

# Appunti ed Esercizi di *Fisica Tecnica e Macchine Termiche*

## Appendici 1-5

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1. Equazioni di stato per i gas ideali e per i liquidi incomprimibili
2. Trasformazioni reversibili per i gas ideali con calori specifici costanti
3. Proprietà termodinamiche dei fluidi.
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5. Metodologia per la soluzione di problemi in termodinamica

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**APPENDICE 1 - Equazioni di stato per i gas ideali, fluidi reali, e i liquidi incomprimibili**

**TABELLA RIASSUNTIVA**

<b>Gas ideale</b>	<b>Fluido reale monofase</b>	<b>Liquido incomprimibile</b>
$pV = n_M \mathcal{R}T$ $pV = MRT$ $pv = RT$	$T = f(p, v)$ $\frac{dv}{v} = \beta dT - \kappa dp$	$v = cost.$
$R = c_p - c_v$ , $k = \frac{c_p}{c_v}$ $c_p = \frac{Rk}{k-1} = f(T)$ $c_v = \frac{R}{k-1} = f(T)$	$\beta = \frac{1}{v} \left( \frac{\partial v}{\partial T} \right)_p$ $\kappa = -\frac{1}{v} \left( \frac{\partial v}{\partial p} \right)_T$ $c_p = \left( \frac{\partial h}{\partial T} \right)_p$	$c_p = c_v = c$
$du = c_v(T) dT$	$du = c_v(v, T) dT + B_u(T, v) dv$	$du = c(T) dT$
$dh = c_p(T) dT$	$dh = c_p(p, T) dT + B_h(T, p) dp$	$dh = c(T) dT + v dp$
$ds = c_v(T) \frac{dT}{T} + R \frac{dv}{v}$ $ds = c_p(T) \frac{dT}{T} - R \frac{dp}{p}$	$ds = \frac{c_v}{T} dT + \frac{B_u + p}{T} dv$ $ds = \frac{c_p}{T} dT + \frac{B_h - v}{T} dp$	$ds = c(T) \frac{dT}{T}$
$\beta = \frac{1}{T}$ $\kappa = \frac{1}{p}$ $B_u = B_h = 0$	$c_v = \left( \frac{\partial u}{\partial T} \right)_v = c_p - \frac{T\beta^2 v}{\kappa}$ $B_u = \left( \frac{\partial u}{\partial v} \right)_T = \frac{\beta T}{\kappa} - p$ $B_h = \left( \frac{\partial h}{\partial p} \right)_T = (1 - \beta T)v$	$\beta = \kappa = 0$ $B_u = 0$ $B_h = v$

Un fluido reale è completamente caratterizzato una volta noti i coefficienti  $c_p$ ,  $\beta$  e  $\kappa$ .  
 Un gas ideale è caratterizzato una volta noti due coefficienti a scelta tra  $c_p$ ,  $c_v$ ,  $k$  o  $R$ .  
 Un liquido incomprimibile è completamente caratterizzato dai valori di  $c$  e  $v$ .

**NOTA**

Le relazioni di Gibbs

$$du = T ds - p dv \quad , \quad dh = T ds + v dp$$

sono valide per qualunque fluido, purchè la trasformazione avvenga tra due stati di equilibrio.

**APPENDICE 2 - Trasformazioni reversibili per i gas ideali con calori specifici costanti: lavoro e calore scambiati**

(N.B.: le variazioni dei termini di energia cinetica e potenziale vengono considerate trascurabili)

**LAVORO DI DILATAZIONE REVERSIBILE (gas ideale)**

$$l_{12} = \int_1^2 p \, dv \quad , \quad r_v = v_2 / v_1, \quad r_p = p_2 / p_1$$

Trasformazione	$v_2$	$T_2$	$p_2$	$l_{12}$	$q_{12}$
ISOTERMA $T = cost$	$\frac{v_1}{r_p}$	$T_1$	$\frac{p_1}{r_v}$	$-RT \ln r_p =$ $= RT \ln r_v$	$q_{12} = l_{12}$
POLITROPICA $p v^n = cost$	$v_1 \left( \frac{T_1}{T_2} \right)^{\frac{1}{n-1}}$	$T_1 r_v^{1-n}$	$p_1 r_v^{-n}$	$\frac{p_1 v_1 - p_2 v_2}{n-1} =$ $= \frac{R}{n-1} (T_1 - T_2) =$ $= \frac{RT_1}{n-1} (1 - r_v^{1-n})$	$\left( c_v - \frac{R}{n-1} \right) (T_2 - T_1)$
ISOCORA $v = cost$	$v_1$	$T_1 r_p$	$p_1 \frac{T_2}{T_1}$	0	$c_v (T_2 - T_1)$

**LAVORO DI COMPRESSIONE/ESPANSIONE REVERSIBILE IN SISTEMI APERTI A REGIME (gas ideale)**

$$l'_{12} = - \int_1^2 v \, dp \quad , \quad r_v = v_2 / v_1, \quad r_p = p_2 / p_1$$

$$a = \frac{n-1}{n}$$

$$a = \frac{k-1}{k} = \frac{R}{c_p} \quad \text{per trasformazione adiabatica}$$

Trasformazione	$v_2$	$T_2$	$p_2$	$l_{12}$	$q_{12}$
ISOTERMA $T = cost$	$\frac{v_1}{r_p}$	$T_1$	$\frac{p_1}{r_v}$	$-RT \ln r_p =$ $= RT \ln r_v$	$q_{12} = l_{12}$
POLITROPICA $p v^n = cost$	$v_1 r_p^{-\frac{1}{n}}$	$T_1 r_p^a$	$p_1 \left( \frac{T_2}{T_1} \right)^{\frac{1}{a}}$	$\frac{n}{n-1} (p_1 v_1 - p_2 v_2) =$ $= \frac{Rn}{n-1} (T_1 - T_2) =$ $= - \frac{Rn}{n-1} T_1 (r_p^a - 1)$	$\left( c_p - \frac{Rn}{n-1} \right) (T_2 - T_1)$
ISOCORA $v = cost$	$v_1$	$T_1 r_p$	$p_1 \frac{T_2}{T_1}$	$v_1 (p_2 - p_1) =$ $= R (T_1 - T_2)$	$c_v (T_2 - T_1)$

**APPENDICE 3 – Proprietà termodinamiche dei fluidi.**

Le tabelle che seguono contengono le proprietà di alcuni fluidi, e precisamente: acqua, ammoniaca (R717), R134a e isobutano (R600a).

Le tabelle sono così organizzate: dapprima le proprietà del liquido e del vapore *in condizioni di saturazione* sono riportate in due tabelle, rispettivamente in funzione della temperatura e della pressione. Seguono poi le tabelle del fluido a pressione costante *al di fuori delle condizioni di saturazione*: le proprietà ( $v$ ,  $u$ ,  $h$  ed  $s$ ) sono espresse in funzione della temperatura, per il valore della pressione riportato in testa alla tabella. Ovviamente, il fluido si trova allo stato liquido per temperature inferiori a quella di saturazione ed allo stato di vapore surriscaldato o gas per temperature superiori a quest'ultima: la transizione risulta evidente da una brusca discontinuità nel valore delle proprietà stesse.

E' importante ricordare che *tutte le proprietà di stato sono definite a meno di una costante arbitraria*: non bisogna pertanto stupirsi se alcuni diagrammi o programmi di calcolo (es. CATT) forniscono valori diversi per alcuni dei fluidi considerati: le variazioni delle proprietà tra due stati rimangono però quasi identiche in tutti i casi. Inoltre i valori delle proprietà possono anche variare leggermente da un manuale ad un altro a seconda dei diversi modelli adottati.

**Acqua**  
**Proprietà del liquido e del vapore saturo in funzione della temperatura**

Temp.	Press.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
T [C]	$\rho$ [MPa]	$v_l$ [m³/kg]	$v_g$ [m³/kg]	$u_l$ [kJ/kg]	$u_g$ [kJ/kg]	$h_l$ [kJ/kg]	$h_g$ [kJ/kg]	$s_l$ [kJ/kg K]	$s_g$ [kJ/kg K]
0	0.001	1.000E-03	206.676	-0.04	2375.32	-0.04	2501.34	0.000	9.157
5	0.001	1.000E-03	147.401	20.97	2382.25	20.98	2510.55	0.076	9.027
10	0.001	1.000E-03	106.586	41.99	2389.16	41.99	2519.75	0.151	8.902
15	0.002	1.001E-03	78.084	62.98	2396.05	62.98	2528.92	0.224	8.782
20	0.002	1.002E-03	57.912	83.94	2402.92	83.94	2538.07	0.297	8.668
25	0.003	1.003E-03	43.454	104.86	2409.77	104.87	2547.18	0.367	8.559
30	0.004	1.004E-03	32.966	125.77	2416.59	125.77	2556.25	0.437	8.454
35	0.006	1.006E-03	25.273	146.66	2423.37	146.66	2565.29	0.505	8.354
40	0.007	1.008E-03	19.567	167.54	2430.12	167.54	2574.27	0.572	8.258
45	0.010	1.010E-03	15.292	188.42	2436.82	188.43	2583.20	0.639	8.166
50	0.012	1.012E-03	12.058	209.30	2443.48	209.31	2592.07	0.704	8.077
55	0.016	1.015E-03	9.588	230.19	2450.09	230.20	2600.87	0.768	7.992
60	0.020	1.017E-03	7.686	251.09	2456.64	251.11	2609.60	0.831	7.910
65	0.025	1.020E-03	6.208	272.00	2463.13	272.03	2618.26	0.893	7.832
70	0.031	1.023E-03	5.051	292.93	2469.56	292.96	2626.82	0.955	7.756
75	0.039	1.026E-03	4.138	313.88	2475.92	313.91	2635.30	1.015	7.683
80	0.047	1.029E-03	3.413	334.84	2482.21	334.89	2643.67	1.075	7.613
85	0.058	1.032E-03	2.832	355.82	2488.41	355.88	2651.95	1.134	7.545
90	0.070	1.036E-03	2.364	376.83	2494.54	376.90	2660.11	1.192	7.480
95	0.084	1.040E-03	1.984	397.86	2500.57	397.95	2668.15	1.250	7.416
100	0.101	1.044E-03	1.675	418.92	2506.52	419.02	2676.07	1.307	7.355
105	0.121	1.047E-03	1.421	440.01	2512.36	440.13	2683.85	1.363	7.296
110	0.143	1.052E-03	1.211	461.13	2518.11	461.28	2691.50	1.418	7.239
115	0.169	1.056E-03	1.038	482.29	2523.74	482.46	2698.99	1.473	7.184
120	0.198	1.060E-03	0.893	503.48	2529.26	503.69	2706.33	1.528	7.130
125	0.232	1.065E-03	0.771	524.72	2534.66	524.97	2713.50	1.581	7.078
130	0.270	1.070E-03	0.669	546.01	2539.93	546.30	2720.49	1.634	7.027
135	0.313	1.075E-03	0.583	567.34	2545.06	567.68	2727.29	1.687	6.978
140	0.361	1.080E-03	0.509	588.73	2550.05	589.12	2733.90	1.739	6.930
145	0.415	1.085E-03	0.447	610.17	2554.89	610.62	2740.30	1.791	6.884
150	0.475	1.090E-03	0.393	631.67	2559.57	632.19	2746.49	1.842	6.838
155	0.543	1.096E-03	0.347	653.23	2564.08	653.83	2752.44	1.892	6.794
160	0.617	1.102E-03	0.307	674.86	2568.42	675.54	2758.14	1.943	6.751
165	0.700	1.108E-03	0.273	696.55	2572.56	697.33	2763.59	1.992	6.708
170	0.791	1.114E-03	0.243	718.32	2576.51	719.20	2768.76	2.042	6.667
175	0.891	1.121E-03	0.217	740.16	2580.25	741.16	2773.65	2.091	6.626
180	1.001	1.127E-03	0.194	762.08	2583.76	763.21	2778.24	2.140	6.586
185	1.122	1.134E-03	0.174	784.09	2587.05	785.36	2782.51	2.188	6.547
190	1.253	1.141E-03	0.157	806.18	2590.08	807.61	2786.46	2.236	6.508
195	1.397	1.149E-03	0.141	828.36	2592.86	829.97	2790.05	2.283	6.470
200	1.552	1.156E-03	0.127	850.64	2595.38	852.44	2793.29	2.331	6.433
205	1.721	1.164E-03	0.115	873.03	2597.60	875.03	2796.14	2.378	6.396
210	1.905	1.173E-03	0.105	895.52	2599.54	897.75	2798.60	2.425	6.359
215	2.102	1.181E-03	0.095	918.13	2601.16	920.61	2800.64	2.471	6.323
220	2.316	1.190E-03	0.086	940.86	2602.45	943.62	2802.25	2.518	6.287
225	2.546	1.199E-03	0.079	963.72	2603.41	966.78	2803.41	2.564	6.251
230	2.793	1.209E-03	0.072	986.73	2604.01	990.10	2804.10	2.610	6.215
235	3.058	1.219E-03	0.065	1009.89	2604.23	1013.61	2804.29	2.656	6.180
240	3.342	1.229E-03	0.060	1033.20	2604.07	1037.31	2803.97	2.701	6.144
245	3.646	1.240E-03	0.055	1056.70	2603.51	1061.22	2803.12	2.747	6.109
250	3.970	1.251E-03	0.050	1080.38	2602.51	1085.35	2801.70	2.793	6.073
260	4.686	1.276E-03	0.042	1128.38	2599.16	1134.36	2797.08	2.884	6.002
270	5.496	1.302E-03	0.036	1177.35	2593.82	1184.50	2789.86	2.975	5.931
280	6.408	1.332E-03	0.030	1227.45	2586.27	1235.98	2779.75	3.067	5.858
290	7.433	1.366E-03	0.026	1278.90	2576.18	1289.05	2766.37	3.159	5.783
300	8.577	1.404E-03	0.022	1331.99	2563.15	1344.03	2749.19	3.253	5.705
310	9.853	1.447E-03	0.018	1387.05	2546.60	1401.31	2727.52	3.349	5.623
320	11.270	1.499E-03	0.015	1444.57	2525.70	1461.47	2700.36	3.448	5.537
330	12.842	1.561E-03	0.013	1505.27	2499.16	1525.31	2666.17	3.551	5.442
340	14.581	1.638E-03	0.011	1570.31	2464.90	1594.19	2622.47	3.659	5.336
350	16.506	1.740E-03	0.009	1641.90	2419.07	1670.62	2564.77	3.778	5.213
360	18.640	1.893E-03	0.007	1725.43	2352.98	1760.72	2482.85	3.915	5.056
370	21.017	2.217E-03	0.005	1844.87	2232.27	1891.47	2336.60	4.112	4.804

**Acqua**  
**Proprietà del liquido e del vapore saturo in funzione della pressione**

Press.	Temp.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
$p$ [MPa]	$T$ [C]	$v_l$ [m³/kg]	$v_g$ [m³/kg]	$u_l$ [kJ/kg]	$u_g$ [kJ/kg]	$h_l$ [kJ/kg]	$h_g$ [kJ/kg]	$s_l$ [kJ/kg K]	$s_g$ [kJ/kg K]
0.00061	0.01	1.000E-03	206.58	-0.02	2375.33	-0.01	2501.35	0.000	9.157
0.0007	1.92	1.000E-03	181.27	8.00	2377.98	8.01	2504.87	0.029	9.107
0.0008	3.80	1.000E-03	159.69	15.91	2380.58	15.91	2508.33	0.058	9.058
0.0010	7.01	1.000E-03	129.22	29.41	2385.02	29.41	2514.24	0.106	8.976
0.0015	13.06	1.001E-03	87.99	54.83	2393.37	54.83	2525.36	0.196	8.828
0.0020	17.53	1.001E-03	67.01	73.60	2399.54	73.61	2533.56	0.261	8.724
0.0025	21.12	1.002E-03	54.26	88.61	2404.45	88.62	2540.10	0.312	8.643
0.0030	24.12	1.003E-03	45.67	101.18	2408.57	101.18	2545.58	0.355	8.578
0.0035	26.71	1.003E-03	39.48	112.03	2412.11	112.03	2550.29	0.391	8.523
0.0040	29.00	1.004E-03	34.80	121.60	2415.23	121.60	2554.45	0.423	8.475
0.0050	32.92	1.005E-03	28.20	137.96	2420.55	137.96	2561.53	0.477	8.395
0.0075	40.34	1.008E-03	19.24	168.94	2430.57	168.94	2574.87	0.577	8.252
0.010	45.85	1.010E-03	14.68	191.98	2437.96	191.99	2584.72	0.650	8.150
0.015	54.02	1.014E-03	10.02	226.08	2448.80	226.10	2599.15	0.755	8.009
0.020	60.11	1.017E-03	7.650	251.54	2456.78	251.56	2609.79	0.832	7.909
0.030	69.15	1.022E-03	5.230	289.35	2468.47	289.38	2625.36	0.944	7.769
0.040	75.91	1.026E-03	3.994	317.68	2477.07	317.72	2636.83	1.026	7.670
0.050	81.37	1.030E-03	3.241	340.58	2483.91	340.63	2645.95	1.091	7.594
0.060	85.98	1.033E-03	2.732	359.93	2489.62	359.99	2653.55	1.146	7.532
0.070	89.98	1.036E-03	2.365	376.76	2494.52	376.83	2660.08	1.192	7.480
0.080	93.54	1.039E-03	2.087	391.71	2498.82	391.79	2665.81	1.233	7.435
0.090	96.74	1.041E-03	1.870	405.18	2502.65	405.28	2670.92	1.270	7.395
0.100	99.66	1.043E-03	1.694	417.48	2506.12	417.58	2675.53	1.303	7.360
0.150	111.40	1.053E-03	1.159	467.06	2519.70	467.22	2693.61	1.434	7.223
0.200	120.26	1.061E-03	0.886	504.61	2529.55	504.82	2706.71	1.530	7.127
0.300	133.58	1.073E-03	0.606	561.27	2543.62	561.59	2725.38	1.672	6.992
0.400	143.67	1.084E-03	0.463	604.45	2553.62	604.88	2738.62	1.777	6.896
0.500	151.89	1.093E-03	0.375	639.82	2561.30	640.37	2748.77	1.861	6.821
0.600	158.89	1.101E-03	0.316	670.05	2567.47	670.71	2756.90	1.932	6.760
0.700	165.01	1.108E-03	0.273	696.60	2572.57	697.38	2763.60	1.993	6.708
0.800	170.47	1.115E-03	0.240	720.39	2576.87	721.28	2769.24	2.047	6.663
0.900	175.42	1.121E-03	0.215	742.00	2580.55	743.01	2774.05	2.095	6.623
1.000	179.95	1.127E-03	0.194	761.86	2583.73	762.99	2778.20	2.139	6.587
1.200	188.03	1.139E-03	0.163	797.47	2588.92	798.84	2784.95	2.217	6.524
1.400	195.12	1.149E-03	0.141	828.88	2592.93	830.49	2790.13	2.285	6.469
1.600	201.45	1.159E-03	0.124	857.13	2596.05	858.98	2794.16	2.345	6.422
1.800	207.19	1.168E-03	0.110	882.88	2598.49	884.99	2797.27	2.399	6.380
2.000	212.46	1.177E-03	0.100	906.63	2600.37	908.99	2799.66	2.448	6.341
2.500	224.04	1.197E-03	0.080	959.31	2603.25	962.30	2803.22	2.555	6.258
3.000	233.94	1.217E-03	0.067	1004.97	2604.22	1008.62	2804.29	2.646	6.187
3.500	242.65	1.235E-03	0.057	1045.61	2603.83	1049.93	2803.59	2.726	6.126
4.000	250.44	1.252E-03	0.050	1082.49	2602.40	1087.50	2801.55	2.797	6.070
4.500	257.52	1.269E-03	0.044	1116.42	2600.17	1122.13	2798.46	2.861	6.020
5.000	264.03	1.286E-03	0.039	1147.98	2597.26	1154.41	2794.50	2.920	5.974
5.500	270.05	1.302E-03	0.036	1177.60	2593.79	1184.77	2789.82	2.975	5.930
6.000	275.67	1.319E-03	0.032	1205.61	2589.83	1213.52	2784.51	3.027	5.889
7.000	285.91	1.351E-03	0.027	1257.70	2580.63	1267.16	2772.26	3.121	5.814
8.000	295.09	1.384E-03	0.024	1305.72	2569.94	1316.79	2758.13	3.207	5.743
9.000	303.43	1.418E-03	0.020	1350.64	2557.91	1363.40	2742.30	3.286	5.677
10.000	311.09	1.453E-03	0.018	1393.17	2544.56	1407.69	2724.86	3.360	5.614
11.000	318.17	1.489E-03	0.016	1433.84	2529.90	1450.21	2705.80	3.430	5.553
12.000	324.77	1.527E-03	0.014	1473.08	2513.85	1491.40	2685.04	3.496	5.493
13.000	330.95	1.567E-03	0.013	1511.26	2496.27	1531.63	2662.46	3.561	5.433
14.000	336.77	1.611E-03	0.011	1548.72	2476.99	1571.28	2637.84	3.623	5.372
15.000	342.26	1.658E-03	0.010	1585.82	2455.73	1610.70	2610.87	3.685	5.310
16.000	347.47	1.711E-03	0.009	1622.94	2432.11	1650.32	2581.11	3.746	5.246
17.000	352.41	1.771E-03	0.008	1660.58	2405.54	1690.68	2547.88	3.808	5.179
18.000	357.11	1.841E-03	0.008	1699.43	2375.13	1732.56	2510.15	3.872	5.106
19.000	361.59	1.926E-03	0.007	1740.66	2339.31	1777.26	2466.08	3.940	5.025
20.000	365.86	2.039E-03	0.006	1786.59	2294.93	1827.37	2412.02	4.016	4.930
21.000	369.93	2.213E-03	0.005	1843.67	2233.62	1890.14	2338.21	4.110	4.807
22.000	373.80	2.766E-03	0.004	1966.01	2094.87	2026.85	2174.63	4.318	4.547

**Acqua: Liquido compresso e vapore surriscaldato.**

H2O	$p = 0.01$	[MPa]	Tsat =	45.9 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	-0.03	0.000
25	1.003E-03	104.86	104.87	0.367
50	1.487E+01	2443.88	2592.57	8.175
75	1.603E+01	2479.62	2639.96	8.316
100	1.720E+01	2515.51	2687.46	8.448
120	1.812E+01	2544.35	2725.58	8.547
150	1.951E+01	2587.87	2782.99	8.688
170	2.044E+01	2617.09	2821.47	8.777
200	2.183E+01	2661.28	2879.53	8.904
250	2.414E+01	2735.96	2977.32	9.100
300	2.645E+01	2812.07	3076.52	9.281
350	2.875E+01	2889.69	3177.23	9.450
400	3.106E+01	2968.90	3279.52	9.608
450	3.337E+01	3049.75	3383.45	9.757
500	3.568E+01	3132.27	3489.06	9.898
550	3.799E+01	3216.50	3596.37	10.032
600	4.029E+01	3302.46	3705.41	10.161
650	4.260E+01	3390.17	3816.20	10.284
700	4.491E+01	3479.64	3928.75	10.403
800	4.953E+01	3663.86	4159.12	10.628

