103
550	1.6004	1178.6	1282.2	1.5795	1.3840	1174.9	1277.3	1.5610	1.2152	1171.1	1272.3	1.5441
600	1.7030	1200.6	1310.9	1.6073	1.4765	1197.6	1306.9	1.5897	1.3001	1194.6	1302.8	1.5737
650	1.8018	1221.9	1338.6	1.6328	1.5650	1219.4	1335.3	1.6158	1.3807	1216.9	1331.9	1.6005
700	1.8979	1242.8	1365.8	1.6567	1.6507	1240.7	1362.9	1.6401	1.4584	1238.5	1360.0	1.6253
800	2.0848	1284.1	1419.1	1.7009	1.8166	1282.5	1417.0	1.6849	1.6080	1280.8	1414.7	1.6706
900	2.2671	1325.3	1472.2	1.7414	1.9777	1324.0	1470.4	1.7257	1.7526	1322.7	1468.6	1.7117
1000	2.4464	1366.9	1525.3	1.7791	2.1358	1365.8	1523.9	1.7636	1.8942	1364.7	1522.4	1.7499
1200	2.7996	1451.7	1633.0	1.8483	2.4465	1450.9	1632.0	1.8331	2.1718	1450.1	1631.0	1.8196
1400	3.1484	1539.6	1743.5	1.9111	2.7527	1539.0	1742.7	1.8960	2.4450	1538.4	1742.0	1.8827
1600	3.4947	1630.8	1857.1	1.9691	3.0565	1630.3	1856.5	1.9541	2.7157	1629.8	1856.0	1.9409
1800	3.8394	1725.4	1974.0	2.0233	3.3586	1725.0	1973.6	2.0084	2.9847	1724.6	1973.2	1.9952
2000	4.1830	1823.3	2094.2	2.0742	3.6597	1823.0	2093.9	2.0594	3.2527	1822.6	2093.5	2.0462
<i>P</i> = 500 psia (467.04°F)				<i>P</i> = 600 psia (486.24°F)				<i>P</i> = 700 psia (503.13°F)				
Sat.	0.92815	1119.1	1205.0	1.4642	0.77020	1118.3	1203.9	1.4463	0.65589	1116.9	1201.9	1.4305
500	0.99304	1140.1	1231.9	1.4928	0.79526	1128.2	1216.5	1.4596				
550	1.07974	1167.1	1267.0	1.5284	0.87542	1158.7	1255.9	1.4996	0.72799	1149.5	1243.8	1.4730
600	1.15876	1191.4	1298.6	1.5590	0.94605	1184.9	1289.9	1.5325	0.79332	1177.9	1280.7	1.5087
650	1.23312	1214.3	1328.4	1.5865	1.01133	1209.0	1321.3	1.5614	0.85242	1203.4	1313.8	1.5393
700	1.30440	1236.4	1357.0	1.6117	1.07316	1231.9	1351.0	1.5877	0.90769	1227.2	1344.8	1.5666
800	1.44097	1279.2	1412.5	1.6576	1.19038	1275.8	1408.0	1.6348	1.01125	1272.4	1403.4	1.6150
900	1.57252	1321.4	1466.9	1.6992	1.30230	1318.7	1463.3	1.6771	1.10921	1316.0	1459.7	1.6581
1000	1.70094	1363.6	1521.0	1.7376	1.41097	1361.4	1518.1	1.7160	1.20381	1359.2	1515.2	1.6974
1100	1.82726	1406.2	1575.3	1.7735	1.51749	1404.4	1572.9	1.7522	1.29621	1402.5	1570.4	1.7341
1200	1.95211	1449.4	1630.0	1.8075	1.62252	1447.8	1627.9	1.7865	1.38709	1446.2	1625.9	1.7685
1400	2.1988	1537.8	1741.2	1.8708	1.82957	1536.6	1739.7	1.8501	1.56580	1535.4	1738.2	1.8324
1600	2.4430	1629.4	1855.4	1.9291	2.0340	1628.4	1854.2	1.9085	1.74192	1627.5	1853.1	1.8911
1800	2.6856	1724.2	1972.7	1.9834	2.2369	1723.4	1971.8	1.9630	1.91643	1722.7	1970.9	1.9457
2000	2.9271	1822.3	2093.1	2.0345	2.4387	1821.7	2092.4	2.0141	2.08987	1821.0	2091.7	1.9969
<i>P</i> = 800 psia (518.27°F)				<i>P</i> = 1000 psia (544.65°F)				<i>P</i> = 1250 psia (572.45°F)				
Sat.	0.56920	1115.0	1199.3	1.4162	0.44604	1110.1	1192.6	1.3906	0.34549	1102.0	1181.9	1.3623
550	0.61586	1139.4	1230.5	1.4476	0.45375	1115.2	1199.2	1.3972				
600	0.67799	1170.5	1270.9	1.4866	0.51431	1154.1	1249.3	1.4457	0.37894	1129.5	1217.2	1.3961
650	0.73279	1197.6	1306.0	1.5191	0.56411	1185.1	1289.5	1.4827	0.42703	1167.5	1266.3	1.4414
700	0.78330	1222.4	1338.4	1.5476	0.60844	1212.4	1325.0	1.5140	0.46735	1198.7	1306.8	1.4771
750	0.83102	1246.0	1369.1	1.5735	0.64944	1237.6	1357.8	1.5418	0.50344	1226.4	1342.9	1.5076
800	0.87678	1268.9	1398.7	1.5975	0.68821	1261.7	1389.0	1.5670	0.53687	1252.2	1376.4	1.5347
900	0.96434	1313.3	1456.0	1.6413	0.76136	1307.7	1448.6	1.6126	0.59876	1300.5	1439.0	1.5826
1000	1.04841	1357.0	1512.2	1.6812	0.83078	1352.5	1506.2	1.6535	0.65656	1346.7	1498.6	1.6249
1100	1.13024	1400.7	1568.0	1.7181	0.89783	1396.9	1563.1	1.6911	0.71184	1392.2	1556.8	1.6635
1200	1.21051	1444.6	1623.8	1.7528	0.96327	1441.4	1619.7	1.7263	0.76545	1437.4	1614.5	1.6993
1400	1.36797	1534.2	1736.7	1.8170	1.09101	1531.8	1733.7	1.7911	0.86944	1528.7	1729.8	1.7649
1600	1.52283	1626.5	1851.9	1.8759	1.21610	1624.6	1849.6	1.8504	0.97072	1622.2	1846.7	1.8246
1800	1.67606	1721.9	1970.0	1.9306	1.33956	1720.3	1968.2	1.9053	1.07036	1718.4	1966.0	1.8799
2000	1.82823	1820.4	2091.0	1.9819	1.46194	1819.1	2089.6	1.9568	1.16892	1817.5	2087.9	1.9315

TABLA A-6E

Vapor de agua sobrecalentado (*conclusión*)

<i>T</i> °F	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/ lbm · R
<i>P</i> = 1500 psia (596.26°F)				<i>P</i> = 1750 psia (617.17°F)				<i>P</i> = 2000 psia (635.85°F)				
Sat.	0.27695	1092.1	1169.0	1.3362	0.22681	1080.5	1153.9	1.3112	0.18815	1066.8	1136.4	1.2863
600	0.28189	1097.2	1175.4	1.3423								
650	0.33310	1147.2	1239.7	1.4016	0.26292	1122.8	1207.9	1.3607	0.20586	1091.4	1167.6	1.3146
700	0.37198	1183.6	1286.9	1.4433	0.30252	1166.8	1264.7	1.4108	0.24894	1147.6	1239.8	1.3783
750	0.40535	1214.4	1326.9	1.4771	0.33455	1201.5	1309.8	1.4489	0.28074	1187.4	1291.3	1.4218
800	0.43550	1242.2	1363.1	1.5064	0.36266	1231.7	1349.1	1.4807	0.30763	1220.5	1334.3	1.4567
850	0.46356	1268.2	1396.9	1.5328	0.38835	1259.3	1385.1	1.5088	0.33169	1250.0	1372.8	1.4867
900	0.49015	1293.1	1429.2	1.5569	0.41238	1285.4	1419.0	1.5341	0.35390	1277.5	1408.5	1.5134
1000	0.54031	1340.9	1490.8	1.6007	0.45719	1334.9	1482.9	1.5796	0.39479	1328.7	1474.9	1.5606
1100	0.58781	1387.3	1550.5	1.6402	0.49917	1382.4	1544.1	1.6201	0.43266	1377.5	1537.6	1.6021
1200	0.63355	1433.3	1609.2	1.6767	0.53932	1429.2	1603.9	1.6572	0.46864	1425.1	1598.5	1.6400
1400	0.72172	1525.7	1726.0	1.7432	0.61621	1522.6	1722.1	1.7245	0.53708	1519.5	1718.3	1.7081
1600	0.80714	1619.8	1843.8	1.8033	0.69031	1617.4	1840.9	1.7852	0.60269	1615.0	1838.0	1.7693
1800	0.89090	1716.4	1963.7	1.8589	0.76273	1714.5	1961.5	1.8410	0.66660	1712.5	1959.2	1.8255
2000	0.97358	1815.9	2086.1	1.9108	0.83406	1814.2	2084.3	1.8931	0.72942	1812.6	2082.6	1.8778
<i>P</i> = 2500 psia (668.17°F)				<i>P</i> = 3000 psia (695.41°F)				<i>P</i> = 3500 psia				
Sat.	0.13076	1031.2	1091.7	1.2330	0.08460	969.8	1016.8	1.1587				
650									0.02492	663.7	679.9	0.8632
700	0.16849	1098.4	1176.3	1.3072	0.09838	1005.3	1059.9	1.1960	0.03065	760.0	779.9	0.9511
750	0.20327	1154.9	1249.0	1.3686	0.14840	1114.1	1196.5	1.3118	0.10460	1057.6	1125.4	1.2434
800	0.22949	1195.9	1302.0	1.4116	0.17601	1167.5	1265.3	1.3676	0.13639	1134.3	1222.6	1.3224
850	0.25174	1230.1	1346.6	1.4463	0.19771	1208.2	1317.9	1.4086	0.15847	1183.8	1286.5	1.3721
900	0.27165	1260.7	1386.4	1.4761	0.21640	1242.8	1362.9	1.4423	0.17659	1223.4	1337.8	1.4106
950	0.29001	1289.1	1423.3	1.5028	0.23321	1273.9	1403.3	1.4716	0.19245	1257.8	1382.4	1.4428
1000	0.30726	1316.1	1458.2	1.5271	0.24876	1302.8	1440.9	1.4978	0.20687	1289.0	1423.0	1.4711
1100	0.33949	1367.3	1524.4	1.5710	0.27732	1356.8	1510.8	1.5441	0.23289	1346.1	1496.9	1.5201
1200	0.36966	1416.6	1587.6	1.6103	0.30367	1408.0	1576.6	1.5850	0.25654	1399.3	1565.4	1.5627
1400	0.42631	1513.3	1710.5	1.6802	0.35249	1507.0	1702.7	1.6567	0.29978	1500.7	1694.8	1.6364
1600	0.48004	1610.1	1832.2	1.7424	0.39830	1605.3	1826.4	1.7199	0.33994	1600.4	1820.5	1.7006
1800	0.53205	1708.6	1954.8	1.7991	0.44237	1704.7	1950.3	1.7773	0.37833	1700.8	1945.8	1.7586
2000	0.58295	1809.4	2079.1	1.8518	0.48532	1806.1	2075.6	1.8304	0.41561	1802.9	2072.1	1.8121
<i>P</i> = 4000 psia				<i>P</i> = 5000 psia				<i>P</i> = 6000 psia				
650	0.02448	657.9	676.1	0.8577	0.02379	648.3	670.3	0.8485	0.02325	640.3	666.1	0.8408
700	0.02871	742.3	763.6	0.9347	0.02678	721.8	746.6	0.9156	0.02564	708.1	736.5	0.9028
750	0.06370	962.1	1009.2	1.1410	0.03373	821.8	853.0	1.0054	0.02981	788.7	821.8	0.9747
800	0.10520	1094.2	1172.1	1.2734	0.05937	986.9	1041.8	1.1581	0.03949	897.1	941.0	1.0711
850	0.12848	1156.7	1251.8	1.3355	0.08551	1092.4	1171.5	1.2593	0.05815	1018.6	1083.1	1.1819
900	0.14647	1202.5	1310.9	1.3799	0.10390	1155.9	1252.1	1.3198	0.07584	1103.5	1187.7	1.2603
950	0.16176	1240.7	1360.5	1.4157	0.11863	1203.9	1313.6	1.3643	0.09010	1163.7	1263.7	1.3153
1000	0.17538	1274.6	1404.4	1.4463	0.13128	1244.0	1365.5	1.4004	0.10208	1211.4	1324.7	1.3578
1100	0.19957	1335.1	1482.8	1.4983	0.15298	1312.2	1453.8	1.4590	0.12211	1288.4	1424.0	1.4237
1200	0.22121	1390.3	1554.1	1.5426	0.17185	1372.1	1531.1	1.5070	0.13911	1353.4	1507.8	1.4758
1300	0.24128	1443.0	1621.6	1.5821	0.18902	1427.8	1602.7	1.5490	0.15434	1412.5	1583.8	1.5203
1400	0.26028	1494.3	1687.0	1.6182	0.20508	1481.4	1671.1	1.5868	0.16841	1468.4	1655.4	1.5598
1600	0.29620	1595.5	1814.7	1.6835	0.23505	1585.6	1803.1	1.6542	0.19438	1575.7	1791.5	1.6294
1800	0.33033	1696.8	1941.4	1.7422	0.26320	1689.0	1932.5	1.7142	0.21853	1681.1	1923.7	1.6907
2000	0.36335	1799.7	2068.6	1.7961	0.29023	1793.2	2061.7	1.7689	0.24155	1786.7	2054.9	1.7463

