Related Commercial Resources

CHAPTER 30

THERMOPHYSICAL PROPERTIES OF REFRIGERANTS

THIS chapter presents data for thermodynamic and transport properties of refrigerants, arranged for the occasional user. The refrigerants have a thermodynamic property chart on pressure-enthalpy coordinates with an abbreviated set of tabular data for saturated liquid and vapor on the facing page. In addition, tabular data in the superheated vapor region are given for R-134a to assist students working on compression cycle examples.

For each cryogenic fluid, a second table of properties is provided for vapor at a pressure of one standard atmosphere; these data are needed when such gases are used in heat transfer or purge gas applications. For zeotropic blends, including R-729 (air), tables are incremented in pressure, with properties given for liquid on the bubble line and vapor on the dew line. This arrangement is used because pressure is more commonly measured in the field while servicing equipment; it also highlights the difference between bubble and dew-point temperatures (the "temperature glide" experienced with blends).

Most CFC refrigerants have been deleted. Tables for R-11, R-13, R-113, R-114, R-141b, R-142b, R-500, R-502, R-503, and R-720 (neon) may be found in the 1997 *ASHRAE Handbook—Fundamentals*. R-12 has been retained to assist in making comparisons. Revised formulations have been used for many refrigerants; these conform to international standards, where applicable. Thermodynamic properties of R-12, R-22, R-32, R-123, R-125, R-134a, R-143a, R-152a, R-717 (ammonia), and R-744 (carbon dioxide) and refrigerant blends R-404A, R-407C, R-410A, and R-507 conform to ISO/DIS *Draft Standard* 17584, Refrigerant Properties.

Reference states used for most refrigerants correspond to the international convention of 200 kJ/kg for enthalpy and 1 kJ/(kg·K) for entropy, both for saturated liquid at 0°C. Exceptions are water and fluids with very low critical temperatures (e.g., ethylene, cryogens).

These data are intended to help engineers make preliminary comparisons among unfamiliar fluids. For greater detail and a wider range of data, see the sources in the References.

Refrigerant	Page
Halocarbon Refrigerants	
Methane Series	
R-12 (dichlorodifluoromethane)	30.2
R-22 (chlorodifluoromethane)	30.4
R-23 (trifluoromethane)	30.6
R-32 (difluoromethane)	30.8
Ethane Series	
R-123 (2,2-dichloro-1,1,1-trifluoroethane)	30.10
R-124 (2-chloro-1,1,1,2-tetrafluoroethane)	30.12
R-125 (pentafluoroethane)	30.14
R-134a (1,1,1,2-tetrafluoroethane)	30.16
R-143a (1,1,1-trifluoroethane)	30.20
R-152a (1,1-difluoroethane)	30.22
Propane Series	
R-245fa (1,1,1,3,3-pentafluoropropane)	30.24
Zeotropic Blends (% by mass)	
R-404A [R-125/143a/134a (44/52/4)]	30.26
R-407C [R-32/125/134a (23/25/52)]	30.28
R-410A [R-32/125 (50/50)]	30.30
Azeotropic Blends	
R-507A [R-125/143a (50/50)]	30.32
Inorganic Refrigerants	
R-717 (ammonia)	30.34
R-718 (water/steam)	30.36
R-744 (carbon dioxide)	30.38
Hydrocarbon Refrigerants	
R-50 (methane)	30.40
R-170 (ethane)	30.42
R-290 (propane)	30.44
R-600 (*n*-butane)	30.46
R-600a (isobutane)	30.48
R-1150 (ethylene)	30.50
R-1270 (propylene)	30.52
Cryogenic Fluids	
R-702 (normal hydrogen)	30.54
R-702p (parahydrogen)	30.56
R-704 (helium)	30.58
R-728 (nitrogen)	30.60
R-729 (air)	30.62
R-732 (oxygen)	30.64
R-740 (argon)	30.66
Absorption Solutions	
Ammonia/Water	30.68
Water/Lithium Bromide	30.70

The preparation of this chapter is assigned to TC 3.1, Refrigerants and Secondary Coolants.

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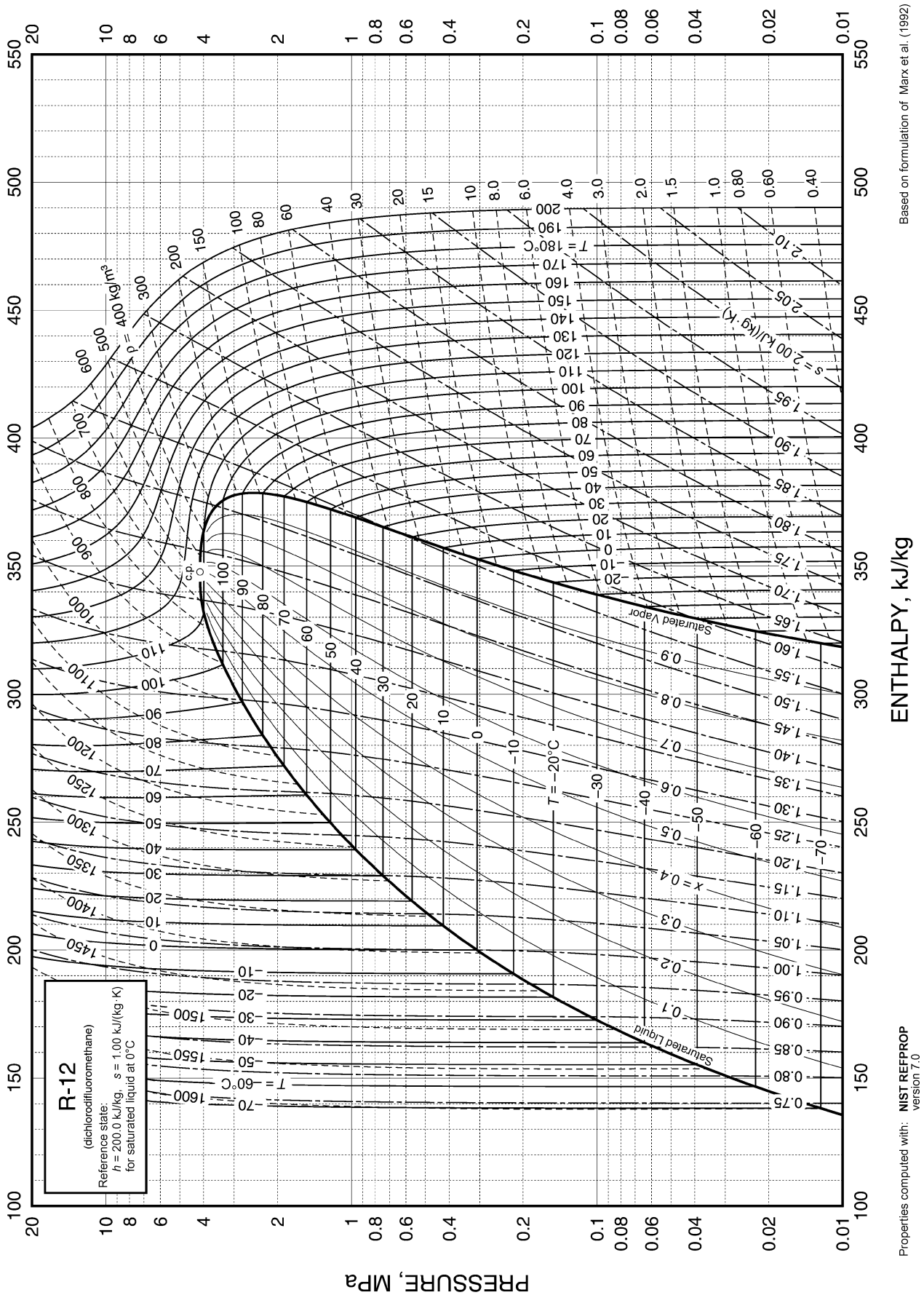

Fig. 1 Pressure-Enthalpy Diagram for Refrigerant 12

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Refrigerant 12 (Dichlorodifluoromethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–100	0.00119	1679.1	10.0040	113.32	306.09	0.6077	1.7210	0.819	0.449	1.182	1035	118.5	1005.0	6.78	116.7	4.27	26.48	–100
–90	0.00286	1652.8	4.3948	121.53	310.59	0.6538	1.6861	0.824	0.465	1.176	990	121.4	819.0	7.18	112.0	4.67	24.90	–90
–80	0.00619	1626.3	2.1355	129.81	315.19	0.6978	1.6576	0.831	0.481	1.172	945	124.1	684.9	7.58	107.4	5.08	23.35	–80
–70	0.01228	1599.5	1.1286	138.17	319.87	0.7400	1.6344	0.840	0.497	1.168	902	126.7	584.0	7.97	103.0	5.50	21.81	–70
–60	0.02261	1572.3	0.63992	146.62	324.61	0.7806	1.6156	0.850	0.513	1.166	859	129.1	505.1	8.37	98.8	5.93	20.30	–60
–50	0.03911	1544.7	0.38494	155.18	329.39	0.8197	1.6004	0.861	0.530	1.165	816	131.2	441.8	8.76	94.7	6.38	18.81	–50
–40	0.06409	1516.5	0.24342	163.86	334.18	0.8577	1.5882	0.873	0.548	1.166	775	133.0	389.8	9.16	90.7	6.84	17.35	–40
–30	0.10026	1487.7	0.16057	172.67	338.94	0.8946	1.5784	0.886	0.566	1.169	733	134.5	346.2	9.55	86.9	7.32	15.91	–30
–29.75[b]	0.10133	1487.0	0.15900	172.89	339.06	0.8955	1.5782	0.887	0.567	1.169	732	134.5	345.2	9.56	86.8	7.33	15.88	–29.75
–28	0.10910	1481.9	0.14841	174.44	339.89	0.9019	1.5767	0.889	0.570	1.170	725	134.7	338.3	9.63	86.1	7.41	15.63	–28
–26	0.11854	1476.0	0.13736	176.23	340.83	0.9091	1.5751	0.892	0.574	1.171	717	135.0	330.6	9.71	85.3	7.51	15.35	–26
–24	0.12860	1470.1	0.12731	178.02	341.78	0.9163	1.5735	0.895	0.578	1.171	709	135.2	323.2	9.79	84.6	7.61	15.06	–24
–22	0.13931	1464.1	0.11815	179.81	342.72	0.9234	1.5720	0.898	0.582	1.172	701	135.4	316.0	9.87	83.8	7.71	14.78	–22
–20	0.15070	1458.1	0.10978	181.62	343.65	0.9305	1.5706	0.901	0.586	1.174	693	135.6	309.0	9.95	83.1	7.80	14.50	–20
–18	0.16279	1452.1	0.10213	183.42	344.59	0.9376	1.5693	0.904	0.590	1.175	684	135.8	302.2	10.03	82.4	7.90	14.23	–18
–16	0.17562	1446.1	0.09512	185.24	345.52	0.9447	1.5680	0.907	0.594	1.176	676	136.0	295.6	10.10	81.6	8.01	13.95	–16
–14	0.18920	1440.0	0.08870	187.06	346.44	0.9517	1.5667	0.910	0.598	1.178	668	136.1	289.2	10.18	80.9	8.11	13.67	–14
–12	0.20358	1433.8	0.08280	188.89	347.37	0.9587	1.5655	0.913	0.602	1.179	660	136.3	283.0	10.26	80.2	8.21	13.40	–12
–10	0.21878	1427.6	0.07737	190.72	348.29	0.9656	1.5644	0.917	0.607	1.181	652	136.4	276.9	10.34	79.4	8.31	13.12	–10
–8	0.23483	1421.4	0.07237	192.56	349.20	0.9726	1.5633	0.920	0.611	1.183	644	136.5	271.0	10.42	78.7	8.41	12.85	–8
–6	0.25176	1415.1	0.06777	194.41	350.11	0.9795	1.5623	0.923	0.616	1.184	636	136.6	265.2	10.50	78.0	8.52	12.58	–6
–4	0.26960	1408.8	0.06352	196.27	351.01	0.9863	1.5613	0.927	0.620	1.186	628	136.6	259.6	10.58	77.3	8.62	12.31	–4
–2	0.28839	1402.5	0.05959	198.13	351.91	0.9932	1.5603	0.930	0.625	1.189	620	136.7	254.1	10.66	76.6	8.73	12.04	–2
0	0.30815	1396.1	0.05595	200.00	352.81	1.0000	1.5594	0.934	0.630	1.191	612	136.7	248.7	10.74	75.9	8.84	11.77	0
2	0.32891	1389.6	0.05258	201.88	353.69	1.0068	1.5586	0.938	0.635	1.193	604	136.7	243.5	10.82	75.1	8.95	11.51	2
4	0.35071	1383.1	0.04946	203.76	354.57	1.0136	1.5577	0.942	0.640	1.196	596	136.7	238.4	10.90	74.4	9.06	11.24	4
6	0.37358	1376.5	0.04656	205.65	355.45	1.0203	1.5569	0.946	0.645	1.199	588	136.7	233.4	10.98	73.7	9.17	10.98	6
8	0.39756	1369.9	0.04386	207.56	356.32	1.0270	1.5561	0.950	0.650	1.202	580	136.6	228.6	11.07	73.0	9.28	10.71	8
10	0.42267	1363.2	0.04135	209.46	357.18	1.0337	1.5554	0.954	0.656	1.205	572	136.5	223.8	11.15	72.3	9.39	10.45	10
12	0.44895	1356.5	0.03901	211.38	358.03	1.0404	1.5547	0.958	0.661	1.208	564	136.5	219.1	11.23	71.6	9.51	10.19	12
14	0.47643	1349.7	0.03683	213.31	358.88	1.0471	1.5540	0.962	0.667	1.211	556	136.3	214.6	11.31	70.9	9.62	9.94	14
16	0.50514	1342.8	0.03480	215.24	359.71	1.0537	1.5533	0.967	0.672	1.215	548	136.2	210.1	11.40	70.2	9.74	9.68	16
18	0.53513	1335.9	0.03290	217.18	360.54	1.0603	1.5527	0.971	0.678	1.219	540	136.1	205.7	11.48	69.6	9.86	9.42	18
20	0.56642	1328.9	0.03112	219.14	361.36	1.0669	1.5521	0.976	0.685	1.223	532	135.9	201.4	11.57	68.9	9.98	9.17	20
22	0.59905	1321.8	0.02946	221.10	362.17	1.0735	1.5515	0.981	0.691	1.228	524	135.7	197.2	11.65	68.2	10.10	8.92	22
24	0.63305	1314.6	0.02790	223.07	362.97	1.0801	1.5509	0.986	0.697	1.232	516	135.5	193.1	11.74	67.5	10.23	8.67	24
26	0.66846	1307.4	0.02643	225.05	363.76	1.0866	1.5503	0.991	0.704	1.237	508	135.2	189.0	11.83	66.8	10.36	8.42	26
28	0.70531	1300.1	0.02506	227.04	364.54	1.0932	1.5498	0.997	0.711	1.242	499	134.9	185.0	11.92	66.1	10.49	8.17	28
30	0.74365	1292.7	0.02377	229.04	365.31	1.0997	1.5492	1.002	0.718	1.248	491	134.7	181.1	12.01	65.4	10.62	7.92	30
32	0.78350	1285.2	0.02256	231.06	366.07	1.1062	1.5487	1.008	0.726	1.254	483	134.3	177.3	12.10	64.8	10.75	7.68	32
34	0.82491	1277.6	0.02142	233.08	366.81	1.1127	1.5481	1.014	0.734	1.260	475	134.0	173.5	12.19	64.1	10.89	7.43	34
36	0.86791	1269.9	0.02034	235.12	367.54	1.1192	1.5476	1.020	0.742	1.267	467	133.6	169.8	12.28	63.4	11.03	7.19	36
38	0.91253	1262.2	0.01933	237.16	368.26	1.1257	1.5470	1.026	0.750	1.274	459	133.2	166.1	12.38	62.7	11.18	6.95	38
40	0.95882	1254.3	0.01838	239.22	368.96	1.1322	1.5465	1.033	0.759	1.282	450	132.8	162.5	12.48	62.1	11.33	6.72	40
42	1.00680	1246.3	0.01748	241.29	369.65	1.1387	1.5459	1.040	0.768	1.290	442	132.4	159.0	12.57	61.4	11.48	6.48	42
44	1.05660	1238.1	0.01662	243.38	370.33	1.1451	1.5454	1.048	0.778	1.299	434	131.9	155.5	12.67	60.7	11.63	6.25	44
46	1.10810	1229.9	0.01582	245.47	370.98	1.1516	1.5448	1.055	0.788	1.308	426	131.4	152.0	12.78	60.0	11.79	6.01	46
48	1.16140	1221.5	0.01505	247.59	371.62	1.1580	1.5443	1.063	0.798	1.318	417	130.9	148.6	12.88	59.4	11.96	5.78	48
50	1.21660	1213.0	0.01433	249.71	372.24	1.1645	1.5437	1.072	0.810	1.329	409	130.3	145.3	12.99	58.7	12.13	5.55	50
52	1.27370	1204.4	0.01365	251.85	372.85	1.1710	1.5431	1.081	0.821	1.340	400	129.7	141.9	13.10	58.0	12.31	5.33	52
54	1.33270	1195.6	0.01300	254.01	373.43	1.1774	1.5425	1.090	0.834	1.353	392	129.1	138.7	13.21	57.3	12.49	5.10	54
56	1.39380	1186.6	0.01238	256.18	373.99	1.1839	1.5418	1.100	0.847	1.366	383	128.4	135.4	13.33	56.7	12.68	4.88	56
58	1.45680	1177.5	0.01180	258.38	374.53	1.1904	1.5411	1.111	0.861	1.381	375	127.7	132.2	13.45	56.0	12.87	4.66	58
60	1.52190	1168.1	0.01124	260.58	375.05	1.1969	1.5404	1.122	0.876	1.397	366	127.0	129.1	13.57	55.3	13.08	4.44	60
62	1.58920	1158.6	0.01071	262.81	375.54	1.2033	1.5397	1.135	0.892	1.414	357	126.3	125.9	13.70	54.7	13.29	4.23	62
64	1.65860	1148.9	0.01021	265.06	376.00	1.2099	1.5389	1.148	0.910	1.433	348	125.5	122.8	13.83	54.0	13.51	4.01	64
66	1.73020	1139.0	0.00973	267.33	376.44	1.2164	1.5381	1.162	0.929	1.453	339	124.6	119.7	13.96	53.3	13.75	3.80	66
68	1.80410	1128.8	0.00927	269.62	376.84	1.2229	1.5372	1.177	0.949	1.476	330	123.8	116.7	14.11	52.6	13.99	3.59	68
70	1.88020	1118.3	0.00883	271.94	377.22	1.2295	1.5363	1.193	0.971	1.501	321	122.9	113.6	14.26	52.0	14.25	3.39	70
75	2.08110	1090.9	0.00782	277.84	377.99	1.2461	1.5337	1.241	1.037	1.576	298	120.4	106.1	14.66	50.3	14.96	2.88	75
80	2.29750	1061.4	0.00691	283.94	378.48	1.2629	1.5306	1.302	1.122	1.677	274	117.7	98.6	15.11	48.7	15.80	2.40	80
85	2.53040	1029.1	0.00608	290.27	378.64	1.2801	1.5268	1.384	1.239	1.817	249	114.7	91.1	15.65	47.2	16.82	1.93	85
90	2.78080	993.2	0.00533	296.91	378.35	1.2978	1.5220	1.501	1.410	2.026	224	111.4	83.4	16.29	45.9	18.11	1.49	90
95	3.05010	952.2	0.00463	303.95	377.45	1.3163	1.5159	1.679	1.683	2.362	197	107.8	75.6	17.11	45.1	19.81	1.07	95
100	3.33990	903.8	0.00396	311.58	375.60	1.3360	1.5076	1.996	2.192	2.990	169	103.7	67.3	18.20	45.7	22.27	0.69	100
105	3.65250	842.2	0.00330	320.24	372.08	1.3581	1.4952	2.754	3.458	4.544	139	99.3	58.1	19.87	51.7	26.34	0.35	105
110	3.99240	742.7	0.00252	331.82	363.95	1.3874	1.4712	7.81	11.440	14.140	105	94.0	46.3	23.46	113.7	39.46	0.07	110
111.97[c]	4.13610	565.0	0.00177	347.76	347.76	1.4283	1.4283	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	111.97

*Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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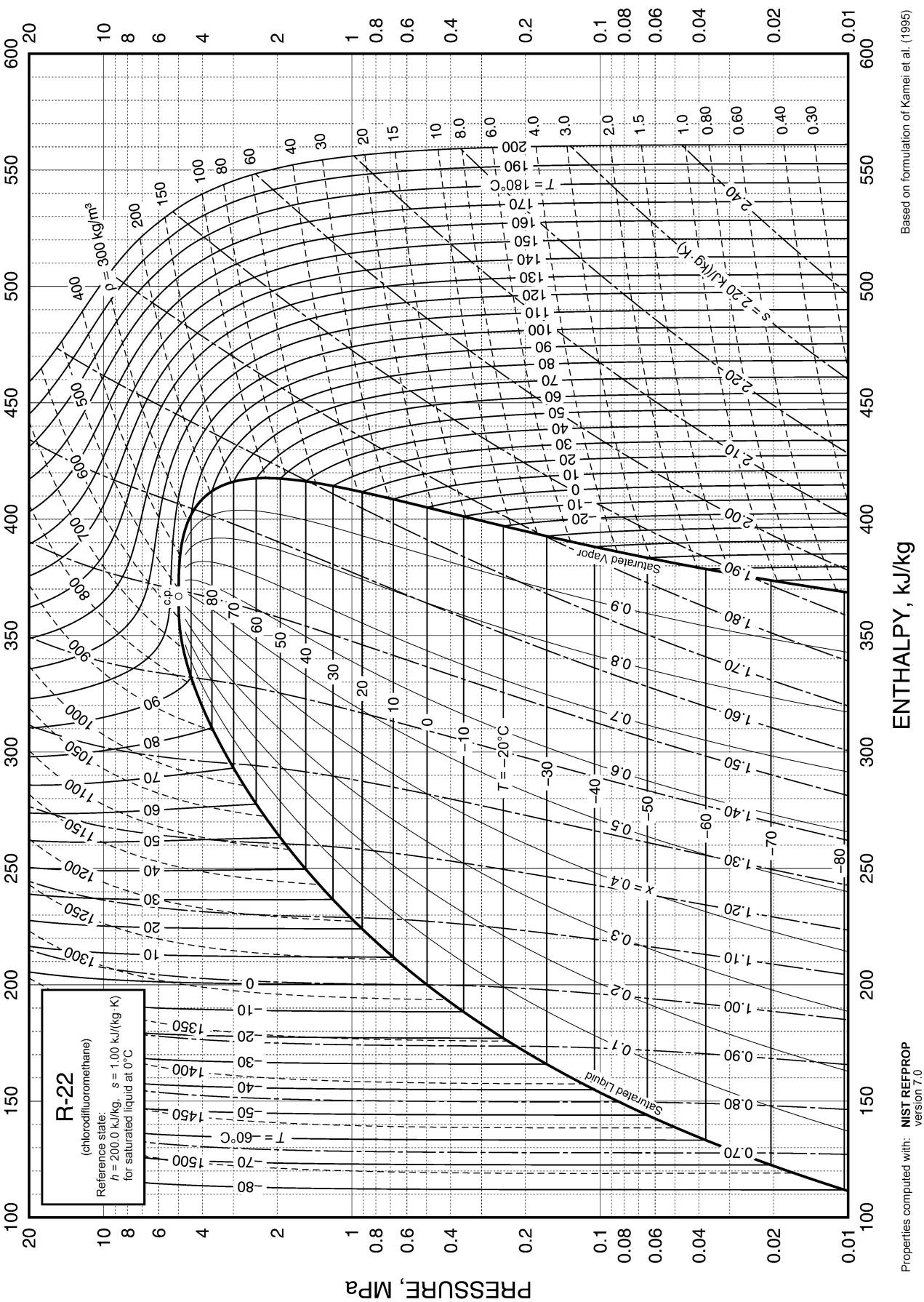

Fig. 2 Pressure-Enthalpy Diagram for Refrigerant 22

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Refrigerant 22 (Chlorodifluoromethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, µPa·s Liquid	Viscosity, µPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–100	0.00201	1571.3	8.26600	90.71	358.97	0.5050	2.0543	1.061	0.497	1.243	1127	143.6	845.6	7.25	143.1	4.46	28.12	–100
–90	0.00481	1544.9	3.64480	101.32	363.85	0.5646	1.9980	1.061	0.512	1.237	1080	147.0	699.4	7.67	137.8	4.84	26.36	–90
–80	0.01037	1518.2	1.77820	111.94	368.77	0.6210	1.9508	1.062	0.528	1.233	1033	150.3	591.0	8.09	132.6	5.25	24.63	–80
–70	0.02047	1491.2	0.94342	122.58	373.70	0.6747	1.9108	1.065	0.545	1.231	986	153.3	507.6	8.52	127.6	5.68	22.92	–70
–60	0.03750	1463.7	0.53680	133.27	378.59	0.7260	1.8770	1.071	0.564	1.230	940	156.0	441.4	8.94	122.6	6.12	21.24	–60
–50	0.06453	1435.6	0.32385	144.03	383.42	0.7752	1.8480	1.079	0.585	1.232	893	158.3	387.5	9.36	117.8	6.59	19.58	–50
–48	0.07145	1429.9	0.29453	146.19	384.37	0.7849	1.8428	1.081	0.589	1.233	884	158.7	377.8	9.45	116.9	6.69	19.25	–48
–46	0.07894	1424.2	0.26837	148.36	385.32	0.7944	1.8376	1.083	0.594	1.234	875	159.1	368.6	9.53	115.9	6.79	18.92	–46
–44	0.08705	1418.4	0.24498	150.53	386.26	0.8039	1.8327	1.086	0.599	1.235	865	159.5	359.6	9.62	115.0	6.89	18.59	–44
–42	0.09580	1412.6	0.22402	152.70	387.20	0.8134	1.8278	1.088	0.603	1.236	856	159.9	351.0	9.70	114.0	6.99	18.27	–42
–40.81[b]	0.10132	1409.2	0.21260	154.00	387.75	0.8189	1.8250	1.090	0.606	1.236	851	160.1	346.0	9.75	113.5	7.05	18.08	–40.81
–40	0.10523	1406.8	0.20521	154.89	388.13	0.8227	1.8231	1.091	0.608	1.237	847	160.3	342.6	9.79	113.1	7.09	17.94	–40
–38	0.11538	1401.0	0.18829	157.07	389.06	0.8320	1.8186	1.093	0.613	1.238	838	160.6	334.5	9.87	112.2	7.19	17.62	–38
–36	0.12628	1395.1	0.17304	159.27	389.97	0.8413	1.8141	1.096	0.619	1.239	828	160.9	326.7	9.96	111.2	7.29	17.30	–36
–34	0.13797	1389.1	0.15927	161.47	390.89	0.8505	1.8098	1.099	0.624	1.241	819	161.2	319.1	10.04	110.3	7.40	16.98	–34
–32	0.15050	1383.2	0.14682	163.67	391.79	0.8596	1.8056	1.102	0.629	1.242	810	161.5	311.7	10.12	109.4	7.51	16.66	–32
–30	0.16389	1377.2	0.13553	165.88	392.69	0.8687	1.8015	1.105	0.635	1.244	800	161.8	304.6	10.21	108.5	7.61	16.34	–30
–28	0.17819	1371.1	0.12528	168.10	393.58	0.8778	1.7975	1.108	0.641	1.246	791	162.0	297.7	10.29	107.5	7.72	16.02	–28
–26	0.19344	1365.0	0.11597	170.33	394.47	0.8868	1.7937	1.112	0.646	1.248	782	162.3	291.0	10.38	106.6	7.83	15.70	–26
–24	0.20968	1358.9	0.10749	172.56	395.34	0.8957	1.7899	1.115	0.653	1.250	772	162.5	284.4	10.46	105.7	7.94	15.39	–24
–22	0.22696	1352.7	0.09975	174.80	396.21	0.9046	1.7862	1.119	0.659	1.253	763	162.7	278.1	10.55	104.8	8.06	15.07	–22
–20	0.24531	1346.5	0.09268	177.04	397.06	0.9135	1.7826	1.123	0.665	1.255	754	162.8	271.9	10.63	103.9	8.17	14.76	–20
–18	0.26479	1340.3	0.08621	179.30	397.91	0.9223	1.7791	1.127	0.672	1.258	744	163.0	265.9	10.72	103.0	8.29	14.45	–18
–16	0.28543	1334.0	0.08029	181.56	398.75	0.9311	1.7757	1.131	0.678	1.261	735	163.1	260.1	10.80	102.1	8.40	14.14	–16
–14	0.30728	1327.6	0.07485	183.83	399.57	0.9398	1.7723	1.135	0.685	1.264	726	163.2	254.4	10.89	101.1	8.52	13.83	–14
–12	0.33038	1321.2	0.06986	186.11	400.39	0.9485	1.7690	1.139	0.692	1.267	716	163.3	248.8	10.98	100.2	8.65	13.52	–12
–10	0.35479	1314.7	0.06527	188.40	401.20	0.9572	1.7658	1.144	0.699	1.270	707	163.3	243.4	11.06	99.3	8.77	13.21	–10
–8	0.38054	1308.2	0.06103	190.70	401.99	0.9658	1.7627	1.149	0.707	1.274	697	163.4	238.1	11.15	98.4	8.89	12.91	–8
–6	0.40769	1301.6	0.05713	193.01	402.77	0.9744	1.7596	1.154	0.715	1.278	688	163.4	233.0	11.24	97.5	9.02	12.60	–6
–4	0.43628	1295.0	0.05352	195.33	403.55	0.9830	1.7566	1.159	0.722	1.282	679	163.4	227.9	11.32	96.6	9.15	12.30	–4
–2	0.46636	1288.3	0.05019	197.66	404.30	0.9915	1.7536	1.164	0.731	1.287	669	163.4	223.0	11.41	95.7	9.28	12.00	–2
0	0.49799	1281.5	0.04710	200.00	405.05	1.0000	1.7507	1.169	0.739	1.291	660	163.3	218.2	11.50	94.8	9.42	11.70	0
2	0.53120	1274.7	0.04424	202.35	405.78	1.0085	1.7478	1.175	0.748	1.296	650	163.2	213.5	11.59	93.9	9.56	11.40	2
4	0.56605	1267.8	0.04159	204.71	406.50	1.0169	1.7450	1.181	0.757	1.301	641	163.1	208.9	11.68	93.1	9.70	11.10	4
6	0.60259	1260.8	0.03913	207.09	407.20	1.0254	1.7422	1.187	0.766	1.307	632	163.0	204.4	11.77	92.2	9.84	10.81	6
8	0.64088	1253.8	0.03683	209.47	407.89	1.0338	1.7395	1.193	0.775	1.313	622	162.8	200.0	11.86	91.3	9.99	10.51	8
10	0.68095	1246.7	0.03470	211.87	408.56	1.0422	1.7368	1.199	0.785	1.319	613	162.6	195.7	11.96	90.4	10.14	10.22	10
12	0.72286	1239.5	0.03271	214.28	409.21	1.0505	1.7341	1.206	0.795	1.326	603	162.4	191.5	12.05	89.5	10.29	9.93	12
14	0.76668	1232.2	0.03086	216.70	409.85	1.0589	1.7315	1.213	0.806	1.333	594	162.2	187.3	12.14	88.6	10.45	9.64	14
16	0.81244	1224.9	0.02912	219.14	410.47	1.0672	1.7289	1.220	0.817	1.340	584	161.9	183.2	12.24	87.7	10.61	9.35	16
18	0.86020	1217.4	0.02750	221.59	411.07	1.0755	1.7263	1.228	0.828	1.348	575	161.6	179.2	12.33	86.8	10.77	9.06	18
20	0.91002	1209.9	0.02599	224.06	411.66	1.0838	1.7238	1.236	0.840	1.357	565	161.3	175.3	12.43	85.9	10.95	8.78	20
22	0.96195	1202.3	0.02457	226.54	412.22	1.0921	1.7212	1.244	0.853	1.366	555	161.0	171.5	12.53	85.0	11.12	8.50	22
24	1.01600	1194.6	0.02324	229.04	412.77	1.1004	1.7187	1.252	0.866	1.375	546	160.6	167.7	12.63	84.1	11.30	8.22	24
26	1.07240	1186.7	0.02199	231.55	413.29	1.1086	1.7162	1.261	0.879	1.385	536	160.2	163.9	12.74	83.2	11.49	7.94	26
28	1.13090	1178.8	0.02082	234.08	413.79	1.1169	1.7136	1.271	0.893	1.396	527	159.7	160.3	12.84	82.3	11.69	7.66	28
30	1.19190	1170.7	0.01972	236.62	414.26	1.1252	1.7111	1.281	0.908	1.408	517	159.2	156.7	12.95	81.4	11.89	7.38	30
32	1.25520	1162.6	0.01869	239.19	414.71	1.1334	1.7086	1.291	0.924	1.420	507	158.7	153.1	13.06	80.5	12.10	7.11	32
34	1.32100	1154.3	0.01771	241.77	415.14	1.1417	1.7061	1.302	0.940	1.434	497	158.2	149.6	13.17	79.6	12.31	6.84	34
36	1.38920	1145.8	0.01679	244.38	415.54	1.1499	1.7036	1.314	0.957	1.448	487	157.6	146.1	13.28	78.7	12.54	6.57	36
38	1.46010	1137.3	0.01593	247.00	415.91	1.1582	1.7010	1.326	0.976	1.463	478	157.0	142.7	13.40	77.8	12.77	6.30	38
40	1.53360	1128.5	0.01511	249.65	416.25	1.1665	1.6985	1.339	0.995	1.480	468	156.4	139.4	13.52	76.9	13.02	6.04	40
42	1.60980	1119.6	0.01433	252.32	416.55	1.1747	1.6959	1.353	1.015	1.498	458	155.7	136.1	13.64	76.0	13.28	5.77	42
44	1.68870	1110.6	0.01360	255.01	416.83	1.1830	1.6933	1.368	1.037	1.517	448	155.0	132.8	13.77	75.1	13.55	5.51	44
46	1.77040	1101.4	0.01291	257.73	417.07	1.1913	1.6906	1.384	1.061	1.538	437	154.2	129.5	13.90	74.1	13.83	5.25	46
48	1.85510	1091.9	0.01226	260.47	417.27	1.1997	1.6879	1.401	1.086	1.561	427	153.4	126.3	14.04	73.2	14.13	5.00	48
50	1.94270	1082.3	0.01163	263.25	417.44	1.2080	1.6852	1.419	1.113	1.586	417	152.6	123.1	14.18	72.3	14.45	4.74	50
52	2.03330	1072.4	0.01104	266.05	417.56	1.2164	1.6824	1.439	1.142	1.614	407	151.7	120.0	14.32	71.4	14.78	4.49	52
54	2.12700	1062.3	0.01048	268.89	417.63	1.2248	1.6795	1.461	1.173	1.644	396	150.8	116.9	14.47	70.4	15.14	4.24	54
56	2.22390	1052.0	0.00995	271.76	417.66	1.2333	1.6766	1.485	1.208	1.677	386	149.8	113.8	14.63	69.5	15.52	4.00	56
58	2.32400	1041.3	0.00944	274.66	417.63	1.2418	1.6736	1.511	1.246	1.714	375	148.8	110.7	14.80	68.6	15.92	3.75	58
60	2.42750	1030.4	0.00896	277.61	417.55	1.2504	1.6705	1.539	1.287	1.755	364	147.7	107.6	14.98	67.6	16.36	3.51	60
65	2.70120	1001.4	0.00785	285.18	417.06	1.2722	1.6622	1.626	1.413	1.881	337	144.9	100.0	15.46	65.3	17.61	2.92	65
70	2.99740	969.7	0.00685	293.10	416.09	1.2945	1.6529	1.743	1.584	2.056	309	141.7	92.4	16.02	62.9	19.16	2.36	70
75	3.31770	934.4	0.00595	301.46	414.49	1.3177	1.6424	1.913	1.832	2.315	280	138.1	84.6	16.70	60.6	21.16	1.82	75
80	3.66380	893.7	0.00512	310.44	412.01	1.3423	1.6299	2.181	2.231	2.735	249	134.2	76.6	17.55	58.6	23.87	1.30	80
85	4.03780	844.8	0.00434	320.38	408.19	1.3690	1.6142	2.682	2.984	3.532	215	129.7	68.1	18.71	57.4	27.82	0.83	85
90	4.44230	780.1	0.00356	332.09	401.87	1.4001	1.5922	3.981	4.975	5.626	177	124.6	58.3	20.48	59.3	34.55	0.40	90
95	4.88240	662.9	0.00262	349.56	387.28	1.4462	1.5486	17.31	25.29	26.43	128	118.0	44.4	24.76	83.5	59.15	0.05	95
96.15[c]	4.99000	523.8	0.00191	366.90	366.90	1.4927	1.4927	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	96.15

*Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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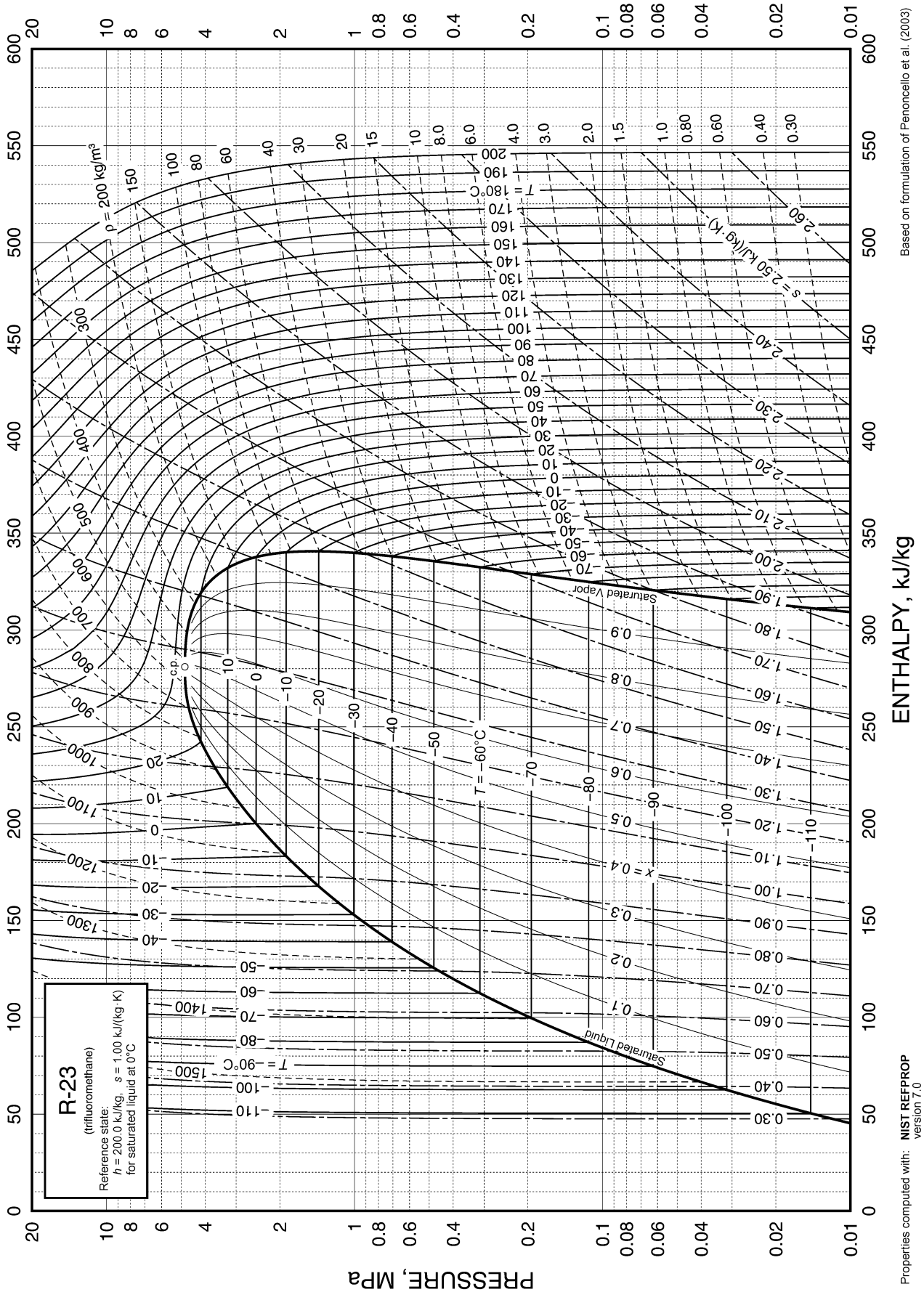

Properties computed with: NIST REFPROP version 7.0

Based on formulation of Penoncello et al. (2003)

Fig. 3 Pressure-Enthalpy Diagram for Refrigerant 23

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Refrigerant 23 (Trifluoromethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, µPa·s Liquid	Viscosity, µPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–155.13[a]	0.00006	1701.9	241.360	–3.67	289.21	–0.0705	2.4111	1.221	0.500	1.315	1211	135.7	2055.0	5.35	268.6	3.80	34.37	–155.13
–150	0.00014	1685.3	105.950	2.54	291.73	–0.0190	2.3293	1.205	0.506	1.311	1200	138.4	1662.0	5.64	250.2	4.07	33.12	–150
–140	0.00060	1652.0	26.330	14.53	296.65	0.0746	2.1934	1.195	0.522	1.304	1151	143.3	1153.0	6.22	220.9	4.61	30.71	–140
–130	0.00206	1617.9	8.21940	26.48	301.56	0.1612	2.0828	1.195	0.541	1.297	1092	147.9	845.9	6.80	198.2	5.15	28.35	–130
–120	0.00588	1583.3	3.06950	38.45	306.45	0.2420	1.9919	1.199	0.565	1.292	1033	152.2	648.3	7.37	180.1	5.70	26.03	–120
–110	0.01447	1548.2	1.32190	50.47	311.27	0.3179	1.9165	1.205	0.593	1.289	976	156.0	514.4	7.93	165.3	6.25	23.75	–110
–100	0.03157	1512.3	0.63807	62.56	315.98	0.3898	1.8534	1.213	0.625	1.290	921	159.5	419.2	8.48	152.9	6.82	21.53	–100
–90	0.06239	1475.7	0.33766	74.76	320.51	0.4582	1.8000	1.225	0.661	1.294	866	162.4	349.0	9.03	142.4	7.42	19.35	–90
–82.02[b]	0.10132	1445.6	0.21446	84.60	323.96	0.5106	1.7630	1.237	0.694	1.301	823	164.3	305.1	9.47	135.0	7.92	17.65	–82.02
–80	0.11370	1437.9	0.19248	87.10	324.81	0.5236	1.7543	1.241	0.702	1.304	812	164.7	295.3	9.58	133.2	8.05	17.23	–80
–78	0.12712	1430.2	0.17333	89.59	325.63	0.5364	1.7459	1.245	0.711	1.306	801	165.1	286.1	9.69	131.5	8.18	16.81	–78
–76	0.14175	1422.5	0.15644	92.09	326.44	0.5491	1.7378	1.249	0.721	1.309	790	165.4	277.2	9.80	129.8	8.31	16.40	–76
–74	0.15768	1414.7	0.14151	94.60	327.24	0.5617	1.7299	1.253	0.730	1.312	779	165.8	268.8	9.91	128.2	8.45	15.98	–74
–72	0.17496	1406.8	0.12828	97.12	328.03	0.5742	1.7221	1.258	0.740	1.315	769	166.1	260.7	10.01	126.6	8.59	15.57	–72
–70	0.19370	1398.9	0.11652	99.64	328.79	0.5866	1.7146	1.262	0.750	1.319	758	166.3	253.0	10.12	125.1	8.73	15.16	–70
–68	0.21395	1390.9	0.10605	102.18	329.55	0.5990	1.7073	1.267	0.760	1.323	747	166.6	245.6	10.23	123.5	8.87	14.76	–68
–66	0.23582	1382.8	0.09669	104.72	330.29	0.6112	1.7001	1.272	0.771	1.327	736	166.8	238.5	10.34	122.0	9.02	14.36	–66
–64	0.25937	1374.7	0.08832	107.28	331.01	0.6234	1.6931	1.278	0.782	1.332	725	167.0	231.6	10.45	120.5	9.16	13.96	–64
–62	0.28469	1366.4	0.08081	109.85	331.71	0.6356	1.6863	1.283	0.793	1.337	714	167.1	225.1	10.56	119.1	9.32	13.56	–62
–60	0.31188	1358.1	0.07406	112.43	332.40	0.6476	1.6796	1.290	0.805	1.342	703	167.2	218.7	10.67	117.7	9.47	13.16	–60
–58	0.34102	1349.7	0.06798	115.02	333.06	0.6596	1.6731	1.296	0.817	1.347	692	167.3	212.6	10.78	116.2	9.63	12.77	–58
–56	0.37220	1341.3	0.06249	117.62	333.71	0.6716	1.6667	1.303	0.830	1.354	681	167.3	206.7	10.89	114.9	9.79	12.38	–56
–54	0.40552	1332.7	0.05753	120.24	334.33	0.6835	1.6604	1.310	0.843	1.360	670	167.4	201.1	11.00	113.5	9.96	11.99	–54
–52	0.44106	1324.0	0.05303	122.88	334.94	0.6953	1.6542	1.317	0.856	1.367	659	167.3	195.6	11.11	112.1	10.13	11.61	–52
–50	0.47893	1315.3	0.04895	125.53	335.52	0.7071	1.6482	1.325	0.870	1.375	648	167.3	190.3	11.22	110.8	10.30	11.22	–50
–48	0.51921	1306.4	0.04523	128.19	336.07	0.7189	1.6422	1.333	0.885	1.383	637	167.2	185.1	11.34	109.5	10.48	10.85	–48
–46	0.56201	1297.4	0.04185	130.87	336.61	0.7306	1.6363	1.342	0.900	1.392	625	167.0	180.1	11.45	108.2	10.66	10.47	–46
–44	0.60743	1288.3	0.03877	133.57	337.11	0.7423	1.6305	1.351	0.915	1.401	614	166.8	175.3	11.57	106.9	10.85	10.10	–44
–42	0.65557	1279.0	0.03595	136.29	337.59	0.7539	1.6248	1.361	0.932	1.411	603	166.6	170.6	11.68	105.6	11.04	9.73	–42
–40	0.70653	1269.7	0.03336	139.02	338.04	0.7655	1.6191	1.371	0.949	1.422	591	166.4	166.0	11.80	104.3	11.24	9.36	–40
–38	0.76042	1260.2	0.03100	141.78	338.46	0.7771	1.6135	1.382	0.967	1.433	580	166.1	161.6	11.92	103.1	11.45	9.00	–38
–36	0.81734	1250.5	0.02882	144.56	338.85	0.7887	1.6080	1.393	0.985	1.446	569	165.7	157.3	12.04	101.8	11.66	8.64	–36
–34	0.87740	1240.7	0.02682	147.36	339.21	0.8002	1.6025	1.405	1.005	1.459	557	165.3	153.1	12.16	100.5	11.88	8.28	–34
–32	0.94071	1230.7	0.02498	150.18	339.53	0.8118	1.5970	1.418	1.026	1.474	545	164.9	149.0	12.29	99.3	12.10	7.93	–32
–30	1.00740	1220.5	0.02328	153.03	339.82	0.8233	1.5915	1.432	1.048	1.490	534	164.4	144.9	12.42	98.0	12.33	7.58	–30
–28	1.07750	1210.1	0.02171	155.90	340.06	0.8348	1.5861	1.447	1.072	1.507	522	163.9	141.0	12.55	96.8	12.57	7.23	–28
–26	1.15130	1199.6	0.02026	158.80	340.27	0.8464	1.5806	1.462	1.097	1.526	510	163.3	137.2	12.68	95.5	12.82	6.89	–26
–24	1.22880	1188.8	0.01892	161.73	340.43	0.8579	1.5752	1.479	1.123	1.546	498	162.7	133.4	12.81	94.3	13.08	6.55	–24
–22	1.31000	1177.8	0.01767	164.69	340.55	0.8695	1.5697	1.497	1.152	1.569	486	162	129.7	12.95	93.1	13.35	6.21	–22
–20	1.39530	1166.6	0.01651	167.68	340.62	0.8810	1.5642	1.517	1.182	1.593	474	161.3	126.1	13.10	91.8	13.63	5.88	–20
–18	1.48460	1155.0	0.01544	170.71	340.63	0.8927	1.5586	1.538	1.215	1.620	462	160.5	122.6	13.25	90.5	13.92	5.56	–18
–16	1.57810	1143.2	0.01443	173.77	340.59	0.9043	1.5530	1.561	1.251	1.650	449	159.7	119.1	13.40	89.3	14.23	5.23	–16
–14	1.67600	1131.1	0.01350	176.88	340.49	0.9160	1.5473	1.586	1.290	1.682	437	158.8	115.6	13.56	88.0	14.55	4.92	–14
–12	1.77840	1118.7	0.01263	180.02	340.33	0.9277	1.5416	1.613	1.333	1.719	424	157.9	112.2	13.73	86.7	14.88	4.60	–12
–10	1.88530	1105.9	0.01181	183.21	340.09	0.9395	1.5357	1.643	1.38	1.759	411	156.9	108.9	13.90	85.4	15.23	4.29	–10
–8	1.99710	1092.7	0.01105	186.45	339.78	0.9514	1.5297	1.676	1.432	1.805	399	155.8	105.6	14.09	84.1	15.60	3.99	–8
–6	2.11370	1079.1	0.01033	189.75	339.39	0.9634	1.5235	1.712	1.491	1.857	386	154.7	102.3	14.28	82.7	15.99	3.69	–6
–4	2.23540	1064.9	0.00966	193.10	338.91	0.9755	1.5172	1.754	1.556	1.916	372	153.5	99.0	14.49	81.4	16.40	3.40	–4
–2	2.36240	1050.3	0.00902	196.51	338.33	0.9877	1.5107	1.800	1.630	1.983	359	152.3	95.8	14.71	80.0	16.83	3.11	–2
0	2.49470	1035.1	0.00843	200.00	337.64	1.0000	1.5039	1.853	1.715	2.061	345	151.0	92.5	14.94	78.5	17.29	2.83	0
2	2.63260	1019.2	0.00786	203.56	336.83	1.0125	1.4969	1.915	1.814	2.152	332	149.6	89.3	15.19	77.1	17.79	2.55	2
4	2.77620	1002.5	0.00733	207.22	335.89	1.0252	1.4895	1.986	1.929	2.259	318	148.1	86.1	15.47	75.6	18.32	2.28	4
6	2.92590	985.0	0.00683	210.97	334.78	1.0382	1.4817	2.071	2.067	2.388	303	146.5	82.8	15.77	74.0	18.89	2.02	6
8	3.08170	966.5	0.00635	214.84	333.50	1.0514	1.4735	2.173	2.234	2.545	289	144.9	79.6	16.10	72.4	19.51	1.76	8
10	3.24380	946.7	0.00589	218.84	332.01	1.0650	1.4647	2.300	2.441	2.742	274	143.2	76.2	16.47	70.7	20.20	1.52	10
12	3.41270	925.6	0.00545	223.00	330.27	1.0790	1.4552	2.461	2.704	2.993	259	141.3	72.9	16.89	68.9	20.95	1.28	12
14	3.58850	902.6	0.00502	227.37	328.22	1.0936	1.4448	2.673	3.053	3.325	243	139.4	69.4	17.38	67.0	21.80	1.05	14
16	3.77150	877.4	0.00461	231.98	325.79	1.1089	1.4333	2.966	3.536	3.787	227	137.3	65.8	17.95	65.0	22.76	0.83	16
18	3.96220	849.1	0.00421	236.93	322.84	1.1252	1.4203	3.404	4.252	4.474	210	135.0	62.0	18.64	62.7	23.88	0.63	18
20	4.16100	816.4	0.00381	242.36	319.17	1.1430	1.4050	4.130	5.429	5.602	193	132.5	57.9	19.51	60.2	25.25	0.44	20
25	4.69860	680.1	0.00263	261.94	301.55	1.2067	1.3396	18.870	26.84	26.080	141	124.3	44.3	24.79	53.4	35.21	0.05	25
26.14[c]	4.83200	526.5	0.00190	280.97	280.97	1.2697	1.2697	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	26.14

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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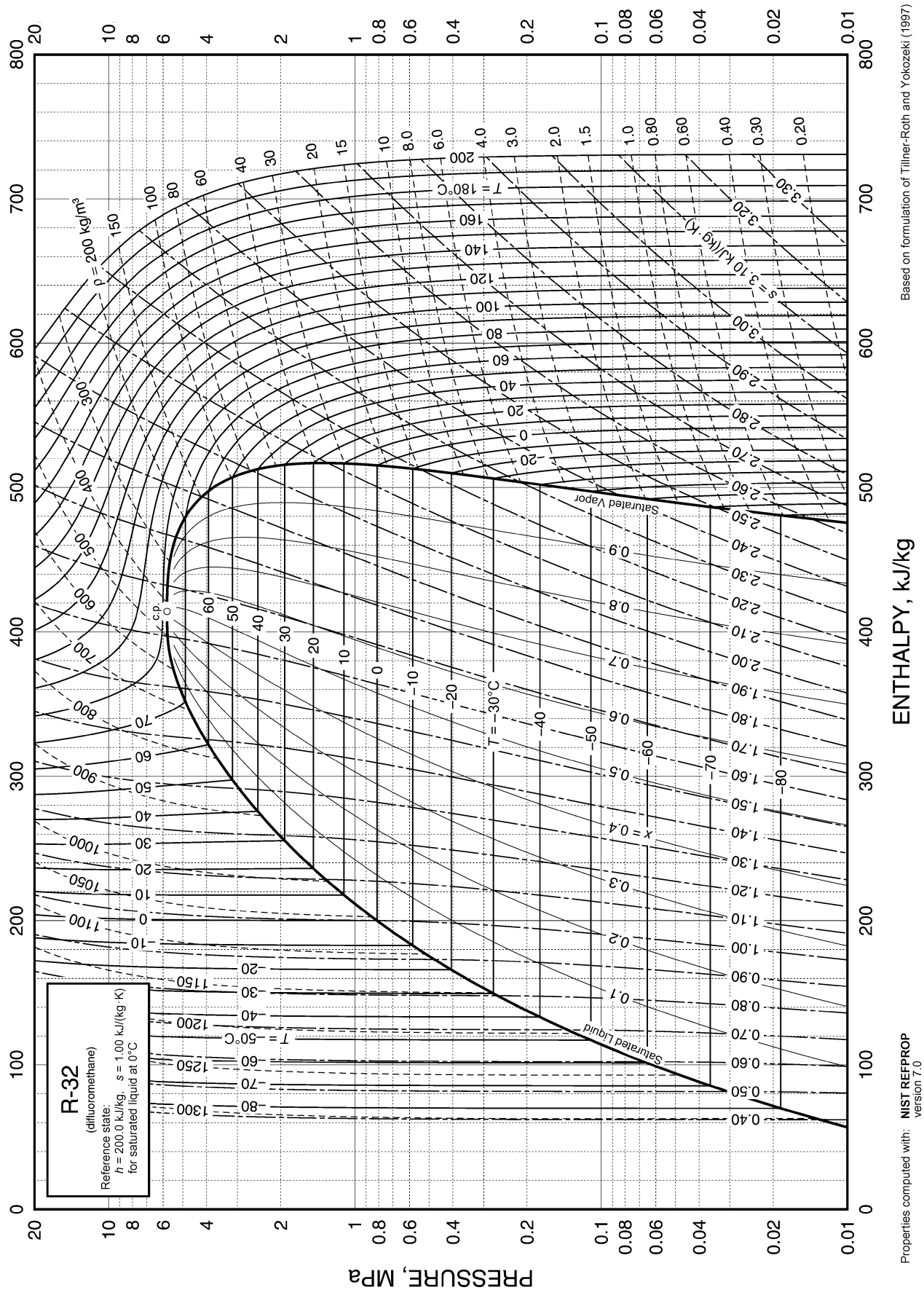