H2O	$p = 0.05$	[MPa]	Tsat =	81.4 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	0.01	0.000
25	1.003E-03	104.86	104.91	0.367
50	1.012E-03	209.29	209.34	0.704
75	1.026E-03	313.87	313.92	1.015
100	3.418E+00	2511.61	2682.53	7.695
120	3.608E+00	2541.24	2721.62	7.797
150	3.889E+00	2585.62	2780.08	7.940
170	4.076E+00	2615.24	2819.06	8.030
200	4.356E+00	2659.85	2877.65	8.158
250	4.820E+00	2734.98	2976.00	8.356
300	5.284E+00	2811.33	3075.53	8.537
350	5.747E+00	2889.12	3176.46	8.706
400	6.209E+00	2968.44	3278.90	8.864
450	6.672E+00	3049.37	3382.94	9.013
500	7.134E+00	3131.95	3488.63	9.155
550	7.596E+00	3216.23	3596.01	9.289
600	8.057E+00	3302.23	3705.11	9.418
650	8.519E+00	3389.98	3815.94	9.541
700	8.981E+00	3479.47	3928.52	9.660
800	9.904E+00	3663.72	4158.95	9.885

H2O	$p = 0.1$	[MPa]	Tsat =	99.7 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	0.06	0.000
25	1.003E-03	104.86	104.96	0.367
50	1.012E-03	209.29	209.39	0.704
75	1.026E-03	313.86	313.96	1.015
100	1.696E+00	2506.64	2676.22	7.361
120	1.793E+00	2537.29	2716.58	7.467
150	1.936E+00	2582.75	2776.39	7.613
170	2.031E+00	2612.89	2816.00	7.705
200	2.172E+00	2658.05	2875.28	7.834
250	2.406E+00	2733.74	2974.34	8.033
300	2.639E+00	2810.41	3074.29	8.216
350	2.871E+00	2888.40	3175.49	8.385
400	3.103E+00	2967.86	3278.12	8.543
450	3.334E+00	3048.89	3382.30	8.693
500	3.565E+00	3131.55	3488.10	8.834
550	3.797E+00	3215.90	3595.57	8.969
600	4.028E+00	3301.95	3704.73	9.098
650	4.259E+00	3389.73	3815.62	9.221
700	4.490E+00	3479.26	3928.24	9.340
800	4.952E+00	3663.55	4158.73	9.565

H2O	$p = 0.2$	[MPa]	Tsat =	120.3 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	0.16	0.000
25	1.003E-03	104.85	105.05	0.367
50	1.012E-03	209.27	209.47	0.704
75	1.026E-03	313.84	314.05	1.015
100	1.043E-03	418.89	419.10	1.307
120	1.060E-03	503.48	503.69	1.528
150	9.596E-01	2576.88	2768.81	7.279
170	1.008E+00	2608.09	2809.75	7.374
200	1.080E+00	2654.40	2870.47	7.507
250	1.199E+00	2731.23	2970.99	7.709
300	1.316E+00	2808.56	3071.80	7.893
350	1.433E+00	2886.96	3173.54	8.063
400	1.549E+00	2966.70	3276.56	8.222
450	1.665E+00	3047.94	3381.02	8.371
500	1.781E+00	3130.76	3487.04	8.513
550	1.897E+00	3215.23	3594.67	8.648
600	2.013E+00	3301.38	3703.97	8.777
650	2.129E+00	3389.24	3814.97	8.901
700	2.244E+00	3478.83	3927.68	9.019
800	2.475E+00	3663.21	4158.29	9.245

H2O	$p = 0.3$	[MPa]	Tsat =	133.6 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	0.26	0.000
25	1.003E-03	104.84	105.14	0.367
50	1.012E-03	209.25	209.56	0.704
75	1.026E-03	313.82	314.13	1.015
100	1.043E-03	418.86	419.17	1.307
120	1.060E-03	503.45	503.76	1.527
150	6.339E-01	2570.80	2760.96	7.078
170	6.673E-01	2603.14	2803.32	7.176
200	7.163E-01	2650.66	2865.55	7.312
250	7.964E-01	2728.69	2967.60	7.517
300	8.753E-01	2806.70	3069.28	7.702
350	9.536E-01	2885.51	3171.59	7.873
400	1.032E+00	2965.54	3274.99	8.033
450	1.109E+00	3046.98	3379.74	8.183
500	1.187E+00	3129.96	3485.97	8.325
550	1.264E+00	3214.55	3593.78	8.460
600	1.341E+00	3300.80	3703.21	8.589
650	1.419E+00	3388.74	3814.32	8.713
700	1.496E+00	3478.40	3927.12	8.832
800	1.650E+00	3662.87	4157.86	9.058

H2O	$p = 0.4$	[MPa]	Tsat =	143.7 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	0.36	0.000
25	1.003E-03	104.83	105.24	0.367
50	1.012E-03	209.24	209.64	0.704
75	1.026E-03	313.80	314.21	1.015
100	1.043E-03	418.83	419.25	1.307
120	1.060E-03	503.41	503.83	1.527
150	4.708E-01	2564.49	2752.82	6.930
170	4.966E-01	2598.05	2796.70	7.031
200	5.342E-01	2646.83	2860.52	7.171
250	5.951E-01	2726.12	2964.17	7.379
300	6.548E-01	2804.82	3066.75	7.566
350	7.139E-01	2884.06	3169.63	7.738
400	7.726E-01	2964.37	3273.42	7.898
450	8.311E-01	3046.02	3378.45	8.049
500	8.893E-01	3129.17	3484.90	8.191
550	9.475E-01	3213.88	3592.88	8.327
600	1.006E+00	3300.23	3702.45	8.456
650	1.064E+00	3388.25	3813.66	8.580
700	1.121E+00	3477.96	3926.55	8.699
800	1.237E+00	3662.53	4157.42	8.924

H2O	$p = 0.5$	[MPa]	Tsat =	151.9 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	1.000E-03	-0.04	0.46	0.000
25	1.003E-03	104.83	105.33	0.367
50	1.012E-03	209.22	209.73	0.703
75	1.026E-03	313.77	314.29	1.015
100	1.043E-03	418.80	419.32	1.306
120	1.060E-03	503.38	503.91	1.527
150	1.090E-03	631.66	632.20	1.842
170	3.942E-01	2592.79	2789.87	6.916
200	4.249E-01	2642.92	2855.38	7.059
250	4.744E-01	2723.51	2960.69	7.271
300	5.226E-01	2802.92	3064.20	7.460
350	5.701E-01	2882.60	3167.65	7.633
400	6.173E-01	2963.20	3271.84	7.794
450	6.642E-01	3045.06	3377.16	7.945
500	7.109E-01	3128.37	3483.83	8.087
550	7.575E-01	3213.21	3591.98	8.223
600	8.041E-01	3299.66	3701.69	8.352
650	8.505E-01	3387.75	3813.01	8.476
700	8.969E-01	3477.53	3925.99	8.595
800	9.896E-01	3662.19	4156.98	8.821

H2O	$p = 0.8$	[MPa]	Tsat =	170.5 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.998E-04	-0.03	0.77	0.000
25	1.003E-03	104.80	105.61	0.367
50	1.012E-03	209.18	209.99	0.703
75	1.026E-03	313.71	314.53	1.015
100	1.043E-03	418.71	419.55	1.306
120	1.060E-03	503.27	504.12	1.527
150	1.090E-03	631.51	632.39	1.841
170	1.114E-03	718.31	719.21	2.042
200	2.608E-01	2630.62	2839.26	6.816
250	2.931E-01	2715.47	2949.98	7.038
300	3.241E-01	2797.15	3056.44	7.233
350	3.544E-01	2878.17	3161.69	7.409
400	3.843E-01	2959.67	3267.08	7.572
450	4.139E-01	3042.17	3373.28	7.724
500	4.433E-01	3125.96	3480.61	7.867
550	4.726E-01	3211.18	3589.28	8.003
600	5.018E-01	3297.93	3699.40	8.133
650	5.310E-01	3386.27	3811.05	8.258
700	5.601E-01	3476.24	3924.29	8.377
800	6.181E-01	3661.17	4155.67	8.603

H2O	$p = 1.2$	[MPa]	Tsat =	188.0 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.996E-04	-0.02	1.17	0.000
25	1.002E-03	104.77	105.98	0.367
50	1.012E-03	209.12	210.33	0.703
75	1.025E-03	313.62	314.85	1.015
100	1.043E-03	418.60	419.85	1.306
120	1.060E-03	503.13	504.40	1.527
150	1.090E-03	631.33	632.63	1.841
170	1.114E-03	718.09	719.42	2.041
200	1.693E-01	2612.75	2815.91	6.590
250	1.923E-01	2704.21	2935.02	6.829
300	2.138E-01	2789.23	3045.81	7.032
350	2.345E-01	2872.17	3153.60	7.212
400	2.548E-01	2954.91	3260.67	7.377
450	2.748E-01	3038.29	3368.06	7.531
500	2.946E-01	3122.73	3476.29	7.676
550	3.143E-01	3208.46	3585.66	7.813
600	3.339E-01	3295.61	3696.33	7.943
650	3.535E-01	3384.27	3808.43	8.068
700	3.729E-01	3474.50	3922.02	8.188
800	4.118E-01	3659.80	4153.92	8.415

H2O	$p = 0.6$	[MPa]	Tsat =	158.9 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.999E-04	-0.03	0.57	0.000
25	1.003E-03	104.82	105.42	0.367
50	1.012E-03	209.21	209.82	0.703
75	1.026E-03	313.75	314.37	1.015
100	1.043E-03	418.77	419.40	1.306
120	1.060E-03	503.34	503.98	1.527
150	1.090E-03	631.61	632.26	1.842
170	3.258E-01	2587.37	2782.83	6.819
200	3.520E-01	2638.92	2850.13	6.966
250	3.938E-01	2720.87	2957.17	7.182
300	4.344E-01	2801.01	3061.64	7.372
350	4.742E-01	2881.13	3165.67	7.546
400	5.137E-01	2962.03	3270.26	7.708
450	5.529E-01	3044.10	3375.87	7.859
500	5.920E-01	3127.57	3482.76	8.002
550	6.309E-01	3212.53	3591.08	8.138
600	6.697E-01	3299.08	3700.93	8.267
650	7.085E-01	3387.26	3812.36	8.391
700	7.472E-01	3477.10	3925.42	8.511
800	8.245E-01	3661.85	4156.55	8.737

H2O	$p = 1.0$	[MPa]	Tsat =	180.0 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.997E-04	-0.03	0.97	0.000
25	1.002E-03	104.79	105.79	0.367
50	1.012E-03	209.15	210.16	0.703
75	1.025E-03	313.67	314.69	1.015
100	1.043E-03	418.66	419.70	1.306
120	1.060E-03	503.20	504.26	1.527
150	1.090E-03	631.42	632.51	1.841
170	1.114E-03	718.20	719.31	2.042
200	2.060E-01	2621.91	2827.86	6.694
250	2.327E-01	2709.92	2942.60	6.925
300	2.579E-01	2793.22	3051.16	7.123
350	2.825E-01	2875.19	3157.66	7.301
400	3.066E-01	2957.30	3263.89	7.465
450	3.304E-01	3040.24	3370.67	7.618
500	3.541E-01	3124.35	3478.46	7.762
550	3.776E-01	3209.82	3587.47	7.899
600	4.011E-01	3296.77	3697.87	8.029
650	4.245E-01	3385.27	3809.74	8.154
700	4.478E-01	3475.37	3923.16	8.273
800	4.943E-01	3660.48	4154.80	8.500

H2O	$p = 1.4$	[MPa]	Tsat =	195.1 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.995E-04	-0.02	1.38	0.000
25	1.002E-03	104.76	106.16	0.367
50	1.012E-03	209.09	210.51	0.703
75	1.025E-03	313.58	315.01	1.015
100	1.043E-03	418.54	420.00	1.306
120	1.060E-03	503.06	504.54	1.526
150	1.090E-03	631.23	632.76	1.841
170	1.114E-03	717.97	719.53	2.041
200	1.430E-01	2603.09	2803.33	6.498
250	1.635E-01	2698.32	2927.23	6.747
300	1.823E-01	2785.17	3040.36	6.953
350	2.003E-01	2869.13	3149.50	7.136
400	2.178E-01	2952.51	3257.44	7.303
450	2.351E-01	3036.34	3365.43	7.457
500	2.521E-01	3121.11	3474.12	7.603
550	2.691E-01	3207.10	3583.84	7.740
600	2.860E-01	3294.45	3694.79	7.871
650	3.027E-01	3383.27	3807.11	7.996
700	3.195E-01	3473.63	3920.89	8.116
800	3.528E-01	3659.11	4153.05	8.343



H2O	$p = 1.6$	[MPa]	Tsat =	201.5 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.994E-04	-0.02	1.58	0.000
25	1.002E-03	104.74	106.35	0.367
50	1.011E-03	209.06	210.68	0.703
75	1.025E-03	313.53	315.17	1.014
100	1.043E-03	418.48	420.15	1.306
120	1.060E-03	502.98	504.68	1.526
150	1.090E-03	631.14	632.88	1.840
170	1.114E-03	717.86	719.64	2.041
200	1.156E-03	850.61	852.46	2.331
250	1.418E-01	2692.27	2919.21	6.673
300	1.586E-01	2781.04	3034.83	6.884
350	1.746E-01	2866.06	3145.36	7.069
400	1.901E-01	2950.10	3254.18	7.237
450	2.053E-01	3034.38	3362.80	7.393
500	2.203E-01	3119.48	3471.94	7.539
550	2.352E-01	3205.73	3582.02	7.677
600	2.500E-01	3293.29	3693.25	7.808
650	2.647E-01	3382.27	3805.79	7.933
700	2.794E-01	3472.76	3919.75	8.054
800	3.086E-01	3658.42	4152.17	8.281

H2O	$p = 1.8$	[MPa]	Tsat =	207.2 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.993E-04	-0.02	1.78	0.000
25	1.002E-03	104.73	106.53	0.367
50	1.011E-03	209.03	210.85	0.703
75	1.025E-03	313.49	315.34	1.014
100	1.043E-03	418.42	420.30	1.305
120	1.059E-03	502.91	504.82	1.526
150	1.090E-03	631.04	633.00	1.840
170	1.113E-03	717.75	719.75	2.041
200	1.156E-03	850.46	852.54	2.330
250	1.250E-01	2686.03	2910.97	6.607
300	1.402E-01	2776.84	3029.22	6.823
350	1.546E-01	2862.96	3141.19	7.010
400	1.685E-01	2947.67	3250.91	7.179
450	1.821E-01	3032.41	3360.15	7.336
500	1.955E-01	3117.85	3469.76	7.482
550	2.088E-01	3204.36	3580.19	7.621
600	2.220E-01	3292.12	3691.70	7.752
650	2.351E-01	3381.27	3804.47	7.878
700	2.482E-01	3471.89	3918.61	7.998
800	2.742E-01	3657.74	4151.29	8.226

H2O	$p = 2.0$	[MPa]	Tsat =	212.5 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.992E-04	-0.01	1.99	0.000
25	1.002E-03	104.71	106.72	0.367
50	1.011E-03	209.00	211.02	0.703
75	1.025E-03	313.45	315.50	1.014
100	1.043E-03	418.37	420.45	1.305
120	1.059E-03	502.84	504.96	1.526
150	1.089E-03	630.95	633.13	1.840
170	1.113E-03	717.63	719.86	2.040
200	1.156E-03	850.31	852.62	2.330
250	1.114E-01	2679.59	2902.47	6.545
300	1.255E-01	2772.57	3023.51	6.766
350	1.386E-01	2859.82	3136.97	6.956
400	1.512E-01	2945.22	3247.61	7.127
450	1.635E-01	3030.43	3357.49	7.284
500	1.757E-01	3116.21	3467.56	7.432
550	1.877E-01	3202.98	3578.35	7.571
600	1.996E-01	3290.95	3690.15	7.702
650	2.114E-01	3380.26	3803.15	7.828
700	2.232E-01	3471.01	3917.47	7.949
800	2.467E-01	3657.05	4150.42	8.177

H2O	$p = 2.5$	[MPa]	Tsat =	224.0 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.990E-04	-0.01	2.49	0.000
25	1.002E-03	104.67	107.18	0.367
50	1.011E-03	208.92	211.45	0.703
75	1.025E-03	313.34	315.90	1.014
100	1.042E-03	418.22	420.83	1.305
120	1.059E-03	502.67	505.31	1.525
150	1.089E-03	630.72	633.44	1.839
170	1.113E-03	717.35	720.14	2.040
200	1.156E-03	849.94	852.82	2.329
250	8.700E-02	2662.56	2880.07	6.408
300	9.890E-02	2761.57	3008.82	6.644
350	1.098E-01	2851.85	3126.25	6.840
400	1.201E-01	2939.04	3239.29	7.015
450	1.301E-01	3025.44	3350.79	7.175
500	1.400E-01	3112.09	3462.05	7.323
550	1.497E-01	3199.52	3573.75	7.463
600	1.593E-01	3288.01	3686.26	7.596
650	1.688E-01	3377.74	3799.83	7.722
700	1.783E-01	3468.82	3914.61	7.844
800	1.972E-01	3655.33	4148.22	8.072

H2O	$p = 3.0$	[MPa]	Tsat =	234.0 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.987E-04	0.00	3.00	0.000
25	1.002E-03	104.64	107.64	0.367
50	1.011E-03	208.85	211.88	0.702
75	1.025E-03	313.23	316.30	1.014
100	1.042E-03	418.08	421.20	1.305
120	1.059E-03	502.49	505.67	1.525
150	1.089E-03	630.48	633.75	1.839
170	1.113E-03	717.07	720.41	2.039
200	1.155E-03	849.56	853.03	2.329
250	7.058E-02	2644.01	2855.76	6.287
300	8.114E-02	2750.05	2993.49	6.539
350	9.053E-02	2843.67	3115.26	6.743
400	9.936E-02	2932.76	3230.84	6.921
450	1.079E-01	3020.40	3344.01	7.083
500	1.162E-01	3107.93	3456.49	7.234
550	1.244E-01	3196.03	3569.11	7.375
600	1.324E-01	3285.05	3682.35	7.508
650	1.404E-01	3375.20	3796.49	7.636
700	1.484E-01	3466.61	3911.74	7.757
800	1.641E-01	3653.60	4146.02	7.986

H2O	$p = 3.5$	[MPa]	Tsat =	242.7 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.985E-04	0.01	3.50	0.000
25	1.001E-03	104.60	108.10	0.366
50	1.011E-03	208.77	212.31	0.702
75	1.024E-03	313.12	316.71	1.013
100	1.042E-03	417.94	421.58	1.304
120	1.058E-03	502.31	506.02	1.525
150	1.088E-03	630.25	634.06	1.838
170	1.112E-03	716.79	720.68	2.038
200	1.154E-03	849.19	853.23	2.328
250	5.873E-02	2623.66	2829.20	6.175
300	6.842E-02	2738.00	2977.47	6.446
350	7.678E-02	2835.28	3104.00	6.658
400	8.453E-02	2926.38	3222.25	6.840
450	9.196E-02	3015.30	3337.16	7.005
500	9.918E-02	3103.74	3450.88	7.157
550	1.063E-01	3192.52	3564.44	7.299
600	1.132E-01	3282.07	3678.42	7.434
650	1.201E-01	3372.64	3793.14	7.562
700	1.270E-01	3464.40	3908.85	7.684
800	1.406E-01	3651.87	4143.82	7.914

H2O	$p = 4.0$	[MPa]	Tsat =	250.4 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.982E-04	0.02	4.01	0.000
25	1.001E-03	104.56	108.56	0.366
50	1.010E-03	208.70	212.74	0.702
75	1.024E-03	313.01	317.11	1.013
100	1.042E-03	417.79	421.96	1.304
120	1.058E-03	502.14	506.37	1.524
150	1.088E-03	630.02	634.37	1.838
170	1.112E-03	716.51	720.96	2.038
200	1.154E-03	848.82	853.44	2.327
250	1.251E-03	1080.35	1085.35	2.793
300	5.884E-02	2725.34	2960.69	6.361
350	6.645E-02	2826.66	3092.44	6.582
400	7.341E-02	2919.89	3213.53	6.769
450	8.003E-02	3010.14	3330.24	6.936
500	8.643E-02	3099.51	3445.23	7.090
550	9.269E-02	3188.99	3559.74	7.234
600	9.885E-02	3279.08	3674.46	7.369
650	1.049E-01	3370.08	3789.78	7.497
700	1.109E-01	3462.17	3905.96	7.620
800	1.229E-01	3650.13	4141.62	7.850

H2O	$p = 5.0$	[MPa]	Tsat =	264.0 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.977E-04	0.03	5.02	0.000
25	1.001E-03	104.48	109.49	0.366
50	1.010E-03	208.55	213.60	0.701
75	1.024E-03	312.80	317.92	1.012
100	1.041E-03	417.51	422.71	1.303
120	1.058E-03	501.79	507.08	1.523
150	1.087E-03	629.55	634.99	1.837
170	1.111E-03	715.96	721.51	2.037
200	1.153E-03	848.09	853.85	2.325
250	1.249E-03	1079.08	1085.33	2.790
300	4.532E-02	2697.95	2924.54	6.208
350	5.194E-02	2808.68	3068.40	6.449
400	5.781E-02	2906.59	3195.66	6.646
450	6.330E-02	2999.65	3316.16	6.819
500	6.857E-02	3090.94	3433.78	6.976
550	7.368E-02	3181.84	3550.25	7.122
600	7.869E-02	3273.03	3666.48	7.259
650	8.362E-02	3364.90	3783.00	7.389
700	8.849E-02	3457.69	3900.15	7.512
800	9.811E-02	3646.65	4137.20	7.744

H2O	$p = 7.0$	[MPa]	Tsat =	285.9 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.967E-04	0.06	7.03	0.000
25	9.998E-04	104.33	111.33	0.366
50	1.009E-03	208.26	215.32	0.700
75	1.023E-03	312.37	319.53	1.011
100	1.040E-03	416.94	424.22	1.301
120	1.057E-03	501.10	508.49	1.521
150	1.086E-03	628.63	636.24	1.835
170	1.109E-03	714.86	722.62	2.034
200	1.151E-03	846.64	854.69	2.322
250	1.246E-03	1076.61	1085.33	2.785
300	2.947E-02	2632.15	2838.41	5.930
350	3.524E-02	2769.36	3016.03	6.228
400	3.993E-02	2878.57	3158.08	6.448
450	4.416E-02	2977.93	3287.06	6.633
500	4.814E-02	3073.35	3410.31	6.797
550	5.195E-02	3167.23	3530.89	6.949
600	5.565E-02	3260.71	3650.28	7.089
650	5.927E-02	3354.39	3769.28	7.222
700	6.283E-02	3448.62	3888.41	7.348
800	6.981E-02	3639.64	4128.32	7.582

H2O	$p = 4.5$	[MPa]	Tsat =	257.5 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.980E-04	0.02	4.51	0.000
25	1.001E-03	104.52	109.03	0.366
50	1.010E-03	208.63	213.17	0.702
75	1.024E-03	312.91	317.51	1.013
100	1.041E-03	417.65	422.33	1.303
120	1.058E-03	501.96	506.73	1.524
150	1.088E-03	629.78	634.68	1.837
170	1.111E-03	716.23	721.24	2.037
200	1.153E-03	848.46	853.65	2.326
250	1.250E-03	1079.71	1085.34	2.791
300	5.135E-02	2712.01	2943.08	6.283
350	5.840E-02	2817.80	3080.58	6.513
400	6.475E-02	2913.30	3204.66	6.705
450	7.074E-02	3004.93	3323.24	6.875
500	7.651E-02	3095.24	3439.53	7.030
550	8.213E-02	3185.42	3555.01	7.175
600	8.765E-02	3276.06	3670.48	7.311
650	9.309E-02	3367.49	3786.40	7.440
700	9.847E-02	3459.94	3903.06	7.563
800	1.091E-01	3648.39	4139.41	7.794