TABLA A-7E

Agua líquida comprimida

<i>T</i> °F	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/lbm · R	<i>v</i> ft ³ /lbm	<i>u</i> Btu/lbm	<i>h</i> Btu/lbm	<i>s</i> Btu/lbm · R
<i>P</i> = 500 psia (467.04°F)				<i>P</i> = 1000 psia (544.65°F)				<i>P</i> = 1500 psia (596.26°F)				
Sat.	0.019750	447.68	449.51	0.64900	0.021595	538.58	542.57	0.74341	0.023456	605.07	611.58	0.80836
32	0.015994	0.01	1.49	0.00001	0.015966	0.03	2.99	0.00005	0.015939	0.05	4.48	0.00008
50	0.015998	18.03	19.51	0.03601	0.015972	17.99	20.95	0.03593	0.015946	17.95	22.38	0.03584
100	0.016107	67.86	69.35	0.12930	0.016083	67.69	70.67	0.12899	0.016059	67.53	71.98	0.12869
150	0.016317	117.70	119.21	0.21462	0.016292	117.42	120.43	0.21416	0.016267	117.14	121.66	0.21369
200	0.016607	167.70	169.24	0.29349	0.016580	167.31	170.38	0.29289	0.016553	166.92	171.52	0.29229
250	0.016972	218.04	219.61	0.36708	0.016941	217.51	220.65	0.36634	0.016911	217.00	221.69	0.36560
300	0.017417	268.92	270.53	0.43641	0.017380	268.24	271.46	0.43551	0.017345	267.57	272.39	0.43463
350	0.017954	320.64	322.30	0.50240	0.017910	319.77	323.08	0.50132	0.017866	318.91	323.87	0.50025
400	0.018609	373.61	375.33	0.56595	0.018552	372.48	375.91	0.56463	0.018496	371.37	376.51	0.56333
450	0.019425	428.44	430.24	0.62802	0.019347	426.93	430.51	0.62635	0.019271	425.47	430.82	0.62472
500					0.020368	484.03	487.80	0.68764	0.020258	482.01	487.63	0.68550
550									0.021595	542.50	548.50	0.74731
<i>P</i> = 2000 psia (635.85°F)				<i>P</i> = 3000 psia (695.41°F)				<i>P</i> = 5000 psia				
Sat.	0.025634	662.33	671.82	0.86224	0.034335	783.39	802.45	0.97321				
32	0.015912	0.07	5.96	0.00010	0.015859	0.10	8.90	0.00011	0.015756	0.13	14.71	0.00002
50	0.015921	17.91	23.80	0.03574	0.015870	17.83	26.64	0.03554	0.015773	17.65	32.25	0.03505
100	0.016035	67.36	73.30	0.12838	0.015988	67.04	75.91	0.12776	0.015897	66.41	81.12	0.12652
200	0.016527	166.54	172.66	0.29170	0.016475	165.79	174.94	0.29053	0.016375	164.36	179.51	0.28824
300	0.017310	266.92	273.33	0.43376	0.017242	265.65	275.22	0.43204	0.017112	263.24	279.07	0.42874
400	0.018442	370.30	377.12	0.56205	0.018338	368.22	378.41	0.55959	0.018145	364.35	381.14	0.55492
450	0.019199	424.06	431.16	0.62314	0.019062	421.36	431.94	0.62010	0.018812	416.40	433.80	0.61445
500	0.020154	480.08	487.54	0.68346	0.019960	476.45	487.53	0.67958	0.019620	469.94	488.10	0.67254
560	0.021739	552.21	560.26	0.75692	0.021405	546.59	558.47	0.75126	0.020862	537.08	556.38	0.74154
600	0.023317	605.77	614.40	0.80898	0.022759	597.42	610.06	0.80086	0.021943	584.42	604.72	0.78803
640					0.024765	654.52	668.27	0.85476	0.023358	634.95	656.56	0.83603
680					0.028821	728.63	744.64	0.92288	0.025366	690.67	714.14	0.88745
700									0.026777	721.78	746.56	0.91564

TABLA A-8E

Hielo saturado. Vapor de agua

Temp., T °F	Pres. sat., P_{sat} psia	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm			Entalpía, Btu/lbm			Entropía, Btu/lbm · R		
		Hielo sat., v_i	Vapor sat., v_g	Hielo sat., u_i	Subl., u_{ig}	Vapor sat., u_g	Hielo sat., h_i	Subl., h_{ig}	Vapor sat., h_g	Hielo sat., s_i	Subl., s_{ig}	Vapor sat., s_g
32.018	0.08871	0.01747	3299.6	-143.34	1164.2	1020.9	-143.34	1218.3	1075.0	-0.29146	2.4779	2.1864
32	0.08864	0.01747	3302.6	-143.35	1164.2	1020.9	-143.35	1218.4	1075.0	-0.29148	2.4779	2.1865
30	0.08086	0.01747	3605.8	-144.35	1164.6	1020.2	-144.35	1218.5	1074.2	-0.29353	2.4883	2.1948
25	0.06405	0.01746	4505.8	-146.85	1165.4	1018.6	-146.85	1218.8	1072.0	-0.29865	2.5146	2.2160
20	0.05049	0.01746	5657.6	-149.32	1166.2	1016.9	-149.32	1219.1	1069.8	-0.30377	2.5414	2.2376
15	0.03960	0.01745	7138.9	-151.76	1167.0	1015.2	-151.76	1219.3	1067.6	-0.30889	2.5687	2.2598
10	0.03089	0.01744	9054.0	-154.18	1167.8	1013.6	-154.18	1219.5	1065.4	-0.31401	2.5965	2.2825
5	0.02397	0.01743	11,543	-156.57	1168.5	1011.9	-156.57	1219.7	1063.1	-0.31913	2.6248	2.3057
0	0.01850	0.01743	14,797	-158.94	1169.2	1010.3	-158.94	1219.9	1060.9	-0.32426	2.6537	2.3295
-5	0.01420	0.01742	19,075	-161.28	1169.9	1008.6	-161.28	1220.0	1058.7	-0.32938	2.6832	2.3538
-10	0.01083	0.01741	24,731	-163.60	1170.6	1007.0	-163.60	1220.1	1056.5	-0.33451	2.7133	2.3788
-15	0.00821	0.01740	32,257	-165.90	1171.2	1005.3	-165.90	1220.2	1054.3	-0.33964	2.7440	2.4044
-20	0.00619	0.01740	42,335	-168.16	1171.8	1003.6	-168.16	1220.3	1052.1	-0.34478	2.7754	2.4306
-25	0.00463	0.01739	55,917	-170.41	1172.4	1002.0	-170.41	1220.3	1049.9	-0.34991	2.8074	2.4575
-30	0.00344	0.01738	74,345	-172.63	1173.0	1000.3	-172.63	1220.3	1047.7	-0.35505	2.8401	2.4850
-35	0.00254	0.01738	99,526	-174.83	1173.5	998.7	-174.83	1220.3	1045.5	-0.36019	2.8735	2.5133
-40	0.00186	0.01737	134,182	-177.00	1174.0	997.0	-177.00	1220.3	1043.3	-0.36534	2.9076	2.5423

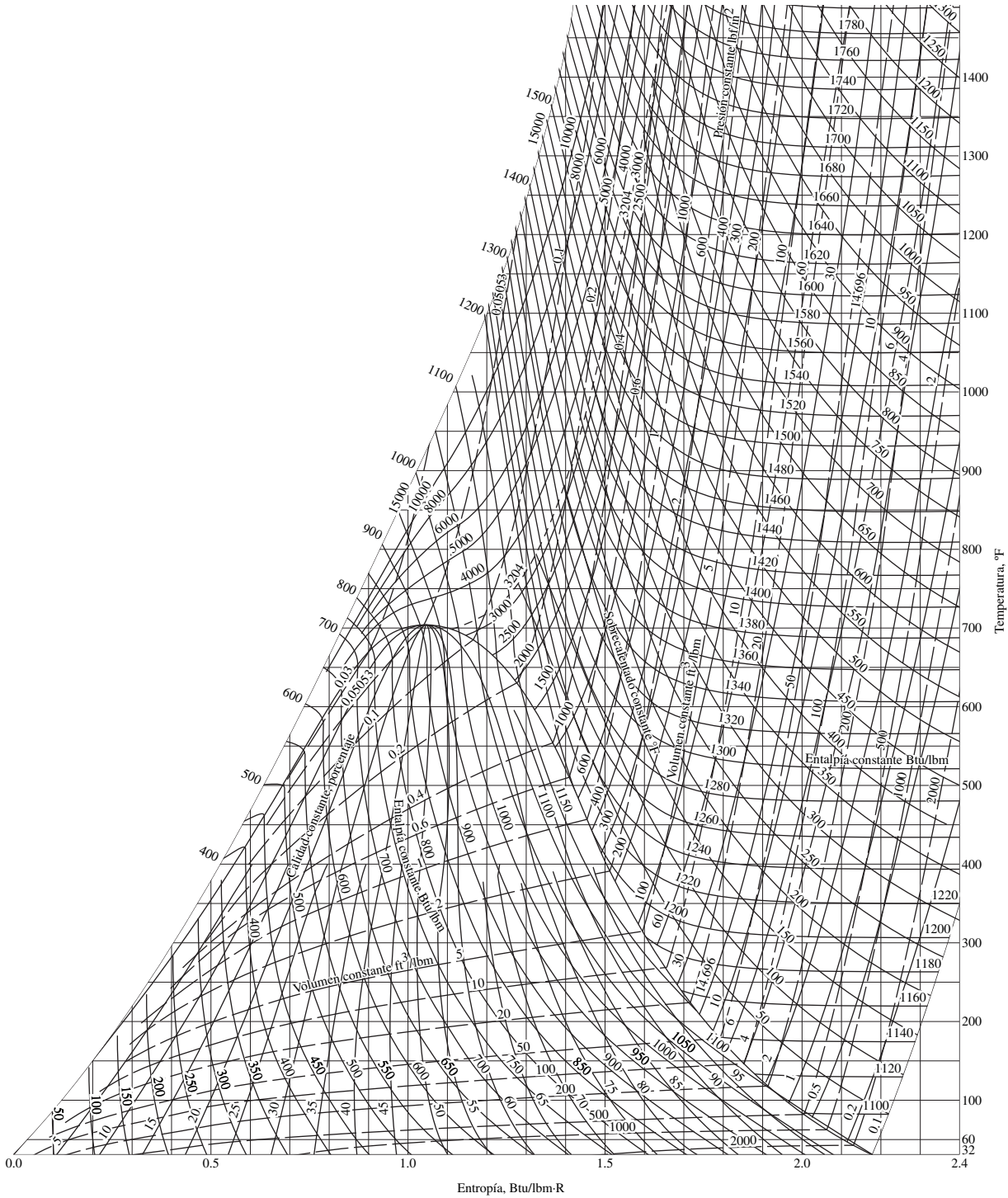


FIGURA A-9E

Diagrama T-s para el agua.

Fuente: Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill y Joan G. Moore, Steam Tables, Nueva York, John Wiley & Sons, 1969.

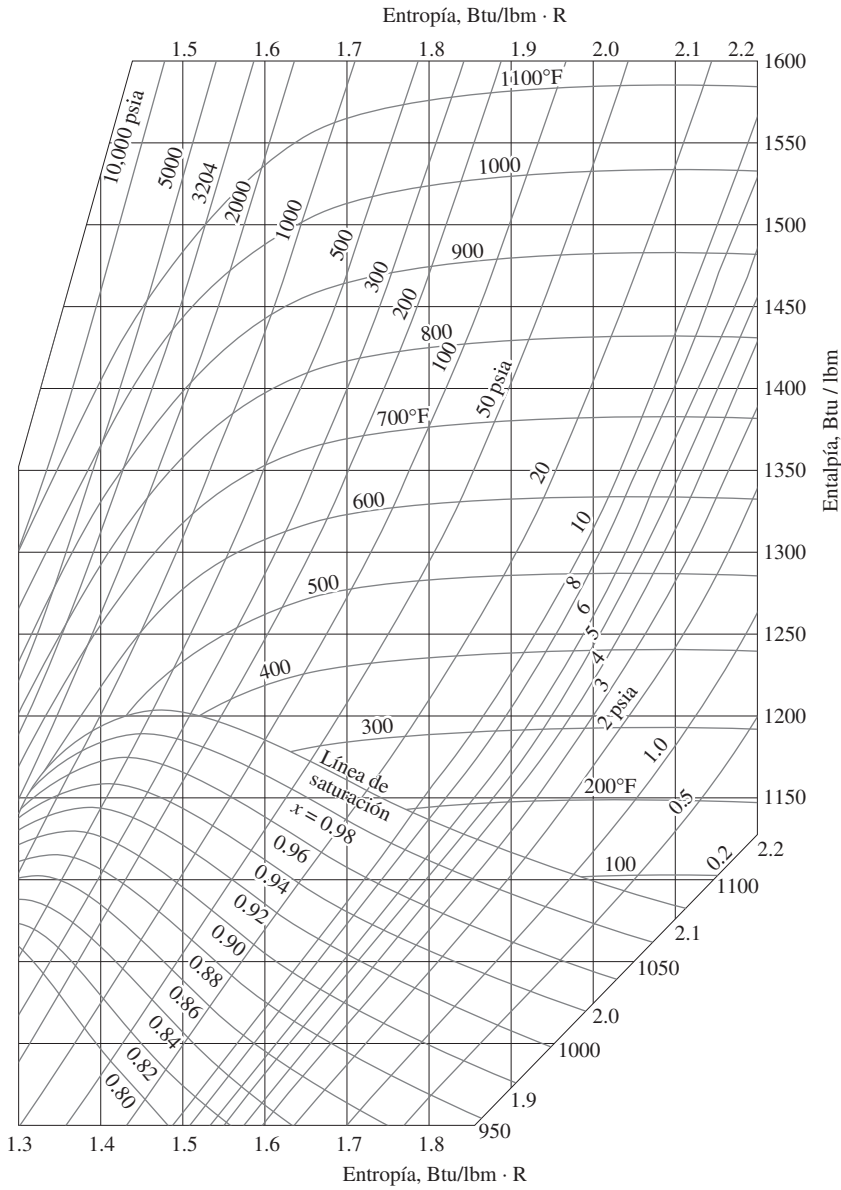


FIGURA A-10E
 Diagrama de Mollier para el agua.

Fuente: Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill y Joan G. Moore, Steam Tables, Nueva York, John Wiley & Sons, 1969.