Fig. 4 Pressure-Enthalpy Diagram for Refrigerant 32

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Refrigerant 32 (Difluoromethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–136.81[a]	0.00005	1429.3	453.850	–19.07	444.31	–0.1050	3.2937	1.592	0.660	1.321	1414	169.6	1226.0	5.70	242.9	6.95	39.01	–136.81
–130	0.00013	1412.7	174.360	–8.26	448.77	–0.0276	3.1651	1.583	0.665	1.318	1378	173.6	1023.0	5.97	240.6	6.97	37.47	–130
–120	0.00048	1388.4	51.1840	7.52	455.33	0.0790	3.0030	1.573	0.674	1.315	1326	179.2	811.8	6.39	236.1	7.02	35.23	–120
–110	0.00145	1363.8	17.9070	23.20	461.86	0.1782	2.8668	1.565	0.686	1.312	1273	184.5	664.6	6.80	230.6	7.12	33.02	–110
–100	0.00381	1339.0	7.22200	38.83	468.31	0.2711	2.7515	1.560	0.703	1.310	1221	189.5	556.1	7.22	224.3	7.27	30.83	–100
–90	0.00887	1313.9	3.27210	54.42	474.61	0.3586	2.6529	1.559	0.725	1.310	1169	194.1	472.6	7.64	217.4	7.45	28.68	–90
–80	0.01865	1288.4	1.63160	70.02	480.72	0.4415	2.5679	1.561	0.754	1.311	1118	198.3	406.4	8.06	210.0	7.68	26.56	–80
–70	0.03607	1262.4	0.88072	85.66	486.57	0.5204	2.4939	1.566	0.790	1.314	1066	202.0	352.7	8.48	202.2	7.96	24.48	–70
–60	0.06496	1235.7	0.50786	101.38	492.11	0.5958	2.4289	1.576	0.833	1.320	1014	205.1	308.2	8.91	194.2	8.28	22.42	–60
–51.65[b]	0.10133	1212.9	0.33468	114.59	496.45	0.6565	2.3805	1.587	0.875	1.328	971	207.4	276.7	9.26	187.4	8.60	20.74	–51.65
–50	0.11014	1208.4	0.30944	117.22	497.27	0.6683	2.3714	1.589	0.883	1.329	962	207.7	271.0	9.33	186.0	8.66	20.41	–50
–40	0.17741	1180.2	0.19743	133.23	502.02	0.7382	2.3200	1.608	0.940	1.343	910	209.7	239.4	9.75	177.8	9.10	18.44	–40
–38	0.19409	1174.4	0.18134	136.45	502.91	0.7519	2.3103	1.612	0.952	1.347	900	210.1	233.6	9.84	176.1	9.19	18.05	–38
–36	0.21197	1168.6	0.16680	139.69	503.78	0.7655	2.3008	1.616	0.965	1.350	889	210.4	228.1	9.92	174.5	9.29	17.66	–36
–34	0.23111	1162.8	0.15365	142.93	504.63	0.7791	2.2916	1.621	0.977	1.354	879	210.6	222.6	10.01	172.8	9.39	17.27	–34
–32	0.25159	1156.9	0.14173	146.18	505.47	0.7926	2.2824	1.626	0.990	1.358	868	210.9	217.4	10.09	171.2	9.50	16.89	–32
–30	0.27344	1151.0	0.13091	149.45	506.27	0.8060	2.2735	1.631	1.004	1.363	858	211.1	212.3	10.18	169.5	9.60	16.50	–30
–28	0.29675	1145.0	0.12107	152.72	507.06	0.8193	2.2647	1.637	1.017	1.367	847	211.3	207.4	10.26	167.9	9.71	16.12	–28
–26	0.32157	1138.9	0.11211	156.01	507.83	0.8326	2.2561	1.642	1.031	1.372	837	211.4	202.6	10.35	166.3	9.83	15.74	–26
–24	0.34796	1132.9	0.10393	159.31	508.57	0.8458	2.2476	1.648	1.045	1.377	826	211.5	197.9	10.43	164.6	9.95	15.36	–24
–22	0.37600	1126.7	0.09646	162.62	509.28	0.8589	2.2392	1.654	1.060	1.383	816	211.6	193.3	10.52	163.0	10.07	14.99	–22
–20	0.40575	1120.6	0.08963	165.94	509.97	0.8720	2.2310	1.661	1.075	1.389	805	211.7	188.9	10.61	161.3	10.19	14.61	–20
–18	0.43728	1114.3	0.08337	169.28	510.64	0.8850	2.2229	1.668	1.090	1.395	794	211.7	184.6	10.70	159.7	10.32	14.24	–18
–16	0.47067	1108.0	0.07762	172.63	511.28	0.8979	2.2149	1.675	1.106	1.401	784	211.7	180.5	10.78	158.1	10.46	13.87	–16
–14	0.50597	1101.7	0.07234	175.99	511.89	0.9109	2.2070	1.682	1.122	1.408	773	211.7	176.4	10.87	156.5	10.60	13.50	–14
–12	0.54327	1095.2	0.06749	179.37	512.47	0.9237	2.1992	1.690	1.139	1.416	762	211.6	172.4	10.96	154.9	10.74	13.14	–12
–10	0.58263	1088.8	0.06301	182.76	513.02	0.9365	2.1915	1.698	1.156	1.423	751	211.5	168.5	11.05	153.2	10.89	12.77	–10
–8	0.62414	1082.2	0.05889	186.18	513.54	0.9493	2.1839	1.706	1.174	1.432	741	211.4	164.8	11.14	151.6	11.04	12.41	–8
–6	0.66786	1075.6	0.05508	189.60	514.03	0.9620	2.1764	1.715	1.192	1.440	730	211.2	161.1	11.23	150.0	11.21	12.05	–6
–4	0.71388	1068.9	0.05155	193.05	514.49	0.9747	2.1690	1.725	1.211	1.450	719	211.0	157.5	11.32	148.4	11.38	11.69	–4
–2	0.76226	1062.1	0.04829	196.52	514.91	0.9874	2.1616	1.735	1.231	1.460	708	210.8	154.0	11.42	146.8	11.55	11.34	–2
0	0.81310	1055.3	0.04527	200.00	515.30	1.0000	2.1543	1.745	1.251	1.470	697	210.5	150.6	11.51	145.3	11.73	10.99	0
2	0.86647	1048.3	0.04246	203.50	515.65	1.0126	2.1471	1.756	1.272	1.481	686	210.2	147.3	11.61	143.7	11.93	10.63	2
4	0.92245	1041.3	0.03986	207.03	515.96	1.0252	2.1399	1.767	1.294	1.493	675	209.8	144.0	11.70	142.1	12.13	10.29	4
6	0.98113	1034.2	0.03743	210.58	516.24	1.0377	2.1327	1.779	1.317	1.506	664	209.4	140.8	11.80	140.5	12.34	9.94	6
8	1.04260	1027.0	0.03518	214.15	516.47	1.0503	2.1256	1.792	1.341	1.519	652	209.0	137.7	11.90	139.0	12.56	9.60	8
10	1.10690	1019.7	0.03308	217.74	516.66	1.0628	2.1185	1.806	1.367	1.534	641	208.5	134.6	12.00	137.4	12.79	9.25	10
12	1.17420	1012.2	0.03112	221.36	516.80	1.0753	2.1114	1.820	1.393	1.549	630	208.0	131.6	12.10	135.9	13.04	8.91	12
14	1.24450	1004.7	0.02929	225.01	516.90	1.0878	2.1043	1.835	1.421	1.565	618	207.5	128.7	12.48	134.3	13.29	8.58	14
16	1.31790	997.1	0.02758	228.68	516.95	1.1003	2.0972	1.851	1.450	1.583	607	206.9	125.8	12.60	132.8	13.56	8.24	16
18	1.39460	989.3	0.02598	232.39	516.95	1.1128	2.0902	1.868	1.481	1.602	595	206.3	123.0	12.73	131.2	13.85	7.91	18
20	1.47460	981.4	0.02448	236.12	516.90	1.1253	2.0831	1.886	1.514	1.622	584	205.6	120.3	12.86	129.7	14.16	7.59	20
22	1.55790	973.3	0.02307	239.89	516.79	1.1378	2.0760	1.905	1.548	1.644	572	204.9	117.5	13.00	128.2	14.48	7.26	22
24	1.64480	965.2	0.02175	243.69	516.62	1.1503	2.0688	1.926	1.585	1.668	560	204.1	114.9	13.14	126.6	14.83	6.94	24
26	1.73530	956.8	0.02051	247.53	516.39	1.1629	2.0616	1.948	1.624	1.693	548	203.3	112.2	13.28	125.1	15.19	6.62	26
28	1.82950	948.3	0.01935	251.40	516.09	1.1755	2.0544	1.972	1.667	1.721	536	202.4	109.7	13.43	123.6	15.59	6.30	28
30	1.92750	939.6	0.01826	255.32	515.72	1.1881	2.0471	1.997	1.712	1.750	524	201.5	107.1	13.58	122.1	16.01	5.99	30
32	2.02940	930.7	0.01722	259.28	515.29	1.2007	2.0397	2.025	1.760	1.783	512	200.6	104.6	13.74	120.6	16.46	5.68	32
34	2.13530	921.7	0.01625	263.28	514.77	1.2134	2.0322	2.055	1.813	1.819	499	199.6	102.1	13.90	119.1	16.95	5.37	34
36	2.24540	912.4	0.01533	267.34	514.17	1.2262	2.0246	2.088	1.870	1.858	487	198.5	99.7	14.07	117.6	17.47	5.07	36
38	2.35970	902.8	0.01447	271.45	513.49	1.2391	2.0169	2.124	1.933	1.901	474	197.4	97.3	14.25	116.1	18.04	4.77	38
40	2.47830	893.0	0.01365	275.61	512.71	1.2520	2.0091	2.163	2.001	1.948	461	196.2	94.9	14.44	114.6	18.65	4.47	40
42	2.60140	883.0	0.01287	279.84	511.82	1.2650	2.0011	2.206	2.077	2.001	448	194.9	92.5	14.64	113.1	19.32	4.18	42
44	2.72920	872.6	0.01214	284.13	510.83	1.2781	1.9929	2.255	2.160	2.060	435	193.6	90.2	14.84	111.6	20.05	3.89	44
46	2.86160	861.9	0.01144	288.50	509.72	1.2914	1.9845	2.309	2.254	2.126	421	192.3	87.8	15.06	110.1	20.85	3.61	46
48	2.99890	850.8	0.01078	292.95	508.48	1.3048	1.9759	2.369	2.358	2.201	408	190.8	85.5	15.29	108.6	21.73	3.33	48
50	3.14120	839.3	0.01015	297.49	507.10	1.3183	1.9670	2.439	2.477	2.287	394	189.3	83.2	15.54	107.0	22.69	3.06	50
52	3.28870	827.3	0.00955	302.12	505.57	1.3321	1.9578	2.518	2.613	2.385	379	187.7	80.8	15.80	105.5	23.77	2.79	52
54	3.44150	814.8	0.00897	306.87	503.86	1.3461	1.9482	2.609	2.771	2.499	365	186.0	78.5	16.09	104.0	24.97	2.52	54
56	3.59970	801.7	0.00843	311.74	501.95	1.3603	1.9382	2.717	2.956	2.633	350	184.3	76.1	16.39	102.5	26.31	2.26	56
58	3.76350	787.9	0.00790	316.75	499.82	1.3749	1.9277	2.845	3.175	2.793	335	182.4	73.8	16.73	100.9	27.83	2.01	58
60	3.93320	773.3	0.00740	321.93	497.44	1.3898	1.9166	3.001	3.441	2.987	320	180.4	71.4	17.09	99.4	29.55	1.76	60
62	4.10890	757.8	0.00691	327.30	494.76	1.4052	1.9048	3.193	3.771	3.228	304	178.3	68.9	17.49	97.8	31.54	1.52	62
64	4.29090	741.1	0.00644	332.90	491.73	1.4211	1.8922	3.438	4.190	3.535	288	176.1	66.4	17.95	96.3	33.85	1.29	64
66	4.47930	723.0	0.00598	338.78	488.26	1.4377	1.8785	3.761	4.743	3.938	271	173.7	63.8	18.46	94.8	36.59	1.06	66
68	4.67450	703.2	0.00553	345.02	484.25	1.4553	1.8634	4.207	5.508	4.495	254	171.2	61.1	19.06	93.3	39.90	0.85	68
70	4.87680	680.9	0.00508	351.73	479.52	1.4740	1.8464	4.865	6.639	5.316	236	168.4	58.2	19.76	92.0	44.04	0.64	70
75	5.41680	605.9	0.00391	372.39	461.72	1.5314	1.7880	10.130	15.600	11.720	186	159.6	49.5	22.56	91.5	62.91	0.19	75
78.11[c]	5.78200	424.0	0.00236	414.15	414.15	1.6486	1.6486	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	78.11

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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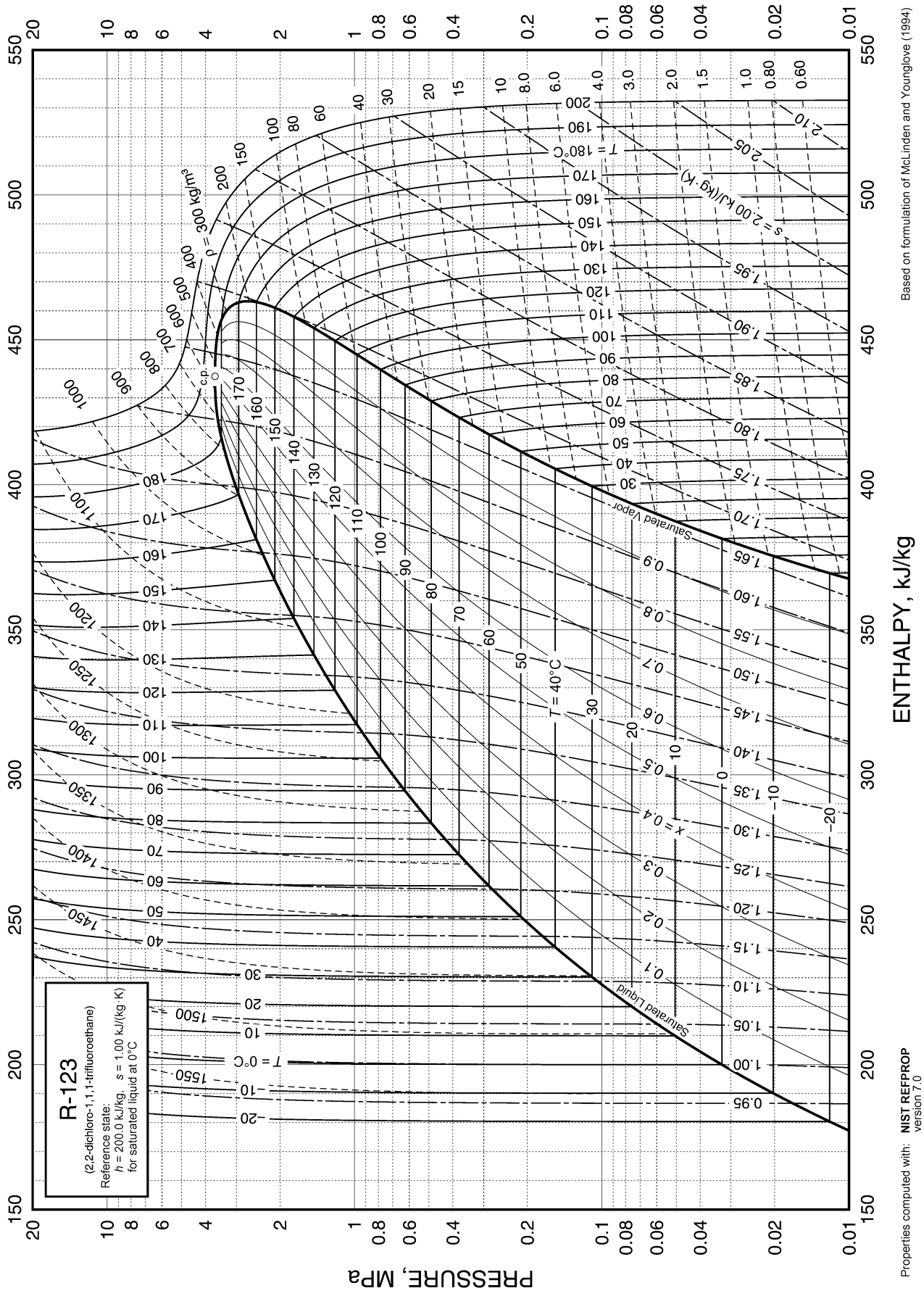

Fig. 5 Pressure-Enthalpy Diagram for Refrigerant 123

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Refrigerant 123 (2,2-Dichloro-1,1,1-Trifluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–80	0.00013	1709.6	83.6670	123.92	335.98	0.6712	1.7691	0.924	0.520	1.117	1133	108.3	2093.0	6.68	107.4	3.22	28.42	–80
–70	0.00034	1687.4	32.8420	133.17	341.25	0.7179	1.7422	0.927	0.537	1.113	1091	110.8	1680.0	7.09	104.8	3.79	27.09	–70
–60	0.00081	1665.1	14.3330	142.46	346.66	0.7625	1.7206	0.932	0.553	1.110	1049	113.3	1383.0	7.50	102.0	4.35	25.78	–60
–50	0.00177	1642.6	6.84600	151.81	352.21	0.8054	1.7034	0.939	0.569	1.107	1006	115.6	1160.0	7.91	99.1	4.92	24.48	–50
–40	0.00358	1620.0	3.53190	161.25	357.88	0.8468	1.6901	0.948	0.585	1.105	964	117.9	986.4	8.31	96.1	5.49	23.19	–40
–30	0.00675	1597.0	1.94700	170.78	363.65	0.8868	1.6800	0.958	0.601	1.103	923	120.0	848.0	8.70	93.0	6.05	21.92	–30
–20	0.01200	1573.8	1.13640	180.41	369.52	0.9256	1.6726	0.968	0.617	1.102	881	122.0	735.4	9.09	89.8	6.61	20.66	–20
–10	0.02025	1550.1	0.69690	190.15	375.45	0.9633	1.6675	0.979	0.634	1.102	841	123.8	642.4	9.47	86.7	7.18	19.41	–10
0	0.03265	1526.1	0.44609	200.00	381.44	1.0000	1.6642	0.990	0.651	1.102	801	125.4	564.6	9.84	83.7	7.74	18.18	0
2	0.03574	1521.3	0.40991	201.98	382.64	1.0072	1.6638	0.993	0.654	1.103	793	125.7	550.6	9.91	83.1	7.86	17.94	2
4	0.03907	1516.4	0.37720	203.97	383.84	1.0144	1.6634	0.995	0.658	1.103	785	126.0	537.0	9.99	82.5	7.97	17.70	4
6	0.04264	1511.5	0.34759	205.97	385.05	1.0216	1.6631	0.997	0.661	1.103	777	126.3	523.8	10.06	81.9	8.08	17.45	6
8	0.04647	1506.6	0.32075	207.96	386.25	1.0287	1.6628	0.999	0.665	1.103	769	126.6	511.1	10.13	81.3	8.20	17.21	8
10	0.05057	1501.6	0.29637	209.97	387.46	1.0358	1.6626	1.002	0.668	1.104	761	126.8	498.8	10.20	80.7	8.31	16.97	10
12	0.05495	1496.7	0.27420	211.97	388.66	1.0428	1.6625	1.004	0.672	1.104	754	127.1	486.8	10.28	80.1	8.43	16.73	12
14	0.05963	1491.7	0.25401	213.99	389.87	1.0499	1.6624	1.006	0.675	1.104	746	127.3	475.3	10.35	79.5	8.54	16.49	14
16	0.06463	1486.7	0.23559	216.00	391.08	1.0569	1.6623	1.009	0.679	1.105	738	127.6	464.0	10.42	79.0	8.66	16.25	16
18	0.06995	1481.7	0.21877	218.02	392.29	1.0638	1.6623	1.011	0.682	1.105	730	127.8	453.2	10.49	78.4	8.77	16.01	18
20	0.07561	1476.6	0.20338	220.05	393.49	1.0707	1.6624	1.014	0.686	1.106	723	128.0	442.6	10.56	77.8	8.89	15.77	20
22	0.08163	1471.5	0.18929	222.08	394.70	1.0776	1.6625	1.016	0.690	1.106	715	128.2	432.4	10.63	77.3	9.01	15.53	22
24	0.08802	1466.4	0.17637	224.12	395.91	1.0845	1.6626	1.018	0.693	1.107	707	128.4	422.4	10.70	76.7	9.12	15.30	24
26	0.09480	1461.3	0.16451	226.16	397.12	1.0913	1.6628	1.021	0.697	1.107	700	128.6	412.8	10.77	76.1	9.24	15.06	26
27.82[b]	0.10133	1456.6	0.15453	228.03	398.22	1.0975	1.6630	1.023	0.701	1.108	693	128.7	404.2	10.84	75.6	9.35	14.84	27.82
28	0.10198	1456.2	0.15360	228.21	398.32	1.0981	1.6630	1.023	0.701	1.108	692	128.7	403.4	10.84	75.6	9.36	14.82	28
30	0.10958	1451.0	0.14356	230.26	399.53	1.1049	1.6633	1.026	0.705	1.109	684	128.9	394.3	10.91	75.0	9.48	14.59	30
32	0.11762	1445.8	0.13431	232.31	400.73	1.1116	1.6635	1.028	0.709	1.109	677	129.0	385.4	10.98	74.5	9.60	14.35	32
34	0.12611	1440.6	0.12577	234.38	401.93	1.1183	1.6639	1.031	0.712	1.110	669	129.1	376.8	11.05	74.0	9.72	14.12	34
36	0.13507	1435.4	0.11789	236.44	403.14	1.1250	1.6642	1.033	0.716	1.111	662	129.3	368.4	11.12	73.4	9.84	13.89	36
38	0.14452	1430.1	0.11060	238.51	404.34	1.1317	1.6646	1.036	0.720	1.112	654	129.4	360.3	11.19	72.9	9.96	13.66	38
40	0.15447	1424.8	0.10385	240.59	405.54	1.1383	1.6651	1.038	0.724	1.113	647	129.5	352.4	11.26	72.4	10.08	13.43	40
42	0.16495	1419.4	0.09759	242.67	406.73	1.1449	1.6655	1.041	0.728	1.114	639	129.5	344.7	11.33	71.8	10.20	13.20	42
44	0.17597	1414.1	0.09179	244.76	407.93	1.1515	1.6660	1.044	0.732	1.115	632	129.6	337.2	11.40	71.3	10.32	12.97	44
46	0.18755	1408.7	0.08641	246.86	409.12	1.1581	1.6665	1.046	0.736	1.116	624	129.7	329.9	11.46	70.8	10.45	12.74	46
48	0.19971	1403.3	0.08140	248.95	410.31	1.1646	1.6670	1.049	0.741	1.117	617	129.7	322.8	11.53	70.3	10.57	12.51	48
50	0.21246	1397.8	0.07674	251.06	411.50	1.1711	1.6676	1.052	0.745	1.119	610	129.7	315.9	11.60	69.8	10.70	12.28	50
52	0.22584	1392.3	0.07240	253.17	412.69	1.1776	1.6682	1.055	0.749	1.120	602	129.7	309.1	11.67	69.3	10.82	12.05	52
54	0.23985	1386.8	0.06836	255.28	413.87	1.1840	1.6688	1.058	0.753	1.121	595	129.7	302.6	11.74	68.8	10.95	11.83	54
56	0.25451	1381.2	0.06458	257.41	415.05	1.1905	1.6694	1.060	0.758	1.123	588	129.7	296.2	11.80	68.3	11.08	11.60	56
58	0.26985	1375.6	0.06106	259.53	416.23	1.1969	1.6701	1.063	0.762	1.124	580	129.7	289.9	11.87	67.8	11.21	11.38	58
60	0.28589	1370.0	0.05777	261.67	417.40	1.2033	1.6707	1.066	0.767	1.126	573	129.6	283.9	11.94	67.3	11.34	11.16	60
62	0.30264	1364.3	0.05469	263.81	418.57	1.2096	1.6714	1.069	0.771	1.127	566	129.6	277.9	12.01	66.8	11.47	10.93	62
64	0.32013	1358.6	0.05180	265.95	419.73	1.2160	1.6721	1.072	0.776	1.129	558	129.5	272.1	12.07	66.3	11.61	10.71	64
66	0.33838	1352.8	0.04910	268.10	420.89	1.2223	1.6728	1.076	0.781	1.131	551	129.4	266.5	12.14	65.9	11.74	10.49	66
68	0.35740	1347.0	0.04656	270.26	422.05	1.2286	1.6735	1.079	0.785	1.133	544	129.3	261.0	12.21	65.4	11.88	10.27	68
70	0.37722	1341.2	0.04418	272.42	423.20	1.2349	1.6743	1.082	0.790	1.135	536	129.2	255.6	12.28	64.9	12.01	10.05	70
72	0.39787	1335.3	0.04195	274.60	424.35	1.2411	1.6750	1.085	0.795	1.137	529	129.0	250.4	12.35	64.5	12.15	9.84	72
74	0.41936	1329.3	0.03985	276.77	425.50	1.2474	1.6758	1.089	0.800	1.139	522	128.9	245.2	12.42	64.0	12.29	9.62	74
76	0.44171	1323.4	0.03787	278.96	426.63	1.2536	1.6766	1.092	0.806	1.142	515	128.7	240.2	12.49	63.5	12.44	9.40	76
78	0.46494	1317.3	0.03601	281.15	427.77	1.2598	1.6774	1.096	0.811	1.144	507	128.5	235.3	12.55	63.1	12.58	9.19	78
80	0.48909	1311.2	0.03426	283.35	428.89	1.2660	1.6781	1.100	0.816	1.147	500	128.3	230.5	12.63	62.6	12.73	8.97	80
82	0.51416	1305.1	0.03261	285.55	430.01	1.2722	1.6789	1.103	0.822	1.150	493	128.1	225.9	12.70	62.2	12.87	8.76	82
84	0.54019	1298.9	0.03105	287.77	431.13	1.2783	1.6797	1.107	0.827	1.152	486	127.8	221.3	12.77	61.7	13.02	8.55	84
86	0.56720	1292.6	0.02958	289.99	432.23	1.2845	1.6806	1.111	0.833	1.156	478	127.6	216.8	12.84	61.3	13.17	8.34	86
88	0.59520	1286.3	0.02819	292.22	433.33	1.2906	1.6814	1.115	0.839	1.159	471	127.3	212.5	12.91	60.8	13.33	8.13	88
90	0.62423	1279.9	0.02687	294.45	434.43	1.2967	1.6822	1.120	0.845	1.162	464	127.0	208.2	12.98	60.4	13.48	7.92	90
92	0.65430	1273.5	0.02563	296.70	435.51	1.3028	1.6830	1.124	0.851	1.166	457	126.6	204.0	13.06	59.9	13.64	7.71	92
94	0.68544	1266.9	0.02445	298.95	436.59	1.3089	1.6838	1.129	0.858	1.169	449	126.3	199.9	13.14	59.5	13.80	7.50	94
96	0.71768	1260.3	0.02334	301.21	437.66	1.3150	1.6846	1.133	0.864	1.173	442	125.9	195.9	13.21	59.1	13.96	7.30	96
98	0.75103	1253.7	0.02228	303.49	438.72	1.3211	1.6854	1.138	0.871	1.177	435	125.5	191.9	13.29	58.6	14.13	7.09	98
100	0.78553	1246.9	0.02128	305.77	439.77	1.3271	1.6862	1.143	0.878	1.182	427	125.1	188.1	13.37	58.2	14.29	6.89	100
110	0.97603	1211.9	0.01697	317.32	444.88	1.3572	1.6902	1.172	0.917	1.208	391	122.8	169.9	13.80	56.0	15.17	5.88	110
120	1.19900	1174.4	0.01361	329.15	449.67	1.3872	1.6938	1.207	0.964	1.243	354	119.8	153.4	14.29	53.9	16.14	4.91	120
130	1.45780	1133.6	0.01094	341.32	454.07	1.4173	1.6969	1.254	1.026	1.294	317	116.0	138.1	14.89	51.7	17.22	3.98	130
140	1.75630	1088.3	0.00879	353.92	457.94	1.4475	1.6992	1.318	1.111	1.369	279	111.5	123.8	15.65	49.5	18.44	3.09	140
150	2.09870	1036.8	0.00703	367.10	461.05	1.4782	1.7003	1.415	1.240	1.493	239	106.0	110.2	16.68	47.2	19.87	2.24	150
160	2.49010	975.7	0.00555	381.13	463.01	1.5101	1.6991	1.584	1.473	1.726	198	99.3	96.8	18.19	44.8	21.63	1.45	160
170	2.93720	896.9	0.00425	396.61	462.89	1.5443	1.6939	1.979	2.033	2.309	154	91.1	82.7	20.71	42.3	24.05	0.74	170
180	3.45060	765.9	0.00292	416.22	456.82	1.5867	1.6763	4.549	5.661	6.158	102	80.6	64.3	26.59	39.7	28.82	0.15	180
183.68[c]	3.66180	550.0	0.00182	437.39	437.39	1.6325	1.6325	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	183.68

*Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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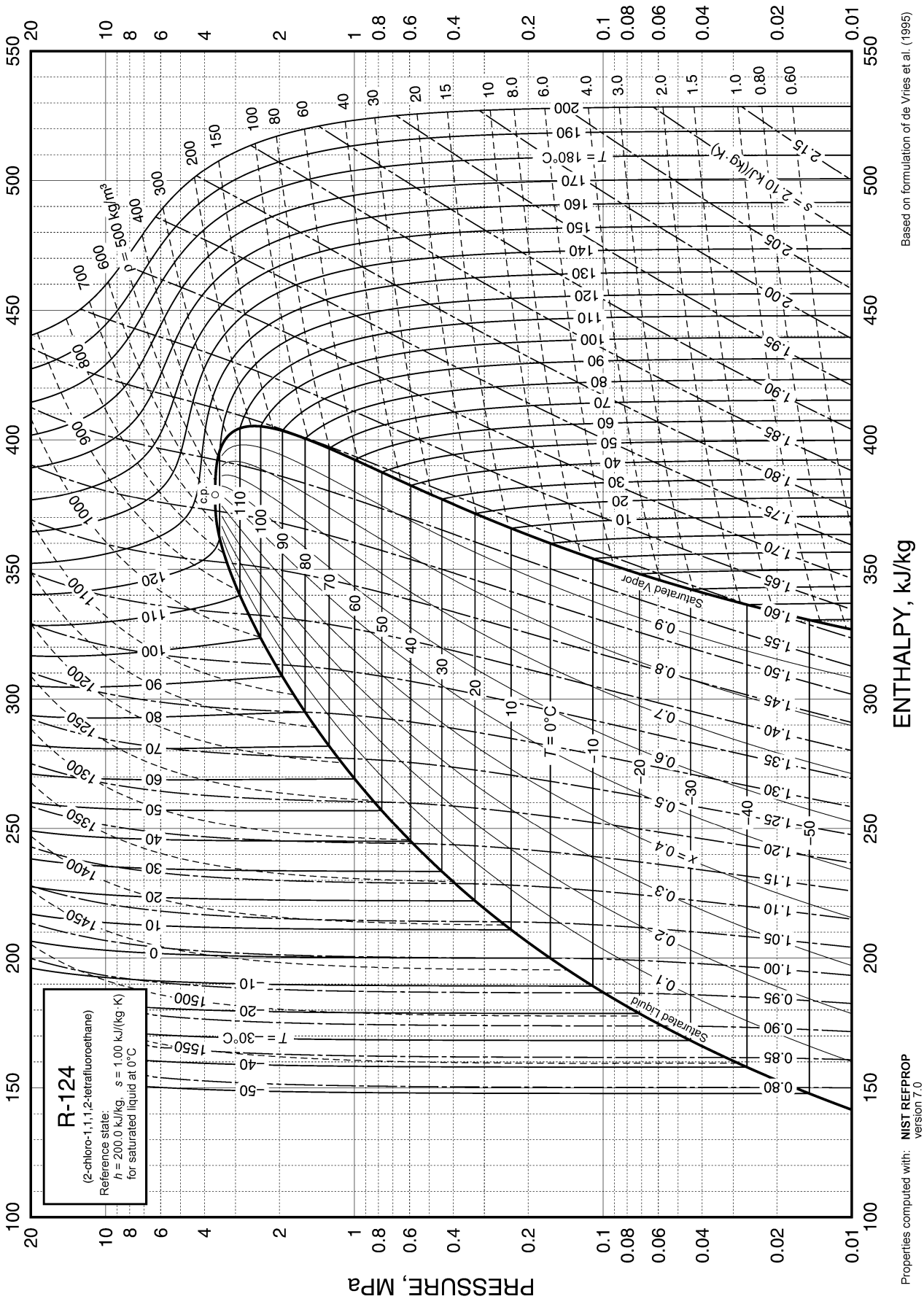

Fig. 6 Pressure-Enthalpy Diagram for Refrigerant 124

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Refrigerant 124 (2-Chloro-1,1,1,2-Tetrafluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–100	0.00024	1714.6	44.37500	98.87	302.29	0.5417	1.7165	0.953	0.534	1.129	1052	109.1	1964.0	6.66	111.8	4.81	26.10	–100
–90	0.00067	1688.6	16.53100	108.45	307.68	0.5954	1.6832	0.962	0.551	1.125	1007	111.9	1521.0	7.05	108.7	5.26	24.69	–90
–80	0.00169	1662.3	6.96450	118.13	313.21	0.6469	1.6569	0.972	0.569	1.122	963	114.6	1215.0	7.45	105.4	5.74	23.30	–80
–70	0.00379	1635.9	3.25230	127.91	318.86	0.6962	1.6362	0.983	0.586	1.119	919	117.2	994.1	7.84	101.9	6.23	21.92	–70
–60	0.00779	1609.1	1.65600	137.80	324.62	0.7437	1.6202	0.995	0.605	1.117	875	119.6	829.0	8.23	98.5	6.74	20.56	–60
–50	0.01482	1582.0	0.90713	147.81	330.46	0.7896	1.6081	1.007	0.624	1.116	832	121.8	701.6	8.62	94.9	7.27	19.21	–50
–40	0.02642	1554.3	0.52863	157.95	336.36	0.8340	1.5993	1.020	0.644	1.116	790	123.8	600.9	9.01	91.3	7.82	17.88	–40
–30	0.04452	1526.1	0.32470	168.23	342.29	0.8772	1.5930	1.034	0.665	1.118	748	125.5	519.4	9.39	87.7	8.39	16.56	–30
–20	0.07145	1497.3	0.20856	178.66	348.23	0.9191	1.5890	1.049	0.688	1.120	706	126.9	452.4	9.78	84.1	8.98	15.26	–20
–18	0.07813	1491.4	0.19180	180.76	349.42	0.9274	1.5884	1.052	0.693	1.121	698	127.1	440.4	9.86	83.4	9.10	15.00	–18
–16	0.08529	1485.5	0.17665	182.87	350.61	0.9356	1.5879	1.056	0.698	1.122	690	127.3	428.8	9.93	82.7	9.22	14.74	–16
–14	0.09296	1479.6	0.16293	184.99	351.79	0.9438	1.5874	1.059	0.703	1.123	682	127.5	417.6	10.01	82.0	9.34	14.49	–14
–12	0.10117	1473.6	0.15048	187.11	352.97	0.9519	1.5870	1.062	0.708	1.124	673	127.7	406.8	10.09	81.2	9.46	14.23	–12
–11.96[b]	0.10133	1473.5	0.15026	187.15	352.99	0.9521	1.5870	1.062	0.708	1.124	673	127.7	406.6	10.09	81.2	9.46	14.23	–11.96
–10	0.10993	1467.6	0.13917	189.24	354.15	0.9600	1.5867	1.065	0.713	1.125	665	127.9	396.3	10.16	80.5	9.59	13.98	–10
–8	0.11928	1461.6	0.12888	191.38	355.33	0.9681	1.5864	1.069	0.718	1.126	657	128.1	386.2	10.24	79.8	9.71	13.72	–8
–6	0.12923	1455.5	0.11950	193.52	356.51	0.9761	1.5862	1.072	0.723	1.127	649	128.2	376.4	10.32	79.1	9.84	13.47	–6
–4	0.13983	1449.4	0.11093	195.68	357.68	0.9841	1.5860	1.076	0.729	1.128	641	128.3	366.9	10.40	78.4	9.96	13.22	–4
–2	0.15108	1443.2	0.10310	197.83	358.86	0.9921	1.5859	1.079	0.734	1.129	633	128.5	357.7	10.47	77.7	10.09	12.97	–2
0	0.16303	1437.0	0.09593	200.00	360.02	1.0000	1.5858	1.083	0.740	1.131	625	128.6	348.8	10.55	77.0	10.22	12.72	0
2	0.17570	1430.8	0.08936	202.17	361.19	1.0079	1.5858	1.087	0.746	1.132	617	128.6	340.2	10.63	76.3	10.35	12.47	2
4	0.18911	1424.5	0.08333	204.35	362.35	1.0158	1.5858	1.090	0.751	1.134	609	128.7	331.8	10.71	75.6	10.49	12.22	4
6	0.20331	1418.1	0.07779	206.54	363.51	1.0236	1.5859	1.094	0.757	1.135	601	128.7	323.7	10.79	74.9	10.62	11.97	6
8	0.21830	1411.8	0.07268	208.74	364.67	1.0314	1.5860	1.098	0.763	1.137	593	128.8	315.8	10.87	74.2	10.75	11.72	8
10	0.23414	1405.3	0.06798	210.94	365.82	1.0392	1.5861	1.102	0.769	1.139	585	128.8	308.2	10.95	73.5	10.89	11.48	10
12	0.25084	1398.9	0.06364	213.15	366.97	1.0469	1.5863	1.106	0.776	1.141	577	128.7	300.8	11.03	72.8	11.03	11.23	12
14	0.26844	1392.3	0.05964	215.37	368.11	1.0546	1.5865	1.110	0.782	1.143	569	128.7	293.5	11.11	72.1	11.17	10.99	14
16	0.28696	1385.7	0.05593	217.60	369.25	1.0623	1.5868	1.114	0.788	1.145	561	128.7	286.5	11.19	71.4	11.31	10.74	16
18	0.30644	1379.1	0.05250	219.84	370.38	1.0700	1.5870	1.119	0.795	1.148	553	128.6	279.7	11.28	70.8	11.46	10.50	18
20	0.32692	1372.4	0.04932	222.09	371.51	1.0776	1.5873	1.123	0.802	1.150	545	128.5	273.1	11.36	70.1	11.61	10.26	20
22	0.34842	1365.6	0.04636	224.34	372.63	1.0852	1.5876	1.128	0.809	1.153	537	128.4	266.6	11.44	69.4	11.75	10.02	22
24	0.37097	1358.8	0.04362	226.60	373.75	1.0928	1.5880	1.132	0.816	1.156	529	128.2	260.3	11.53	68.7	11.91	9.78	24
26	0.39462	1351.9	0.04107	228.88	374.85	1.1004	1.5883	1.137	0.823	1.159	521	128.1	254.2	11.61	68.1	12.06	9.54	26
28	0.41938	1345.0	0.03870	231.16	375.96	1.1079	1.5887	1.142	0.830	1.162	513	127.9	248.2	11.70	67.4	12.22	9.30	28
30	0.44530	1337.9	0.03648	233.45	377.05	1.1154	1.5891	1.147	0.838	1.165	505	127.7	242.4	11.79	66.8	12.38	9.06	30
32	0.47241	1330.8	0.03442	235.75	378.14	1.1229	1.5895	1.152	0.845	1.169	497	127.5	236.7	11.88	66.1	12.54	8.83	32
34	0.50075	1323.7	0.03249	238.07	379.22	1.1304	1.5900	1.157	0.853	1.172	489	127.2	231.2	11.97	65.5	12.71	8.59	34
36	0.53034	1316.4	0.03069	240.39	380.29	1.1379	1.5904	1.163	0.861	1.176	481	126.9	225.8	12.06	64.8	12.88	8.36	36
38	0.56123	1309.1	0.02901	242.72	381.36	1.1453	1.5909	1.168	0.870	1.180	473	126.6	220.5	12.16	64.2	13.05	8.13	38
40	0.59345	1301.6	0.02743	245.07	382.41	1.1528	1.5913	1.174	0.878	1.185	465	126.3	215.4	12.25	63.5	13.23	7.90	40
42	0.62704	1294.1	0.02596	247.43	383.45	1.1602	1.5918	1.180	0.887	1.189	457	125.9	210.4	12.35	62.9	13.41	7.67	42
44	0.66202	1286.5	0.02457	249.79	384.49	1.1676	1.5923	1.187	0.897	1.194	449	125.6	205.5	12.45	62.3	13.59	7.44	44
46	0.69845	1278.8	0.02327	252.17	385.51	1.1750	1.5928	1.193	0.906	1.199	441	125.2	200.7	12.55	61.7	13.79	7.21	46
48	0.73635	1271.0	0.02205	254.56	386.52	1.1824	1.5933	1.200	0.916	1.205	433	124.7	196.0	12.66	61.0	13.98	6.98	48
50	0.77577	1263.1	0.02090	256.97	387.53	1.1897	1.5937	1.207	0.926	1.211	425	124.3	191.4	12.77	60.4	14.18	6.76	50
52	0.81675	1255.1	0.01982	259.39	388.51	1.1971	1.5942	1.214	0.937	1.217	417	123.8	187.0	12.88	59.8	14.39	6.53	52
54	0.85931	1247.0	0.01880	261.82	389.49	1.2044	1.5947	1.221	0.948	1.224	409	123.3	182.6	12.99	59.2	14.61	6.31	54
56	0.90350	1238.7	0.01784	264.26	390.45	1.2118	1.5951	1.229	0.959	1.231	401	122.7	178.3	13.11	58.6	14.83	6.09	56
58	0.94937	1230.3	0.01693	266.73	391.39	1.2191	1.5956	1.238	0.971	1.239	393	122.1	174.1	13.27	58.0	15.08	5.87	58
60	0.99695	1221.8	0.01607	269.20	392.33	1.2265	1.5960	1.246	0.984	1.247	385	121.5	169.9	13.40	57.5	15.32	5.65	60
62	1.04630	1213.2	0.01527	271.69	393.24	1.2338	1.5965	1.255	0.997	1.256	376	120.9	165.9	13.53	56.9	15.57	5.43	62
64	1.09740	1204.3	0.01450	274.20	394.14	1.2411	1.5969	1.265	1.011	1.266	368	120.2	161.9	13.67	56.3	15.83	5.21	64
66	1.15040	1195.4	0.01378	276.72	395.01	1.2485	1.5972	1.275	1.026	1.276	360	119.5	158.0	13.82	55.7	16.10	5.00	66
68	1.20520	1186.2	0.01309	279.27	395.87	1.2558	1.5976	1.286	1.042	1.287	351	118.7	154.2	13.97	55.2	16.38	4.79	68
70	1.26200	1176.9	0.01244	281.83	396.71	1.2631	1.5979	1.297	1.058	1.299	343	117.9	150.4	14.12	54.6	16.68	4.58	70
72	1.32070	1167.4	0.01183	284.41	397.52	1.2705	1.5982	1.310	1.076	1.313	334	117.1	146.7	14.28	54.1	16.98	4.37	72
74	1.38150	1157.6	0.01124	287.01	398.31	1.2779	1.5985	1.323	1.095	1.327	326	116.2	143.0	14.45	53.5	17.30	4.16	74
76	1.44430	1147.7	0.01069	289.63	399.08	1.2852	1.5987	1.337	1.115	1.343	317	115.3	139.4	14.63	53.0	17.64	3.95	76
78	1.50930	1137.5	0.01016	292.28	399.81	1.2926	1.5989	1.352	1.137	1.360	309	114.4	135.8	14.82	52.5	17.99	3.75	78
80	1.57640	1127.0	0.00965	294.95	400.52	1.3001	1.5990	1.368	1.160	1.379	300	113.4	132.3	15.01	51.9	18.36	3.54	80
85	1.75400	1099.6	0.00849	301.75	402.14	1.3187	1.5990	1.415	1.229	1.436	278	110.7	123.7	15.54	50.6	19.39	3.05	85
90	1.94620	1070.1	0.00746	308.74	403.51	1.3376	1.5986	1.475	1.318	1.513	255	107.8	115.2	16.16	49.4	20.58	2.56	90
95	2.15420	1037.8	0.00653	315.97	404.56	1.3568	1.5975	1.554	1.437	1.618	231	104.4	106.9	16.88	48.2	22.00	2.09	95
100	2.37870	1001.8	0.00569	323.50	405.20	1.3766	1.5955	1.665	1.607	1.773	207	100.7	98.4	17.75	47.0	23.73	1.64	100
105	2.62120	960.8	0.00492	331.44	405.26	1.3971	1.5923	1.835	1.873	2.022	182	96.6	89.8	18.85	46.0	25.94	1.21	105
110	2.88310	912.1	0.00419	339.99	404.46	1.4188	1.5870	2.135	2.357	2.478	156	91.9	80.8	20.30	45.1	28.94	0.80	110
115	3.16620	849.5	0.00347	349.58	402.13	1.4428	1.5782	2.837	3.513	3.576	127	86.6	70.7	22.45	45.0	33.62	0.43	115
120	3.47390	749.1	0.00267	361.94	395.71	1.4734	1.5593	6.828	9.976	9.676	93	80.2	57.3	26.73	48.2	44.96	0.11	120
122.28[c]	3.62430	560.0	0.00179	378.79	378.79	1.5156	1.5156	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	122.28

*Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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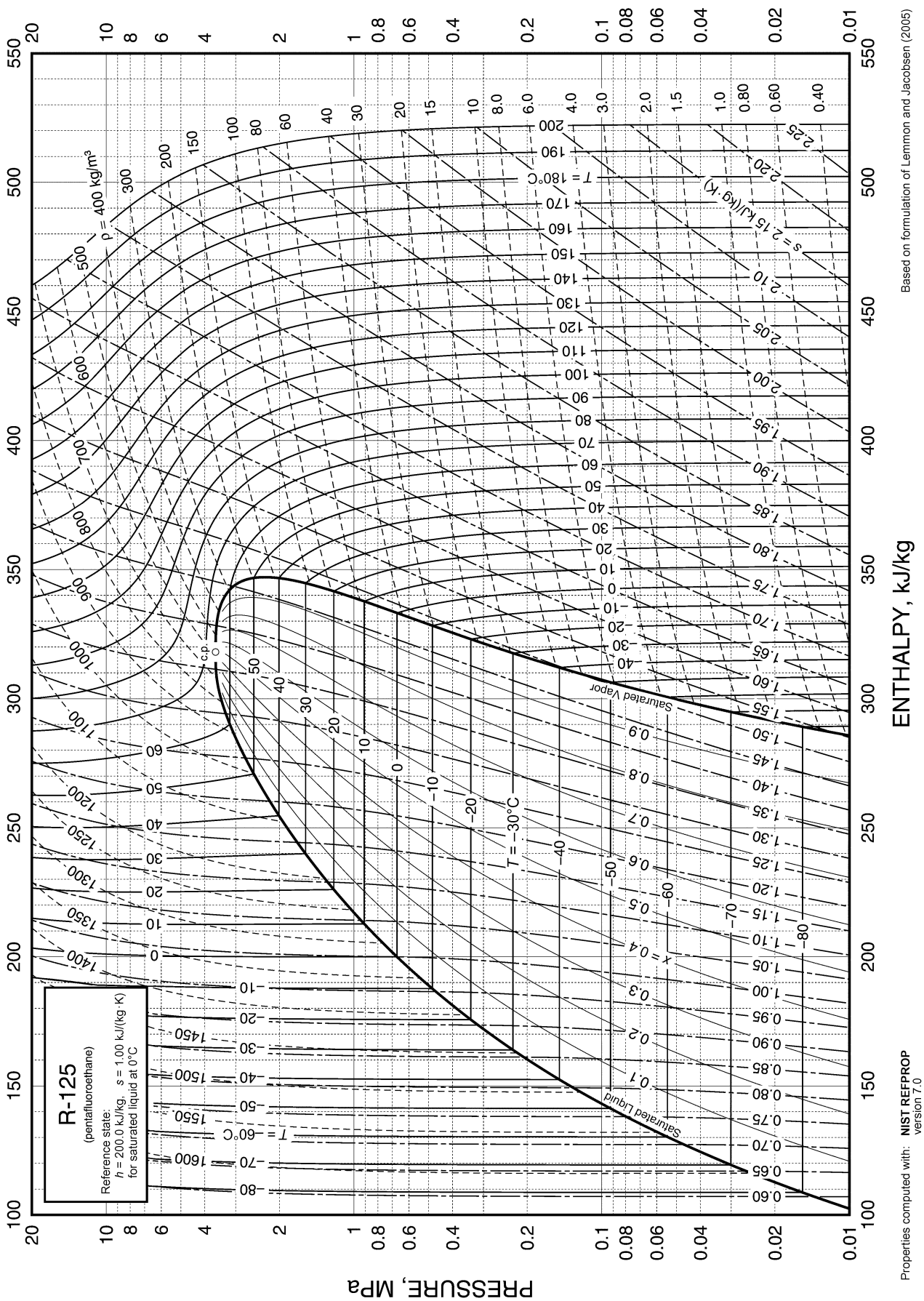