H2O	$p = 6.0$	[MPa]	Tsat =	275.7 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.972E-04	0.04	6.03	0.000
25	1.000E-03	104.41	110.41	0.366
50	1.009E-03	208.40	214.46	0.701
75	1.023E-03	312.58	318.72	1.012
100	1.041E-03	417.22	423.47	1.302
120	1.057E-03	501.44	507.79	1.522
150	1.087E-03	629.09	635.61	1.836
170	1.110E-03	715.41	722.07	2.035
200	1.152E-03	847.36	854.27	2.324
250	1.248E-03	1077.84	1085.32	2.788
300	3.616E-02	2667.23	2884.21	6.067
350	4.223E-02	2789.63	3042.99	6.333
400	4.739E-02	2892.83	3177.19	6.541
450	5.214E-02	2988.92	3301.77	6.719
500	5.665E-02	3082.22	3422.14	6.880
550	6.101E-02	3174.59	3540.63	7.029
600	6.525E-02	3266.91	3658.42	7.168
650	6.942E-02	3359.67	3776.17	7.299
700	7.352E-02	3453.17	3894.30	7.423
800	8.160E-02	3643.15	4132.77	7.657

H2O	$p = 8.0$	[MPa]	Tsat =	285.1 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.962E-04	0.07	8.04	0.000
25	9.993E-04	104.26	112.25	0.365
50	1.009E-03	208.11	216.18	0.700
75	1.022E-03	312.16	320.34	1.010
100	1.040E-03	416.66	424.97	1.301
120	1.056E-03	500.75	509.20	1.521
150	1.085E-03	628.18	636.86	1.833
170	1.109E-03	714.31	723.18	2.033
200	1.150E-03	845.92	855.12	2.321
250	1.244E-03	1075.40	1085.35	2.783
300	2.426E-02	2590.94	2785.00	5.791
350	2.995E-02	2747.69	2987.32	6.130
400	3.432E-02	2863.77	3138.30	6.363
450	3.817E-02	2966.68	3272.01	6.555
500	4.175E-02	3064.32	3398.29	6.724
550	4.516E-02	3159.78	3521.03	6.878
600	4.845E-02	3254.45	3642.05	7.021
650	5.166E-02	3349.06	3762.34	7.155
700	5.481E-02	3444.03	3882.49	7.281
800	6.097E-02	3636.11	4123.87	7.517

H2O	$p = 10.0$	[MPa]	Tsat =	311.1 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.952E-04	0.09	10.05	0.000
25	9.984E-04	104.11	114.09	0.365
50	1.008E-03	207.82	217.89	0.699
75	1.021E-03	311.74	321.95	1.009
100	1.039E-03	416.10	426.48	1.299
120	1.055E-03	500.07	510.62	1.519
150	1.084E-03	627.28	638.12	1.831
170	1.107E-03	713.23	724.30	2.030
200	1.148E-03	844.50	855.98	2.318
250	1.240E-03	1073.01	1085.42	2.778
300	1.397E-03	1328.35	1342.32	3.247
350	2.242E-02	2699.17	2923.40	5.944
400	2.641E-02	2832.40	3096.48	6.212
450	2.975E-02	2943.34	3240.85	6.419
500	3.279E-02	3045.79	3373.65	6.597
550	3.564E-02	3144.56	3500.94	6.756
600	3.837E-02	3241.71	3625.36	6.903
650	4.101E-02	3338.24	3748.30	7.040
700	4.358E-02	3434.75	3870.54	7.169
800	4.859E-02	3629.00	4114.94	7.408

H2O	$p = 12.5$	[MPa]	Tsat =	327.9 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.940E-04	0.12	12.55	0.000
25	9.973E-04	103.92	116.39	0.364
50	1.007E-03	207.45	220.04	0.698
75	1.020E-03	311.21	323.97	1.008
100	1.037E-03	415.41	428.37	1.297
120	1.054E-03	499.23	512.39	1.517
150	1.083E-03	626.16	639.69	1.829
170	1.105E-03	711.90	725.71	2.027
200	1.146E-03	842.76	857.08	2.314
250	1.236E-03	1070.11	1085.56	2.773
300	1.387E-03	1322.28	1339.62	3.236
350	1.613E-02	2624.59	2826.17	5.712
400	2.000E-02	2789.27	3039.32	6.042
450	2.299E-02	2912.46	3199.80	6.272
500	2.560E-02	3021.70	3341.74	6.462
550	2.801E-02	3124.97	3475.15	6.629
600	3.029E-02	3225.40	3604.07	6.781
650	3.248E-02	3324.46	3730.46	6.922
700	3.460E-02	3422.96	3855.43	7.054
800	3.869E-02	3620.05	4103.72	7.297

H2O	$p = 1.50$	[MPa]	Tsat =	342.3 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.928E-04	0.15	15.04	0.000
25	9.963E-04	103.73	118.68	0.363
50	1.006E-03	207.09	222.18	0.697
75	1.019E-03	310.70	325.98	1.006
100	1.036E-03	414.72	430.26	1.295
120	1.052E-03	498.39	514.17	1.514
150	1.081E-03	625.06	641.28	1.826
170	1.103E-03	710.58	727.14	2.024
200	1.143E-03	841.04	858.19	2.310
250	1.232E-03	1067.29	1085.77	2.767
300	1.377E-03	1316.59	1337.24	3.226
350	1.147E-02	2520.38	2692.44	5.442
400	1.565E-02	2740.72	2975.46	5.881
450	1.845E-02	2879.50	3156.18	6.140
500	2.080E-02	2996.55	3308.55	6.344
550	2.293E-02	3104.73	3448.63	6.520
600	2.491E-02	3208.67	3582.33	6.678
650	2.680E-02	3310.40	3712.34	6.822
700	2.861E-02	3410.97	3840.15	6.957
800	3.210E-02	3611.03	4092.46	7.204

H2O	$p = 17.5$	[MPa]	Tsat =	354.8 °C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.916E-04	0.18	17.53	0.000
25	9.952E-04	103.55	120.96	0.363
50	1.005E-03	206.74	224.32	0.696
75	1.018E-03	310.18	328.00	1.005
100	1.035E-03	414.05	432.16	1.294
120	1.051E-03	497.57	515.96	1.512
150	1.079E-03	623.98	642.86	1.823
170	1.102E-03	709.29	728.57	2.021
200	1.141E-03	839.36	859.32	2.307
250	1.228E-03	1064.55	1086.04	2.762
300	1.368E-03	1311.21	1335.15	3.216
350	1.714E-03	1632.04	1662.03	3.761
400	1.245E-02	2685.01	2902.84	5.721
450	1.517E-02	2844.17	3109.71	6.018
500	1.736E-02	2970.28	3274.05	6.238
550	1.929E-02	3083.87	3421.40	6.423
600	2.106E-02	3191.54	3560.16	6.587
650	2.274E-02	3296.07	3693.96	6.736
700	2.434E-02	3398.82	3824.70	6.874
800	2.738E-02	3601.93	4081.16	7.125

H2O	$p = 20.0$	[MPa]	Tsat =	365.9 C
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.904E-04	0.20	20.00	0.000
25	9.941E-04	103.36	123.24	0.362
50	1.003E-03	206.38	226.45	0.694
75	1.017E-03	309.68	330.01	1.003
100	1.034E-03	413.38	434.05	1.292
120	1.050E-03	496.75	517.74	1.510
150	1.078E-03	622.90	644.46	1.821
170	1.100E-03	708.01	730.01	2.018
200	1.139E-03	837.70	860.48	2.303
250	1.224E-03	1061.87	1086.36	2.757
300	1.360E-03	1306.11	1333.30	3.207
350	1.664E-03	1612.29	1645.57	3.728
400	9.942E-03	2619.25	2818.10	5.554
450	1.270E-02	2806.18	3060.09	5.902
500	1.477E-02	2942.84	3238.21	6.140
550	1.656E-02	3062.37	3393.48	6.335
600	1.818E-02	3174.04	3537.59	6.505
650	1.969E-02	3281.49	3675.35	6.658
700	2.113E-02	3386.50	3809.12	6.799
800	2.385E-02	3592.78	4069.83	7.054

H2O	$p = 25.0$	[MPa]		
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
0	9.880E-04	0.23	24.93	0.000
25	9.920E-04	102.99	127.79	0.361
50	1.001E-03	205.68	230.72	0.692
75	1.015E-03	308.68	334.05	1.000
100	1.031E-03	412.06	437.84	1.288
120	1.047E-03	495.15	521.32	1.506
150	1.075E-03	620.80	647.67	1.816
170	1.096E-03	705.51	732.93	2.012
200	1.134E-03	834.47	862.83	2.296
250	1.217E-03	1056.73	1087.16	2.747
300	1.344E-03	1296.61	1330.21	3.190
350	1.598E-03	1583.56	1623.51	3.680
400	6.004E-03	2430.08	2580.19	5.142
450	9.162E-03	2720.68	2949.73	5.674
500	1.112E-02	2884.33	3162.41	5.959
550	1.272E-02	3017.54	3335.65	6.176
600	1.414E-02	3137.95	3491.39	6.360
650	1.543E-02	3251.67	3637.49	6.523
700	1.665E-02	3361.43	3777.59	6.671
800	1.891E-02	3574.30	4047.11	6.935

H2O	$p = 30.0$	[MPa]			
$T$	$v$	$u$	$h$	$s$	
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]	
0	9.856E-04	0.25	29.82	0.000	
25	9.899E-04	102.62	132.32	0.359	
50	9.994E-04	205.00	234.98	0.690	
75	1.013E-03	307.70	338.08	0.997	
100	1.029E-03	410.77	441.64	1.284	
120	1.044E-03	493.58	524.91	1.502	
150	1.072E-03	618.75	650.90	1.811	
170	1.093E-03	703.08	735.87	2.007	
200	1.130E-03	831.34	865.25	2.289	
250	1.210E-03	1051.82	1088.13	2.737	
300	1.330E-03	1287.90	1327.81	3.174	
350	1.552E-03	1561.87	1608.42	3.643	
400	2.790E-03	2067.38	2151.08	4.473	
450	6.735E-03	2619.33	2821.38	5.442	
500	8.679E-03	2820.71	3081.06	5.790	
550	1.017E-02	2970.35	3275.39	6.034	
600	1.145E-02	3100.57	3443.94	6.233	
650	1.260E-02	3221.08	3598.96	6.406	
700	1.366E-02	3335.88	3745.71	6.561	
800	1.562E-02	3555.65	4024.34	6.833	

H2O	$p = 35.0$	[MPa]			
$T$	$v$	$u$	$h$	$s$	
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]	
0	9.833E-04	0.26	34.68	0.000	
25	9.879E-04	102.26	136.83	0.358	
50	9.973E-04	204.32	239.23	0.688	
75	1.010E-03	306.74	342.10	0.994	
100	1.027E-03	409.50	445.44	1.281	
120	1.042E-03	492.05	528.52	1.498	
150	1.069E-03	616.75	654.16	1.806	
170	1.090E-03	700.71	738.86	2.001	
200	1.126E-03	828.31	867.73	2.283	
250	1.204E-03	1047.14	1089.27	2.727	
300	1.318E-03	1279.84	1325.96	3.159	
350	1.516E-03	1544.04	1597.12	3.612	
400	2.100E-03	1914.05	1987.55	4.212	
450	4.962E-03	2498.74	2672.40	5.196	
500	6.927E-03	2751.91	2994.37	5.628	
550	8.345E-03	2920.98	3213.04	5.903	
600	9.527E-03	3062.07	3395.52	6.118	
650	1.057E-02	3189.84	3559.94	6.301	
700	1.153E-02	3309.93	3713.58	6.463	
800	1.328E-02	3536.86	4001.58	6.745	

H2O	$p = 40.0$	[MPa]			
$T$	$v$	$u$	$h$	$s$	
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]	
0	9.811E-04	0.25	39.50	0.000	
25	9.858E-04	101.90	141.33	0.356	
50	9.953E-04	203.66	243.47	0.685	
75	1.008E-03	305.79	346.13	0.991	
100	1.024E-03	408.27	449.25	1.277	
120	1.040E-03	490.54	532.13	1.494	
150	1.066E-03	614.79	657.43	1.801	
170	1.087E-03	698.40	741.87	1.996	
200	1.122E-03	825.37	870.26	2.276	
250	1.198E-03	1042.65	1090.55	2.718	
300	1.306E-03	1272.33	1324.58	3.145	
350	1.487E-03	1528.75	1588.24	3.586	
400	1.908E-03	1854.54	1930.85	4.113	
450	3.693E-03	2365.11	2512.83	4.946	
500	5.622E-03	2678.40	2903.30	5.470	
550	6.984E-03	2869.73	3149.09	5.778	
600	8.094E-03	3022.65	3346.42	6.011	
650	9.063E-03	3158.08	3520.62	6.205	
700	9.941E-03	3283.68	3681.33	6.375	
800	1.152E-02	3517.94	3978.85	6.666	

H2O	$p = 50.0$	[MPa]			
$T$	$v$	$u$	$h$	$s$	
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]	
0	9.766E-04	0.20	49.03	-0.001	
25	9.819E-04	101.18	150.27	0.353	
50	9.914E-04	202.36	251.94	0.681	
75	1.004E-03	303.96	354.18	0.985	
100	1.020E-03	405.86	456.87	1.270	
120	1.035E-03	487.63	539.38	1.486	
150	1.061E-03	611.01	664.04	1.791	
170	1.080E-03	693.95	747.98	1.985	
200	1.115E-03	819.73	875.46	2.263	
250	1.186E-03	1034.19	1093.50	2.701	
300	1.286E-03	1258.67	1322.96	3.120	
350	1.441E-03	1503.19	1575.24	3.542	
400	1.731E-03	1788.06	1874.61	4.003	
450	2.486E-03	2159.64	2283.95	4.588	
500	3.892E-03	2525.49	2720.12	5.173	
550	5.118E-03	2763.66	3019.56	5.549	
600	6.112E-03	2942.02	3247.64	5.818	
650	6.966E-03	3093.60	3441.89	6.034	
700	7.727E-03	3230.59	3616.95	6.219	
800	9.076E-03	3479.88	3933.67	6.529	

H2O	$p = 60.0$	[MPa]			
$T$	$v$	$u$	$h$	$s$	
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]	
0	9.723E-04	0.10	58.44	-0.003	
25	9.780E-04	100.47	159.15	0.350	
50	9.876E-04	201.11	260.37	0.676	
75	1.000E-03	302.19	362.22	0.980	
100	1.016E-03	403.55	464.50	1.263	
120	1.030E-03	484.84	546.66	1.478	
150	1.055E-03	607.39	670.71	1.782	
170	1.075E-03	689.70	754.18	1.975	
200	1.108E-03	814.39	880.85	2.251	
250	1.176E-03	1026.35	1096.89	2.685	
300	1.268E-03	1246.47	1322.55	3.097	
350	1.405E-03	1482.12	1566.41	3.505	
400	1.633E-03	1745.36	1843.37	3.932	
450	2.085E-03	2053.89	2178.99	4.412	
500	2.956E-03	2390.58	2567.93	4.932	
550	3.957E-03	2658.81	2896.21	5.344	
600	4.835E-03	2861.19	3151.26	5.645	
650	5.595E-03	3028.88	3364.60	5.883	
700	6.272E-03	3177.30	3553.61	6.082	
800	7.459E-03	3441.66	3889.18	6.411	

H2O	$p = 70.0$	[MPa]			
$T$	$v$	$u$	$h$	$s$	
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]	
0	9.682E-04	-0.05	67.72	-0.004	
25	9.742E-04	99.78	167.98	0.347	
50	9.839E-04	199.90	268.77	0.672	
75	9.965E-04	300.49	370.24	0.974	
100	1.012E-03	401.32	472.15	1.257	
120	1.026E-03	482.15	553.96	1.470	
150	1.050E-03	603.92	677.44	1.773	
170	1.069E-03	685.64	760.48	1.965	
200	1.101E-03	809.32	886.38	2.240	
250	1.166E-03	1019.02	1100.64	2.670	
300	1.252E-03	1235.44	1323.09	3.076	
350	1.375E-03	1464.12	1560.37	3.473	
400	1.566E-03	1713.14	1822.79	3.877	
450	1.893E-03	1990.15	2122.66	4.307	
500	2.466E-03	2290.58	2463.19	4.762	
550	3.227E-03	2563.90	2789.80	5.172	
600	3.976E-03	2783.45	3061.76	5.493	
650	4.650E-03	2965.40	3290.90	5.748	
700	5.256E-03	3124.59	3492.48	5.961	
800	6.318E-03	3403.51	3845.78	6.307	



**R717 – Ammoniaca**

**Proprietà del liquido e del vapore saturo in funzione della temperatura**

Temp.	Press.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
$T$ [C]	$p$ [MPa]	$v_l$ [m³/kg]	$v_g$ [m³/kg]	$u_l$ [kJ/kg]	$u_g$ [kJ/kg]	$h_l$ [kJ/kg]	$h_g$ [kJ/kg]	$s_l$ [kJ/kg K]	$s_g$ [kJ/kg K]
-75.00	0.00751	0.00137	12.82	-180.7	1201	-180.7	1297	-0.8265	6.634
-70.00	0.01094	0.00138	9.008	-159.6	1208	-159.6	1307	-0.7211	6.497
-65.00	0.01562	0.00139	6.452	-138.3	1215	-138.3	1316	-0.6175	6.369
-60.00	0.02189	0.00140	4.706	-116.9	1222	-116.8	1325	-0.5157	6.248
-55.00	0.03014	0.00141	3.490	-95.27	1229	-95.23	1334	-0.4157	6.135
-50.00	0.04084	0.00142	2.628	-73.55	1235	-73.49	1342	-0.3172	6.028
-45.00	0.05449	0.00144	2.007	-51.69	1241	-51.61	1351	-0.2203	5.927
-40.00	0.07169	0.00145	1.553	-29.70	1248	-29.59	1359	-0.1250	5.831
-35.00	0.09310	0.00146	1.217	-7.580	1254	-7.443	1367	-0.0311	5.740
-30.00	0.1194	0.00148	0.9640	14.66	1259	14.84	1375	0.06134	5.653
-25.00	0.1515	0.00149	0.7717	37.02	1265	37.25	1382	0.1524	5.571
-20.00	0.1901	0.00150	0.6237	59.50	1270	59.79	1389	0.2421	5.492
-15.00	0.2362	0.00152	0.5087	82.09	1275	82.45	1396	0.3304	5.417
-10.00	0.2907	0.00153	0.4183	104.8	1280	105.2	1402	0.4176	5.345
-5.000	0.3548	0.00155	0.3466	127.6	1285	128.2	1408	0.5035	5.276
0.0	0.4294	0.00157	0.2893	150.6	1289	151.2	1413	0.5883	5.209
5.000	0.5157	0.00158	0.2430	173.6	1293	174.4	1419	0.6720	5.145
10.00	0.6150	0.00160	0.2054	196.8	1297	197.8	1423	0.7547	5.083
15.00	0.7285	0.00162	0.1746	220.1	1300	221.3	1428	0.8364	5.023
20.00	0.8575	0.00164	0.1492	243.6	1303	245.0	1431	0.9172	4.964
25.00	1.003	0.00166	0.1281	267.2	1306	268.9	1435	0.9972	4.907
30.00	1.167	0.00168	0.1105	291.0	1308	293.0	1437	1.076	4.851
35.00	1.351	0.00170	0.09563	315.0	1310	317.3	1440	1.155	4.797
40.00	1.555	0.00173	0.08310	339.2	1312	341.9	1441	1.233	4.743
45.00	1.783	0.00175	0.07245	363.6	1313	366.7	1442	1.310	4.690
50.00	2.034	0.00178	0.06335	388.2	1313	391.9	1442	1.387	4.638
55.00	2.311	0.00180	0.05554	413.2	1313	417.3	1442	1.464	4.586
60.00	2.616	0.00183	0.04880	438.4	1313	443.2	1441	1.541	4.534
65.00	2.949	0.00187	0.04296	464.0	1312	469.5	1438	1.617	4.482
70.00	3.313	0.00190	0.03787	490.0	1310	496.3	1435	1.694	4.430
75.00	3.710	0.00194	0.03342	516.4	1307	523.6	1431	1.771	4.377
80.00	4.142	0.00198	0.02951	543.4	1303	551.6	1426	1.848	4.323
85.00	4.610	0.00202	0.02606	571.0	1299	580.3	1419	1.926	4.267
90.00	5.117	0.00207	0.02300	599.2	1293	609.8	1410	2.005	4.210
95.00	5.664	0.00213	0.02027	628.4	1285	640.4	1400	2.086	4.149
100.0	6.255	0.00219	0.01782	658.5	1276	672.2	1388	2.168	4.086
105.0	6.892	0.00226	0.01561	690.0	1265	705.6	1373	2.253	4.017
110.0	7.578	0.00235	0.01360	723.1	1251	740.9	1354	2.342	3.943
115.0	8.317	0.00246	0.01174	758.5	1234	779.0	1331	2.436	3.858
120.0	9.112	0.00259	0.00999	797.5	1210	821.2	1301	2.539	3.760
125.0	9.970	0.00279	0.00828	843.1	1178	870.9	1260	2.658	3.637
130.0	10.90	0.00320	0.00638	908.4	1121	943.3	1191	2.832	3.445