TABLA A-11E

Refrigerante 134a saturado. Tabla de temperatura

Temp., T °F	Pres. sat., P_{sat} psia	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm		Entalpía, Btu/lbm			Entropía, Btu/lbm · R			
		Líquido sat., v_f	Vapor sat., v_g	Líquido sat., u_f	Evaporación, u_{fg}	Vapor sat., u_g	Líquido sat., h_f	Evaporación, h_{fg}	Vapor sat., h_g	Líquido sat., s_f	Evaporación, s_{fg}	Vapor sat., s_g
-40	7.432	0.01130	5.7796	-0.016	89.167	89.15	0.000	97.100	97.10	0.00000	0.23135	0.23135
-35	8.581	0.01136	5.0509	1.484	88.352	89.84	1.502	96.354	97.86	0.00355	0.22687	0.23043
-30	9.869	0.01143	4.4300	2.990	87.532	90.52	3.011	95.601	98.61	0.00708	0.22248	0.22956
-25	11.306	0.01150	3.8988	4.502	86.706	91.21	4.526	94.839	99.36	0.01058	0.21817	0.22875
-20	12.906	0.01156	3.4426	6.019	85.874	91.89	6.047	94.068	100.12	0.01405	0.21394	0.22798
-15	14.680	0.01163	3.0494	7.543	85.036	92.58	7.574	93.288	100.86	0.01749	0.20978	0.22727
-10	16.642	0.01171	2.7091	9.073	84.191	93.26	9.109	92.498	101.61	0.02092	0.20569	0.22660
-5	18.806	0.01178	2.4137	10.609	83.339	93.95	10.650	91.698	102.35	0.02431	0.20166	0.22598
0	21.185	0.01185	2.1564	12.152	82.479	94.63	12.199	90.886	103.08	0.02769	0.19770	0.22539
5	23.793	0.01193	1.9316	13.702	81.610	95.31	13.755	90.062	103.82	0.03104	0.19380	0.22485
10	26.646	0.01201	1.7345	15.259	80.733	95.99	15.318	89.226	104.54	0.03438	0.18996	0.22434
15	29.759	0.01209	1.5612	16.823	79.846	96.67	16.889	88.377	105.27	0.03769	0.18617	0.22386
20	33.147	0.01217	1.4084	18.394	78.950	97.34	18.469	87.514	105.98	0.04098	0.18243	0.22341
25	36.826	0.01225	1.2732	19.973	78.043	98.02	20.056	86.636	106.69	0.04426	0.17874	0.22300
30	40.813	0.01234	1.1534	21.560	77.124	98.68	21.653	85.742	107.40	0.04752	0.17509	0.22260
35	45.124	0.01242	1.0470	23.154	76.195	99.35	23.258	84.833	108.09	0.05076	0.17148	0.22224
40	49.776	0.01251	0.95205	24.757	75.253	100.01	24.873	83.907	108.78	0.05398	0.16791	0.22189
45	54.787	0.01261	0.86727	26.369	74.298	100.67	26.497	82.963	109.46	0.05720	0.16437	0.22157
50	60.175	0.01270	0.79136	27.990	73.329	101.32	28.131	82.000	110.13	0.06039	0.16087	0.22127
55	65.957	0.01280	0.72323	29.619	72.346	101.97	29.775	81.017	110.79	0.06358	0.15740	0.22098
60	72.152	0.01290	0.66195	31.258	71.347	102.61	31.431	80.013	111.44	0.06675	0.15396	0.22070
65	78.780	0.01301	0.60671	32.908	70.333	103.24	33.097	78.988	112.09	0.06991	0.15053	0.22044
70	85.858	0.01312	0.55681	34.567	69.301	103.87	34.776	77.939	112.71	0.07306	0.14713	0.22019
75	93.408	0.01323	0.51165	36.237	68.251	104.49	36.466	76.866	113.33	0.07620	0.14375	0.21995
80	101.45	0.01334	0.47069	37.919	67.181	105.10	38.169	75.767	113.94	0.07934	0.14038	0.21972
85	110.00	0.01347	0.43348	39.612	66.091	105.70	39.886	74.641	114.53	0.08246	0.13703	0.21949
90	119.08	0.01359	0.39959	41.317	64.979	106.30	41.617	73.485	115.10	0.08559	0.13368	0.21926
95	128.72	0.01372	0.36869	43.036	63.844	106.88	43.363	72.299	115.66	0.08870	0.13033	0.21904
100	138.93	0.01386	0.34045	44.768	62.683	107.45	45.124	71.080	116.20	0.09182	0.12699	0.21881
105	149.73	0.01400	0.31460	46.514	61.496	108.01	46.902	69.825	116.73	0.09493	0.12365	0.21858
110	161.16	0.01415	0.29090	48.276	60.279	108.56	48.698	68.533	117.23	0.09804	0.12029	0.21834
115	173.23	0.01430	0.26913	50.054	59.031	109.08	50.512	67.200	117.71	0.10116	0.11693	0.21809
120	185.96	0.01446	0.24909	51.849	57.749	109.60	52.346	65.823	118.17	0.10428	0.11354	0.21782
130	213.53	0.01482	0.21356	55.495	55.071	110.57	56.080	62.924	119.00	0.11054	0.10670	0.21724
140	244.06	0.01521	0.18315	59.226	52.216	111.44	59.913	59.801	119.71	0.11684	0.09971	0.21655
150	277.79	0.01567	0.15692	63.059	49.144	112.20	63.864	56.405	120.27	0.12321	0.09251	0.21572
160	314.94	0.01619	0.13410	67.014	45.799	112.81	67.958	52.671	120.63	0.12970	0.08499	0.21469
170	355.80	0.01681	0.11405	71.126	42.097	113.22	72.233	48.499	120.73	0.13634	0.07701	0.21335
180	400.66	0.01759	0.09618	75.448	37.899	113.35	76.752	43.726	120.48	0.14323	0.06835	0.21158
190	449.90	0.01860	0.07990	80.082	32.950	113.03	81.631	38.053	119.68	0.15055	0.05857	0.20911
200	504.00	0.02009	0.06441	85.267	26.651	111.92	87.140	30.785	117.93	0.15867	0.04666	0.20533
210	563.76	0.02309	0.04722	91.986	16.498	108.48	94.395	19.015	113.41	0.16922	0.02839	0.19761

Fuente: Las tablas A-11E a A-13E se generaron utilizando el programa para resolver ecuaciones de ingeniería (EES) desarrollado por S. A. Klein y F. L. Alvarado. La rutina utilizada en los cálculos es el R134a, el cual está basado en la ecuación fundamental de estado desarrollada por R. Tillner-Roth y H. D. Baehr, "An International Standard Formulation for the Thermodynamic Properties of 1,1,1,2-Tetrafluoroetano (HFC-134a) for temperatures from 170 K to 455 K and pressures up to 70 MPa", J. Phys. Chem, Ref. Data, vol. 23, núm. 5, 1994. Los valores de entalpía y entropía para el líquido saturado son cero a -40°C (y -40°F).

TABLA A-12E

Refrigerante 134a saturado. Tabla de presión

Pres., <i>P</i> psia	Temp. sat., <i>T</i> °F	Volumen específico, ft ³ /lbm		Energía interna, Btu/lbm			Entalpía, Btu/lbm			Entropía, Btu/lbm · R		
		Líqu. sat., <i>v_f</i>	Vapor sat., <i>v_g</i>	Líqu. sat., <i>u_f</i>	Evap., <i>u_{fg}</i>	Vapor sat., <i>u_g</i>	Líqu. sat., <i>h_f</i>	Evap., <i>h_{fg}</i>	Vapor sat., <i>h_g</i>	Líqu. sat., <i>s_f</i>	Evap., <i>s_{fg}</i>	Vapor sat., <i>s_g</i>
5	-53.09	0.01113	8.3785	-3.918	91.280	87.36	-3.907	99.022	95.11	-0.00945	0.24353	0.23408
10	-29.52	0.01144	4.3753	3.135	87.453	90.59	3.156	95.528	98.68	0.00742	0.22206	0.22948
15	-14.15	0.01165	2.9880	7.803	84.893	92.70	7.835	93.155	100.99	0.01808	0.20908	0.22715
20	-2.43	0.01182	2.2772	11.401	82.898	94.30	11.445	91.282	102.73	0.02605	0.19962	0.22567
25	7.17	0.01196	1.8429	14.377	81.231	95.61	14.432	89.701	104.13	0.03249	0.19213	0.22462
30	15.37	0.01209	1.5492	16.939	79.780	96.72	17.006	88.313	105.32	0.03793	0.18589	0.22383
35	22.57	0.01221	1.3369	19.205	78.485	97.69	19.284	87.064	106.35	0.04267	0.18053	0.22319
40	29.01	0.01232	1.1760	21.246	77.307	98.55	21.337	85.920	107.26	0.04688	0.17580	0.22268
45	34.86	0.01242	1.0497	23.110	76.221	99.33	23.214	84.858	108.07	0.05067	0.17158	0.22225
50	40.23	0.01252	0.94791	24.832	75.209	100.04	24.948	83.863	108.81	0.05413	0.16774	0.22188
55	45.20	0.01261	0.86400	26.435	74.258	100.69	26.564	82.924	109.49	0.05733	0.16423	0.22156
60	49.84	0.01270	0.79361	27.939	73.360	101.30	28.080	82.030	110.11	0.06029	0.16098	0.22127
65	54.20	0.01279	0.73370	29.357	72.505	101.86	29.510	81.176	110.69	0.06307	0.15796	0.22102
70	58.30	0.01287	0.68205	30.700	71.688	102.39	30.867	80.357	111.22	0.06567	0.15512	0.22080
75	62.19	0.01295	0.63706	31.979	70.905	102.88	32.159	79.567	111.73	0.06813	0.15245	0.22059
80	65.89	0.01303	0.59750	33.201	70.151	103.35	33.394	78.804	112.20	0.07047	0.14993	0.22040
85	69.41	0.01310	0.56244	34.371	69.424	103.79	34.577	78.064	112.64	0.07269	0.14753	0.22022
90	72.78	0.01318	0.53113	35.495	68.719	104.21	35.715	77.345	113.06	0.07481	0.14525	0.22006
95	76.02	0.01325	0.50301	36.578	68.035	104.61	36.811	76.645	113.46	0.07684	0.14307	0.21991
100	79.12	0.01332	0.47760	37.623	67.371	104.99	37.869	75.962	113.83	0.07879	0.14097	0.21976
110	85.00	0.01347	0.43347	39.612	66.091	105.70	39.886	74.641	114.53	0.08246	0.13703	0.21949
120	90.49	0.01360	0.39644	41.485	64.869	106.35	41.787	73.371	115.16	0.08589	0.13335	0.21924
130	95.64	0.01374	0.36491	43.258	63.696	106.95	43.589	72.144	115.73	0.08911	0.12990	0.21901
140	100.51	0.01387	0.33771	44.945	62.564	107.51	45.304	70.954	116.26	0.09214	0.12665	0.21879
150	105.12	0.01400	0.31401	46.556	61.467	108.02	46.945	69.795	116.74	0.09501	0.12357	0.21857
160	109.50	0.01413	0.29316	48.101	60.401	108.50	48.519	68.662	117.18	0.09774	0.12062	0.21836
170	113.69	0.01426	0.27466	49.586	59.362	108.95	50.035	67.553	117.59	0.10034	0.11781	0.21815
180	117.69	0.01439	0.25813	51.018	58.345	109.36	51.497	66.464	117.96	0.10284	0.11511	0.21795
190	121.53	0.01452	0.24327	52.402	57.349	109.75	52.912	65.392	118.30	0.10524	0.11250	0.21774
200	125.22	0.01464	0.22983	53.743	56.371	110.11	54.285	64.335	118.62	0.10754	0.10998	0.21753
220	132.21	0.01490	0.20645	56.310	54.458	110.77	56.917	62.256	119.17	0.11192	0.10517	0.21710
240	138.73	0.01516	0.18677	58.746	52.591	111.34	59.419	60.213	119.63	0.11603	0.10061	0.21665
260	144.85	0.01543	0.16996	61.071	50.757	111.83	61.813	58.192	120.00	0.11992	0.09625	0.21617
280	150.62	0.01570	0.15541	63.301	48.945	112.25	64.115	56.184	120.30	0.12362	0.09205	0.21567
300	156.09	0.01598	0.14266	65.452	47.143	112.60	66.339	54.176	120.52	0.12715	0.08797	0.21512
350	168.64	0.01672	0.11664	70.554	42.627	113.18	71.638	49.099	120.74	0.13542	0.07814	0.21356
400	179.86	0.01757	0.09642	75.385	37.963	113.35	76.686	43.798	120.48	0.14314	0.06848	0.21161
450	190.02	0.01860	0.07987	80.092	32.939	113.03	81.641	38.041	119.68	0.15056	0.05854	0.20911
500	199.29	0.01995	0.06551	84.871	27.168	112.04	86.718	31.382	118.10	0.15805	0.04762	0.20566

TABLA A-13E

Refrigerante 134a sobrecalentado

T °F	v ft ³ /lbm	u Btu/lbm	h Btu/lbm	s Btu/ lbm · R	v ft ³ /lbm	u Btu/lbm	h Btu/lbm	s Btu/ lbm · R	v ft ³ /lbm	u Btu/lbm	h Btu/lbm	s Btu/ lbm · R
$P = 10$ psia ($T_{\text{sat}} = -29.52^\circ\text{F}$)				$P = 15$ psia ($T_{\text{sat}} = -14.15^\circ\text{F}$)				$P = 20$ psia ($T_{\text{sat}} = -2.43^\circ\text{F}$)				
Sat.	4.3753	90.59	98.68	0.22948	2.9880	92.70	100.99	0.22715	2.2772	94.30	102.73	0.22567
-20	4.4856	92.13	100.43	0.23350								
0	4.7135	95.41	104.14	0.24174	3.1001	95.08	103.68	0.23310	2.2922	94.72	103.20	0.22671
20	4.9380	98.77	107.91	0.24976	3.2551	98.48	107.52	0.24127	2.4130	98.19	107.12	0.23504
40	5.1600	102.20	111.75	0.25761	3.4074	101.95	111.41	0.24922	2.5306	101.70	111.07	0.24311
60	5.3802	105.72	115.67	0.26531	3.5577	105.50	115.38	0.25700	2.6461	105.28	115.07	0.25097
80	5.5989	109.32	119.68	0.27288	3.7064	109.13	119.42	0.26463	2.7600	108.93	119.15	0.25866
100	5.8165	113.01	123.78	0.28033	3.8540	112.84	123.54	0.27212	2.8726	112.66	123.29	0.26621
120	6.0331	116.79	127.96	0.28767	4.0006	116.63	127.74	0.27950	2.9842	116.47	127.52	0.27363
140	6.2490	120.66	132.22	0.29490	4.1464	120.51	132.02	0.28677	3.0950	120.37	131.82	0.28093
160	6.4642	124.61	136.57	0.30203	4.2915	124.48	136.39	0.29393	3.2051	124.35	136.21	0.28812
180	6.6789	128.65	141.01	0.30908	4.4361	128.53	140.84	0.30100	3.3146	128.41	140.67	0.29521
200	6.8930	132.77	145.53	0.31604	4.5802	132.66	145.37	0.30798	3.4237	132.55	145.22	0.30221
220	7.1068	136.98	150.13	0.32292	4.7239	136.88	149.99	0.31487	3.5324	136.78	149.85	0.30912
$P = 30$ psia ($T_{\text{sat}} = 15.37^\circ\text{F}$)				$P = 40$ psia ($T_{\text{sat}} = 29.01^\circ\text{F}$)				$P = 50$ psia ($T_{\text{sat}} = 40.23^\circ\text{F}$)				
Sat.	1.5492	96.72	105.32	0.22383	1.1760	98.55	107.26	0.22268	0.9479	100.04	108.81	0.22188
20	1.5691	97.56	106.27	0.22581								
40	1.6528	101.17	110.35	0.23414	1.2126	100.61	109.58	0.22738				
60	1.7338	104.82	114.45	0.24219	1.2768	104.34	113.79	0.23565	1.0019	103.84	113.11	0.23031
80	1.8130	108.53	118.59	0.25002	1.3389	108.11	118.02	0.24363	1.0540	107.68	117.43	0.23847
100	1.8908	112.30	122.80	0.25767	1.3995	111.93	122.29	0.25140	1.1043	111.55	121.77	0.24637
120	1.9675	116.15	127.07	0.26517	1.4588	115.82	126.62	0.25900	1.1534	115.48	126.16	0.25406
140	2.0434	120.08	131.42	0.27254	1.5173	119.78	131.01	0.26644	1.2015	119.47	130.59	0.26159
160	2.1185	124.08	135.84	0.27979	1.5750	123.81	135.47	0.27375	1.2488	123.53	135.09	0.26896
180	2.1931	128.16	140.34	0.28693	1.6321	127.91	140.00	0.28095	1.2955	127.66	139.65	0.27621
200	2.2671	132.32	144.91	0.29398	1.6887	132.10	144.60	0.28803	1.3416	131.87	144.28	0.28333
220	2.3408	136.57	149.56	0.30092	1.7449	136.36	149.27	0.29501	1.3873	136.15	148.98	0.29036
240	2.4141	140.89	154.29	0.30778	1.8007	140.70	154.03	0.30190	1.4326	140.50	153.76	0.29728
260	2.4871	145.30	159.10	0.31456	1.8562	145.12	158.86	0.30871	1.4776	144.93	158.60	0.30411
280	2.5598	149.78	163.99	0.32126	1.9114	149.61	163.76	0.31543	1.5223	149.44	163.53	0.31086
$P = 60$ psia ($T_{\text{sat}} = 49.84^\circ\text{F}$)				$P = 70$ psia ($T_{\text{sat}} = 58.30^\circ\text{F}$)				$P = 80$ psia ($T_{\text{sat}} = 65.89^\circ\text{F}$)				
Sat.	0.7936	101.30	110.11	0.22127	0.6821	102.39	111.22	0.22080	0.59750	103.35	112.20	0.22040
60	0.8179	103.31	112.39	0.22570	0.6857	102.73	111.62	0.22155				
80	0.8636	107.23	116.82	0.23407	0.7271	106.76	116.18	0.23016	0.62430	106.26	115.51	0.22661
100	0.9072	111.16	121.24	0.24211	0.7662	110.76	120.68	0.23836	0.66009	110.34	120.11	0.23499
120	0.9495	115.14	125.68	0.24991	0.8037	114.78	125.19	0.24628	0.69415	114.42	124.69	0.24304
140	0.9908	119.16	130.16	0.25751	0.8401	118.85	129.73	0.25398	0.72698	118.52	129.29	0.25083
160	1.0312	123.25	134.70	0.26496	0.8756	122.97	134.31	0.26149	0.75888	122.68	133.91	0.25841
180	1.0709	127.41	139.30	0.27226	0.9105	127.15	138.94	0.26885	0.79003	126.89	138.58	0.26583
200	1.1101	131.63	143.96	0.27943	0.9447	131.40	143.63	0.27607	0.82059	131.16	143.31	0.27310
220	1.1489	135.93	148.69	0.28649	0.9785	135.71	148.39	0.28317	0.85065	135.49	148.09	0.28024
240	1.1872	140.30	153.48	0.29344	1.0118	140.10	153.21	0.29015	0.88030	139.90	152.93	0.28726
260	1.2252	144.75	158.35	0.30030	1.0449	144.56	158.10	0.29704	0.90961	144.37	157.84	0.29418
280	1.2629	149.27	163.29	0.30707	1.0776	149.10	163.06	0.30384	0.93861	148.92	162.82	0.30100
300	1.3004	153.87	168.31	0.31376	1.1101	153.71	168.09	0.31055	0.96737	153.54	167.86	0.30773
320	1.3377	158.54	173.39	0.32037	1.1424	158.39	173.19	0.31718	0.99590	158.24	172.98	0.31438