Fig. 7 Pressure-Enthalpy Diagram for Refrigerant 125

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Refrigerant 125 (Pentafluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,[a] °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp., °C
–100.63[b]	0.00291	1690.7	4.0880	87.13	277.39	0.4902	1.5931	1.035	0.569	1.142	933	116.4	1152	7.43	116.0	5.23	21.79	–100.63
–100	0.00309	1688.7	3.8709	87.78	277.74	0.4940	1.5911	1.035	0.570	1.141	929	116.6	1134	7.46	115.7	5.28	21.69	–100
–90	0.00729	1656.2	1.7303	98.18	283.36	0.5524	1.5634	1.045	0.592	1.138	878	119.4	890.8	7.90	111.0	5.92	20.08	–90
–80	0.01547	1623.4	0.85534	108.70	289.06	0.6082	1.5421	1.058	0.615	1.136	827	121.9	720.6	8.34	106.3	6.58	18.50	–80
–70	0.03008	1589.9	0.45942	119.36	294.83	0.6620	1.5257	1.074	0.639	1.136	779	124.1	595.2	8.77	101.6	7.25	16.94	–70
–60	0.05432	1555.7	0.26432	130.19	300.60	0.7140	1.5135	1.091	0.664	1.138	731	126.0	499.3	9.20	96.8	7.92	15.41	–60
–58	0.06066	1548.7	0.23836	132.38	301.75	0.7242	1.5114	1.095	0.669	1.138	721	126.3	482.8	9.29	95.9	8.06	15.11	–58
–56	0.06758	1541.7	0.21542	134.57	302.91	0.7343	1.5095	1.099	0.675	1.139	712	126.6	467.0	9.37	95.0	8.20	14.81	–56
–54	0.07511	1534.7	0.19510	136.78	304.06	0.7444	1.5077	1.103	0.680	1.140	702	126.9	452.0	9.46	94.0	8.33	14.51	–54
–52	0.08329	1527.6	0.17706	138.99	305.20	0.7544	1.5060	1.107	0.686	1.141	693	127.2	437.6	9.54	93.1	8.47	14.21	–52
–50	0.09216	1520.5	0.16100	141.21	306.35	0.7644	1.5044	1.111	0.692	1.142	683	127.4	423.8	9.63	92.2	8.61	13.91	–50
–48.09[c]	0.10132	1513.6	0.14728	143.34	307.44	0.7739	1.5030	1.115	0.697	1.143	674	127.6	411.1	9.71	91.3	8.75	13.63	–48.09
–48	0.10177	1513.3	0.14668	143.44	307.49	0.7743	1.5029	1.115	0.697	1.143	674	127.6	410.5	9.71	91.3	8.75	13.61	–48
–46	0.11214	1506.0	0.13387	145.68	308.63	0.7842	1.5016	1.119	0.703	1.144	664	127.8	397.9	9.80	90.3	8.89	13.32	–46
–44	0.12332	1498.8	0.12240	147.92	309.77	0.7940	1.5003	1.123	0.709	1.145	655	128.0	385.7	9.89	89.4	9.03	13.02	–44
–42	0.13536	1491.4	0.11209	150.18	310.90	0.8037	1.4991	1.128	0.715	1.146	645	128.2	374.0	9.97	88.5	9.17	12.73	–42
–40	0.14830	1484.0	0.10283	152.44	312.03	0.8134	1.4980	1.132	0.722	1.148	636	128.3	362.8	10.06	87.6	9.32	12.44	–40
–38	0.16218	1476.6	0.09448	154.71	313.16	0.8231	1.4969	1.137	0.728	1.150	627	128.5	352.0	10.14	86.7	9.46	12.15	–38
–36	0.17705	1469.1	0.08693	157.00	314.28	0.8327	1.4960	1.142	0.734	1.151	617	128.6	341.6	10.23	85.7	9.61	11.86	–36
–34	0.19295	1461.5	0.08011	159.29	315.40	0.8423	1.4951	1.146	0.741	1.153	608	128.7	331.6	10.32	84.8	9.75	11.57	–34
–32	0.20994	1453.8	0.07393	161.59	316.51	0.8519	1.4943	1.151	0.748	1.155	599	128.7	321.9	10.40	83.9	9.90	11.29	–32
–30	0.22806	1446.1	0.06831	163.90	317.61	0.8614	1.4935	1.157	0.755	1.157	589	128.7	312.6	10.49	83.0	10.05	11.00	–30
–28	0.24735	1438.4	0.06321	166.22	318.71	0.8708	1.4928	1.162	0.762	1.160	580	128.7	303.6	10.58	82.1	10.20	10.72	–28
–26	0.26787	1430.5	0.05855	168.56	319.80	0.8802	1.4922	1.167	0.769	1.162	570	128.7	294.9	10.66	81.2	10.35	10.44	–26
–24	0.28968	1422.6	0.05431	170.90	320.88	0.8896	1.4916	1.173	0.776	1.165	561	128.7	286.5	10.75	80.3	10.50	10.15	–24
–22	0.31281	1414.5	0.05043	173.26	321.96	0.8990	1.4911	1.178	0.784	1.167	552	128.6	278.4	10.84	79.4	10.65	9.88	–22
–20	0.33733	1406.4	0.04688	175.62	323.03	0.9083	1.4906	1.184	0.791	1.170	542	128.5	270.5	10.93	78.5	10.81	9.60	–20
–18	0.36328	1398.3	0.04363	178.00	324.09	0.9176	1.4901	1.190	0.799	1.173	533	128.4	262.9	11.02	77.7	10.97	9.32	–18
–16	0.39072	1390.0	0.04064	180.39	325.14	0.9268	1.4897	1.196	0.807	1.177	523	128.2	255.5	11.11	76.8	11.12	9.05	–16
–14	0.41970	1381.6	0.03789	182.80	326.19	0.9361	1.4894	1.203	0.815	1.181	514	128.0	248.4	11.21	75.9	11.29	8.78	–14
–12	0.45028	1373.1	0.03536	185.21	327.22	0.9453	1.4890	1.209	0.824	1.184	505	127.8	241.4	11.30	75.0	11.45	8.50	–12
–10	0.48252	1364.5	0.03303	187.64	328.24	0.9544	1.4887	1.216	0.832	1.189	495	127.5	234.7	11.40	74.1	11.62	8.23	–10
–8	0.51646	1355.8	0.03088	190.08	329.25	0.9636	1.4884	1.223	0.841	1.193	486	127.3	228.1	11.49	73.3	11.79	7.97	–8
–6	0.55218	1347.0	0.02890	192.54	330.25	0.9727	1.4882	1.231	0.850	1.198	476	126.9	221.8	11.59	72.4	11.96	7.70	–6
–4	0.58972	1338.1	0.02706	195.01	331.23	0.9818	1.4879	1.238	0.860	1.203	467	126.6	215.6	11.69	71.6	12.14	7.44	–4
–2	0.62915	1329.0	0.02535	197.50	332.20	0.9909	1.4877	1.246	0.870	1.209	457	126.2	209.6	11.79	70.7	12.32	7.17	–2
0	0.67052	1319.8	0.02377	200.00	333.16	1.0000	1.4875	1.255	0.880	1.215	448	125.8	203.7	11.89	69.8	12.50	6.91	0
2	0.71390	1310.5	0.02230	202.52	334.10	1.0091	1.4873	1.263	0.890	1.222	439	125.3	198.0	12.00	69.0	12.69	6.65	2
4	0.75935	1301.0	0.02093	205.05	335.02	1.0181	1.4870	1.273	0.902	1.229	429	124.9	192.4	12.11	68.1	12.88	6.40	4
6	0.80694	1291.3	0.01966	207.60	335.92	1.0272	1.4868	1.282	0.913	1.237	420	124.3	187.0	12.22	67.3	13.08	6.14	6
8	0.85672	1281.5	0.01848	210.17	336.80	1.0362	1.4866	1.292	0.926	1.246	410	123.8	181.7	12.33	66.5	13.29	5.89	8
10	0.90875	1271.5	0.01737	212.76	337.66	1.0452	1.4863	1.303	0.939	1.255	400	123.2	176.5	12.45	65.6	13.50	5.64	10
12	0.96312	1261.3	0.01634	215.37	338.50	1.0542	1.4860	1.314	0.954	1.265	391	122.5	171.4	12.57	64.8	13.72	5.39	12
14	1.0199	1250.9	0.01537	218.00	339.31	1.0633	1.4857	1.326	0.969	1.277	381	121.9	166.5	12.70	64.0	13.95	5.14	14
16	1.0791	1240.3	0.01447	220.65	340.10	1.0723	1.4854	1.339	0.986	1.289	371	121.1	161.6	12.83	63.1	14.18	4.90	16
18	1.1408	1229.4	0.01362	223.32	340.85	1.0813	1.4850	1.352	1.003	1.303	362	120.4	156.9	12.96	62.3	14.43	4.66	18
20	1.2052	1218.3	0.01283	226.02	341.58	1.0904	1.4846	1.367	1.023	1.318	352	119.6	152.2	13.10	61.5	14.69	4.42	20
22	1.2722	1206.9	0.01208	228.74	342.28	1.0995	1.4842	1.382	1.044	1.334	342	118.7	147.6	13.25	60.7	14.96	4.18	22
24	1.3420	1195.3	0.01138	231.49	342.95	1.1085	1.4836	1.399	1.067	1.352	332	117.8	143.1	13.40	59.8	15.24	3.95	24
26	1.4146	1183.3	0.01072	234.26	343.57	1.1176	1.4831	1.417	1.093	1.372	322	116.8	138.7	13.57	59.0	15.55	3.72	26
28	1.4901	1171.0	0.01010	237.07	344.16	1.1268	1.4824	1.436	1.121	1.395	312	115.8	134.4	13.74	58.2	15.87	3.49	28
30	1.5685	1158.4	0.00951	239.91	344.71	1.1359	1.4817	1.457	1.152	1.420	302	114.8	130.1	13.92	57.4	16.21	3.26	30
32	1.6501	1145.4	0.00895	242.78	345.22	1.1452	1.4809	1.481	1.186	1.448	292	113.7	125.9	14.11	56.6	16.57	3.04	32
34	1.7347	1131.9	0.00843	245.69	345.67	1.1544	1.4799	1.507	1.224	1.480	282	112.5	121.7	14.32	55.8	16.97	2.82	34
36	1.8226	1117.9	0.00793	248.64	346.07	1.1637	1.4789	1.536	1.267	1.516	272	111.3	117.6	14.54	54.9	17.39	2.60	36
38	1.9138	1103.5	0.00746	251.63	346.42	1.1731	1.4778	1.568	1.316	1.558	261	109.9	113.5	14.77	54.1	17.86	2.39	38
40	2.0085	1088.4	0.00702	254.67	346.69	1.1826	1.4764	1.605	1.372	1.606	251	108.6	109.4	15.03	53.3	18.37	2.18	40
42	2.1067	1072.7	0.00659	257.76	346.90	1.1921	1.4750	1.647	1.436	1.662	240	107.1	105.4	15.31	52.5	18.93	1.97	42
44	2.2084	1056.2	0.00619	260.92	347.02	1.2018	1.4733	1.697	1.511	1.728	229	105.6	101.3	15.61	51.7	19.55	1.77	44
46	2.3140	1038.9	0.00580	264.14	347.05	1.2116	1.4714	1.755	1.600	1.808	218	104.0	97.3	15.95	50.9	20.25	1.57	46
48	2.4234	1020.6	0.00543	267.44	346.96	1.2216	1.4692	1.824	1.708	1.906	207	102.3	93.3	16.32	50.1	21.04	1.38	48
50	2.5368	1001.1	0.00507	270.83	346.75	1.2318	1.4667	1.910	1.842	2.029	196	100.5	89.2	16.75	49.3	21.95	1.19	50
52	2.6544	980.2	0.00472	274.33	346.38	1.2422	1.4638	2.019	2.014	2.187	184	98.6	85.1	17.23	48.5	23.02	1.01	52
54	2.7763	957.5	0.00439	277.95	345.82	1.2529	1.4604	2.162	2.241	2.398	172	96.6	80.9	17.79	47.7	24.29	0.84	54
56	2.9027	932.6	0.00406	281.75	345.00	1.2641	1.4563	2.359	2.559	2.695	159	94.5	76.5	18.45	47.0	25.83	0.67	56
58	3.0339	904.5	0.00373	285.77	343.85	1.2758	1.4512	2.652	3.036	3.142	146	92.2	71.9	19.25	46.3	27.80	0.51	58
60	3.1703	872.1	0.00340	290.10	342.21	1.2884	1.4448	3.139	3.833	3.889	132	89.8	67.1	20.27	45.9	30.44	0.36	60
62	3.3121	832.4	0.00305	294.95	339.79	1.3024	1.4362	4.120	5.435	5.389	116	87.3	61.6	21.67	46.0	34.37	0.22	62
64	3.4602	777.5	0.00265	300.86	335.77	1.3195	1.4230	7.17	10.29	9.90	100	84.4	54.8	23.90	47.8	41.79	0.09	64
66.02[d]	3.6177	573.6	0.00174	318.06	318.06	1.3696	1.3696	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	66.02

[a]Temperatures on ITS-90 scale [b]Triple point [c]Normal boiling point [d]Critical point

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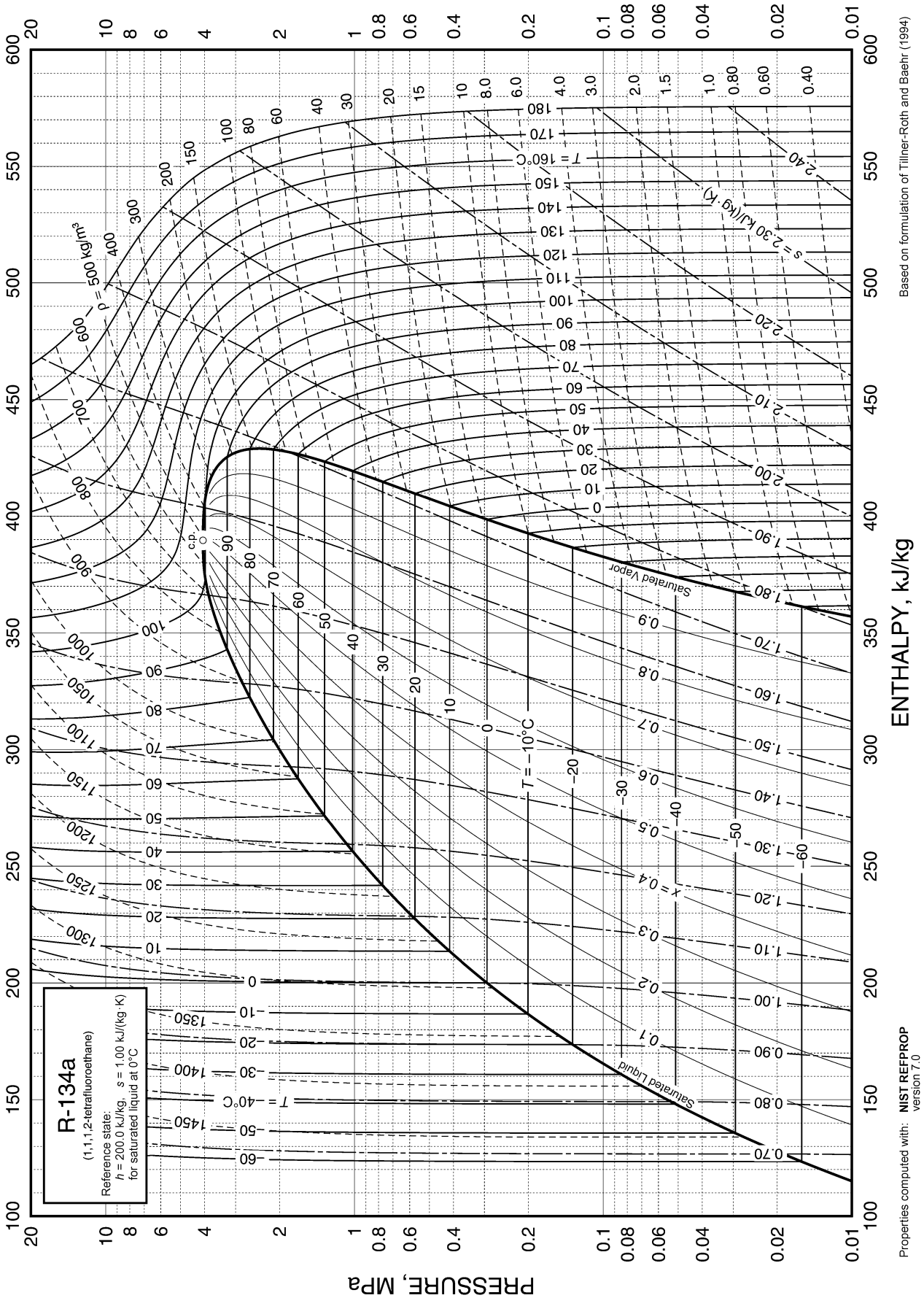

Fig. 8 Pressure-Enthalpy Diagram for Refrigerant 134a

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Refrigerant 134a (1,1,1,2-Tetrafluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–103.30[a]	0.00039	1591.1	35.4960	71.46	334.94	0.4126	1.9639	1.184	0.585	1.164	1120	126.8	2175.0	6.46	145.2	3.08	28.07	–103.30
–100	0.00056	1582.4	25.1930	75.36	336.85	0.4354	1.9456	1.184	0.593	1.162	1103	127.9	1893.0	6.60	143.2	3.34	27.50	–100
–90	0.00152	1555.8	9.7698	87.23	342.76	0.5020	1.8972	1.189	0.617	1.156	1052	131.0	1339.0	7.03	137.3	4.15	25.79	–90
–80	0.00367	1529.0	4.2682	99.16	348.83	0.5654	1.8580	1.198	0.642	1.151	1002	134.0	1018.0	7.46	131.5	4.95	24.10	–80
–70	0.00798	1501.9	2.0590	111.20	355.02	0.6262	1.8264	1.210	0.667	1.148	952	136.8	809.2	7.89	126.0	5.75	22.44	–70
–60	0.01591	1474.3	1.0790	123.36	361.31	0.6846	1.8010	1.223	0.692	1.146	903	139.4	663.1	8.30	120.7	6.56	20.80	–60
–50	0.02945	1446.3	0.60620	135.67	367.65	0.7410	1.7806	1.238	0.720	1.146	855	141.7	555.1	8.72	115.6	7.36	19.18	–50
–40	0.05121	1417.7	0.36108	148.14	374.00	0.7956	1.7643	1.255	0.749	1.148	807	143.6	472.2	9.12	110.6	8.17	17.60	–40
–30	0.08438	1388.4	0.22594	160.79	380.32	0.8486	1.7515	1.273	0.781	1.152	760	145.2	406.4	9.52	105.8	8.99	16.04	–30
–28	0.09270	1382.4	0.20680	163.34	381.57	0.8591	1.7492	1.277	0.788	1.153	751	145.4	394.9	9.60	104.8	9.15	15.73	–28
–26.07[b]	0.10133	1376.7	0.19018	165.81	382.78	0.8690	1.7472	1.281	0.794	1.154	742	145.7	384.2	9.68	103.9	9.31	15.44	–26.07
–26	0.10167	1376.5	0.18958	165.90	382.82	0.8694	1.7471	1.281	0.794	1.154	742	145.7	383.8	9.68	103.9	9.32	15.43	–26
–24	0.11130	1370.4	0.17407	168.47	384.07	0.8798	1.7451	1.285	0.801	1.155	732	145.9	373.1	9.77	102.9	9.48	15.12	–24
–22	0.12165	1364.4	0.16006	171.05	385.32	0.8900	1.7432	1.289	0.809	1.156	723	146.1	362.9	9.85	102.0	9.65	14.82	–22
–20	0.13273	1358.3	0.14739	173.64	386.55	0.9002	1.7413	1.293	0.816	1.158	714	146.3	353.0	9.92	101.1	9.82	14.51	–20
–18	0.14460	1352.1	0.13592	176.23	387.79	0.9104	1.7396	1.297	0.823	1.159	705	146.4	343.5	10.01	100.1	9.98	14.21	–18
–16	0.15728	1345.9	0.12551	178.83	389.02	0.9205	1.7379	1.302	0.831	1.161	695	146.6	334.3	10.09	99.2	10.15	13.91	–16
–14	0.17082	1339.7	0.11605	181.44	390.24	0.9306	1.7363	1.306	0.838	1.163	686	146.7	325.4	10.17	98.3	10.32	13.61	–14
–12	0.18524	1333.4	0.10744	184.07	391.46	0.9407	1.7348	1.311	0.846	1.165	677	146.8	316.9	10.25	97.4	10.49	13.32	–12
–10	0.20060	1327.1	0.09959	186.70	392.66	0.9506	1.7334	1.316	0.854	1.167	668	146.9	308.6	10.33	96.5	10.66	13.02	–10
–8	0.21693	1320.8	0.09242	189.34	393.87	0.9606	1.7320	1.320	0.863	1.169	658	146.9	300.6	10.41	95.6	10.83	12.72	–8
–6	0.23428	1314.3	0.08587	191.99	395.06	0.9705	1.7307	1.325	0.871	1.171	649	147.0	292.9	10.49	94.7	11.00	12.43	–6
–4	0.25268	1307.9	0.07987	194.65	396.25	0.9804	1.7294	1.330	0.880	1.174	640	147.0	285.4	10.57	93.8	11.17	12.14	–4
–2	0.27217	1301.4	0.07436	197.32	397.43	0.9902	1.7282	1.336	0.888	1.176	631	147.0	278.1	10.65	92.9	11.34	11.85	–2
0	0.29280	1294.8	0.06931	200.00	398.60	1.0000	1.7271	1.341	0.897	1.179	622	146.9	271.1	10.73	92.0	11.51	11.56	0
2	0.31462	1288.1	0.06466	202.69	399.77	1.0098	1.7260	1.347	0.906	1.182	612	146.9	264.3	10.81	91.1	11.69	11.27	2
4	0.33766	1281.4	0.06039	205.40	400.92	1.0195	1.7250	1.352	0.916	1.185	603	146.8	257.6	10.90	90.2	11.86	10.99	4
6	0.36198	1274.7	0.05644	208.11	402.06	1.0292	1.7240	1.358	0.925	1.189	594	146.7	251.2	10.98	89.4	12.04	10.70	6
8	0.38761	1267.9	0.05280	210.84	403.20	1.0388	1.7230	1.364	0.935	1.192	585	146.5	244.9	11.06	88.5	12.22	10.42	8
10	0.41461	1261.0	0.04944	213.58	404.32	1.0485	1.7221	1.370	0.945	1.196	576	146.4	238.8	11.15	87.6	12.40	10.14	10
12	0.44301	1254.0	0.04633	216.33	405.43	1.0581	1.7212	1.377	0.956	1.200	566	146.2	232.9	11.23	86.7	12.58	9.86	12
14	0.47288	1246.9	0.04345	219.09	406.53	1.0677	1.7204	1.383	0.967	1.204	557	146.0	227.1	11.32	85.9	12.77	9.58	14
16	0.50425	1239.8	0.04078	221.87	407.61	1.0772	1.7196	1.390	0.978	1.209	548	145.7	221.5	11.40	85.0	12.95	9.30	16
18	0.53718	1232.6	0.03830	224.66	408.69	1.0867	1.7188	1.397	0.989	1.214	539	145.5	216.0	11.49	84.1	13.14	9.03	18
20	0.57171	1225.3	0.03600	227.47	409.75	1.0962	1.7180	1.405	1.001	1.219	530	145.1	210.7	11.58	83.3	13.33	8.76	20
22	0.60789	1218.0	0.03385	230.29	410.79	1.1057	1.7173	1.413	1.013	1.224	520	144.8	205.5	11.67	82.4	13.53	8.48	22
24	0.64578	1210.5	0.03186	233.12	411.82	1.1152	1.7166	1.421	1.025	1.230	511	144.5	200.4	11.76	81.6	13.72	8.21	24
26	0.68543	1202.9	0.03000	235.97	412.84	1.1246	1.7159	1.429	1.038	1.236	502	144.1	195.4	11.85	80.7	13.92	7.95	26
28	0.72688	1195.2	0.02826	238.84	413.84	1.1341	1.7152	1.437	1.052	1.243	493	143.6	190.5	11.95	79.8	14.13	7.68	28
30	0.77020	1187.5	0.02664	241.72	414.82	1.1435	1.7145	1.446	1.065	1.249	483	143.2	185.8	12.04	79.0	14.33	7.42	30
32	0.81543	1179.6	0.02513	244.62	415.78	1.1529	1.7138	1.456	1.080	1.257	474	142.7	181.1	12.14	78.1	14.54	7.15	32
34	0.86263	1171.6	0.02371	247.54	416.72	1.1623	1.7131	1.466	1.095	1.265	465	142.1	176.6	12.24	77.3	14.76	6.89	34
36	0.91185	1163.4	0.02238	250.48	417.65	1.1717	1.7124	1.476	1.111	1.273	455	141.6	172.1	12.34	76.4	14.98	6.64	36
38	0.96315	1155.1	0.02113	253.43	418.55	1.1811	1.7118	1.487	1.127	1.282	446	141.0	167.7	12.44	75.6	15.21	6.38	38
40	1.0166	1146.7	0.01997	256.41	419.43	1.1905	1.7111	1.498	1.145	1.292	436	140.3	163.4	12.55	74.7	15.44	6.13	40
42	1.0722	1138.2	0.01887	259.41	420.28	1.1999	1.7103	1.510	1.163	1.303	427	139.7	159.2	12.65	73.9	15.68	5.88	42
44	1.1301	1129.5	0.01784	262.43	421.11	1.2092	1.7096	1.523	1.182	1.314	418	138.9	155.1	12.76	73.0	15.93	5.63	44
46	1.1903	1120.6	0.01687	265.47	421.92	1.2186	1.7089	1.537	1.202	1.326	408	138.2	151.0	12.88	72.1	16.18	5.38	46
48	1.2529	1111.5	0.01595	268.53	422.69	1.2280	1.7081	1.551	1.223	1.339	399	137.4	147.0	13.00	71.3	16.45	5.13	48
50	1.3179	1102.3	0.01509	271.62	423.44	1.2375	1.7072	1.566	1.246	1.354	389	136.6	143.1	13.12	70.4	16.72	4.89	50
52	1.3854	1092.9	0.01428	274.74	424.15	1.2469	1.7064	1.582	1.270	1.369	379	135.7	139.2	13.24	69.6	17.01	4.65	52
54	1.4555	1083.2	0.01351	277.89	424.83	1.2563	1.7055	1.600	1.296	1.386	370	134.7	135.4	13.37	68.7	17.31	4.41	54
56	1.5282	1073.4	0.01278	281.06	425.47	1.2658	1.7045	1.618	1.324	1.405	360	133.8	131.6	13.51	67.8	17.63	4.18	56
58	1.6036	1063.2	0.01209	284.27	426.07	1.2753	1.7035	1.638	1.354	1.425	350	132.7	127.9	13.65	67.0	17.96	3.95	58
60	1.6818	1052.9	0.01144	287.50	426.63	1.2848	1.7024	1.660	1.387	1.448	340	131.7	124.2	13.79	66.1	18.31	3.72	60
62	1.7628	1042.2	0.01083	290.78	427.14	1.2944	1.7013	1.684	1.422	1.473	331	130.5	120.6	13.95	65.2	18.68	3.49	62
64	1.8467	1031.2	0.01024	294.09	427.61	1.3040	1.7000	1.710	1.461	1.501	321	129.4	117.0	14.11	64.3	19.07	3.27	64
66	1.9337	1020.0	0.00969	297.44	428.02	1.3137	1.6987	1.738	1.504	1.532	311	128.1	113.5	14.28	63.4	19.50	3.05	66
68	2.0237	1008.3	0.00916	300.84	428.36	1.3234	1.6972	1.769	1.552	1.567	301	126.8	109.9	14.46	62.6	19.95	2.83	68
70	2.1168	996.2	0.00865	304.28	428.65	1.3332	1.6956	1.804	1.605	1.607	290	125.5	106.4	14.65	61.7	20.45	2.61	70
72	2.2132	983.8	0.00817	307.78	428.86	1.3430	1.6939	1.843	1.665	1.653	280	124.0	102.9	14.85	60.8	20.98	2.40	72
74	2.3130	970.8	0.00771	311.33	429.00	1.3530	1.6920	1.887	1.734	1.705	269	122.6	99.5	15.07	59.9	21.56	2.20	74
76	2.4161	957.3	0.00727	314.94	429.04	1.3631	1.6899	1.938	1.812	1.766	259	121.0	96.0	15.30	59.0	22.21	1.99	76
78	2.5228	943.1	0.00685	318.63	428.98	1.3733	1.6876	1.996	1.904	1.838	248	119.4	92.5	15.56	58.1	22.92	1.80	78
80	2.6332	928.2	0.00645	322.39	428.81	1.3836	1.6850	2.065	2.012	1.924	237	117.7	89.0	15.84	57.2	23.72	1.60	80
85	2.9258	887.2	0.00550	332.22	427.76	1.4104	1.6771	2.306	2.397	2.232	207	113.1	80.2	16.67	54.9	26.22	1.14	85
90	3.2442	837.8	0.00461	342.93	425.42	1.4390	1.6662	2.756	3.121	2.820	176	107.9	70.9	17.81	52.8	29.91	0.71	90
95	3.5912	772.7	0.00374	355.25	420.67	1.4715	1.6492	3.938	5.020	4.369	141	101.9	60.4	19.61	51.7	36.40	0.33	95
100	3.9724	651.2	0.00268	373.30	407.68	1.5188	1.6109	17.59	25.35	20.81	101	94.0	45.1	24.21	59.9	60.58	0.04	100
101.06[c]	4.0593	511.9	0.00195	389.64	389.64	1.5621	1.5621	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	101.06

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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Refrigerant 134a Properties of Superheated Vapor

Pressure = 0.101325 MPa
Saturation temperature = –26.07°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1374.34	166.07	0.8701	747.1
Vapor	5.26	382.90	1.7476	145.7
–20	5.11	387.68	1.7667	147.8
–10	4.89	395.65	1.7976	151.0
0	4.69	403.74	1.8278	154.2
10	4.50	411.97	1.8574	157.2
20	4.34	420.34	1.8864	160.1
30	4.18	428.85	1.9150	162.9
40	4.04	437.52	1.9431	165.7
50	3.91	446.33	1.9708	168.4
60	3.78	455.30	1.9981	171.0
70	3.67	464.43	2.0251	173.6
80	3.56	473.70	2.0518	176.1
90	3.46	483.13	2.0781	178.6
100	3.36	492.71	2.1041	181.0
110	3.27	502.44	2.1298	183.4
120	3.19	512.32	2.1553	185.7
130	3.11	522.35	2.1805	188.1
140	3.03	532.52	2.2054	190.3
150	2.96	542.83	2.2301	192.6

Pressure = 0.200 MPa
Saturation temperature = –10.07°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1325.78	186.69	0.9506	672.8
Vapor	10.01	392.71	1.7337	146.9
–10	10.01	392.77	1.7339	147.0
0	9.54	401.21	1.7654	150.6
10	9.13	409.73	1.7961	154.0
20	8.76	418.35	1.8260	157.3
30	8.42	427.07	1.8552	160.4
40	8.12	435.90	1.8839	163.4
50	7.83	444.87	1.9121	166.3
60	7.57	453.97	1.9398	169.2
70	7.33	463.20	1.9671	171.9
80	7.11	472.57	1.9940	174.6
90	6.89	482.08	2.0206	177.2
100	6.70	491.74	2.0468	179.7
110	6.51	501.53	2.0727	182.2
120	6.34	511.47	2.0983	184.7
130	6.17	521.55	2.1236	187.1
140	6.01	531.76	2.1486	189.4
150	5.87	542.12	2.1734	191.7

Pressure = 0.400 MPa
Saturation temperature = 8.94°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1263.84	212.08	1.0432	583.8
Vapor	19.52	403.80	1.7229	146.6
10	19.41	404.78	1.7263	147.0
20	18.45	414.00	1.7583	151.2
30	17.61	423.21	1.7892	155.0
40	16.87	432.46	1.8192	158.6
50	16.20	441.76	1.8485	162.0
60	15.60	451.15	1.8771	165.3
70	15.05	460.63	1.9051	168.4
80	14.54	470.21	1.9326	171.4
90	14.08	479.91	1.9597	174.3
100	13.65	489.72	1.9864	177.1
110	13.24	499.65	2.0126	179.8
120	12.87	509.71	2.0386	182.4
130	12.51	519.90	2.0641	185.0
140	12.18	530.21	2.0894	187.5
150	11.87	540.66	2.1144	190.0

Pressure = 0.600 MPa
Saturation temperature = 21.58°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1219.08	229.62	1.1035	524.0
Vapor	29.13	410.67	1.7178	145.0
30	27.79	418.97	1.7455	149.0
40	26.41	428.72	1.7772	153.4
50	25.21	438.44	1.8077	157.4
60	24.16	448.16	1.8374	161.2
70	23.22	457.93	1.8662	164.7
80	22.37	467.75	1.8944	168.0
90	21.59	477.65	1.9221	171.2
100	20.88	487.64	1.9492	174.3
110	20.22	497.72	1.9759	177.3
120	19.61	507.92	2.0022	180.1
130	19.04	518.22	2.0280	182.9
140	18.51	528.63	2.0536	185.6
150	18.01	539.17	2.0787	188.2
160	17.54	549.82	2.1036	190.8
170	17.10	560.59	2.1282	193.3
180	16.68	571.48	2.1525	195.8
190	16.29	582.50	2.1766	198.2
200	15.91	593.63	2.2003	200.6

Pressure = 0.800 MPa
Saturation temperature = 31.33°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1181.92	243.58	1.1495	477.4
Vapor	38.99	415.58	1.7144	142.9
40	36.98	424.61	1.7437	147.6
50	35.03	434.85	1.7758	152.4
60	33.36	444.98	1.8067	156.8
70	31.90	455.08	1.8366	160.8
80	30.62	465.17	1.8656	164.6
90	29.46	475.30	1.8939	168.1
100	28.41	485.49	1.9215	171.5
110	27.46	495.74	1.9486	174.7
120	26.58	506.07	1.9753	177.8
130	25.77	516.50	215	180.8
140	25.01	527.03	2.0272	183.7
150	24.31	537.66	2.0527	186.4
160	23.65	548.40	2.0777	189.2
170	23.03	559.24	2.1025	191.8
180	22.45	570.20	2.1270	194.4
190	21.89	581.28	2.1511	196.9
200	21.37	592.46	2.1750	199.4

Pressure = 1.000 MPa
Saturation temperature = 39.39°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1149.06	255.44	1.1874	438.6
Vapor	49.16	419.31	1.7117	140.6
40	48.95	419.99	1.7139	141.0
50	45.86	430.91	1.7482	146.9
60	43.34	441.56	1.7807	152.0
70	41.21	452.05	1.8117	156.7
80	39.36	462.47	1.8416	160.9
90	37.74	472.86	1.8706	164.9
100	36.29	483.26	1.8989	168.6
110	34.99	493.69	1.9265	172.1
120	33.80	504.19	1.9535	175.4
130	32.71	514.75	1.9800	178.6
140	31.70	525.39	2.0061	181.7
150	30.76	536.12	2.0318	184.6
160	29.90	546.95	2.0571	187.5
170	29.08	557.88	2.0820	190.3
180	28.32	568.91	2.1066	193.0
190	27.60	580.05	2.1309	195.6
200	26.92	591.29	2.1550	198.2

Pressure = 1.200 MPa
Saturation temperature = 46.32°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1118.89	265.91	1.2200	405.0
Vapor	59.73	422.22	1.7092	138.2
50	58.09	426.51	1.7226	140.7
60	54.32	437.83	1.7571	146.9
70	51.26	448.81	1.7896	152.3
80	48.69	459.61	1.8206	157.1
90	46.49	470.30	1.8504	161.5
100	44.55	480.94	1.8794	165.6
110	42.83	491.58	1.9075	169.4
120	41.28	502.25	1.9350	173.0
130	39.87	512.95	1.9619	176.4
140	38.58	523.72	1.9882	179.7
150	37.39	534.56	2.0142	182.8
160	36.29	545.48	2.0397	185.8
170	35.26	556.50	2.0648	188.8
180	34.31	567.60	2.0896	191.6
190	33.40	578.80	2.1141	194.4
200	32.56	590.11	2.1382	197.1
210	31.76	601.51	2.1621	199.7
220	31.01	613.02	2.1856	202.3
230	30.29	624.64	2.2090	204.8
240	29.61	636.36	2.2320	207.2
250	28.96	648.18	2.2548	209.7

Pressure = 1.400 MPa
Saturation temperature = 52.43°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1090.50	275.38	1.2488	375.1
Vapor	70.76	424.50	1.7068	135.6
60	66.61	433.69	1.7347	141.2
70	62.25	445.31	1.7691	147.5
80	58.74	456.56	1.8014	153.0
90	55.79	467.60	1.8322	158.0
100	53.24	478.53	1.8619	162.5
110	51.03	489.39	1.8906	166.6
120	49.05	500.25	1.9186	170.5
130	47.28	511.11	1.9459	174.2
140	45.67	522.02	1.9726	177.7
150	44.19	532.97	1.9988	181.0
160	42.83	544	2.0246	184.2
170	41.57	555.10	2.0499	187.2
180	40.41	566.28	2.0748	190.2
190	39.31	577.55	2.0994	193.1
200	38.28	588.92	2.1237	195.9
210	37.32	600.38	2.1477	198.6
220	36.41	611.94	2.1714	201.3
230	35.55	623.60	2.1948	203.9
240	34.73	635.35	2.2179	206.4
250	33.96	647.22	2.2408	208.9

Pressure = 1.600 MPa
Saturation temperature = 57.91°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1063.28	284.11	1.2748	348.1
Vapor	82.34	426.27	1.7042	132.9
60	80.74	428.99	1.7124	134.7
70	74.43	441.47	1.7493	142.3
80	69.61	453.30	1.7833	148.7
90	65.71	464.76	1.8153	154.2
100	62.43	476.01	1.8458	159.2
110	59.62	487.13	1.8753	163.8
120	57.14	498.19	1.9038	168.0
130	54.95	509.23	1.9315	171.9
140	52.98	520.28	1.9586	175.6
150	51.18	531.36	1.9851	179.1
160	49.54	542.49	2.0111	182.5
170	48.03	553.68	2.0366	185.7
180	46.63	564.94	2.0617	188.8
190	45.32	576.29	2.0865	191.8
200	44.10	587.71	2.1109	194.7
210	42.96	599.23	2.1350	197.6
220	41.88	610.84	2.1588	200.3
230	40.87	622.55	2.1823	203.0
240	39.91	634.35	2.2055	205.6
250	39.00	646.25	2.2285	208.2

*Temperatures on ITS-90 scale

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Refrigerant 134a Properties of Superheated Vapor (*Concluded*)

Pressure = 1.800 MPa
Saturation temperature = 62.90°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1036.81	292.26	1.2987	323.2
Vapor	94.53	427.59	1.7014	130.1
70	88.23	437.17	1.7296	136.5
80	81.54	449.76	1.7657	144.0
90	76.38	461.74	1.7992	150.3
100	72.17	473.36	1.8308	155.9
110	68.64	484.78	1.8610	160.8
120	65.60	496.06	1.8900	165.4
130	62.91	507.29	1.9183	169.6
140	60.53	518.50	1.9457	173.5
150	58.37	529.71	1.9725	177.3
160	56.42	540.95	1.9988	180.8
170	54.62	552.24	2.0246	184.2
180	52.97	563.59	2.0499	187.4
190	51.44	575.01	2.0748	190.6
200	50.01	586.50	2.0993	193.6
210	48.68	598.08	2.1236	196.5
220	47.43	609.74	2.1475	199.4
230	46.25	621.50	2.1710	202.1
240	45.14	633.34	2.1944	204.9
250	44.09	645.28	2.2174	207.5

Pressure = 2.000 MPa
Saturation temperature = 67.49°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	1010.74	299.96	1.3209	300.1
Vapor	107.46	428.52	1.6983	127.2
70	104.37	432.22	1.7091	129.9
80	94.85	445.86	1.7483	138.9
90	87.97	458.49	1.7835	146.2
100	82.58	470.57	1.8164	152.4
110	78.17	482.32	1.8474	157.8
120	74.44	493.86	1.8772	162.7
130	71.18	505.30	1.9059	167.2
140	68.33	516.68	1.9338	171.4
150	65.78	528.03	1.9609	175.4
160	63.47	539.39	1.9875	179.1
170	61.37	550.79	2.0135	182.6
180	59.45	562.23	2.0390	186.0
190	57.67	573.72	2.0641	189.3
200	56.02	585.28	2.0888	192.4
210	54.49	596.92	2.1131	195.5
220	53.05	608.64	2.1371	198.4
230	51.70	620.44	2.1608	201.3
240	50.43	632.33	2.1842	204.1
250	49.23	644.30	2.2073	206.8

Pressure = 2.200 MPa
Saturation temperature = 71.74°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	984.76	307.32	1.3417	278.4
Vapor	121.25	429.08	1.6948	124.3
80	110.03	441.49	1.7303	133.3
90	100.70	454.98	1.7680	141.8
100	93.78	467.61	1.8023	148.7
110	88.25	479.75	1.8344	154.7
120	83.70	491.59	1.8649	160.0
130	79.79	503.25	1.8942	164.9
140	76.41	514.81	1.9226	169.3
150	73.40	526.32	1.9501	173.5
160	70.71	537.81	1.9769	177.4
170	68.28	549.31	2.0032	181.1
180	66.06	560.84	2.0289	184.6
190	64.02	572.42	2.0542	188.0
200	62.13	584.06	2.0790	191.3
210	60.38	595.76	2.1035	194.4
220	58.74	607.53	2.1276	197.5
230	57.21	619.38	2.1514	200.4
240	55.77	631.31	2.1749	203.3
250	54.42	643.33	2.1981	206.1

Pressure =2.400 MPa
Saturation temperature = 75.70°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	958.58	314.40	1.3616	257.9
Vapor	136.07	429.27	1.6908	121.4
80	127.96	436.42	1.7112	126.9
90	114.90	451.12	1.7523	137.0
100	105.89	464.44	1.7885	144.8
110	99.00	477.04	1.8218	151.5
120	93.44	489.22	1.8532	157.2
130	88.79	501.14	1.8831	162.4
140	84.77	512.90	1.9119	167.2
150	81.27	524.57	1.9398	171.6
160	78.15	536.20	1.9670	175.7
170	75.35	547.82	1.9935	179.6
180	72.81	559.45	2.0195	183.3
190	70.48	571.11	2.0449	186.8
200	68.34	582.82	2.0699	190.2
210	66.36	594.58	2.0945	193.4
220	64.51	606.41	2.1188	196.6
230	62.79	618.31	2.1427	199.6
240	61.18	630.29	2.1662	202.5
250	59.66	642.35	2.1895	205.4

Pressure = 2.600 MPa
Saturation temperature = 79.41°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	931.88	321.29	1.3806	238.2
Vapor	152.12	429.08	1.6863	118.3
80	150.48	430.22	1.6895	119.3
90	131.08	446.81	1.7359	131.7
100	119.15	461.03	1.7745	140.8
110	110.50	474.19	1.8093	148.1
120	103.72	486.75	1.8417	154.4
130	98.17	498.96	1.8724	160.0
140	93.46	510.94	1.9017	165.0
150	89.39	522.79	1.9301	169.7
160	85.80	534.57	1.9576	174.0
170	82.59	546.30	1.9844	178.1
180	79.70	558.04	2.0106	181.9
190	77.07	569.79	2.0362	185.5
200	74.65	581.57	2.0614	189.0
210	72.43	593.40	2.0861	192.4
220	70.36	605.29	2.1105	195.6
230	68.44	617.24	2.1345	198.8
240	66.64	629.27	2.1581	201.8
250	64.95	641.37	2.1815	204.8

Pressure = 2.800 MPa
Saturation temperature = 82.90°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	904.29	328.05	1.3990	219.1
Vapor	169.71	428.50	1.6812	115.3
90	150.13	441.84	1.7183	125.9
100	133.85	457.32	1.7603	136.4
110	122.89	471.16	1.7970	144.6
120	114.63	484.17	1.8305	151.5
130	108.00	496.70	1.8620	157.5
140	102.49	508.93	1.8919	162.9
150	97.78	520.97	1.9207	167.8
160	93.66	532.90	1.9486	172.3
170	90.01	544.77	1.9757	176.5
180	86.74	556.61	2.0021	180.5
190	83.78	568.45	2.0279	184.3
200	81.08	580.31	2.0533	187.9
210	78.59	592.21	2.0782	191.4
220	76.29	604.16	2.1027	194.7
230	74.15	616.17	2.1268	198.0
240	72.16	628.25	2.1505	201.1
250	70.30	640.39	2.1740	204.1

Pressure = 3.000 MPa
Saturation temperature = 86.20°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	875.30	334.75	1.4171	200.4
Vapor	189.25	427.47	1.6752	112.2
90	173.82	435.84	1.6983	119.1
100	150.47	453.20	1.7455	131.8
110	136.36	467.93	1.7845	141.0
120	126.23	481.47	1.8194	148.5
130	118.34	494.36	1.8518	155.0
140	111.89	506.86	1.8824	160.7
150	106.45	519.11	1.9117	165.9
160	101.75	531.21	1.9399	170.6
170	97.62	543.21	1.9673	175.0
180	93.94	555.16	1.9940	179.2
190	90.62	567.10	2.0201	183.1
200	87.61	579.05	2.0456	186.8
210	84.84	591.02	2.0706	190.4
220	82.30	603.03	2.0952	193.8
230	79.94	615.10	2.1195	197.2
240	77.74	627.22	2.1433	200.4
250	75.69	639.41	2.1668	203.4
260	73.77	651.66	2.1900	206.5
270	71.96	664	2.2130	209.4
280	70.25	676.41	2.2356	212.2
290	68.63	688.89	2.2580	215.0
300	67.10	701.46	2.2801	217.8

Pressure = 4.000 MPa
Saturation temperature = 100.35°C

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid	626.95	376.48	1.5272	101.3
Vapor	396.29	404.57	1.6024	93.4
110	233.68	446.28	1.7131	119.8
120	199.79	465.29	1.7621	132.5
130	179.83	481.11	1.8018	142.0
140	165.73	495.51	1.8371	149.7
150	154.89	509.13	1.8697	156.4
160	146.10	522.25	1.9004	162.4
170	138.74	535.07	1.9296	167.8
180	132.41	547.69	1.9578	172.7
190	126.88	560.17	1.9850	177.4
200	121.97	572.58	2.0115	181.7
210	117.55	584.95	2.0374	185.8
220	113.56	597.30	2.0627	189.7
230	109.90	609.66	2.0875	193.4
240	106.55	622.05	2.1119	197.0
250	103.44	634.47	2.1359	200.5
260	100.56	646.93	2.1595	203.8
270	97.87	659.45	2.1827	207.1
280	95.35	672.03	2.2057	210.2
290	92.98	684.67	2.2283	213.3
300	90.75	697.38	2.2507	216.2

Pressure = 6.00 MPa
Saturation temperature = n/a (supercritical)

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. of Sound, m/s
Saturated				
Liquid				
Vapor				
110	762.66	375.61	1.5174	173.6
120	591.77	405.75	1.5950	127.4
130	418.90	439.87	1.6807	120.4
140	333.91	465.19	1.7428	130.1
150	289.37	484.69	1.7894	139.9
160	260.70	501.52	1.8288	148.3
170	239.96	516.92	1.8639	155.7
180	223.87	531.45	1.8963	162.2
190	210.82	545.43	1.9269	168.1
200	199.88	559.04	1.9559	173.6
210	190.50	572.39	1.9839	178.6
220	182.31	585.57	2.0109	183.4
230	175.06	598.64	2.0371	187.8
240	168.56	611.63	2.0626	192.1
250	162.68	624.57	2.0876	196.2
260	157.33	637.50	2.1121	200.0
270	152.41	650.43	2.1361	203.8
280	147.88	663.38	2.1598	207.4
290	143.67	676.35	2.1830	210.9
300	139.75	689.36	2.2059	214.3

*Temperatures on ITS-90 scale

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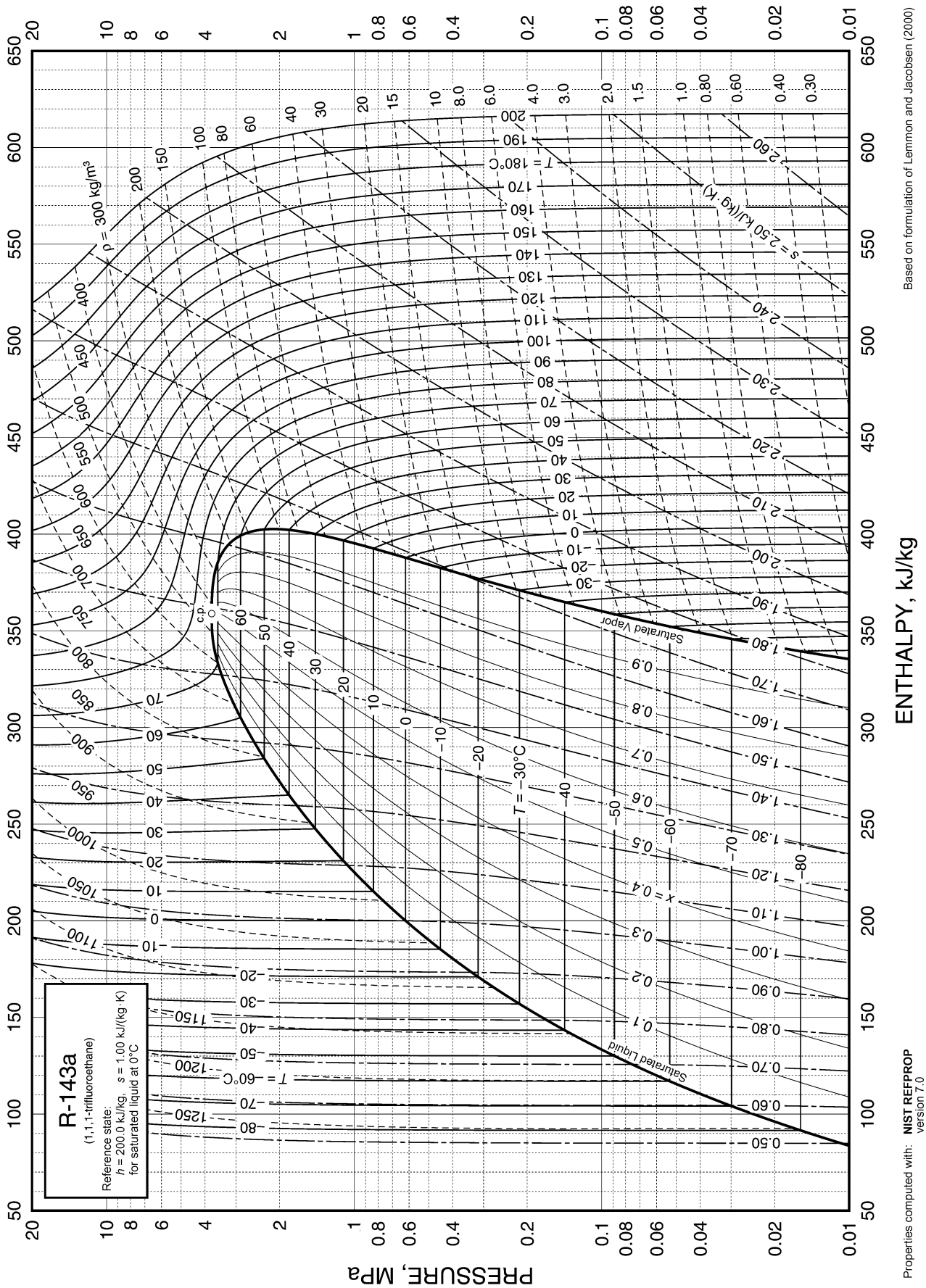

Fig. 9 Pressure-Enthalpy Diagram for Refrigerant 143a

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Refrigerant 143a (1,1,1-Trifluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–111.81[a]	0.00107	1330.5	14.807	52.52	319.59	0.3142	1.9695	1.211	0.630	1.192	1058	137.6	912.1	5.91	137.0	4.90	13.72	–111.81
–110	0.00129	1326.2	12.430	54.71	320.68	0.3277	1.9579	1.212	0.635	1.191	1049	138.2	867.9	5.97	135.8	5.00	13.75	–110
–100	0.00333	1301.9	5.1127	66.87	326.81	0.4000	1.9012	1.220	0.664	1.185	1002	141.7	680.1	6.34	129.5	5.53	13.80	–100
–90	0.00761	1277.2	2.3596	79.13	333.06	0.4688	1.8553	1.233	0.694	1.181	954	144.9	553.4	6.72	123.5	6.10	13.71	–90
–80	0.01572	1252.2	1.1971	91.55	339.40	0.5348	1.8180	1.250	0.726	1.178	907	147.8	462.1	7.08	117.8	6.70	13.48	–80
–70	0.02991	1226.7	0.65675	104.16	345.80	0.5984	1.7879	1.270	0.759	1.177	859	150.4	393.0	7.45	112.5	7.34	13.11	–70
–60	0.05307	1200.6	0.38446	116.99	352.21	0.6599	1.7635	1.293	0.794	1.178	811	152.5	338.8	7.82	107.4	8.02	12.61	–60
–50	0.08874	1173.9	0.23754	130.05	358.58	0.7197	1.7438	1.318	0.833	1.182	764	154.2	294.9	8.19	102.5	8.73	12.00	–50
–48	0.09773	1168.5	0.21695	132.69	359.85	0.7314	1.7403	1.323	0.841	1.184	754	154.5	287.1	8.26	101.6	8.88	11.86	–48
–47.24[b]	0.10133	1166.4	0.20971	133.70	360.33	0.7359	1.7391	1.325	0.844	1.184	751	154.6	284.2	8.29	101.2	8.94	11.81	–47.24
–46	0.10742	1163.0	0.19849	135.35	361.11	0.7431	1.7370	1.328	0.850	1.185	745	154.7	279.6	8.33	100.6	9.03	11.72	–46
–44	0.11786	1157.5	0.18191	138.01	362.37	0.7548	1.7339	1.334	0.858	1.186	735	154.9	272.3	8.41	99.7	9.18	11.57	–44
–42	0.12907	1152.0	0.16697	140.69	363.62	0.7664	1.7308	1.339	0.867	1.188	726	155.1	265.3	8.48	98.8	9.33	11.42	–42
–40	0.14109	1146.4	0.15350	143.38	364.86	0.7779	1.7279	1.345	0.876	1.189	716	155.3	258.6	8.56	97.8	9.49	11.27	–40
–38	0.15398	1140.8	0.14133	146.08	366.10	0.7894	1.7251	1.351	0.885	1.191	707	155.5	252.0	8.63	96.9	9.65	11.11	–38
–36	0.16775	1135.1	0.13031	148.79	367.34	0.8008	1.7224	1.357	0.894	1.193	697	155.6	245.7	8.70	96.0	9.81	10.95	–36
–34	0.18247	1129.4	0.12032	151.52	368.56	0.8122	1.7198	1.363	0.904	1.195	688	155.7	239.6	8.78	95.1	9.97	10.79	–34
–32	0.19816	1123.7	0.11124	154.25	369.78	0.8236	1.7173	1.369	0.913	1.198	678	155.8	233.6	8.85	94.2	10.13	10.62	–32
–30	0.21488	1117.9	0.10297	157.00	370.99	0.8348	1.7149	1.375	0.923	1.200	669	155.8	227.8	8.93	93.3	10.30	10.44	–30
–28	0.23267	1112.1	0.09544	159.77	372.19	0.8461	1.7126	1.382	0.933	1.203	659	155.9	222.3	9.18	92.4	10.49	10.27	–28
–26	0.25156	1106.2	0.08857	162.54	373.39	0.8573	1.7104	1.388	0.944	1.206	650	155.9	216.8	9.26	91.6	10.66	10.09	–26
–24	0.27161	1100.3	0.08228	165.33	374.57	0.8685	1.7083	1.395	0.955	1.209	640	155.8	211.6	9.33	90.7	10.83	9.90	–24
–22	0.29286	1094.3	0.07652	168.13	375.74	0.8796	1.7062	1.402	0.966	1.212	630	155.8	206.4	9.41	89.8	11.01	9.72	–22
–20	0.31535	1088.3	0.07125	170.95	376.91	0.8907	1.7043	1.409	0.977	1.216	621	155.7	201.4	9.48	89.0	11.19	9.53	–20
–18	0.33915	1082.2	0.06640	173.78	378.06	0.9018	1.7024	1.417	0.988	1.219	611	155.6	196.6	9.56	88.1	11.37	9.33	–18
–16	0.36428	1076.0	0.06194	176.63	379.20	0.9128	1.7005	1.424	1.000	1.223	602	155.4	191.8	9.64	87.2	11.55	9.14	–16
–14	0.39081	1069.8	0.05784	179.49	380.33	0.9238	1.6987	1.432	1.012	1.227	592	155.2	187.2	9.71	86.4	11.74	8.94	–14
–12	0.41877	1063.6	0.05405	182.37	381.44	0.9347	1.6970	1.440	1.025	1.232	582	155.0	182.7	9.79	85.5	11.94	8.74	–12
–10	0.44823	1057.2	0.05056	185.27	382.54	0.9457	1.6953	1.449	1.038	1.237	573	154.8	178.4	9.87	84.7	12.13	8.53	–10
–8	0.47923	1050.8	0.04733	188.18	383.63	0.9566	1.6937	1.457	1.051	1.242	563	154.5	174.1	9.95	83.9	12.33	8.32	–8
–6	0.51182	1044.3	0.04434	191.11	384.70	0.9675	1.6921	1.466	1.065	1.247	553	154.2	169.9	10.04	83.0	12.53	8.12	–6
–4	0.54606	1037.7	0.04158	194.05	385.75	0.9783	1.6906	1.476	1.079	1.253	544	153.9	165.8	10.12	82.2	12.74	7.90	–4
–2	0.58199	1031.0	0.03901	197.02	386.79	0.9892	1.6890	1.485	1.093	1.260	534	153.5	161.8	10.21	81.4	12.96	7.69	–2
0	0.61967	1024.3	0.03662	200.00	387.81	1.0000	1.6876	1.495	1.109	1.266	524	153.1	157.9	10.29	80.5	13.17	7.47	0
2	0.65916	1017.4	0.03440	203.00	388.81	1.0108	1.6861	1.505	1.124	1.273	515	152.6	154.1	10.38	79.7	13.40	7.25	2
4	0.70051	1010.5	0.03234	206.03	389.79	1.0216	1.6846	1.516	1.141	1.281	505	152.1	150.3	10.47	78.9	13.63	7.03	4
6	0.74378	1003.5	0.03042	209.07	390.75	1.0324	1.6832	1.528	1.158	1.289	495	151.6	146.6	10.57	78.1	13.87	6.81	6
8	0.78901	996.3	0.02862	212.13	391.68	1.0432	1.6818	1.539	1.176	1.298	485	151.0	143.0	10.66	77.2	14.12	6.59	8
10	0.83628	989.1	0.02695	215.22	392.60	1.0539	1.6804	1.552	1.194	1.307	475	150.4	139.5	10.76	76.4	14.38	6.36	10
12	0.88564	981.7	0.02538	218.33	393.48	1.0647	1.6790	1.565	1.214	1.317	465	149.8	136.0	10.86	75.6	14.64	6.14	12
14	0.93714	974.2	0.02392	221.47	394.35	1.0755	1.6775	1.578	1.234	1.328	455	149.1	132.6	10.96	74.8	14.92	5.91	14
16	0.99085	966.5	0.02255	224.63	395.18	1.0863	1.6761	1.593	1.256	1.340	445	148.4	129.3	11.07	74.0	15.21	5.68	16
18	1.0468	958.7	0.02126	227.81	395.98	1.0970	1.6747	1.608	1.278	1.353	435	147.6	126.0	11.18	73.2	15.51	5.45	18
20	1.1052	950.8	0.02005	231.02	396.76	1.1078	1.6732	1.624	1.302	1.366	425	146.8	122.7	11.29	72.4	15.82	5.22	20
22	1.1659	942.7	0.01892	234.27	397.50	1.1186	1.6717	1.641	1.328	1.381	415	145.9	119.5	11.40	71.5	16.15	4.99	22
24	1.2290	934.4	0.01785	237.54	398.20	1.1295	1.6701	1.659	1.355	1.398	405	145.0	116.4	11.52	70.7	16.50	4.76	24
26	1.2947	926.0	0.01685	240.84	398.87	1.1403	1.6685	1.679	1.384	1.416	394	144.0	113.3	11.64	69.9	16.87	4.53	26
28	1.3630	917.3	0.01591	244.18	399.49	1.1512	1.6669	1.699	1.416	1.435	384	143.0	110.2	11.77	69.1	17.26	4.30	28
30	1.4340	908.4	0.01501	247.56	400.07	1.1621	1.6652	1.722	1.449	1.457	374	141.9	107.2	11.91	68.3	17.67	4.07	30
32	1.5077	899.3	0.01417	250.97	400.61	1.1730	1.6634	1.746	1.486	1.480	363	140.8	104.2	12.04	67.5	18.11	3.84	32
34	1.5842	890.0	0.01338	254.42	401.09	1.1840	1.6616	1.772	1.526	1.507	352	139.6	101.2	12.19	66.6	18.58	3.61	34
36	1.6636	880.4	0.01262	257.91	401.52	1.1951	1.6596	1.801	1.570	1.536	342	138.4	98.3	12.34	65.8	19.09	3.38	36
38	1.7460	870.5	0.01191	261.45	401.89	1.2062	1.6575	1.832	1.618	1.569	331	137.1	95.4	12.50	65.0	19.63	3.16	38
40	1.8314	860.3	0.01123	265.04	402.19	1.2174	1.6553	1.867	1.671	1.606	320	135.7	92.5	12.67	64.2	20.22	2.93	40
42	1.9200	849.7	0.01059	268.68	402.42	1.2286	1.6530	1.906	1.732	1.648	309	134.3	89.7	12.85	63.3	20.87	2.71	42
44	2.0117	838.7	0.00998	272.39	402.56	1.2400	1.6505	1.949	1.799	1.696	298	132.8	86.8	13.03	62.5	21.57	2.49	44
46	2.1068	827.3	0.00940	276.15	402.62	1.2515	1.6478	1.998	1.877	1.752	286	131.2	84.0	13.24	61.7	22.35	2.27	46
48	2.2053	815.4	0.00884	279.98	402.58	1.2631	1.6448	2.054	1.966	1.817	275	129.6	81.1	13.45	60.8	23.20	2.06	48
50	2.3073	803.0	0.00831	283.90	402.43	1.2748	1.6416	2.118	2.070	1.894	263	127.9	78.3	13.69	60.0	24.16	1.85	50
52	2.4130	789.9	0.00780	287.90	402.15	1.2868	1.6381	2.194	2.194	1.985	251	126.1	75.4	13.94	59.1	25.23	1.64	52
54	2.5224	776.1	0.00731	292.00	401.72	1.2989	1.6343	2.285	2.343	2.097	238	124.2	72.5	14.23	58.2	26.45	1.44	54
56	2.6357	761.5	0.00684	296.22	401.12	1.3113	1.6300	2.395	2.528	2.236	226	122.2	69.6	14.54	57.4	27.84	1.24	56
58	2.7530	745.8	0.00639	300.57	400.31	1.3240	1.6252	2.534	2.762	2.413	213	120.1	66.6	14.89	56.5	29.45	1.05	58
60	2.8744	728.9	0.00594	305.09	399.24	1.3371	1.6197	2.714	3.069	2.647	200	117.9	63.6	15.29	55.6	31.37	0.87	60
65	3.1977	678.3	0.00486	317.45	394.94	1.3726	1.6018	3.564	4.532	3.763	164	111.8	55.4	16.64	53.6	38.41	0.45	65
70	3.5527	600.8	0.00370	333.19	385.42	1.4172	1.5694	7.720	11.500	9.040	122	104.2	45.1	19.30	53.2	55.97	0.11	70
72.71[c]	3.7610	431.0	0.00232	358.91	358.91	1.4906	1.4906	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	72.71