**R717 – Ammoniac**  
**Proprietà del liquido e del vapore saturo in funzione della pressione**

Press.	Temp.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
$p$ [MPa]	$T$ [C]	$v_l$ [m³/kg]	$v_g$ [m³/kg]	$u_l$ [kJ/kg]	$u_g$ [kJ/kg]	$h_l$ [kJ/kg]	$h_g$ [kJ/kg]	$s_l$ [kJ/kg K]	$s_g$ [kJ/kg K]
0.030	-55.08	0.00141	3.505	-95.61	1229	-95.57	1334	-0.4172	6.137
0.040	-50.35	0.00142	2.679	-75.07	1235	-75.01	1342	-0.324	6.035
0.050	-46.52	0.00143	2.175	-58.34	1240	-58.27	1348	-0.2496	5.957
0.060	-43.27	0.00144	1.834	-44.11	1244	-44.02	1354	-0.1872	5.893
0.070	-40.45	0.00145	1.588	-31.66	1247	-31.56	1358	-0.1334	5.839
0.080	-37.93	0.00145	1.402	-20.56	1250	-20.44	1362	-0.08595	5.793
0.090	-35.66	0.00146	1.256	-10.51	1253	-10.38	1366	-0.04343	5.752
0.100	-33.59	0.00147	1.138	-1.312	1255	-1.166	1369	-0.00486	5.715
0.110	-31.68	0.00147	1.041	7.188	1258	7.35	1372	0.03049	5.682
0.120	-29.9	0.00148	0.9597	15.1	1260	15.28	1375	0.06314	5.652
0.130	-28.24	0.00148	0.8904	22.51	1261	22.7	1377	0.0935	5.624
0.140	-26.68	0.00148	0.8307	29.49	1263	29.69	1379	0.1219	5.598
0.150	-25.21	0.00149	0.7788	36.08	1265	36.3	1382	0.1486	5.574
0.160	-23.81	0.00149	0.7331	42.34	1266	42.58	1384	0.1738	5.552
0.170	-22.49	0.0015	0.6926	48.31	1268	48.56	1385	0.1976	5.531
0.180	-21.22	0.0015	0.6564	54	1269	54.27	1387	0.2203	5.511
0.190	-20.01	0.0015	0.624	59.46	1270	59.74	1389	0.2419	5.493
0.200	-18.85	0.00151	0.5946	64.7	1272	65	1390	0.2625	5.475
0.225	-16.13	0.00151	0.5324	76.95	1274	77.3	1394	0.3105	5.434
0.250	-13.65	0.00152	0.4822	88.2	1277	88.58	1397	0.3541	5.398
0.275	-11.36	0.00153	0.4408	98.62	1279	99.04	1400	0.394	5.364
0.300	-9.224	0.00154	0.4061	108.3	1281	108.8	1403	0.431	5.334
0.325	-7.226	0.00154	0.3765	117.4	1283	117.9	1405	0.4654	5.306
0.350	-5.346	0.00155	0.3511	126	1285	126.6	1408	0.4976	5.281
0.375	-3.568	0.00155	0.3289	134.2	1286	134.8	1410	0.5279	5.257
0.400	-1.881	0.00156	0.3094	141.9	1288	142.5	1411	0.5565	5.234
0.500	4.14	0.00158	0.2503	169.6	1293	170.4	1418	0.6577	5.156
0.600	9.285	0.0016	0.2104	193.5	1296	194.4	1423	0.7429	5.092
0.700	13.8	0.00161	0.1815	214.5	1300	215.7	1427	0.8169	5.037
0.800	17.85	0.00163	0.1596	233.5	1302	234.8	1430	0.8825	4.989
0.900	21.52	0.00164	0.1424	250.8	1304	252.3	1432	0.9416	4.947
1.000	24.9	0.00166	0.1285	266.7	1306	268.4	1435	0.9955	4.908
1.200	30.94	0.00168	0.1075	295.5	1309	297.5	1438	1.091	4.841
1.400	36.25	0.00171	0.0923	321	1311	323.4	1440	1.174	4.783
1.600	41.02	0.00173	0.08078	344.2	1312	346.9	1441	1.249	4.732
1.800	45.36	0.00175	0.07174	365.4	1313	368.5	1442	1.316	4.687
2.000	49.35	0.00177	0.06445	385	1313	388.6	1442	1.377	4.645
2.200	53.05	0.00179	0.05844	403.4	1314	407.4	1442	1.434	4.606
2.400	56.51	0.00181	0.0534	420.7	1313	425.1	1442	1.487	4.57
2.600	59.75	0.00183	0.04911	437.2	1313	441.9	1441	1.537	4.537
2.800	62.82	0.00185	0.0454	452.8	1312	458	1439	1.584	4.505
3.000	65.72	0.00187	0.04217	467.7	1311	473.3	1438	1.628	4.475
3.500	72.4	0.00192	0.03566	502.6	1308	509.3	1433	1.731	4.404
4.000	78.4	0.00196	0.03071	534.7	1305	542.6	1427	1.823	4.34
4.500	83.86	0.00201	0.02681	564.6	1300	573.7	1420	1.908	4.28
5.000	88.88	0.00206	0.02365	592.9	1294	603.2	1412	1.987	4.223
5.500	93.54	0.00211	0.02103	619.8	1288	631.4	1403	2.062	4.167
6.000	97.89	0.00216	0.01882	645.6	1280	658.6	1393	2.133	4.113
6.500	102	0.00222	0.01693	670.7	1272	685.1	1382	2.201	4.06
7.000	105.8	0.00228	0.01527	695.2	1263	711.2	1370	2.267	4.006
7.500	109.4	0.00234	0.01381	719.4	1253	736.9	1357	2.332	3.951
8.000	112.9	0.00241	0.0125	743.3	1242	762.6	1342	2.395	3.895
8.500	116.2	0.00249	0.01132	767.4	1229	788.5	1325	2.459	3.837
9.000	119.3	0.00257	0.01023	791.9	1214	815	1306	2.524	3.775
9.500	122.3	0.00268	0.00921	817.4	1197	842.8	1284	2.591	3.708
10.000	125.2	0.0028	0.00823	844.8	1176	872.8	1259	2.663	3.632
10.500	127.9	0.00298	0.00724	876.2	1150	907.5	1226	2.746	3.541

**R717 – Ammoniaca: Liquido compresso e vapore surriscaldato.**

R717	p =	0.06	[MPa]	
T	v	u	h	s
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.56	-73.47	-0.3172
-40.00	1.863	1249	1361	5.924
-30.00	1.949	1266	1383	6.016
-20.00	2.034	1282	1404	6.103
-10.00	2.119	1299	1426	6.186
0.0	2.203	1315	1447	6.266
10.00	2.286	1331	1468	6.342
20.00	2.369	1348	1490	6.416
30.00	2.452	1364	1511	6.488
40.00	2.535	1380	1532	6.557
50.00	2.618	1397	1554	6.625
60.00	2.700	1414	1576	6.691
70.00	2.782	1430	1597	6.755
80.00	2.864	1447	1619	6.818
90.00	2.946	1465	1641	6.880
100.0	3.028	1482	1664	6.940
110.0	3.110	1499	1686	6.999
120.0	3.192	1517	1708	7.057
140.0	3.356	1553	1754	7.170
150.0	3.437	1571	1777	7.226
160.0	3.519	1589	1801	7.280
170.0	3.601	1608	1824	7.334
180.0	3.682	1627	1848	7.387
190.0	3.764	1646	1872	7.439
200.0	3.846	1665	1896	7.490

R717	p =	0.08	[MPa]	
T	v	u	h	s
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.57	-73.46	-0.3173
-40.00	0.00145	-29.7	-29.59	-0.125
-30.00	1.454	1264	1380	5.867
-20.00	1.519	1281	1402	5.956
-10.00	1.583	1297	1424	6.04
0.0	1.647	1314	1445	6.12
10.00	1.71	1330	1467	6.198
20.00	1.773	1347	1488	6.272
30.00	1.836	1363	1510	6.344
40.00	1.898	1380	1531	6.414
50.00	1.96	1396	1553	6.482
60.00	2.022	1413	1575	6.548
70.00	2.084	1430	1597	6.613
80.00	2.146	1447	1619	6.676
90.00	2.208	1464	1641	6.738
100.0	2.269	1481	1663	6.798
110.0	2.331	1499	1685	6.858
120.0	2.392	1517	1708	6.916
140.0	2.515	1552	1754	7.029
150.0	2.577	1571	1777	7.084
160.0	2.638	1589	1800	7.139
170.0	2.699	1608	1824	7.193
180.0	2.761	1627	1847	7.246
190.0	2.822	1646	1871	7.298
200.0	2.883	1665	1895	7.349

R717	p =	0.1	[MPa]	
T	v	u	h	s
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.58	-73.44	-0.3173
-40.00	0.00145	-29.72	-29.57	-0.125
-30.00	1.157	1262	1377	5.749
-20.00	1.21	1279	1400	5.84
-10.00	1.262	1296	1422	5.925
0.0	1.314	1312	1444	6.007
10.00	1.365	1329	1465	6.085
20.00	1.415	1346	1487	6.16
30.00	1.466	1362	1509	6.233
40.00	1.516	1379	1530	6.303
50.00	1.566	1396	1552	6.371
60.00	1.616	1412	1574	6.438
70.00	1.665	1429	1596	6.502
80.00	1.715	1446	1618	6.566
90.00	1.764	1464	1640	6.628
100.0	1.814	1481	1662	6.688
110.0	1.863	1498	1685	6.748
120.0	1.912	1516	1707	6.806
140.0	2.011	1552	1753	6.919
150.0	2.06	1570	1776	6.975
160.0	2.109	1589	1800	7.029
170.0	2.158	1607	1823	7.083
180.0	2.208	1626	1847	7.136
190.0	2.257	1645	1871	7.188
200.0	2.306	1665	1895	7.24

R717	p =	0.2	[MPa]	
T	v	u	h	s
[C]	[m³/kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.63	-73.35	-0.3176
-40.00	0.00145	-29.77	-29.48	-0.1253
-30.00	0.00148	14.61	14.9	0.06112
-20.00	0.0015	59.49	59.79	0.242
-10.00	0.6193	1288	1412	5.557
0.0	0.6465	1306	1435	5.644
10.00	0.6732	1323	1458	5.726
20.00	0.6995	1341	1481	5.805
30.00	0.7255	1358	1503	5.88
40.00	0.7512	1375	1525	5.952
50.00	0.7768	1392	1547	6.022
60.00	0.8022	1409	1570	6.09
70.00	0.8275	1427	1592	6.156
80.00	0.8527	1444	1614	6.22
90.00	0.8778	1461	1637	6.283
100.0	0.9028	1479	1659	6.344
110.0	0.9278	1496	1682	6.404
120.0	0.9527	1514	1705	6.463
140.0	1.002	1550	1751	6.577
150.0	1.027	1569	1774	6.633
160.0	1.052	1587	1798	6.688
170.0	1.077	1606	1821	6.742
180.0	1.101	1625	1845	6.795
190.0	1.126	1644	1869	6.847
200.0	1.151	1663	1894	6.899



R717	$p =$	0.4	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.74	-73.17	-0.3181
-40.00	0.00145	-29.89	-29.31	-0.1258
-30.00	0.00147	14.48	15.07	0.06057
-20.00	0.0015	59.34	59.95	0.2414
-10.00	0.00153	104.7	105.3	0.4172
0.0	0.3122	1291	1416	5.252
10.00	0.327	1311	1442	5.345
20.00	0.3412	1330	1467	5.43
30.00	0.3551	1349	1491	5.511
40.00	0.3688	1367	1515	5.588
50.00	0.3822	1385	1538	5.662
60.00	0.3955	1403	1561	5.732
70.00	0.4086	1421	1584	5.801
80.00	0.4216	1439	1607	5.867
90.00	0.4345	1456	1630	5.931
100.0	0.4473	1474	1653	5.994
110.0	0.4601	1492	1676	6.055
120.0	0.4728	1511	1700	6.115
140.0	0.4981	1547	1746	6.231
150.0	0.5107	1566	1770	6.287
160.0	0.5232	1584	1794	6.343
170.0	0.5358	1603	1818	6.397
180.0	0.5483	1622	1842	6.451
190.0	0.5607	1642	1866	6.504
200.0	0.5732	1661	1890	6.556

R717	$p =$	0.6	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.85	-72.99	-0.3185
-40.00	0.00145	-30.01	-29.14	-0.1263
-30.00	0.00147	14.34	15.23	0.06003
-20.00	0.0015	59.2	60.1	0.2409
-10.00	0.00153	104.5	105.5	0.4166
0.0	0.00157	150.4	151.3	0.5877
10.00	0.2111	1298	1425	5.099
20.00	0.2215	1319	1452	5.194
30.00	0.2315	1339	1478	5.281
40.00	0.2411	1359	1503	5.363
50.00	0.2505	1378	1528	5.441
60.00	0.2598	1396	1552	5.515
70.00	0.2689	1415	1576	5.585
80.00	0.2778	1433	1600	5.654
90.00	0.2867	1452	1624	5.72
100.0	0.2955	1470	1647	5.784
110.0	0.3042	1488	1671	5.846
120.0	0.3128	1507	1694	5.907
140.0	0.33	1544	1742	6.025
150.0	0.3385	1563	1766	6.082
160.0	0.347	1582	1790	6.138
170.0	0.3555	1601	1814	6.193
180.0	0.3639	1620	1838	6.247
190.0	0.3723	1639	1863	6.3
200.0	0.3807	1659	1887	6.353

R717	$p =$	0.8	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-73.95	-72.81	-0.319
-40.00	0.00145	-30.13	-28.97	-0.1268
-30.00	0.00147	14.21	15.39	0.05948
-20.00	0.0015	59.05	60.25	0.2403
-10.00	0.00153	104.4	105.6	0.416
0.0	0.00157	150.2	151.5	0.587
10.00	0.0016	196.6	197.9	0.754
20.00	0.1614	1307	1436	5.011
30.00	0.1694	1329	1465	5.107
40.00	0.1772	1350	1492	5.194
50.00	0.1846	1370	1518	5.276
60.00	0.1919	1390	1543	5.353
70.00	0.1989	1409	1568	5.427
80.00	0.2059	1428	1593	5.498
90.00	0.2127	1447	1617	5.565
100.0	0.2195	1465	1641	5.631
110.0	0.2262	1484	1665	5.695
120.0	0.2328	1503	1689	5.757
140.0	0.2459	1541	1737	5.876
150.0	0.2524	1560	1761	5.934
160.0	0.2589	1579	1786	5.991
170.0	0.2653	1598	1810	6.046
180.0	0.2717	1617	1835	6.101
190.0	0.2781	1637	1859	6.155
200.0	0.2844	1656	1884	6.208

R717	$p =$	1	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-74.06	-72.64	-0.3195
-40.00	0.00145	-30.25	-28.8	-0.1273
-30.00	0.00147	14.08	15.55	0.05894
-20.00	0.0015	58.9	60.41	0.2397
-10.00	0.00153	104.2	105.7	0.4154
0.0	0.00157	150	151.6	0.5864
10.00	0.0016	196.4	198	0.7533
20.00	0.00164	243.4	245.1	0.9166
30.00	0.132	1318	1450	4.96
40.00	0.1387	1341	1479	5.055
50.00	0.145	1362	1507	5.142
60.00	0.151	1383	1534	5.223
70.00	0.1569	1403	1560	5.3
80.00	0.1627	1422	1585	5.372
90.00	0.1683	1442	1610	5.442
100.0	0.1739	1461	1635	5.51
110.0	0.1794	1480	1659	5.575
120.0	0.1848	1499	1684	5.638
130.0	0.1901	1518	1708	5.699
140.0	0.1955	1537	1733	5.759
150.0	0.2007	1556	1757	5.818
160.0	0.206	1576	1782	5.875
170.0	0.2112	1595	1806	5.931
180.0	0.2164	1615	1831	5.986
190.0	0.2215	1634	1856	6.04
200.0	0.2267	1654	1881	6.094

R717	$p =$	2	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-74.59	-71.74	-0.3218
-40.00	0.00145	-30.84	-27.94	-0.1299
-30.00	0.00147	13.42	16.37	0.05623
-20.00	0.0015	58.17	61.17	0.2368
-10.00	0.00153	103.4	106.5	0.4122
0.0	0.00156	149.1	152.2	0.583
10.00	0.0016	195.4	198.6	0.7496
20.00	0.00164	242.3	245.6	0.9126
30.00	0.00168	289.9	293.3	1.073
40.00	0.00172	338.5	342	1.231
50.00	0.00177	384.8	384.8	1.376
60.00	0.00183	435.5	435.5	1.532
70.00	0.0019	488.2	488.2	1.688
80.00	0.002	542.2	542.2	1.844
90.00	0.0021	597.2	597.2	2.001
100.0	0.0022	653.2	653.2	2.158
110.0	0.0023	710.2	710.2	2.315
120.0	0.0024	768.2	768.2	2.472
130.0	0.0025	827.2	827.2	2.629
140.0	0.0026	887.2	887.2	2.786
150.0	0.0027	948.2	948.2	2.943
160.0	0.0028	1010.2	1010.2	3.100
170.0	0.0029	1073.2	1073.2	3.257
180.0	0.003	1137.2	1137.2	3.414
190.0	0.0031	1202.2	1202.2	3.571
200.0	0.0032	1268.2	1268.2	3.728

R717	$p =$	4	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-75.63	-69.95	-0.3265
-40.00	0.00145	-32	-26.22	-0.1349
-30.00	0.00147	12.12	18.01	0.05086
-20.00	0.0015	56.72	62.72	0.2311
-10.00	0.00153	101.8	107.9	0.4061
0.0	0.00156	147.3	153.6	0.5764
10.00	0.00159	193.4	199.7	0.7424
20.00	0.00163	240	246.5	0.9048
30.00	0.00167	287.3	294	1.064
40.00	0.00172	335.5	342.4	1.221
50.00	0.00177	384.8	391.8	1.376
60.00	0.00183	435.5	442.8	1.532
70.00	0.0019	488.2	495.8	1.688
80.00	0.002	542.2	548.8	1.844
90.00	0.0021	597.2	605.8	2.001
100.0	0.0022	653.2	663.3	2.158
110.0	0.0023	710.2	721.3	2.315
120.0	0.0024	768.2	779.8	2.472
130.0	0.0025	827.2	838.8	2.629
140.0	0.0026	887.2	898.3	2.786
150.0	0.0027	948.2	958.3	2.943
160.0	0.0028	1010.2	1018.8	3.100
170.0	0.0029	1073.2	1079.8	3.257
180.0	0.003	1137.2	1141.3	3.414
190.0	0.0031	1202.2	1203.3	3.571
200.0	0.0032	1268.2	1265.8	3.728

R717	$p =$	6	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-76.66	-68.14	-0.3312
-40.00	0.00144	-33.15	-24.49	-0.1399
-30.00	0.00147	10.84	19.66	0.04555
-20.00	0.0015	55.3	64.28	0.2254
-10.00	0.00153	100.2	109.4	0.4
0.0	0.00156	145.5	154.9	0.5698
10.00	0.00159	191.4	200.9	0.7353
20.00	0.00163	237.8	247.5	0.8971
30.00	0.00167	284.8	294.8	1.056
40.00	0.00171	332.6	342.8	1.212
50.00	0.00176	381.4	391.9	1.366
60.00	0.00182	431.5	442.3	1.519
70.00	0.00188	483.3	494.6	1.674
80.00	0.00196	537.6	549.3	1.831
90.00	0.00206	595.6	607.9	1.995
100.0	0.00218	657.2	668.4	2.166
110.0	0.0023	722.6	731.9	2.343
120.0	0.0024	791.8	800.2	2.526
130.0	0.0025	864.8	867.6	2.714
140.0	0.0026	941.6	944.1	2.907
150.0	0.0027	1022.2	1029.3	3.105
160.0	0.0028	1106.6	1115.8	3.308
170.0	0.0029	1194.8	1206.8	3.516
180.0	0.003	1286.8	1302.3	3.729
190.0	0.0031	1382.6	1402.3	3.947
200.0	0.0032	1482.2	1506.8	4.17

R717	$p =$	8	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00142	-77.68	-66.34	-0.3358
-40.00	0.00144	-34.29	-22.76	-0.1448
-30.00	0.00147	9.579	21.31	0.04029
-20.00	0.00149	53.89	65.84	0.2198
-10.00	0.00152	98.64	110.8	0.394
0.0	0.00155	143.8	156.2	0.5634
10.00	0.00159	189.4	202.1	0.7284
20.00	0.00162	235.6	248.6	0.8895
30.00	0.00166	282.3	295.6	1.047
40.00	0.0017	329.7	343.4	1.202
50.00	0.00175	378.1	392.1	1.356
60.00	0.00181	427.6	442.1	1.508
70.00	0.00187	478.6	493.6	1.66
80.00	0.00194	531.8	547.3	1.814
90.00	0.00203	587.9	604.2	1.973
100.0	0.00215	648.9	666.1	2.141
110.0	0.0023	719.3	737.9	2.311
120.0	0.0024	793.2	807.2	2.486
130.0	0.0025	870.6	883.1	2.667
140.0	0.0026	951.6	964.6	2.854
150.0	0.0027	1036.2	1051.8	3.047
160.0	0.0028	1124.4	1144.8	3.246
170.0	0.0029	1216.2	1243.8	3.451
180.0	0.003	1311.6	1348.8	3.662
190.0	0.0031	1410.6	1460.8	3.879
200.0	0.0032	1513.2	1579.8	4.102

**R134a –  
Proprietà del liquido e del vapore saturo in funzione della temperatura**

Temp.	Press.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
T [C]	p [MPa]	$v_f$ [m³/kg]	$v_g$ [m³/kg]	$u_f$ [kJ/kg]	$u_g$ [kJ/kg]	$h_f$ [kJ/kg]	$h_g$ [kJ/kg]	$s_f$ [kJ/kg K]	$s_g$ [kJ/kg K]
-50.0	0.02945	0.00069	0.6062	-30.16	184	-30.14	201.8	-0.128	0.9115
-47.5	0.03401	0.00069	0.5298	-27.06	185.4	-27.03	203.4	-0.1142	0.9071
-45.0	0.03912	0.0007	0.4647	-23.95	186.8	-23.92	205	-0.1005	0.9029
-42.5	0.04483	0.0007	0.409	-20.83	188.3	-20.8	206.6	-0.08693	0.899
-40.0	0.05121	0.00071	0.3611	-17.7	189.7	-17.67	208.2	-0.07344	0.8953
-37.5	0.05829	0.00071	0.3198	-14.56	191.1	-14.52	209.8	-0.06004	0.8918
-35.0	0.06614	0.00071	0.284	-11.41	192.6	-11.37	211.4	-0.04675	0.8885
-32.5	0.07482	0.00072	0.253	-8.251	194	-8.198	212.9	-0.03354	0.8854
-30.0	0.08438	0.00072	0.2259	-5.079	195.4	-5.018	214.5	-0.02042	0.8824
-27.5	0.09488	0.00072	0.2023	-1.895	196.9	-1.826	216.1	-0.00739	0.8797
-25.0	0.1064	0.00073	0.1816	1.3	198.3	1.378	217.6	0.00555	0.877
-22.5	0.119	0.00073	0.1634	4.508	199.7	4.595	219.2	0.01841	0.8746
-20.0	0.1327	0.00074	0.1474	7.728	201.2	7.826	220.7	0.0312	0.8723
-17.5	0.1477	0.00074	0.1332	10.96	202.6	11.07	222.3	0.04391	0.8701
-15.0	0.1639	0.00074	0.1207	14.21	204	14.33	223.8	0.05654	0.868
-12.5	0.1816	0.00075	0.1095	17.46	205.5	17.6	225.3	0.0691	0.8661
-10.0	0.2006	0.00075	0.09959	20.74	206.9	20.89	226.9	0.0816	0.8643
-7.5	0.2212	0.00076	0.09073	24.02	208.3	24.19	228.4	0.09403	0.8626
-5.0	0.2433	0.00076	0.0828	27.32	209.7	27.51	229.8	0.1064	0.861
-2.5	0.2672	0.00077	0.07569	30.63	211.1	30.84	231.3	0.1187	0.8595
0.0	0.2928	0.00077	0.06931	33.96	212.5	34.19	232.8	0.131	0.858
2.5	0.3203	0.00078	0.06356	37.31	213.9	37.56	234.2	0.1431	0.8567
5.0	0.3497	0.00078	0.05837	40.67	215.3	40.94	235.7	0.1553	0.8554
7.5	0.3811	0.00079	0.05369	44.04	216.6	44.35	237.1	0.1674	0.8542
10.0	0.4146	0.00079	0.04944	47.44	218	47.77	238.5	0.1794	0.8531
12.5	0.4503	0.0008	0.04559	50.85	219.4	51.21	239.9	0.1914	0.852
15.0	0.4884	0.0008	0.04209	54.28	220.7	54.67	241.3	0.2034	0.8509
17.5	0.5288	0.00081	0.0389	57.72	222	58.15	242.6	0.2153	0.8499
20.0	0.5717	0.00082	0.036	61.19	223.4	61.66	243.9	0.2272	0.849
22.5	0.6172	0.00082	0.03334	64.68	224.7	65.18	245.2	0.239	0.8481
25.0	0.6654	0.00083	0.03091	68.18	226	68.74	246.5	0.2509	0.8472
27.5	0.7163	0.00084	0.02869	71.71	227.2	72.31	247.8	0.2627	0.8463
30.0	0.7702	0.00084	0.02664	75.26	228.5	75.91	249	0.2745	0.8454
32.5	0.827	0.00085	0.02476	78.84	229.7	79.54	250.2	0.2862	0.8446
35.0	0.887	0.00086	0.02303	82.44	230.9	83.2	251.4	0.298	0.8437
37.5	0.9501	0.00086	0.02144	86.06	232.1	86.88	252.5	0.3097	0.8429
40.0	1.017	0.00087	0.01997	89.71	233.3	90.6	253.6	0.3214	0.842
42.5	1.086	0.00088	0.0186	93.39	234.5	94.35	254.7	0.3332	0.8411
45.0	1.16	0.00089	0.01734	97.1	235.6	98.13	255.7	0.3449	0.8402
47.5	1.237	0.0009	0.01617	100.8	236.7	102	256.7	0.3566	0.8392
50.0	1.318	0.00091	0.01509	104.6	237.7	105.8	257.6	0.3684	0.8382
52.5	1.403	0.00092	0.01408	108.4	238.8	109.7	258.5	0.3802	0.8371
55.0	1.492	0.00093	0.01314	112.3	239.7	113.7	259.3	0.392	0.836
57.5	1.584	0.00094	0.01226	116.2	240.7	117.7	260.1	0.4039	0.8347
60.0	1.682	0.00095	0.01144	120.1	241.6	121.7	260.8	0.4158	0.8334
62.5	1.784	0.00096	0.01068	124.1	242.4	125.8	261.5	0.4277	0.8319
65.0	1.89	0.00097	0.00996	128.1	243.2	130	262	0.4398	0.8303
67.5	2.001	0.00099	0.00929	132.2	243.9	134.2	262.5	0.4519	0.8285
70.0	2.117	0.001	0.00865	136.3	244.5	138.5	262.8	0.4641	0.8266
72.5	2.238	0.00102	0.00806	140.6	245.1	142.8	263.1	0.4765	0.8244
75.0	2.364	0.00104	0.00749	144.9	245.5	147.3	263.2	0.489	0.8219
77.5	2.496	0.00106	0.00696	149.3	245.8	151.9	263.2	0.5017	0.8191
80.0	2.633	0.00108	0.00645	153.7	246	156.6	263	0.5146	0.8159
82.5	2.776	0.0011	0.00596	158.4	246	161.4	262.6	0.5278	0.8123
85.0	2.926	0.00113	0.0055	163.1	245.9	166.4	261.9	0.5413	0.8081
87.5	3.082	0.00116	0.00505	168.1	245.4	171.6	261	0.5553	0.8031
90.0	3.244	0.00119	0.00461	173.2	244.6	177.1	259.6	0.57	0.7971
92.5	3.414	0.00124	0.00418	178.8	243.4	183	257.7	0.5855	0.7897
95.0	3.591	0.00129	0.00374	184.8	241.4	189.4	254.9	0.6025	0.7802
97.5	3.777	0.00138	0.00328	191.7	238.1	196.9	250.5	0.6221	0.7667
100.0	3.972	0.00154	0.00268	201.4	231.2	207.5	241.9	0.6497	0.7419