TABLA A-13E

Refrigerante 134a sobrecalentado (*conclusión*)

T °F	v ft ³ /lbm	u Btu/lbm	h Btu/lbm	s Btu/ lbm · R	v ft ³ /lbm	u Btu/lbm	h Btu/lbm	s Btu/ lbm · R	v ft ³ /lbm	u Btu/lbm	h Btu/lbm	s Btu/ lbm · R
$P = 90$ psia ($T_{\text{sat}} = 72.78^\circ\text{F}$)				$P = 100$ psia ($T_{\text{sat}} = 79.12^\circ\text{F}$)				$P = 120$ psia ($T_{\text{sat}} = 90.49^\circ\text{F}$)				
Sat.	0.53113	104.21	113.06	0.22006	0.47760	104.99	113.83	0.21976	0.39644	106.35	115.16	0.21924
80	0.54388	105.74	114.80	0.22330	0.47906	105.18	114.05	0.22016				
100	0.57729	109.91	119.52	0.23189	0.51076	109.45	118.90	0.22900	0.41013	108.48	117.59	0.22362
120	0.60874	114.04	124.18	0.24008	0.54022	113.66	123.65	0.23733	0.43692	112.84	122.54	0.23232
140	0.63885	118.19	128.83	0.24797	0.56821	117.86	128.37	0.24534	0.46190	117.15	127.41	0.24058
160	0.66796	122.38	133.51	0.25563	0.59513	122.08	133.09	0.25309	0.48563	121.46	132.25	0.24851
180	0.69629	126.62	138.22	0.26311	0.62122	126.35	137.85	0.26063	0.50844	125.79	137.09	0.25619
200	0.72399	130.92	142.97	0.27043	0.64667	130.67	142.64	0.26801	0.53054	130.17	141.95	0.26368
220	0.75119	135.27	147.78	0.27762	0.67158	135.05	147.47	0.27523	0.55206	134.59	146.85	0.27100
240	0.77796	139.69	152.65	0.28468	0.69605	139.49	152.37	0.28233	0.57312	139.07	151.80	0.27817
260	0.80437	144.19	157.58	0.29162	0.72016	143.99	157.32	0.28931	0.59379	143.61	156.79	0.28521
280	0.83048	148.75	162.58	0.29847	0.74396	148.57	162.34	0.29618	0.61413	148.21	161.85	0.29214
300	0.85633	153.38	167.64	0.30522	0.76749	153.21	167.42	0.30296	0.63420	152.88	166.96	0.29896
320	0.88195	158.08	172.77	0.31189	0.79079	157.93	172.56	0.30964	0.65402	157.62	172.14	0.30569
$P = 140$ psia ($T_{\text{sat}} = 100.50^\circ\text{F}$)				$P = 160$ psia ($T_{\text{sat}} = 109.50^\circ\text{F}$)				$P = 180$ psia ($T_{\text{sat}} = 117.69^\circ\text{F}$)				
Sat.	0.33771	107.51	116.26	0.21879	0.29316	108.50	117.18	0.21836	0.25813	109.36	117.96	0.21795
120	0.36243	111.96	121.35	0.22773	0.30578	111.01	120.06	0.22337	0.26083	109.94	118.63	0.21910
140	0.38551	116.41	126.40	0.23628	0.32774	115.62	125.32	0.23230	0.28231	114.77	124.17	0.22850
160	0.40711	120.81	131.36	0.24443	0.34790	120.13	130.43	0.24069	0.30154	119.42	129.46	0.23718
180	0.42766	125.22	136.30	0.25227	0.36686	124.62	135.49	0.24871	0.31936	124.00	134.64	0.24540
200	0.44743	129.65	141.24	0.25988	0.38494	129.12	140.52	0.25645	0.33619	128.57	139.77	0.25330
220	0.46657	134.12	146.21	0.26730	0.40234	133.64	145.55	0.26397	0.35228	133.15	144.88	0.26094
240	0.48522	138.64	151.21	0.27455	0.41921	138.20	150.62	0.27131	0.36779	137.76	150.01	0.26837
260	0.50345	143.21	156.26	0.28166	0.43564	142.81	155.71	0.27849	0.38284	142.40	155.16	0.27562
280	0.52134	147.85	161.35	0.28864	0.45171	147.48	160.85	0.28554	0.39751	147.10	160.34	0.28273
300	0.53895	152.54	166.50	0.29551	0.46748	152.20	166.04	0.29246	0.41186	151.85	165.57	0.28970
320	0.55630	157.30	171.71	0.30228	0.48299	156.98	171.28	0.29927	0.42594	156.66	170.85	0.29656
340	0.57345	162.13	176.98	0.30896	0.49828	161.83	176.58	0.30598	0.43980	161.53	176.18	0.30331
360	0.59041	167.02	182.32	0.31555	0.51338	166.74	181.94	0.31260	0.45347	166.46	181.56	0.30996
$P = 200$ psia ($T_{\text{sat}} = 125.22^\circ\text{F}$)				$P = 300$ psia ($T_{\text{sat}} = 156.09^\circ\text{F}$)				$P = 400$ psia ($T_{\text{sat}} = 179.86^\circ\text{F}$)				
Sat.	0.22983	110.11	118.62	0.21753	0.14266	112.60	120.52	0.21512	0.09642	113.35	120.48	0.21161
140	0.24541	113.85	122.93	0.22481								
160	0.26412	118.66	128.44	0.23384	0.14656	113.82	121.95	0.21745				
180	0.28115	123.35	133.76	0.24229	0.16355	119.52	128.60	0.22802	0.09658	113.41	120.56	0.21173
200	0.29704	128.00	138.99	0.25035	0.17776	124.78	134.65	0.23733	0.11440	120.52	128.99	0.22471
220	0.31212	132.64	144.19	0.25812	0.19044	129.85	140.42	0.24594	0.12746	126.44	135.88	0.23500
240	0.32658	137.30	149.38	0.26565	0.20211	134.83	146.05	0.25410	0.13853	131.95	142.20	0.24418
260	0.34054	141.99	154.59	0.27298	0.21306	139.77	151.59	0.26192	0.14844	137.26	148.25	0.25270
280	0.35410	146.72	159.82	0.28015	0.22347	144.70	157.11	0.26947	0.15756	142.48	154.14	0.26077
300	0.36733	151.50	165.09	0.28718	0.23346	149.65	162.61	0.27681	0.16611	147.65	159.94	0.26851
320	0.38029	156.33	170.40	0.29408	0.24310	154.63	168.12	0.28398	0.17423	152.80	165.70	0.27599
340	0.39300	161.22	175.77	0.30087	0.25246	159.64	173.66	0.29098	0.18201	157.97	171.44	0.28326
360	0.40552	166.17	181.18	0.30756	0.26159	164.70	179.22	0.29786	0.18951	163.15	177.18	0.29035

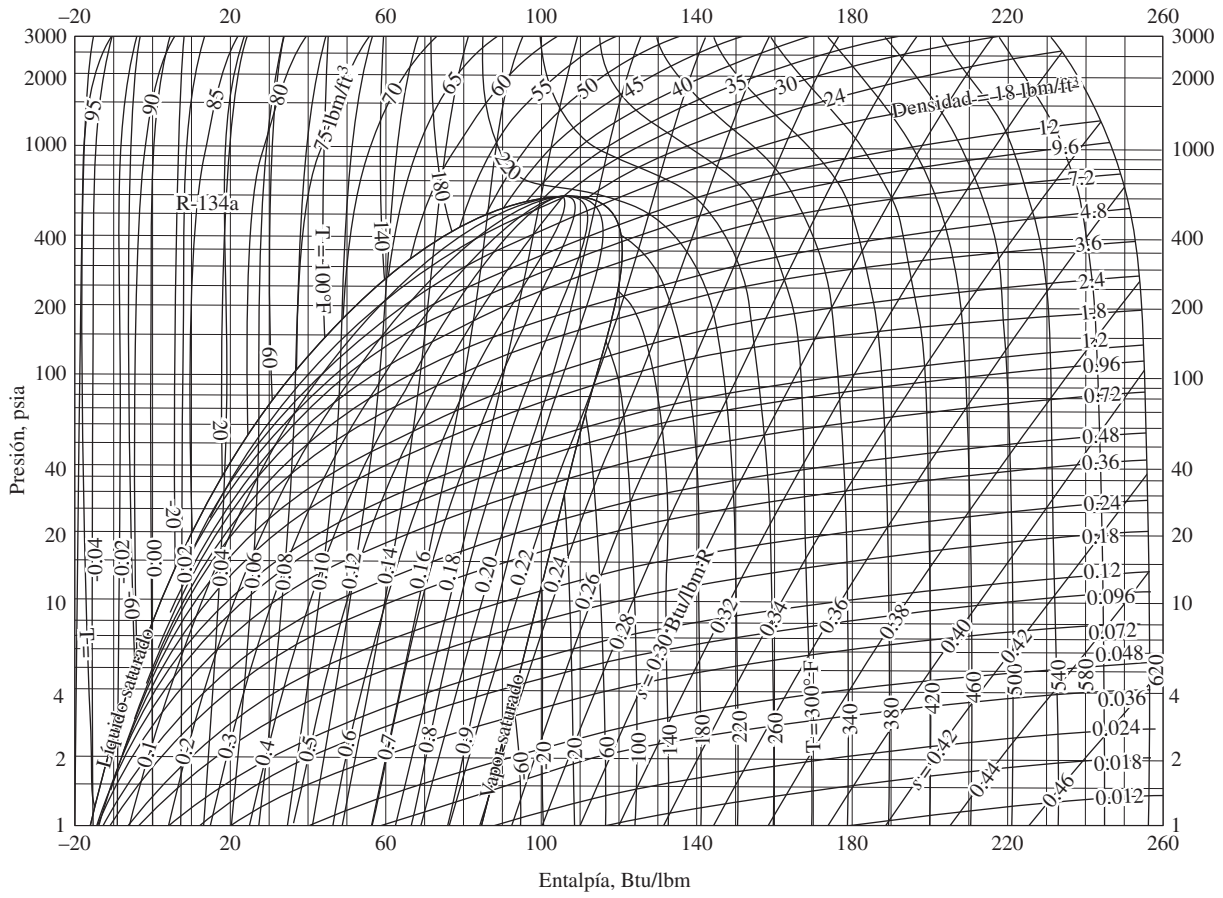


FIGURA A-14E

Diagrama P-h para el refrigerante 134a.