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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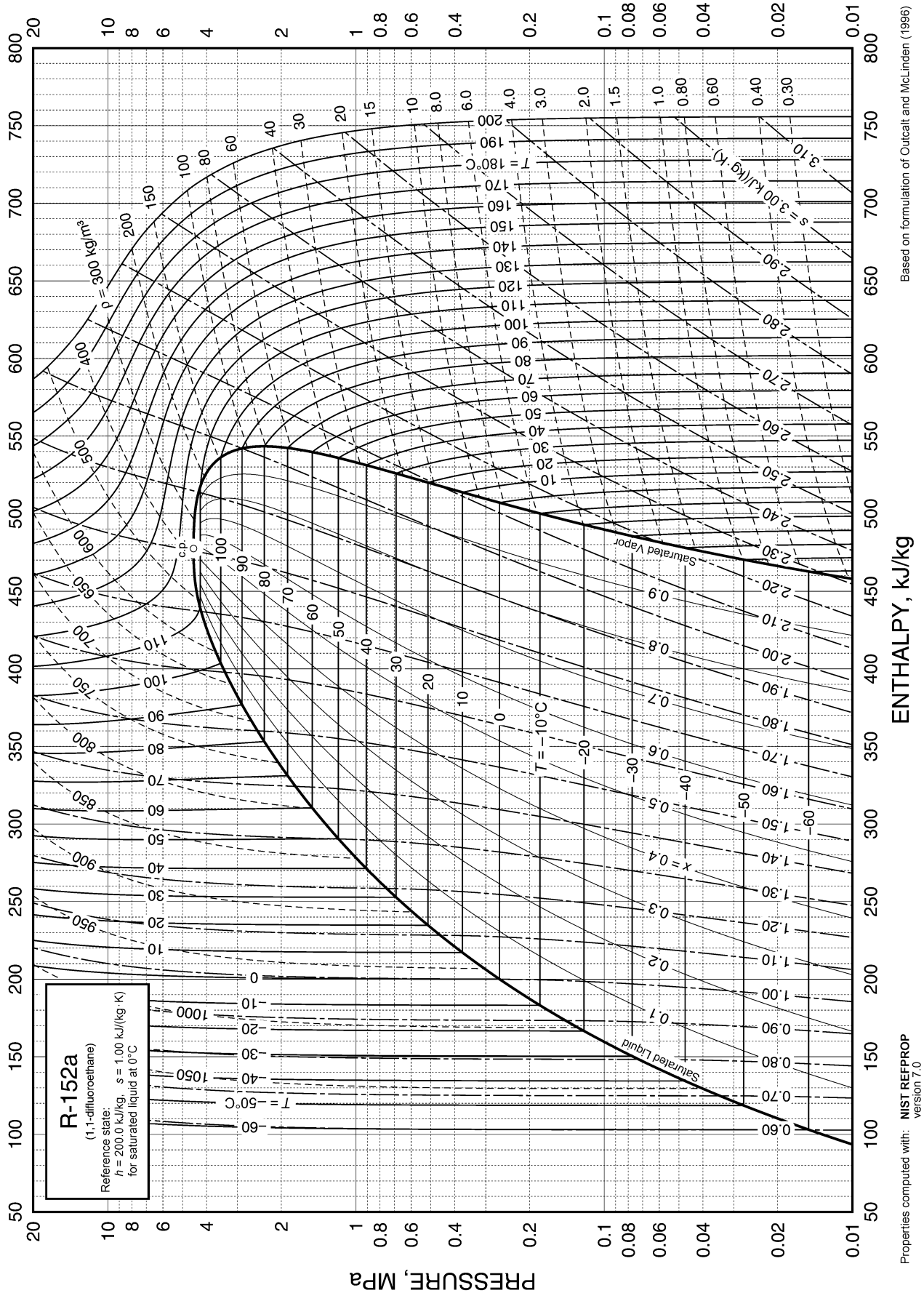

Fig. 10 Pressure-Enthalpy Diagram for Refrigerant 152a

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Refrigerant 152a (1,1-Difluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–118.59[a]	0.00006	1192.9	303.290	13.79	419.32	0.1119	2.7357	1.477	0.699	1.220	1401	154.0	2025.0	5.20	176.3	0.10	31.65	–118.59
–110	0.00019	1177.1	107.740	26.62	425.38	0.1927	2.6368	1.505	0.717	1.214	1337	157.8	1528.0	5.48	170.2	0.94	30.23	–110
–100	0.00058	1158.7	37.6170	41.75	432.59	0.2827	2.5399	1.518	0.740	1.207	1275	162.0	1153.0	5.81	163.4	1.91	28.58	–100
–90	0.00153	1140.1	15.0520	56.96	439.97	0.3681	2.4593	1.524	0.763	1.201	1219	166.0	904.0	6.14	156.9	2.89	26.96	–90
–80	0.00359	1121.3	6.74380	72.23	447.48	0.4492	2.3920	1.530	0.789	1.196	1166	169.8	730.2	6.47	150.7	3.86	25.34	–80
–70	0.00765	1102.4	3.31970	87.57	455.08	0.5266	2.3357	1.539	0.816	1.192	1115	173.4	603.5	6.80	144.7	4.84	23.75	–70
–60	0.01500	1083.2	1.76820	103.02	462.74	0.6009	2.2885	1.551	0.845	1.190	1066	176.6	507.4	7.14	139.0	5.82	22.18	–60
–50	0.02742	1063.7	1.00640	118.62	470.40	0.6723	2.2487	1.567	0.877	1.189	1016	179.5	432.5	7.47	133.5	6.81	20.63	–50
–40	0.04721	1043.8	0.60583	134.40	478.02	0.7414	2.2152	1.587	0.913	1.190	967	182.1	372.5	7.80	128.2	7.80	19.09	–40
–30	0.07718	1023.5	0.38242	150.39	485.55	0.8085	2.1868	1.610	0.952	1.193	919	184.2	323.6	8.14	123.1	8.80	17.58	–30
–28	0.08469	1019.4	0.35056	153.62	487.04	0.8216	2.1817	1.615	0.960	1.194	909	184.5	314.8	8.21	122.1	9.01	17.29	–28
–26	0.09276	1015.3	0.32186	156.86	488.52	0.8348	2.1767	1.620	0.968	1.195	899	184.9	306.4	8.27	121.2	9.21	16.99	–26
–24.02[b]	0.10133	1011.2	0.29622	160.07	489.98	0.8477	2.1719	1.625	0.977	1.196	889	185.2	298.4	8.34	120.2	9.41	16.69	–24.02
–24	0.10142	1011.1	0.29595	160.11	490.00	0.8478	2.1719	1.625	0.977	1.196	889	185.2	298.3	8.34	120.2	9.41	16.69	–24
–22	0.11072	1006.9	0.27253	163.37	491.47	0.8608	2.1672	1.630	0.985	1.197	880	185.5	290.5	8.41	119.2	9.62	16.39	–22
–20	0.12068	1002.7	0.25131	166.64	492.94	0.8737	2.1627	1.635	0.994	1.199	870	185.8	282.9	8.48	118.2	9.82	16.10	–20
–18	0.13133	998.5	0.23206	169.92	494.40	0.8866	2.1583	1.641	1.003	1.200	860	186.1	275.6	8.54	117.3	10.03	15.80	–18
–16	0.14271	994.2	0.21457	173.21	495.85	0.8994	2.1541	1.647	1.013	1.202	850	186.3	268.6	8.61	116.3	10.23	15.51	–16
–14	0.15484	989.9	0.19865	176.52	497.29	0.9122	2.1500	1.653	1.022	1.203	841	186.5	261.7	8.68	115.4	10.44	15.22	–14
–12	0.16777	985.6	0.18414	179.83	498.72	0.9249	2.1460	1.658	1.032	1.205	831	186.7	255.1	8.75	114.5	10.65	14.93	–12
–10	0.18152	981.3	0.17090	183.16	500.15	0.9375	2.1421	1.665	1.041	1.207	821	186.9	248.7	8.82	113.5	10.86	14.64	–10
–8	0.19614	976.9	0.15879	186.50	501.56	0.9501	2.1383	1.671	1.051	1.209	811	187.0	242.6	8.88	112.6	11.07	14.35	–8
–6	0.21166	972.5	0.14770	189.86	502.96	0.9627	2.1347	1.677	1.062	1.211	801	187.1	236.6	8.95	111.7	11.28	14.06	–6
–4	0.22812	968.1	0.13754	193.22	504.36	0.9752	2.1311	1.684	1.072	1.213	792	187.2	230.8	9.02	110.8	11.50	13.77	–4
–2	0.24555	963.6	0.12821	196.61	505.74	0.9876	2.1277	1.690	1.083	1.215	782	187.3	225.1	9.09	109.8	11.71	13.48	–2
0	0.26399	959.1	0.11963	200.00	507.11	1.0000	2.1243	1.697	1.094	1.218	772	187.4	219.7	9.16	108.9	11.93	13.20	0
2	0.28349	954.6	0.11174	203.41	508.47	1.0124	2.1211	1.704	1.105	1.221	762	187.4	214.4	9.23	108.0	12.14	12.91	2
4	0.30407	950.0	0.10447	206.83	509.82	1.0247	2.1179	1.711	1.116	1.224	752	187.4	209.2	9.30	107.1	12.36	12.63	4
6	0.32578	945.4	0.09776	210.27	511.16	1.0370	2.1148	1.719	1.128	1.227	742	187.4	204.2	9.37	106.2	12.58	12.35	6
8	0.34867	940.8	0.09156	213.72	512.48	1.0492	2.1118	1.726	1.139	1.230	733	187.3	199.4	9.44	105.4	12.80	12.07	8
10	0.37277	936.1	0.08583	217.19	513.78	1.0614	2.1089	1.734	1.152	1.233	723	187.2	194.7	9.51	104.5	13.03	11.79	10
12	0.39812	931.3	0.08052	220.67	515.08	1.0736	2.1060	1.742	1.164	1.237	713	187.1	190.1	9.58	103.6	13.25	11.51	12
14	0.42476	926.6	0.07560	224.17	516.36	1.0857	2.1032	1.750	1.177	1.240	703	187.0	185.6	9.65	102.7	13.48	11.23	14
16	0.45275	921.8	0.07104	227.69	517.62	1.0978	2.1005	1.759	1.190	1.244	693	186.8	181.3	9.73	101.8	13.71	10.96	16
18	0.48211	916.9	0.06680	231.22	518.86	1.1098	2.0978	1.768	1.203	1.249	683	186.6	177.1	9.80	101.0	13.95	10.68	18
20	0.51291	912.0	0.06286	234.77	520.09	1.1219	2.0952	1.776	1.217	1.253	673	186.4	173.0	9.87	100.1	14.18	10.41	20
22	0.54517	907.0	0.05919	238.34	521.30	1.1339	2.0926	1.786	1.231	1.258	663	186.1	169.0	9.95	99.3	14.42	10.14	22
24	0.57894	902.0	0.05577	241.93	522.50	1.1459	2.0901	1.795	1.246	1.263	653	185.8	165.1	10.02	98.4	14.66	9.87	24
26	0.61428	896.9	0.05258	245.53	523.67	1.1578	2.0876	1.805	1.261	1.268	643	185.5	161.3	10.10	97.5	14.91	9.60	26
28	0.65122	891.8	0.04960	249.16	524.83	1.1698	2.0852	1.815	1.277	1.274	633	185.1	157.6	10.18	96.7	15.16	9.33	28
30	0.68982	886.6	0.04682	252.80	525.96	1.1817	2.0828	1.826	1.293	1.280	623	184.7	154.0	10.26	95.9	15.41	9.06	30
32	0.73012	881.4	0.04422	256.47	527.07	1.1936	2.0804	1.837	1.309	1.286	613	184.3	150.4	10.34	95.0	15.67	8.80	32
34	0.77216	876.0	0.04179	260.16	528.16	1.2055	2.0780	1.848	1.326	1.293	602	183.9	147.0	10.42	94.2	15.93	8.54	34
36	0.81600	870.7	0.03951	263.86	529.23	1.2174	2.0757	1.860	1.344	1.300	592	183.4	143.6	10.50	93.3	16.20	8.27	36
38	0.86169	865.2	0.03737	267.60	530.27	1.2292	2.0734	1.872	1.362	1.307	582	182.9	140.3	10.58	92.5	16.47	8.01	38
40	0.90927	859.7	0.03536	271.35	531.28	1.2411	2.0711	1.885	1.381	1.315	572	182.3	137.1	10.66	91.7	16.74	7.75	40
42	0.95879	854.1	0.03348	275.13	532.27	1.2529	2.0689	1.898	1.401	1.324	561	181.7	134.0	10.75	90.8	17.03	7.50	42
44	1.01030	848.4	0.03170	278.93	533.23	1.2648	2.0666	1.912	1.421	1.333	551	181.1	130.9	10.84	90.0	17.32	7.24	44
46	1.06390	842.6	0.03004	282.76	534.16	1.2766	2.0643	1.926	1.443	1.342	541	180.4	127.9	11.21	89.2	17.60	6.99	46
48	1.11960	836.7	0.02846	286.62	535.06	1.2884	2.0620	1.941	1.465	1.353	530	179.7	125.0	11.32	88.4	17.90	6.73	48
50	1.17740	830.8	0.02699	290.50	535.93	1.3003	2.0598	1.957	1.489	1.364	520	178.9	122.1	11.42	87.5	18.22	6.48	50
52	1.23740	824.7	0.02559	294.41	536.77	1.3121	2.0575	1.974	1.513	1.375	509	178.2	119.2	11.53	86.7	18.54	6.23	52
54	1.29970	818.6	0.02427	298.35	537.56	1.3240	2.0552	1.992	1.539	1.388	499	177.3	116.5	11.64	85.9	18.87	5.98	54
56	1.36430	812.3	0.02303	302.33	538.32	1.3358	2.0528	2.010	1.566	1.402	488	176.4	113.7	11.76	85.1	19.21	5.74	56
58	1.43130	805.9	0.02185	306.34	539.04	1.3477	2.0504	2.030	1.595	1.416	478	175.5	111.1	11.88	84.2	19.56	5.50	58
60	1.50070	799.4	0.02074	310.38	539.72	1.3596	2.0480	2.051	1.626	1.432	467	174.6	108.4	12.00	83.4	19.92	5.25	60
62	1.57260	792.7	0.01968	314.45	540.35	1.3716	2.0456	2.073	1.658	1.450	456	173.6	105.8	12.12	82.6	20.30	5.01	62
64	1.64710	785.9	0.01868	318.57	540.94	1.3835	2.0431	2.097	1.693	1.468	445	172.5	103.3	12.26	81.8	20.70	4.78	64
66	1.72420	779.0	0.01774	322.72	541.47	1.3955	2.0405	2.122	1.730	1.488	435	171.4	100.8	12.39	80.9	21.11	4.54	66
68	1.80390	771.9	0.01684	326.92	541.95	1.4076	2.0379	2.150	1.769	1.511	424	170.2	98.3	12.53	80.1	21.54	4.31	68
70	1.88640	764.6	0.01598	331.16	542.37	1.4196	2.0351	2.179	1.812	1.535	413	169.0	95.9	12.68	79.3	22.00	4.08	70
72	1.97170	757.2	0.01517	335.45	542.73	1.4318	2.0323	2.211	1.859	1.562	402	167.8	93.5	12.83	78.5	22.48	3.85	72
74	2.05990	749.5	0.01440	339.79	543.02	1.4440	2.0294	2.245	1.909	1.591	390	166.5	91.1	12.99	77.6	22.98	3.62	74
76	2.15100	741.6	0.01366	344.18	543.24	1.4562	2.0264	2.283	1.964	1.624	379	165.1	88.7	13.16	76.8	23.51	3.40	76
78	2.24520	733.5	0.01296	348.63	543.38	1.4686	2.0232	2.324	2.025	1.661	368	163.7	86.4	13.34	76.0	24.08	3.18	78
80	2.34240	725.2	0.01228	353.15	543.43	1.4810	2.0198	2.370	2.092	1.702	356	162.2	84.1	13.52	75.2	24.69	2.96	80
90	2.87800	678.5	0.00933	376.87	542.06	1.5451	2.0000	2.703	2.586	2.016	297	153.7	72.6	14.64	71.0	28.54	1.91	90
100	3.50500	618.5	0.00686	403.59	536.28	1.6151	1.9707	3.495	3.776	2.805	233	143.1	60.7	16.35	67.0	35.03	0.96	100
110	4.24320	517.4	0.00446	439.22	517.31	1.7058	1.9096	9.260	12.220	8.530	158	129.1	45.6	20.19	67.5	53.48	0.17	110
113.26[c]	4.51680	368.0	0.00272	477.55	477.55	1.8037	1.8037	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	113.26

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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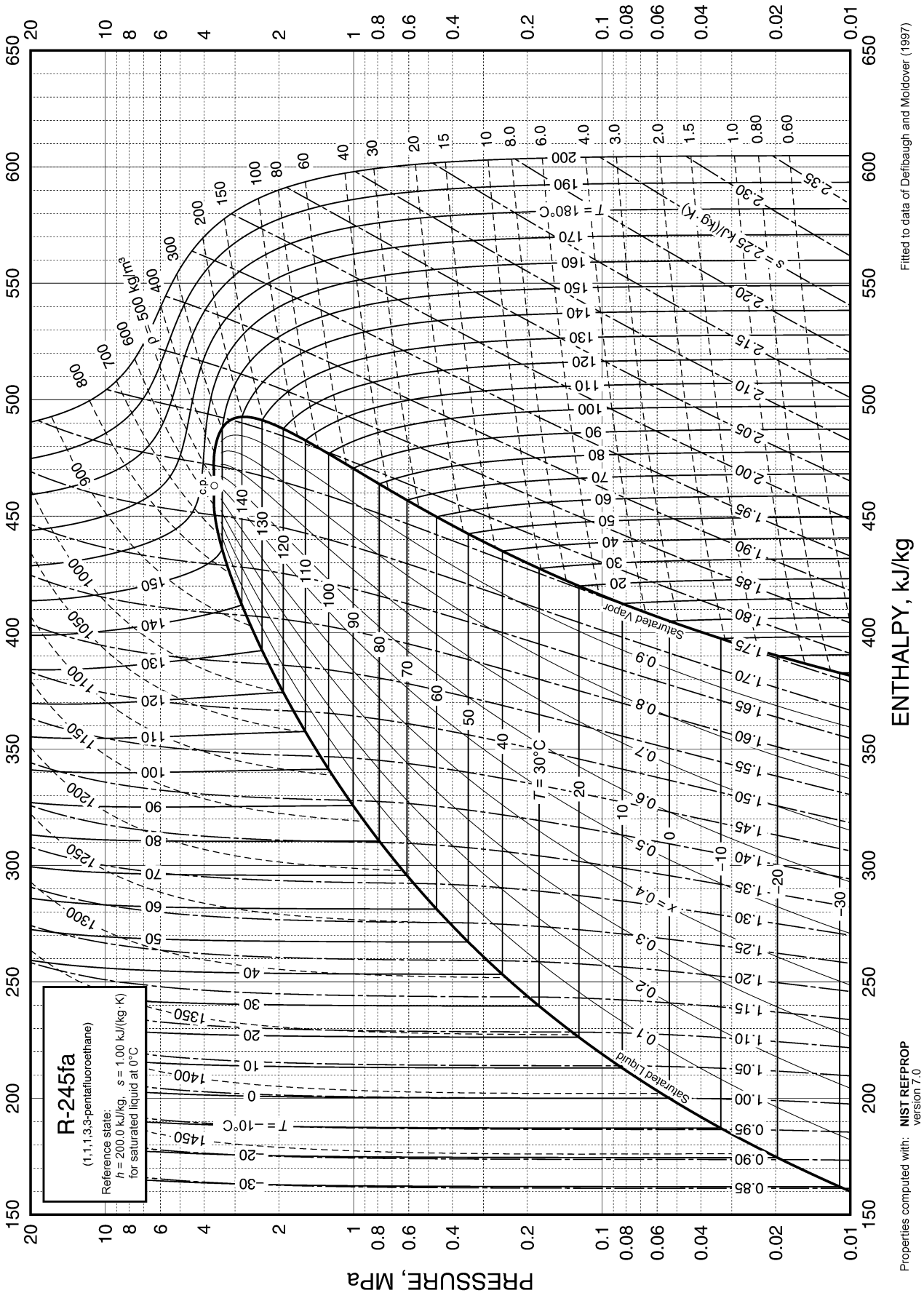

Fig. 11 Pressure-Enthalpy Diagram for Refrigerant 245fa

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Refrigerant 245fa (1,1,1,3,3-Pentafluoropropane) Properties of Saturated Liquid and Saturated Vapor

Temp.,[a] °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp., °C
–60	0.00127	1548.7	10.380	126.08	361.82	0.6949	1.8009	1.200	0.701	1.101	1041	120.3	2026.	7.36	115.5	9.08	24.67	–60
–50	0.00281	1525.2	4.9038	138.12	368.68	0.7501	1.7834	1.208	0.725	1.099	994	122.7	1501.	7.71	111.9	9.27	23.47	–50
–40	0.00572	1501.6	2.5079	150.24	375.67	0.8033	1.7702	1.218	0.751	1.098	948	125.0	1174.	8.06	108.5	9.54	22.26	–40
–30	0.01085	1477.7	1.3726	162.48	382.76	0.8547	1.7606	1.229	0.778	1.098	902	127.1	951.2	8.40	105.2	9.89	21.03	–30
–20	0.01937	1453.6	0.79638	174.84	389.94	0.9044	1.7541	1.242	0.806	1.099	859	129.0	790.1	8.75	102.1	10.30	19.78	–20
–10	0.03277	1429.0	0.48586	187.34	397.18	0.9528	1.7502	1.257	0.837	1.100	815	130.7	668.3	9.09	99.0	10.77	18.52	–10
0	0.05292	1404.0	0.30955	200.00	404.47	1.0000	1.7486	1.274	0.868	1.103	773	132.1	573.2	9.42	95.9	11.31	17.25	0
2	0.05795	1398.9	0.28419	202.55	405.93	1.0093	1.7484	1.277	0.875	1.104	765	132.3	556.7	9.49	95.3	11.43	16.99	2
4	0.06336	1393.8	0.26129	205.11	407.39	1.0186	1.7484	1.281	0.881	1.104	756	132.5	540.8	9.56	94.7	11.55	16.74	4
6	0.06916	1388.7	0.24057	207.68	408.86	1.0278	1.7484	1.284	0.888	1.105	748	132.8	525.6	9.62	94.0	11.67	16.48	6
8	0.07538	1383.5	0.22180	210.25	410.32	1.0369	1.7485	1.288	0.895	1.106	740	133.0	511.0	9.69	93.4	11.79	16.22	8
10	0.08204	1378.3	0.20477	212.84	411.79	1.0461	1.7487	1.292	0.901	1.107	731	133.2	497.0	9.76	92.8	11.91	15.97	10
12	0.08917	1373.1	0.18929	215.43	413.25	1.0552	1.7489	1.296	0.908	1.108	723	133.4	483.5	9.82	92.2	12.04	15.71	12
14	0.09677	1367.9	0.17520	218.02	414.72	1.0642	1.7492	1.299	0.915	1.109	715	133.5	470.6	9.89	91.5	12.17	15.46	14
15.14[b]	0.10133	1364.9	0.16774	219.51	415.55	1.0694	1.7494	1.302	0.919	1.109	710	133.6	463.4	9.93	91.2	12.24	15.31	15.14
16	0.10488	1362.6	0.16236	220.63	416.18	1.0733	1.7496	1.303	0.922	1.110	707	133.7	458.1	9.96	90.9	12.30	15.20	16
18	0.11352	1357.3	0.15063	223.24	417.65	1.0822	1.7500	1.307	0.929	1.111	698	133.8	446.1	10.02	90.3	12.43	14.94	18
20	0.12270	1352.0	0.13992	225.86	419.12	1.0912	1.7504	1.312	0.936	1.112	690	133.9	434.5	10.09	89.7	12.56	14.69	20
22	0.13247	1346.6	0.13012	228.49	420.58	1.1001	1.7509	1.316	0.943	1.113	682	134.1	423.3	10.16	89.0	12.70	14.43	22
24	0.14283	1341.3	0.12113	231.13	422.04	1.1090	1.7515	1.320	0.950	1.114	674	134.1	412.5	10.22	88.4	12.84	14.17	24
26	0.15383	1335.8	0.11288	233.78	423.51	1.1178	1.7521	1.324	0.958	1.115	666	134.2	402.1	10.29	87.8	12.98	13.92	26
28	0.16547	1330.4	0.10530	236.44	424.97	1.1267	1.7527	1.329	0.965	1.117	657	134.3	392.0	10.36	87.2	13.12	13.66	28
30	0.17779	1324.9	0.09833	239.10	426.43	1.1355	1.7534	1.333	0.973	1.118	649	134.3	382.3	10.42	86.5	13.27	13.40	30
32	0.19081	1319.3	0.09191	241.78	427.89	1.1442	1.7541	1.338	0.980	1.120	641	134.4	372.8	10.49	85.9	13.42	13.15	32
34	0.20456	1313.7	0.08599	244.46	429.35	1.1529	1.7549	1.342	0.988	1.121	633	134.4	363.7	10.56	85.3	13.57	12.89	34
36	0.21907	1308.1	0.08053	247.15	430.81	1.1617	1.7557	1.347	0.996	1.123	625	134.4	354.8	10.62	84.6	13.72	12.63	36
38	0.23436	1302.4	0.07548	249.86	432.26	1.1703	1.7566	1.352	1.003	1.125	617	134.4	346.2	10.69	84.0	13.87	12.38	38
40	0.25046	1296.7	0.07080	252.57	433.71	1.1790	1.7574	1.357	1.011	1.126	609	134.3	337.9	10.76	83.4	14.02	12.12	40
42	0.26741	1291.0	0.06647	255.29	435.16	1.1876	1.7583	1.362	1.019	1.128	600	134.3	329.8	10.83	82.7	14.18	11.87	42
44	0.28522	1285.2	0.06246	258.03	436.61	1.1962	1.7593	1.367	1.028	1.130	592	134.2	321.9	10.89	82.1	14.34	11.61	44
46	0.30394	1279.3	0.05873	260.77	438.05	1.2048	1.7603	1.373	1.036	1.132	584	134.1	314.3	10.96	81.4	14.50	11.36	46
48	0.32358	1273.4	0.05527	263.52	439.49	1.2133	1.7613	1.378	1.044	1.135	576	134.0	306.9	11.03	80.8	14.66	11.10	48
50	0.34417	1267.4	0.05205	266.29	440.93	1.2219	1.7623	1.383	1.053	1.137	568	133.8	299.7	11.10	80.2	14.83	10.85	50
52	0.36576	1261.4	0.04905	269.07	442.36	1.2304	1.7633	1.389	1.061	1.139	560	133.7	292.6	11.17	79.5	15.00	10.60	52
54	0.38836	1255.3	0.04625	271.85	443.78	1.2389	1.7644	1.395	1.070	1.142	552	133.5	285.8	11.24	78.9	15.17	10.34	54
56	0.41201	1249.2	0.04365	274.65	445.21	1.2474	1.7655	1.401	1.079	1.145	544	133.3	279.1	11.32	78.2	15.34	10.09	56
58	0.43674	1243.0	0.04122	277.46	446.62	1.2558	1.7666	1.407	1.088	1.147	536	133.1	272.6	11.39	77.6	15.51	9.84	58
60	0.46259	1236.8	0.03894	280.29	448.04	1.2642	1.7678	1.413	1.098	1.150	527	132.8	266.2	11.46	76.9	15.69	9.59	60
62	0.48957	1230.4	0.03682	283.12	449.44	1.2727	1.7689	1.419	1.107	1.153	519	132.6	260.1	11.54	76.3	15.86	9.34	62
64	0.51773	1224.1	0.03482	285.97	450.84	1.2811	1.7701	1.426	1.117	1.157	511	132.3	254.0	11.61	75.6	16.04	9.09	64
66	0.54710	1217.6	0.03296	288.83	452.23	1.2894	1.7713	1.433	1.127	1.160	503	132.0	248.1	11.69	75.0	16.23	8.84	66
68	0.57771	1211.1	0.03121	291.70	453.62	1.2978	1.7724	1.439	1.137	1.164	495	131.6	242.3	11.77	74.4	16.41	8.59	68
70	0.60960	1204.4	0.02957	294.59	455.00	1.3062	1.7736	1.447	1.147	1.168	487	131.3	236.7	11.85	73.7	16.60	8.35	70
72	0.64279	1197.8	0.02803	297.49	456.36	1.3145	1.7748	1.454	1.158	1.172	479	130.9	231.2	11.93	73.1	16.79	8.10	72
74	0.67732	1191.0	0.02658	300.40	457.72	1.3229	1.7760	1.461	1.169	1.176	470	130.5	225.8	12.01	72.4	16.98	7.85	74
76	0.71323	1184.1	0.02521	303.33	459.08	1.3312	1.7773	1.469	1.180	1.181	462	130.0	220.5	12.10	71.8	17.18	7.61	76
78	0.75055	1177.2	0.02393	306.28	460.42	1.3395	1.7785	1.477	1.192	1.186	454	129.5	215.3	12.18	71.2	17.38	7.37	78
80	0.78931	1170.1	0.02272	309.24	461.75	1.3478	1.7797	1.486	1.204	1.191	446	129.0	210.2	12.27	70.5	17.58	7.13	80
82	0.82956	1163.0	0.02158	312.21	463.06	1.3561	1.7809	1.494	1.217	1.196	437	128.5	205.3	12.37	69.9	17.79	6.88	82
84	0.87132	1155.7	0.02050	315.20	464.37	1.3644	1.7821	1.503	1.230	1.202	429	127.9	200.4	12.46	69.3	18.00	6.65	84
86	0.91464	1148.4	0.01949	318.21	465.66	1.3727	1.7833	1.512	1.243	1.209	421	127.4	195.6	12.56	68.6	18.22	6.41	86
88	0.95955	1140.9	0.01853	321.24	466.94	1.3810	1.7845	1.522	1.257	1.215	412	126.7	190.9	12.66	68.0	18.44	6.17	88
90	1.0061	1133.3	0.01762	324.28	468.20	1.3893	1.7856	1.532	1.272	1.223	404	126.1	186.3	12.76	67.4	18.66	5.93	90
92	1.0543	1125.6	0.01676	327.34	469.45	1.3976	1.7868	1.543	1.287	1.230	396	125.4	181.8	12.87	66.7	18.89	5.70	92
94	1.1042	1117.7	0.01594	330.42	470.68	1.4059	1.7879	1.554	1.303	1.239	387	124.7	177.3	12.98	66.1	19.13	5.47	94
96	1.1559	1109.7	0.01517	333.52	471.89	1.4142	1.7890	1.565	1.320	1.247	379	123.9	172.9	13.10	65.5	19.38	5.24	96
98	1.2093	1101.6	0.01444	336.64	473.09	1.4225	1.7901	1.577	1.337	1.257	370	123.1	168.6	13.22	64.9	19.63	5.01	98
100	1.2646	1093.3	0.01374	339.78	474.26	1.4308	1.7912	1.590	1.356	1.267	362	122.3	164.3	13.35	64.3	19.89	4.78	100
105	1.4110	1071.8	0.01215	347.74	477.09	1.4516	1.7936	1.625	1.408	1.297	340	120.0	154.0	13.70	62.8	20.59	4.22	105
110	1.5698	1049.1	0.01074	355.85	479.74	1.4725	1.7959	1.667	1.469	1.335	319	117.4	143.9	14.09	61.3	21.36	3.68	110
115	1.7417	1025.0	0.00949	364.13	482.19	1.4936	1.7977	1.716	1.544	1.383	296	114.6	134.2	14.54	59.9	22.24	3.15	115
120	1.9275	999.2	0.00837	372.62	484.39	1.5148	1.7991	1.777	1.638	1.445	274	111.4	124.7	15.07	58.5	23.27	2.64	120
125	2.1280	971.2	0.00736	381.35	486.25	1.5364	1.7998	1.854	1.762	1.530	250	107.9	115.3	15.71	57.1	24.49	2.15	125
130	2.3442	940.4	0.00644	390.39	487.70	1.5584	1.7997	1.959	1.932	1.652	226	103.9	106.0	16.49	55.9	25.99	1.68	130
135	2.5773	905.8	0.00560	399.81	488.57	1.5810	1.7984	2.113	2.188	1.840	201	99.5	96.6	17.48	54.7	27.93	1.24	135
140	2.8287	865.6	0.00481	409.80	488.59	1.6046	1.7953	2.367	2.617	2.161	174	94.5	87.0	18.82	53.6	30.55	0.83	140
145	3.1003	815.9	0.00404	420.68	487.22	1.6300	1.7891	2.888	3.504	2.835	144	88.8	76.6	20.77	53.0	34.48	0.47	145
150	3.3946	744.6	0.00324	433.55	482.85	1.6597	1.7762	4.720	6.517	5.146	111	82.2	64.1	24.20	54.2	42.04	0.16	150
154.01[c]	3.6510	516.1	0.00194	460.34	460.34	1.7217	1.7217	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	154.01

[a]Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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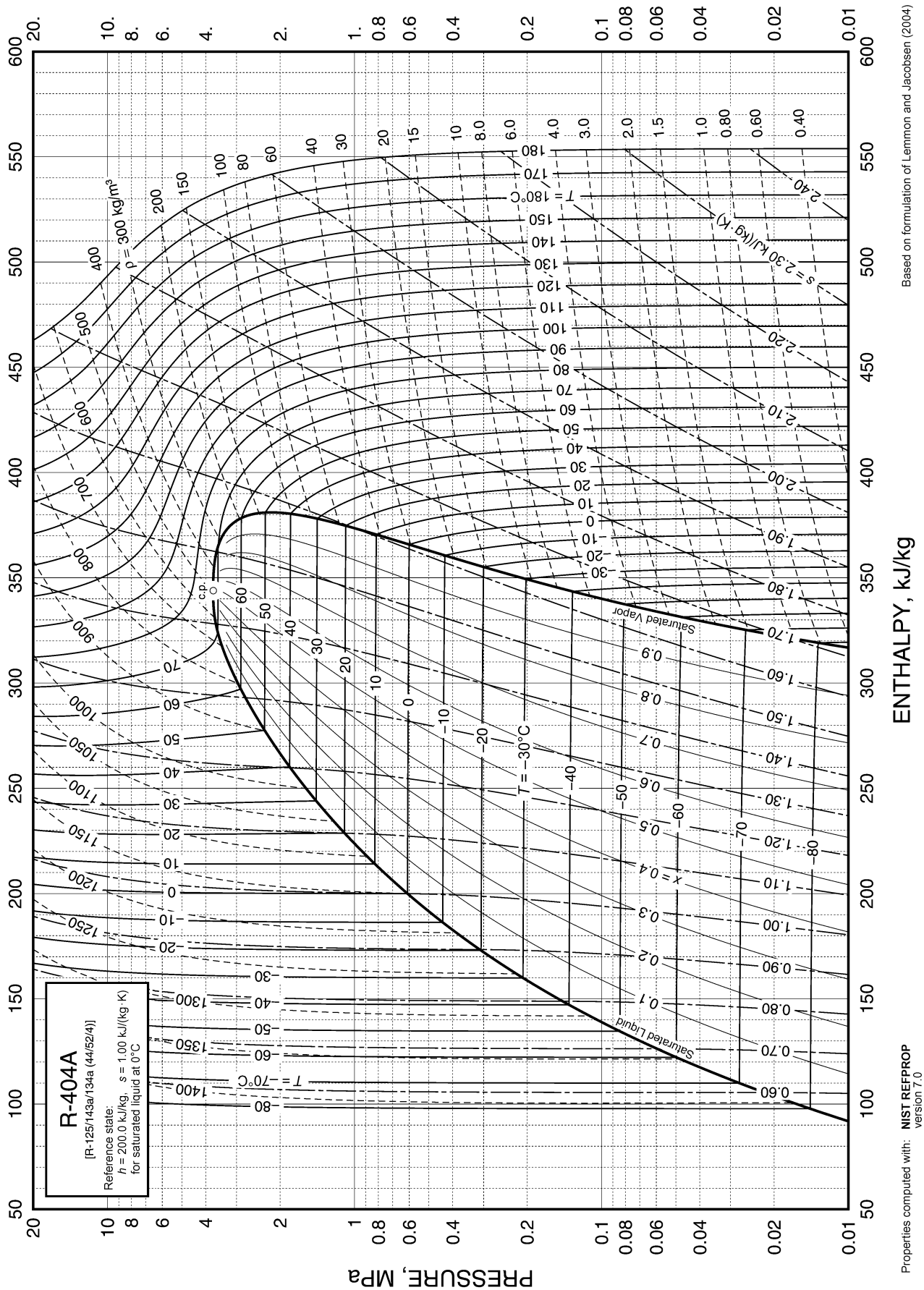

Fig. 12 Pressure-Enthalpy Diagram for Refrigerant 404A

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Refrigerant 404A [R-125/143a/134a (44/52/4)] Properties of Liquid on Bubble Line and Vapor on Dew Line

Pressure, MPa	Temperature,* °C		Density, kg/m³	Volume, m³/kg	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p, kJ/(kg·K)		c_p/c_v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m	Pressure, MPa
	Bubble	Dew	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		
0.005	–93.70	–92.50	1447.1	3.05794	81.16	311.61	0.4716	1.7532	1.220	0.640	1.163	998	132.9	764.9	7.32	122.5	6.15	17.78	0.005
0.006	–91.48	–90.32	1440.6	2.57690	83.85	312.92	0.4865	1.7450	1.218	0.646	1.162	980	133.6	727.8	7.41	121.2	6.28	17.58	0.006
0.007	–89.56	–88.42	1434.9	2.22992	86.19	314.06	0.4993	1.7382	1.216	0.651	1.161	966	134.1	697.9	7.48	120.1	6.40	17.40	0.007
0.008	–87.86	–86.74	1429.9	1.96748	88.26	315.07	0.5106	1.7324	1.215	0.655	1.161	953	134.6	673.0	7.55	119.2	6.50	17.24	0.008
0.009	–86.32	–85.22	1425.4	1.76182	90.13	315.99	0.5206	1.7273	1.214	0.660	1.160	942	135.0	651.7	7.61	118.3	6.60	17.09	0.009
0.01	–84.93	–83.84	1421.3	1.59620	91.83	316.83	0.5296	1.7229	1.214	0.663	1.160	933	135.4	633.3	7.66	117.5	6.68	16.96	0.01
0.02	–75.05	–74.08	1392.4	0.83425	103.81	322.78	0.5917	1.6953	1.215	0.691	1.159	870	137.9	523.7	8.04	112.2	7.31	16.00	0.02
0.04	–63.85	–62.97	1359.4	0.43619	117.48	329.58	0.6587	1.6707	1.225	0.725	1.159	807	140.4	431.3	8.47	106.4	8.05	14.85	0.04
0.06	–56.57	–55.75	1337.7	0.29837	126.44	334.00	0.7007	1.6578	1.234	0.749	1.161	770	141.7	383.8	8.74	102.8	8.55	14.08	0.06
0.08	–51.03	–50.25	1321.0	0.22779	133.31	337.36	0.7320	1.6494	1.243	0.767	1.163	742	142.6	352.7	8.95	100.1	8.93	13.48	0.08
0.1	–46.50	–45.74	1307.1	0.18467	138.97	340.08	0.7571	1.6434	1.251	0.784	1.166	719	143.2	329.8	9.12	98.0	9.25	12.98	0.1
0.10132[b]	–46.22	–45.47	1306.3	0.18240	139.31	340.25	0.7586	1.6430	1.252	0.785	1.166	718	143.2	328.5	9.13	97.8	9.27	12.95	0.10132
0.12	–42.63	–41.90	1295.1	0.15551	143.83	342.40	0.7783	1.6387	1.259	0.798	1.169	700	143.6	311.9	9.26	96.2	9.53	12.55	0.12
0.14	–39.24	–38.53	1284.5	0.13443	148.12	344.41	0.7967	1.6349	1.266	0.811	1.171	684	143.9	297.3	9.39	94.6	9.78	12.17	0.14
0.16	–36.20	–35.51	1275.0	0.11846	151.97	346.20	0.8130	1.6318	1.273	0.823	1.174	669	144.1	285.0	9.50	93.2	10.01	11.82	0.16
0.18	–33.45	–32.78	1266.2	0.10592	155.49	347.81	0.8277	1.6292	1.279	0.834	1.177	656	144.2	274.4	9.60	91.9	10.21	11.51	0.18
0.2	–30.93	–30.27	1258.0	0.09581	158.73	349.28	0.8411	1.6270	1.285	0.844	1.179	644	144.3	265.1	9.69	90.8	10.40	11.21	0.2
0.22	–28.59	–27.94	1250.4	0.08748	161.75	350.63	0.8534	1.6250	1.291	0.855	1.182	633	144.3	256.9	9.78	89.7	10.58	10.94	0.22
0.24	–26.42	–25.78	1243.3	0.08049	164.57	351.88	0.8649	1.6233	1.297	0.864	1.185	623	144.4	249.5	9.86	88.7	10.75	10.69	0.24
0.26	–24.37	–23.75	1236.5	0.07454	167.23	353.04	0.8755	1.6217	1.303	0.873	1.188	613	144.3	242.8	9.94	87.8	10.91	10.45	0.26
0.28	–22.45	–21.83	1230.1	0.06941	169.75	354.13	0.8855	1.6203	1.308	0.882	1.190	604	144.3	236.7	10.01	87.0	11.06	10.22	0.28
0.3	–20.62	–20.02	1223.9	0.06494	172.14	355.15	0.8950	1.6190	1.313	0.891	1.193	595	144.2	231.1	10.08	86.2	11.21	10.01	0.3
0.32	–18.89	–18.29	1218.0	0.06101	174.43	356.12	0.9039	1.6179	1.319	0.899	1.196	587	144.1	225.9	10.15	85.4	11.34	9.81	0.32
0.34	–17.24	–16.65	1212.4	0.05752	176.61	357.03	0.9125	1.6168	1.324	0.907	1.199	579	144.0	221.1	10.21	84.7	11.48	9.61	0.34
0.36	–15.66	–15.08	1206.9	0.05441	178.71	357.90	0.9206	1.6158	1.329	0.915	1.202	572	143.9	216.6	10.27	84.0	11.61	9.42	0.36
0.38	–14.15	–13.57	1201.6	0.05162	180.73	358.72	0.9283	1.6149	1.334	0.923	1.205	565	143.8	212.4	10.33	83.3	11.73	9.24	0.38
0.4	–12.69	–12.12	1196.5	0.04909	182.68	359.51	0.9358	1.6141	1.339	0.931	1.208	558	143.7	208.4	10.39	82.7	11.85	9.07	0.4
0.42	–11.29	–10.73	1191.6	0.04680	184.56	360.26	0.9429	1.6133	1.344	0.938	1.211	551	143.5	204.7	10.44	82.1	11.97	8.90	0.42
0.44	–9.94	–9.39	1186.7	0.04471	186.38	360.98	0.9498	1.6125	1.349	0.946	1.214	545	143.4	201.2	10.49	81.5	12.08	8.74	0.44
0.46	–8.64	–8.09	1182.0	0.04279	188.15	361.67	0.9564	1.6118	1.353	0.953	1.217	538	143.2	197.8	10.55	81.0	12.19	8.58	0.46
0.48	–7.37	–6.83	1177.5	0.04103	189.86	362.33	0.9628	1.6112	1.358	0.960	1.220	532	143.0	194.6	10.60	80.4	12.30	8.43	0.48
0.5	–6.15	–5.61	1173.0	0.03940	191.53	362.96	0.9690	1.6105	1.363	0.967	1.223	527	142.8	191.6	10.65	79.9	12.41	8.28	0.5
0.55	–3.24	–2.72	1162.3	0.03584	195.51	364.45	0.9837	1.6091	1.374	0.984	1.231	513	142.4	184.6	10.77	78.7	12.66	7.93	0.55
0.6	–0.53	–0.02	1152.0	0.03284	199.26	365.81	0.9973	1.6078	1.386	1.001	1.239	500	141.9	178.2	10.88	77.5	12.91	7.61	0.6
0.65	2.02	2.52	1142.3	0.03029	202.81	367.06	1.0101	1.6066	1.397	1.018	1.247	488	141.3	172.5	10.99	76.5	13.16	7.30	0.65
0.7	4.42	4.91	1132.9	0.02809	206.18	368.21	1.0222	1.6055	1.409	1.034	1.256	476	140.8	167.2	11.10	75.5	13.41	7.01	0.7
0.75	6.70	7.18	1123.8	0.02618	209.41	369.28	1.0336	1.6044	1.420	1.051	1.264	465	140.2	162.4	11.20	74.5	13.65	6.74	0.75
0.8	8.87	9.34	1115.1	0.02449	212.49	370.27	1.0444	1.6035	1.432	1.067	1.274	455	139.6	157.9	11.30	73.6	13.89	6.48	0.8
0.85	10.94	11.40	1106.5	0.02300	215.46	371.19	1.0547	1.6025	1.443	1.084	1.283	445	139.0	153.6	11.40	72.8	14.12	6.23	0.85
0.9	12.92	13.37	1098.2	0.02166	218.32	372.05	1.0646	1.6016	1.455	1.100	1.293	435	138.3	149.7	11.50	72.0	14.35	5.99	0.9
0.95	14.81	15.26	1090.2	0.02046	221.09	372.85	1.0741	1.6007	1.466	1.117	1.303	426	137.7	146.0	11.59	71.2	14.59	5.76	0.95
1.0	16.64	17.08	1082.2	0.01937	223.77	373.59	1.0832	1.5999	1.478	1.134	1.313	417	137.1	142.5	11.69	70.4	14.82	5.54	1.0
1.1	20.09	20.52	1066.9	0.01749	228.89	374.94	1.1005	1.5982	1.503	1.169	1.336	400	135.7	136.1	11.88	69.0	15.29	5.13	1.1
1.2	23.32	23.73	1052.0	0.01590	233.75	376.12	1.1166	1.5965	1.528	1.206	1.360	384	134.4	130.2	12.07	67.7	15.76	4.75	1.2
1.3	26.35	26.75	1037.5	0.01455	238.37	377.14	1.1318	1.5949	1.554	1.244	1.386	368	133.0	124.9	12.26	66.5	16.23	4.39	1.3
1.4	29.22	29.60	1023.4	0.01338	242.81	378.02	1.1462	1.5932	1.582	1.285	1.414	354	131.6	119.9	12.45	65.3	16.71	4.06	1.4
1.5	31.93	32.30	1009.5	0.01236	247.07	378.78	1.1599	1.5914	1.611	1.329	1.445	340	130.1	115.3	12.65	64.2	17.21	3.75	1.5
1.6	34.51	34.87	995.7	0.01146	251.19	379.42	1.1730	1.5896	1.643	1.376	1.478	327	128.7	111.0	12.84	63.1	17.72	3.45	1.6
1.7	36.97	37.32	982.1	0.01066	255.17	379.95	1.1856	1.5878	1.676	1.426	1.515	314	127.2	107.0	13.05	62.1	18.24	3.17	1.7
1.8	39.33	39.67	968.6	0.00994	259.05	380.38	1.1977	1.5858	1.712	1.481	1.556	301	125.7	103.2	13.25	61.2	18.80	2.91	1.8
1.9	41.58	41.91	955.1	0.00930	262.83	380.70	1.2095	1.5838	1.751	1.541	1.601	289	124.1	99.5	13.47	60.2	19.37	2.66	1.9
2.0	43.75	44.07	941.6	0.00871	266.52	380.92	1.2208	1.5817	1.794	1.607	1.652	277	122.6	96.1	13.70	59.3	19.98	2.43	2.0
2.1	45.84	46.15	928.1	0.00817	270.14	381.05	1.2319	1.5794	1.841	1.681	1.709	266	121.0	92.7	13.93	58.5	20.62	2.21	2.1
2.2	47.85	48.15	914.4	0.00768	273.70	381.08	1.2427	1.5770	1.893	1.763	1.774	254	119.4	89.5	14.18	57.6	21.31	2.00	2.2
2.3	49.80	50.08	900.6	0.00723	277.20	381.01	1.2532	1.5745	1.952	1.856	1.847	243	117.8	86.5	14.44	56.8	22.04	1.80	2.3
2.4	51.68	51.95	886.5	0.00680	280.66	380.83	1.2635	1.5718	2.019	1.962	1.932	232	116.2	83.5	14.72	56.0	22.83	1.61	2.4
2.5	53.50	53.76	872.2	0.00641	284.09	380.55	1.2737	1.5689	2.095	2.085	2.032	222	114.5	80.5	15.02	55.3	23.69	1.43	2.5
2.6	55.26	55.51	857.5	0.00604	287.50	380.15	1.2837	1.5658	2.183	2.229	2.149	211	112.9	77.7	15.34	54.5	24.62	1.26	2.6
2.7	56.97	57.21	842.4	0.00569	290.89	379.62	1.2937	1.5624	2.288	2.401	2.289	200	111.2	74.9	15.69	53.8	25.65	1.10	2.7
2.8	58.63	58.86	826.8	0.00536	294.29	378.96	1.3036	1.5587	2.414	2.609	2.459	190	109.5	72.1	16.07	53.2	26.79	0.94	2.8
2.9	60.24	60.46	810.5	0.00505	297.70	378.14	1.3135	1.5547	2.569	2.868	2.672	179	107.7	69.3	16.49	52.6	28.06	0.80	2.9
3.0	61.81	62.01	793.4	0.00475	301.15	377.15	1.3234	1.5503	2.765	3.197	2.944	169	106.0	66.5	16.95	52.0	29.51	0.67	3.0
3.2	64.82	64.99	755.6	0.00417	308.25	374.49	1.3438	1.5397	3.381	4.233	3.797	148	102.3	60.9	18.09	51.2	33.17	0.43	3.2
3.4	67.67	67.81	709.8	0.00361	315.97	370.45	1.3657	1.5255	4.771	6.536	5.689	126	98.5	54.7	19.68	51.3	38.73	0.23	3.4
3.729[c]	72.05	72.05	486.5	0.00206	343.92	343.92	1.4455	1.4455	—	—	—	—	—	—	—	—	—	0.00	3.729

*Temperatures on ITS-90 scale [b]Bubble and dew points at one standard atmosphere [c]Critical point

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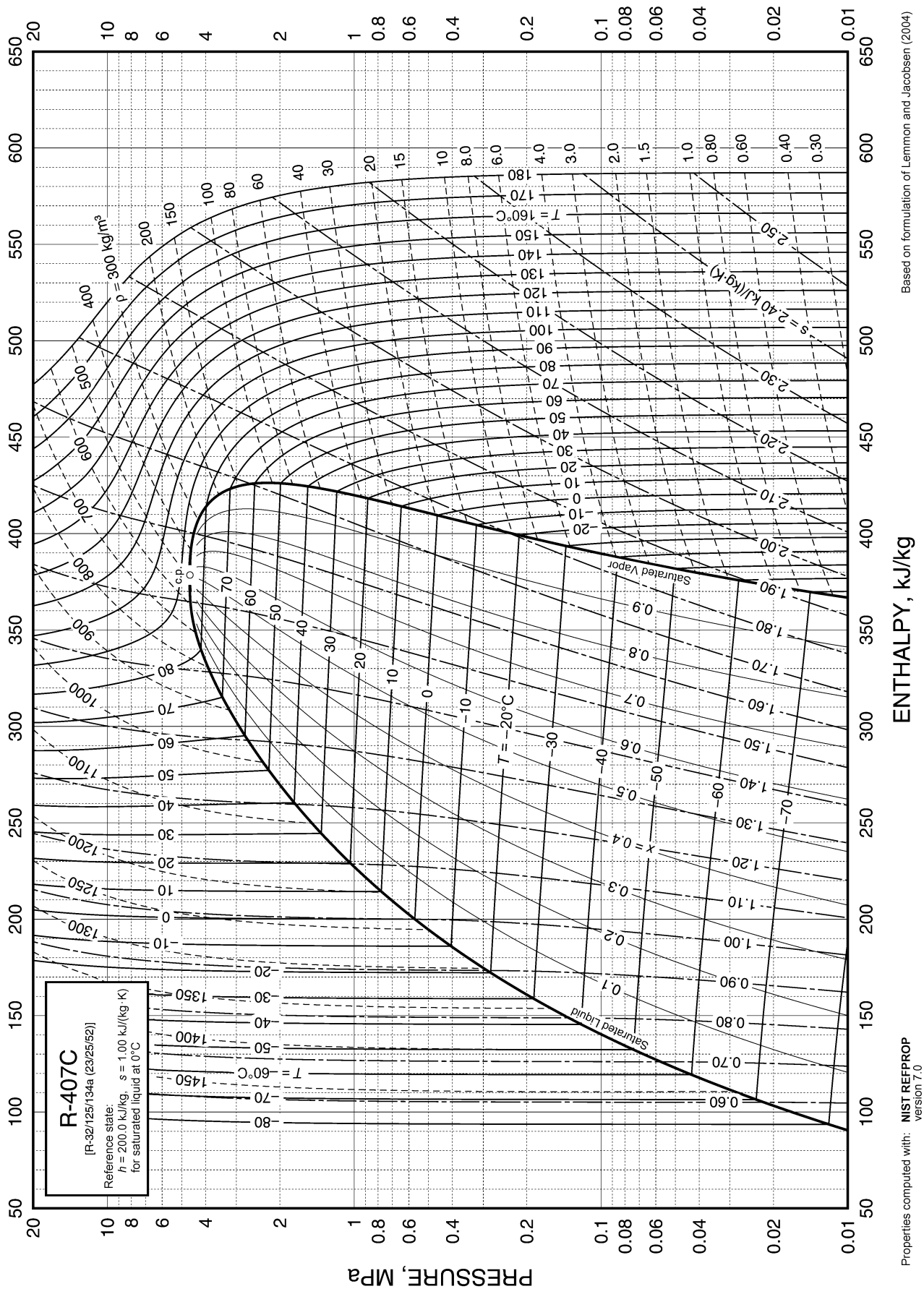