**R134a –  
Proprietà del liquido e del vapore saturo in funzione della pressione**

Press.	Temp.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
$p$ [MPa]	$T$ [C]	$v_l$ [m³/kg]	$v_g$ [m³/kg]	$u_l$ [kJ/kg]	$u_g$ [kJ/kg]	$h_l$ [kJ/kg]	$h_g$ [kJ/kg]	$s_l$ [kJ/kg K]	$s_g$ [kJ/kg K]
0.03	-49.68	0.00069	0.5958	-29.76	184.2	-29.74	202	-0.1263	0.911
0.04	-44.60	0.0007	0.4551	-23.45	187.1	-23.42	205.3	-0.09832	0.9023
0.05	-40.45	0.0007	0.3693	-18.27	189.4	-18.24	207.9	-0.07588	0.8959
0.06	-36.93	0.00071	0.3112	-13.85	191.5	-13.81	210.1	-0.05703	0.891
0.07	-33.86	0.00071	0.2693	-9.97	193.2	-9.92	212.1	-0.0407	0.887
0.08	-31.12	0.00072	0.2376	-6.496	194.8	-6.438	213.8	-0.02626	0.8837
0.09	-28.63	0.00072	0.2126	-3.34	196.2	-3.275	215.4	-0.01329	0.8809
0.10	-26.36	0.00073	0.1926	-0.4409	197.5	-0.3683	216.8	-0.00149	0.8784
0.11	-24.26	0.00073	0.176	2.245	198.7	2.326	218.1	0.00935	0.8763
0.12	-22.31	0.00073	0.1621	4.753	199.9	4.841	219.3	0.01939	0.8744
0.13	-20.48	0.00074	0.1503	7.108	200.9	7.203	220.4	0.02874	0.8727
0.14	-18.76	0.00074	0.1401	9.33	201.9	9.433	221.5	0.03751	0.8712
0.15	-17.13	0.00074	0.1313	11.44	202.8	11.55	222.5	0.04577	0.8698
0.16	-15.59	0.00074	0.1235	13.44	203.7	13.56	223.5	0.05358	0.8685
0.18	-12.71	0.00075	0.1104	17.19	205.3	17.32	225.2	0.06804	0.8663
0.20	-10.08	0.00075	0.09988	20.64	206.8	20.79	226.8	0.08122	0.8644
0.22	-7.64	0.00076	0.09119	23.84	208.2	24.01	228.3	0.09335	0.8627
0.24	-5.37	0.00076	0.08391	26.84	209.5	27.02	229.6	0.1046	0.8612
0.26	-3.24	0.00077	0.0777	29.66	210.7	29.86	230.9	0.1151	0.8599
0.28	-1.23	0.00077	0.07236	32.33	211.8	32.54	232.1	0.1249	0.8587
0.30	0.67	0.00077	0.0677	34.86	212.9	35.09	233.2	0.1342	0.8577
0.32	2.48	0.00078	0.06361	37.28	213.9	37.53	234.2	0.143	0.8567
0.34	4.20	0.00078	0.05998	39.59	214.8	39.85	235.2	0.1514	0.8558
0.36	5.84	0.00078	0.05674	41.8	215.7	42.08	236.2	0.1594	0.855
0.40	8.93	0.00079	0.05121	45.98	217.4	46.3	237.9	0.1743	0.8535
0.45	12.48	0.0008	0.04562	50.82	219.4	51.18	239.9	0.1913	0.852
0.50	15.73	0.00081	0.04112	55.29	221.1	55.69	241.7	0.2069	0.8506
0.55	18.75	0.00081	0.03741	59.46	222.7	59.91	243.3	0.2213	0.8495
0.60	21.57	0.00082	0.0343	63.38	224.2	63.87	244.8	0.2346	0.8484
0.65	24.22	0.00083	0.03165	67.08	225.6	67.62	246.1	0.2472	0.8475
0.70	26.71	0.00083	0.02937	70.6	226.8	71.18	247.4	0.259	0.8466
0.80	31.33	0.00085	0.02562	77.16	229.1	77.84	249.6	0.2807	0.845
0.90	35.53	0.00086	0.02269	83.2	231.2	83.97	251.6	0.3004	0.8436
1.00	39.39	0.00087	0.02032	88.82	233	89.69	253.4	0.3186	0.8422
1.10	42.97	0.00088	0.01836	94.09	234.7	95.06	254.9	0.3354	0.8409
1.20	46.31	0.00089	0.01672	99.06	236.2	100.1	256.2	0.3511	0.8397
1.30	49.46	0.00091	0.01532	103.8	237.5	105	257.4	0.3658	0.8384
1.40	52.42	0.00092	0.01411	108.3	238.7	109.6	258.5	0.3798	0.8372
1.50	55.23	0.00093	0.01306	112.6	239.8	114	259.4	0.3931	0.8359
1.60	57.91	0.00094	0.01213	116.8	240.8	118.3	260.2	0.4058	0.8345
1.70	60.46	0.00095	0.0113	120.8	241.7	122.4	260.9	0.4179	0.8331
1.80	62.90	0.00096	0.01056	124.7	242.5	126.4	261.5	0.4296	0.8317
1.90	65.23	0.00098	0.0099	128.5	243.3	130.3	262.1	0.4409	0.8301
2.00	67.48	0.00099	0.00929	132.2	243.9	134.1	262.5	0.4518	0.8285
2.10	69.64	0.001	0.00874	135.8	244.4	137.9	262.8	0.4624	0.8268
2.20	71.73	0.00101	0.00824	139.3	244.9	141.5	263	0.4727	0.8251
2.30	73.74	0.00103	0.00777	142.7	245.3	145.1	263.2	0.4827	0.8232
2.40	75.69	0.00104	0.00734	146.1	245.6	148.6	263.2	0.4925	0.8212
2.50	77.58	0.00106	0.00694	149.4	245.8	152	263.2	0.5021	0.819
2.60	79.41	0.00107	0.00657	152.7	246	155.5	263.1	0.5115	0.8167
2.70	81.18	0.00109	0.00622	155.9	246.1	158.8	262.8	0.5208	0.8143
2.80	82.90	0.0011	0.00589	159.1	246	162.2	262.5	0.5299	0.8117
2.90	84.58	0.00112	0.00558	162.3	245.9	165.6	262.1	0.539	0.8088
3.00	86.20	0.00114	0.00528	165.5	245.7	168.9	261.5	0.548	0.8058
3.10	87.79	0.00116	0.005	168.6	245.3	172.2	260.8	0.557	0.8025
3.20	89.33	0.00118	0.00473	171.8	244.9	175.6	260	0.566	0.7988
3.30	90.83	0.00121	0.00447	175	244.3	179	259	0.5751	0.7949
3.40	92.30	0.00123	0.00422	178.3	243.5	182.5	257.8	0.5842	0.7904
3.50	93.73	0.00126	0.00397	181.6	242.5	186.1	256.4	0.5936	0.7854
3.60	95.12	0.0013	0.00372	185.1	241.3	189.8	254.7	0.6034	0.7797
3.80	97.80	0.00139	0.00321	192.7	237.6	198	249.8	0.6248	0.7646
4.00	100.3	0.00158	0.00256	203.4	229.3	209.8	239.6	0.6557	0.7355

**R134a – Liquido compresso e vapore surriscaldato.**

R134a	$p =$	0.03	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.16	-30.14	-0.128
-40.0	0.6235	190.4	209.1	0.9417
-30.0	0.6519	196.9	216.5	0.9728
-20.0	0.68	203.6	224	1.003
-10.0	0.7079	210.5	231.7	1.033
0.0	0.7358	217.5	239.6	1.062
10.0	0.7635	224.7	247.6	1.091
20.0	0.7912	232.1	255.8	1.12
30.0	0.8188	239.7	264.2	1.148
40.0	0.8463	247.4	272.8	1.176
50.0	0.8738	255.3	281.5	1.203
60.0	0.9013	263.4	290.4	1.23
70.0	0.9287	271.6	299.5	1.257
80.0	0.9562	280	308.7	1.283
90.0	0.9835	288.6	318.1	1.31
110.0	1.038	306.2	337.3	1.361
120.0	1.066	315.2	347.2	1.387
130.0	1.093	324.5	357.2	1.412
140.0	1.12	333.8	367.4	1.437
150.0	1.147	343.4	377.8	1.462
160.0	1.175	353	388.3	1.486
170.0	1.202	362.9	398.9	1.511
180.0	1.229	372.9	409.7	1.535
190.0	1.257	383	420.7	1.559
200.0	1.284	393.3	431.8	1.582

R134a	$p =$	0.04	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.16	-30.13	-0.1281
-40.0	0.4651	190.1	208.7	0.917
-30.0	0.4867	196.6	216.1	0.9483
-20.0	0.5081	203.4	223.7	0.9788
-10.0	0.5292	210.3	231.4	1.009
0.0	0.5503	217.3	239.3	1.038
10.0	0.5712	224.6	247.4	1.067
20.0	0.5921	232	255.7	1.096
30.0	0.6129	239.5	264.1	1.124
40.0	0.6337	247.3	272.6	1.152
50.0	0.6544	255.2	281.4	1.179
60.0	0.6751	263.3	290.3	1.206
70.0	0.6957	271.5	299.3	1.233
80.0	0.7163	279.9	308.6	1.26
90.0	0.7369	288.5	318	1.286
110.0	0.7781	306.1	337.2	1.338
120.0	0.7986	315.2	347.1	1.363
130.0	0.8191	324.4	357.2	1.388
140.0	0.8396	333.8	367.4	1.413
150.0	0.8601	343.3	377.7	1.438
160.0	0.8806	353	388.2	1.463
170.0	0.9011	362.8	398.9	1.487
180.0	0.9216	372.8	409.7	1.511
190.0	0.942	383	420.7	1.535
200.0	0.9625	393.3	431.8	1.559

R134a	$p =$	0.05	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.16	-30.13	-0.1281
-40.0	0.3701	189.7	208.2	0.8974
-30.0	0.3876	196.4	215.8	0.929
-20.0	0.4049	203.2	223.4	0.9598
-10.0	0.422	210.1	231.2	0.9899
0.0	0.439	217.2	239.1	1.019
10.0	0.4559	224.4	247.2	1.049
20.0	0.4727	231.8	255.5	1.077
30.0	0.4894	239.4	263.9	1.105
40.0	0.5061	247.2	272.5	1.133
50.0	0.5227	255.1	281.2	1.161
60.0	0.5393	263.2	290.1	1.188
70.0	0.5559	271.4	299.2	1.215
80.0	0.5724	279.8	308.5	1.241
90.0	0.589	288.4	317.9	1.268
110.0	0.6219	306.1	337.2	1.319
120.0	0.6384	315.1	347	1.345
130.0	0.6549	324.3	357.1	1.37
140.0	0.6713	333.7	367.3	1.395
150.0	0.6877	343.3	377.6	1.42
160.0	0.7041	352.9	388.1	1.444
170.0	0.7205	362.8	398.8	1.469
180.0	0.7369	372.8	409.6	1.493
190.0	0.7533	382.9	420.6	1.517
200.0	0.7697	393.2	431.7	1.541

R134a	$p =$	0.06	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.17	-30.12	-0.1281
-40.0	0.00071	-17.71	-17.66	-0.07345
-30.0	0.3215	196.1	215.4	0.913
-20.0	0.3361	202.9	223.1	0.944
-10.0	0.3505	209.9	230.9	0.9743
0.0	0.3648	217	238.9	1.004
10.0	0.3789	224.3	247	1.033
20.0	0.393	231.7	255.3	1.062
30.0	0.4071	239.3	263.7	1.09
40.0	0.421	247	272.3	1.118
50.0	0.4349	255	281.1	1.146
60.0	0.4488	263.1	290	1.173
70.0	0.4627	271.3	299.1	1.2
80.0	0.4765	279.7	308.3	1.226
90.0	0.4903	288.3	317.8	1.253
110.0	0.5179	306	337.1	1.304
120.0	0.5316	315.1	347	1.33
130.0	0.5453	324.3	357	1.355
140.0	0.5591	333.7	367.2	1.38
150.0	0.5728	343.2	377.6	1.405
160.0	0.5865	352.9	388.1	1.429
170.0	0.6002	362.7	398.7	1.454
180.0	0.6139	372.7	409.6	1.478
190.0	0.6275	382.9	420.5	1.502
200.0	0.6412	393.2	431.7	1.526

<b>R134a</b>	<b>p =</b>	<b>0.08</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.17	-30.12	-0.1281
-40.0	0.00071	-17.71	-17.66	-0.07348
-30.0	0.2388	195.6	214.7	0.8873
-20.0	0.2501	202.5	222.5	0.9187
-10.0	0.2611	209.5	230.4	0.9493
0.0	0.272	216.6	238.4	0.9793
10.0	0.2828	223.9	246.6	1.009
20.0	0.2935	231.4	254.9	1.038
30.0	0.3041	239	263.4	1.066
40.0	0.3147	246.8	272	1.094
50.0	0.3252	254.8	280.8	1.122
60.0	0.3357	262.9	289.7	1.149
70.0	0.3462	271.1	298.8	1.176
80.0	0.3566	279.6	308.1	1.202
90.0	0.367	288.2	317.5	1.229
110.0	0.3878	305.9	336.9	1.281
120.0	0.3981	314.9	346.8	1.306
130.0	0.4085	324.2	356.8	1.331
140.0	0.4188	333.5	367.1	1.356
150.0	0.4291	343.1	377.4	1.381
160.0	0.4394	352.8	387.9	1.406
170.0	0.4497	362.6	398.6	1.43
180.0	0.46	372.6	409.4	1.454
190.0	0.4703	382.8	420.4	1.478
200.0	0.4806	393.1	431.5	1.502

<b>R134a</b>	<b>p =</b>	<b>0.1</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.18	-30.11	-0.1281
-40.0	0.00071	-17.72	-17.65	-0.07351
-30.0	0.00072	-5.085	-5.013	-0.02045
-20.0	0.1984	202	221.8	0.8986
-10.0	0.2074	209.1	229.8	0.9296
0.0	0.2163	216.3	237.9	0.9598
10.0	0.2251	223.6	246.1	0.9893
20.0	0.2337	231.1	254.5	1.018
30.0	0.2423	238.8	263	1.047
40.0	0.2509	246.6	271.7	1.075
50.0	0.2594	254.6	280.5	1.103
60.0	0.2678	262.7	289.5	1.13
70.0	0.2763	271	298.6	1.157
80.0	0.2847	279.4	307.9	1.184
90.0	0.293	288	317.3	1.21
110.0	0.3097	305.7	336.7	1.262
120.0	0.318	314.8	346.6	1.288
130.0	0.3263	324	356.7	1.313
140.0	0.3346	333.4	366.9	1.338
150.0	0.3429	343	377.3	1.363
160.0	0.3512	352.7	387.8	1.387
170.0	0.3594	362.5	398.5	1.412
180.0	0.3677	372.6	409.3	1.436
190.0	0.3759	382.7	420.3	1.46
200.0	0.3842	393	431.4	1.484

<b>R134a</b>	<b>p =</b>	<b>0.15</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.19	-30.09	-0.1282
-40.0	0.00071	-17.74	-17.63	-0.07358
-30.0	0.00072	-5.104	-4.996	-0.02052
-20.0	0.00074	7.721	7.831	0.03117
-10.0	0.1358	208	228.4	0.8925
0.0	0.142	215.4	236.7	0.9234
10.0	0.1481	222.8	245	0.9534
20.0	0.1541	230.4	253.5	0.9829
30.0	0.16	238.1	262.1	1.012
40.0	0.1658	246	270.9	1.04
50.0	0.1716	254	279.8	1.068
60.0	0.1773	262.2	288.8	1.096
70.0	0.183	270.5	298	1.123
80.0	0.1887	279	307.3	1.15
90.0	0.1944	287.6	316.8	1.176
110.0	0.2056	305.4	336.2	1.228
120.0	0.2112	314.5	346.2	1.254
130.0	0.2168	323.7	356.3	1.279
140.0	0.2224	333.2	366.5	1.304
150.0	0.228	342.7	376.9	1.329
160.0	0.2335	352.4	387.5	1.354
170.0	0.2391	362.3	398.2	1.378
180.0	0.2446	372.3	409	1.402
190.0	0.2501	382.5	420	1.426
200.0	0.2556	392.8	431.2	1.45

<b>R134a</b>	<b>p =</b>	<b>0.20</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00069	-30.21	-30.07	-0.1283
-40.0	0.00071	-17.75	-17.61	-0.07365
-30.0	0.00072	-5.122	-4.978	-0.0206
-20.0	0.00074	7.699	7.847	0.03108
-10.0	0.09991	206.9	226.9	0.8646
0.0	0.1048	214.4	235.4	0.8964
10.0	0.1096	222	243.9	0.927
20.0	0.1142	229.7	252.5	0.9569
30.0	0.1187	237.5	261.2	0.9861
40.0	0.1232	245.4	270.1	1.015
50.0	0.1277	253.5	279	1.043
60.0	0.1321	261.7	288.1	1.071
70.0	0.1364	270.1	297.4	1.098
80.0	0.1407	278.6	306.7	1.125
90.0	0.145	287.3	316.3	1.152
110.0	0.1536	305	335.8	1.204
120.0	0.1578	314.2	345.7	1.229
130.0	0.1621	323.4	355.9	1.255
140.0	0.1663	332.9	366.1	1.28
150.0	0.1705	342.5	376.6	1.305
160.0	0.1747	352.2	387.1	1.33
170.0	0.1789	362.1	397.8	1.354
180.0	0.183	372.1	408.7	1.378
190.0	0.1872	382.3	419.7	1.402
200.0	0.1914	392.6	430.9	1.426

<b>R134a</b>	<b>p =</b>	<b>0.30</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.24	-30.03	-0.1284
-40.00	0.00071	-17.79	-17.57	-0.0738
-30.00	0.00072	-5.16	-4.944	-0.02076
-20.00	0.00074	7.657	7.878	0.03092
-10.00	0.00075	20.69	20.91	0.08142
0.0	0.00077	33.96	34.19	0.1309
10.00	0.07093	220.2	241.5	0.8876
20.00	0.07425	228.2	250.4	0.9185
30.00	0.07748	236.1	259.4	0.9485
40.00	0.08063	244.2	268.4	0.9778
50.00	0.08372	252.4	277.5	1.006
60.00	0.08677	260.7	286.7	1.035
70.00	0.08978	269.1	296.1	1.062
80.00	0.09276	277.7	305.6	1.089
90.00	0.0957	286.5	315.2	1.116
110.0	0.1015	304.4	334.8	1.169
120.0	0.1044	313.5	344.9	1.195
130.0	0.1073	322.8	355	1.22
140.0	0.1102	332.3	365.4	1.246
150.0	0.113	341.9	375.8	1.271
160.0	0.1158	351.7	386.4	1.295
170.0	0.1187	361.6	397.2	1.32
180.0	0.1215	371.6	408.1	1.344
190.0	0.1243	381.8	419.1	1.368
200.0	0.1271	392.2	430.3	1.392

<b>R134a</b>	<b>p =</b>	<b>0.35</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.25	-30.01	-0.1285
-40.00	0.00071	-17.8	-17.56	-0.07387
-30.00	0.00072	-5.179	-4.927	-0.02083
-20.00	0.00074	7.636	7.894	0.03084
-10.00	0.00075	20.66	20.93	0.08133
0.0	0.00077	33.93	34.2	0.1308
10.00	0.05985	219.3	240.3	0.8716
20.00	0.06281	227.3	249.3	0.9031
30.00	0.06567	235.4	258.4	0.9336
40.00	0.06844	243.6	267.5	0.9631
50.00	0.07116	251.8	276.7	0.9921
60.00	0.07382	260.2	286	1.02
70.00	0.07645	268.7	295.4	1.048
80.00	0.07904	277.3	305	1.076
90.00	0.0816	286.1	314.6	1.103
110.0	0.08666	304	334.3	1.155
120.0	0.08916	313.2	344.4	1.181
130.0	0.09165	322.5	354.6	1.207
140.0	0.09412	332	365	1.232
150.0	0.09659	341.7	375.5	1.257
160.0	0.09904	351.4	386.1	1.282
170.0	0.1015	361.4	396.9	1.307
180.0	0.1039	371.4	407.8	1.331
190.0	0.1063	381.6	418.9	1.355
200.0	0.1088	392	430.1	1.379