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TABLA A-16E

Propiedades de la atmósfera a gran altitud

Altitud, ft	Temperatura, °F	Presión, psia	Gravedad, g, ft/s ²	Velocidad del sonido, ft/s	Densidad, lbm/ft ³	Viscosidad μ , lbm/ft · s	Conductividad térmica, Btu/h · ft · R
0	59.00	14.7	32.174	1116	0.07647	1.202×10^{-5}	0.0146
500	57.22	14.4	32.173	1115	0.07536	1.199×10^{-5}	0.0146
1000	55.43	14.2	32.171	1113	0.07426	1.196×10^{-5}	0.0146
1500	53.65	13.9	32.169	1111	0.07317	1.193×10^{-5}	0.0145
2000	51.87	13.7	32.168	1109	0.07210	1.190×10^{-5}	0.0145
2500	50.09	13.4	32.166	1107	0.07104	1.186×10^{-5}	0.0144
3000	48.30	13.2	32.165	1105	0.06998	1.183×10^{-5}	0.0144
3500	46.52	12.9	32.163	1103	0.06985	1.180×10^{-5}	0.0143
4000	44.74	12.7	32.162	1101	0.06792	1.177×10^{-5}	0.0143
4500	42.96	12.5	32.160	1099	0.06690	1.173×10^{-5}	0.0142
5000	41.17	12.2	32.159	1097	0.06590	1.170×10^{-5}	0.0142
5500	39.39	12.0	32.157	1095	0.06491	1.167×10^{-5}	0.0141
6000	37.61	11.8	32.156	1093	0.06393	1.164×10^{-5}	0.0141
6500	35.83	11.6	32.154	1091	0.06296	1.160×10^{-5}	0.0141
7000	34.05	11.3	32.152	1089	0.06200	1.157×10^{-5}	0.0140
7500	32.26	11.1	32.151	1087	0.06105	1.154×10^{-5}	0.0140
8000	30.48	10.9	32.149	1085	0.06012	1.150×10^{-5}	0.0139
8500	28.70	10.7	32.148	1083	0.05919	1.147×10^{-5}	0.0139
9000	26.92	10.5	32.146	1081	0.05828	1.144×10^{-5}	0.0138
9500	25.14	10.3	32.145	1079	0.05738	1.140×10^{-5}	0.0138
10,000	23.36	10.1	32.145	1077	0.05648	1.137×10^{-5}	0.0137
11,000	19.79	9.72	32.140	1073	0.05473	1.130×10^{-5}	0.0136
12,000	16.23	9.34	32.137	1069	0.05302	1.124×10^{-5}	0.0136
13,000	12.67	8.99	32.134	1065	0.05135	1.117×10^{-5}	0.0135
14,000	9.12	8.63	32.131	1061	0.04973	1.110×10^{-5}	0.0134
15,000	5.55	8.29	32.128	1057	0.04814	1.104×10^{-5}	0.0133
16,000	+1.99	7.97	32.125	1053	0.04659	1.097×10^{-5}	0.0132
17,000	-1.58	7.65	32.122	1049	0.04508	1.090×10^{-5}	0.0132
18,000	-5.14	7.34	32.119	1045	0.04361	1.083×10^{-5}	0.0130
19,000	-8.70	7.05	32.115	1041	0.04217	1.076×10^{-5}	0.0129
20,000	-12.2	6.76	32.112	1037	0.04077	1.070×10^{-5}	0.0128
22,000	-19.4	6.21	32.106	1029	0.03808	1.056×10^{-5}	0.0126
24,000	-26.5	5.70	32.100	1020	0.03553	1.042×10^{-5}	0.0124
26,000	-33.6	5.22	32.094	1012	0.03311	1.028×10^{-5}	0.0122
28,000	-40.7	4.78	32.088	1003	0.03082	1.014×10^{-5}	0.0121
30,000	-47.8	4.37	32.082	995	0.02866	1.000×10^{-5}	0.0119
32,000	-54.9	3.99	32.08	987	0.02661	0.986×10^{-5}	0.0117
34,000	-62.0	3.63	32.07	978	0.02468	0.971×10^{-5}	0.0115
36,000	-69.2	3.30	32.06	969	0.02285	0.956×10^{-5}	0.0113
38,000	-69.7	3.05	32.06	968	0.02079	0.955×10^{-5}	0.0113
40,000	-69.7	2.73	32.05	968	0.01890	0.955×10^{-5}	0.0113
45,000	-69.7	2.148	32.04	968	0.01487	0.955×10^{-5}	0.0113
50,000	-69.7	1.691	32.02	968	0.01171	0.955×10^{-5}	0.0113
55,000	-69.7	1.332	32.00	968	0.00922	0.955×10^{-5}	0.0113
60,000	-69.7	1.048	31.99	968	0.00726	0.955×10^{-5}	0.0113

Fuente: U.S. Standard Atmosphere Supplements. Oficina de Impresiones del Gobierno de Estados Unidos, 1966. Basadas en las condiciones medias anuales a una latitud de 45° y una variación de acuerdo con la época del año y con los patrones del clima. Las condiciones al nivel del mar ($z = 0$) se consideran como $P = 14.696$ psia, $T = 59$ °F, $\rho = 0.076474$ lbm/ft³, $g = 32.1741$ ft²/s.

TABLA A-17E

Propiedades de gas ideal del aire

T R	h Btu/lbm	P_r	u Btu/lbm	v_r	s° Btu/lbm · R	T R	h Btu/lbm	P_r	u Btu/lbm	v_r	s° Btu/lbm · R
360	85.97	0.3363	61.29	396.6	0.50369	1600	395.74	71.13	286.06	8.263	0.87130
380	90.75	0.4061	64.70	346.6	0.51663	1650	409.13	80.89	296.03	7.556	0.87954
400	95.53	0.4858	68.11	305.0	0.52890	1700	422.59	90.95	306.06	6.924	0.88758
420	100.32	0.5760	71.52	270.1	0.54058	1750	436.12	101.98	316.16	6.357	0.89542
440	105.11	0.6776	74.93	240.6	0.55172	1800	449.71	114.0	326.32	5.847	0.90308
460	109.90	0.7913	78.36	215.33	0.56235	1850	463.37	127.2	336.55	5.388	0.91056
480	114.69	0.9182	81.77	193.65	0.57255	1900	477.09	141.5	346.85	4.974	0.91788
500	119.48	1.0590	85.20	174.90	0.58233	1950	490.88	157.1	357.20	4.598	0.92504
520	124.27	1.2147	88.62	158.58	0.59173	2000	504.71	174.0	367.61	4.258	0.93205
537	128.10	1.3593	91.53	146.34	0.59945	2050	518.71	192.3	378.08	3.949	0.93891
540	129.06	1.3860	92.04	144.32	0.60078	2100	532.55	212.1	388.60	3.667	0.94564
560	133.86	1.5742	95.47	131.78	0.60950	2150	546.54	223.5	399.17	3.410	0.95222
580	138.66	1.7800	98.90	120.70	0.61793	2200	560.59	256.6	409.78	3.176	0.95919
600	143.47	2.005	102.34	110.88	0.62607	2250	574.69	281.4	420.46	2.961	0.96501
620	148.28	2.249	105.78	102.12	0.63395	2300	588.82	308.1	431.16	2.765	0.97123
640	153.09	2.514	109.21	94.30	0.64159	2350	603.00	336.8	441.91	2.585	0.97732
660	157.92	2.801	112.67	87.27	0.64902	2400	617.22	367.6	452.70	2.419	0.98331
680	162.73	3.111	116.12	80.96	0.65621	2450	631.48	400.5	463.54	2.266	0.98919
700	167.56	3.446	119.58	75.25	0.66321	2500	645.78	435.7	474.40	2.125	0.99497
720	172.39	3.806	123.04	70.07	0.67002	2550	660.12	473.3	485.31	1.996	1.00064
740	177.23	4.193	126.51	65.38	0.67665	2600	674.49	513.5	496.26	1.876	1.00623
760	182.08	4.607	129.99	61.10	0.68312	2650	688.90	556.3	507.25	1.765	1.01172
780	186.94	5.051	133.47	57.20	0.68942	2700	703.35	601.9	518.26	1.662	1.01712
800	191.81	5.526	136.97	53.63	0.69558	2750	717.83	650.4	529.31	1.566	1.02244
820	196.69	6.033	140.47	50.35	0.70160	2800	732.33	702.0	540.40	1.478	1.02767
840	201.56	6.573	143.98	47.34	0.70747	2850	746.88	756.7	551.52	1.395	1.03282
860	206.46	7.149	147.50	44.57	0.71323	2900	761.45	814.8	562.66	1.318	1.03788
880	211.35	7.761	151.02	42.01	0.71886	2950	776.05	876.4	573.84	1.247	1.04288
900	216.26	8.411	154.57	39.64	0.72438	3000	790.68	941.4	585.04	1.180	1.04779
920	221.18	9.102	158.12	37.44	0.72979	3050	805.34	1011	596.28	1.118	1.05264
940	226.11	9.834	161.68	35.41	0.73509	3100	820.03	1083	607.53	1.060	1.05741
960	231.06	10.61	165.26	33.52	0.74030	3150	834.75	1161	618.82	1.006	1.06212
980	236.02	11.43	168.83	31.76	0.74540	3200	849.48	1242	630.12	0.955	1.06676
1000	240.98	12.30	172.43	30.12	0.75042	3250	864.24	1328	641.46	0.907	1.07134
1040	250.95	14.18	179.66	27.17	0.76019	3300	879.02	1418	652.81	0.8621	1.07585
1080	260.97	16.28	186.93	24.58	0.76964	3350	893.83	1513	664.20	0.8202	1.08031
1120	271.03	18.60	194.25	22.30	0.77880	3400	908.66	1613	675.60	0.7807	1.08470
1160	281.14	21.18	201.63	20.29	0.78767	3450	923.52	1719	687.04	0.7436	1.08904
1200	291.30	24.01	209.05	18.51	0.79628	3500	938.40	1829	698.48	0.7087	1.09332
1240	301.52	27.13	216.53	16.93	0.80466	3550	953.30	1946	709.95	0.6759	1.09755
1280	311.79	30.55	224.05	15.52	0.81280	3600	968.21	2068	721.44	0.6449	1.10172
1320	322.11	34.31	231.63	14.25	0.82075	3650	983.15	2196	732.95	0.6157	1.10584
1360	332.48	38.41	239.25	13.12	0.82848	3700	998.11	2330	744.48	0.5882	1.10991
1400	342.90	42.88	246.93	12.10	0.83604	3750	1013.1	2471	756.04	0.5621	1.11393
1440	353.37	47.75	254.66	11.17	0.84341	3800	1028.1	2618	767.60	0.5376	1.11791
1480	363.89	53.04	262.44	10.34	0.85062	3850	1043.1	2773	779.19	0.5143	1.12183
1520	374.47	58.78	270.26	9.578	0.85767	3900	1058.1	2934	790.80	0.4923	1.12571
1560	385.08	65.00	278.13	8.890	0.86456	3950	1073.2	3103	802.43	0.4715	1.12955

TABLA A-17E

Propiedades de gas ideal del aire (*conclusión*)

T R	h Btu/lbm	P_r	u Btu/lbm	v_r	s° Btu/lbm · R	T R	h Btu/lbm	P_r	u Btu/lbm	v_r	s° Btu/lbm · R
4000	1088.3	3280	814.06	0.4518	1.13334	4600	1270.4	6089	955.04	0.2799	1.17575
4050	1103.4	3464	825.72	0.4331	1.13709	4700	1300.9	6701	978.73	0.2598	1.18232
4100	1118.5	3656	837.40	0.4154	1.14079	4800	1331.5	7362	1002.5	0.2415	1.18876
4150	1133.6	3858	849.09	0.3985	1.14446	4900	1362.2	8073	1026.3	0.2248	1.19508
4200	1148.7	4067	860.81	0.3826	1.14809	5000	1392.9	8837	1050.1	0.2096	1.20129
4300	1179.0	4513	884.28	0.3529	1.15522	5100	1423.6	9658	1074.0	0.1956	1.20738
4400	1209.4	4997	907.81	0.3262	1.16221	5200	1454.4	10,539	1098.0	0.1828	1.21336
4500	1239.9	5521	931.39	0.3019	1.16905	5300	1485.3	11,481	1122.0	0.1710	1.21923

Nota: Las propiedades P_r (presión relativa) y v_r (volumen específico relativo) son cantidades adimensionales utilizadas en el análisis de procesos isentrópicos y no debe confundirse con las propiedades de presión y volumen específico.

Fuente: Kenneth Wark, *Thermodynamics*, 4a. ed., Nueva York, McGraw-Hill, 1983, pp. 832-833, Tabla A-5. Publicada originalmente en J. H. Keenan y J. Kaye, *Gas Tables*, Nueva York, John Wiley & Sons, 1948.

TABLA A-18E

Propiedades de gas ideal del nitrógeno, N₂

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
300	2,082.0	1,486.2	41.695	1080	7,551.0	5,406.2	50.651
320	2,221.0	1,585.5	42.143	1100	7,695.0	5,510.5	50.783
340	2,360.0	1,684.4	42.564	1120	7,839.3	5,615.2	50.912
360	2,498.9	1,784.0	42.962	1140	7,984.0	5,720.1	51.040
380	2,638.0	1,883.4	43.337	1160	8,129.0	5,825.4	51.167
400	2,777.0	1,982.6	43.694	1180	8,274.4	5,931.0	51.291
420	2,916.1	2,082.0	44.034	1200	8,420.0	6,037.0	51.143
440	3,055.1	2,181.3	44.357	1220	8,566.1	6,143.4	51.534
460	3,194.1	2,280.6	44.665	1240	8,712.6	6,250.1	51.653
480	3,333.1	2,379.9	44.962	1260	8,859.3	6,357.2	51.771
500	3,472.2	2,479.3	45.246	1280	9,006.4	6,464.5	51.887
520	3,611.3	2,578.6	45.519	1300	9,153.9	6,572.3	51.001
537	3,729.5	2,663.1	45.743	1320	9,301.8	6,680.4	52.114
540	3,750.3	2,678.0	45.781	1340	9,450.0	6,788.9	52.225
560	3,889.5	2,777.4	46.034	1360	9,598.6	6,897.8	52.335
580	4,028.7	2,876.9	46.278	1380	9,747.5	7,007.0	52.444
600	4,167.9	2,976.4	46.514	1400	9,896.9	7,116.7	52.551
620	4,307.1	3,075.9	46.742	1420	10,046.6	7,226.7	52.658
640	4,446.4	3,175.5	46.964	1440	10,196.6	7,337.0	52.763
660	4,585.8	3,275.2	47.178	1460	10,347.0	7,447.6	52.867
680	4,725.3	3,374.9	47.386	1480	10,497.8	7,558.7	52.969
700	4,864.9	3,474.8	47.588	1500	10,648.0	7,670.1	53.071
720	5,004.5	3,574.7	47.785	1520	10,800.4	7,781.9	53.171
740	5,144.3	3,674.7	47.977	1540	10,952.2	7,893.9	53.271
760	5,284.1	3,774.9	48.164	1560	11,104.3	8,006.4	53.369
780	5,424.2	3,875.2	48.345	1580	11,256.9	8,119.2	53.465
800	5,564.4	3,975.7	48.522	1600	11,409.7	8,232.3	53.561
820	5,704.7	4,076.3	48.696	1620	11,562.8	8,345.7	53.656
840	5,845.3	4,177.1	48.865	1640	11,716.4	8,459.6	53.751
860	5,985.9	4,278.1	49.031	1660	11,870.2	8,573.6	53.844
880	6,126.9	4,379.4	49.193	1680	12,024.3	8,688.1	53.936
900	6,268.1	4,480.8	49.352	1700	12,178.9	8,802.9	54.028
920	6,409.6	4,582.6	49.507	1720	12,333.7	8,918.0	54.118
940	6,551.2	4,684.5	49.659	1740	12,488.8	9,033.4	54.208
960	6,693.1	4,786.7	49.808	1760	12,644.3	9,149.2	54.297
980	6,835.4	4,889.3	49.955	1780	12,800.2	9,265.3	54.385
1000	6,977.9	4,992.0	50.099	1800	12,956.3	9,381.7	54.472
1020	7,120.7	5,095.1	50.241	1820	13,112.7	9,498.4	54.559
1040	7,263.8	5,198.5	50.380	1840	13,269.5	9,615.5	54.645
1060	7,407.2	5,302.2	50.516	1860	13,426.5	9,732.8	54.729