Fig. 13 Pressure-Enthalpy Diagram for Refrigerant 407C

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Refrigerant 407C [R-32/125/134a (23/25/52)] Properties of Liquid on Bubble Line and Vapor on Dew Line

Pressure, MPa	Temperature,* °C		Density, kg/m³	Volume, m³/kg	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p, kJ/(kg·K)		c_p/c_v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m	Pressure, MPa
	Bubble	Dew	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		
0.01	–82.45	–74.81	1495.5	1.89703	90.48	366.78	0.5259	1.9471	1.281	0.668	1.182	1008	149.1	779.8	8.43	151.5	6.94	24.75	0.01
0.02	–72.50	–65.02	1466.7	0.99017	103.24	372.75	0.5910	1.9104	1.283	0.694	1.181	953	151.8	632.8	8.83	145.4	7.52	22.93	0.02
0.04	–61.25	–53.95	1433.7	0.51705	117.72	379.47	0.6612	1.8761	1.291	0.727	1.182	893	154.6	513.1	9.28	138.5	8.19	20.91	0.04
0.06	–53.96	–46.79	1412.0	0.35346	127.17	383.77	0.7050	1.8573	1.299	0.750	1.184	856	156.1	453.1	9.57	134.1	8.64	19.62	0.06
0.08	–48.42	–41.34	1395.3	0.26975	134.39	386.99	0.7374	1.8445	1.306	0.769	1.187	828	157.1	414.4	9.79	130.7	8.99	18.65	0.08
0.1	–43.90	–36.90	1381.5	0.21865	140.31	389.59	0.7635	1.8349	1.312	0.786	1.190	806	157.8	386.2	9.97	128.1	9.28	17.87	0.1
0.10132[b]	–43.63	–36.63	1380.7	0.21595	140.67	389.75	0.7650	1.8343	1.312	0.787	1.190	804	157.8	384.6	9.98	127.9	9.29	17.82	0.10132
0.12	–40.05	–33.11	1369.7	0.18411	145.39	391.78	0.7854	1.8273	1.318	0.800	1.193	787	158.3	364.3	10.12	125.8	9.52	17.21	0.12
0.14	–36.67	–29.79	1359.1	0.15916	149.86	393.68	0.8043	1.8210	1.324	0.813	1.196	770	158.7	346.6	10.25	123.8	9.75	16.63	0.14
0.16	–33.65	–26.83	1349.7	0.14025	153.86	395.36	0.8211	1.8156	1.329	0.825	1.199	755	159.0	331.8	10.37	122.0	9.94	16.12	0.16
0.18	–30.92	–24.15	1341.0	0.12542	157.51	396.86	0.8362	1.8110	1.334	0.837	1.201	742	159.3	319.1	10.48	120.4	10.13	15.66	0.18
0.2	–28.41	–21.69	1333.0	0.11347	160.87	398.22	0.8499	1.8069	1.339	0.848	1.204	730	159.5	308.0	10.57	119.0	10.29	15.24	0.2
0.22	–26.09	–19.41	1325.5	0.10362	163.99	399.47	0.8625	1.8033	1.344	0.858	1.207	719	159.6	298.2	10.66	117.6	10.45	14.86	0.22
0.24	–23.93	–17.29	1318.4	0.09536	166.91	400.62	0.8742	1.8000	1.349	0.868	1.210	708	159.7	289.5	10.75	116.4	10.60	14.50	0.24
0.26	–21.90	–15.31	1311.8	0.08833	169.65	401.69	0.8851	1.7970	1.354	0.877	1.213	698	159.8	281.6	10.83	115.2	10.74	14.16	0.26
0.28	–19.99	–13.43	1305.5	0.08227	172.24	402.69	0.8954	1.7942	1.358	0.886	1.216	689	159.8	274.4	10.90	114.2	10.87	13.85	0.28
0.3	–18.19	–11.66	1299.5	0.07699	174.71	403.62	0.9050	1.7917	1.362	0.895	1.219	680	159.8	267.8	10.97	113.1	10.99	13.56	0.3
0.32	–16.47	–9.98	1293.7	0.07235	177.06	404.49	0.9141	1.7894	1.367	0.903	1.222	672	159.8	261.8	11.04	112.2	11.11	13.28	0.32
0.34	–14.83	–8.38	1288.2	0.06824	179.30	405.32	0.9228	1.7872	1.371	0.911	1.224	664	159.8	256.1	11.11	111.2	11.23	13.01	0.34
0.36	–13.27	–6.85	1282.9	0.06457	181.45	406.10	0.9310	1.7851	1.375	0.919	1.227	656	159.8	250.9	11.17	110.4	11.35	12.76	0.36
0.38	–11.77	–5.38	1277.8	0.06127	183.52	406.85	0.9389	1.7832	1.379	0.927	1.230	649	159.7	246.0	11.23	109.5	11.46	12.52	0.38
0.4	–10.33	–3.97	1272.8	0.05830	185.52	407.55	0.9465	1.7814	1.383	0.934	1.233	642	159.7	241.4	11.28	108.7	11.57	12.29	0.4
0.42	–8.94	–2.61	1268.0	0.05559	187.44	408.23	0.9537	1.7796	1.387	0.942	1.236	635	159.6	237.1	11.34	107.9	11.68	12.07	0.42
0.44	–7.61	–1.31	1263.4	0.05313	189.30	408.87	0.9607	1.7780	1.391	0.949	1.239	629	159.5	233.0	11.39	107.2	11.78	11.85	0.44
0.46	–6.31	–0.04	1258.8	0.05087	191.11	409.48	0.9674	1.7764	1.395	0.956	1.242	622	159.4	229.1	11.45	106.5	11.88	11.65	0.46
0.48	–5.06	1.18	1254.4	0.04879	192.86	410.07	0.9739	1.7750	1.399	0.963	1.245	616	159.3	225.4	11.50	105.8	11.98	11.45	0.48
0.5	–3.85	2.36	1250.1	0.04687	194.56	410.64	0.9801	1.7735	1.403	0.970	1.248	610	159.2	221.9	11.54	105.1	12.08	11.26	0.5
0.55	–0.98	5.17	1239.8	0.04267	198.61	411.95	0.9950	1.7702	1.413	0.987	1.255	596	158.9	213.9	11.66	103.5	12.31	10.81	0.55
0.6	1.70	7.79	1230.0	0.03915	202.42	413.15	1.0087	1.7672	1.422	1.004	1.262	583	158.6	206.7	11.77	102.1	12.54	10.40	0.6
0.65	4.22	10.24	1220.7	0.03615	206.02	414.25	1.0216	1.7644	1.432	1.020	1.270	571	158.2	200.1	11.88	100.7	12.75	10.01	0.65
0.7	6.60	12.56	1211.7	0.03356	209.44	415.25	1.0338	1.7618	1.441	1.036	1.278	559	157.8	194.1	11.98	99.4	12.96	9.64	0.7
0.75	8.85	14.76	1203.1	0.03131	212.71	416.18	1.0452	1.7594	1.451	1.052	1.286	548	157.4	188.6	12.08	98.2	13.17	9.30	0.75
0.8	11.00	16.85	1194.9	0.02933	215.83	417.03	1.0561	1.7571	1.460	1.067	1.294	537	157.0	183.6	12.17	97.1	13.37	8.98	0.8
0.85	13.04	18.84	1186.8	0.02757	218.83	417.83	1.0665	1.7550	1.469	1.082	1.302	527	156.6	178.8	12.26	96.0	13.58	8.67	0.85
0.9	15.00	20.74	1179.1	0.02600	221.71	418.57	1.0764	1.7529	1.479	1.098	1.310	518	156.1	174.4	12.35	94.9	13.78	8.38	0.9
0.95	16.88	22.56	1171.5	0.02460	224.50	419.25	1.0859	1.7509	1.488	1.113	1.319	508	155.6	170.3	12.44	93.9	13.98	8.11	0.95
1.0	18.69	24.32	1164.1	0.02332	227.19	419.89	1.0950	1.7491	1.498	1.128	1.327	499	155.2	166.4	12.52	93.0	14.18	7.84	1.0
1.1	22.11	27.63	1149.9	0.02111	232.34	421.03	1.1122	1.7455	1.517	1.159	1.346	482	154.2	159.2	12.68	91.1	14.59	7.35	1.1
1.2	25.30	30.73	1136.2	0.01926	237.20	422.03	1.1283	1.7421	1.537	1.190	1.365	466	153.2	152.8	12.84	89.5	14.99	6.89	1.2
1.3	28.30	33.63	1123.0	0.01768	241.82	422.89	1.1434	1.7389	1.557	1.222	1.385	451	152.1	146.9	13.01	87.9	15.39	6.47	1.3
1.4	31.14	36.37	1110.2	0.01631	246.24	423.63	1.1577	1.7358	1.578	1.255	1.406	436	151.0	141.5	13.15	86.4	15.80	6.07	1.4
1.5	33.83	38.97	1097.7	0.01512	250.48	424.27	1.1713	1.7328	1.600	1.289	1.428	423	150.0	136.5	13.31	85.0	16.22	5.70	1.5
1.6	36.39	41.43	1085.5	0.01408	254.57	424.80	1.1843	1.7298	1.622	1.324	1.452	409	148.8	131.8	13.47	83.7	16.64	5.35	1.6
1.7	38.84	43.78	1073.5	0.01315	258.51	425.25	1.1967	1.7269	1.645	1.361	1.477	397	147.7	127.5	13.62	82.4	17.07	5.02	1.7
1.8	41.18	46.03	1061.7	0.01231	262.33	425.61	1.2086	1.7241	1.669	1.400	1.504	385	146.6	123.4	13.78	81.2	17.52	4.71	1.8
1.9	43.43	48.18	1050.0	0.01157	266.05	425.89	1.2200	1.7212	1.695	1.440	1.533	373	145.4	119.6	13.94	80.1	17.98	4.42	1.9
2.0	45.59	50.25	1038.5	0.01089	269.66	426.10	1.2311	1.7184	1.722	1.483	1.564	361	144.2	115.9	14.10	78.9	18.45	4.14	2.0
2.1	47.67	52.24	1027.1	0.01027	273.19	426.23	1.2418	1.7155	1.750	1.529	1.597	350	143.0	112.5	14.27	77.9	18.94	3.87	2.1
2.2	49.68	54.15	1015.7	0.00971	276.64	426.29	1.2522	1.7126	1.780	1.577	1.633	339	141.8	109.2	14.44	76.8	19.45	3.62	2.2
2.3	51.63	56.00	1004.4	0.00919	280.02	426.28	1.2624	1.7097	1.813	1.629	1.671	329	140.6	106.0	14.62	75.8	19.98	3.38	2.3
2.4	53.51	57.79	993.1	0.00871	283.34	426.20	1.2723	1.7068	1.847	1.684	1.713	318	139.4	103.0	14.79	74.9	20.54	3.15	2.4
2.5	55.34	59.51	981.8	0.00827	286.60	426.06	1.2819	1.7038	1.884	1.744	1.758	308	138.2	100.0	14.98	73.9	21.12	2.93	2.5
2.6	57.11	61.19	970.5	0.00786	289.82	425.85	1.2914	1.7007	1.924	1.810	1.808	298	136.9	97.2	15.17	73.0	21.73	2.72	2.6
2.7	58.83	62.81	959.0	0.00747	292.99	425.57	1.3006	1.6976	1.968	1.881	1.863	288	135.6	94.5	15.37	72.1	22.38	2.52	2.7
2.8	60.51	64.38	947.5	0.00711	296.12	425.21	1.3097	1.6944	2.016	1.958	1.923	279	134.4	91.9	15.58	71.3	23.06	2.33	2.8
2.9	62.14	65.91	935.9	0.00677	299.23	424.79	1.3187	1.6911	2.069	2.044	1.990	269	133.1	89.3	15.80	70.4	23.79	2.14	2.9
3.0	63.73	67.40	924.1	0.00645	302.31	424.29	1.3276	1.6877	2.128	2.139	2.065	259	131.7	86.8	16.03	69.6	24.56	1.96	3.0
3.2	66.80	70.25	899.9	0.00587	308.43	423.06	1.3450	1.6805	2.268	2.365	2.243	240	129.1	81.9	16.53	68.1	26.26	1.63	3.2
3.4	69.73	72.94	874.6	0.00533	314.54	421.46	1.3622	1.6726	2.451	2.657	2.475	222	126.4	77.1	17.09	66.6	28.22	1.33	3.4
3.6	72.53	75.50	847.6	0.00484	320.71	419.45	1.3795	1.6639	2.701	3.050	2.789	203	123.6	72.5	17.75	65.2	30.54	1.05	3.6
3.8	75.22	77.92	818.1	0.00439	327.02	416.91	1.3970	1.6540	3.065	3.613	3.239	184	120.7	67.7	18.52	64.0	33.33	0.79	3.8
4.0	77.82	80.21	785.1	0.00395	333.64	413.66	1.4152	1.6424	3.647	4.486	3.935	165	117.7	62.9	19.48	63.1	36.86	0.56	4.0
4.2	80.32	82.37	746.0	0.00352	340.83	409.34	1.4348	1.6281	4.726	6.029	5.159	146	114.6	57.6	20.75	62.7	41.59	0.36	4.2
4.63[c]	86.03	86.03	484.2	0.00207	378.48	378.48	1.5384	1.5384	—	—	—	—	—	—	—	—	—	0.00	4.63

*Temperatures on ITS-90 scale [b]Bubble and dew points at one standard atmosphere [c]Critical point

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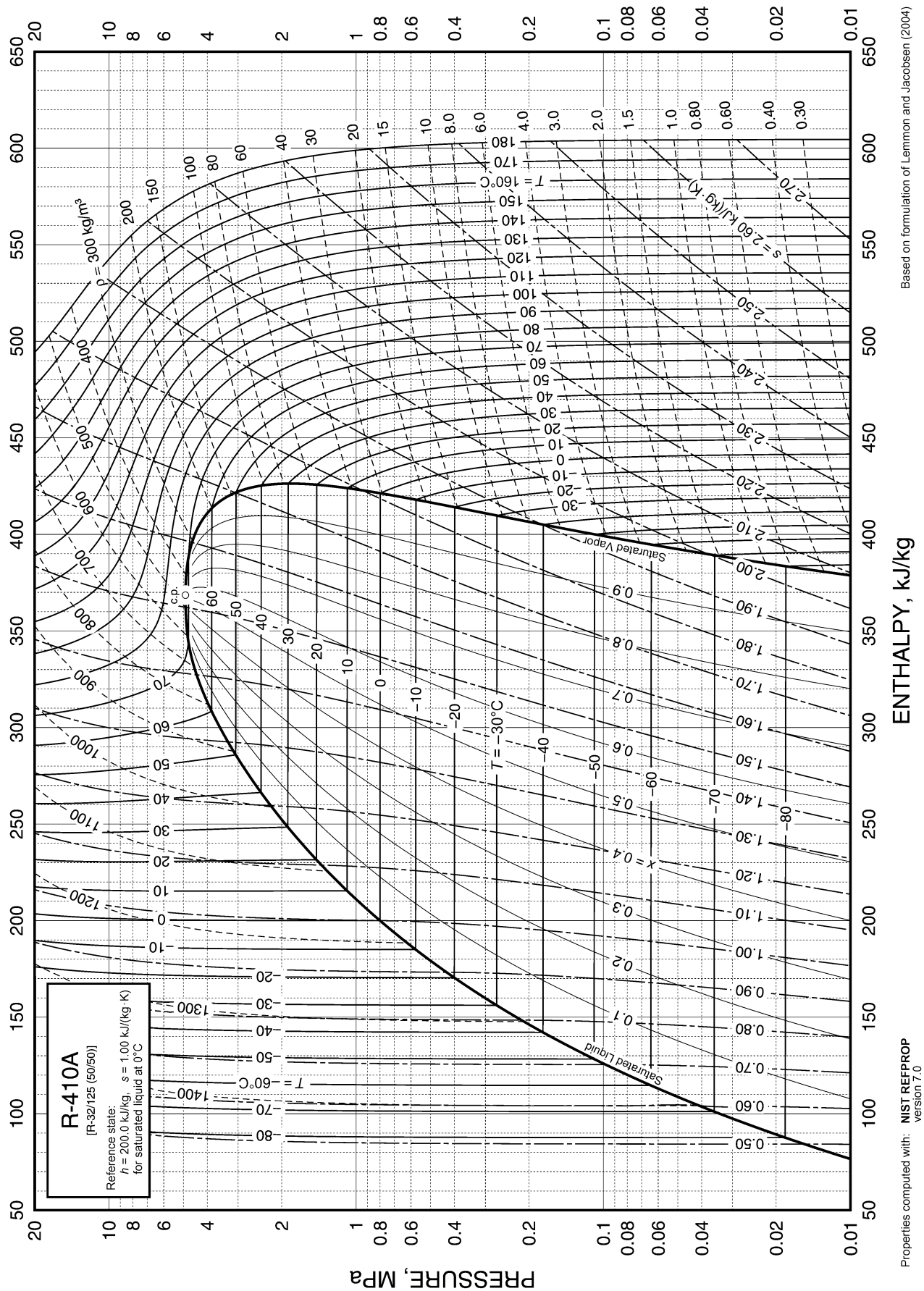

Fig. 14 Pressure-Enthalpy Diagram for Refrigerant 410A

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Refrigerant 410A [R-32/125 (50/50)] Properties of Liquid on Bubble Line and Vapor on Dew Line

Pressure, MPa	Temperature,* °C		Density, kg/m³	Volume, m³/kg	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p, kJ/(kg·K)		c_p/c_v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m	Pressure, MPa
	Bubble	Dew	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		
0.01	–88.23	–88.14	1460.6	2.09888	76.56	378.76	0.4588	2.0927	1.344	0.668	1.227	1004	159.7	669.9	8.29	177.3	7.44	24.72	0.01
0.02	–78.79	–78.70	1432.9	1.09659	89.26	384.25	0.5258	2.0432	1.345	0.696	1.228	958	162.8	552.9	8.71	170.8	7.79	22.91	0.02
0.04	–68.12	–68.04	1401.1	0.57309	103.64	390.29	0.5978	1.9956	1.351	0.734	1.231	906	165.8	454.8	9.17	163.3	8.21	20.90	0.04
0.06	–61.22	–61.14	1380.0	0.39193	113.00	394.10	0.6426	1.9687	1.358	0.762	1.235	872	167.5	404.6	9.47	158.3	8.50	19.62	0.06
0.08	–55.98	–55.90	1363.9	0.29918	120.14	396.92	0.6758	1.9500	1.364	0.785	1.239	847	168.7	371.8	9.70	154.6	8.73	18.66	0.08
0.1	–51.70	–51.62	1350.5	0.24256	125.99	399.17	0.7024	1.9358	1.369	0.805	1.243	826	169.5	347.8	9.88	151.5	8.93	17.88	0.1
0.10132[b]	–51.44	–51.36	1349.7	0.23957	126.34	399.31	0.7040	1.9350	1.370	0.807	1.244	824	169.5	346.4	9.90	151.3	8.94	17.84	0.10132
0.12	–48.06	–47.98	1339.0	0.20427	130.99	401.05	0.7247	1.9243	1.375	0.823	1.247	808	170.1	329.0	10.04	148.9	9.11	17.23	0.12
0.14	–44.87	–44.79	1328.8	0.17661	135.39	402.67	0.7441	1.9147	1.380	0.839	1.251	792	170.6	313.8	10.18	146.6	9.26	16.65	0.14
0.16	–42.02	–41.94	1319.6	0.15565	139.34	404.09	0.7612	1.9065	1.385	0.854	1.255	778	170.9	300.9	10.30	144.6	9.40	16.15	0.16
0.18	–39.44	–39.36	1311.2	0.13921	142.93	405.36	0.7766	1.8993	1.390	0.868	1.259	765	171.2	289.9	10.41	142.8	9.53	15.69	0.18
0.2	–37.07	–36.99	1303.4	0.12595	146.23	406.50	0.7905	1.8928	1.395	0.881	1.263	753	171.5	280.3	10.51	141.1	9.66	15.27	0.2
0.22	–34.89	–34.80	1296.2	0.11503	149.29	407.53	0.8034	1.8871	1.399	0.893	1.266	743	171.6	271.8	10.61	139.5	9.77	14.89	0.22
0.24	–32.85	–32.76	1289.4	0.10587	152.15	408.49	0.8153	1.8818	1.404	0.904	1.270	732	171.8	264.2	10.70	138.1	9.88	14.54	0.24
0.26	–30.94	–30.85	1283.0	0.09807	154.84	409.36	0.8264	1.8770	1.408	0.916	1.274	723	171.9	257.2	10.78	136.7	9.98	14.21	0.26
0.28	–29.14	–29.05	1276.9	0.09135	157.38	410.18	0.8368	1.8726	1.413	0.926	1.277	714	172.0	251.0	10.86	135.5	10.08	13.90	0.28
0.3	–27.44	–27.35	1271.1	0.08550	159.80	410.94	0.8466	1.8685	1.417	0.936	1.281	705	172.0	245.2	10.93	134.3	10.18	13.60	0.30
0.32	–25.82	–25.73	1265.5	0.08035	162.10	411.65	0.8558	1.8647	1.421	0.946	1.285	697	172.0	239.8	11.00	133.10	10.27	13.33	0.32
0.34	–24.28	–24.19	1260.2	0.07579	164.29	412.32	0.8646	1.8611	1.426	0.956	1.288	689	172.1	234.9	11.07	132.10	10.36	13.06	0.34
0.36	–22.81	–22.72	1255.0	0.07172	166.40	412.95	0.8703	1.8577	1.430	0.965	1.292	682	172.1	230.3	11.13	131.00	10.46	12.81	0.36
0.38	–21.40	–21.31	1250.1	0.06806	168.43	413.54	0.8810	1.8545	1.434	0.975	1.295	675	172.0	226.0	11.19	130.10	10.55	12.57	0.38
0.4	–20.04	–19.95	1245.3	0.06476	170.38	414.10	0.8887	1.8514	1.438	0.983	1.299	668	172.0	221.9	11.25	129.10	10.64	12.35	0.40
0.42	–18.74	–18.65	1240.6	0.06176	172.26	414.64	0.8960	1.8486	1.443	0.992	1.303	661	172.0	218.1	11.31	128.20	10.73	12.13	0.42
0.44	–17.48	–17.39	1236.1	0.05902	174.08	415.14	0.9031	1.8458	1.447	1.001	1.306	655	171.9	214.5	11.36	127.30	10.82	11.92	0.44
0.46	–16.27	–16.18	1231.8	0.05652	175.84	415.63	0.9099	1.8432	1.451	1.009	1.310	649	171.8	211.1	11.42	126.50	10.91	11.71	0.46
0.48	–15.10	–15.00	1227.5	0.05421	177.55	416.09	0.9165	1.8407	1.455	1.017	1.313	643	171.8	207.8	11.47	125.70	10.99	11.52	0.48
0.5	–13.96	–13.86	1223.3	0.05209	179.21	416.53	0.9228	1.8383	1.459	1.025	1.317	637	171.7	204.7	11.52	124.90	11.08	11.33	0.50
0.55	–11.26	–11.16	1213.4	0.04743	183.17	417.54	0.9379	1.8326	1.469	1.045	1.326	623	171.4	197.6	11.64	123.10	11.28	10.89	0.55
0.6	–8.74	–8.64	1203.9	0.04352	186.89	418.46	0.9518	1.8275	1.479	1.064	1.335	610	171.2	191.2	11.75	121.40	11.48	10.47	0.60
0.65	–6.38	–6.28	1194.9	0.04019	190.40	419.28	0.9649	1.8227	1.489	1.083	1.344	597	170.9	185.3	11.86	119.70	11.68	10.09	0.65
0.7	–4.15	–4.05	1186.3	0.03732	193.74	420.03	0.9772	1.8183	1.499	1.101	1.354	586	170.5	180.0	11.96	118.20	11.88	9.73	0.70
0.75	–2.04	–1.93	1178.1	0.03482	196.92	420.71	0.9888	1.8141	1.509	1.119	1.363	574	170.2	175.1	12.06	116.80	12.07	9.39	0.75
0.8	–0.03	0.08	1170.1	0.03262	199.96	421.33	0.9998	1.8102	1.519	1.136	1.373	564	169.8	170.6	12.15	115.50	12.26	9.07	0.80
0.85	1.89	1.99	1162.4	0.03068	202.88	421.89	1.0103	1.8065	1.529	1.154	1.382	554	169.4	166.4	12.24	114.20	12.45	8.77	0.85
0.9	3.72	3.83	1154.9	0.02894	205.69	422.41	1.0204	1.8030	1.540	1.171	1.392	544	169.0	162.4	12.33	113.00	12.64	8.48	0.90
0.95	5.48	5.58	1147.6	0.02738	208.40	422.88	1.0300	1.7996	1.550	1.188	1.402	535	168.6	158.7	12.41	111.80	12.82	8.21	0.95
1.0	7.17	7.27	1140.5	0.02596	211.02	423.31	1.0392	1.7964	1.560	1.205	1.413	525	168.1	155.3	12.49	110.70	13.01	7.95	1.00
1.1	10.36	10.47	1126.8	0.02351	216.03	424.07	1.0567	1.7903	1.581	1.239	1.434	508	167.2	148.8	12.65	108.60	13.39	7.46	1.10
1.2	13.34	13.46	1113.7	0.02145	220.76	424.68	1.0730	1.7846	1.603	1.274	1.457	492	166.3	143.1	12.81	106.70	13.79	7.01	1.20
1.3	16.15	16.26	1101.0	0.01970	225.26	425.19	1.0883	1.7792	1.624	1.31	1.481	477	165.4	137.8	12.95	104.80	14.19	6.59	1.30
1.4	18.79	18.91	1088.8	0.01819	229.56	425.59	1.1027	1.7741	1.647	1.347	1.506	462	164.4	133.0	13.12	103.10	14.60	6.20	1.40
1.5	21.30	21.41	1076.9	0.01687	233.68	425.89	1.1165	1.7691	1.670	1.385	1.532	448	163.4	128.5	13.23	101.50	15.03	5.83	1.50
1.6	23.68	23.80	1065.2	0.01571	237.65	426.11	1.1296	1.7644	1.694	1.424	1.560	435	162.4	124.3	13.38	99.98	15.46	5.49	1.60
1.7	25.96	26.07	1053.8	0.01468	241.48	426.25	1.1421	1.7597	1.719	1.465	1.590	422	161.4	120.4	13.52	98.53	15.91	5.16	1.70
1.8	28.13	28.25	1042.6	0.01376	245.19	426.31	1.1542	1.7552	1.745	1.509	1.621	410	160.3	116.8	13.66	97.15	16.38	4.86	1.80
1.9	30.22	30.34	1031.6	0.01293	248.79	426.31	1.1657	1.7508	1.772	1.555	1.655	398	159.3	113.3	13.81	95.82	16.86	4.57	1.90
2.0	32.22	32.34	1020.7	0.01218	252.29	426.24	1.1769	1.7464	1.800	1.603	1.690	386	158.2	110.1	13.95	94.56	17.36	4.29	2.00
2.1	34.16	34.28	1009.9	0.0115	255.71	426.10	1.1878	1.7421	1.830	1.655	1.728	375	157.1	107.0	14.10	93.34	17.88	4.03	2.10
2.2	36.02	36.14	999.2	0.01088	259.05	425.90	1.1983	1.7379	1.861	1.709	1.769	364	156.0	104.0	14.25	92.17	18.42	3.78	2.20
2.3	37.82	37.94	988.6	0.01031	262.32	425.64	1.2085	1.7336	1.894	1.768	1.813	353	154.9	101.2	14.40	91.05	18.99	3.54	2.30
2.4	39.56	39.68	978.0	0.00978	265.52	425.33	1.2185	1.7294	1.929	1.831	1.860	343	153.8	98.5	14.55	89.96	19.58	3.31	2.40
2.5	41.25	41.37	967.5	0.00929	268.67	424.95	1.2282	1.7251	1.967	1.898	1.911	332	152.6	95.9	14.71	88.91	20.21	3.10	2.50
2.6	42.89	43.00	957.0	0.00883	271.77	424.51	1.2377	1.7209	2.008	1.971	1.966	322	151.5	93.4	14.87	87.89	20.87	2.89	2.60
2.7	44.48	44.59	946.4	0.00841	274.82	424.02	1.2470	1.7166	2.052	2.050	2.026	313	150.3	91.0	15.03	86.91	21.56	2.69	2.70
2.8	46.02	46.14	935.8	0.00802	277.84	423.47	1.2561	1.7123	2.100	2.136	2.091	303	149.1	88.6	15.21	85.96	22.29	2.50	2.80
2.9	47.53	47.64	925.2	0.00764	280.82	422.85	1.2651	1.7079	2.153	2.230	2.163	293	147.9	86.3	15.38	85.04	23.07	2.31	2.90
3.0	48.99	49.10	914.5	0.00729	283.78	422.18	1.2740	1.7035	2.211	2.333	2.243	284	146.7	84.1	15.57	84.14	23.89	2.14	3.00
3.2	51.81	51.91	892.6	0.00665	289.62	420.62	1.2913	1.6944	2.348	2.575	2.429	265	144.2	79.9	15.96	82.42	25.70	1.81	3.20
3.4	54.49	54.59	870.0	0.00607	295.43	418.78	1.3085	1.6849	2.522	2.879	2.663	247	141.7	75.7	16.39	80.81	27.77	1.50	3.40
3.6	57.05	57.15	846.3	0.00555	301.26	416.60	1.3254	1.6747	2.752	3.276	2.970	229	139.0	71.7	16.87	79.29	30.17	1.22	3.60
3.8	59.50	59.59	821.0	0.00506	307.16	414.03	1.3425	1.6638	3.070	3.815	3.386	210	136.3	67.7	17.43	77.90	33.02	0.97	3.80
4.0	61.85	61.93	793.5	0.00460	313.24	410.97	1.3600	1.6517	3.541	4.596	3.987	192	133.4	63.7	18.08	76.68	36.48	0.74	4.00
4.2	64.10	64.17	762.6	0.00417	319.65	407.24	1.3783	1.6380	4.306	5.826	4.929	173	130.4	59.4	18.87	75.77	40.86	0.53	4.20
4.903[c]	71.36	71.36	459.5	0.00218	368.55	368.55	1.5181	1.5181	—	—	—	—	—	—	—	—	—	0.00	4.903

*Temperatures on ITS-90 scale

[b]Bubble and dew points at one standard atmosphere

[c]Critical point

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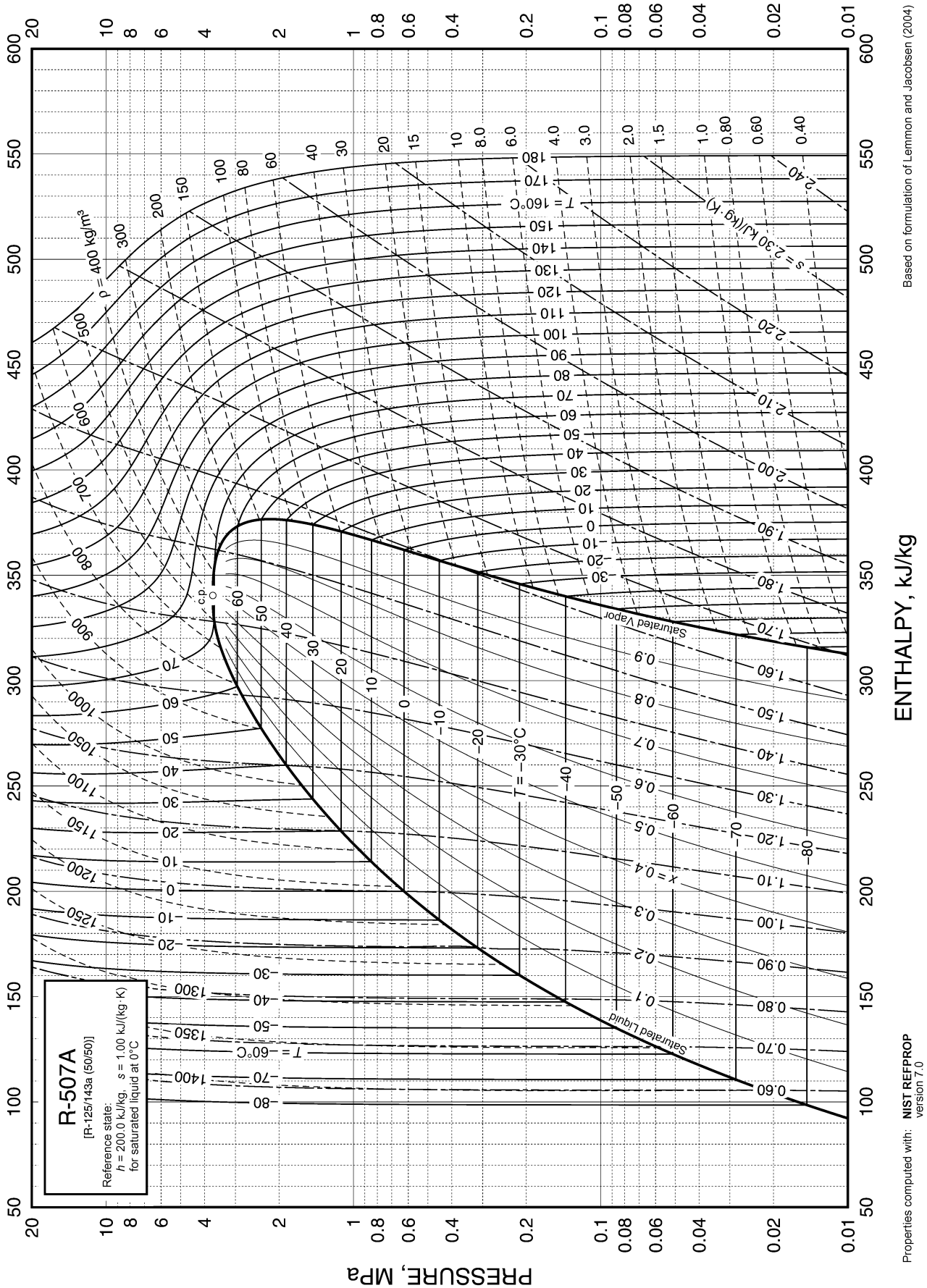

Fig. 15 Pressure-Enthalpy Diagram for Refrigerant 507A

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Refrigerant 507A [R-125/143[a] (50/50)] Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure,** MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–100	0.00295	1476.9	4.92920	74.41	303.90	0.4323	1.7579	1.219	0.618	1.164	1046	129.6	—	—	124.6	5.77	18.35	–100
–95	0.00458	1461.7	3.25360	80.48	306.85	0.4669	1.7377	1.210	0.631	1.162	1000	131.2	784.2	7.29	121.7	6.06	17.88	–95
–90	0.00693	1446.8	2.20850	86.51	309.83	0.5003	1.7197	1.205	0.644	1.161	960	132.6	701.5	7.49	118.8	6.36	17.41	–90
–85	0.01019	1431.9	1.53750	92.53	312.83	0.5327	1.7036	1.203	0.658	1.159	925	134.0	631.9	7.68	116.1	6.67	16.92	–85
–80	0.01464	1417.1	1.09510	98.54	315.85	0.5642	1.6893	1.203	0.672	1.159	892	135.4	572.7	7.88	113.4	6.99	16.43	–80
–75	0.02058	1402.3	0.79638	104.57	318.88	0.5950	1.6766	1.205	0.686	1.158	862	136.6	521.7	8.07	110.8	7.31	15.92	–75
–70	0.02836	1387.4	0.59012	110.60	321.92	0.6250	1.6652	1.208	0.701	1.158	833	137.8	477.4	8.27	108.2	7.63	15.40	–70
–65	0.03837	1372.5	0.44482	116.66	324.96	0.6545	1.6552	1.213	0.716	1.159	806	138.9	438.5	8.46	105.7	7.96	14.88	–65
–60	0.05105	1357.4	0.34056	122.74	328.00	0.6833	1.6463	1.220	0.732	1.160	779	139.8	404.3	8.65	103.2	8.30	14.34	–60
–55	0.06688	1342.3	0.26444	128.87	331.03	0.7116	1.6384	1.227	0.749	1.161	754	140.7	373.8	8.84	100.8	8.65	13.80	–55
–50	0.08638	1326.9	0.20801	135.03	334.05	0.7395	1.6314	1.235	0.766	1.164	729	141.4	346.5	9.02	98.4	9.00	13.24	–50
–48	0.09533	1320.7	0.18960	137.51	335.25	0.7505	1.6288	1.239	0.773	1.165	719	141.6	336.4	9.10	97.4	9.14	13.02	–48
–46.74[b]	0.10132	1316.8	0.17902	139.07	336.01	0.7574	1.6273	1.241	0.777	1.166	713	141.8	330.2	9.15	96.8	9.23	12.88	–46.74
–46	0.10499	1314.5	0.17313	139.99	336.45	0.7615	1.6264	1.243	0.780	1.166	709	141.9	326.7	9.17	96.5	9.28	12.80	–46
–44	0.11541	1308.2	0.15836	142.48	337.65	0.7724	1.6241	1.247	0.787	1.167	699	142.1	317.4	9.25	95.5	9.42	12.57	–44
–42	0.12662	1301.9	0.14510	144.99	338.84	0.7832	1.6219	1.251	0.795	1.169	690	142.3	308.4	9.32	94.6	9.57	12.34	–42
–40	0.13867	1295.6	0.13317	147.49	340.03	0.7940	1.6198	1.255	0.803	1.170	680	142.5	299.8	9.40	93.7	9.71	12.12	–40
–38	0.15159	1289.2	0.12240	150.01	341.21	0.8047	1.6178	1.259	0.810	1.172	670	142.6	291.4	9.47	92.7	9.86	11.89	–38
–36	0.16542	1282.8	0.11268	152.54	342.38	0.8153	1.6159	1.264	0.818	1.174	661	142.7	283.4	9.55	91.8	10.01	11.66	–36
–34	0.18022	1276.3	0.10388	155.08	343.55	0.8260	1.6141	1.269	0.826	1.176	651	142.8	275.7	9.62	90.9	10.16	11.42	–34
–32	0.19602	1269.7	0.09590	157.63	344.72	0.8365	1.6123	1.274	0.835	1.178	642	142.9	268.3	9.70	90.0	10.31	11.19	–32
–30	0.21287	1263.2	0.08865	160.18	345.88	0.8470	1.6107	1.279	0.843	1.180	632	142.9	261.1	9.77	89.1	10.46	10.96	–30
–28	0.23081	1256.5	0.08205	162.75	347.03	0.8575	1.6092	1.284	0.852	1.183	622	143.0	254.1	9.85	88.2	10.61	10.72	–28
–26	0.24989	1249.8	0.07604	165.33	348.17	0.8679	1.6077	1.289	0.861	1.186	613	143.0	247.4	9.93	87.3	10.77	10.49	–26
–24	0.27016	1243.1	0.07055	167.92	349.30	0.8783	1.6063	1.295	0.870	1.188	603	142.9	240.9	10.00	86.5	10.93	10.25	–24
–22	0.29167	1236.3	0.06553	170.52	350.43	0.8886	1.6049	1.301	0.879	1.191	594	142.9	234.5	10.08	85.6	11.08	10.02	–22
–20	0.31446	1229.4	0.06094	173.13	351.54	0.8989	1.6037	1.307	0.888	1.195	584	142.8	228.4	10.15	84.7	11.24	9.78	–20
–18	0.33858	1222.5	0.05673	175.76	352.65	0.9091	1.6024	1.313	0.898	1.198	575	142.7	222.5	10.23	83.8	11.40	9.54	–18
–16	0.36408	1215.4	0.05286	178.39	353.75	0.9193	1.6013	1.319	0.908	1.202	566	142.5	216.8	10.31	83.0	11.56	9.30	–16
–14	0.39102	1208.4	0.04931	181.04	354.83	0.9295	1.6001	1.326	0.918	1.206	556	142.3	211.2	10.39	82.1	11.73	9.06	–14
–12	0.41945	1201.2	0.04603	183.71	355.91	0.9397	1.5991	1.333	0.929	1.210	547	142.1	205.7	10.47	81.2	11.89	8.82	–12
–10	0.44941	1193.9	0.04301	186.39	356.97	0.9498	1.5980	1.340	0.940	1.214	537	141.9	200.5	10.55	80.4	12.06	8.58	–10
–8	0.48096	1186.6	0.04023	189.08	358.02	0.9599	1.5971	1.348	0.951	1.219	528	141.6	195.3	10.63	79.5	12.23	8.34	–8
–6	0.51416	1179.2	0.03765	191.78	359.06	0.9699	1.5961	1.355	0.962	1.224	518	141.3	190.3	10.71	78.7	12.41	8.10	–6
–4	0.54906	1171.7	0.03527	194.51	360.08	0.9800	1.5952	1.363	0.974	1.230	508	141.0	185.5	10.79	77.8	12.58	7.86	–4
–2	0.58571	1164.0	0.03306	197.25	361.08	0.9900	1.5943	1.372	0.987	1.236	499	140.6	180.7	10.88	77.0	12.76	7.62	–2
0	0.62417	1156.3	0.03101	200.00	362.07	1.0000	1.5934	1.381	0.999	1.242	489	140.2	176.1	10.97	76.2	12.96	7.37	0
2	0.66450	1148.5	0.02910	202.77	363.05	1.0100	1.5925	1.390	1.012	1.249	480	139.8	171.6	11.05	75.3	13.16	7.13	2
4	0.70676	1140.5	0.02733	205.56	364.00	1.0199	1.5917	1.399	1.026	1.256	470	139.3	167.2	11.14	74.5	13.36	6.89	4
6	0.75099	1132.4	0.02568	208.37	364.94	1.0299	1.5908	1.410	1.040	1.264	460	138.8	162.9	11.23	73.7	13.57	6.65	6
8	0.79728	1124.2	0.02415	211.20	365.85	1.0398	1.5900	1.420	1.055	1.272	451	138.2	158.7	11.33	72.8	13.79	6.41	8
10	0.84566	1115.9	0.02271	214.04	366.75	1.0498	1.5891	1.431	1.071	1.282	441	137.6	154.5	11.43	72.0	14.01	6.17	10
12	0.89622	1107.4	0.02138	216.91	367.61	1.0597	1.5883	1.443	1.088	1.291	431	137.0	150.5	11.52	71.2	14.24	5.93	12
14	0.94900	1098.7	0.02012	219.80	368.46	1.0696	1.5874	1.455	1.105	1.302	422	136.3	146.6	11.63	70.4	14.49	5.69	14
16	1.00410	1089.9	0.01895	222.71	369.28	1.0796	1.5865	1.468	1.124	1.314	412	135.6	142.7	11.73	69.6	14.75	5.45	16
18	1.06150	1080.9	0.01785	225.65	370.07	1.0895	1.5856	1.482	1.144	1.327	402	134.9	138.9	11.86	68.8	15.01	5.21	18
20	1.12140	1071.7	0.01683	228.61	370.83	1.0995	1.5846	1.497	1.165	1.341	392	134.1	135.1	11.97	67.9	15.29	4.97	20
22	1.18370	1062.4	0.01586	231.60	371.55	1.1094	1.5836	1.513	1.188	1.356	382	133.2	131.5	12.09	67.1	15.58	4.74	22
24	1.24860	1052.8	0.01495	234.61	372.25	1.1194	1.5826	1.530	1.212	1.372	372	132.3	127.9	12.22	66.3	15.89	4.50	24
26	1.31610	1043.0	0.01410	237.66	372.91	1.1294	1.5815	1.548	1.239	1.391	362	131.4	124.3	12.35	65.5	16.21	4.27	26
28	1.38640	1032.9	0.01329	240.73	373.52	1.1394	1.5804	1.568	1.268	1.411	352	130.4	120.8	12.48	64.7	16.54	4.04	28
30	1.45940	1022.6	0.01253	243.84	374.10	1.1495	1.5792	1.589	1.299	1.433	341	129.3	117.4	12.62	63.9	16.90	3.81	30
32	1.53520	1011.9	0.01182	246.98	374.63	1.1595	1.5779	1.612	1.333	1.458	331	128.2	114.0	12.77	63.1	17.28	3.58	32
34	1.61400	1001.0	0.01114	250.16	375.11	1.1697	1.5765	1.637	1.371	1.485	321	127.1	110.6	12.93	62.2	17.68	3.35	34
36	1.69580	989.7	0.01050	253.39	375.54	1.1799	1.5750	1.664	1.413	1.516	310	125.9	107.3	13.10	61.4	18.12	3.12	36
38	1.78070	978.1	0.00989	256.65	375.91	1.1901	1.5734	1.695	1.459	1.551	300	124.6	104.0	13.28	60.6	18.58	2.90	38
40	1.86880	966.0	0.00932	259.96	376.22	1.2004	1.5717	1.729	1.511	1.591	289	123.2	100.7	13.47	59.8	19.09	2.68	40
42	1.96020	953.5	0.00877	263.33	376.46	1.2108	1.5698	1.767	1.570	1.636	278	121.8	97.5	13.68	59.0	19.63	2.47	42
44	2.05490	940.5	0.00825	266.74	376.61	1.2213	1.5678	1.811	1.638	1.689	267	120.4	94.3	13.90	58.1	20.23	2.25	44
46	2.15310	926.9	0.00776	270.23	376.68	1.2320	1.5655	1.860	1.716	1.750	256	118.8	91.0	14.14	57.3	20.89	2.04	46
48	2.25480	912.7	0.00728	273.78	376.66	1.2427	1.5631	1.918	1.807	1.823	245	117.2	87.8	14.41	56.5	21.62	1.83	48
50	2.36030	897.7	0.00683	277.41	376.52	1.2536	1.5603	1.985	1.915	1.910	233	115.5	84.6	14.70	55.7	22.43	1.63	50
55	2.64090	856.2	0.00578	286.91	375.54	1.2818	1.5519	2.225	2.304	2.228	203	110.8	76.4	15.59	53.6	24.98	1.15	55
60	2.94760	806.1	0.00480	297.28	373.26	1.3120	1.5401	2.677	3.060	2.855	171	105.5	67.7	16.86	51.7	28.77	0.70	60
65	3.28380	739.1	0.00384	309.30	368.44	1.3465	1.5215	3.940	5.190	4.625	135	99.3	57.9	18.93	50.7	35.54	0.31	65
70	3.65570	599.6	0.00260	328.32	353.47	1.4007	1.4740	31.960	44.630	36.780	92	90.7	42.0	25.07	63.2	67.27	0.02	70
70.62[c]	3.70500	490.8	0.00204	340.45	340.45	1.4358	1.4358	∞	∞	∞	0	0.0	—	—	—	—	0.00	70.62

*Temperatures on ITS-90 scale **Small deviations from azeotropic behavior occur at some conditions; tabulated pressures are average of bubble and dew-point pressures [b]Normal boiling point [c]Critical point

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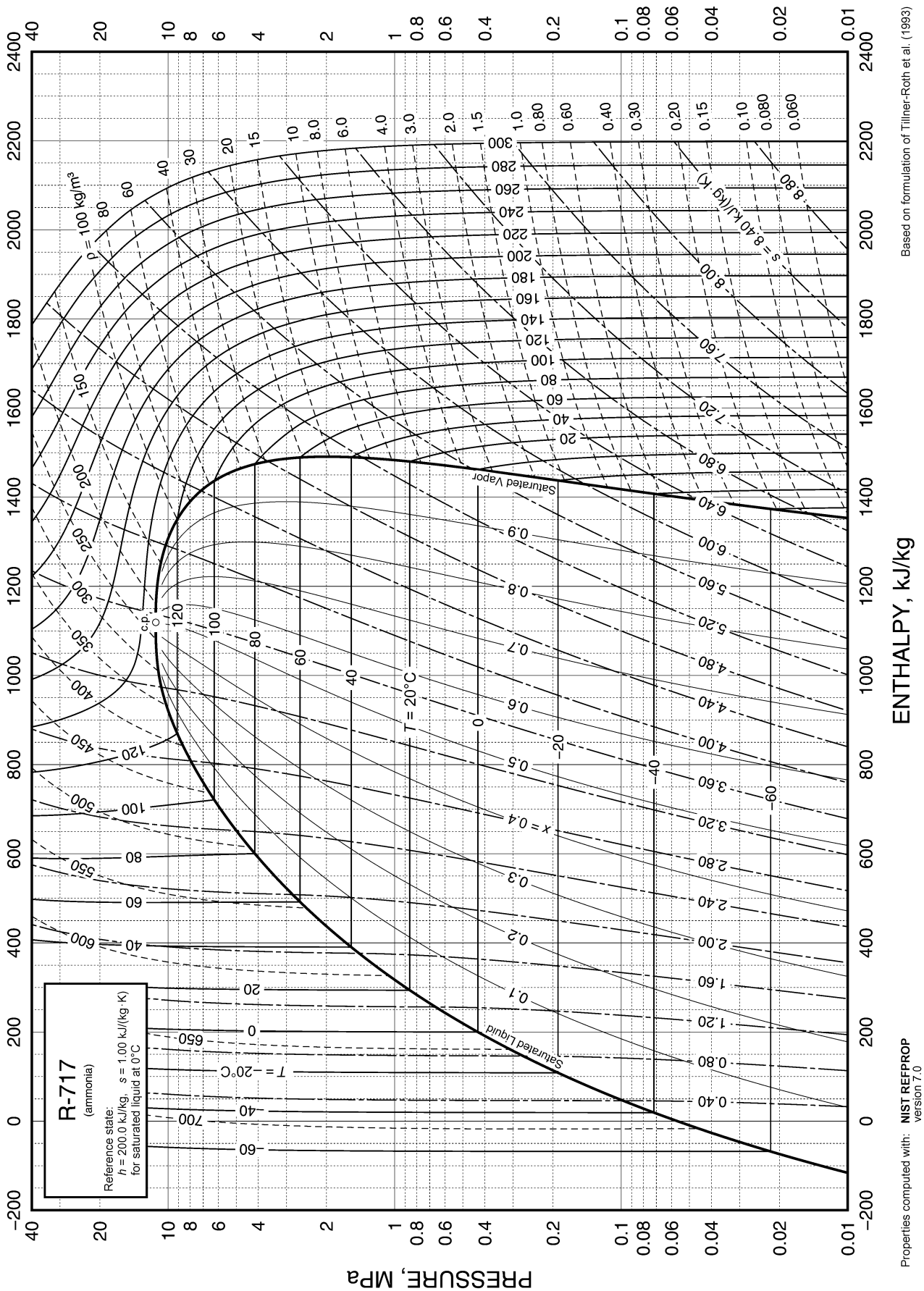

Fig. 16 Pressure-Enthalpy Diagram for Refrigerant 717 (Ammonia)