<b>R134a</b>	<b>p =</b>	<b>0.40</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.27	-29.99	-0.1285
-40.00	0.0007	-17.82	-17.54	-0.07394
-30.00	0.00072	-5.197	-4.909	-0.02091
-20.00	0.00074	7.615	7.91	0.03075
-10.00	0.00075	20.64	20.94	0.08124
0.0	0.00077	33.91	34.21	0.1307
10.00	0.05151	218.3	238.9	0.8571
20.00	0.05421	226.5	248.2	0.8893
30.00	0.0568	234.7	257.4	0.9202
40.00	0.05929	242.9	266.6	0.9502
50.00	0.06172	251.2	275.9	0.9794
60.00	0.0641	259.7	285.3	1.008
70.00	0.06644	268.2	294.8	1.036
80.00	0.06875	276.9	304.4	1.063
90.00	0.07102	285.7	314.1	1.091
100.0	0.07327	294.6	323.9	1.117
110.0	0.07551	303.7	333.9	1.144
120.0	0.07772	312.9	344	1.17
130.0	0.07991	322.2	354.2	1.195
140.0	0.0821	331.7	364.6	1.221
150.0	0.08427	341.4	375.1	1.246
160.0	0.08643	351.2	385.7	1.271
170.0	0.08858	361.1	396.5	1.295
180.0	0.09072	371.2	407.5	1.32
190.0	0.09286	381.4	418.6	1.344
200.0	0.09499	391.8	429.8	1.368

<b>R134a</b>	<b>p =</b>	<b>0.50</b>	<b>[MPa]</b>	
<i>T</i>	<i>v</i>	<i>u</i>	<i>h</i>	<i>s</i>
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.3	-29.95	-0.1287
-40.00	0.0007	-17.85	-17.5	-0.07408
-30.00	0.00072	-5.235	-4.875	-0.02106
-20.00	0.00074	7.573	7.941	0.03059
-10.00	0.00075	20.59	20.97	0.08106
0.0	0.00077	33.85	34.24	0.1305
10.00	0.00079	47.38	47.78	0.1792
20.00	0.04212	224.7	245.8	0.8649
30.00	0.04434	233.2	255.3	0.8969
40.00	0.04646	241.6	264.8	0.9276
50.00	0.0485	250.1	274.3	0.9574
60.00	0.05049	258.6	283.8	0.9865
70.00	0.05243	267.2	293.4	1.015
80.00	0.05433	276	303.1	1.043
90.00	0.05621	284.8	312.9	1.07
100.0	0.05805	293.8	322.9	1.097
110.0	0.05988	303	332.9	1.124
120.0	0.06169	312.2	343.1	1.15
130.0	0.06348	321.6	353.4	1.176
140.0	0.06526	331.2	363.8	1.201
150.0	0.06702	340.8	374.4	1.226
160.0	0.06878	350.7	385.1	1.251
170.0	0.07052	360.6	395.9	1.276
180.0	0.07226	370.7	406.9	1.301
190.0	0.07398	381	418	1.325
200.0	0.07571	391.4	429.2	1.349

R134a	$p =$	0.60	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.33	-29.91	-0.1288
-40.00	0.0007	-17.89	-17.46	-0.07423
-30.00	0.00072	-5.272	-4.84	-0.02122
-20.00	0.00074	7.532	7.973	0.03042
-10.00	0.00075	20.55	21	0.08088
0.0	0.00077	33.8	34.26	0.1303
10.00	0.00079	47.32	47.8	0.179
20.00	0.00082	61.17	61.66	0.2271
30.00	0.03598	231.6	253.2	0.8765
40.00	0.03787	240.2	262.9	0.9082
50.00	0.03966	248.8	272.6	0.9387
60.00	0.04139	257.5	282.3	0.9682
70.00	0.04307	266.2	292.1	0.9971
80.00	0.04471	275.1	301.9	1.025
90.00	0.04632	284	311.8	1.053
100.0	0.0479	293.1	321.8	1.08
110.0	0.04946	302.3	331.9	1.107
120.0	0.051	311.6	342.2	1.133
130.0	0.05252	321	352.5	1.159
140.0	0.05403	330.6	363	1.185
150.0	0.05552	340.3	373.6	1.21
160.0	0.05701	350.1	384.4	1.235
170.0	0.05848	360.1	395.2	1.26
180.0	0.05995	370.3	406.2	1.285
190.0	0.0614	380.5	417.4	1.309
200.0	0.06285	390.9	428.7	1.333

R134a	$p =$	0.80	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.39	-29.84	-0.1291
-40.00	0.0007	-17.95	-17.39	-0.07451
-30.00	0.00072	-5.346	-4.771	-0.02152
-20.00	0.00074	7.448	8.036	0.03009
-10.00	0.00075	20.45	21.05	0.08052
0.0	0.00077	33.69	34.31	0.1299
10.00	0.00079	47.2	47.83	0.1786
20.00	0.00082	61.02	61.68	0.2266
30.00	0.00084	75.24	75.91	0.2744
40.00	0.02704	237.2	258.8	0.8746
50.00	0.02855	246.2	269	0.9068
60.00	0.02997	255.2	279.1	0.9376
70.00	0.03134	264.1	289.2	0.9674
80.00	0.03266	273.2	299.3	0.9964
90.00	0.03394	282.3	309.4	1.025
100.0	0.03519	291.5	319.6	1.052
110.0	0.03642	300.8	329.9	1.08
120.0	0.03763	310.2	340.3	1.106
130.0	0.03881	319.7	350.8	1.133
140.0	0.03999	329.4	361.4	1.159
150.0	0.04114	339.2	372.1	1.184
160.0	0.04229	349.1	382.9	1.21
170.0	0.04343	359.1	393.9	1.235
180.0	0.04455	369.3	405	1.259
190.0	0.04567	379.6	416.2	1.284
200.0	0.04679	390.1	427.5	1.308

R134a	$p =$	1.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.45	-29.76	-0.1293
-40.00	0.0007	-18.02	-17.31	-0.0748
-30.00	0.00072	-5.42	-4.701	-0.02183
-20.00	0.00073	7.365	8.1	0.02976
-10.00	0.00075	20.36	21.11	0.08016
0.0	0.00077	33.58	34.35	0.1296
10.00	0.00079	47.07	47.87	0.1781
20.00	0.00081	60.88	61.69	0.2261
30.00	0.00084	75.06	75.91	0.2738
40.00	0.02041	233.6	254	0.8444
50.00	0.0218	243.3	265.1	0.8791
60.00	0.02307	252.7	275.7	0.9116
70.00	0.02426	261.9	286.2	0.9425
80.00	0.0254	271.2	296.6	0.9724
90.00	0.02649	280.5	307	1.001
100.0	0.02755	289.8	317.4	1.03
110.0	0.02858	299.3	327.9	1.057
120.0	0.02959	308.8	338.4	1.085
130.0	0.03058	318.4	349	1.111
140.0	0.03155	328.2	359.7	1.137
150.0	0.03251	338	370.6	1.163
160.0	0.03346	348	381.5	1.189
170.0	0.03439	358.1	392.5	1.214
180.0	0.03532	368.4	403.7	1.239
190.0	0.03623	378.7	415	1.264
200.0	0.03714	389.2	426.4	1.288

R134a	$p =$	1.50	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.6	-29.56	-0.13
-40.00	0.0007	-18.18	-17.13	-0.07551
-30.00	0.00072	-5.604	-4.527	-0.02259
-20.00	0.00073	7.159	8.26	0.02894
-10.00	0.00075	20.12	21.25	0.07927
0.0	0.00077	33.32	34.47	0.1286
10.00	0.00079	46.77	47.95	0.1771
20.00	0.00081	60.52	61.74	0.2249
30.00	0.00084	74.64	75.9	0.2724
40.00	0.00087	89.21	90.51	0.3198
50.00	0.00091	104.4	105.7	0.3677
60.00	0.01361	245.1	265.5	0.8543
70.00	0.01466	255.6	277.6	0.8899
80.00	0.01561	265.7	289.1	0.923
90.00	0.01648	275.6	300.3	0.9543
100.0	0.01731	285.4	311.4	0.9844
110.0	0.01809	295.3	322.4	1.014
120.0	0.01885	305.1	333.4	1.042
130.0	0.01958	315	344.4	1.07
140.0	0.02029	325	355.5	1.097
150.0	0.02099	335.1	366.6	1.123
160.0	0.02167	345.3	377.8	1.149
170.0	0.02234	355.6	389.1	1.175
180.0	0.023	365.9	400.4	1.201
190.0	0.02365	376.4	411.9	1.226
200.0	0.02429	387.1	423.5	1.25



R134a	$p =$	2.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.74	-29.37	-0.1307
-40.00	0.0007	-18.35	-16.94	-0.07622
-30.00	0.00072	-5.786	-4.351	-0.02334
-20.00	0.00073	6.955	8.421	0.02813
-10.00	0.00075	19.89	21.39	0.07839
0.0	0.00077	33.06	34.59	0.1276
10.00	0.00079	46.47	48.05	0.176
20.00	0.00081	60.17	61.8	0.2237
30.00	0.00084	74.23	75.9	0.271
40.00	0.00087	88.71	90.44	0.3182
50.00	0.0009	103.7	105.5	0.3657
60.00	0.00095	119.6	121.4	0.4141
70.00	0.00957	247.1	266.2	0.8396
80.00	0.01054	258.9	280	0.879
90.00	0.01136	269.8	292.6	0.9142
100.0	0.0121	280.4	304.6	0.947
110.0	0.01279	290.8	316.4	0.9781
120.0	0.01344	301.1	328	1.008
130.0	0.01405	311.4	339.5	1.037
140.0	0.01464	321.7	351	1.065
150.0	0.01521	332	362.4	1.092
160.0	0.01576	342.4	373.9	1.119
170.0	0.0163	352.9	385.5	1.146
180.0	0.01683	363.4	397.1	1.171
190.0	0.01735	374.1	408.8	1.197
200.0	0.01786	384.8	420.5	1.222

R134a	$p =$	2.50	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-30.89	-29.17	-0.1313
-40.00	0.0007	-18.51	-16.75	-0.07692
-30.00	0.00072	-5.967	-4.175	-0.02409
-20.00	0.00073	6.753	8.584	0.02733
-10.00	0.00075	19.67	21.54	0.07752
0.0	0.00077	32.8	34.72	0.1267
10.00	0.00079	46.17	48.14	0.1749
20.00	0.00081	59.83	61.86	0.2225
30.00	0.00083	73.82	75.91	0.2697
40.00	0.00086	88.22	90.38	0.3166
50.00	0.0009	103.1	105.4	0.3637
60.00	0.00094	118.8	121.1	0.4117
70.00	0.001	135.5	137.9	0.4615
80.00	0.00722	249.5	267.6	0.8314
90.00	0.00815	262.8	283.1	0.8749
100.0	0.0089	274.6	296.8	0.9121
110.0	0.00955	285.8	309.7	0.9461
120.0	0.01015	296.7	322.1	0.9781
130.0	0.0107	307.4	334.2	1.009
140.0	0.01123	318.1	346.2	1.038
150.0	0.01173	328.7	358.1	1.066
160.0	0.01221	339.4	369.9	1.094
170.0	0.01267	350.1	381.7	1.121
180.0	0.01313	360.8	393.6	1.147
190.0	0.01357	371.6	405.5	1.173
200.0	0.014	382.5	417.5	1.199

R134a	$p =$	3.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-31.04	-28.97	-0.132
-40.00	0.0007	-18.67	-16.56	-0.07762
-30.00	0.00072	-6.146	-3.997	-0.02484
-20.00	0.00073	6.552	8.748	0.02653
-10.00	0.00075	19.44	21.69	0.07665
0.0	0.00077	32.54	34.84	0.1257
10.00	0.00079	45.88	48.24	0.1739
20.00	0.00081	59.5	61.92	0.2214
30.00	0.00083	73.43	75.92	0.2683
40.00	0.00086	87.74	90.32	0.3151
50.00	0.00089	102.5	105.2	0.3619
60.00	0.00093	118	120.8	0.4093
70.00	0.00099	134.4	137.3	0.4583
80.00	0.00106	152.4	155.6	0.5108
90.00	0.00575	252.7	270	0.8292
100.0	0.00664	267.4	287.3	0.8762
110.0	0.00733	280	302	0.915
120.0	0.00792	291.8	315.5	0.9499
130.0	0.00845	303.1	328.5	0.9825
140.0	0.00894	314.2	341	1.013
150.0	0.0094	325.2	353.4	1.043
160.0	0.00983	336.2	365.7	1.072
170.0	0.01025	347.1	377.9	1.099
180.0	0.01065	358.1	390	1.127
190.0	0.01104	369.1	402.2	1.153
200.0	0.01142	380.1	414.4	1.179

R134a	$p =$	3.50	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00069	-31.18	-28.77	-0.1327
-40.00	0.0007	-18.83	-16.38	-0.07831
-30.00	0.00072	-6.324	-3.819	-0.02558
-20.00	0.00073	6.354	8.913	0.02573
-10.00	0.00075	19.22	21.84	0.0758
0.0	0.00077	32.29	34.97	0.1248
10.00	0.00078	45.6	48.34	0.1729
20.00	0.00081	59.17	61.99	0.2202
30.00	0.00083	73.04	75.95	0.267
40.00	0.00086	87.28	90.29	0.3136
50.00	0.00089	102	105.1	0.3601
60.00	0.00093	117.3	120.5	0.4071
70.00	0.00098	133.4	136.8	0.4553
80.00	0.00105	150.9	154.5	0.5062
90.00	0.00117	171.4	175.5	0.5647
100.0	0.00483	257.2	274.2	0.8334
110.0	0.00565	272.9	292.7	0.8823
120.0	0.00628	286.1	308	0.922
130.0	0.00681	298.3	322.1	0.9574
140.0	0.00728	310.1	335.5	0.9902
150.0	0.00772	321.5	348.5	1.021
160.0	0.00813	332.8	361.3	1.051
170.0	0.00851	344	373.8	1.08
180.0	0.00888	355.2	386.3	1.108
190.0	0.00924	366.4	398.8	1.135
200.0	0.00958	377.7	411.2	1.161

**R600a – Isobutano**

**Proprietà del liquido e del vapore saturo in funzione della temperatura**

Temp.	Press.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
T [C]	p [MPa]	$v_f$ [m³/kg]	$v_g$ [m³/kg]	$u_f$ [kJ/kg]	$u_g$ [kJ/kg]	$h_f$ [kJ/kg]	$h_g$ [kJ/kg]	$s_f$ [kJ/kg K]	$s_g$ [kJ/kg K]
-50	0.01651	0.00158	1.911	-82.8	285.1	-82.78	316.7	-0.3413	1.449
-45	0.02177	0.00159	1.477	-72.41	290.9	-72.37	323	-0.2953	1.438
-40	0.02832	0.0016	1.157	-61.91	296.7	-61.86	329.4	-0.2498	1.429
-35	0.03637	0.00162	0.9173	-51.3	302.5	-51.24	335.9	-0.2047	1.421
-30	0.04616	0.00163	0.7352	-40.58	308.5	-40.51	342.4	-0.1602	1.415
-25	0.05793	0.00164	0.5953	-29.75	314.5	-29.66	349	-0.1161	1.41
-20	0.07195	0.00166	0.4866	-18.81	320.5	-18.69	355.6	-0.07242	1.406
-15	0.08851	0.00167	0.4013	-7.741	326.7	-7.593	362.2	-0.02914	1.403
-10	0.1079	0.00169	0.3336	3.444	332.8	3.627	368.8	0.01378	1.402
-5	0.1304	0.00171	0.2794	14.75	339	14.98	375.5	0.05636	1.401
0	0.1564	0.00172	0.2357	26.19	345.3	26.46	382.2	0.09863	1.401
5	0.1862	0.00174	0.2001	37.76	351.6	38.08	388.9	0.1406	1.402
10	0.2201	0.00176	0.1709	49.46	358	49.85	395.6	0.1823	1.403
15	0.2585	0.00178	0.1467	61.3	364.4	61.76	402.3	0.2238	1.406
20	0.3018	0.0018	0.1266	73.29	370.8	73.83	409.1	0.265	1.409
25	0.3503	0.00182	0.1098	85.41	377.3	86.05	415.8	0.3061	1.412
30	0.4043	0.00184	0.09562	97.69	383.8	98.44	422.5	0.347	1.416
35	0.4644	0.00186	0.08359	110.1	390.3	111	429.2	0.3877	1.42
40	0.5308	0.00188	0.07334	122.7	396.9	123.7	435.8	0.4283	1.425
45	0.604	0.00191	0.06455	135.5	403.4	136.6	442.4	0.4688	1.43
50	0.6843	0.00193	0.05698	148.4	409.9	149.8	448.9	0.5092	1.435
55	0.7723	0.00196	0.05043	161.6	416.5	163.1	455.4	0.5495	1.44
60	0.8683	0.00199	0.04472	174.9	422.9	176.6	461.8	0.5899	1.446
65	0.9728	0.00202	0.03973	188.4	429.4	190.4	468	0.6303	1.451
70	1.086	0.00205	0.03535	202.1	435.8	204.4	474.2	0.6707	1.457
75	1.209	0.00209	0.03149	216.1	442	218.6	480.1	0.7112	1.462
80	1.342	0.00213	0.02807	230.3	448.2	233.2	485.9	0.7519	1.467
85	1.485	0.00217	0.02502	244.8	454.2	248	491.4	0.7927	1.472
90	1.639	0.00222	0.02229	259.6	460	263.2	496.6	0.8339	1.477
95	1.805	0.00227	0.01984	274.7	465.6	278.8	501.4	0.8755	1.48
100	1.984	0.00233	0.01762	290.2	470.8	294.8	505.7	0.9175	1.483
105	2.175	0.00239	0.01561	306.1	475.5	311.3	509.5	0.9603	1.484
110	2.381	0.00247	0.01376	322.6	479.7	328.4	512.4	1.004	1.484
115	2.601	0.00257	0.01205	339.7	483	346.4	514.3	1.049	1.482
120	2.837	0.00268	0.01044	357.9	485	365.5	514.7	1.096	1.476
125	3.091	0.00285	0.00888	377.6	485.1	386.4	512.6	1.147	1.464
130	3.364	0.00311	0.00725	400.6	481.1	411	505.5	1.207	1.441

**R600a – Isobutano**

**Proprietà del liquido e del vapore saturo in funzione della pressione**

Press.	Temp.	Vol. Spec. (L)	Vol. Spec. (V)	E.Interna (L)	E.Interna (V)	Entalpia (L)	Entalpia (V)	Entropia (L)	Entropia (V)
$p$ [MPa]	$T$ [C]	$v_l$ [m³/kg]	$v_g$ [m³/kg]	$u_l$ [kJ/kg]	$u_g$ [kJ/kg]	$h_l$ [kJ/kg]	$h_g$ [kJ/kg]	$s_l$ [kJ/kg K]	$s_g$ [kJ/kg K]
0.01	-58.44	0.00156	3.046	-100.1	275.6	-100.1	306	-0.4204	1.471
0.02	-46.56	0.00159	1.599	-75.67	289.1	-75.64	321	-0.3096	1.441
0.03	-38.87	0.00161	1.097	-59.53	298	-59.48	330.9	-0.2396	1.427
0.04	-33.03	0.00162	0.8398	-47.1	304.9	-47.03	338.5	-0.1872	1.418
0.05	-28.27	0.00163	0.6826	-36.84	310.6	-36.76	344.7	-0.1449	1.413
0.06	-24.2	0.00165	0.5762	-28.02	315.4	-27.92	350	-0.1091	1.409
0.07	-20.65	0.00166	0.4992	-20.23	319.8	-20.11	354.7	-0.07805	1.406
0.08	-17.47	0.00167	0.4409	-13.22	323.6	-13.08	358.9	-0.05046	1.404
0.09	-14.59	0.00168	0.3951	-6.82	327.2	-6.669	362.7	-0.02557	1.403
0.1	-11.94	0.00168	0.3581	-0.92	330.4	-0.7517	366.2	-0.00287	1.402
0.2	7.111	0.00175	0.187	42.68	354.3	43.03	391.7	0.1583	1.402
0.3	19.8	0.00179	0.1273	72.81	370.6	73.35	408.8	0.2634	1.408
0.4	29.62	0.00184	0.09662	96.75	383.3	97.49	422	0.3438	1.416
0.5	37.74	0.00187	0.07777	117	393.9	118	432.8	0.41	1.423
0.6	44.74	0.00191	0.06498	134.8	403.1	136	442.1	0.4667	1.43
0.7	50.92	0.00194	0.0557	150.9	411.1	152.2	450.1	0.5166	1.436
0.8	56.49	0.00197	0.04865	165.5	418.4	167.1	457.3	0.5616	1.442
0.9	61.56	0.002	0.04309	179.1	425	180.9	463.7	0.6025	1.448
1	66.24	0.00203	0.0386	191.8	431	193.8	469.6	0.6403	1.453
1.2	74.65	0.00209	0.03175	215.1	441.6	217.6	479.7	0.7083	1.462
1.4	82.08	0.00215	0.02676	236.3	450.7	239.3	488.2	0.7688	1.469
1.6	88.76	0.00221	0.02294	255.9	458.6	259.4	495.3	0.8236	1.476
1.8	94.84	0.00227	0.01991	274.2	465.4	278.3	501.2	0.8741	1.48
2	100.4	0.00233	0.01744	291.5	471.2	296.2	506.1	0.9212	1.483
2.2	105.6	0.0024	0.01537	308.1	476.1	313.4	509.9	0.9656	1.484
2.4	110.4	0.00248	0.0136	324.1	480	330	512.6	1.008	1.484
2.6	115	0.00257	0.01205	339.6	482.9	346.3	514.3	1.049	1.482
2.8	119.2	0.00266	0.01068	355	484.8	362.5	514.7	1.089	1.477
3	123.2	0.00278	0.00942	370.4	485.4	378.8	513.7	1.129	1.469
3.2	127	0.00293	0.00823	386.4	484.2	395.8	510.6	1.17	1.457
3.4	130.6	0.00316	0.00703	404	480	414.8	503.9	1.216	1.437
3.6	134	0.00372	0.00543	430	465.8	443.4	485.4	1.285	1.388

**R600a – Isobutano: Liquido compresso e vapore surriscaldato.**

R600a	$p =$	0.02	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.81	-82.77	-0.3414
-40.0	1.647	297.1	330.1	1.48
-30.0	1.721	309.8	344.2	1.54
-20.0	1.794	322.8	358.7	1.598
-10.0	1.867	336.3	373.6	1.656
0.0	1.94	350.2	389	1.713
10.0	2.013	364.5	404.8	1.77
20.0	2.086	379.3	421	1.826
30.0	2.158	394.6	437.7	1.882
40.0	2.23	410.3	454.9	1.938
50.0	2.302	426.4	472.5	1.993
60.0	2.375	443.1	490.6	2.049
70.0	2.447	460.2	509.1	2.103
80.0	2.519	477.8	528.2	2.158
90.0	2.591	495.8	547.7	2.212
100.0	2.662	514.4	567.6	2.267
110.0	2.734	533.3	588	2.321
120.0	2.806	552.8	608.9	2.374
130.0	2.878	572.7	630.3	2.428
140.0	2.95	593.1	652	2.481
150.0	3.022	613.9	674.3	2.535
160.0	3.093	635.1	697	2.588
170.0	3.165	656.8	720.1	2.64
180.0	3.237	678.9	743.6	2.693
190.0	3.309	701.4	767.6	2.745
200.0	3.38	724.4	792	2.797