TABLA A-18E

Propiedades de gas ideal del nitrógeno, N₂ (conclusión)

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
1900	13,742	9,968	54.896	3500	27,016	20,065	59.944
1940	14,058	10,205	55.061	3540	27,359	20,329	60.041
1980	14,375	10,443	55.223	3580	27,703	20,593	60.138
2020	14,694	10,682	55.383	3620	28,046	20,858	60.234
2060	15,013	10,923	55.540	3660	28,391	21,122	60.328
2100	15,334	11,164	55.694	3700	28,735	21,387	60.422
2140	15,656	11,406	55.846	3740	29,080	21,653	60.515
2180	15,978	11,649	55.995	3780	29,425	21,919	60.607
2220	16,302	11,893	56.141	3820	29,771	22,185	60.698
2260	16,626	12,138	56.286	3860	30,117	22,451	60.788
2300	16,951	12,384	56.429	3900	30,463	22,718	60.877
2340	17,277	12,630	56.570	3940	30,809	22,985	60.966
2380	17,604	12,878	56.708	3980	31,156	23,252	61.053
2420	17,932	13,126	56.845	4020	31,503	23,520	61.139
2460	18,260	13,375	56.980	4060	31,850	23,788	61.225
2500	18,590	13,625	57.112	4100	32,198	24,056	61.310
2540	18,919	13,875	57.243	4140	32,546	24,324	61.395
2580	19,250	14,127	57.372	4180	32,894	24,593	61.479
2620	19,582	14,379	57.499	4220	33,242	24,862	61.562
2660	19,914	14,631	57.625	4260	33,591	25,131	61.644
2700	20,246	14,885	57.750	4300	33,940	25,401	61.726
2740	20,580	15,139	57.872	4340	34,289	25,670	61.806
2780	20,914	15,393	57.993	4380	34,638	25,940	61.887
2820	21,248	15,648	58.113	4420	34,988	26,210	61.966
2860	21,584	15,905	58.231	4460	35,338	26,481	62.045
2900	21,920	16,161	58.348	4500	35,688	26,751	62.123
2940	22,256	16,417	58.463	4540	36,038	27,022	62.201
2980	22,593	16,675	58.576	4580	36,389	27,293	62.278
3020	22,930	16,933	58.688	4620	36,739	27,565	62.354
3060	23,268	17,192	58.800	4660	37,090	27,836	62.429
3100	23,607	17,451	58.910	4700	37,441	28,108	62.504
3140	23,946	17,710	59.019	4740	37,792	28,379	62.578
3180	24,285	17,970	59.126	4780	38,144	28,651	62.652
3220	24,625	18,231	59.232	4820	38,495	28,924	62.725
3260	24,965	18,491	59.338	4860	38,847	29,196	62.798
3300	25,306	18,753	59.442	4900	39,199	29,468	62.870
3340	25,647	19,014	59.544	5000	40,080	30,151	63.049
3380	25,989	19,277	59.646	5100	40,962	30,834	63.223
3420	26,331	19,539	59.747	5200	41,844	31,518	63.395
3460	26,673	19,802	59.846	5300	42,728	32,203	63.563

Fuente: Las tablas A-18E a A-23E se adaptaron de Kenneth Wark, *Thermodynamics*, 4a. ed., Nueva York, McGraw-Hill, 1983, pp. 834-844. Originalmente publicadas en J. H. Keenan y J. Kaye, *Gas Tables*, Nueva York, John Wiley & Sons, 1945.

TABLA A-19E

Propiedades de gas ideal del oxígeno, O₂

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
300	2,073.5	1,477.8	44.927	1080	7,696.8	5,552.1	54.064
320	2,212.6	1,577.1	45.375	1100	7,850.4	5,665.9	54.204
340	2,351.7	1,676.5	45.797	1120	8,004.5	5,780.3	54.343
360	2,490.8	1,775.9	46.195	1140	8,159.1	5,895.2	54.480
380	2,630.0	1,875.3	46.571	1160	8,314.2	6,010.6	54.614
400	2,769.1	1,974.8	46.927	1180	8,469.8	6,126.5	54.748
420	2,908.3	2,074.3	47.267	1200	8,625.8	6,242.8	54.879
440	3,047.5	2,173.8	47.591	1220	8,782.4	6,359.6	55.008
460	3,186.9	2,273.4	47.900	1240	8,939.4	6,476.9	55.136
480	3,326.5	2,373.3	48.198	1260	9,096.7	6,594.5	55.262
500	3,466.2	2,473.2	48.483	1280	9,254.6	6,712.7	55.386
520	3,606.1	2,573.4	48.757	1300	9,412.9	6,831.3	55.508
537	3,725.1	2,658.7	48.982	1320	9,571.9	6,950.2	55.630
540	3,746.2	2,673.8	49.021	1340	9,730.7	7,069.6	55.750
560	3,886.6	2,774.5	49.276	1360	9,890.2	7,189.4	55.867
580	4,027.3	2,875.5	49.522	1380	10,050.1	7,309.6	55.984
600	4,168.3	2,976.8	49.762	1400	10,210.4	7,430.1	56.099
620	4,309.7	3,078.4	49.993	1420	10,371.0	7,551.1	56.213
640	4,451.4	3,180.4	50.218	1440	10,532.0	7,672.4	56.326
660	4,593.5	3,282.9	50.437	1460	10,693.3	7,793.9	56.437
680	4,736.2	3,385.8	50.650	1480	10,855.1	7,916.0	56.547
700	4,879.3	3,489.2	50.858	1500	11,017.1	8,038.3	56.656
720	5,022.9	3,593.1	51.059	1520	11,179.6	8,161.1	56.763
740	5,167.0	3,697.4	51.257	1540	11,342.4	8,284.2	56.869
760	5,311.4	3,802.4	51.450	1560	11,505.4	8,407.4	56.975
780	5,456.4	3,907.5	51.638	1580	11,668.8	8,531.1	57.079
800	5,602.0	4,013.3	51.821	1600	11,832.5	8,655.1	57.182
820	5,748.1	4,119.7	52.002	1620	11,996.6	8,779.5	57.284
840	5,894.8	4,226.6	52.179	1640	12,160.9	8,904.1	57.385
860	6,041.9	4,334.1	52.352	1660	12,325.5	9,029.0	57.484
880	6,189.6	4,442.0	52.522	1680	12,490.4	9,154.1	57.582
900	6,337.9	4,550.6	52.688	1700	12,655.6	9,279.6	57.680
920	6,486.7	4,659.7	52.852	1720	12,821.1	9,405.4	57.777
940	6,636.1	4,769.4	53.012	1740	12,986.9	9,531.5	57.873
960	6,786.0	4,879.5	53.170	1760	13,153.0	9,657.9	57.968
980	6,936.4	4,990.3	53.326	1780	13,319.2	9,784.4	58.062
1000	7,087.5	5,101.6	53.477	1800	13,485.8	9,911.2	58.155
1020	7,238.9	5,213.3	53.628	1820	13,652.5	10,038.2	58.247
1040	7,391.0	5,325.7	53.775	1840	13,819.6	10,165.6	58.339
1060	7,543.6	5,438.6	53.921	1860	13,986.8	10,293.1	58.428

TABLA A-19E

Propiedades de gas ideal del oxígeno, O₂ (conclusión)

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
1900	14,322	10,549	58.607	3500	28,273	21,323	63.914
1940	14,658	10,806	58.782	3540	28,633	21,603	64.016
1980	14,995	11,063	58.954	3580	28,994	21,884	64.114
2020	15,333	11,321	59.123	3620	29,354	22,165	64.217
2060	15,672	11,581	59.289	3660	29,716	22,447	64.316
2100	16,011	11,841	59.451	3700	30,078	22,730	64.415
2140	16,351	12,101	59.612	3740	30,440	23,013	64.512
2180	16,692	12,363	59.770	3780	30,803	23,296	64.609
2220	17,036	12,625	59.926	3820	31,166	23,580	64.704
2260	17,376	12,888	60.077	3860	31,529	23,864	64.800
2300	17,719	13,151	60.228	3900	31,894	24,149	64.893
2340	18,062	13,416	60.376	3940	32,258	24,434	64.986
2380	18,407	13,680	60.522	3980	32,623	24,720	65.078
2420	18,572	13,946	60.666	4020	32,989	25,006	65.169
2460	19,097	14,212	60.808	4060	33,355	25,292	65.260
2500	19,443	14,479	60.946	4100	33,722	25,580	65.350
2540	19,790	14,746	61.084	4140	34,089	25,867	64.439
2580	20,138	15,014	61.220	4180	34,456	26,155	65.527
2620	20,485	15,282	61.354	4220	34,824	26,144	65.615
2660	20,834	15,551	61.486	4260	35,192	26,733	65.702
2700	21,183	15,821	61.616	4300	35,561	27,022	65.788
2740	21,533	16,091	61.744	4340	35,930	27,312	65.873
2780	21,883	16,362	61.871	4380	36,300	27,602	65.958
2820	22,232	16,633	61.996	4420	36,670	27,823	66.042
2860	22,584	16,905	62.120	4460	37,041	28,184	66.125
2900	22,936	17,177	62.242	4500	37,412	28,475	66.208
2940	23,288	17,450	62.363	4540	37,783	28,768	66.290
2980	23,641	17,723	62.483	4580	38,155	29,060	66.372
3020	23,994	17,997	62.599	4620	38,528	29,353	66.453
3060	24,348	18,271	62.716	4660	38,900	29,646	66.533
3100	24,703	18,546	62.831	4700	39,274	29,940	66.613
3140	25,057	18,822	62.945	4740	39,647	30,234	66.691
3180	25,413	19,098	63.057	4780	40,021	30,529	66.770
3220	25,769	19,374	63.169	4820	40,396	30,824	66.848
3260	26,175	19,651	63.279	4860	40,771	31,120	66.925
3300	26,412	19,928	63.386	4900	41,146	31,415	67.003
3340	26,839	20,206	63.494	5000	42,086	32,157	67.193
3380	27,197	20,485	63.601	5100	43,021	32,901	67.380
3420	27,555	20,763	63.706	5200	43,974	33,648	67.562
3460	27,914	21,043	63.811	5300	44,922	34,397	67.743

TABLA A-20E

Propiedades de gas ideal del dióxido de carbono, CO₂

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
300	2,108.2	1,512.4	46.353	1080	9,575.8	7,431.1	58.072
320	2,256.6	1,621.1	46.832	1100	9,802.6	7,618.1	58.281
340	2,407.3	1,732.1	47.289	1120	10,030.6	7,806.4	58.485
360	2,560.5	1,845.6	47.728	1140	10,260.1	7,996.2	58.689
380	2,716.4	1,961.8	48.148	1160	10,490.6	8,187.0	58.889
400	2,874.7	2,080.4	48.555	1180	10,722.3	8,379.0	59.088
420	3,035.7	2,201.7	48.947	1200	10,955.3	8,572.3	59.283
440	3,199.4	2,325.6	49.329	1220	11,189.4	8,766.6	59.477
460	3,365.7	2,452.2	49.698	1240	11,424.6	8,962.1	59.668
480	3,534.7	2,581.5	50.058	1260	11,661.0	9,158.8	59.858
500	3,706.2	2,713.3	50.408	1280	11,898.4	9,356.5	60.044
520	3,880.3	2,847.7	50.750	1300	12,136.9	9,555.3	60.229
537	4,027.5	2,963.8	51.032	1320	12,376.4	9,755.0	60.412
540	4,056.8	2,984.4	51.082	1340	12,617.0	9,955.9	60.593
560	4,235.8	3,123.7	51.408	1360	12,858.5	10,157.7	60.772
580	4,417.2	3,265.4	51.726	1380	13,101.0	10,360.5	60.949
600	4,600.9	3,409.4	52.038	1400	13,344.7	10,564.5	61.124
620	4,786.6	3,555.6	52.343	1420	13,589.1	10,769.2	61.298
640	4,974.9	3,704.0	52.641	1440	13,834.5	10,974.8	61.469
660	5,165.2	3,854.6	52.934	1460	14,080.8	11,181.4	61.639
680	5,357.6	4,007.2	53.225	1480	14,328.0	11,388.9	61.800
700	5,552.0	4,161.9	53.503	1500	14,576.0	11,597.2	61.974
720	5,748.4	4,318.6	53.780	1520	14,824.9	11,806.4	62.138
740	5,946.8	4,477.3	54.051	1540	15,074.7	12,016.5	62.302
760	6,147.0	4,637.9	54.319	1560	15,325.3	12,227.3	62.464
780	6,349.1	4,800.1	54.582	1580	15,576.7	12,439.0	62.624
800	6,552.9	4,964.2	54.839	1600	15,829.0	12,651.6	62.783
820	6,758.3	5,129.9	55.093	1620	16,081.9	12,864.8	62.939
840	6,965.7	5,297.6	55.343	1640	16,335.7	13,078.9	63.095
860	7,174.7	5,466.9	55.589	1660	16,590.2	13,293.7	63.250
880	7,385.3	5,637.7	55.831	1680	16,845.5	13,509.2	63.403
900	7,597.6	5,810.3	56.070	1700	17,101.4	13,725.4	63.555
920	7,811.4	5,984.4	56.305	1720	17,358.1	13,942.4	63.704
940	8,026.8	6,160.1	56.536	1740	17,615.5	14,160.1	63.853
960	8,243.8	6,337.4	56.765	1760	17,873.5	14,378.4	64.001
980	8,462.2	6,516.1	56.990	1780	18,132.2	14,597.4	64.147
1000	8,682.1	6,696.2	57.212	1800	18,391.5	14,816.9	64.292
1020	8,903.4	6,877.8	57.432	1820	18,651.5	15,037.2	64.435
1040	9,126.2	7,060.9	57.647	1840	18,912.2	15,258.2	64.578
1060	9,350.3	7,245.3	57.861	1860	19,173.4	15,479.7	64.719

TABLA A-20E

Propiedades de gas ideal del dióxido de carbono, CO₂ (conclusión)