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Refrigerant 717 (Ammonia) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–77.65[a]	0.00609	732.9	15.602	–143.15	1341.23	–0.4716	7.1213	4.202	2.063	1.325	2124	354.1	559.6	6.84	819.0	19.64	62.26	–77.65
–70	0.01094	724.7	9.0079	–110.81	1355.55	–0.3094	6.9088	4.245	2.086	1.327	2051	360.5	475.0	7.03	792.1	19.73	59.10	–70
–60	0.02189	713.6	4.7057	–68.06	1373.73	–0.1040	6.6602	4.303	2.125	1.330	1967	368.4	391.3	7.30	757.0	19.93	55.05	–60
–50	0.04084	702.1	2.6277	–24.73	1391.19	0.0945	6.4396	4.360	2.178	1.335	1890	375.6	328.9	7.57	722.3	20.24	51.11	–50
–40	0.07169	690.2	1.5533	19.17	1407.76	0.2867	6.2425	4.414	2.244	1.342	1816	382.2	281.2	7.86	688.1	20.64	47.26	–40
–38	0.07971	687.7	1.4068	28.01	1410.96	0.3245	6.2056	4.424	2.259	1.343	1802	383.4	273.1	7.92	681.4	20.73	46.51	–38
–36	0.08845	685.3	1.2765	36.88	1414.11	0.3619	6.1694	4.434	2.275	1.345	1787	384.6	265.3	7.98	674.6	20.83	45.75	–36
–34	0.09795	682.8	1.1604	45.77	1417.23	0.3992	6.1339	4.444	2.291	1.347	1773	385.8	257.9	8.03	667.9	20.93	45.00	–34
–33.33[b]	0.10133	682.0	1.1242	48.76	1418.26	0.4117	6.1221	4.448	2.297	1.348	1768	386.2	255.5	8.05	665.7	20.97	44.75	–33.33
–32	0.10826	680.3	1.0567	54.67	1420.29	0.4362	6.0992	4.455	2.308	1.349	1759	387.0	250.8	8.09	661.3	21.04	44.26	–32
–30	0.11943	677.8	0.96396	63.60	1423.31	0.4730	6.0651	4.465	2.326	1.351	1744	388.1	244.1	8.15	654.6	21.15	43.52	–30
–28	0.13151	675.3	0.88082	72.55	1426.28	0.5096	6.0317	4.474	2.344	1.353	1730	389.2	237.6	8.21	648.0	21.26	42.78	–28
–26	0.14457	672.8	0.80614	81.52	1429.21	0.5460	5.9989	4.484	2.363	1.355	1716	390.2	231.4	8.27	641.5	21.38	42.05	–26
–24	0.15864	670.3	0.73896	90.51	1432.08	0.5821	5.9667	4.494	2.383	1.358	1702	391.2	225.5	8.33	634.9	21.51	41.32	–24
–22	0.17379	667.7	0.67840	99.52	1434.91	0.6180	5.9351	4.504	2.403	1.360	1687	392.2	219.8	8.39	628.4	21.63	40.60	–22
–20	0.19008	665.1	0.62373	108.55	1437.68	0.6538	5.9041	4.514	2.425	1.363	1673	393.2	214.4	8.45	622.0	21.77	39.88	–20
–18	0.20756	662.6	0.57428	117.60	1440.39	0.6893	5.8736	4.524	2.446	1.365	1659	394.1	209.2	8.51	615.5	21.90	39.16	–18
–16	0.22630	660.0	0.52949	126.67	1443.06	0.7246	5.8437	4.534	2.469	1.368	1645	395.0	204.2	8.57	609.1	22.05	38.45	–16
–14	0.24637	657.3	0.48885	135.76	1445.66	0.7597	5.8143	4.543	2.493	1.371	1631	395.8	199.3	8.63	602.8	22.19	37.74	–14
–12	0.26782	654.7	0.45192	144.88	1448.21	0.7946	5.7853	4.553	2.517	1.375	1616	396.7	194.7	8.69	596.4	22.35	37.04	–12
–10	0.29071	652.1	0.41830	154.01	1450.70	0.8293	5.7569	4.564	2.542	1.378	1602	397.5	190.2	8.75	590.1	22.50	36.34	–10
–8	0.31513	649.4	0.38767	163.16	1453.14	0.8638	5.7289	4.574	2.568	1.382	1588	398.2	185.9	8.81	583.9	22.67	35.65	–8
–6	0.34114	646.7	0.35970	172.34	1455.51	0.8981	5.7013	4.584	2.594	1.385	1574	398.9	181.7	8.87	577.7	22.83	34.96	–6
–4	0.36880	644.0	0.33414	181.54	1457.81	0.9323	5.6741	4.595	2.622	1.389	1559	399.6	177.7	8.93	571.5	23.00	34.27	–4
–2	0.39819	641.3	0.31074	190.76	1460.06	0.9662	5.6474	4.606	2.651	1.393	1545	400.2	173.8	8.99	565.3	23.18	33.59	–2
0	0.42938	638.6	0.28930	200.00	1462.24	1.0000	5.6210	4.617	2.680	1.398	1531	400.8	170.1	9.06	559.2	23.37	32.91	0
2	0.46246	635.8	0.26962	209.27	1464.35	1.0336	5.5951	4.628	2.710	1.402	1516	401.4	166.5	9.12	553.1	23.55	32.24	2
4	0.49748	633.1	0.25153	218.55	1466.40	1.0670	5.5695	4.639	2.742	1.407	1502	401.9	162.9	9.18	547.1	23.75	31.57	4
6	0.53453	630.3	0.23489	227.87	1468.37	1.1003	5.5442	4.651	2.774	1.412	1487	402.4	159.5	9.24	541.1	23.95	30.91	6
8	0.57370	627.5	0.21956	237.20	1470.28	1.1334	5.5192	4.663	2.807	1.417	1473	402.8	156.2	9.30	535.1	24.15	30.24	8
10	0.61505	624.6	0.20543	246.57	1472.11	1.1664	5.4946	4.676	2.841	1.422	1458	403.2	153.0	9.36	529.1	24.37	29.59	10
12	0.65866	621.8	0.19237	255.95	1473.88	1.1992	5.4703	4.689	2.877	1.428	1443	403.6	149.9	9.43	523.2	24.58	28.94	12
14	0.70463	618.9	0.18031	265.37	1475.56	1.2318	5.4463	4.702	2.913	1.434	1429	403.9	146.9	9.49	517.3	24.81	28.29	14
16	0.75303	616.0	0.16914	274.81	1477.17	1.2643	5.4226	4.716	2.951	1.440	1414	404.2	144.0	9.55	511.5	25.04	27.65	16
18	0.80395	613.1	0.15879	284.28	1478.70	1.2967	5.3991	4.730	2.990	1.446	1399	404.4	141.1	9.61	505.6	25.27	27.01	18
20	0.85748	610.2	0.14920	293.78	1480.16	1.3289	5.3759	4.745	3.030	1.453	1384	404.6	138.3	9.68	499.9	25.52	26.38	20
22	0.91369	607.2	0.14029	303.31	1481.53	1.3610	5.3529	4.760	3.071	1.460	1370	404.8	135.6	9.74	494.1	25.77	25.75	22
24	0.97268	604.3	0.13201	312.87	1482.82	1.3929	5.3301	4.776	3.113	1.468	1355	404.9	133.0	9.80	488.4	26.03	25.12	24
26	1.03450	601.3	0.12431	322.47	1484.02	1.4248	5.3076	4.793	3.158	1.475	1340	404.9	130.4	9.87	482.7	26.29	24.50	26
28	1.09930	598.2	0.11714	332.09	1485.14	1.4565	5.2853	4.810	3.203	1.484	1324	405.0	127.9	9.93	477.0	26.57	23.89	28
30	1.16720	595.2	0.11046	341.76	1486.17	1.4881	5.2631	4.828	3.250	1.492	1309	404.9	125.5	10.00	471.4	26.85	23.28	30
32	1.23820	592.1	0.10422	351.45	1487.11	1.5196	5.2412	4.847	3.299	1.501	1294	404.8	123.1	10.06	465.7	27.14	22.67	32
34	1.31240	589.0	0.09840	361.19	1487.95	1.5509	5.2194	4.867	3.349	1.510	1279	404.7	120.7	10.13	460.1	27.43	22.07	34
36	1.39000	585.8	0.09296	370.96	1488.70	1.5822	5.1978	4.888	3.401	1.520	1263	404.5	118.4	10.19	454.6	27.74	21.47	36
38	1.47090	582.6	0.08787	380.78	1489.36	1.6134	5.1763	4.909	3.455	1.530	1248	404.3	116.2	10.26	449.1	28.05	20.88	38
40	1.55540	579.4	0.08310	390.64	1489.91	1.6446	5.1549	4.932	3.510	1.541	1232	404.0	114.0	10.33	443.5	28.38	20.29	40
42	1.64350	576.2	0.07863	400.54	1490.36	1.6756	5.1337	4.956	3.568	1.553	1216	403.7	111.9	10.39	438.0	28.71	19.71	42
44	1.73530	572.9	0.07445	410.48	1490.70	1.7065	5.1126	4.981	3.628	1.565	1201	403.3	109.8	10.46	432.6	29.06	19.13	44
46	1.83100	569.6	0.07052	420.48	1490.94	1.7374	5.0915	5.007	3.691	1.577	1185	402.9	107.8	10.53	427.1	29.41	18.56	46
48	1.93050	566.3	0.06682	430.52	1491.06	1.7683	5.0706	5.034	3.756	1.591	1169	402.4	105.8	10.60	421.7	29.78	17.99	48
50	2.03400	562.9	0.06335	440.62	1491.07	1.7990	5.0497	5.064	3.823	1.605	1153	401.9	103.8	10.67	416.3	30.16	17.43	50
55	2.31110	554.2	0.05554	466.10	1490.57	1.8758	4.9977	5.143	4.005	1.643	1112	400.3	99.0	10.86	402.9	31.16	16.04	55
60	2.61560	545.2	0.04880	491.97	1489.27	1.9523	4.9458	5.235	4.208	1.687	1070	398.3	94.5	11.05	389.6	32.26	14.69	60
65	2.94910	536.0	0.04296	518.26	1487.09	2.0288	4.8939	5.341	4.438	1.739	1028	396.0	90.1	11.25	376.4	33.47	13.37	65
70	3.31350	526.3	0.03787	545.04	1483.94	2.1054	4.8415	5.465	4.699	1.799	984	393.3	85.9	11.47	363.2	34.80	12.08	70
75	3.71050	516.2	0.03342	572.37	1479.72	2.1823	4.7885	5.610	5.001	1.870	940	390.1	81.9	11.70	350.2	36.30	10.83	75
80	4.14200	505.7	0.02951	600.34	1474.31	2.2596	4.7344	5.784	5.355	1.955	895	386.5	78.0	11.95	337.1	38.00	9.61	80
85	4.61000	494.5	0.02606	629.04	1467.53	2.3377	4.6789	5.993	5.777	2.058	848	382.5	74.2	12.23	324.1	39.95	8.44	85
90	5.11670	482.8	0.02300	658.61	1459.19	2.4168	4.6213	6.250	6.291	2.187	800	377.9	70.5	12.55	311.0	42.24	7.30	90
95	5.66430	470.2	0.02027	689.19	1449.01	2.4973	4.5612	6.573	6.933	2.349	751	372.7	66.8	12.91	297.9	44.99	6.20	95
100	6.25530	456.6	0.01782	721.00	1436.63	2.5797	4.4975	6.991	7.762	2.562	701	367.0	63.2	13.32	284.8	48.36	5.15	100
105	6.89230	441.9	0.01561	754.35	1421.57	2.6647	4.4291	7.555	8.877	2.851	649	360.5	59.6	13.82	271.5	52.65	4.15	105
110	7.57830	425.6	0.01360	789.68	1403.08	2.7533	4.3542	8.360	10.46	3.26	594	353.3	56.0	14.42	258.1	58.33	3.20	110
115	8.31700	407.2	0.01174	827.74	1379.99	2.8474	4.2702	9.630	12.91	3.91	538	345.0	52.3	15.19	244.6	66.28	2.31	115
120	9.11250	385.5	0.00999	869.92	1350.23	2.9502	4.1719	11.940	17.21	5.04	477	335.4	48.3	16.21	231.2	78.40	1.50	120
125	9.97002	357.8	0.00828	919.68	1309.12	3.0702	4.0483	17.660	27.00	7.62	411	323.6	43.8	17.73	219.1	100.01	0.77	125
130	10.89770	312.3	0.00638	992.02	1239.32	3.2437	3.8571	54.210	76.49	20.66	334	306.6	37.3	20.63	221.9	160.39	0.18	130
132.25[c]	11.33300	225.0	0.00444	1119.22	1119.22	3.5542	3.5542	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	132.25

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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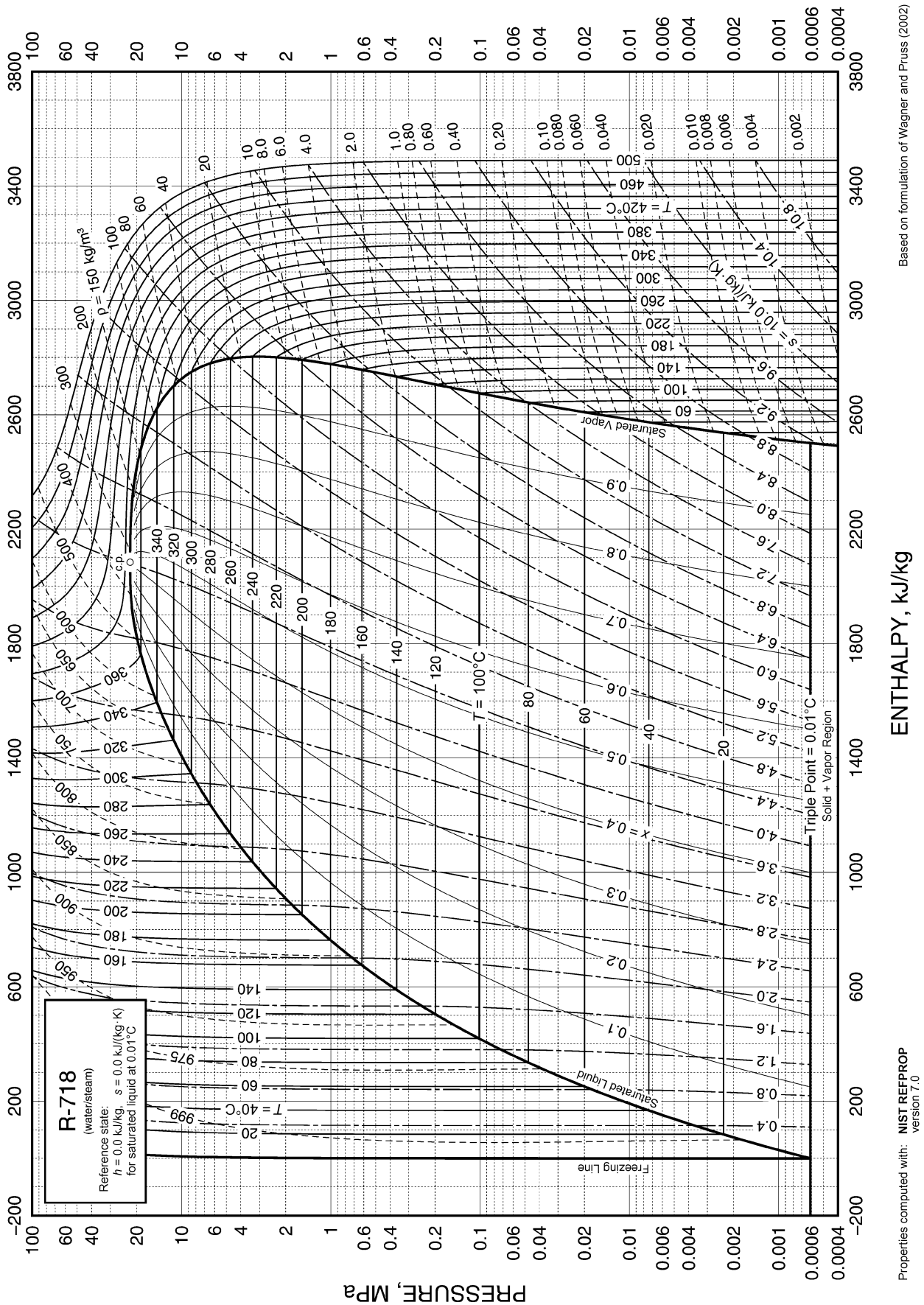

Fig. 17 Pressure-Enthalpy Diagram for Refrigerant 718 (Water/Steam)

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Refrigerant 718 (Water/Steam) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
0.01[a]	0.00061	999.8	205.990	0.00	2500.92	0.0000	9.1555	4.220	1.884	1.329	1402	409.0	1791.2	9.22	561.0	17.07	75.65	0.01
5	0.00087	999.9	147.010	21.02	2510.06	0.0763	9.0248	4.205	1.889	1.328	1426	412.6	1518.3	9.34	570.5	17.34	74.94	5
10	0.00123	999.7	106.300	42.02	2519.21	0.1511	8.8998	4.196	1.895	1.328	1447	416.2	1306.0	9.46	580.0	17.62	74.22	10
15	0.00171	999.1	77.8750	62.98	2528.33	0.2245	8.7803	4.189	1.900	1.328	1466	419.7	1137.6	9.59	589.3	17.92	73.49	15
20	0.00234	998.2	57.7570	83.91	2537.43	0.2965	8.6660	4.184	1.906	1.327	1482	423.2	1001.6	9.73	598.4	18.23	72.74	20
25	0.00317	997.0	43.3370	104.83	2546.51	0.3672	8.5566	4.182	1.912	1.327	1497	426.6	890.1	9.87	607.2	18.55	71.97	25
30	0.00425	995.6	32.8780	125.73	2555.55	0.4368	8.4520	4.180	1.918	1.327	1509	430.0	797.4	10.01	615.5	18.89	71.19	30
35	0.00563	994.0	25.2050	146.63	2564.55	0.5051	8.3517	4.180	1.925	1.327	1520	433.4	719.3	10.16	623.3	19.24	70.40	35
40	0.00738	992.2	19.5150	167.53	2573.51	0.5724	8.2555	4.180	1.931	1.327	1529	436.7	653.0	10.31	630.6	19.60	69.60	40
45	0.00959	990.2	15.2520	188.43	2582.43	0.6386	8.1633	4.180	1.939	1.327	1536	440.0	596.1	10.46	637.3	19.97	68.78	45
50	0.01235	988.0	12.0270	209.34	2591.29	0.7038	8.0748	4.182	1.947	1.328	1542	443.2	546.8	10.62	643.6	20.36	67.94	50
55	0.01576	985.7	9.5643	230.26	2600.09	0.7680	7.9898	4.183	1.955	1.328	1547	446.4	504.0	10.77	649.2	20.77	67.10	55
60	0.01995	983.2	7.6672	251.18	2608.83	0.8313	7.9081	4.185	1.965	1.328	1551	449.5	466.4	10.93	654.3	21.19	66.24	60
65	0.02504	980.5	6.1935	272.12	2617.50	0.8937	7.8296	4.187	1.975	1.329	1553	452.6	433.2	11.10	659.0	21.62	65.37	65
70	0.03120	977.7	5.0395	293.07	2626.10	0.9551	7.7540	4.190	1.986	1.330	1555	455.6	403.9	11.26	663.1	22.07	64.48	70
75	0.03860	974.8	4.1289	314.03	2634.60	1.0158	7.6812	4.193	1.999	1.331	1555	458.5	377.7	11.43	666.8	22.53	63.58	75
80	0.04741	971.8	3.4052	335.01	2643.02	1.0756	7.6111	4.197	2.012	1.332	1554	461.4	354.3	11.59	670.0	23.01	62.67	80
85	0.05787	968.6	2.8258	356.01	2651.33	1.1346	7.5434	4.201	2.027	1.333	1553	464.2	333.3	11.76	672.8	23.51	61.75	85
90	0.07018	965.3	2.3591	377.04	2659.53	1.1929	7.4781	4.205	2.043	1.334	1550	466.9	314.4	11.93	675.3	24.02	60.82	90
95	0.08461	961.9	1.9806	398.09	2667.61	1.2504	7.4151	4.210	2.061	1.335	1547	469.6	297.3	12.10	677.3	24.55	59.87	95
99.97[b]	0.10133	958.4	1.6732	419.06	2675.53	1.3069	7.3544	4.216	2.080	1.337	1543	472.2	281.8	12.27	679.1	25.09	58.92	99.97
100	0.10142	958.3	1.6718	419.17	2675.57	1.3072	7.3541	4.216	2.080	1.337	1543	472.2	281.7	12.27	679.1	25.10	58.91	100
105	0.12090	954.7	1.4184	440.27	2683.39	1.3633	7.2952	4.222	2.101	1.339	1538	474.7	267.6	12.44	680.5	25.66	57.94	105
110	0.14338	950.9	1.2093	461.42	2691.06	1.4188	7.2381	4.228	2.124	1.341	1533	477.1	254.7	12.61	681.7	26.24	56.96	110
115	0.16918	947.1	1.0358	482.59	2698.58	1.4737	7.1828	4.236	2.150	1.343	1527	479.5	242.9	12.78	682.6	26.85	55.97	115
120	0.19867	943.1	0.89121	503.81	2705.93	1.5279	7.1291	4.244	2.177	1.346	1520	481.7	232.1	12.96	683.2	27.47	54.97	120
125	0.23224	939.0	0.77003	525.07	2713.10	1.5816	7.0770	4.252	2.207	1.349	1512	483.9	222.1	13.13	683.6	28.11	53.96	125
130	0.27028	934.8	0.66800	546.38	2720.08	1.6346	7.0264	4.261	2.239	1.352	1504	486.0	212.9	13.30	683.7	28.76	52.93	130
135	0.31323	930.5	0.58173	567.74	2726.87	1.6872	6.9772	4.272	2.274	1.355	1496	487.9	204.4	13.47	683.6	29.44	51.90	135
140	0.36154	926.1	0.50845	589.16	2733.44	1.7392	6.9293	4.283	2.311	1.359	1486	489.8	196.5	13.65	683.3	30.14	50.86	140
145	0.41568	921.6	0.44596	610.64	2739.80	1.7907	6.8826	4.294	2.351	1.363	1476	491.6	189.2	13.82	682.8	30.86	49.80	145
150	0.47616	917.0	0.39245	632.18	2745.93	1.8418	6.8371	4.307	2.394	1.368	1466	493.3	182.5	13.99	682.0	31.60	48.74	150
155	0.54350	912.3	0.34646	653.79	2751.81	1.8924	6.7926	4.321	2.440	1.373	1455	494.8	176.1	14.16	681.1	32.35	47.67	155
160	0.61823	907.4	0.30678	675.47	2757.44	1.9426	6.7491	4.335	2.488	1.379	1443	496.3	170.2	14.34	680.0	33.13	46.59	160
165	0.70093	902.5	0.27243	697.24	2762.81	1.9923	6.7066	4.351	2.540	1.385	1431	497.6	164.7	14.51	678.6	33.93	45.50	165
170	0.79219	897.5	0.24259	719.08	2767.90	2.0417	6.6650	4.368	2.594	1.392	1419	498.9	159.6	14.68	677.0	34.75	44.41	170
175	0.89260	892.3	0.21658	741.02	2772.71	2.0906	6.6241	4.386	2.652	1.399	1405	500.0	154.7	14.85	675.3	35.59	43.30	175
180	1.00280	887.0	0.19384	763.05	2777.21	2.1392	6.5840	4.405	2.713	1.407	1392	501.0	150.1	15.03	673.3	36.45	42.19	180
185	1.12350	881.6	0.17390	785.19	2781.41	2.1875	6.5447	4.425	2.777	1.416	1378	501.9	145.8	15.20	671.1	37.33	41.07	185
190	1.25520	876.1	0.15636	807.43	2785.28	2.2355	6.5059	4.447	2.844	1.425	1363	502.7	141.8	15.37	668.8	38.24	39.95	190
195	1.39880	870.4	0.14089	829.79	2788.82	2.2832	6.4678	4.471	2.915	1.436	1348	503.4	137.9	15.54	666.1	39.16	38.81	195
200	1.55490	864.7	0.12721	852.27	2792.01	2.3305	6.4302	4.496	2.990	1.447	1332	503.9	134.3	15.71	663.3	40.11	37.67	200
205	1.72430	858.8	0.11508	874.88	2794.83	2.3777	6.3930	4.523	3.068	1.459	1316	504.3	130.9	15.89	660.3	41.09	36.53	205
210	1.90770	852.7	0.10429	897.63	2797.27	2.4245	6.3563	4.551	3.150	1.472	1299	504.6	127.6	16.06	657.0	42.09	35.38	210
215	2.10580	846.5	0.09468	920.53	2799.32	2.4712	6.3200	4.582	3.237	1.486	1282	504.8	124.5	16.24	653.4	43.11	34.23	215
220	2.31960	840.2	0.08609	943.58	2800.95	2.5177	6.2840	4.615	3.329	1.501	1264	504.8	121.5	16.41	649.7	44.17	33.07	220
225	2.54970	833.7	0.07840	966.80	2802.15	2.5640	6.2483	4.650	3.426	1.518	1246	504.6	118.7	16.59	645.6	45.26	31.90	225
230	2.79710	827.1	0.07150	990.19	2802.90	2.6101	6.2128	4.688	3.528	1.536	1228	504.4	116.0	16.76	641.3	46.38	30.74	230
235	3.06250	820.3	0.06530	1013.77	2803.17	2.6561	6.1775	4.728	3.638	1.556	1209	503.9	113.4	16.94	636.7	47.53	29.57	235
240	3.34690	813.4	0.05970	1037.55	2802.96	2.7020	6.1423	4.772	3.754	1.578	1189	503.3	110.9	17.12	631.8	48.73	28.39	240
245	3.65120	806.2	0.05465	1061.55	2802.22	2.7478	6.1072	4.819	3.878	1.601	1169	502.6	108.4	17.31	626.7	49.97	27.22	245
250	3.97620	798.9	0.05008	1085.77	2800.93	2.7935	6.0721	4.870	4.011	1.627	1148	501.6	106.1	17.49	621.2	51.26	26.04	250
255	4.32290	791.4	0.04594	1110.23	2799.07	2.8392	6.0369	4.925	4.153	1.655	1127	500.5	103.9	17.68	615.4	52.61	24.87	255
260	4.69230	783.6	0.04217	1134.96	2796.60	2.8849	6.0016	4.986	4.308	1.686	1105	499.2	101.7	17.88	609.2	54.03	23.69	260
265	5.08530	775.7	0.03875	1159.96	2793.49	2.9307	5.9661	5.051	4.475	1.720	1083	497.7	99.6	18.07	602.8	55.53	22.51	265
270	5.50300	767.5	0.03562	1185.27	2789.69	2.9765	5.9304	5.123	4.656	1.757	1060	496.0	97.5	18.28	595.9	57.11	21.34	270
275	5.94640	759.0	0.03277	1210.90	2785.17	3.0224	5.8944	5.202	4.855	1.798	1037	494.1	95.5	18.48	588.7	58.80	20.16	275
280	6.41660	750.3	0.03015	1236.88	2779.87	3.0685	5.8579	5.289	5.073	1.845	1013	491.9	93.5	18.70	581.1	60.61	18.99	280
285	6.91470	741.3	0.02776	1263.25	2773.73	3.1147	5.8209	5.385	5.314	1.896	988	489.5	91.6	18.92	573.2	62.57	17.83	285
290	7.44180	731.9	0.02555	1290.03	2766.70	3.1612	5.7834	5.493	5.582	1.954	962	486.9	89.7	19.15	565.0	64.71	16.66	290
295	7.99910	722.2	0.02353	1317.27	2758.70	3.2080	5.7451	5.614	5.882	2.019	936	483.9	87.8	19.40	556.3	67.05	15.51	295
300	8.58790	712.1	0.02166	1345.01	2749.64	3.2552	5.7059	5.750	6.220	2.094	909	480.7	85.9	19.65	547.4	69.65	14.36	300
310	9.86510	690.7	0.01833	1402.22	2727.95	3.3510	5.6244	6.085	7.045	2.277	853	473.3	82.2	20.21	528.7	75.84	12.09	310
320	11.28430	667.1	0.01547	1462.22	2700.59	3.4494	5.5372	6.537	8.159	2.528	793	464.4	78.4	20.85	509.2	83.91	9.86	320
330	12.85810	640.8	0.01298	1525.87	2666.03	3.5518	5.4422	7.186	9.753	2.889	729	453.7	74.5	21.61	489.1	94.94	7.70	330
340	14.60070	610.7	0.01078	1594.53	2621.85	3.6601	5.3356	8.210	12.24	3.45	658	440.7	70.4	22.55	468.5	110.91	5.63	340
350	16.52940	574.7	0.00880	1670.89	2563.64	3.7784	5.2110	10.120	16.69	4.46	578	424.4	65.9	23.82	447.4	135.95	3.67	350
360	18.66600	527.6	0.00695	1761.66	2481.49	3.9167	5.0536	15.000	27.36	6.83	480	402.4	60.3	25.72	425.7	181.51	1.88	360
370	21.04360	451.4	0.00495	1890.69	2334.52	4.1112	4.8012	45.160	96.60	21.15	360	362.8	52.1	29.68	425.0	323.84	0.39	370
373.95[c]	22.06400	322.0	0.00311	2084.26	2084.26	4.4070	4.4070	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	373.95

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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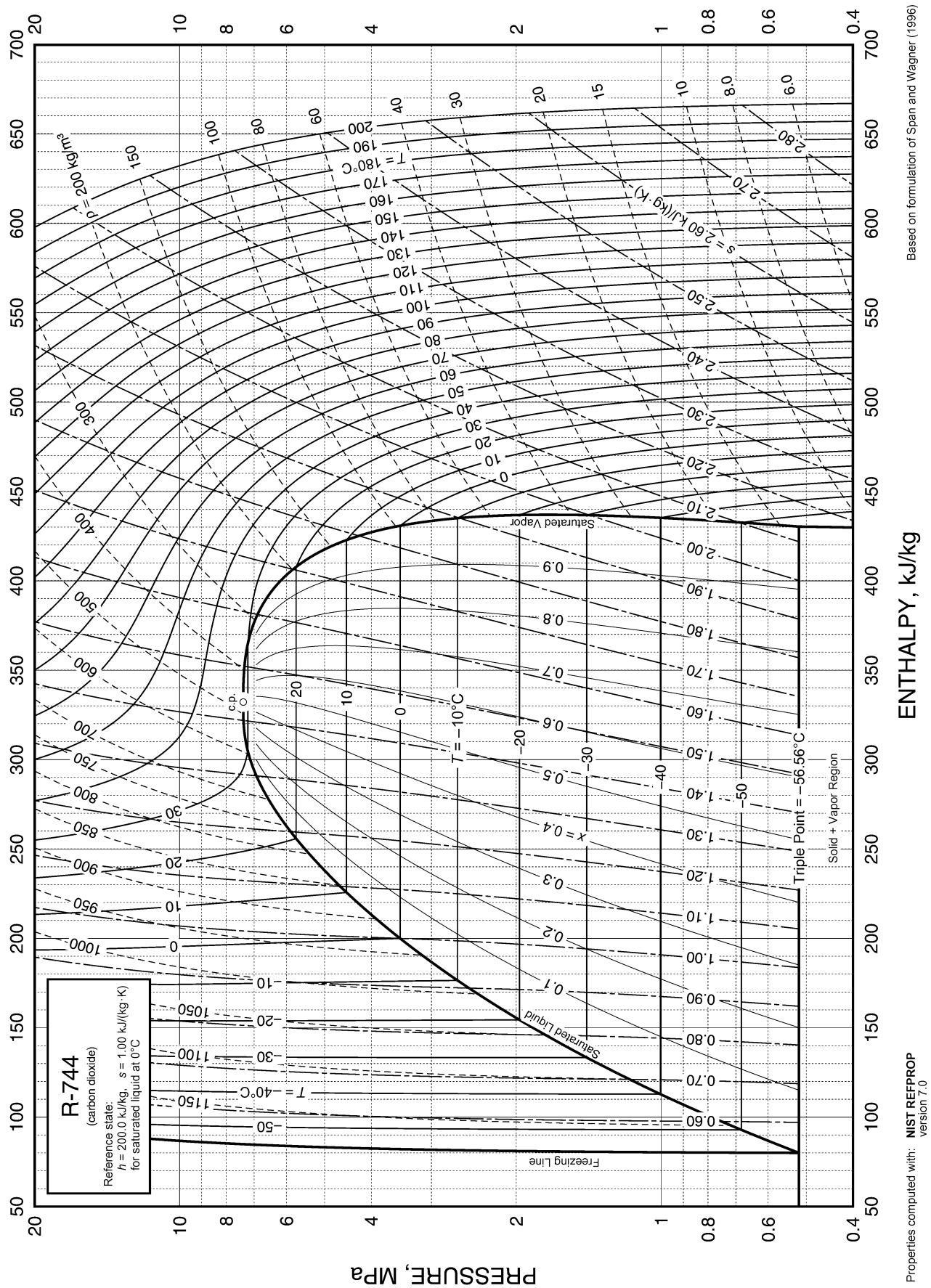

Fig. 18 Pressure-Enthalpy Diagram for Refrigerant 744 (Carbon Dioxide)

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Refrigerant 744 (Carbon Dioxide) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–56.56[a]	0.51796	1178.5	0.07267	80.04	430.42	0.5213	2.1390	1.953	0.909	1.444	976	222.8	256.7	10.95	180.6	11.01	17.16	–56.56
–50	0.68234	1154.6	0.05579	92.94	432.68	0.5794	2.1018	1.971	0.952	1.468	928	223.4	229.3	11.31	172.1	11.58	15.53	–50
–48	0.73949	1147.1	0.05162	96.90	433.29	0.5968	2.0909	1.978	0.967	1.477	914	223.5	221.6	11.42	169.5	11.76	15.04	–48
–46	0.80015	1139.6	0.04782	100.88	433.86	0.6142	2.0801	1.985	0.982	1.486	900	223.6	214.3	11.53	166.9	11.95	14.56	–46
–44	0.86445	1132.0	0.04435	104.87	434.39	0.6314	2.0694	1.993	0.998	1.496	885	223.6	207.2	11.64	164.4	12.14	14.07	–44
–42	0.93252	1124.2	0.04118	108.88	434.88	0.6486	2.0589	2.002	1.015	1.507	871	223.6	200.3	11.75	161.8	12.34	13.60	–42
–40	1.00450	1116.4	0.03828	112.90	435.32	0.6656	2.0485	2.012	1.033	1.518	856	223.5	193.8	11.87	159.3	12.54	13.12	–40
–38	1.08050	1108.5	0.03562	116.95	435.72	0.6826	2.0382	2.022	1.052	1.530	842	223.4	187.4	11.98	156.8	12.75	12.65	–38
–36	1.16070	1100.5	0.03318	121.01	436.07	0.6995	2.0281	2.033	1.072	1.544	827	223.2	181.3	12.10	154.3	12.97	12.18	–36
–34	1.24520	1092.4	0.03093	125.10	436.37	0.7163	2.0180	2.045	1.094	1.558	813	223.1	175.4	12.22	151.8	13.20	11.72	–34
–32	1.33420	1084.1	0.02886	129.20	436.62	0.7331	2.0079	2.059	1.116	1.573	798	222.8	169.7	12.34	149.3	13.43	11.26	–32
–30	1.42780	1075.7	0.02696	133.34	436.82	0.7498	1.9980	2.073	1.141	1.590	783	222.5	164.2	12.46	146.9	13.68	10.80	–30
–28	1.52610	1067.2	0.02519	137.50	436.96	0.7665	1.9880	2.089	1.166	1.608	768	222.2	158.9	12.59	144.4	13.94	10.35	–28
–26	1.62930	1058.6	0.02356	141.69	437.04	0.7831	1.9781	2.105	1.194	1.627	753	221.8	153.8	12.72	141.9	14.20	9.90	–26
–24	1.73750	1049.8	0.02205	145.91	437.06	0.7997	1.9683	2.124	1.223	1.648	738	221.4	148.8	12.85	139.5	14.49	9.46	–24
–22	1.85090	1040.8	0.02065	150.16	437.01	0.8163	1.9584	2.144	1.255	1.671	723	220.9	144.0	12.98	137.1	14.78	9.02	–22
–20	1.96960	1031.7	0.01934	154.45	436.89	0.8328	1.9485	2.165	1.289	1.696	708	220.4	139.3	13.12	134.6	15.09	8.59	–20
–19	2.03100	1027.0	0.01873	156.61	436.81	0.8411	1.9436	2.177	1.307	1.709	700	220.1	137.1	13.18	133.4	15.25	8.37	–19
–18	2.09380	1022.3	0.01813	158.77	436.70	0.8494	1.9386	2.189	1.326	1.723	692	219.8	134.8	13.26	132.2	15.42	8.16	–18
–17	2.15810	1017.6	0.01756	160.95	436.58	0.8576	1.9337	2.201	1.346	1.738	684	219.5	132.6	13.33	131.0	15.59	7.95	–17
–16	2.22370	1012.8	0.01700	163.14	436.44	0.8659	1.9287	2.215	1.366	1.753	676	219.2	130.4	13.40	129.8	15.77	7.74	–16
–15	2.29080	1008.0	0.01647	165.34	436.27	0.8742	1.9237	2.228	1.388	1.768	668	218.8	128.3	13.47	128.6	15.95	7.53	–15
–14	2.35930	1003.1	0.01595	167.55	436.09	0.8825	1.9187	2.243	1.410	1.785	660	218.5	126.2	13.55	127.4	16.14	7.32	–14
–13	2.42940	998.1	0.01545	169.78	435.89	0.8908	1.9137	2.258	1.433	1.802	651	218.1	124.1	13.63	126.2	16.34	7.11	–13
–12	2.50100	993.1	0.01497	172.01	435.66	0.8991	1.9086	2.273	1.457	1.821	643	217.7	122.0	13.70	125.0	16.54	6.90	–12
–11	2.57400	988.1	0.01450	174.26	435.41	0.9074	1.9036	2.290	1.483	1.840	635	217.4	120.0	13.78	123.8	16.74	6.70	–11
–10	2.64870	982.9	0.01405	176.52	435.14	0.9157	1.8985	2.307	1.509	1.860	626	216.9	118.0	13.86	122.5	16.96	6.50	–10
–9	2.72490	977.7	0.01361	178.80	434.84	0.9240	1.8934	2.325	1.537	1.881	617	216.5	116.1	13.95	121.3	17.18	6.29	–9
–8	2.80270	972.5	0.01319	181.09	434.51	0.9324	1.8882	2.345	1.566	1.904	609	216.1	114.1	14.03	120.1	17.42	6.09	–8
–7	2.88210	967.1	0.01278	183.39	434.17	0.9408	1.8830	2.365	1.597	1.927	600	215.6	112.2	14.12	118.9	17.66	5.89	–7
–6	2.96320	961.7	0.01238	185.71	433.79	0.9491	1.8778	2.386	1.629	1.952	591	215.2	110.3	14.20	117.7	17.91	5.70	–6
–5	3.04590	956.2	0.01200	188.05	433.38	0.9576	1.8725	2.408	1.663	1.979	582	214.7	108.4	14.30	116.5	18.17	5.50	–5
–4	3.13030	950.6	0.01162	190.40	432.95	0.9660	1.8672	2.432	1.699	2.007	573	214.2	106.6	14.39	115.3	18.44	5.30	–4
–3	3.21640	945.0	0.01126	192.77	432.48	0.9744	1.8618	2.457	1.737	2.037	564	213.7	104.8	14.48	114.1	18.73	5.11	–3
–2	3.30420	939.2	0.01091	195.16	431.99	0.9829	1.8563	2.484	1.777	2.068	555	213.1	102.9	14.58	112.9	19.03	4.92	–2
–1	3.39380	933.4	0.01057	197.57	431.46	0.9914	1.8509	2.512	1.819	2.102	546	212.6	101.2	14.68	111.6	19.34	4.73	–1
0	3.48510	927.4	0.01024	200.00	430.89	1.0000	1.8453	2.542	1.865	2.138	536	212.0	99.4	14.79	110.4	19.67	4.54	0
1	3.57830	921.4	0.00992	202.45	430.29	1.0086	1.8397	2.574	1.913	2.176	527	211.5	97.6	14.89	109.2	20.02	4.35	1
2	3.67330	915.2	0.00961	204.93	429.65	1.0172	1.8340	2.609	1.965	2.218	518	210.9	95.9	15.00	108.0	20.38	4.17	2
3	3.77010	909.0	0.00931	207.43	428.97	1.0259	1.8282	2.645	2.020	2.262	508	210.3	94.2	15.12	106.8	20.76	3.99	3
4	3.86880	902.6	0.00901	209.95	428.25	1.0346	1.8223	2.685	2.080	2.309	499	209.6	92.5	15.24	105.5	21.17	3.80	4
5	3.96950	896.0	0.00872	212.50	427.48	1.0434	1.8163	2.727	2.144	2.360	489	209.0	90.8	15.36	104.3	21.60	3.62	5
6	4.07200	889.4	0.00845	215.08	426.67	1.0523	1.8102	2.772	2.213	2.416	480	208.3	89.1	15.49	103.1	22.06	3.45	6
7	4.17650	882.6	0.00817	217.69	425.81	1.0612	1.8041	2.822	2.289	2.476	470	207.6	87.5	15.62	101.8	22.54	3.27	7
8	4.28310	875.6	0.00791	220.34	424.89	1.0702	1.7977	2.875	2.370	2.541	460	206.9	85.8	15.76	100.6	23.06	3.10	8
9	4.39160	868.4	0.00765	223.01	423.92	1.0792	1.7913	2.934	2.460	2.612	451	206.2	84.2	15.91	99.4	23.61	2.93	9
10	4.50220	861.1	0.00740	225.73	422.88	1.0884	1.7847	2.998	2.558	2.690	441	205.4	82.6	16.06	98.1	24.21	2.76	10
11	4.61490	853.6	0.00715	228.49	421.79	1.0976	1.7779	3.068	2.666	2.776	431	204.6	80.9	16.22	96.9	24.84	2.59	11
12	4.72970	845.9	0.00691	231.29	420.62	1.1070	1.7710	3.145	2.786	2.871	421	203.8	79.3	16.39	95.6	25.53	2.42	12
13	4.84660	837.9	0.00668	234.13	419.37	1.1165	1.7638	3.232	2.919	2.977	411	203.0	77.7	16.56	94.4	26.27	2.26	13
14	4.96580	829.7	0.00645	237.03	418.05	1.1261	1.7565	3.328	3.068	3.095	401	202.1	76.1	16.75	93.1	27.08	2.10	14
15	5.08701	821.2	0.00622	239.99	416.64	1.1359	1.7489	3.436	3.237	3.228	391	201.2	74.4	16.95	91.9	27.96	1.95	15
16	5.21080	812.4	0.00600	243.01	415.12	1.1458	1.7411	3.558	3.429	3.378	381	200.3	72.8	17.16	90.6	28.93	1.79	16
17	5.33680	803.3	0.00578	246.10	413.50	1.1559	1.7329	3.698	3.649	3.550	370	199.3	71.2	17.39	89.4	29.99	1.64	17
18	5.46510	793.8	0.00557	249.26	411.76	1.1663	1.7244	3.858	3.905	3.748	360	198.3	69.5	17.64	88.1	31.16	1.49	18
19	5.59580	783.8	0.00536	252.52	409.89	1.1769	1.7155	4.044	4.204	3.979	349	197.2	67.8	17.90	86.9	32.47	1.35	19
20	5.72910	773.4	0.00515	255.87	407.87	1.1877	1.7062	4.264	4.560	4.252	338	196.1	66.1	18.19	85.7	33.94	1.20	20
21	5.86480	762.4	0.00494	259.33	405.67	1.1989	1.6964	4.526	4.990	4.578	326	194.9	64.4	18.50	84.5	35.61	1.06	21
22	6.00310	750.8	0.00474	262.93	403.26	1.2105	1.6860	4.846	5.519	4.976	314	193.6	62.7	18.85	83.4	37.52	0.93	22
23	6.14400	738.4	0.00453	266.68	400.63	1.2225	1.6749	5.248	6.185	5.472	302	192.3	60.9	19.23	82.4	39.74	0.80	23
24	6.28770	725.0	0.00433	270.61	397.70	1.2352	1.6629	5.767	7.049	6.107	288	190.8	59.0	19.66	81.5	42.35	0.67	24
25	6.43420	710.5	0.00412	274.78	394.43	1.2485	1.6498	6.467	8.212	6.949	274	189.1	57.0	20.16	80.8	45.51	0.55	25
26	6.58370	694.5	0.00391	279.26	390.71	1.2627	1.6353	7.460	9.862	8.121	259	187.2	55.0	20.73	80.5	49.44	0.44	26
27	6.73610	676.4	0.00369	284.14	386.39	1.2783	1.6189	8.970	12.38	9.870	243	185.0	52.8	21.42	80.7	54.56	0.33	27
28	6.89180	655.3	0.00346	289.62	381.20	1.2958	1.5999	11.550	16.69	12.780	225	182.1	50.3	22.27	81.9	61.73	0.23	28
29	7.05090	629.4	0.00320	296.07	374.61	1.3163	1.5763	16.950	25.74	18.630	205	178.2	47.5	23.41	85.2	73.19	0.13	29
30	7.21370	593.3	0.00290	304.55	365.13	1.3435	1.5433	35.340	55.82	36.660	177	171.3	43.8	25.17	95.4	98.02	0.05	30
30.98[c]	7.37730	467.6	0.00214	332.25	332.25	1.4336	1.4336	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	30.98

*Temperatures on ITS-90 scale [a]Triple point [c]Critical point

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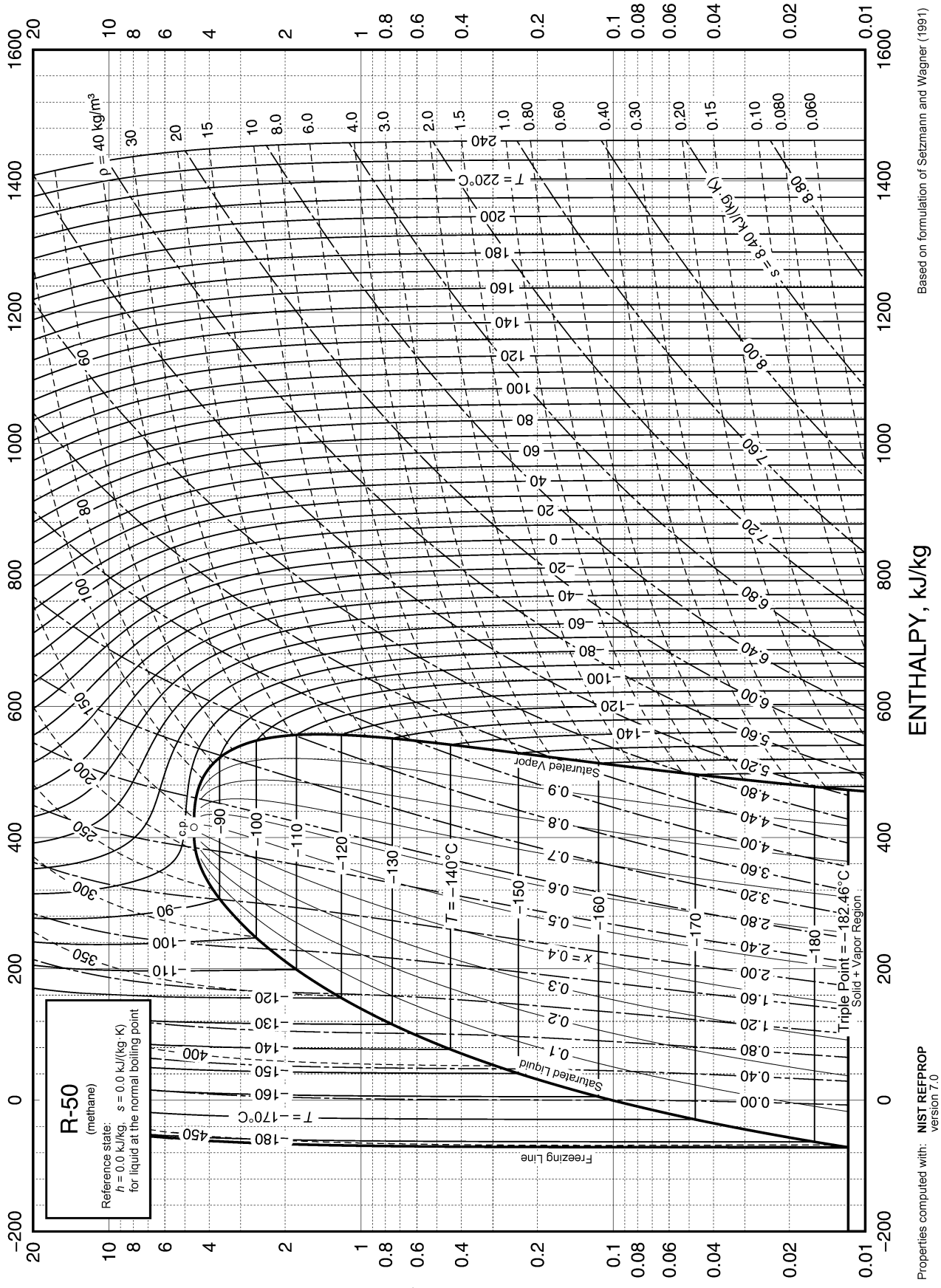

Fig. 19 Pressure-Enthalpy Diagram for Refrigerant 50 (Methane)

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Refrigerant 50 (Methane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–182.46[a]	0.01170	451.5	3.9881	–71.82	472.44	–0.7099	5.2911	3.368	2.110	1.341	1539	249.1	204.5	3.64	211.2	8.85	18.76	–182.46
–180	0.01590	448.2	3.0071	–63.53	477.22	–0.6199	5.1853	3.377	2.118	1.343	1516	252.2	189.5	3.73	208.3	9.15	18.09	–180
–175	0.02823	441.4	1.7755	–46.58	486.76	–0.4429	4.9910	3.399	2.137	1.348	1470	258.0	163.9	3.93	202.1	9.78	16.74	–175
–170	0.04723	434.5	1.1081	–29.49	495.99	–0.2735	4.8208	3.426	2.162	1.355	1422	263.4	143.4	4.12	195.5	10.42	15.43	–170
–165	0.07509	427.4	0.72466	–12.24	504.85	–0.1108	4.6704	3.457	2.192	1.365	1373	268.3	126.8	4.32	188.7	11.09	14.17	–165
–161.48[b]	0.10133	422.4	0.55054	0.00	510.83	0.0000	4.5746	3.481	2.218	1.373	1338	271.5	116.8	4.46	183.9	11.58	13.30	–161.48
–160	0.11429	420.2	0.49291	5.19	513.28	0.0459	4.5363	3.492	2.229	1.377	1323	272.7	112.9	4.52	181.8	11.79	12.94	–160
–155	0.16757	412.7	0.34665	22.82	521.22	0.1973	4.4156	3.533	2.274	1.392	1273	276.5	101.3	4.73	174.8	12.53	11.75	–155
–150	0.23784	405.0	0.25077	40.69	528.60	0.3440	4.3058	3.580	2.328	1.412	1221	279.7	91.4	4.95	167.7	13.30	10.60	–150
–145	0.32817	397.1	0.18583	58.84	535.34	0.4866	4.2049	3.635	2.393	1.436	1168	282.3	82.8	5.17	160.5	14.13	9.49	–145
–140	0.44177	388.8	0.14054	77.30	541.38	0.6257	4.1111	3.701	2.472	1.466	1114	284.3	75.2	5.40	153.4	15.01	8.43	–140
–135	0.58192	380.2	0.10813	96.13	546.63	0.7618	4.0228	3.780	2.569	1.504	1059	285.6	68.6	5.63	146.3	15.96	7.42	–135
–130	0.75201	371.1	0.08440	115.39	550.97	0.8956	3.9384	3.876	2.690	1.552	1002	286.2	62.7	5.88	139.2	16.99	6.44	–130
–125	0.95550	361.6	0.06666	135.17	554.29	1.0276	3.8566	3.996	2.842	1.613	943	286.2	57.3	6.15	132.1	18.13	5.52	–125
–120	1.1959	351.4	0.05315	155.58	556.43	1.1585	3.7759	4.148	3.038	1.694	882	285.4	52.4	6.43	125.0	19.39	4.64	–120
–118	1.3033	347.2	0.04865	163.94	556.91	1.2108	3.7437	4.220	3.133	1.733	858	284.8	50.5	6.55	122.1	19.95	4.31	–118
–116	1.4174	342.8	0.04457	172.44	557.16	1.2631	3.7112	4.302	3.240	1.777	832	284.2	48.7	6.68	119.3	20.53	3.98	–116
–114	1.5384	338.3	0.04087	181.08	557.15	1.3155	3.6785	4.393	3.362	1.827	807	283.4	47.0	6.81	116.4	21.15	3.66	–114
–112	1.6668	333.6	0.03750	189.88	556.87	1.3681	3.6454	4.497	3.501	1.885	780	282.5	45.3	6.95	113.5	21.81	3.35	–112
–110	1.8026	328.8	0.03442	198.85	556.28	1.4209	3.6117	4.615	3.662	1.951	754	281.4	43.6	7.09	110.7	22.52	3.04	–110
–108	1.9462	323.7	0.03160	208.03	555.37	1.4741	3.5773	4.751	3.848	2.028	726	280.2	42.0	7.24	107.8	23.28	2.75	–108
–106	2.0978	318.4	0.02900	217.42	554.09	1.5278	3.5419	4.910	4.068	2.119	698	278.9	40.4	7.40	104.9	24.12	2.46	–106
–104	2.2578	312.9	0.02662	227.06	552.39	1.5821	3.5054	5.097	4.331	2.227	670	277.4	38.8	7.57	102.0	25.05	2.19	–104
–102	2.4264	307.1	0.02441	236.99	550.24	1.6372	3.4675	5.322	4.650	2.358	641	275.7	37.2	7.76	99.0	26.09	1.92	–102
–100	2.6040	301.0	0.02236	247.25	547.56	1.6934	3.4278	5.596	5.044	2.520	610	273.9	35.6	7.96	96.1	27.28	1.66	–100
–95	3.0895	283.6	0.01781	274.80	537.86	1.8408	3.3174	6.654	6.608	3.153	529	268.4	31.7	8.55	88.6	31.27	1.07	–95
–90	3.6399	261.7	0.01384	306.71	521.52	2.0062	3.1791	9.10	10.37	4.64	437	261.3	27.5	9.39	81.2	38.68	0.55	–90
–85	4.2648	227.5	0.00993	349.75	488.81	2.2241	2.9632	21.88	30.57	12.16	320	250.2	22.3	10.95	77.5	62.99	0.13	–85
–82.59[c]	4.5992	162.7	0.00615	415.59	415.59	2.5624	2.5624	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	–82.59

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

Refrigerant 50 (Methane) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–161.5[a]	1.8164	510.83	4.5746	2.218	1.373	271.5	4.46	11.58
–160	1.7899	514.11	4.6037	2.208	1.371	273.5	4.52	11.74
–155	1.7064	525.08	4.6986	2.183	1.366	280.3	4.71	12.30
–150	1.6310	535.95	4.7887	2.165	1.362	286.9	4.90	12.87
–145	1.5626	546.74	4.8746	2.151	1.359	293.2	5.10	13.45
–140	1.5000	557.47	4.9567	2.141	1.356	299.4	5.29	14.03
–135	1.4425	568.15	5.0355	2.132	1.354	305.4	5.48	14.62
–130	1.3894	578.79	5.1112	2.125	1.351	311.2	5.67	15.21
–120	1.2947	599.99	5.2543	2.116	1.348	322.5	6.06	16.40
–110	1.2124	621.11	5.3879	2.109	1.345	333.3	6.44	17.58
–100	1.1403	642.18	5.5133	2.106	1.343	343.8	6.81	18.77
–90	1.0764	663.23	5.6315	2.104	1.341	353.8	7.19	19.96
–80	1.0194	684.27	5.7433	2.105	1.339	363.5	7.56	21.15
–70	0.9683	705.33	5.8496	2.107	1.337	372.9	7.92	22.31
–60	0.9221	726.42	5.9509	2.111	1.335	382.0	8.29	23.49
–50	0.8802	747.57	6.0479	2.118	1.332	390.7	8.64	24.68
–40	0.8419	768.78	6.1409	2.126	1.330	399.2	9.00	25.89
–30	0.8069	790.10	6.2304	2.137	1.327	407.5	9.35	27.12
–20	0.7747	811.53	6.3168	2.149	1.324	415.4	9.69	28.36
–10	0.7450	833.09	6.4003	2.164	1.320	423.2	10.03	29.63
0	0.7175	854.82	6.4814	2.181	1.316	430.7	10.37	30.93
10	0.6919	876.72	6.5601	2.200	1.312	437.9	10.70	32.25
20	0.6682	898.82	6.6368	2.221	1.308	445.0	11.02	33.61
30	0.6460	921.14	6.7117	2.243	1.304	451.9	11.35	34.99
40	0.6252	943.69	6.7849	2.268	1.299	458.6	11.66	36.41
50	0.6058	966.50	6.8565	2.293	1.295	465.1	11.98	37.86
60	0.5875	989.57	6.9269	2.321	1.290	471.4	12.29	39.35
70	0.5703	1012.92	6.9959	2.350	1.285	477.6	12.60	40.87
80	0.5541	1036.57	7.0638	2.380	1.281	483.7	12.90	42.42
90	0.5388	1060.52	7.1307	2.411	1.276	489.6	13.20	44.01
100	0.5243	1084.79	7.1967	2.443	1.271	495.5	13.49	45.63
110	0.5106	1109.39	7.2617	2.476	1.266	501.2	13.79	47.28
120	0.4975	1134.32	7.3259	2.510	1.262	506.8	14.08	48.96
130	0.4852	1159.60	7.3894	2.545	1.257	512.3	14.36	50.67
140	0.4734	1185.22	7.4522	2.580	1.253	517.7	14.64	52.41
150	0.4622	1211.21	7.5143	2.616	1.248	523.1	14.92	54.18
160	0.4515	1237.55	7.5759	2.652	1.244	528.3	15.20	55.97
170	0.4413	1264.25	7.6368	2.689	1.240	533.5	15.47	57.79
180	0.4315	1291.32	7.6972	2.726	1.236	538.6	15.74	59.63
190	0.4222	1318.76	7.7571	2.763	1.232	543.7	16.01	61.50
200	0.4132	1346.57	7.8165	2.800	1.228	548.7	16.28	63.39
210	0.4047	1374.76	7.8755	2.837	1.224	553.6	16.54	65.30
220	0.3965	1403.32	7.9340	2.875	1.221	558.5	16.80	67.23
230	0.3886	1432.26	7.9921	2.912	1.217	563.4	17.06	69.18
240	0.3810	1461.57	8.0498	2.950	1.214	568.2	17.31	71.15
250	0.3737	1491.26	8.1071	2.988	1.211	572.9	17.56	73.14
260	0.3667	1521.32	8.1640	3.025	1.207	577.6	17.81	75.14
270	0.3599	1551.76	8.2205	3.062	1.204	582.3	18.06	77.16
280	0.3534	1582.57	8.2768	3.100	1.201	586.9	18.31	79.20
290	0.3471	1613.75	8.3326	3.137	1.198	591.5	18.55	81.25
300	0.3411	1645.31	8.3882	3.174	1.196	596.0	18.79	83.31