R600a	$p =$	0.03	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.81	-82.76	-0.3414
-40.0	0.0016	-61.91	-61.86	-0.2498
-30.0	1.141	309.3	343.5	1.48
-20.0	1.191	322.4	358.1	1.538
-10.0	1.24	335.9	373.1	1.596
0.0	1.289	349.8	388.5	1.654
10.0	1.338	364.2	404.3	1.711
20.0	1.387	379	420.6	1.767
30.0	1.435	394.3	437.4	1.824
40.0	1.484	410	454.5	1.879
50.0	1.532	426.2	472.2	1.935
60.0	1.58	442.9	490.3	1.99
70.0	1.628	460	508.9	2.045
80.0	1.677	477.6	527.9	2.1
90.0	1.725	495.7	547.4	2.154
100.0	1.773	514.2	567.4	2.208
110.0	1.821	533.2	587.8	2.262
120.0	1.869	552.7	608.7	2.316
130.0	1.917	572.6	630.1	2.37
140.0	1.965	592.9	651.9	2.423
150.0	2.013	613.7	674.1	2.476
160.0	2.061	635	696.8	2.529
170.0	2.109	656.7	719.9	2.582
180.0	2.156	678.8	743.5	2.635
190.0	2.204	701.3	767.5	2.687
200.0	2.252	724.3	791.9	2.739

R600a	$p =$	0.04	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.82	-82.75	-0.3414
-40.0	0.0016	-61.92	-61.85	-0.2498
-30.0	0.8513	308.8	342.8	1.436
-20.0	0.8889	322	357.5	1.496
-10.0	0.9263	335.5	372.6	1.554
0.0	0.9634	349.5	388	1.612
10.0	1	363.9	403.9	1.669
20.0	1.037	378.8	420.2	1.725
30.0	1.074	394.1	437	1.782
40.0	1.11	409.8	454.2	1.837
50.0	1.147	426	471.9	1.893
60.0	1.183	442.7	490	1.948
70.0	1.219	459.9	508.6	2.003
80.0	1.256	477.5	527.7	2.058
90.0	1.292	495.5	547.2	2.112
100.0	1.328	514.1	567.2	2.167
110.0	1.364	533.1	587.7	2.221
120.0	1.4	552.5	608.6	2.275
130.0	1.436	572.5	629.9	2.328
140.0	1.472	592.8	651.7	2.382
150.0	1.508	613.6	674	2.435
160.0	1.544	634.9	696.7	2.488
170.0	1.58	656.6	719.8	2.541
180.0	1.616	678.7	743.4	2.593
190.0	1.652	701.2	767.3	2.646
200.0	1.688	724.2	791.7	2.698

R600a	$p =$	0.05	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.82	-82.74	-0.3414
-40.0	0.0016	-61.92	-61.84	-0.2498
-30.0	0.00163	-40.59	-40.5	-0.1602
-20.0	0.7078	321.5	356.9	1.462
-10.0	0.738	335.1	372	1.52
0.0	0.768	349.2	387.6	1.578
10.0	0.7978	363.6	403.5	1.636
20.0	0.8274	378.5	419.9	1.692
30.0	0.8569	393.8	436.7	1.749
40.0	0.8863	409.6	453.9	1.805
50.0	0.9156	425.8	471.6	1.86
60.0	0.9448	442.5	489.8	1.916
70.0	0.9739	459.7	508.4	1.971
80.0	1.003	477.3	527.5	2.026
90.0	1.032	495.4	547	2.08
100.0	1.061	513.9	567	2.134
110.0	1.09	533	587.5	2.189
120.0	1.119	552.4	608.4	2.242
130.0	1.148	572.3	629.7	2.296
140.0	1.177	592.7	651.6	2.35
150.0	1.206	613.5	673.8	2.403
160.0	1.235	634.8	696.5	2.456
170.0	1.263	656.5	719.7	2.509
180.0	1.292	678.6	743.2	2.561
190.0	1.321	701.2	767.2	2.614
200.0	1.35	724.1	791.6	2.666

R600a	$p =$	0.06	[MPa]	
T	v	u	h	s
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.83	-82.73	-0.3415
-40.0	0.0016	-61.93	-61.83	-0.2498
-30.0	0.00163	-40.59	-40.49	-0.1602
-20.0	0.587	321.1	356.3	1.434
-10.0	0.6125	334.7	371.5	1.493
0.0	0.6377	348.8	387.1	1.551
10.0	0.6627	363.3	403.1	1.608
20.0	0.6876	378.2	419.5	1.665
30.0	0.7123	393.6	436.3	1.722
40.0	0.7369	409.4	453.6	1.778
50.0	0.7615	425.6	471.3	1.834
60.0	0.7859	442.3	489.5	1.889
70.0	0.8103	459.5	508.1	1.944
80.0	0.8346	477.1	527.2	1.999
90.0	0.8589	495.2	546.8	2.054
100.0	0.8832	513.8	566.8	2.108
110.0	0.9074	532.8	587.3	2.162
120.0	0.9315	552.3	608.2	2.216
130.0	0.9557	572.2	629.6	2.27
140.0	0.9798	592.6	651.4	2.323
150.0	1.004	613.4	673.7	2.377
160.0	1.028	634.7	696.4	2.43
170.0	1.052	656.4	719.5	2.482
180.0	1.076	678.5	743.1	2.535
190.0	1.1	701.1	767.1	2.587
200.0	1.124	724	791.5	2.639

R600a	$p =$	0.08	[MPa]	
T	v	u	h	s
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.84	-82.71	-0.3415
-40.0	0.0016	-61.94	-61.81	-0.2499
-30.0	0.00163	-40.61	-40.48	-0.1603
-20.0	0.00166	-18.81	-18.68	-0.07245
-10.0	0.4555	334	370.4	1.449
0.0	0.4748	348.1	386.1	1.507
10.0	0.4939	362.7	402.2	1.565
20.0	0.5128	377.6	418.7	1.622
30.0	0.5316	393.1	435.6	1.679
40.0	0.5502	408.9	452.9	1.735
50.0	0.5688	425.2	470.7	1.791
60.0	0.5873	441.9	488.9	1.847
70.0	0.6058	459.1	507.6	1.902
80.0	0.6241	476.8	526.7	1.957
90.0	0.6425	494.9	546.3	2.012
100.0	0.6607	513.5	566.4	2.066
110.0	0.679	532.6	586.9	2.12
120.0	0.6972	552	607.8	2.174
130.0	0.7154	572	629.2	2.228
140.0	0.7335	592.4	651.1	2.282
150.0	0.7517	613.2	673.4	2.335
160.0	0.7698	634.5	696.1	2.388
170.0	0.7879	656.2	719.2	2.441
180.0	0.806	678.3	742.8	2.493
190.0	0.8241	700.9	766.8	2.546
200.0	0.8421	723.9	791.2	2.598

R600a	$p =$	0.1	[MPa]	
T	v	u	h	s
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.85	-82.69	-0.3416
-40.0	0.0016	-61.95	-61.79	-0.2499
-30.0	0.00163	-40.62	-40.46	-0.1603
-20.0	0.00166	-18.83	-18.66	-0.07251
-10.0	0.3612	333.1	369.3	1.414
0.0	0.377	347.4	385.1	1.473
10.0	0.3925	362	401.3	1.531
20.0	0.4079	377.1	417.9	1.588
30.0	0.4231	392.5	434.9	1.645
40.0	0.4382	408.4	452.3	1.702
50.0	0.4532	424.8	470.1	1.758
60.0	0.4681	441.6	488.4	1.814
70.0	0.483	458.8	507.1	1.869
80.0	0.4978	476.5	526.3	1.924
90.0	0.5126	494.6	545.9	1.979
100.0	0.5273	513.2	566	2.033
110.0	0.5419	532.3	586.5	2.088
120.0	0.5566	551.8	607.5	2.142
130.0	0.5712	571.8	628.9	2.196
140.0	0.5858	592.2	650.7	2.249
150.0	0.6004	613	673	2.302
160.0	0.6149	634.3	695.8	2.356
170.0	0.6294	656	719	2.408
180.0	0.6439	678.2	742.6	2.461
190.0	0.6584	700.7	766.6	2.514
200.0	0.6729	723.7	791	2.566

R600a	$p =$	0.15	[MPa]	
T	v	u	h	s
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.0	0.00158	-82.88	-82.64	-0.3417
-40.0	0.0016	-61.98	-61.74	-0.2501
-30.0	0.00163	-40.65	-40.41	-0.1605
-20.0	0.00166	-18.86	-18.62	-0.07266
-10.0	0.00169	3.409	3.662	0.01365
0.0	0.2464	345.6	382.5	1.408
10.0	0.2572	360.4	399	1.467
20.0	0.2679	375.6	415.8	1.525
30.0	0.2784	391.2	433	1.583
40.0	0.2888	407.3	450.6	1.64
50.0	0.299	423.7	468.6	1.697
60.0	0.3092	440.6	487	1.753
70.0	0.3193	457.9	505.8	1.808
80.0	0.3294	475.6	525.1	1.864
90.0	0.3394	493.9	544.8	1.919
100.0	0.3493	512.5	564.9	1.973
110.0	0.3592	531.6	585.5	2.028
120.0	0.3691	551.2	606.5	2.082
130.0	0.3789	571.2	628	2.136
140.0	0.3888	591.6	649.9	2.19
150.0	0.3986	612.5	672.3	2.243
160.0	0.4083	633.8	695	2.296
170.0	0.4181	655.5	718.3	2.349
180.0	0.4279	677.7	741.9	2.402
190.0	0.4376	700.3	765.9	2.455
200.0	0.4473	723.3	790.4	2.507

R600a	$p =$	0.20	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00158	-82.91	-82.59	-0.3418
-40.00	0.0016	-62.02	-61.69	-0.2502
-30.00	0.00163	-40.69	-40.36	-0.1606
-20.00	0.00166	-18.9	-18.57	-0.07281
-10.00	0.00169	3.367	3.705	0.01349
0.0	0.00172	26.15	26.5	0.09848
10.00	0.1895	358.7	396.6	1.42
20.00	0.1978	374.1	413.7	1.479
30.00	0.206	389.9	431.1	1.537
40.00	0.214	406	448.8	1.595
50.00	0.2219	422.6	467	1.652
60.00	0.2297	439.6	485.5	1.708
70.00	0.2374	457	504.5	1.765
80.00	0.2451	474.8	523.8	1.82
90.00	0.2527	493.1	543.6	1.875
100.0	0.2603	511.8	563.8	1.93
110.0	0.2678	530.9	584.5	1.985
120.0	0.2753	550.5	605.6	2.039
130.0	0.2828	570.6	627.1	2.093
140.0	0.2902	591	649.1	2.147
150.0	0.2977	611.9	671.5	2.201
160.0	0.3051	633.3	694.3	2.254
170.0	0.3124	655	717.5	2.307
180.0	0.3198	677.2	741.2	2.36
190.0	0.3272	699.8	765.3	2.412
200.0	0.3345	722.9	789.8	2.465

R600a	$p =$	0.30	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00158	-82.96	-82.49	-0.3421
-40.00	0.0016	-62.08	-61.6	-0.2505
-30.00	0.00163	-40.76	-40.27	-0.1609
-20.00	0.00166	-18.98	-18.48	-0.07311
-10.00	0.00169	3.284	3.79	0.01317
0.0	0.00172	26.06	26.57	0.09814
10.00	0.00176	49.38	49.91	0.182
20.00	0.1275	370.9	409.1	1.41
30.00	0.1333	387	427	1.47
40.00	0.139	403.5	445.2	1.529
50.00	0.1446	420.3	463.7	1.587
60.00	0.1501	437.5	482.5	1.644
70.00	0.1555	455.1	501.7	1.701
80.00	0.1608	473	521.3	1.757
90.00	0.166	491.5	541.3	1.813
100.0	0.1713	510.3	561.7	1.868
110.0	0.1764	529.5	582.5	1.923
120.0	0.1815	549.2	603.7	1.978
130.0	0.1866	569.3	625.3	2.032
140.0	0.1917	589.9	647.4	2.086
150.0	0.1967	610.9	669.9	2.14
160.0	0.2018	632.2	692.8	2.194
170.0	0.2068	654.1	716.1	2.247
180.0	0.2118	676.3	739.8	2.3
190.0	0.2167	698.9	764	2.353
200.0	0.2217	722	788.5	2.405

R600a	$p =$	0.40	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00158	-83.02	-82.39	-0.3423
-40.00	0.0016	-62.14	-61.5	-0.2507
-30.00	0.00163	-40.82	-40.17	-0.1612
-20.00	0.00166	-19.05	-18.39	-0.0734
-10.00	0.00169	3.2	3.875	0.01285
0.0	0.00172	25.96	26.65	0.0978
10.00	0.00176	49.27	49.98	0.1817
20.00	0.0018	73.17	73.89	0.2646
30.00	0.0968	384	422.7	1.418
40.00	0.1014	400.8	441.3	1.478
50.00	0.1058	417.9	460.2	1.538
60.00	0.1102	435.3	479.4	1.596
70.00	0.1144	453.1	498.8	1.654
80.00	0.1186	471.2	518.6	1.711
90.00	0.1227	489.8	538.8	1.767
100.0	0.1267	508.7	559.4	1.823
110.0	0.1307	528.1	580.4	1.878
120.0	0.1346	547.9	601.7	1.933
130.0	0.1385	568.1	623.5	1.988
140.0	0.1424	588.7	645.7	2.042
150.0	0.1463	609.7	668.2	2.096
160.0	0.1501	631.2	691.2	2.15
170.0	0.1539	653.1	714.6	2.203
180.0	0.1577	675.3	738.4	2.257
190.0	0.1615	698	762.6	2.309
200.0	0.1653	721.1	787.2	2.362

R600a	$p =$	0.60	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00158	-83.13	-82.19	-0.3428
-40.00	0.0016	-62.26	-61.3	-0.2513
-30.00	0.00163	-40.96	-39.98	-0.1617
-20.00	0.00166	-19.2	-18.21	-0.074
-10.00	0.00169	3.034	4.046	0.01222
0.0	0.00172	25.78	26.81	0.09712
10.00	0.00176	49.07	50.12	0.1809
20.00	0.00179	72.94	74.01	0.2638
30.00	0.00184	97.43	98.54	0.3461
40.00	0.00188	122.6	123.8	0.4279
50.00	0.06676	412.5	452.5	1.462
60.00	0.07002	430.5	472.5	1.523
70.00	0.07315	448.8	492.7	1.583
80.00	0.07618	467.3	513	1.641
90.00	0.07913	486.2	533.7	1.699
100.0	0.08202	505.5	554.7	1.756
110.0	0.08484	525.1	576	1.812
120.0	0.08762	545.1	597.7	1.868
130.0	0.09036	565.5	619.7	1.923
140.0	0.09307	586.3	642.1	1.978
150.0	0.09575	607.4	664.9	2.033
160.0	0.09841	629	688.1	2.087
170.0	0.101	651	711.6	2.141
180.0	0.1037	673.4	735.6	2.194
190.0	0.1063	696.2	759.9	2.247
200.0	0.1088	719.4	784.7	2.3

R600a	$p =$	0.80	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-83.24	-81.98	-0.3433
-40.00	0.0016	-62.39	-61.11	-0.2518
-30.00	0.00163	-41.1	-39.79	-0.1623
-20.00	0.00166	-19.35	-18.03	-0.07459
-10.00	0.00169	2.868	4.218	0.01159
0.0	0.00172	25.6	26.97	0.09644
10.00	0.00175	48.86	50.26	0.1802
20.00	0.00179	72.7	74.14	0.263
30.00	0.00183	97.17	98.64	0.3452
40.00	0.00188	122.3	123.8	0.427
50.00	0.00193	148.2	149.8	0.5085
60.00	0.04962	425	464.7	1.464
70.00	0.05229	444	485.8	1.527
80.00	0.05481	463	506.9	1.587
90.00	0.05723	482.4	528.1	1.647
100.0	0.05957	502	549.6	1.705
110.0	0.06184	521.9	571.3	1.762
120.0	0.06405	542.1	593.4	1.819
130.0	0.06622	562.7	615.7	1.875
140.0	0.06836	583.7	638.4	1.931
150.0	0.07046	605	661.4	1.986
160.0	0.07253	626.8	684.8	2.04
170.0	0.07458	648.9	708.5	2.095
180.0	0.0766	671.4	732.7	2.149
190.0	0.07861	694.3	757.2	2.202
200.0	0.08061	717.5	782	2.255

R600a	$p =$	1.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-83.36	-81.78	-0.3438
-40.00	0.0016	-62.51	-60.91	-0.2523
-30.00	0.00163	-41.23	-39.6	-0.1629
-20.00	0.00166	-19.5	-17.85	-0.07518
-10.00	0.00169	2.703	4.389	0.01096
0.0	0.00172	25.41	27.13	0.09577
10.00	0.00175	48.66	50.41	0.1795
20.00	0.00179	72.47	74.26	0.2623
30.00	0.00183	96.91	98.74	0.3443
40.00	0.00188	122	123.9	0.426
50.00	0.00193	147.9	149.8	0.5074
60.00	0.00199	174.6	176.6	0.5891
70.00	0.03951	438.4	477.9	1.477
80.00	0.0418	458.2	500	1.541
90.00	0.04395	478.1	522.1	1.602
100.0	0.04599	498.1	544.1	1.662
110.0	0.04795	518.4	566.4	1.721
120.0	0.04985	539	588.8	1.779
130.0	0.05169	559.8	611.5	1.836
140.0	0.05348	581	634.5	1.892
150.0	0.05524	602.5	657.8	1.948
160.0	0.05697	624.4	681.4	2.003
170.0	0.05868	646.7	705.3	2.058
180.0	0.06036	669.3	729.7	2.112
190.0	0.06202	692.3	754.3	2.166
200.0	0.06366	715.7	779.3	2.219

R600a	$p =$	1.50	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-83.63	-81.27	-0.3451
-40.00	0.0016	-62.81	-60.42	-0.2536
-30.00	0.00163	-41.57	-39.13	-0.1643
-20.00	0.00165	-19.87	-17.39	-0.07665
-10.00	0.00168	2.295	4.821	0.0094
0.0	0.00172	24.96	27.53	0.0941
10.00	0.00175	48.15	50.77	0.1777
20.00	0.00179	71.9	74.58	0.2603
30.00	0.00183	96.26	99.01	0.3422
40.00	0.00187	121.3	124.1	0.4236
50.00	0.00192	147	149.9	0.5048
60.00	0.00198	173.6	176.6	0.586
70.00	0.00205	201.1	204.2	0.6677
80.00	0.00212	229.8	233	0.7505
90.00	0.02564	464.8	503.3	1.504
100.0	0.02747	486.7	527.9	1.571
110.0	0.02913	508.4	552	1.635
120.0	0.03067	530	576	1.697
130.0	0.03213	551.7	599.9	1.757
140.0	0.03352	573.6	623.8	1.815
150.0	0.03486	595.7	648	1.873
160.0	0.03615	618.1	672.3	1.93
170.0	0.03741	640.7	696.9	1.986
180.0	0.03864	663.7	721.7	2.041
190.0	0.03985	687.1	746.8	2.096
200.0	0.04103	710.7	772.3	2.151

R600a	$p =$	2.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-83.91	-80.77	-0.3463
-40.00	0.0016	-63.12	-59.92	-0.255
-30.00	0.00162	-41.9	-38.65	-0.1656
-20.00	0.00165	-20.24	-16.93	-0.07811
-10.00	0.00168	1.89	5.254	0.00785
0.0	0.00171	24.51	27.94	0.09244
10.00	0.00175	47.65	51.15	0.1759
20.00	0.00178	71.34	74.91	0.2584
30.00	0.00183	95.63	99.28	0.3401
40.00	0.00187	120.6	124.3	0.4213
50.00	0.00192	146.2	150	0.5022
60.00	0.00197	172.6	176.6	0.583
70.00	0.00204	199.9	204	0.6642
80.00	0.00211	228.4	232.6	0.7462
90.00	0.0022	258.2	262.6	0.83
100.0	0.00233	290.1	294.7	0.9173
110.0	0.01919	495	533.4	1.555
120.0	0.02073	518.7	560.2	1.624
130.0	0.0221	541.9	586.1	1.689
140.0	0.02335	564.8	611.6	1.752
150.0	0.02453	587.8	636.9	1.812
160.0	0.02564	610.9	662.2	1.871
170.0	0.0267	634.2	687.6	1.929
180.0	0.02773	657.6	713.1	1.986
190.0	0.02872	681.4	738.8	2.042
200.0	0.02968	705.4	764.8	2.098

R600a	$p =$	2.50	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-84.18	-80.26	-0.3476
-40.00	0.0016	-63.42	-59.43	-0.2563
-30.00	0.00162	-42.23	-38.17	-0.167
-20.00	0.00165	-20.6	-16.47	-0.07955
-10.00	0.00168	1.49	5.691	0.00631
0.0	0.00171	24.07	28.35	0.0908
10.00	0.00175	47.16	51.52	0.1741
20.00	0.00178	70.79	75.25	0.2565
30.00	0.00182	95.01	99.56	0.338
40.00	0.00186	119.8	124.5	0.419
50.00	0.00191	145.4	150.2	0.4996
60.00	0.00197	171.7	176.6	0.5801
70.00	0.00203	198.8	203.9	0.6608
80.00	0.0021	227	232.2	0.7422
90.00	0.00219	256.4	261.9	0.825
100.0	0.0023	287.6	293.3	0.9104
110.0	0.00246	321.6	327.8	1.002
120.0	0.01424	502.9	538.5	1.547
130.0	0.01577	529.3	568.7	1.623
140.0	0.01705	554.3	596.9	1.692
150.0	0.01819	578.6	624.1	1.757
160.0	0.01923	602.7	650.8	1.82
170.0	0.02021	626.8	677.3	1.88
180.0	0.02113	650.9	703.7	1.939
190.0	0.02201	675.2	730.2	1.997
200.0	0.02285	699.6	756.8	2.053

R600a	$p =$	3.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-84.46	-79.75	-0.3488
-40.00	0.00159	-63.71	-58.93	-0.2575
-30.00	0.00162	-42.55	-37.69	-0.1684
-20.00	0.00165	-20.96	-16.01	-0.08099
-10.00	0.00168	1.095	6.13	0.00479
0.0	0.00171	23.63	28.76	0.08918
10.00	0.00174	46.67	51.9	0.1724
20.00	0.00178	70.25	75.58	0.2546
30.00	0.00182	94.4	99.85	0.336
40.00	0.00186	119.2	124.7	0.4167
50.00	0.00191	144.6	150.3	0.4971
60.00	0.00196	170.7	176.6	0.5773
70.00	0.00202	197.7	203.8	0.6576
80.00	0.00209	225.6	231.9	0.7384
90.00	0.00217	254.7	261.2	0.8203
100.0	0.00227	285.3	292.1	0.9042
110.0	0.00241	318.2	325.4	0.9922
120.0	0.00265	355.7	363.6	1.091
130.0	0.01103	510.8	543.9	1.545
140.0	0.01259	540.5	578.3	1.629
150.0	0.01382	567.4	608.9	1.702
160.0	0.01487	593.2	637.8	1.77
170.0	0.01581	618.4	665.8	1.834
180.0	0.01669	643.4	693.5	1.896
190.0	0.01751	668.4	720.9	1.955
200.0	0.01828	693.4	748.2	2.014