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
1900	19,698	15,925	64.999	3500	41,965	35,015	73.462
1940	20,224	16,372	65.272	3540	42,543	35,513	73.627
1980	20,753	16,821	65.543	3580	43,121	36,012	73.789
2020	21,284	17,273	65.809	3620	43,701	36,512	73.951
2060	21,818	17,727	66.069	3660	44,280	37,012	74.110
2100	22,353	18,182	66.327	3700	44,861	37,513	74.267
2140	22,890	18,640	66.581	3740	45,442	38,014	74.423
2180	23,429	19,101	66.830	3780	46,023	38,517	74.578
2220	23,970	19,561	67.076	3820	46,605	39,019	74.732
2260	24,512	20,024	67.319	3860	47,188	39,522	74.884
2300	25,056	20,489	67.557	3900	47,771	40,026	75.033
2340	25,602	20,955	67.792	3940	48,355	40,531	75.182
2380	26,150	21,423	68.025	3980	48,939	41,035	75.330
2420	26,699	21,893	68.253	4020	49,524	41,541	75.477
2460	27,249	22,364	68.479	4060	50,109	42,047	75.622
2500	27,801	22,837	68.702	4100	50,695	42,553	75.765
2540	28,355	23,310	68.921	4140	51,282	43,060	75.907
2580	28,910	23,786	69.138	4180	51,868	43,568	76.048
2620	29,465	24,262	69.352	4220	52,456	44,075	76.188
2660	30,023	24,740	69.563	4260	53,044	44,584	76.327
2700	30,581	25,220	69.771	4300	53,632	45,093	76.464
2740	31,141	25,701	69.977	4340	54,221	45,602	76.601
2780	31,702	26,181	70.181	4380	54,810	46,112	76.736
2820	32,264	26,664	70.382	4420	55,400	46,622	76.870
2860	32,827	27,148	70.580	4460	55,990	47,133	77.003
2900	33,392	27,633	70.776	4500	56,581	47,645	77.135
2940	33,957	28,118	70.970	4540	57,172	48,156	77.266
2980	34,523	28,605	71.160	4580	57,764	48,668	77.395
3020	35,090	29,093	71.350	4620	58,356	49,181	77.521
3060	35,659	29,582	71.537	4660	58,948	49,694	77.652
3100	36,228	30,072	71.722	4700	59,541	50,208	77.779
3140	36,798	30,562	71.904	4740	60,134	50,721	77.905
3180	37,369	31,054	72.085	4780	60,728	51,236	78.029
3220	37,941	31,546	72.264	4820	61,322	51,750	78.153
3260	38,513	32,039	72.441	4860	61,916	52,265	78.276
3300	39,087	32,533	72.616	4900	62,511	52,781	78.398
3340	39,661	33,028	72.788	5000	64,000	54,071	78.698
3380	40,236	33,524	72.960	5100	65,491	55,363	78.994
3420	40,812	34,020	73.129	5200	66,984	56,658	79.284
3460	41,388	34,517	73.297	5300	68,471	57,954	79.569

TABLA A-21E

Propiedades de gas ideal del monóxido de carbono, CO

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
300	2,081.9	1,486.1	43.223	1080	7,571.1	5,426.4	52.203
320	2,220.9	1,585.4	43.672	1100	7,716.8	5,532.3	52.337
340	2,359.9	1,684.7	44.093	1120	7,862.9	5,638.7	52.468
360	2,498.8	1,783.9	44.490	1140	8,009.2	5,745.4	52.598
380	2,637.9	1,883.3	44.866	1160	8,156.1	5,851.5	52.726
400	2,776.9	1,982.6	45.223	1180	8,303.3	5,960.0	52.852
420	2,916.0	2,081.9	45.563	1200	8,450.8	6,067.8	52.976
440	3,055.0	2,181.2	45.886	1220	8,598.8	6,176.0	53.098
460	3,194.0	2,280.5	46.194	1240	8,747.2	6,284.7	53.218
480	3,333.0	2,379.8	46.491	1260	8,896.0	6,393.8	53.337
500	3,472.1	2,479.2	46.775	1280	9,045.0	6,503.1	53.455
520	3,611.2	2,578.6	47.048	1300	9,194.6	6,613.0	53.571
537	3,725.1	2,663.1	47.272	1320	9,344.6	6,723.2	53.685
540	3,750.3	2,677.9	47.310	1340	9,494.8	6,833.7	53.799
560	3,889.5	2,777.4	47.563	1360	9,645.5	6,944.7	53.910
580	4,028.7	2,876.9	47.807	1380	9,796.6	7,056.1	54.021
600	4,168.0	2,976.5	48.044	1400	9,948.1	7,167.9	54.129
620	4,307.4	3,076.2	48.272	1420	10,100.0	7,280.1	54.237
640	4,446.9	3,175.9	48.494	1440	10,252.2	7,392.6	54.344
660	4,586.6	3,275.8	48.709	1460	10,404.8	7,505.4	54.448
680	4,726.2	3,375.8	48.917	1480	10,557.8	7,618.7	54.522
700	4,886.0	3,475.9	49.120	1500	10,711.1	7,732.3	54.665
720	5,006.1	3,576.3	49.317	1520	10,864.9	7,846.4	54.757
740	5,146.4	3,676.9	49.509	1540	11,019.0	7,960.8	54.858
760	5,286.8	3,777.5	49.697	1560	11,173.4	8,075.4	54.958
780	5,427.4	3,878.4	49.880	1580	11,328.2	8,190.5	55.056
800	5,568.2	3,979.5	50.058	1600	11,483.4	8,306.0	55.154
820	5,709.4	4,081.0	50.232	1620	11,638.9	8,421.8	55.251
840	5,850.7	4,182.6	50.402	1640	11,794.7	8,537.9	55.347
860	5,992.3	4,284.5	50.569	1660	11,950.9	8,654.4	55.411
880	6,134.2	4,386.6	50.732	1680	12,107.5	8,771.2	55.535
900	6,276.4	4,489.1	50.892	1700	12,264.3	8,888.3	55.628
920	6,419.0	4,592.0	51.048	1720	12,421.4	9,005.7	55.720
940	6,561.7	4,695.0	51.202	1740	12,579.0	9,123.6	55.811
960	6,704.9	4,798.5	51.353	1760	12,736.7	9,241.6	55.900
980	6,848.4	4,902.3	51.501	1780	12,894.9	9,360.0	55.990
1000	6,992.2	5,006.3	51.646	1800	13,053.2	9,478.6	56.078
1020	7,136.4	5,110.8	51.788	1820	13,212.0	9,597.7	56.166
1040	7,281.0	5,215.7	51.929	1840	13,371.0	9,717.0	56.253
1060	7,425.9	5,320.9	52.067	1860	13,530.2	9,836.5	56.339

TABLA A-21E

Propiedades de gas ideal del monóxido de carbono, CO (*conclusión*)

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
1900	13,850	10,077	56.509	3500	27,262	20,311	61.612
1940	14,170	10,318	56.677	3540	27,608	20,576	61.710
1980	14,492	10,560	56.841	3580	27,954	20,844	61.807
2020	14,815	10,803	57.007	3620	28,300	21,111	61.903
2060	15,139	11,048	57.161	3660	28,647	21,378	61.998
2100	15,463	11,293	57.317	3700	28,994	21,646	62.093
2140	15,789	11,539	57.470	3740	29,341	21,914	62.186
2180	16,116	11,787	57.621	3780	29,688	22,182	62.279
2220	16,443	12,035	57.770	3820	30,036	22,450	62.370
2260	16,722	12,284	57.917	3860	30,384	22,719	62.461
2300	17,101	12,534	58.062	3900	30,733	22,988	62.511
2340	17,431	12,784	58.204	3940	31,082	23,257	62.640
2380	17,762	13,035	58.344	3980	31,431	23,527	62.728
2420	18,093	13,287	58.482	4020	31,780	23,797	62.816
2460	18,426	13,541	58.619	4060	32,129	24,067	62.902
2500	18,759	13,794	58.754	4100	32,479	24,337	62.988
2540	19,093	14,048	58.885	4140	32,829	24,608	63.072
2580	19,427	14,303	59.016	4180	33,179	24,878	63.156
2620	19,762	14,559	59.145	4220	33,530	25,149	63.240
2660	20,098	14,815	59.272	4260	33,880	25,421	63.323
2700	20,434	15,072	59.398	4300	34,231	25,692	63.405
2740	20,771	15,330	59.521	4340	34,582	25,934	63.486
2780	21,108	15,588	59.644	4380	34,934	26,235	63.567
2820	21,446	15,846	59.765	4420	35,285	26,508	63.647
2860	21,785	16,105	59.884	4460	35,637	26,780	63.726
2900	22,124	16,365	60.002	4500	35,989	27,052	63.805
2940	22,463	16,225	60.118	4540	36,341	27,325	63.883
2980	22,803	16,885	60.232	4580	36,693	27,598	63.960
3020	23,144	17,146	60.346	4620	37,046	27,871	64.036
3060	23,485	17,408	60.458	4660	37,398	28,144	64.113
3100	23,826	17,670	60.569	4700	37,751	28,417	64.188
3140	24,168	17,932	60.679	4740	38,104	28,691	64.263
3180	24,510	18,195	60.787	4780	38,457	28,965	64.337
3220	24,853	18,458	60.894	4820	38,811	29,239	64.411
3260	25,196	18,722	61.000	4860	39,164	29,513	64.484
3300	25,539	18,986	61.105	4900	39,518	29,787	64.556
3340	25,883	19,250	61.209	5000	40,403	30,473	64.735
3380	26,227	19,515	61.311	5100	41,289	31,161	64.910
3420	26,572	19,780	61.412	5200	42,176	31,849	65.082
3460	26,917	20,045	61.513	5300	43,063	32,538	65.252

TABLA A-22E

Propiedades de gas ideal del hidrógeno, H₂

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
300	2,063.5	1,467.7	27.337	1400	9,673.8	6,893.6	37.883
320	2,189.4	1,553.9	27.742	1500	10,381.5	7,402.7	38.372
340	2,317.2	1,642.0	28.130	1600	11,092.5	7,915.1	38.830
360	2,446.8	1,731.9	28.501	1700	11,807.4	8,431.4	39.264
380	2,577.8	1,823.2	28.856	1800	12,526.8	8,952.2	39.675
400	2,710.2	1,915.8	29.195	1900	13,250.9	9,477.8	40.067
420	2,843.7	2,009.6	29.520	2000	13,980.1	10,008.4	40.441
440	2,978.1	2,104.3	29.833	2100	14,714.5	10,544.2	40.799
460	3,113.5	2,200.0	30.133	2200	15,454.4	11,085.5	41.143
480	3,249.4	2,296.2	30.424	2300	16,199.8	11,632.3	41.475
500	3,386.1	2,393.2	30.703	2400	16,950.6	12,184.5	41.794
520	3,523.2	2,490.6	30.972	2500	17,707.3	12,742.6	42.104
537	3,640.3	2,573.9	31.194	2600	18,469.7	13,306.4	42.403
540	3,660.9	2,588.5	31.232	2700	19,237.8	13,876.0	42.692
560	3,798.8	2,686.7	31.482	2800	20,011.8	14,451.4	42.973
580	3,937.1	2,785.3	31.724	2900	20,791.5	15,032.5	43.247
600	4,075.6	2,884.1	31.959	3000	21,576.9	15,619.3	43.514
620	4,214.3	2,983.1	32.187	3100	22,367.7	16,211.5	43.773
640	4,353.1	3,082.1	32.407	3200	23,164.1	16,809.3	44.026
660	4,492.1	3,181.4	32.621	3300	23,965.5	17,412.1	44.273
680	4,631.1	3,280.7	32.829	3400	24,771.9	18,019.9	44.513
700	4,770.2	3,380.1	33.031	3500	25,582.9	18,632.4	44.748
720	4,909.5	3,479.6	33.226	3600	26,398.5	19,249.4	44.978
740	5,048.8	3,579.2	33.417	3700	27,218.5	19,870.8	45.203
760	5,188.1	3,678.8	33.603	3800	28,042.8	20,496.5	45.423
780	5,327.6	3,778.6	33.784	3900	28,871.1	21,126.2	45.638
800	5,467.1	3,878.4	33.961	4000	29,703.5	21,760.0	45.849
820	5,606.7	3,978.3	34.134	4100	30,539.8	22,397.7	46.056
840	5,746.3	4,078.2	34.302	4200	31,379.8	23,039.2	46.257
860	5,885.9	4,178.0	34.466	4300	32,223.5	23,684.3	46.456
880	6,025.6	4,278.0	34.627	4400	33,070.9	24,333.1	46.651
900	6,165.3	4,378.0	34.784	4500	33,921.6	24,985.2	46.842
920	6,305.1	4,478.1	34.938	4600	34,775.7	25,640.7	47.030
940	6,444.9	4,578.1	35.087	4700	35,633.0	26,299.4	47.215
960	6,584.7	4,678.3	35.235	4800	36,493.4	26,961.2	47.396
980	6,724.6	4,778.4	35.379	4900	37,356.9	27,626.1	47.574
1000	6,864.5	4,878.6	35.520	5000	38,223.3	28,294.0	47.749
1100	7,564.6	5,380.1	36.188	5100	39,092.8	28,964.9	47.921
1200	8,265.8	5,882.8	36.798	5200	39,965.1	29,638.6	48.090
1300	8,968.7	6,387.1	37.360	5300	40,840.2	30,315.1	48.257

TABLA A-23E

Propiedades de gas ideal del vapor de agua, H₂O

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
300	2,367.6	1,771.8	40.439	1080	8,768.2	6,623.5	50.854
320	2,526.8	1,891.3	40.952	1100	8,942.0	6,757.5	51.013
340	2,686.0	2,010.8	41.435	1120	9,116.4	6,892.2	51.171
360	2,845.1	2,130.2	41.889	1140	9,291.4	7,027.5	51.325
380	3,004.4	2,249.8	42.320	1160	9,467.1	7,163.5	51.478
400	3,163.8	2,369.4	42.728	1180	9,643.4	7,300.1	51.360
420	3,323.2	2,489.1	43.117	1200	9,820.4	7,437.4	51.777
440	3,482.7	2,608.9	43.487	1220	9,998.0	7,575.2	51.925
460	3,642.3	2,728.8	43.841	1240	10,176.1	7,713.6	52.070
480	3,802.0	2,848.8	44.182	1260	10,354.9	7,852.7	52.212
500	3,962.0	2,969.1	44.508	1280	10,534.4	7,992.5	52.354
520	4,122.0	3,089.4	44.821	1300	10,714.5	8,132.9	52.494
537	4,258.0	3,191.9	45.079	1320	10,895.3	8,274.0	52.631
540	4,282.4	3,210.0	45.124	1340	11,076.6	8,415.5	52.768
560	4,442.8	3,330.7	45.415	1360	11,258.7	8,557.9	52.903
580	4,603.7	3,451.9	45.696	1380	11,441.4	8,700.9	53.037
600	4,764.7	3,573.2	45.970	1400	11,624.8	8,844.6	53.168
620	4,926.1	3,694.9	46.235	1420	11,808.8	8,988.9	53.299
640	5,087.8	3,816.8	46.492	1440	11,993.4	9,133.8	53.428
660	5,250.0	3,939.3	46.741	1460	12,178.8	9,279.4	53.556
680	5,412.5	4,062.1	46.984	1480	12,364.8	9,425.7	53.682
700	5,575.4	4,185.3	47.219	1500	12,551.4	9,572.7	53.808
720	5,738.8	4,309.0	47.450	1520	12,738.8	9,720.3	53.932
740	5,902.6	4,433.1	47.673	1540	12,926.8	9,868.6	54.055
760	6,066.9	4,557.6	47.893	1560	13,115.6	10,017.6	54.117
780	6,231.7	4,682.7	48.106	1580	13,305.0	10,167.3	54.298
800	6,396.9	4,808.2	48.316	1600	13,494.4	10,317.6	54.418
820	6,562.6	4,934.2	48.520	1620	13,685.7	10,468.6	54.535
840	6,728.9	5,060.8	48.721	1640	13,877.0	10,620.2	54.653
860	6,895.6	5,187.8	48.916	1660	14,069.2	10,772.7	54.770
880	7,062.9	5,315.3	49.109	1680	14,261.9	10,925.6	54.886
900	7,230.9	5,443.6	49.298	1700	14,455.4	11,079.4	54.999
920	7,399.4	5,572.4	49.483	1720	14,649.5	11,233.8	55.113
940	7,568.4	5,701.7	49.665	1740	14,844.3	11,388.9	55.226
960	7,738.0	5,831.6	49.843	1760	15,039.8	11,544.7	55.339
980	7,908.2	5,962.0	50.019	1780	15,236.1	11,701.2	55.449
1000	8,078.2	6,093.0	50.191	1800	15,433.0	11,858.4	55.559
1020	8,250.4	6,224.8	50.360	1820	15,630.6	12,016.3	55.668
1040	8,422.4	6,357.1	50.528	1840	15,828.7	12,174.7	55.777
1060	8,595.0	6,490.0	50.693	1860	16,027.6	12,333.9	55.884