[a]Saturated vapor at normal boiling point

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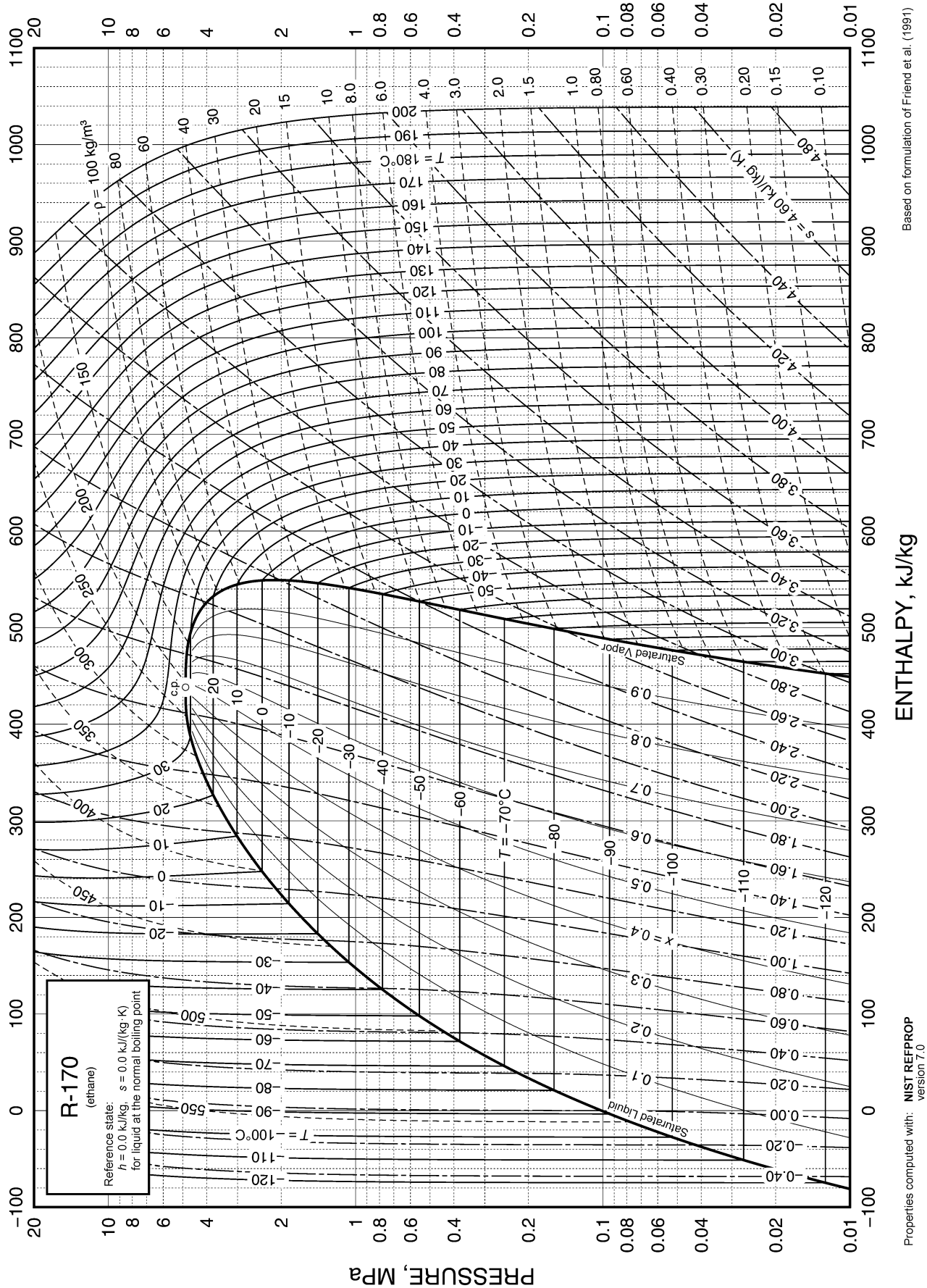

Fig. 20 Pressure-Enthalpy Diagram for Refrigerant 170 (Ethane)

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Refrigerant 170 (Ethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,[a] °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp., °C
–175	0.00001	643.0	3649.3	–201.26	384.73	–1.4643	4.5060	2.288	1.184	1.305	1952	188.2	933.9	3.26	249.4	3.35	30.35	–175
–170	0.00002	637.5	1353.1	–189.85	390.67	–1.3510	4.2770	2.277	1.194	1.302	1916	192.7	783.6	3.41	245.2	3.64	29.51	–170
–165	0.00005	632.0	555.95	–178.48	396.66	–1.2433	4.0747	2.273	1.204	1.298	1880	197.0	669.0	3.55	240.8	3.93	28.67	–165
–160	0.00013	626.5	249.56	–167.11	402.69	–1.1405	3.8953	2.274	1.215	1.295	1844	201.3	579.6	3.70	236.3	4.23	27.83	–160
–155	0.00027	621.0	120.95	–155.73	408.76	–1.0421	3.7356	2.278	1.226	1.292	1808	205.4	508.5	3.84	231.6	4.54	26.99	–155
–150	0.00054	615.5	62.674	–144.33	414.87	–0.9476	3.5932	2.283	1.238	1.289	1772	209.4	450.9	3.99	226.9	4.86	26.15	–150
–145	0.00103	609.9	34.435	–132.89	421.00	–0.8566	3.4657	2.290	1.251	1.287	1735	213.3	403.6	4.14	222.1	5.18	25.31	–145
–140	0.00185	604.3	19.920	–121.42	427.16	–0.7688	3.3513	2.299	1.265	1.284	1699	217.0	364.1	4.29	217.3	5.50	24.48	–140
–135	0.00316	598.7	12.060	–109.90	433.34	–0.6839	3.2484	2.308	1.279	1.282	1663	220.7	330.8	4.44	212.4	5.84	23.64	–135
–130	0.00519	593.0	7.6020	–98.34	439.53	–0.6017	3.1557	2.318	1.293	1.280	1626	224.2	302.4	4.59	207.5	6.18	22.81	–130
–125	0.00821	587.3	4.9668	–86.72	445.71	–0.5219	3.0719	2.328	1.307	1.278	1589	227.6	277.8	4.74	202.5	6.54	21.98	–125
–120	0.01255	581.5	3.3504	–75.04	451.89	–0.4445	2.9962	2.340	1.320	1.277	1552	230.9	256.4	4.90	197.6	6.90	21.15	–120
–115	0.01863	575.7	2.3254	–63.31	458.04	–0.3691	2.9274	2.353	1.333	1.277	1515	234.0	237.6	5.05	192.7	7.28	20.33	–115
–110	0.02691	569.8	1.6556	–51.50	464.15	–0.2957	2.8649	2.366	1.347	1.277	1478	237.0	220.9	5.21	187.7	7.67	19.51	–110
–105	0.03793	563.9	1.2060	–39.62	470.20	–0.2241	2.8078	2.381	1.362	1.278	1440	239.7	206.0	5.36	182.8	8.07	18.69	–105
–100	0.05230	557.9	0.89662	–27.66	476.16	–0.1542	2.7556	2.397	1.380	1.280	1403	242.3	192.5	5.52	178.0	8.48	17.88	–100
–95	0.07068	551.8	0.67900	–15.61	482.04	–0.0858	2.7076	2.415	1.401	1.282	1365	244.7	180.4	5.68	173.1	8.92	17.07	–95
–90	0.09380	545.6	0.52278	–3.46	487.79	–0.0188	2.6635	2.434	1.425	1.286	1326	246.9	169.3	5.84	168.3	9.36	16.26	–90
–88.58[b]	0.10132	543.8	0.48676	0.00	489.40	0.0000	2.6516	2.439	1.433	1.287	1316	247.4	166.4	5.89	167.0	9.49	16.03	–88.58
–85	0.12243	539.3	0.40856	8.79	493.42	0.0469	2.6227	2.455	1.454	1.290	1288	248.8	159.2	6.00	163.6	9.83	15.46	–85
–80	0.15741	532.9	0.32361	21.15	498.91	0.1115	2.5850	2.478	1.487	1.295	1249	250.4	149.9	6.16	158.9	10.31	14.67	–80
–78	0.17338	530.3	0.29583	26.13	501.07	0.1370	2.5707	2.487	1.501	1.297	1234	251.0	146.4	6.23	157.0	10.51	14.35	–78
–76	0.19055	527.7	0.27094	31.13	503.20	0.1623	2.5567	2.497	1.515	1.300	1218	251.6	143.0	6.30	155.2	10.72	14.04	–76
–74	0.20899	525.1	0.24859	36.16	505.30	0.1875	2.5432	2.508	1.531	1.302	1203	252.1	139.6	6.36	153.3	10.92	13.72	–74
–72	0.22877	522.5	0.22847	41.20	507.38	0.2125	2.5300	2.519	1.546	1.305	1187	252.5	136.4	6.43	151.5	11.13	13.41	–72
–70	0.24993	519.8	0.21033	46.27	509.43	0.2373	2.5172	2.530	1.562	1.308	1171	252.9	133.3	6.50	149.7	11.35	13.09	–70
–68	0.27255	517.1	0.19394	51.36	511.45	0.2621	2.5048	2.542	1.579	1.312	1156	253.3	130.3	6.56	147.9	11.56	12.78	–68
–66	0.29668	514.4	0.17909	56.48	513.44	0.2867	2.4926	2.554	1.596	1.315	1140	253.6	127.3	6.63	146.0	11.79	12.47	–66
–64	0.32238	511.6	0.16563	61.62	515.40	0.3111	2.4808	2.567	1.614	1.319	1124	253.9	124.4	6.70	144.2	12.01	12.16	–64
–62	0.34972	508.9	0.15339	66.79	517.34	0.3355	2.4692	2.580	1.633	1.323	1108	254.2	121.6	6.77	142.4	12.24	11.86	–62
–60	0.37877	506.1	0.14224	71.99	519.23	0.3597	2.4580	2.594	1.651	1.327	1092	254.3	118.9	6.84	140.6	12.48	11.55	–60
–58	0.40958	503.2	0.13208	77.21	521.10	0.3838	2.4470	2.608	1.671	1.331	1076	254.5	116.2	6.91	138.9	12.72	11.24	–58
–56	0.44223	500.4	0.12279	82.47	522.93	0.4078	2.4362	2.623	1.691	1.336	1060	254.6	113.6	6.99	137.1	12.96	10.94	–56
–54	0.47677	497.5	0.11429	87.75	524.73	0.4317	2.4257	2.638	1.711	1.342	1044	254.6	111.1	7.06	135.3	13.21	10.63	–54
–52	0.51328	494.6	0.10650	93.07	526.48	0.4556	2.4154	2.654	1.732	1.347	1028	254.6	108.6	7.13	133.6	13.46	10.33	–52
–50	0.55183	491.6	0.09935	98.42	528.20	0.4793	2.4053	2.671	1.754	1.353	1012	254.6	106.2	7.21	131.8	13.73	10.03	–50
–48	0.59247	488.7	0.09277	103.80	529.88	0.5029	2.3954	2.689	1.777	1.359	996	254.5	103.9	7.28	130.1	13.99	9.73	–48
–46	0.63529	485.7	0.08671	109.22	531.52	0.5265	2.3856	2.707	1.800	1.366	979	254.4	101.5	7.36	128.4	14.26	9.44	–46
–44	0.68034	482.6	0.08113	114.68	533.11	0.5500	2.3760	2.726	1.824	1.373	963	254.2	99.3	7.44	126.7	14.54	9.14	–44
–42	0.72770	479.5	0.07597	120.18	534.66	0.5735	2.3666	2.746	1.850	1.381	947	253.9	97.1	7.51	125.0	14.83	8.85	–42
–40	0.77744	476.4	0.07120	125.71	536.16	0.5969	2.3573	2.767	1.876	1.390	930	253.6	94.9	7.59	123.3	15.12	8.55	–40
–38	0.82963	473.2	0.06679	131.29	537.60	0.6202	2.3481	2.789	1.904	1.399	914	253.2	92.8	7.68	121.6	15.42	8.26	–38
–36	0.88433	470.0	0.06269	136.91	539.00	0.6435	2.3390	2.812	1.932	1.408	897	252.8	90.7	7.76	119.9	15.73	7.97	–36
–34	0.94163	466.7	0.05889	142.57	540.34	0.6668	2.3301	2.836	1.963	1.419	880	252.4	88.7	7.84	118.2	16.04	7.68	–34
–32	1.0016	463.4	0.05536	148.28	541.62	0.6900	2.3211	2.862	1.995	1.430	864	251.8	86.7	7.93	116.6	16.37	7.40	–32
–30	1.0643	460.0	0.05207	154.04	542.85	0.7133	2.3123	2.889	2.028	1.442	847	251.2	84.7	8.02	114.9	16.70	7.11	–30
–28	1.1298	456.6	0.04900	159.86	544.00	0.7365	2.3035	2.918	2.064	1.455	830	250.6	82.7	8.11	113.3	17.05	6.83	–28
–26	1.1982	453.1	0.04614	165.72	545.10	0.7597	2.2947	2.948	2.102	1.469	813	249.9	80.8	8.20	111.6	17.40	6.55	–26
–24	1.2696	449.6	0.04347	171.64	546.12	0.7829	2.2859	2.980	2.142	1.485	796	249.1	79.0	8.30	110.0	17.77	6.27	–24
–22	1.3440	446.0	0.04097	177.62	547.06	0.8062	2.2772	3.014	2.185	1.501	778	248.3	77.1	8.40	108.4	18.15	6.00	–22
–20	1.4215	442.3	0.03863	183.67	547.93	0.8295	2.2684	3.050	2.231	1.519	761	247.4	75.3	8.50	106.7	18.55	5.72	–20
–18	1.5023	438.5	0.03644	189.78	548.72	0.8528	2.2596	3.089	2.281	1.539	744	246.4	73.5	8.61	105.1	18.96	5.45	–18
–16	1.5863	434.7	0.03439	195.95	549.41	0.8761	2.2507	3.130	2.334	1.561	726	245.4	71.8	8.71	103.5	19.38	5.18	–16
–14	1.6737	430.8	0.03245	202.20	550.02	0.8996	2.2417	3.175	2.392	1.584	708	244.3	70.0	8.83	101.9	19.83	4.92	–14
–12	1.7645	426.8	0.03064	208.53	550.52	0.9231	2.2326	3.223	2.455	1.610	690	243.1	68.3	8.94	100.3	20.29	4.65	–12
–10	1.8588	422.6	0.02892	214.94	550.91	0.9467	2.2234	3.275	2.523	1.639	672	241.9	66.6	9.07	98.7	20.78	4.39	–10
–8	1.9568	418.4	0.02731	221.43	551.19	0.9704	2.2140	3.331	2.598	1.671	654	240.6	64.9	9.19	97.1	21.30	4.13	–8
–6	2.0585	414.1	0.02579	228.02	551.35	0.9942	2.2045	3.393	2.681	1.706	635	239.2	63.3	9.33	95.6	21.84	3.88	–6
–4	2.1640	409.7	0.02435	234.71	551.37	1.0182	2.1947	3.460	2.773	1.746	617	237.7	61.6	9.46	94.0	22.41	3.63	–4
–2	2.2734	405.1	0.02298	241.50	551.24	1.0423	2.1847	3.534	2.875	1.791	598	236.1	60.0	9.61	92.4	23.02	3.38	–2
0	2.3867	400.3	0.02169	248.41	550.96	1.0667	2.1743	3.617	2.990	1.841	579	234.5	58.4	9.77	90.8	23.68	3.13	0
5	2.6883	387.7	0.01874	266.27	549.46	1.1287	2.1468	3.871	3.352	2.001	531	229.9	54.3	10.20	86.9	25.53	2.54	5
10	3.0172	373.7	0.01612	285.14	546.55	1.1928	2.1161	4.227	3.878	2.236	480	224.8	50.3	10.71	83.0	27.85	1.97	10
15	3.3755	357.9	0.01377	305.36	541.71	1.2602	2.0804	4.773	4.713	2.611	427	218.9	46.2	11.34	79.0	30.90	1.43	15
20	3.7655	339.0	0.01160	327.57	533.99	1.3328	2.0369	5.746	6.249	3.299	368	212.1	41.8	12.17	75.2	35.30	0.93	20
25	4.1903	315.0	0.00952	353.26	521.20	1.4152	1.9785	8.05	10.02	4.96	302	204.1	37.0	13.38	72.0	42.79	0.48	25
30	4.6551	276.3	0.00723	388.24	494.95	1.5263	1.8783	21.69	32.79	14.35	220	192.0	30.6	15.75	74.9	64.07	0.11	30
32.17[c]	4.8722	206.2	0.00485	438.99	438.99	1.6901	1.6901	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	32.17

[a]Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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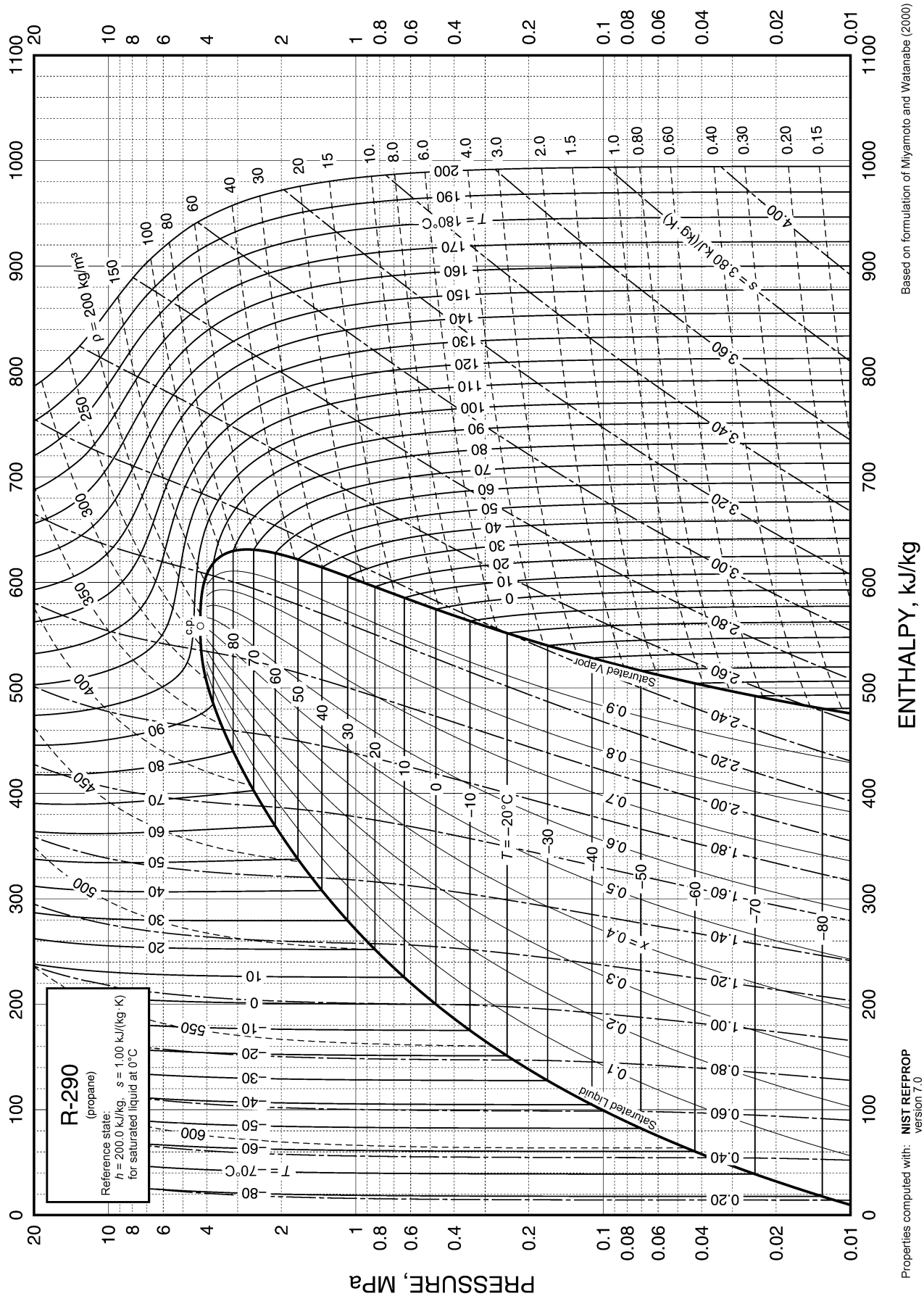

Fig. 21 Pressure-Enthalpy Diagram for Refrigerant 290 (Propane)

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Refrigerant 290 (Propane) Properties of Saturated Liquid and Saturated Vapor

Temp., °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp., °C
–150	0.00001	694.6	4316.4	–123.78	402.06	–0.6903	3.5796	1.962	1.020	1.227	1880	168.8	1343.0	3.55	192.9	3.68	31.84	–150
–140	0.00003	684.5	864.49	–104.09	412.43	–0.5366	3.3426	1.977	1.054	1.218	1813	174.9	985.4	3.80	187.7	4.28	30.29	–140
–130	0.00012	674.4	223.53	–84.23	423.12	–0.3929	3.1514	1.994	1.087	1.210	1745	180.7	761.7	4.05	182.2	4.90	28.76	–130
–120	0.00041	664.3	70.785	–64.21	434.11	–0.2576	2.9962	2.012	1.119	1.203	1679	186.3	611.6	4.31	176.4	5.55	27.24	–120
–110	0.00116	654.0	26.386	–43.99	445.38	–0.1298	2.8697	2.032	1.151	1.197	1612	191.7	505.0	4.56	170.4	6.23	25.73	–110
–100	0.00290	643.7	11.231	–23.56	456.88	–0.0083	2.7664	2.054	1.184	1.192	1545	196.8	425.7	4.82	164.4	6.94	24.23	–100
–90	0.00645	633.3	5.3300	–2.90	468.58	0.1077	2.6820	2.078	1.220	1.188	1478	201.5	364.5	5.08	158.2	7.67	22.74	–90
–80	0.01305	622.8	2.7676	18.03	480.44	0.2189	2.6130	2.106	1.258	1.184	1411	205.9	315.9	5.34	152.1	8.43	21.27	–80
–70	0.02440	612.0	1.5487	39.25	492.41	0.3259	2.5566	2.137	1.300	1.182	1345	209.9	276.4	5.60	145.9	9.22	19.81	–70
–60	0.04269	601.1	0.92250	60.81	504.44	0.4294	2.5107	2.172	1.346	1.181	1278	213.5	243.6	5.85	139.8	10.04	18.37	–60
–50	0.07057	589.9	0.57905	82.75	516.48	0.5298	2.4734	2.212	1.397	1.182	1213	216.5	216.0	6.11	133.8	10.88	16.94	–50
–42.11[b]	0.10133	580.9	0.41388	100.36	525.95	0.6070	2.4491	2.246	1.440	1.183	1161	218.4	197.2	6.31	129.2	11.57	15.83	–42.11
–40	0.11112	578.4	0.37985	105.12	528.48	0.6275	2.4433	2.256	1.453	1.184	1147	218.9	192.6	6.36	128.0	11.76	15.54	–40
–38	0.12105	576.1	0.35076	109.65	530.87	0.6468	2.4380	2.265	1.464	1.185	1134	219.3	188.3	6.41	126.8	11.94	15.26	–38
–36	0.13166	573.8	0.32437	114.20	533.26	0.6660	2.4330	2.275	1.476	1.185	1121	219.6	184.1	6.47	125.6	12.12	14.98	–36
–34	0.14297	571.4	0.30037	118.77	535.64	0.6851	2.4282	2.285	1.488	1.186	1108	220.0	180.1	6.52	124.5	12.30	14.70	–34
–32	0.15502	569.0	0.27853	123.36	538.01	0.7041	2.4236	2.295	1.501	1.187	1095	220.3	176.1	6.57	123.3	12.48	14.42	–32
–30	0.16783	566.6	0.25861	127.97	540.38	0.7231	2.4192	2.305	1.513	1.188	1082	220.6	172.3	6.62	122.2	12.67	14.15	–30
–28	0.18144	564.2	0.24041	132.61	542.75	0.7419	2.4150	2.316	1.526	1.189	1069	220.9	168.6	6.67	121.1	12.86	13.87	–28
–26	0.19589	561.8	0.22376	137.26	545.11	0.7607	2.4109	2.327	1.539	1.191	1056	221.1	165.0	6.73	120.0	13.05	13.60	–26
–24	0.21119	559.4	0.20851	141.94	547.46	0.7795	2.4071	2.338	1.553	1.192	1043	221.3	161.5	6.78	118.8	13.24	13.33	–24
–22	0.22739	556.9	0.19452	146.64	549.80	0.7982	2.4034	2.349	1.566	1.193	1030	221.5	158.1	6.83	117.7	13.43	13.06	–22
–20	0.24452	554.5	0.18167	151.36	552.13	0.8168	2.3999	2.361	1.580	1.195	1016	221.6	154.7	6.89	116.6	13.63	12.79	–20
–18	0.26261	552.0	0.16984	156.11	554.46	0.8353	2.3965	2.373	1.595	1.197	1003	221.8	151.5	6.94	115.5	13.83	12.52	–18
–16	0.28170	549.5	0.15894	160.88	556.77	0.8538	2.3933	2.385	1.609	1.198	990	221.8	148.3	6.99	114.4	14.03	12.25	–16
–14	0.30181	546.9	0.14889	165.68	559.08	0.8722	2.3903	2.397	1.624	1.200	977	221.9	145.2	7.05	113.4	14.23	11.98	–14
–12	0.32300	544.4	0.13961	170.50	561.37	0.8906	2.3874	2.410	1.639	1.202	964	221.9	142.2	7.10	112.3	14.44	11.71	–12
–10	0.34528	541.8	0.13103	175.35	563.65	0.9090	2.3846	2.423	1.655	1.205	951	221.9	139.3	7.16	111.2	14.65	11.45	–10
–8	0.36870	539.2	0.12308	180.22	565.92	0.9273	2.3819	2.436	1.671	1.207	938	221.8	136.4	7.22	110.1	14.86	11.18	–8
–6	0.39329	536.6	0.11571	185.12	568.18	0.9455	2.3794	2.450	1.687	1.209	925	221.8	133.6	7.27	109.1	15.08	10.92	–6
–4	0.41909	533.9	0.10887	190.05	570.42	0.9637	2.3769	2.464	1.704	1.212	912	221.6	130.9	7.33	108.0	15.29	10.65	–4
–2	0.44613	531.3	0.10252	195.01	572.65	0.9819	2.3746	2.478	1.721	1.215	899	221.5	128.2	7.39	107.0	15.52	10.39	–2
0	0.47446	528.6	0.09661	200.00	574.87	1.0000	2.3724	2.493	1.739	1.218	885	221.3	125.6	7.45	106.0	15.74	10.13	0
2	0.50410	525.9	0.09111	205.02	577.06	1.0181	2.3703	2.508	1.757	1.221	872	221.1	123.0	7.51	104.9	15.97	9.87	2
4	0.53510	523.1	0.08598	210.06	579.24	1.0362	2.3682	2.524	1.776	1.225	859	220.8	120.5	7.57	103.9	16.20	9.62	4
6	0.56749	520.4	0.08120	215.14	581.41	1.0542	2.3663	2.540	1.795	1.229	846	220.5	118.1	7.63	102.9	16.44	9.36	6
8	0.60131	517.6	0.07673	220.25	583.55	1.0722	2.3644	2.556	1.815	1.232	833	220.2	115.7	7.69	101.9	16.68	9.10	8
10	0.63660	514.7	0.07255	225.40	585.67	1.0902	2.3626	2.573	1.835	1.237	819	219.8	113.3	7.75	100.9	16.93	8.85	10
12	0.67340	511.9	0.06865	230.57	587.77	1.1082	2.3608	2.591	1.856	1.241	806	219.3	111.0	7.82	99.9	17.18	8.60	12
14	0.71175	509.0	0.06498	235.79	589.85	1.1261	2.3592	2.609	1.878	1.246	793	218.9	108.8	7.88	99.0	17.44	8.34	14
16	0.75168	506.0	0.06155	241.03	591.91	1.1440	2.3575	2.627	1.901	1.251	780	218.4	106.6	7.95	98.0	17.70	8.09	16
18	0.79324	503.1	0.05833	246.32	593.94	1.1620	2.3560	2.646	1.925	1.256	766	217.8	104.4	8.02	97.0	17.97	7.85	18
20	0.83646	500.1	0.05530	251.64	595.95	1.1799	2.3544	2.666	1.949	1.262	753	217.2	102.3	8.09	96.1	18.24	7.60	20
22	0.88139	497.0	0.05246	256.99	597.93	1.1978	2.3529	2.687	1.975	1.268	739	216.6	100.2	8.16	95.1	18.53	7.35	22
24	0.92807	493.9	0.04978	262.39	599.88	1.2157	2.3514	2.708	2.001	1.275	726	215.9	98.1	8.23	94.2	18.81	7.11	24
26	0.97653	490.8	0.04726	267.83	601.80	1.2336	2.3500	2.730	2.029	1.282	713	215.2	96.1	8.31	93.3	19.11	6.87	26
28	1.0268	487.6	0.04488	273.31	603.68	1.2515	2.3486	2.753	2.058	1.290	699	214.4	94.1	8.38	92.3	19.41	6.62	28
30	1.0790	484.4	0.04264	278.83	605.54	1.2695	2.3471	2.777	2.088	1.298	685	213.5	92.2	8.46	91.4	19.72	6.38	30
32	1.1331	481.1	0.04053	284.40	607.35	1.2874	2.3457	2.802	2.119	1.307	672	212.6	90.3	8.54	90.5	20.05	6.15	32
34	1.1891	477.8	0.03853	290.01	609.13	1.3053	2.3443	2.827	2.152	1.316	658	211.7	88.4	8.63	89.6	20.38	5.91	34
36	1.2472	474.4	0.03664	295.68	610.87	1.3233	2.3429	2.855	2.187	1.326	645	210.7	86.5	8.71	88.7	20.72	5.68	36
38	1.3072	471.0	0.03485	301.39	612.57	1.3413	2.3414	2.883	2.224	1.337	631	209.7	84.7	8.80	87.8	21.07	5.44	38
40	1.3694	467.5	0.03315	307.15	614.21	1.3594	2.3399	2.913	2.263	1.349	617	208.6	82.8	8.89	86.9	21.43	5.21	40
42	1.4337	463.9	0.03154	312.96	615.81	1.3774	2.3384	2.944	2.304	1.362	603	207.4	81.0	8.99	86.0	21.81	4.98	42
44	1.5002	460.3	0.03002	318.83	617.36	1.3955	2.3368	2.977	2.348	1.375	589	206.2	79.3	9.08	85.2	22.20	4.76	44
46	1.5690	456.5	0.02857	324.76	618.86	1.4137	2.3352	3.012	2.395	1.391	575	204.9	77.5	9.19	84.3	22.60	4.53	46
48	1.6400	452.7	0.02720	330.75	620.29	1.4319	2.3335	3.050	2.445	1.407	561	203.6	75.8	9.29	83.5	23.03	4.31	48
50	1.7133	448.9	0.02589	336.80	621.66	1.4502	2.3317	3.089	2.499	1.425	547	202.2	74.1	9.40	82.6	23.47	4.09	50
55	1.9072	438.8	0.02288	352.23	624.77	1.4962	2.3268	3.201	2.652	1.478	511	198.3	69.8	9.70	80.5	24.65	3.55	55
60	2.1168	428.0	0.02020	368.14	627.36	1.5429	2.3210	3.337	2.841	1.548	474	194.1	65.7	10.03	78.4	26.00	3.02	60
65	2.3430	416.3	0.01781	384.60	629.29	1.5903	2.3139	3.509	3.086	1.641	437	189.3	61.5	10.42	76.3	27.56	2.52	65
70	2.5868	403.6	0.01565	401.75	630.37	1.6389	2.3052	3.735	3.421	1.773	398	184.0	57.4	10.86	74.3	29.41	2.03	70
75	2.8493	389.5	0.01367	419.76	630.33	1.6891	2.2939	4.053	3.914	1.970	358	178.2	53.2	11.40	72.2	31.71	1.56	75
80	3.1319	373.3	0.01185	438.93	628.73	1.7417	2.2791	4.545	4.707	2.288	315	171.6	48.8	12.07	70.2	34.75	1.12	80
85	3.4361	354.0	0.01012	459.81	624.75	1.7980	2.2586	5.433	6.182	2.883	269	164.1	44.1	12.96	68.3	39.13	0.72	85
90	3.7641	328.8	0.00840	483.71	616.47	1.8616	2.2272	7.623	9.888	4.374	218	155.5	38.8	14.28	67.1	46.66	0.36	90
95	4.1195	286.5	0.00640	516.33	595.81	1.9476	2.1635	23.59	36.07	14.62	158	144.1	31.4	17.00	73.6	69.48	0.06	95
96.74[c]	4.2512	220.5	0.00454	555.24	555.24	2.0516	2.0516	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	96.74

[b]Normal boiling point

[c]Critical point

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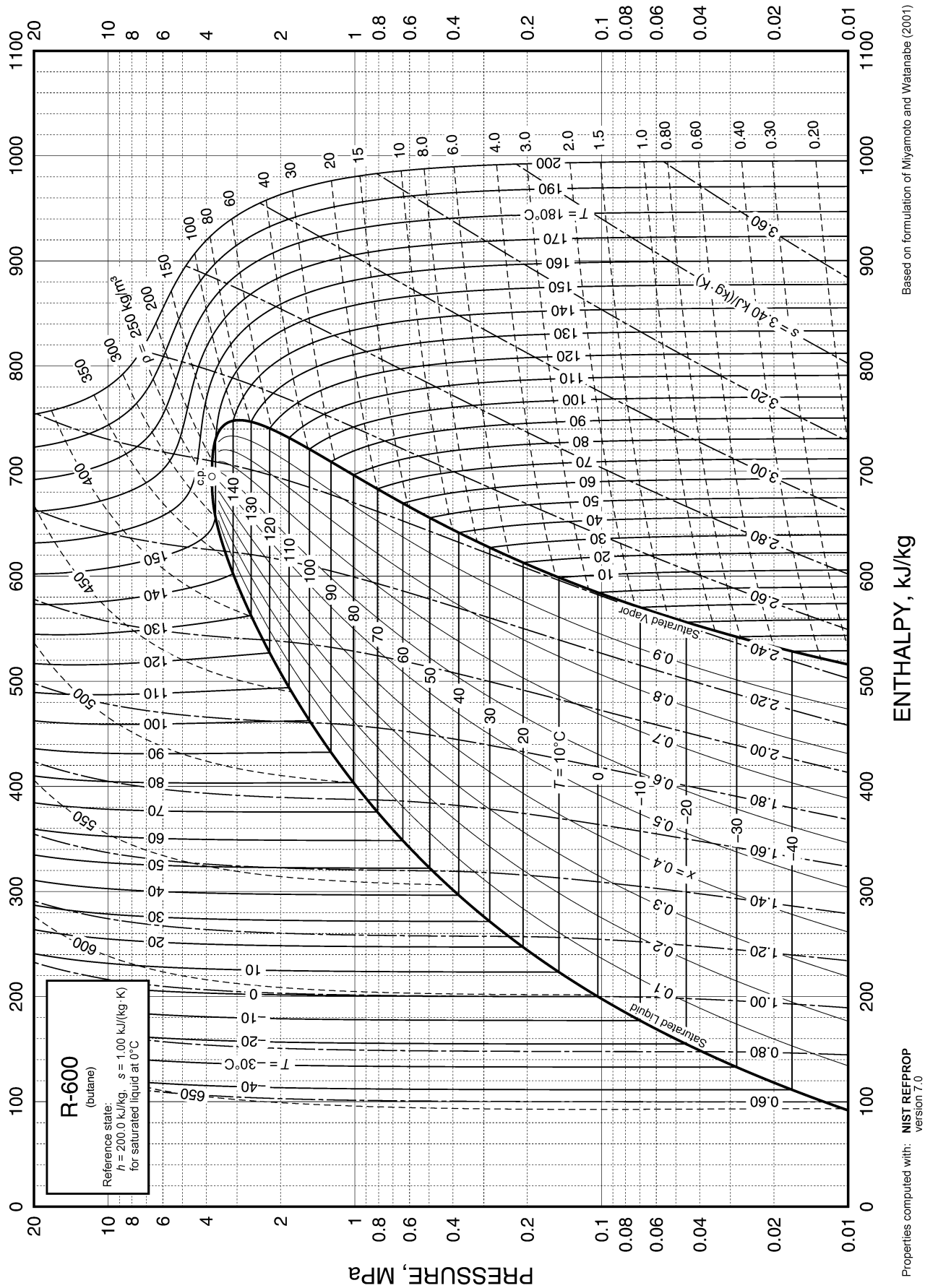

Properties computed with: NIST REFPROP version 7.0

Based on formulation of Miyamoto and Watanabe (2001)

Fig. 22 Pressure-Enthalpy Diagram for Refrigerant 600 (*n*-Butane)

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Refrigerant 600 (*n*-Butane) Properties of Saturated Liquid and Saturated Vapor

Temp.,[a] °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp., °C
–100	0.00016	699.3	150.44	–13.65	450.85	0.0318	2.7144	2.013	1.231	1.132	1592	167.4	792.2	4.30	161.6	6.83	28.03	–100
–95	0.00028	694.6	91.606	–3.57	457.02	0.0892	2.6746	2.021	1.247	1.130	1563	169.6	719.0	4.43	159.4	7.12	27.33	–95
–90	0.00045	689.9	57.588	6.56	463.27	0.1453	2.6389	2.029	1.263	1.128	1534	171.8	655.9	4.55	157.2	7.43	26.64	–90
–85	0.00072	685.2	37.271	16.73	469.58	0.2000	2.6069	2.038	1.279	1.127	1505	174.0	601.2	4.68	154.9	7.73	25.94	–85
–80	0.00111	680.5	24.773	26.94	475.97	0.2536	2.5784	2.048	1.295	1.125	1477	176.1	553.2	4.81	152.6	8.05	25.26	–80
–75	0.00168	675.8	16.873	37.21	482.41	0.3061	2.5529	2.058	1.312	1.124	1449	178.1	510.9	4.93	150.2	8.38	24.57	–75
–70	0.00247	671.0	11.752	47.53	488.92	0.3575	2.5303	2.069	1.330	1.122	1420	180.1	473.4	5.06	147.9	8.71	23.89	–70
–65	0.00355	666.2	8.3565	57.90	495.50	0.4080	2.5103	2.081	1.347	1.121	1392	182.1	439.9	5.18	145.5	9.05	23.22	–65
–60	0.00501	661.4	6.0558	68.34	502.13	0.4575	2.4926	2.094	1.366	1.120	1364	184.0	409.8	5.31	143.1	9.40	22.54	–60
–55	0.00695	656.6	4.4659	78.85	508.82	0.5062	2.4772	2.108	1.385	1.119	1336	185.8	382.8	5.43	140.8	9.75	21.88	–55
–50	0.00947	651.7	3.3470	89.42	515.56	0.5541	2.4638	2.122	1.404	1.118	1309	187.5	358.3	5.55	138.4	10.11	21.21	–50
–45	0.01270	646.8	2.5462	100.07	522.35	0.6013	2.4522	2.137	1.425	1.118	1281	189.2	336.1	5.68	136.0	10.48	20.55	–45
–40	0.01679	641.9	1.9638	110.80	529.19	0.6478	2.4423	2.153	1.446	1.117	1253	190.8	315.8	5.80	133.6	10.86	19.90	–40
–35	0.02190	636.9	1.5341	121.62	536.08	0.6937	2.4340	2.170	1.468	1.117	1226	192.3	297.3	5.92	131.3	11.25	19.25	–35
–30	0.02821	631.9	1.2127	132.52	543.01	0.7389	2.4271	2.188	1.490	1.116	1198	193.8	280.3	6.04	128.9	11.64	18.60	–30
–25	0.03591	626.8	0.96911	143.51	549.98	0.7836	2.4216	2.206	1.514	1.116	1171	195.1	264.7	6.16	126.6	12.05	17.96	–25
–20	0.04521	621.7	0.78237	154.60	556.98	0.8278	2.4173	2.226	1.538	1.116	1144	196.3	250.3	6.28	124.3	12.46	17.32	–20
–15	0.05635	616.6	0.63759	165.79	564.02	0.8715	2.4141	2.246	1.563	1.117	1116	197.5	237.0	6.41	122.0	12.88	16.69	–15
–10	0.06955	611.4	0.52415	177.08	571.08	0.9147	2.4120	2.267	1.589	1.117	1089	198.5	224.7	6.53	119.8	13.30	16.06	–10
–5	0.08509	606.1	0.43441	188.48	578.17	0.9576	2.4108	2.289	1.616	1.118	1062	199.4	213.2	6.65	117.5	13.74	15.44	–5
–0.49[b]	0.10132	601.3	0.36910	198.87	584.58	0.9959	2.4105	2.310	1.641	1.119	1038	200.1	203.5	6.76	115.5	14.14	14.88	–0.49
0	0.10323	600.7	0.36275	200.00	585.27	1.0000	2.4105	2.312	1.644	1.119	1035	200.2	202.5	6.77	115.3	14.19	14.82	0
2	0.11127	598.6	0.33818	204.64	588.12	1.0169	2.4106	2.321	1.655	1.120	1024	200.5	198.4	6.82	114.4	14.37	14.58	2
4	0.11980	596.4	0.31562	209.30	590.97	1.0337	2.4108	2.331	1.667	1.120	1014	200.7	194.4	6.87	113.6	14.55	14.33	4
6	0.12882	594.2	0.29488	213.98	593.82	1.0505	2.4112	2.341	1.678	1.121	1003	201.0	190.6	6.91	112.7	14.74	14.09	6
8	0.13837	592.0	0.27578	218.68	596.67	1.0672	2.4116	2.350	1.690	1.122	992	201.2	186.8	6.96	111.8	14.93	13.85	8
10	0.14845	589.8	0.25817	223.40	599.53	1.0838	2.4122	2.360	1.702	1.122	981	201.4	183.2	7.01	111.0	15.11	13.60	10
12	0.15909	587.6	0.24192	228.13	602.38	1.1005	2.4129	2.371	1.715	1.123	971	201.6	179.6	7.06	110.1	15.31	13.36	12
14	0.17031	585.4	0.22691	232.89	605.24	1.1170	2.4137	2.381	1.727	1.124	960	201.7	176.1	7.11	109.3	15.50	13.12	14
16	0.18213	583.1	0.21302	237.68	608.09	1.1335	2.4146	2.391	1.740	1.125	949	201.9	172.7	7.16	108.4	15.69	12.88	16
18	0.19457	580.9	0.20016	242.48	610.95	1.1500	2.4156	2.402	1.752	1.126	938	202.0	169.4	7.21	107.6	15.89	12.65	18
20	0.20765	578.6	0.18823	247.30	613.80	1.1665	2.4167	2.413	1.765	1.127	928	202.0	166.2	7.26	106.7	16.09	12.41	20
22	0.22139	576.3	0.17717	252.15	616.66	1.1829	2.4179	2.424	1.778	1.128	917	202.1	163.0	7.31	105.9	16.29	12.17	22
24	0.23582	574.0	0.16688	257.02	619.51	1.1992	2.4191	2.435	1.792	1.129	906	202.1	159.9	7.36	105.1	16.49	11.94	24
26	0.25095	571.7	0.15732	261.91	622.36	1.2155	2.4205	2.446	1.805	1.130	895	202.2	156.9	7.41	104.3	16.70	11.70	26
28	0.26680	569.3	0.14842	266.82	625.21	1.2318	2.4219	2.458	1.819	1.131	885	202.1	153.9	7.47	103.5	16.90	11.47	28
30	0.28341	567.0	0.14012	271.76	628.06	1.2481	2.4234	2.470	1.833	1.133	874	202.1	151.1	7.52	102.7	17.11	11.24	30
32	0.30079	564.6	0.13238	276.72	630.91	1.2643	2.4250	2.481	1.847	1.134	863	202.0	148.2	7.57	101.9	17.33	11.00	32
34	0.31897	562.2	0.12516	281.71	633.75	1.2805	2.4266	2.494	1.862	1.136	853	201.9	145.5	7.62	101.1	17.54	10.77	34
36	0.33796	559.8	0.11841	286.72	636.59	1.2966	2.4283	2.506	1.876	1.137	842	201.8	142.8	7.68	100.3	17.76	10.54	36
38	0.35779	557.4	0.11209	291.76	639.42	1.3127	2.4301	2.518	1.891	1.139	831	201.7	140.2	7.73	99.5	17.98	10.32	38
40	0.37849	554.9	0.10618	296.82	642.25	1.3288	2.4319	2.531	1.906	1.141	820	201.5	137.6	7.79	98.7	18.21	10.09	40
42	0.40007	552.4	0.10065	301.90	645.08	1.3449	2.4338	2.544	1.922	1.143	810	201.3	135.0	7.84	97.9	18.43	9.86	42
44	0.42256	550.0	0.09545	307.02	647.90	1.3609	2.4358	2.557	1.937	1.145	799	201.1	132.5	7.90	97.2	18.66	9.64	44
46	0.44599	547.4	0.09058	312.15	650.71	1.3769	2.4378	2.571	1.953	1.147	788	200.8	130.1	7.95	96.4	18.90	9.41	46
48	0.47038	544.9	0.08600	317.32	653.52	1.3929	2.4398	2.585	1.970	1.149	777	200.5	127.7	8.01	95.7	19.14	9.19	48
50	0.49575	542.3	0.08170	322.51	656.32	1.4089	2.4419	2.598	1.986	1.151	767	200.2	125.4	8.07	94.9	19.38	8.97	50
55	0.56365	535.8	0.07201	335.62	663.28	1.4488	2.4473	2.635	2.029	1.158	740	199.2	119.7	8.22	93.1	20.00	8.42	55
60	0.63824	529.1	0.06366	348.91	670.19	1.4885	2.4529	2.673	2.075	1.165	713	198.1	114.3	8.38	91.3	20.64	7.87	60
65	0.71991	522.3	0.05642	362.39	677.02	1.5282	2.4587	2.713	2.123	1.173	685	196.7	109.1	8.54	89.5	21.32	7.34	65
70	0.80908	515.2	0.05012	376.06	683.77	1.5679	2.4646	2.756	2.174	1.183	658	195.1	104.1	8.71	87.8	22.03	6.81	70
75	0.90616	507.9	0.04462	389.95	690.41	1.6075	2.4705	2.802	2.229	1.194	631	193.3	99.3	8.89	86.1	22.77	6.29	75
80	1.0116	500.4	0.03978	404.06	696.94	1.6471	2.4765	2.851	2.288	1.207	603	191.2	94.7	9.08	84.5	23.56	5.78	80
85	1.1258	492.6	0.03552	418.40	703.32	1.6868	2.4824	2.905	2.353	1.223	575	188.8	90.2	9.29	82.9	24.39	5.28	85
90	1.2493	484.5	0.03175	433.00	709.53	1.7266	2.4881	2.964	2.425	1.241	546	186.1	85.8	9.51	81.3	25.28	4.79	90
95	1.3825	476.0	0.02840	447.87	715.53	1.7665	2.4936	3.029	2.506	1.263	518	183.1	81.6	9.75	79.7	26.23	4.31	95
100	1.5259	467.1	0.02541	463.03	721.29	1.8066	2.4987	3.102	2.599	1.290	488	179.8	77.4	10.01	78.2	27.26	3.84	100
105	1.6801	457.8	0.02273	478.51	726.75	1.8469	2.5034	3.186	2.708	1.324	458	176.1	73.3	10.29	76.8	28.37	3.38	105
110	1.8456	447.9	0.02032	494.36	731.87	1.8876	2.5075	3.285	2.841	1.366	428	172.0	69.3	10.61	75.3	29.60	2.93	110
115	2.0230	437.3	0.01813	510.61	736.55	1.9287	2.5108	3.403	3.004	1.420	396	167.5	65.4	10.96	73.9	30.96	2.50	115
120	2.2131	425.9	0.01615	527.34	740.69	1.9704	2.5131	3.552	3.213	1.492	364	162.5	61.4	11.37	72.5	32.50	2.08	120
125	2.4166	413.4	0.01432	544.65	744.15	2.0129	2.5140	3.748	3.493	1.592	331	157.0	57.4	11.83	71.1	34.29	1.68	125
130	2.6344	399.6	0.01264	562.68	746.70	2.0566	2.5130	4.023	3.891	1.739	296	150.8	53.4	12.39	69.8	36.44	1.30	130
135	2.8675	383.7	0.01105	581.69	747.97	2.1020	2.5094	4.450	4.511	1.973	260	144.1	49.2	13.07	68.4	39.16	0.94	135
140	3.1172	364.7	0.00953	602.17	747.29	2.1502	2.5015	5.227	5.631	2.405	222	136.5	44.7	13.97	67.3	42.94	0.60	140
145	3.3853	339.9	0.00801	625.32	743.11	2.2041	2.4858	7.147	8.349	3.462	182	128.0	39.6	15.27	66.7	49.21	0.31	145
150	3.6746	297.7	0.00621	656.27	729.01	2.2755	2.4474	19.80	25.55	10.14	136	117.8	32.5	17.87	73.0	67.32	0.06	150
151.98[c]	3.7960	228.0	0.00439	693.91	693.91	2.3631	2.3631	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	151.98

[a]Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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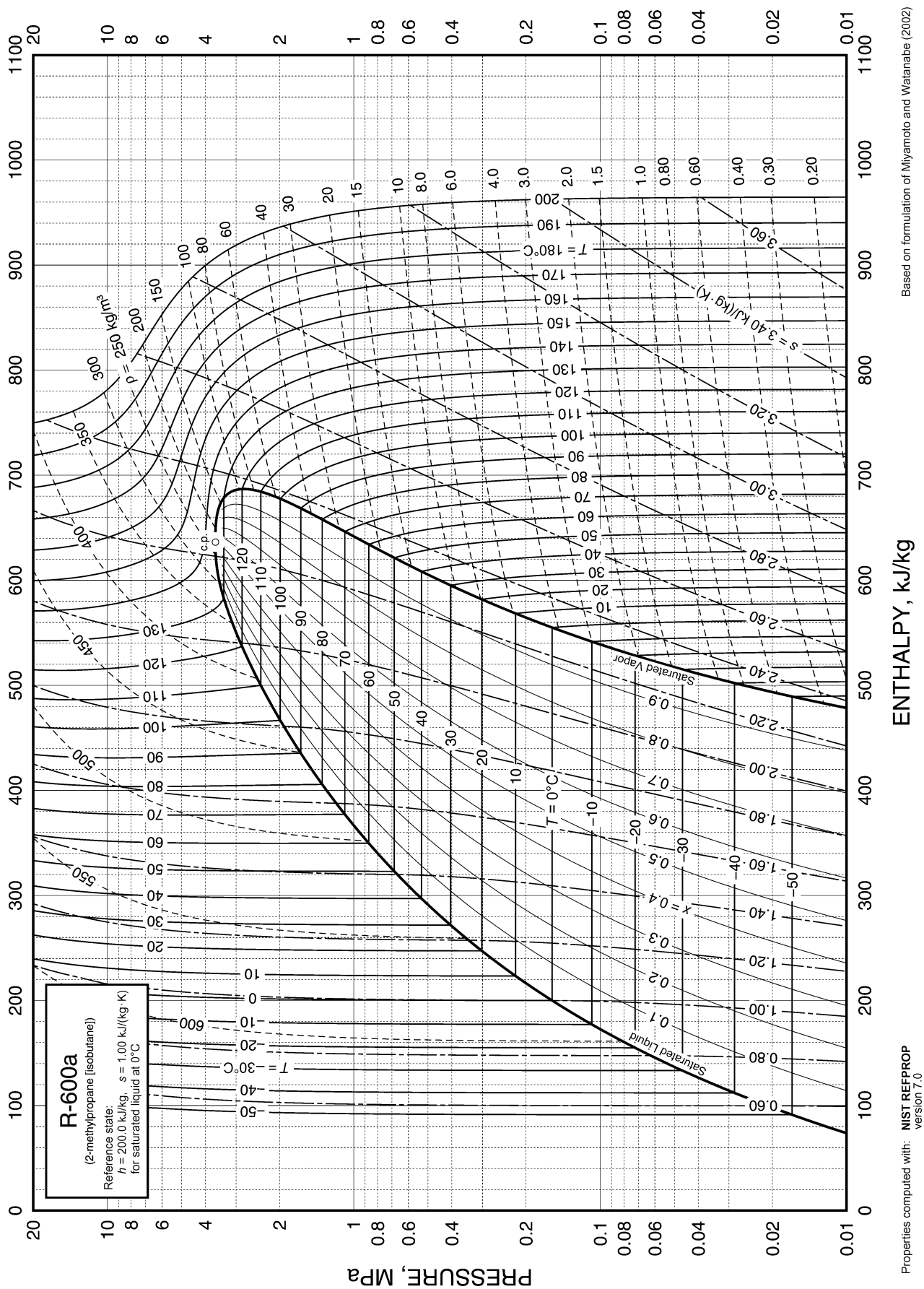

Properties computed with: NIST REFPROP version 7.0

Based on formulation of Miyamoto and Watanabe (2002)

Fig. 23 Pressure-Enthalpy Diagram for Refrigerant 600a (Isobutane)

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Refrigerant 600a (Isobutane) Properties of Saturated Liquid and Saturated Vapor