R600a	$p =$	3.50	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-84.73	-79.24	-0.35
-40.00	0.00159	-64.01	-58.43	-0.2588
-30.00	0.00162	-42.88	-37.21	-0.1697
-20.00	0.00165	-21.31	-15.55	-0.08241
-10.00	0.00168	0.7036	6.571	0.00328
0.0	0.00171	23.2	29.17	0.08757
10.00	0.00174	46.19	52.28	0.1707
20.00	0.00178	69.71	75.93	0.2527
30.00	0.00181	93.8	100.1	0.334
40.00	0.00186	118.5	125	0.4145
50.00	0.0019	143.8	150.5	0.4947
60.00	0.00195	169.8	176.7	0.5745
70.00	0.00201	196.7	203.7	0.6544
80.00	0.00208	224.4	231.7	0.7347
90.00	0.00216	253.2	260.7	0.8158
100.0	0.00225	283.3	291.2	0.8986
110.0	0.00238	315.3	323.6	0.9843
120.0	0.00256	350.4	359.4	1.076
130.0	0.00298	394.9	405.3	1.192
140.0	0.00893	519.9	551.1	1.551
150.0	0.01048	553	589.7	1.643
160.0	0.01164	581.7	622.4	1.719
170.0	0.01261	608.7	652.9	1.789
180.0	0.01348	635	682.1	1.854
190.0	0.01427	660.9	710.8	1.917
200.0	0.015	686.6	739.1	1.977

R600a	$p =$	4.00	[MPa]	
$T$	$v$	$u$	$h$	$s$
[C]	[m <sup>3</sup> /kg]	[kJ/kg]	[kJ/kg]	[kJ/kg K]
-50.00	0.00157	-84.99	-78.72	-0.3512
-40.00	0.00159	-64.3	-57.93	-0.2601
-30.00	0.00162	-43.2	-36.73	-0.171
-20.00	0.00165	-21.67	-15.08	-0.08383
-10.00	0.00167	0.3164	7.015	0.00178
0.0	0.00171	22.77	29.59	0.08598
10.00	0.00174	45.72	52.67	0.169
20.00	0.00177	69.19	76.28	0.2509
30.00	0.00181	93.21	100.5	0.332
40.00	0.00185	117.8	125.2	0.4124
50.00	0.0019	143.1	150.6	0.4923
60.00	0.00195	169	176.8	0.5719
70.00	0.002	195.7	203.7	0.6514
80.00	0.00207	223.2	231.4	0.7312
90.00	0.00214	251.7	260.3	0.8117
100.0	0.00223	281.4	290.3	0.8934
110.0	0.00235	312.7	322.1	0.9773
120.0	0.00251	346.4	356.4	1.066
130.0	0.00277	384.8	395.9	1.165
140.0	0.00409	453.4	469.7	1.345
150.0	0.00764	531.9	562.5	1.568
160.0	0.00908	567.2	603.6	1.664
170.0	0.01014	597.3	637.9	1.742
180.0	0.01103	625.4	669.6	1.813
190.0	0.01182	652.6	699.9	1.879
200.0	0.01253	679.3	729.4	1.942



## Valori di $c_p$ , $c_v$ e $k$ per vari gas ideali in funzione di $T$

Temp	Aria			Azoto			Ossigeno			Temp
K	$c_p$	$c_v$	$k$	$c_p$	$c_v$	$k$	$c_p$	$c_v$	$k$	K
250	1.003	0.716	1.401	1.039	0.742	1.400	0.913	0.653	1.398	250
300	1.005	0.718	1.400	1.039	0.743	1.400	0.918	0.658	1.395	300
350	1.008	0.721	1.398	1.041	0.744	1.399	0.928	0.668	1.389	350
400	1.013	0.726	1.395	1.044	0.747	1.397	0.941	0.681	1.382	400
450	1.020	0.733	1.391	1.049	0.752	1.395	0.956	0.696	1.373	450
500	1.029	0.742	1.387	1.056	0.759	1.391	0.972	0.712	1.365	500
550	1.040	0.753	1.381	1.065	0.768	1.387	0.988	0.728	1.358	550
600	1.051	0.764	1.376	1.075	0.778	1.382	1.003	0.743	1.350	600
650	1.063	0.776	1.370	1.086	0.789	1.376	1.017	0.758	1.343	650
700	1.075	0.788	1.364	1.098	0.801	1.371	1.031	0.771	1.337	700
750	1.087	0.800	1.359	1.110	0.813	1.365	1.043	0.783	1.332	750
800	1.099	0.812	1.354	1.121	0.825	1.360	1.054	0.794	1.327	800
900	1.121	0.834	1.344	1.145	0.849	1.349	1.074	0.814	1.319	900
1000	1.142	0.855	1.336	1.167	0.870	1.341	1.090	0.830	1.313	1000

Temp	Anidride Carbonica			Monoss. di Carbonio			Idrogeno			Temp
K	$c_p$	$c_v$	$k$	$c_p$	$c_v$	$k$	$c_p$	$c_v$	$k$	K
250	0.791	0.602	1.314	1.039	0.743	1.400	14.051	9.927	1.416	250
300	0.846	0.657	1.288	1.040	0.744	1.399	14.307	10.183	1.405	300
350	0.895	0.706	1.268	1.043	0.746	1.398	14.427	10.302	1.400	350
400	0.939	0.750	1.252	1.047	0.751	1.395	14.476	10.352	1.398	400
450	0.978	0.790	1.239	1.054	0.757	1.392	14.501	10.377	1.398	450
500	1.014	0.825	1.229	1.063	0.767	1.387	14.513	10.389	1.397	500
550	1.046	0.857	1.220	1.075	0.778	1.382	14.530	10.405	1.396	550
600	1.075	0.886	1.213	1.087	0.790	1.376	14.546	10.422	1.396	600
650	1.102	0.913	1.207	1.100	0.803	1.370	14.571	10.447	1.395	650
700	1.126	0.937	1.202	1.113	0.816	1.364	14.604	10.480	1.394	700
750	1.148	0.959	1.197	1.126	0.829	1.358	14.645	10.521	1.392	750
800	1.169	0.980	1.193	1.139	0.842	1.353	14.695	10.570	1.390	800
900	1.204	1.015	1.186	1.163	0.866	1.343	14.822	10.698	1.385	900
1000	1.234	1.045	1.181	1.185	0.888	1.335	14.983	10.859	1.380	1000

### Valori del calore specifico $c$ per liquidi

Liquido	Stato	$c$ (kJ/kgK)
Ammoniaca	sat. liq., -20°C	4.52
	sat. liq., 10°C	4.67
	sat. liq., 50°C	5.10
Alcool etilico	1 atm, 25°C	2.43
Glicerina	1 atm, 10°C	2.32
	1 atm, 50°C	2.58
Mercurio	1 atm, 10°C	0.138
	1 atm, 315°C	0.134
Refrigerante 12	sat. liq., -20°C	0.90
	sat. liq., 20°C	0.96
Acqua	1 atm, 0°C	4.217
	1 atm, 27°C	4.179
	1 atm, 100°C	4.218

### Valori del calore specifico $c$ per solidi

Solido	$T$ (K)	$c$ (kJ/kg K)
Alluminio	300	0.903
Argento	300	0.235
Ferro	300	0.447
Ghiaccio	200	1.56
	240	1.86
	273	2.11
Piombo	300	0.129
Rame	300	0.385
	400	0.393

## APPENDICE 4 - Unità di misura – Sistema Internazionale

Per caratterizzare un sistema fisico, siamo soliti definirne le proprietà: tali sono ad esempio la lunghezza, il volume, la temperatura, etc. *Misurare* vuol dire *assegnare mediante una procedura codificata un numero per rappresentare una proprietà*. Alcune misure (es. quelle di lunghezza sono di tipo *diretto*, ovvero si va a vedere quante volte un campione (in questo caso il metro, od un suo multiplo o sottomultiplo) è contenuto nella grandezza da misurare. La maggior parte delle misure è tuttavia di tipo *indiretto*, ovvero si misura in realtà una proprietà correlata in maniera nota a quella da misurare effettivamente: nel caso della temperatura, si misura la lunghezza di una colonnina di mercurio, o la differenza di potenziale ai capi di un dispositivo elettronico.

Le unità di misura sono state definite dall'uomo nel corso della storia in maniera caotica e scoordinata. Soltanto all'inizio dell'800, con la introduzione del sistema metrico decimale, è iniziato un processo di razionalizzazione e unificazione, che è culminato nella creazione del Sistema Internazionale di Unità di Misura, indicato semplicemente come sistema SI.

Tale sistema è basato sulla definizione di:

- un numero limitato di *grandezze fondamentali*, le cui unità sono definite dalla loro stessa procedura di misura;
- e di *grandezze derivate*, le cui unità di misura derivano dalle leggi fisiche che le definiscono.

Ad esempio, una volta definite le unità fondamentali di spazio (il metro, m) e tempo (il secondo, s), non è necessaria una ulteriore unità fondamentale per la velocità: essendo la velocità uguale allo spazio diviso il tempo, la sua unità è m/s.

Le grandezze fondamentali di cui abbiamo bisogno sono solo sette: *lunghezza* (metro, m), *tempo* (secondo, s), *massa* (chilogrammo, kg), *temperatura* (kelvin, K), *corrente elettrica* (ampere, A), *ammontare di sostanza* (mole, mol), *intensità luminosa* (candela, cd). Le loro definizioni sono riportate alla fine di questo paragrafo. Recentemente, le definizioni di chilogrammo e kelvin sono state aggiornate per potere fare a meno di uno standard fisico

Tra le numerosissime grandezze derivate, quelle che ci interessano maggiormente sono la *forza* (newton,  $N=kg\ m/s^2$ ), il *lavoro* (joule,  $J=N\ m$ ) e la *potenza* (watt,  $W=J/s$ ).

Le unità definite con questa procedura hanno il pregio della razionalità, in quanto non richiedono l'introduzione di fattori di conversione all'interno delle formule; per contro, talvolta esse sono troppo grandi o troppo piccole rispetto alle grandezze con cui di ha a che fare in pratica, per cui è necessario usare i loro multipli o sottomultipli. Essi si ottengono aggiungendo un prefisso alla grandezza. I prefissi definiti variano da  $10^{-24}$  a  $10^{24}$  e sono riportati nella seguente tabella 1.

Prefisso	Simb.	Fattore	Prefisso	Simb.	Fattore	Prefisso	Simb.	Fattore
yotta	Y	$10^{24}$	etto	h	$10^2$	milli	m	$10^{-3}$
zetta	Z	$10^{21}$	deca	da	$10^1$	micro	$\mu$	$10^{-6}$
exa	E	$10^{18}$				nano	n	$10^{-9}$
peta	P	$10^{15}$				pico	p	$10^{-12}$
tera	T	$10^{12}$				femto	f	$10^{-15}$
giga	G	$10^9$				atto	a	$10^{-18}$
mega	M	$10^6$	deci	d	$10^{-1}$	zepto	z	$10^{-21}$
kilo	k	$10^3$	centi	c	$10^{-2}$	yocto	y	$10^{-24}$

**Tabella 1:** prefissi per multipli e sottomultipli nel sistema SI.

La pressione (forza diviso superficie) ha come unità di misura  $N/m^2$ , detto anche *pascal* (Pa). La pressione atmosferica standard equivale a 101325 Pa, per cui nella pratica si usano i multipli kPa o MPa. E' molto usato anche il *bar* (100 kPa) che però non è un multiplo standard del sistema SI.

Accanto alle unità SI (il cui uso è obbligatorio per legge nei documenti ufficiali, anche se spesso questa regola viene violata) sopravvivono le vecchie unità pratiche, che è necessario convertire con appositi fattori di conversione (vedi tabelle seguenti). Ad esempio, sono unità pratiche di energia la kilocaloria (1 kcal = 4186 J) ed il chilowattora (1 kWh = 3.6 MJ), la British Thermal Unit (1 BTU= 1016 J).

Per maggiori dettagli si veda ad es. Colombo, Manuale dell'Ingegnere, ed. Hoepli, sezione P.

**Tablelle di conversione tra unità di misura**

a) Unità di forza

Unità di misura	N	dine	kgf	pdl	lbf
1 N =	1	$10^5$	0.102	7.23	0.225
1 dina =	$10^{-5}$	1	$1.02 \cdot 10^{-6}$	$7.23 \cdot 10^{-5}$	$2.25 \cdot 10^{-6}$
1 kgf =	9.80665*	$9.81 \cdot 10^5$	1	70.9	2.205
1 pdl** =	0.138	$1.38 \cdot 10^4$	$1.41 \cdot 10^{-2}$	1	0.031
1 lbf =	4.44	$4.44 \cdot 10^5$	0.4536	32.1740	1

\* valore esatto per convenzione internazionale approssimato a 9.81 nei calcoli pratici

\*\* (lbf ft/s<sup>2</sup>) Poundal

b) Unità di pressione

Unità di misura	Pa	bar	atm	torr	at	Kgf/m <sup>2</sup>	psi
1 Pa =	1	$10^{-5}$	$9.87 \cdot 10^{-6}$	$7.5 \cdot 10^{-3}$	$1.02 \cdot 10^{-5}$	0.102	$1.45 \cdot 10^{-4}$
1 bar =	$10^5$	1	0.987	$7.5 \cdot 10^{-2}$	1.02	$102 \cdot 10^{-2}$	14.5
1 atm =	101325	0.01325	1	760	1.033	$1.033 \cdot 10^4$	14.696
1 torr = (mm Hg)	133.322	$1.33 \cdot 10^{-3}$	$1.31 \cdot 10^{-3}$	1	$1.359 \cdot 10^{-3}$	13.595	$1.93 \cdot 10^{-2}$
1 at =	98066.5	0.980665	0.968	735.5	1	$10^4$	14.22
1 kgf/m <sup>2</sup>	9.80665	$9.81 \cdot 10^{-5}$	$9.68 \cdot 10^{-5}$	$7.355 \cdot 10^{-2}$	$10^{-4}$	1	$1.42 \cdot 10^{-3}$
1 psi (lbf/in <sup>2</sup> )	6894.76	$6.89 \cdot 10^{-2}$	$6.8 \cdot 10^{-2}$	51.7	$7.03 \cdot 10^{-2}$	703.07	1
1 baria (dine/cm <sup>2</sup> )	0.1	$10^{-6}$	$9.87 \cdot 10^{-7}$	$7.5 \cdot 10^{-4}$	$1.02 \cdot 10^{-6}$	0.0102	$1.45 \cdot 10^{-5}$

c) Unità di energia

Unità di misura	J	erg	kgf m	kWh	Cvh	kcal <sub>IT</sub>	lbf ft	Btu <sub>IT</sub>
1 J=	1	10 <sup>7</sup>	0.102	2.78 10 <sup>-7</sup>	3.78 10 <sup>-7</sup>	0.239 10 <sup>-3</sup>	0.783	0.948 10 <sup>-3</sup>
1 erg=	10 <sup>-7</sup>	1	0.102 10 <sup>-7</sup>	2.78 10 <sup>-14</sup>	3.78 10 <sup>-14</sup>	0.239 10 <sup>-10</sup>	0.783 10 <sup>-7</sup>	0.948 10 <sup>-10</sup>
1 kgf m=	9.80665	9.81 10 <sup>7</sup>	1	2.72 10 <sup>-6</sup>	3.704 10 <sup>-6</sup>	2.34 10 <sup>-3</sup>	7.23	9.3 10 <sup>-3</sup>
1 kWh=	3.6 10 <sup>6</sup>	3.6 10 <sup>13</sup>	3.6 10 <sup>5</sup>	1	1.3596	859.845	2.66 10 <sup>6</sup>	3.41 10 <sup>3</sup>
1 Cvh=	2.648 10 <sup>6</sup>	2.648 10 <sup>13</sup>	270000	0.735	1	632.4	1.953 10 <sup>6</sup>	2509.6
1 kcal <sub>IT</sub> =	4186.8	4186.8 10 <sup>7</sup>	426.9	1.163 10 <sup>-3</sup>	1.58 10 <sup>-3</sup>	1	3.09 10 <sup>3</sup>	3.97
1 lbf ft=	1.36	1.36 10 <sup>7</sup>	0.138	3.77 10 <sup>-7</sup>	5.12 10 <sup>-7</sup>	3.24 10 <sup>-4</sup>	1	1.29 10 <sup>-3</sup>
1 Btu <sub>IT</sub> =	1055.06	1055.06 10 <sup>7</sup>	107.6	2.93 10 <sup>-4</sup>	3.98 10 <sup>-4</sup>	0.252	778.169	1

d) Unità di potenza

Unità di misura	W	kgf m/s	Cv	kcal <sub>IT</sub> /h	ft lbf/s	Btu <sub>IT</sub> /h
1 W=	1	0.102	1.36 10 <sup>-3</sup>	0.8594	0.738	3.414
1 kgf m/s=	9.80665	1	1.33 10 <sup>-2</sup>	8.432	7.23	33.46
1 Cv=	735.5	75	1	632.4	542.5	2509.6
1 kcal <sub>IT</sub> /h=	1.163	0.1186	1.58 10 <sup>-3</sup>	1	0.585	3.97
1 ft lbf/s=	1.36	0.138	1.84 10 <sup>-3</sup>	1.166	1	4.626
1 Btu <sub>IT</sub> /h=	0.293	2.988 10 <sup>-2</sup>	3.98 10 <sup>-4</sup>	0.252	0.216	1

*Costanti fisiche notevoli*

Costante universale dei gas	$R = 8.31445 \pm 0.00034 \text{ kJ/kmol K}$
Numero di Avogadro	$N_A = 6.022214076 \times 10^{26} \text{ molecole/kmol}$
Volume molare del gas ideale in condizioni normali (1 bar e 273.15 K)	$V_0 = 22.4139 \pm 0.0006 \text{ m}^3/\text{kmol}$
Pressione atmosferica standard (a livello del mare)	$p = 101.325 \text{ kPa}$
Accelerazione standard di gravità	$g_0 = 9.80665 \text{ m/s}^2$
Costante di Stefan-Boltzmann	$\sigma = 5.673 \cdot 10^{-8} \text{ W/m}^2 \text{ K}^4$
Costante di Planck	$h = 6.62607015 \times 10^{-34} \text{ J s}$
Costante di Boltzmann	$k = 1.380649 \cdot 10^{-23} \text{ J/K}$
Velocità della luce nel vuoto	$c_0 = (2.997925 \pm 0.000003) \cdot 10^8 \text{ m/s}$
Carica dell'elettrone	$e = 1.602176634 \times 10^{-19} \text{ C}$

*Definizioni delle grandezze fondamentali*

- **secondo (s)**: la durata di 9 192 631 770 periodi della radiazione corrispondente alla transizione tra i due livelli iperfini dello stato fondamentale dell'atomo di cesio 133.
- **metro (m)**: lunghezza del tragitto percorso dalla luce nel vuoto in un intervallo di tempo di 1/(299 792 458) di secondo.
- **kilogrammo (kg)**:  $1.4755214 \times 10^{40} (9 \ 192 \ 631 \ 770 \ h / c^2)$  dove  $h$  è la costante di Planck e  $c$  la velocità della luce. In pratica, ci si basa sul valore della costante di Planck che è pari a  $6.62607015 \times 10^{-34} \text{ J s} = \text{kg m}^2/\text{s}$  e sulle definizioni di metro e secondo. In precedenza: la massa del prototipo internazionale del kilogrammo, conservato al museo di pesi e misure di Sevres, Parigi.

- **ampere (A)**: la corrente elettrica che corrisponde al passaggio di  $1/e$  cariche elementari per secondo dove  $e = 1.602176634 \times 10^{-19}$  C è la *carica dell'elettrone*. In precedenza: l'intensità di una corrente elettrica costante che, mantenuta in due conduttori rettilinei paralleli di lunghezza infinita, di sezione circolare trascurabile, posti alla distanza di un metro l'uno dall'altro nel vuoto, produrrebbe tra gli stessi una forza pari a  $2 \times 10^{-7}$  N per metro di lunghezza.
- **kelvin (K)**: Un kelvin è la differenza di temperatura termodinamica corrispondente a una differenza di energia termica pari a  $k_B T$ , dove  $k_B = 1.380649 \times 10^{-23}$  J/K è il valore della *costante di Boltzmann*. (definizione precedente: la frazione  $1/273.16$  della temperatura termodinamica del punto triplo dell'acqua).
- **mole (mol)**: la quantità di sostanza di un sistema che contiene un numero di atomi pari al *numero di Avogadro*  $= 6.022214076 \times 10^{23}$ .
- **candela (cd)**: l'intensità luminosa, in una determinata direzione, di una sorgente che emette una radiazione monocromatica di frequenza  $540 \times 10^{12}$  Hz e la cui intensità in tale direzione è di  $1/683$  di watt per steradiante.

### **APPENDICE 5 – Metodologia di risoluzione di problemi di termodinamica**

Il primo passo in una analisi termodinamica è la identificazione del sistema delle sue interazioni con l'esterno (es. il sistema è chiuso, aperto, le pareti sono adiabatiche, etc.).

Devono quindi essere prese in considerazione le leggi fisiche che governano il comportamento del sistema e le altre relazioni pertinenti (es. leggi costitutive della sostanza presente nel sistema).

Nella maggior parte delle analisi si usano, direttamente o indirettamente, una o più delle seguenti tre equazioni di bilancio, che sono *indipendenti dalla particolare sostanza o sostanze considerate e dal tipo di trasformazione che avviene*:

- conservazione della massa
- conservazione dell'energia
- secondo principio della termodinamica

In aggiunta, di solito è necessario aggiungere i legami tra le proprietà della particolare sostanza o sostanze considerate: le cosiddette *equazioni di stato* della sostanza.

Per ottenere buoni risultati è necessario seguire un approccio sistematico. Bisogna evitare la tentazione di cominciare il problema dal mezzo, selezionando ad esempio alcune equazioni che sembrano appropriate, sostituendo numeri o semplicemente affidarsi al calcolatore.

E' fortemente consigliato perciò che la soluzione di un problema sia organizzata utilizzando i seguenti passi.

**Variabili note:** Descrivere concisamente e con parole proprie che cosa è noto. Questo richiede di aver letto il problema attentamente e di aver attentamente pensato ad esso.

**Variabili da determinare:** Definire in maniera concisa e con proprie parole che cosa deve essere determinato.

**Dati schematici:** Disegnare un piccolo quadro rappresentativo del sistema in considerazione. Decidere ad esempio se un sistema chiuso od aperto sono appropriati per l'analisi ed identificarne con precisione il contorno.

Identificare i diagrammi di stato che contengono rilevanti informazioni circa il problema in esame e disegnarli, localizzando i punti chiave e indicando, se possibile, la trasformazione eseguita dal sistema.

**Assunzioni:** Elencare tutte le assunzioni semplificative e le idealizzazioni che possono essere fatte.

**Analisi:** Utilizzando tutte le assunzioni e le idealizzazioni fatte, semplificare le equazioni che governano il fenomeno fino a formare la sequenza di esse che produrrà il risultato.

E' consigliabile lavorare con le equazioni, senza sostituire valori numerici, il più a lungo possibile, per evitare la accumulazione degli errori di arrotondamento nei calcoli successivi. In ogni caso, i calcoli devono essere condotti con un numero di cifre significative superiore (ma non eccessivamente!) a quello con cui si vuole ottenere la soluzione finale.

Quando le equazioni sono ridotte alla loro forma finale, analizzarle per vedere quali dati aggiuntivi sono richiesti. Per quanto possa sembrare ovvio, spesso ci si dimentica che il numero delle incognite deve essere pari a quello delle equazioni *indipendenti* che si hanno a disposizione. Identificare i dati, le tabelle, i diagrammi o le equazioni aggiuntive eventualmente necessarie.

Quando tutti i dati e tutte le equazioni sono disponibili, sostituire i valori numerici all'interno delle equazioni. *Controllare se c'è uniformità a livello dimensionale* e quindi eseguire i calcoli richiesti.

Alla fine, considerare se le grandezze dei valori numerici sembrano ragionevoli e se i segni algebrici associati ai valori numerici sono corretti