TABLA A-23E

Propiedades de gas ideal del vapor de agua, H₂O (conclusión)

T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R	T R	\bar{h} Btu/lbmol	\bar{u} Btu/lbmol	\bar{s}° Btu/lbmol · R
1900	16,428	12,654	56.097	3500	34,324	27,373	62.876
1940	16,830	12,977	56.307	3540	34,809	27,779	63.015
1980	17,235	13,303	56.514	3580	35,296	28,187	63.153
2020	17,643	13,632	56.719	3620	35,785	28,596	63.288
2060	18,054	13,963	56.920	3660	36,274	29,006	63.423
2100	18,467	14,297	57.119	3700	36,765	29,418	63.557
2140	18,883	14,633	57.315	3740	37,258	29,831	63.690
2180	19,301	14,972	57.509	3780	37,752	30,245	63.821
2220	19,722	15,313	57.701	3820	38,247	30,661	63.952
2260	20,145	15,657	57.889	3860	38,743	31,077	64.082
2300	20,571	16,003	58.077	3900	39,240	31,495	64.210
2340	20,999	16,352	58.261	3940	39,739	31,915	64.338
2380	21,429	16,703	58.445	3980	40,239	32,335	64.465
2420	21,862	17,057	58.625	4020	40,740	32,757	64.591
2460	22,298	17,413	58.803	4060	41,242	33,179	64.715
2500	22,735	17,771	58.980	4100	41,745	33,603	64.839
2540	23,175	18,131	59.155	4140	42,250	34,028	64.962
2580	23,618	18,494	59.328	4180	42,755	34,454	65.084
2620	24,062	18,859	59.500	4220	43,267	34,881	65.204
2660	24,508	19,226	59.669	4260	43,769	35,310	65.325
2700	24,957	19,595	59.837	4300	44,278	35,739	65.444
2740	25,408	19,967	60.003	4340	44,788	36,169	65.563
2780	25,861	20,340	60.167	4380	45,298	36,600	65.680
2820	26,316	20,715	60.330	4420	45,810	37,032	65.797
2860	26,773	21,093	60.490	4460	46,322	37,465	65.913
2900	27,231	21,472	60.650	4500	46,836	37,900	66.028
2940	27,692	21,853	60.809	4540	47,350	38,334	66.142
2980	28,154	22,237	60.965	4580	47,866	38,770	66.255
3020	28,619	22,621	61.120	4620	48,382	39,207	66.368
3060	29,085	23,085	61.274	4660	48,899	39,645	66.480
3100	29,553	23,397	61.426	4700	49,417	40,083	66.591
3140	30,023	23,787	61.577	4740	49,936	40,523	66.701
3180	30,494	24,179	61.727	4780	50,455	40,963	66.811
3220	30,967	24,572	61.874	4820	50,976	41,404	66.920
3260	31,442	24,968	62.022	4860	51,497	41,856	67.028
3300	31,918	25,365	62.167	4900	52,019	42,288	67.135
3340	32,396	25,763	62.312	5000	53,327	43,398	67.401
3380	32,876	26,164	62.454	5100	54,640	44,512	67.662
3420	33,357	26,565	62.597	5200	55,957	45,631	67.918
3460	33,839	26,968	62.738	5300	57,279	46,754	68.172

TABLA A-26E

Entalpía de formación, función de Gibbs de formación y entropía absoluta a 77°F, 1 atm

Sustancia	Fórmula	\bar{h}_f° Btu/lbmol	\bar{g}_f° Btu/lbmol	\bar{s}° Btu/lbmol · R
Acetileno	C ₂ H ₂ (g)	+97,540	+87,990	48.00
Agua	H ₂ O(ℓ)	-122,970	-102,040	16.71
Alcohol etílico	C ₂ H ₅ OH(g)	-101,230	-72,520	67.54
Alcohol etílico	C ₂ H ₅ OH(ℓ)	-119,470	-75,240	38.40
Alcohol metílico	CH ₃ OH(g)	-86,540	-69,700	57.29
Alcohol metílico	CH ₃ OH(ℓ)	-102,670	-71,570	30.30
Amoniaco	NH ₃ (g)	-19,750	-7,140	45.97
Benceno	C ₆ H ₆ (g)	+35,680	+55,780	64.34
n-Butano	C ₄ H ₁₀ (g)	-54,270	-6,760	74.11
Carbón	C(s)	0	0	1.36
Dióxido de carbono	CO ₂ (g)	-169,300	-169,680	51.07
n-Dodecano	C ₁₂ H ₂₆ (g)	-125,190	+21,570	148.86
Etano	C ₂ H ₆ (g)	-36,420	-14,150	54.85
Etileno	C ₂ H ₄ (g)	+22,490	+29,306	52.54
Hidrógeno	H(g)	+93,780	+87,460	27.39
Hidrógeno	H ₂ (g)	0	0	31.21
Hidroxilo	OH(g)	+16,790	+14,750	43.92
Metano	CH ₄ (g)	-32,210	-21,860	44.49
Monóxido de carbono	CO(g)	-47,540	-59,010	47.21
Nitrógeno	N ₂ (g)	0	0	45.77
Nitrógeno	N(g)	+203,340	+195,970	36.61
n-Octano	C ₈ H ₁₈ (g)	-89,680	+7,110	111.55
n-Octano	C ₈ H ₁₈ (ℓ)	-107,530	+2,840	86.23
Oxígeno	O ₂ (g)	0	0	49.00
Oxígeno	O(g)	+107,210	+99,710	38.47
Peróxido de hidrógeno	H ₂ O ₂ (g)	-58,640	-45,430	55.60
Propano	C ₃ H ₈ (g)	-44,680	-10,105	64.51
Propileno	C ₃ H ₆ (g)	+8,790	+26,980	63.80
Vapor de agua	H ₂ O(g)	-104,040	-98,350	45.11

Fuente: De JANAF, *Thermochemical Tables*, Midland, MI, Dow Chemical Co., 1971; *Selected Values of Chemical Thermodynamic Properties*, NBS Technical Note 270-3, 1968; y *API Research Project 44*, Carnegie Press, 1953.

TABLA A-27E

Propiedades de algunos combustibles e hidrocarburos comunes

Combustible (fase)	Fórmula	Masa molar, lbm/lbmol	Densidad, ¹ lbm/ft ³	Entalpía de vaporización, ² Btu/lbm	Calor específico, ¹ c _p Btu/lbm · °F	Poder calorífico superior, ³ Btu/lbm	Poder calorífico inferior, ³ Btu/lbm
Acetileno (g)	C ₂ H ₂	26.038	—	—	0.404	21,490	20,760
Benceno (ℓ)	C ₆ H ₆	78.114	54.7	186	0.411	17,970	17,240
Butano (ℓ)	C ₄ H ₁₀	58.123	36.1	156	0.578	21,130	19,510
Carbono (s)	C	12.011	125	—	0.169	14,100	14,100
Decano (ℓ)	C ₁₀ H ₂₂	142.285	45.6	155	0.528	20,490	19,020
Diesel ligero (ℓ)	C _n H _{1.8n}	170	49-52	116	0.53	19,800	18,600
Diesel pesado (ℓ)	C _n H _{1.7n}	200	51-55	99	0.45	19,600	18,400
Etano (g)	C ₂ H ₆	30.070	—	74	0.418	22,320	20,430
Etanol (ℓ)	C ₂ H ₆ O	46.069	49.3	395	0.583	12,760	11,530
Gas natural (g)	C _n H _{3.8n} N _{0.1n}	18	—	—	0.48	21,500	19,400
Gasolina (ℓ)	C _n H _{1.87n}	100-110	45-49	151	0.57	20,300	18,900
Heptano (ℓ)	C ₇ H ₁₆	100.204	42.7	157	0.535	20,680	19,180
Hexano (ℓ)	C ₆ H ₁₂	84.161	42.0	169	0.439	20,430	19,090
Hexeno (ℓ)	C ₆ H ₁₄	86.177	41.2	157	0.542	20,770	19,240
Hidrógeno (g)	H ₂	2.016	—	—	3.44	60,970	51,600
Isopentano (ℓ)	C ₅ H ₁₂	72.150	39.1	—	0.554	20,890	19,310
Metano (g)	CH ₄	16.043	—	219	0.525	23,880	21,520
Metanol (ℓ)	CH ₄ O	32.042	49.3	502	0.604	9,740	8,570
Monóxido de carbono (g)	CO	28.013	—	—	0.251	4,340	4,340
Octano (ℓ)	C ₈ H ₁₈	114.231	43.9	156	0.533	20,590	19,100
1-Penteno (ℓ)	C ₅ H ₁₀	70.134	40.0	156	0.525	20,540	19,190
Propano (ℓ)	C ₃ H ₈	44.097	31.2	144	0.662	21,640	19,930
Tolueno (ℓ)	C ₇ H ₈	92.141	54.1	177	0.408	18,230	17,420

¹A 1 atm y 68°F.²A 77°F para combustibles líquidos, y 1 atm y temperatura normal de ebullición para combustibles gaseosos.³A 77°F. Multiplique por la masa molar para obtener los valores caloríficos en Btu/lbmol.

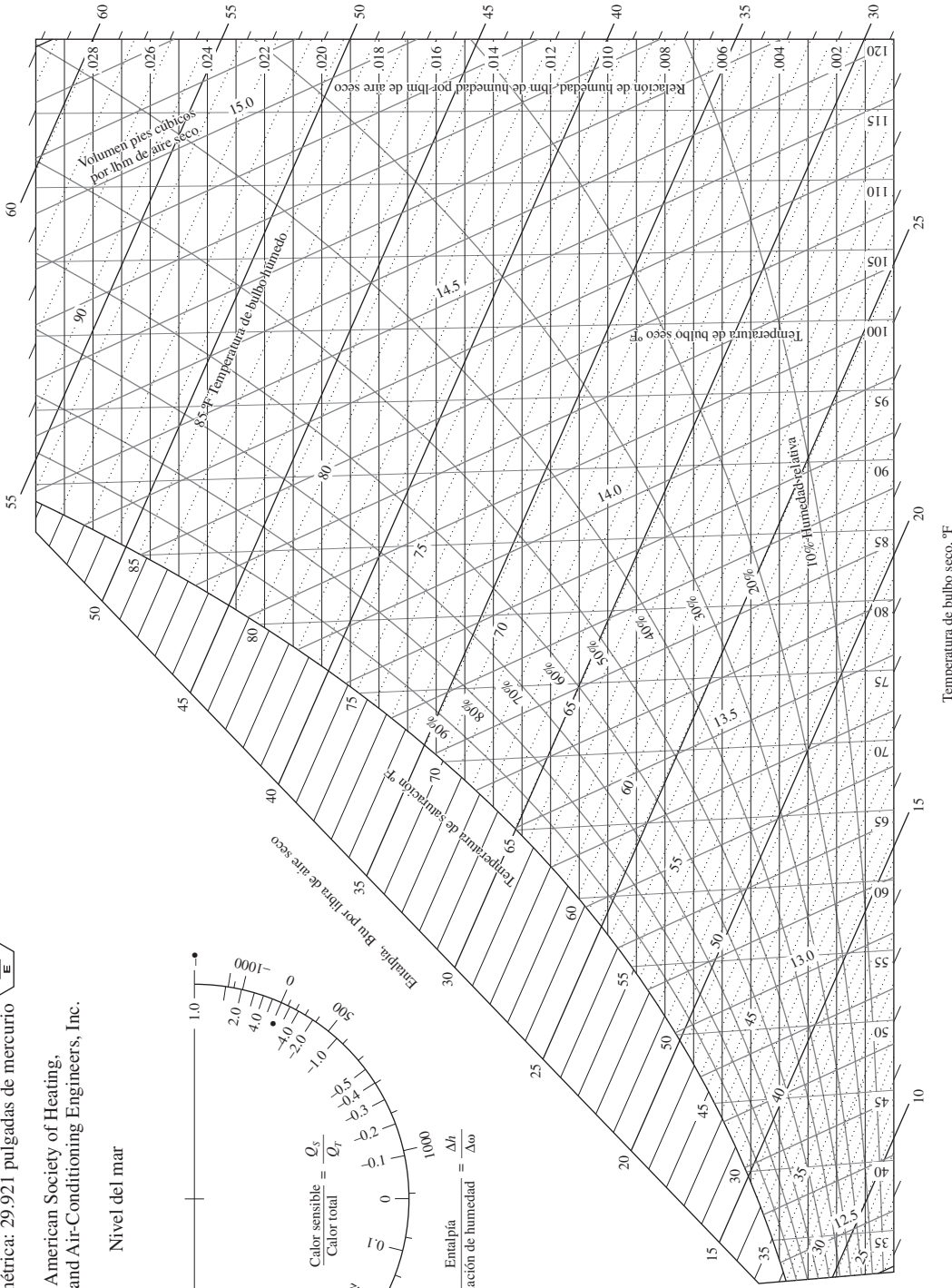
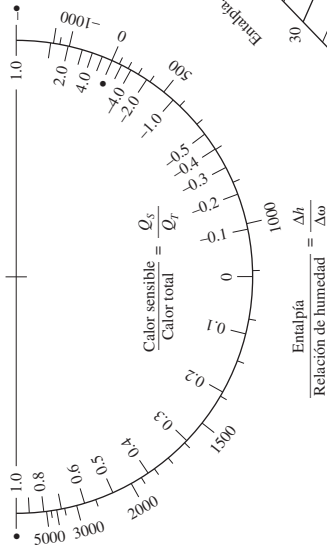


Gráfica psicrométrica ASHRAE Núm. 1

Temperatura normal
 Presión barométrica: 29.921 pulgadas de mercurio

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Nivel del mar



Preparado por el Centro de Estudios Aplicados de Termodinámica, Universidad de Idaho

FIGURA A-31E

Gráfica psicrométrica a 1 atm de presión total.

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