Temp.,[a] °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp., °C
–100	0.00038	683.9	65.234	–6.40	428.19	0.0671	2.5770	1.878	1.131	1.145	1558	168.3	936.5	4.40	140.0	6.03	25.52	–100
–95	0.00062	679.1	41.078	3.04	433.86	0.1208	2.5391	1.894	1.151	1.143	1526	170.5	837.2	4.53	138.0	6.39	24.88	–95
–90	0.00098	674.2	26.648	12.55	439.62	0.1734	2.5052	1.911	1.171	1.140	1494	172.6	753.2	4.65	136.0	6.76	24.24	–90
–85	0.00151	669.4	17.764	22.14	445.46	0.2251	2.4750	1.927	1.191	1.138	1462	174.7	681.3	4.78	134.0	7.13	23.59	–85
–80	0.00227	664.5	12.140	31.82	451.39	0.2759	2.4481	1.944	1.212	1.136	1431	176.7	619.2	4.91	131.9	7.50	22.96	–80
–75	0.00333	659.5	8.4874	41.59	457.40	0.3258	2.4242	1.961	1.233	1.134	1400	178.7	565.3	5.03	129.8	7.88	22.32	–75
–70	0.00478	654.6	6.0592	51.44	463.48	0.3749	2.4031	1.979	1.254	1.132	1370	180.6	518.1	5.16	127.7	8.27	21.68	–70
–65	0.00671	649.6	4.4096	61.38	469.63	0.4232	2.3845	1.997	1.276	1.130	1340	182.4	476.6	5.28	125.6	8.67	21.05	–65
–60	0.00927	644.6	3.2662	71.41	475.86	0.4708	2.3683	2.015	1.298	1.129	1309	184.2	439.8	5.41	123.5	9.06	20.41	–60
–55	0.01258	639.5	2.4590	81.54	482.14	0.5177	2.3541	2.034	1.321	1.128	1280	185.9	407.0	5.53	121.3	9.47	19.78	–55
–50	0.01680	634.4	1.8792	91.76	488.49	0.5640	2.3419	2.054	1.344	1.126	1250	187.5	377.6	5.65	119.2	9.88	19.16	–50
–45	0.02211	629.3	1.4561	102.09	494.89	0.6098	2.3315	2.074	1.368	1.126	1220	189.0	351.2	5.78	117.1	10.29	18.53	–45
–40	0.02870	624.1	1.1427	112.51	501.35	0.6549	2.3227	2.094	1.393	1.125	1191	190.4	327.4	5.90	115.0	10.71	17.91	–40
–35	0.03680	618.9	0.90737	123.04	507.85	0.6995	2.3154	2.115	1.418	1.125	1162	191.8	305.8	6.02	112.9	11.14	17.29	–35
–30	0.04662	613.6	0.72839	133.68	514.40	0.7437	2.3095	2.137	1.444	1.125	1133	193.0	286.2	6.14	110.8	11.57	16.67	–30
–25	0.05843	608.3	0.59062	144.43	520.99	0.7874	2.3048	2.159	1.471	1.125	1104	194.1	268.3	6.26	108.7	12.01	16.05	–25
–20	0.07248	602.9	0.48339	155.30	527.61	0.8306	2.3013	2.182	1.499	1.125	1075	195.1	251.9	6.38	106.6	12.45	15.44	–20
–15	0.08905	597.4	0.39904	166.29	534.26	0.8735	2.2989	2.206	1.527	1.126	1047	196.0	236.9	6.50	104.6	12.90	14.83	–15
–11.75[b]	0.10133	593.8	0.35378	173.49	538.60	0.9012	2.2979	2.222	1.547	1.126	1028	196.5	227.8	6.58	103.3	13.20	14.44	–11.75
–10	0.10845	591.9	0.33204	177.40	540.93	0.9160	2.2975	2.231	1.557	1.127	1018	196.8	223.1	6.62	102.6	13.36	14.23	–10
–5	0.13098	586.3	0.27833	188.63	547.63	0.9582	2.2969	2.256	1.587	1.128	990	197.4	210.3	6.74	100.6	13.83	13.63	–5
0	0.15696	580.6	0.23491	200.00	554.34	1.0000	2.2972	2.283	1.619	1.130	961	197.9	198.6	6.86	98.6	14.30	13.03	0
2	0.16839	578.3	0.21989	204.59	557.02	1.0167	2.2975	2.293	1.632	1.131	950	198.0	194.1	6.91	97.9	14.49	12.79	2
4	0.18045	576.0	0.20604	209.19	559.71	1.0333	2.2980	2.304	1.645	1.132	939	198.2	189.8	6.96	97.1	14.68	12.55	4
6	0.19316	573.6	0.19324	213.82	562.40	1.0498	2.2985	2.316	1.658	1.132	928	198.3	185.6	7.01	96.3	14.88	12.32	6
8	0.20654	571.3	0.18140	218.47	565.09	1.0663	2.2992	2.327	1.672	1.133	916	198.3	181.5	7.06	95.5	15.07	12.08	8
10	0.22061	568.9	0.17044	223.15	567.78	1.0828	2.3000	2.338	1.686	1.135	905	198.4	177.5	7.11	94.8	15.27	11.84	10
12	0.23541	566.5	0.16028	227.85	570.47	1.0993	2.3008	2.350	1.699	1.136	894	198.4	173.7	7.16	94.0	15.47	11.61	12
14	0.25094	564.2	0.15086	232.57	573.15	1.1157	2.3018	2.362	1.714	1.137	883	198.4	170.0	7.21	93.3	15.67	11.38	14
16	0.26724	561.7	0.14210	237.32	575.84	1.1320	2.3028	2.374	1.728	1.138	871	198.4	166.3	7.26	92.5	15.88	11.14	16
18	0.28432	559.3	0.13395	242.09	578.52	1.1484	2.3039	2.386	1.743	1.140	860	198.3	162.8	7.31	91.8	16.08	10.91	18
20	0.30222	556.9	0.12637	246.88	581.21	1.1647	2.3051	2.398	1.757	1.141	849	198.2	159.3	7.37	91.1	16.29	10.68	20
22	0.32095	554.4	0.11930	251.70	583.89	1.1810	2.3064	2.411	1.772	1.143	838	198.1	156.0	7.42	90.3	16.50	10.45	22
24	0.34054	551.9	0.11271	256.55	586.56	1.1972	2.3078	2.424	1.788	1.144	826	198.0	152.7	7.47	89.6	16.72	10.22	24
26	0.36102	549.4	0.10655	261.42	589.24	1.2134	2.3093	2.437	1.803	1.146	815	197.8	149.5	7.52	88.9	16.93	9.99	26
28	0.38240	546.9	0.10080	266.32	591.91	1.2296	2.3108	2.450	1.819	1.148	804	197.6	146.5	7.58	88.2	17.15	9.76	28
30	0.40472	544.3	0.09542	271.24	594.57	1.2458	2.3123	2.463	1.835	1.150	793	197.4	143.4	7.63	87.5	17.37	9.53	30
32	0.42800	541.7	0.09038	276.19	597.23	1.2619	2.3140	2.477	1.852	1.152	781	197.1	140.5	7.69	86.8	17.59	9.31	32
34	0.45226	539.1	0.08566	281.17	599.88	1.2780	2.3157	2.491	1.869	1.154	770	196.8	137.6	7.74	86.1	17.82	9.08	34
36	0.47753	536.5	0.08124	286.18	602.53	1.2941	2.3174	2.505	1.886	1.157	759	196.5	134.8	7.80	85.4	18.05	8.86	36
38	0.50384	533.9	0.07708	291.22	605.17	1.3102	2.3192	2.520	1.903	1.159	747	196.2	132.1	7.85	84.7	18.29	8.63	38
40	0.53121	531.2	0.07317	296.28	607.80	1.3263	2.3211	2.535	1.921	1.162	736	195.8	129.4	7.91	84.1	18.52	8.41	40
42	0.55966	528.5	0.06950	301.37	610.43	1.3423	2.3230	2.550	1.939	1.165	725	195.3	126.8	7.97	83.4	18.77	8.19	42
44	0.58923	525.8	0.06605	306.50	613.04	1.3583	2.3249	2.566	1.958	1.168	714	194.9	124.2	8.03	82.7	19.01	7.97	44
46	0.61995	523.0	0.06279	311.65	615.65	1.3744	2.3269	2.582	1.977	1.171	702	194.4	121.7	8.09	82.1	19.26	7.75	46
48	0.65182	520.2	0.05973	316.84	618.24	1.3904	2.3289	2.598	1.997	1.174	691	193.9	119.3	8.15	81.4	19.52	7.53	48
50	0.68490	517.4	0.05683	322.06	620.82	1.4064	2.3309	2.615	2.017	1.178	680	193.3	116.9	8.22	80.8	19.78	7.31	50
55	0.77299	510.2	0.05029	335.25	627.22	1.4464	2.3361	2.659	2.069	1.188	651	191.7	111.1	8.38	79.2	20.45	6.78	55
60	0.86916	502.7	0.04459	348.66	633.53	1.4863	2.3414	2.706	2.125	1.199	622	189.9	105.6	8.56	77.6	21.16	6.24	60
65	0.97386	495.0	0.03962	362.29	639.72	1.5263	2.3467	2.757	2.186	1.213	593	187.8	100.3	8.74	76.1	21.92	5.72	65
70	1.0875	487.0	0.03525	376.17	645.77	1.5664	2.3520	2.812	2.252	1.229	564	185.4	95.2	8.94	74.6	22.72	5.21	70
75	1.2107	478.6	0.03140	390.31	651.64	1.6065	2.3572	2.874	2.326	1.248	535	182.7	90.4	9.16	73.2	23.59	4.71	75
80	1.3438	469.9	0.02799	404.73	657.31	1.6469	2.3621	2.942	2.409	1.272	505	179.7	85.6	9.39	71.8	24.53	4.21	80
85	1.4874	460.7	0.02496	419.46	662.73	1.6874	2.3667	3.020	2.507	1.301	475	176.3	81.0	9.65	70.4	25.56	3.73	85
90	1.6420	451.1	0.02226	434.54	667.86	1.7283	2.3708	3.110	2.625	1.338	444	172.6	76.6	9.95	69.1	26.70	3.26	90
95	1.8081	440.7	0.01983	450.00	672.62	1.7696	2.3743	3.217	2.769	1.385	413	168.4	72.1	10.27	67.8	27.98	2.80	95
100	1.9865	429.6	0.01764	465.90	676.94	1.8114	2.3769	3.347	2.951	1.447	381	163.8	67.8	10.65	66.6	29.44	2.36	100
105	2.1778	417.6	0.01565	482.33	680.70	1.8539	2.3785	3.513	3.189	1.531	348	158.7	63.4	11.09	65.4	31.14	1.93	105
110	2.3826	404.3	0.01383	499.39	683.74	1.8974	2.3785	3.736	3.517	1.650	313	153.1	59.0	11.62	64.2	33.18	1.53	110
115	2.6019	389.4	0.01214	517.26	685.81	1.9423	2.3765	4.059	4.002	1.831	278	146.9	54.5	12.27	63.1	35.72	1.14	115
120	2.8366	372.0	0.01056	536.26	686.46	1.9893	2.3714	4.585	4.806	2.139	240	139.9	49.8	13.09	62.2	39.05	0.78	120
125	3.0880	350.6	0.00902	557.01	684.81	2.0400	2.3610	5.629	6.428	2.770	200	132.1	44.6	14.22	61.8	43.91	0.46	125
130	3.3578	321.0	0.00742	581.26	678.44	2.0985	2.3396	8.91	11.56	4.77	156	123.0	38.5	15.99	63.3	52.88	0.18	130
134.66[c]	3.6290	225.5	0.00443	633.94	633.94	2.2259	2.2259	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	134.66

[a]Temperatures on ITS-90 scale [b]Normal boiling point [c]Critical point

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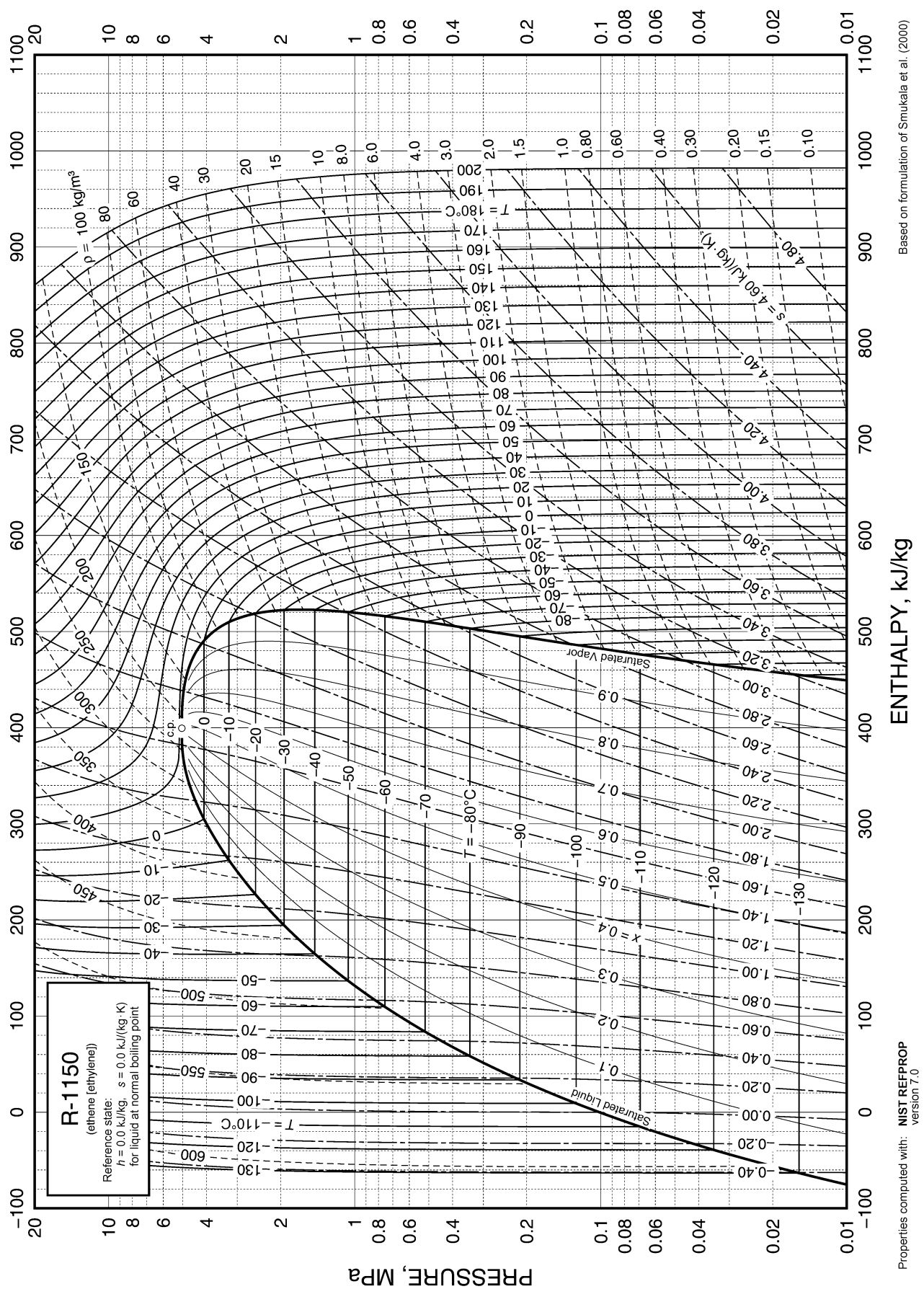

Fig. 24 Pressure-Enthalpy Diagram for Refrigerant 1150 (Ethylene)

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Refrigerant 1150 (Ethylene) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–169.16[a]	0.00012	654.6	252.640	–158.09	409.42	–1.1789	4.2787	2.429	1.187	1.333	1767	202.7	685.7	0.77	270.6	6.80	28.14	–169.16
–165	0.00025	649.3	129.690	–147.97	414.35	–1.0835	4.1160	2.432	1.188	1.333	1740	206.7	598.1	1.64	264.9	6.62	27.31	–165
–160	0.00053	643.0	62.7190	–135.81	420.24	–0.9736	3.9408	2.432	1.189	1.333	1707	211.3	514.5	2.47	258.1	6.59	26.33	–160
–155	0.00107	636.6	32.5570	–123.66	426.12	–0.8685	3.7848	2.429	1.191	1.334	1673	215.9	448.6	3.13	251.3	6.71	25.35	–155
–150	0.00203	630.1	17.9740	–111.52	431.97	–0.7679	3.6454	2.424	1.194	1.334	1639	220.3	395.8	3.66	244.5	6.92	24.38	–150
–145	0.00362	623.6	10.4720	–99.41	437.78	–0.6715	3.5204	2.419	1.198	1.335	1604	224.5	352.7	4.09	237.9	7.18	23.42	–145
–140	0.00614	617.1	6.39510	–87.33	443.54	–0.5790	3.4080	2.414	1.203	1.336	1569	228.6	317.2	4.44	231.2	7.47	22.47	–140
–135	0.01000	610.5	4.07100	–75.27	449.24	–0.4902	3.3065	2.409	1.210	1.337	1534	232.5	287.5	4.74	224.7	7.78	21.53	–135
–130	0.01565	603.8	2.68800	–63.22	454.85	–0.4046	3.2145	2.406	1.218	1.339	1498	236.3	262.3	5.00	218.3	8.09	20.59	–130
–125	0.02368	597.1	1.83310	–51.19	460.37	–0.3220	3.1310	2.404	1.228	1.341	1463	239.8	240.7	5.23	212.0	8.39	19.66	–125
–120	0.03474	590.3	1.28650	–39.16	465.79	–0.2423	3.0548	2.404	1.240	1.344	1427	243.2	222.0	5.44	205.8	8.70	18.74	–120
–115	0.04961	583.4	0.92612	–27.12	471.08	–0.1651	2.9850	2.406	1.254	1.348	1390	246.3	205.7	5.63	199.7	9.00	17.83	–115
–110	0.06911	576.5	0.68196	–15.06	476.22	–0.0903	2.9210	2.409	1.271	1.353	1354	249.2	191.3	5.81	193.7	9.30	16.93	–110
–105	0.09420	569.4	0.51239	–2.97	481.21	–0.0176	2.8619	2.416	1.290	1.358	1316	251.8	178.5	5.99	187.9	9.61	16.04	–105
–103.77[b]	0.10133	567.7	0.47899	0.00	482.41	0.0000	2.8481	2.418	1.295	1.360	1307	252.4	175.6	6.03	186.5	9.68	15.83	–103.77
–100	0.12585	562.2	0.39198	9.16	486.03	0.0532	2.8073	2.424	1.312	1.365	1279	254.2	167.0	6.16	182.2	9.92	15.16	–100
–98	0.14059	559.3	0.35377	14.02	487.90	0.0810	2.7866	2.429	1.321	1.368	1264	255.1	162.7	6.23	179.9	10.04	14.82	–98
–96	0.15662	556.4	0.32007	18.90	489.74	0.1085	2.7664	2.434	1.331	1.371	1249	255.9	158.6	6.30	177.7	10.17	14.47	–96
–94	0.17402	553.5	0.29026	23.79	491.55	0.1358	2.7468	2.439	1.342	1.375	1233	256.7	154.7	6.37	175.5	10.30	14.12	–94
–92	0.19285	550.5	0.26382	28.69	493.32	0.1628	2.7277	2.445	1.353	1.379	1218	257.4	150.9	6.44	173.3	10.44	13.78	–92
–90	0.21320	547.5	0.24030	33.60	495.06	0.1896	2.7092	2.451	1.365	1.383	1203	258.1	147.2	6.51	171.2	10.57	13.44	–90
–88	0.23514	544.5	0.21933	38.53	496.76	0.2161	2.6911	2.458	1.377	1.387	1187	258.7	143.6	6.58	169.0	10.71	13.10	–88
–86	0.25874	541.4	0.20058	43.48	498.43	0.2425	2.6734	2.465	1.391	1.392	1172	259.3	140.2	6.65	166.9	10.85	12.76	–86
–84	0.28409	538.4	0.18378	48.44	500.05	0.2686	2.6562	2.473	1.404	1.397	1156	259.9	136.9	6.72	164.8	11.00	12.42	–84
–82	0.31127	535.3	0.16869	53.41	501.64	0.2945	2.6394	2.482	1.419	1.402	1140	260.4	133.7	6.80	162.7	11.15	12.09	–82
–80	0.34034	532.2	0.15510	58.41	503.18	0.3202	2.6229	2.491	1.434	1.408	1125	260.8	130.6	6.87	160.7	11.30	11.75	–80
–78	0.37141	529.0	0.14284	63.43	504.68	0.3457	2.6069	2.501	1.450	1.414	1109	261.2	127.5	6.95	158.6	11.46	11.42	–78
–76	0.40454	525.8	0.13176	68.47	506.14	0.3711	2.5911	2.512	1.467	1.420	1093	261.5	124.6	7.02	156.6	11.62	11.09	–76
–74	0.43982	522.6	0.12172	73.53	507.55	0.3963	2.5757	2.524	1.484	1.427	1077	261.8	121.7	7.10	154.6	11.79	10.77	–74
–72	0.47733	519.3	0.11260	78.61	508.91	0.4214	2.5606	2.536	1.503	1.435	1061	262.1	118.9	7.18	152.6	11.96	10.44	–72
–70	0.51716	516.1	0.10431	83.72	510.23	0.4463	2.5457	2.549	1.522	1.443	1044	262.3	116.2	7.26	150.6	12.14	10.12	–70
–68	0.55939	512.7	0.09675	88.86	511.49	0.4710	2.5311	2.563	1.543	1.451	1028	262.4	113.6	7.34	148.6	12.33	9.80	–68
–66	0.60411	509.4	0.08985	94.03	512.70	0.4957	2.5168	2.578	1.565	1.460	1012	262.5	111.0	7.42	146.7	12.52	9.48	–66
–64	0.65141	506.0	0.08354	99.23	513.85	0.5202	2.5026	2.594	1.588	1.470	995	262.5	108.5	7.51	144.7	12.72	9.16	–64
–62	0.70136	502.5	0.07776	104.46	514.95	0.5446	2.4887	2.611	1.612	1.480	978	262.4	106.0	7.60	142.8	12.92	8.85	–62
–60	0.75406	499.0	0.07246	109.72	515.99	0.5689	2.4749	2.629	1.638	1.491	962	262.3	103.6	7.68	140.9	13.14	8.53	–60
–58	0.80960	495.5	0.06758	115.02	516.97	0.5932	2.4614	2.648	1.665	1.503	945	262.2	101.2	7.78	139.0	13.36	8.23	–58
–56	0.86807	491.9	0.06310	120.36	517.88	0.6173	2.4479	2.668	1.694	1.516	928	262.0	98.9	7.87	137.1	13.59	7.92	–56
–54	0.92955	488.2	0.05896	125.74	518.73	0.6414	2.4346	2.690	1.725	1.529	911	261.7	96.6	7.96	135.2	13.84	7.61	–54
–52	0.99414	484.5	0.05514	131.16	519.51	0.6654	2.4214	2.714	1.757	1.544	894	261.3	94.4	8.06	133.4	14.09	7.31	–52
–50	1.0619	480.8	0.05161	136.62	520.21	0.6894	2.4083	2.739	1.792	1.560	876	260.9	92.2	8.16	131.5	14.35	7.01	–50
–48	1.1330	476.9	0.04834	142.14	520.84	0.7133	2.3953	2.766	1.829	1.577	859	260.5	90.1	8.27	129.7	14.63	6.71	–48
–46	1.2075	473.0	0.04530	147.70	521.39	0.7372	2.3824	2.795	1.869	1.596	841	259.9	87.9	8.38	127.8	14.91	6.42	–46
–44	1.2854	469.1	0.04249	153.32	521.86	0.7611	2.3694	2.826	1.912	1.616	823	259.3	85.8	8.49	126.0	15.22	6.13	–44
–42	1.3669	465.0	0.03987	158.99	522.24	0.7850	2.3565	2.859	1.958	1.638	806	258.7	83.8	8.60	124.2	15.53	5.84	–42
–40	1.4521	460.9	0.03743	164.73	522.53	0.8089	2.3436	2.895	2.007	1.662	787	257.9	81.8	8.72	122.3	15.86	5.55	–40
–38	1.5410	456.7	0.03515	170.52	522.72	0.8328	2.3306	2.934	2.061	1.688	769	257.1	79.7	8.84	120.5	16.21	5.27	–38
–36	1.6339	452.4	0.03303	176.39	522.81	0.8568	2.3176	2.976	2.119	1.717	751	256.3	77.8	8.97	118.7	16.58	4.99	–36
–34	1.7307	448.0	0.03105	182.33	522.79	0.8809	2.3045	3.022	2.182	1.749	732	255.3	75.8	9.10	116.8	16.97	4.71	–34
–32	1.8315	443.5	0.02919	188.35	522.65	0.9050	2.2913	3.072	2.252	1.784	714	254.3	73.8	9.24	115.0	17.38	4.44	–32
–30	1.9366	438.9	0.02745	194.45	522.38	0.9292	2.2779	3.127	2.328	1.823	695	253.2	71.9	9.39	113.2	17.82	4.17	–30
–28	2.0459	434.1	0.02581	200.65	521.98	0.9535	2.2643	3.188	2.413	1.866	676	252.0	70.0	9.54	111.3	18.29	3.90	–28
–26	2.1596	429.2	0.02427	206.94	521.44	0.9780	2.2505	3.254	2.507	1.914	656	250.7	68.1	9.69	109.5	18.78	3.64	–26
–24	2.2779	424.2	0.02283	213.34	520.74	1.0027	2.2365	3.329	2.612	1.969	637	249.4	66.2	9.86	107.6	19.32	3.38	–24
–22	2.4008	419.0	0.02146	219.85	519.86	1.0276	2.2221	3.412	2.731	2.031	617	248.0	64.3	10.04	105.8	19.90	3.13	–22
–20	2.5284	413.6	0.02017	226.49	518.80	1.0527	2.2074	3.506	2.866	2.101	596	246.4	62.4	10.22	103.9	20.53	2.88	–20
–18	2.6610	408.0	0.01895	233.27	517.53	1.0781	2.1922	3.612	3.021	2.182	576	244.8	60.5	10.42	102.0	21.22	2.63	–18
–16	2.7985	402.2	0.01780	240.21	516.04	1.1039	2.1765	3.735	3.200	2.277	555	243.1	58.7	10.63	100.0	21.98	2.39	–16
–14	2.9412	396.1	0.01670	247.32	514.28	1.1300	2.1602	3.878	3.411	2.387	533	241.3	56.8	10.86	98.1	22.83	2.15	–14
–12	3.0893	389.8	0.01565	254.63	512.24	1.1567	2.1431	4.046	3.661	2.520	511	239.3	54.9	11.10	96.1	23.78	1.92	–12
–10	3.2428	383.0	0.01466	262.17	509.87	1.1839	2.1252	4.247	3.965	2.680	489	237.3	52.9	11.36	94.1	24.88	1.70	–10
–8	3.4019	375.9	0.01370	269.96	507.10	1.2118	2.1062	4.493	4.339	2.877	465	235.1	51.0	11.65	92.0	26.15	1.48	–8
–6	3.5669	368.3	0.01278	278.07	503.89	1.2406	2.0859	4.802	4.815	3.127	441	232.8	49.0	11.98	89.9	27.66	1.26	–6
–4	3.7379	360.1	0.01189	286.56	500.12	1.2705	2.0640	5.201	5.438	3.452	416	230.3	46.9	12.34	87.8	29.52	1.06	–4
–2	3.9152	351.1	0.01103	295.51	495.66	1.3018	2.0400	5.739	6.291	3.894	390	227.6	44.8	12.75	85.6	31.88	0.86	–2
0	4.0990	341.2	0.01018	305.06	490.32	1.3350	2.0132	6.507	7.526	4.526	362	224.6	42.6	13.23	83.5	35.04	0.67	0
5	4.5896	308.8	0.00802	333.52	470.25	1.4327	1.9243	11.680	16.100	8.720	283	214.9	36.2	15.01	79.8	52.44	0.25	5
9.20[c]	5.0418	214.2	0.00467	399.43	399.43	1.6614	1.6614	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	9.20

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

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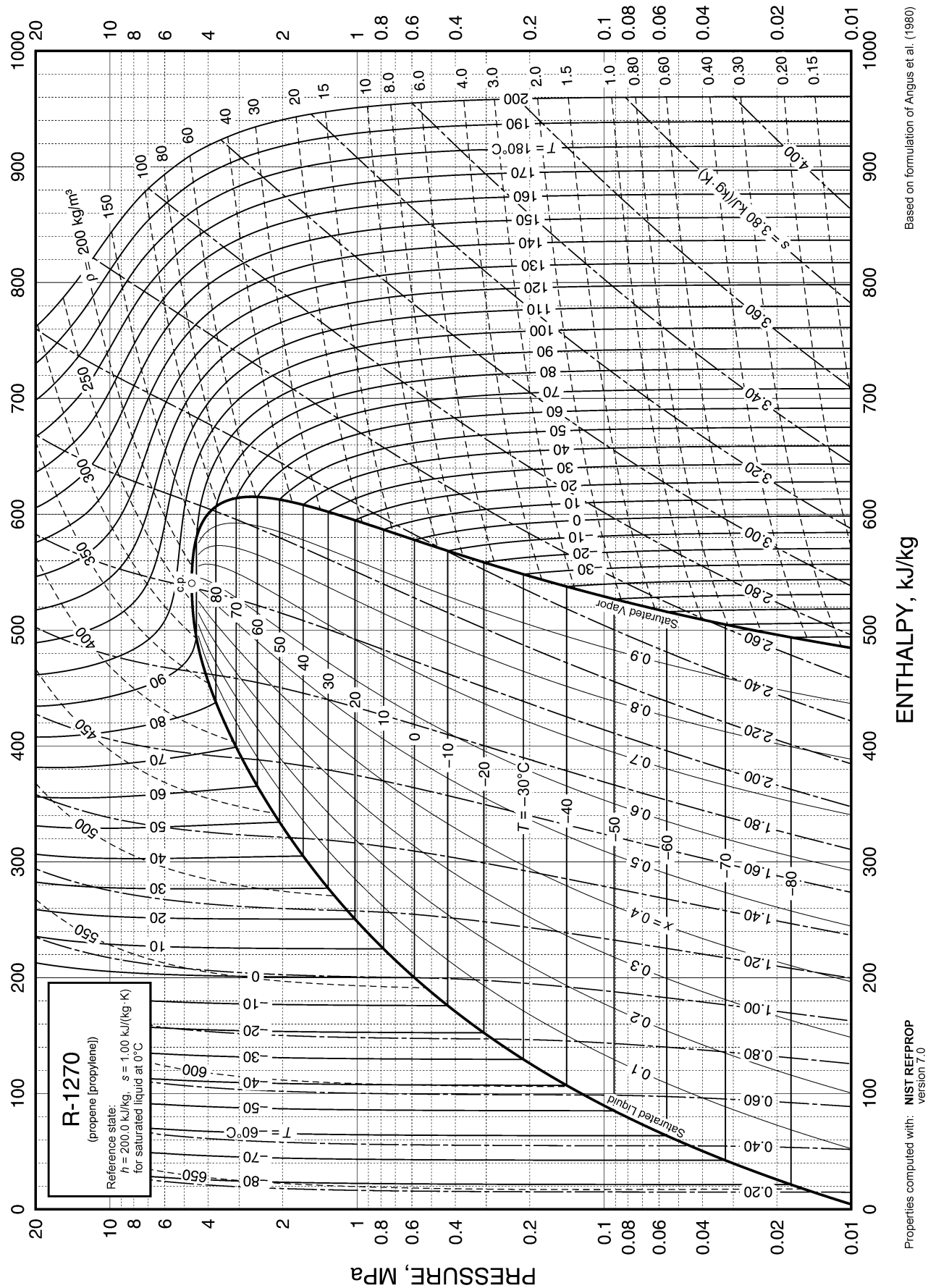

Fig. 25 Pressure-Enthalpy Diagram for Refrigerant 1270 (Propylene)

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Refrigerant 1270 (Propylene) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* °C
–150	0.00001	727.9	2789.30000	–117.02	419.51	–0.6521	3.7046	1.834	0.991	1.249	1834	174.3	1324.0	3.51	179.9	4.60	33.49	–150
–140	0.00005	716.3	583.08000	–98.37	429.53	–0.5066	3.4582	1.893	1.015	1.242	1754	180.7	945.7	3.79	177.6	5.07	31.76	–140
–130	0.00018	704.9	156.04000	–79.20	439.78	–0.3677	3.2577	1.939	1.039	1.235	1683	186.9	718.7	4.06	175.0	5.55	30.05	–130
–120	0.00059	693.6	50.84700	–59.62	450.25	–0.2356	3.0936	1.974	1.064	1.229	1617	192.7	571.2	4.34	172.2	6.06	28.36	–120
–110	0.00166	682.2	19.42300	–39.73	460.91	–0.1098	2.9588	2.002	1.090	1.223	1554	198.3	468.9	4.62	169.1	6.60	26.69	–110
–100	0.00404	670.8	8.44420	–19.59	471.73	0.0100	2.8475	2.026	1.118	1.218	1493	203.5	394.1	4.90	165.8	7.16	25.04	–100
–90	0.00881	659.4	4.08250	0.80	482.68	0.1244	2.7555	2.050	1.149	1.214	1432	208.4	337.1	5.18	162.3	7.75	23.41	–90
–80	0.01754	647.8	2.15470	21.43	493.72	0.2341	2.6793	2.075	1.183	1.211	1370	212.9	292.2	5.46	158.6	8.36	21.80	–80
–70	0.03232	636.1	1.22310	42.34	504.79	0.3395	2.6159	2.103	1.220	1.209	1309	216.9	255.9	5.73	154.7	9.01	20.22	–70
–60	0.05578	624.1	0.73772	63.55	515.84	0.4412	2.5631	2.135	1.263	1.209	1247	220.4	226.1	6.01	150.6	9.69	18.66	–60
–50	0.09111	611.9	0.46816	85.11	526.79	0.5398	2.5191	2.171	1.309	1.211	1184	223.4	201.1	6.29	146.4	10.40	17.14	–50
–48	0.09991	609.4	0.42975	89.47	528.96	0.5592	2.5112	2.179	1.319	1.211	1171	223.9	196.6	6.35	145.6	10.55	16.83	–48
–47.69[b]	0.10133	609.1	0.42416	90.14	529.30	0.5621	2.5100	2.180	1.321	1.211	1169	224.0	195.9	6.36	145.4	10.58	16.79	–47.69
–46	0.10935	606.9	0.39515	93.84	531.13	0.5784	2.5035	2.187	1.330	1.212	1158	224.4	192.2	6.40	144.7	10.70	16.53	–46
–44	0.11949	604.4	0.36390	98.23	533.29	0.5976	2.4962	2.195	1.340	1.213	1145	224.8	188.0	6.46	143.8	10.86	16.23	–44
–42	0.13033	601.9	0.33564	102.64	535.45	0.6167	2.4891	2.203	1.351	1.214	1133	225.3	183.9	6.52	143.0	11.01	15.93	–42
–40	0.14192	599.4	0.31004	107.06	537.59	0.6356	2.4822	2.212	1.362	1.215	1120	225.7	179.9	6.57	142.1	11.17	15.63	–40
–38	0.15429	596.8	0.28680	111.51	539.73	0.6545	2.4756	2.221	1.373	1.216	1107	226.1	176.0	6.63	141.2	11.33	15.34	–38
–36	0.16748	594.3	0.26566	115.97	541.85	0.6733	2.4692	2.230	1.385	1.217	1094	226.4	172.3	6.69	140.3	11.49	15.04	–36
–34	0.18152	591.7	0.24642	120.45	543.97	0.6921	2.4630	2.239	1.396	1.218	1081	226.7	168.7	6.75	139.4	11.65	14.75	–34
–32	0.19644	589.1	0.22886	124.95	546.08	0.7107	2.4570	2.249	1.408	1.220	1068	227.0	165.1	6.80	138.5	11.82	14.45	–32
–30	0.21228	586.5	0.21282	129.47	548.17	0.7292	2.4512	2.259	1.421	1.221	1056	227.3	161.7	6.86	137.6	11.99	14.16	–30
–28	0.22908	583.8	0.19814	134.01	550.26	0.7477	2.4456	2.269	1.433	1.223	1043	227.5	158.4	6.92	136.7	12.16	13.87	–28
–26	0.24687	581.2	0.18469	138.57	552.33	0.7661	2.4402	2.279	1.446	1.225	1030	227.7	155.1	6.98	135.7	12.34	13.58	–26
–24	0.26569	578.5	0.17234	143.15	554.38	0.7845	2.4350	2.290	1.459	1.227	1017	227.9	152.0	7.04	134.8	12.52	13.29	–24
–22	0.28558	575.8	0.16100	147.76	556.43	0.8027	2.4299	2.300	1.473	1.229	1004	228.1	148.9	7.10	133.9	12.70	13.00	–22
–20	0.30657	573.1	0.15056	152.38	558.46	0.8209	2.4250	2.311	1.487	1.231	991	228.2	145.9	7.17	132.9	12.89	12.72	–20
–18	0.32871	570.4	0.14093	157.03	560.48	0.8391	2.4203	2.323	1.501	1.234	978	228.3	143.0	7.23	132.0	13.08	12.43	–18
–16	0.35203	567.6	0.13206	161.71	562.48	0.8571	2.4157	2.335	1.515	1.236	965	228.3	140.2	7.29	131.0	13.28	12.15	–16
–14	0.37657	564.8	0.12385	166.40	564.46	0.8752	2.4112	2.347	1.530	1.239	952	228.3	137.4	7.36	130.1	13.48	11.87	–14
–12	0.40237	562.0	0.11626	171.12	566.43	0.8931	2.4068	2.359	1.546	1.242	939	228.3	134.8	7.42	129.1	13.68	11.59	–12
–10	0.42947	559.2	0.10924	175.87	568.37	0.9111	2.4026	2.372	1.562	1.245	925	228.2	132.1	7.49	128.2	13.89	11.31	–10
–8	0.45791	556.3	0.10272	180.64	570.30	0.9289	2.3985	2.385	1.578	1.248	912	228.1	129.6	7.56	127.2	14.11	11.03	–8
–6	0.48773	553.5	0.09667	185.44	572.22	0.9468	2.3945	2.398	1.594	1.252	899	228.0	127.1	7.63	126.2	14.33	10.76	–6
–4	0.51897	550.6	0.09105	190.27	574.11	0.9645	2.3907	2.412	1.612	1.256	886	227.8	124.6	7.69	125.3	14.55	10.48	–4
–2	0.55167	547.6	0.08582	195.12	575.98	0.9823	2.3869	2.426	1.629	1.260	873	227.6	122.2	7.77	124.3	14.78	10.21	–2
0	0.58588	544.6	0.08094	200.00	577.82	1.0000	2.3832	2.441	1.648	1.264	860	227.4	119.9	7.84	123.3	15.02	9.94	0
2	0.62163	541.6	0.07640	204.91	579.65	1.0177	2.3796	2.456	1.666	1.268	847	227.1	117.6	7.91	122.3	15.27	9.67	2
4	0.65896	538.6	0.07216	209.85	581.45	1.0353	2.3761	2.471	1.686	1.273	834	226.7	115.4	7.99	121.3	15.52	9.40	4
6	0.69793	535.5	0.06820	214.82	583.22	1.0529	2.3726	2.487	1.706	1.278	820	226.4	113.2	8.07	120.3	15.79	9.13	6
8	0.73856	532.4	0.06449	219.83	584.97	1.0705	2.3693	2.504	1.726	1.284	807	226.0	111.1	8.15	119.3	16.06	8.87	8
10	0.78091	529.3	0.06102	224.86	586.69	1.0881	2.3660	2.521	1.748	1.289	794	225.5	109.0	8.23	118.3	16.33	8.60	10
12	0.82502	526.1	0.05777	229.93	588.39	1.1056	2.3627	2.538	1.770	1.296	781	225.0	106.9	8.31	117.3	16.62	8.34	12
14	0.87093	522.9	0.05472	235.03	590.05	1.1231	2.3595	2.557	1.793	1.302	767	224.5	104.9	8.4	116.3	16.92	8.08	14
16	0.91868	519.7	0.05186	240.17	591.68	1.1407	2.3563	2.575	1.817	1.309	754	223.9	102.9	8.48	115.3	17.23	7.82	16
18	0.96832	516.4	0.04917	245.34	593.28	1.1582	2.3532	2.595	1.842	1.316	741	223.3	101.0	8.57	114.3	17.55	7.56	18
20	1.01990	513.0	0.04664	250.55	594.84	1.1756	2.3501	2.615	1.867	1.324	727	222.6	99.1	8.67	113.3	17.88	7.31	20
22	1.07350	509.6	0.04426	255.8	596.37	1.1931	2.3470	2.637	1.894	1.333	714	221.9	97.2	8.76	112.2	18.22	7.05	22
24	1.12900	506.2	0.04202	261.09	597.86	1.2106	2.3440	2.659	1.923	1.342	701	221.1	95.4	8.86	111.2	18.58	6.80	24
26	1.18670	502.7	0.03990	266.42	599.31	1.2281	2.3409	2.682	1.952	1.351	687	220.3	93.6	8.97	110.2	18.95	6.55	26
28	1.24650	499.2	0.03791	271.79	600.72	1.2456	2.3378	2.706	1.983	1.362	674	219.4	91.8	9.06	109.2	19.34	6.31	28
30	1.30840	495.6	0.03602	277.21	602.08	1.2631	2.3348	2.731	2.015	1.373	661	218.5	90.0	9.17	108.1	19.74	6.06	30
32	1.37250	491.9	0.03424	282.67	603.40	1.2807	2.3317	2.757	2.049	1.385	647	217.5	88.3	9.28	107.1	20.15	5.82	32
34	1.43900	488.2	0.03255	288.18	604.67	1.2982	2.3286	2.785	2.085	1.398	634	216.5	86.6	9.40	106.0	20.58	5.58	34
36	1.50770	484.4	0.03095	293.74	605.88	1.3158	2.3255	2.814	2.123	1.412	620	215.4	84.9	9.52	105.0	21.03	5.34	36
38	1.57880	480.6	0.02944	299.35	607.05	1.3334	2.3223	2.845	2.163	1.427	606	214.3	83.3	9.64	104.0	21.50	5.10	38
40	1.65230	476.7	0.02801	305.01	608.15	1.3510	2.3191	2.878	2.206	1.443	593	213.1	81.6	9.77	102.9	22.00	4.86	40
42	1.72820	472.7	0.02664	310.72	609.19	1.3687	2.3158	2.913	2.251	1.460	579	211.8	80.0	9.91	101.9	22.52	4.63	42
44	1.80670	468.6	0.02535	316.50	610.17	1.3865	2.3124	2.950	2.300	1.480	565	210.5	78.4	10.05	100.8	23.06	4.40	44
46	1.88780	464.4	0.02412	322.34	611.07	1.4043	2.3090	2.990	2.352	1.501	552	209.1	76.8	10.20	99.7	23.63	4.17	46
48	1.97150	460.2	0.02295	328.24	611.90	1.4221	2.3054	3.032	2.408	1.523	538	207.7	75.2	10.36	98.7	24.24	3.95	48
50	2.05790	455.8	0.02183	334.21	612.65	1.4401	2.3017	3.078	2.469	1.549	524	206.2	73.6	10.52	97.6	24.88	3.73	50
55	2.28610	444.4	0.01926	349.47	614.13	1.4854	2.2919	3.211	2.644	1.624	488	202.2	69.7	10.97	94.9	26.63	3.18	55
60	2.53250	432.1	0.01696	365.26	614.95	1.5315	2.2809	3.380	2.868	1.723	452	197.7	65.8	11.49	92.2	28.67	2.65	60
65	2.79810	418.8	0.01490	381.71	614.94	1.5786	2.2683	3.604	3.163	1.859	415	192.8	61.9	12.10	89.4	31.07	2.15	65
70	3.08420	404.1	0.01302	399.01	613.87	1.6273	2.2535	3.921	3.578	2.055	377	187.4	57.9	12.83	86.6	33.94	1.67	70
75	3.39220	387.4	0.01130	417.46	611.33	1.6785	2.2353	4.416	4.213	2.363	337	181.3	53.7	13.73	83.8	37.50	1.21	75
80	3.72380	367.5	0.00967	437.66	606.61	1.7335	2.2120	5.315	5.332	2.918	294	174.7	49.1	14.90	81.1	42.14	0.79	80
85	4.08100	341.7	0.00808	461.03	598.06	1.7964	2.1790	7.507	7.921	4.221	248	167.2	43.8	16.55	79.2	48.98	0.41	85
90	4.46680	298.9	0.00630	493.45	579.55	1.8829	2.1200	20.390	21.470	11.110	195	159.2	36.3	19.59	81.9	64.05	0.10	90
92.42[c]	4.66460	223.4	0.00448	540.41	540.41	2.0097	2.0097	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	92.42

*Temperatures on IPTS-68 scale [b]Normal boiling point [c]Critical point

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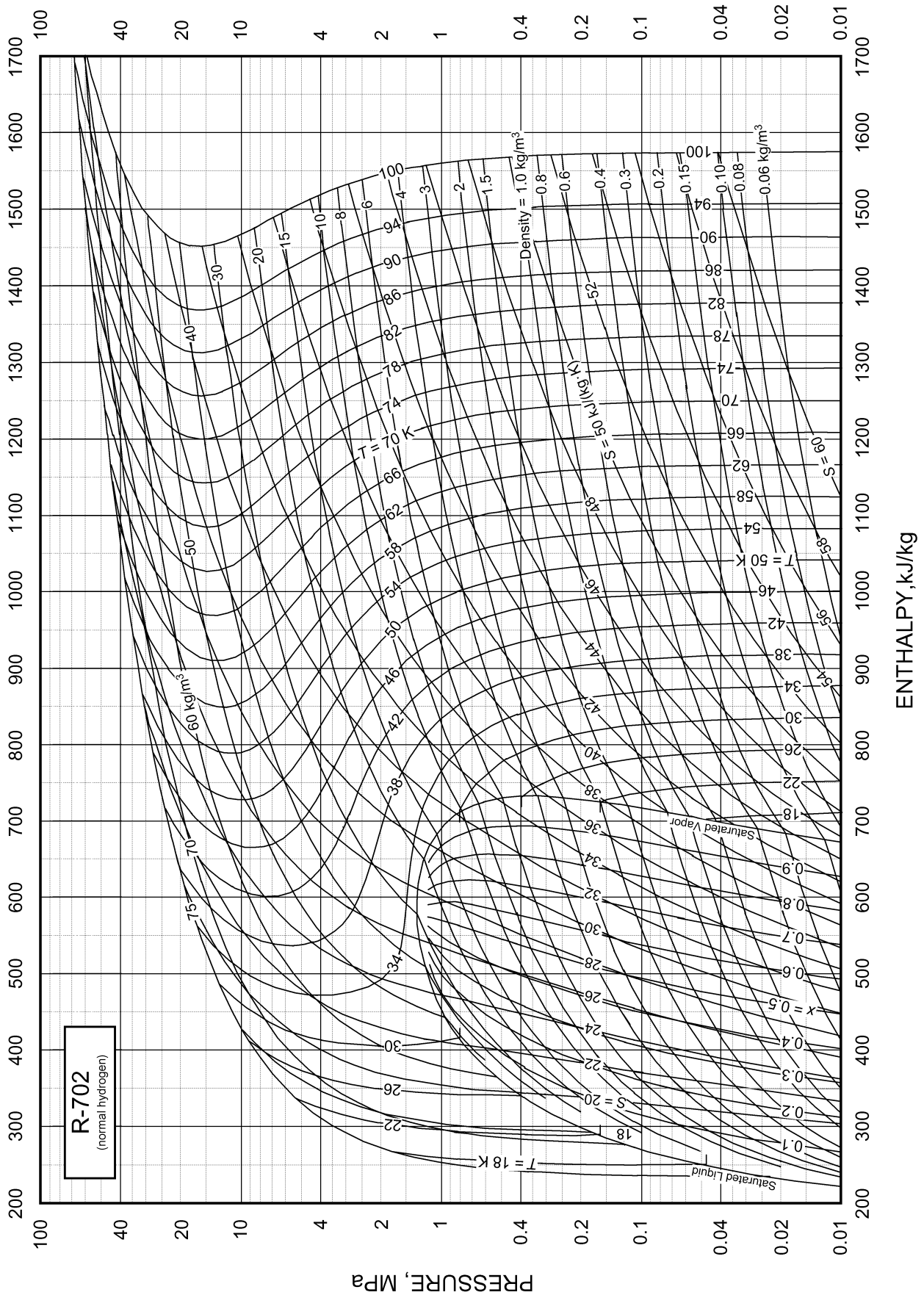

Fig. 26 Pressure-Enthalpy Diagram for Refrigerant 702 (Normal Hydrogen)

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Refrigerant 702 (Normal Hydrogen) Properties of Saturated Liquid and Saturated Vapor

Temp.,* K	Absolute Pressure, MPa	Density, kg/m³	Volume, m³/kg	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p, kJ/(kg·K)		c_p/c_v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m	Temp.,* K
		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		
13.95[a]	0.00776	76.90	7.2871	218.1	667.4	14.082	46.224	7.78	10.90	1.669	1362	304.5	25.5	0.66	76.2	10.37	3.181	13.95
14	0.00797	76.86	7.1136	218.6	667.8	14.108	46.147	7.71	10.89	1.672	1360	305.1	25.3	0.67	76.7	10.43	3.171	14
15	0.01334	76.02	4.5226	226.3	676.9	14.610	44.697	7.15	10.86	1.701	1318	316.2	22.2	0.74	84.1	11.62	2.970	15
16	0.02113	75.12	3.0172	233.4	685.6	15.075	43.411	7.30	11.00	1.719	1272	325.2	19.8	0.81	90.1	12.68	2.771	16
17	0.03200	74.18	2.0940	240.9	693.7	15.530	42.260	7.72	11.19	1.739	1226	333.2	17.8	0.87	94.8	13.68	2.575	17
18	0.04663	73.20	1.5017	249.0	701.3	15.984	41.220	8.26	11.43	1.764	1185	340.6	16.2	0.94	98.4	14.67	2.381	18
19	0.06577	72.18	1.1068	257.8	708.3	16.441	40.270	8.85	11.71	1.795	1147	347.3	14.8	1.00	101.1	15.68	2.191	19
20	0.09020	71.11	0.83478	267.3	714.6	16.904	39.393	9.49	12.04	1.833	1111	353.3	13.6	1.06	103.0	16.72	2.003	20
20.39[b]	0.10132	70.67	0.75195	271.2	716.8	17.086	39.068	9.74	12.20	1.851	1097	355.4	13.2	1.08	103.6	17.13	1.931	20.39
21	0.12072	69.96	0.64193	277.4	720.1	17.374	38.576	10.15	12.46	1.881	1075	358.6	12.6	1.12	104.2	17.81	1.819	21
22	0.15816	68.73	0.50178	288.3	724.8	17.852	37.806	10.88	12.96	1.940	1039	363.2	11.6	1.18	104.9	18.96	1.638	22
23	0.20336	67.41	0.39766	299.9	728.4	18.340	37.074	11.68	13.58	2.013	1001	367.2	10.8	1.25	105.0	20.18	1.460	23
24	0.25717	65.98	0.31878	312.3	731.0	18.840	36.369	12.58	14.35	2.106	960	370.6	10.1	1.32	104.6	21.50	1.287	24
25	0.32045	64.43	0.25795	325.8	732.3	19.351	35.683	13.65	15.34	2.224	918	373.3	9.4	1.39	103.8	22.92	1.117	25
26	0.39404	62.75	0.21028	340.3	732.2	19.877	35.007	14.94	16.63	2.378	872	375.4	8.7	1.46	102.5	24.48	0.953	26
27	0.47879	60.91	0.17233	356.1	730.4	20.421	34.331	16.56	18.36	2.586	824	376.9	8.1	1.54	100.8	26.23	0.793	27
28	0.57555	58.87	0.14165	373.5	726.5	20.989	33.642	18.72	20.79	2.877	772	377.8	7.5	1.63	98.7	28.22	0.639	28
29	0.68516	56.55	0.11647	392.7	720.2	21.596	32.925	21.85	24.41	3.310	715	378.2	6.9	1.74	96.0	30.56	0.492	29
30	0.80844	53.76	0.09540	414.7	710.5	22.267	32.157	27.13	30.32	4.013	650	378.1	6.4	1.86	92.6	33.46	0.352	30
31	0.94620	50.17	0.07735	441.4	696.2	23.059	31.298	38.73	41.37	5.321	573	377.7	5.8	2.04	88.3	37.32	0.222	31
32	1.0993	44.89	0.06132	477.9	674.4	24.112	30.271	84.77	67.41	8.383	482	377.6	5.1	2.35	82.3	43.40	0.105	32
33	1.2684	34.38	0.04665	547.5	640.5	26.097	28.951	—	—	—	—	—	—	—	—	—	0.011	33
33.19[c]	1.3152	30.11	0.03321	577.2	577.2	26.962	26.962	∞	∞	∞	0	0.0	—	—	∞	∞	0.000	33.19

*Temperatures on IPTS-68 scale [a]Triple point [b]Normal boiling point [c]Critical point

Refrigerant 702 (Normal Hydrogen) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–252.8[b]	1.3299	716.8	39.068	12.20	1.851	355.4	1.08	17.10	0	0.0899	3843.3	69.168	14.20	1.410	1261.1	8.40	172.58
–250	1.1366	749.3	40.564	11.45	1.793	385.4	1.22	19.29	5	0.0883	3914.4	69.425	14.22	1.409	1272.1	8.50	175.07
–245	0.9089	805.0	42.744	10.91	1.744	431.8	1.47	23.26	10	0.0867	3985.5	69.679	14.24	1.408	1283.0	8.61	177.56
–240	0.7609	859.0	44.508	10.69	1.720	472.2	1.72	27.06	15	0.0852	4056.8	69.928	14.27	1.407	1293.9	8.71	180.05
–235	0.6557	912.1	46.001	10.58	1.706	508.7	1.95	30.62	20	0.0838	4128.2	70.174	14.29	1.406	1304.7	8.81	182.48
–230	0.5767	964.8	47.300	10.52	1.696	542.3	2.18	34.00	25	0.0824	4199.7	70.416	14.31	1.405	1315.4	8.92	184.88
–225	0.5150	1017.4	48.452	10.49	1.688	573.6	2.40	37.23	30	0.0810	4271.3	70.654	14.32	1.405	1326.0	9.02	187.28
–220	0.4655	1069.7	49.487	10.47	1.682	603.0	2.60	40.37	35	0.0797	4342.9	70.888	14.34	1.404	1336.6	9.12	189.67
–215	0.4247	1122.1	50.429	10.48	1.676	630.6	2.80	43.47	40	0.0784	4414.7	71.119	14.36	1.403	1347.1	9.22	192.01
–210	0.3906	1174.6	51.294	10.51	1.668	656.6	2.98	46.55	45	0.0772	4486.5	71.347	14.37	1.403	1357.5	9.32	194.32
–200	0.3366	1280.1	52.845	10.62	1.650	704.1	3.34	52.56	50	0.0760	4558.3	71.571	14.38	1.402	1367.9	9.42	196.78
–190	0.2958	1387.2	54.217	10.81	1.629	746.5	3.67	58.30	55	0.0748	4630.3	71.792	14.39	1.402	1378.2	9.52	199.33
–180	0.2639	1496.4	55.457	11.05	1.604	784.7	3.98	64.12	60	0.0737	4702.3	72.010	14.40	1.401	1388.4	9.62	201.86
–170	0.2382	1608.2	56.597	11.32	1.580	819.7	4.28	70.43	65	0.0726	4774.3	72.224	14.41	1.401	1398.6	9.72	204.37
–160	0.2171	1722.8	57.657	11.61	1.556	852.3	4.57	77.02	70	0.0716	4846.4	72.436	14.42	1.401	1408.7	9.81	206.88
–150	0.1994	1840.3	58.652	11.89	1.534	883.2	4.85	83.56	75	0.0705	4918.5	72.644	14.43	1.400	1418.8	9.91	209.39
–140	0.1844	1960.7	59.592	12.17	1.515	912.7	5.12	90.15	80	0.0695	4990.7	72.850	14.44	1.400	1428.8	10.01	211.88
–130	0.1715	2083.7	60.483	12.44	1.499	941.2	5.38	96.62	85	0.0686	5062.9	73.053	14.44	1.400	1438.7	10.10	214.34
–120	0.1603	2209.3	61.331	12.68	1.484	968.8	5.64	103.03	90	0.0676	5135.1	73.254	14.45	1.400	1448.6	10.20	216.72
–110	0.1505	2337.3	62.140	12.90	1.471	995.7	5.89	109.55	95	0.0667	5207.4	73.451	14.45	1.399	1458.4	10.29	219.04
–100	0.1418	2467.3	62.913	13.10	1.461	1022.1	6.14	115.95	100	0.0658	5279.7	73.646	14.46	1.399	1468.2	10.39	221.42
–90	0.1340	2599.2	63.654	13.28	1.452	1047.9	6.38	122.20	110	0.0641	5424.3	74.029	14.47	1.399	1487.5	10.58	226.21
–80	0.1271	2732.8	64.364	13.44	1.444	1073.2	6.62	128.33	120	0.0625	5569.0	74.401	14.47	1.399	1506.7	10.77	230.86
–70	0.1208	2867.9	65.046	13.58	1.437	1098.0	6.85	134.30	130	0.0609	5713.8	74.765	14.48	1.398	1525.6	—	—
–60	0.1152	3004.4	65.702	13.71	1.431	1122.5	7.08	140.15	140	0.0594	5858.6	75.120	14.48	1.398	1544.3	—	—
–50	0.1100	3142.0	66.333	13.82	1.426	1146.5	7.31	145.84	150	0.0580	6003.4	75.466	14.49	1.398	1562.8	—	—
–40	0.1053	3280.7	66.941	13.91	1.422	1170.1	7.53	151.44	160	0.0567	6148.3	75.805	14.49	1.398	1581.0	—	—
–30	0.1010	3420.2	67.527	14.00	1.418	1193.4	7.75	156.92	170	0.0554	6293.2	76.135	14.49	1.398	1599.1	—	—
–20	0.0970	3560.6	68.093	14.07	1.415	1216.3	7.97	162.24	180	0.0542	6438.1	76.459	14.50	1.398	1616.9	—	—
–10	0.0933	3701.7	68.639	14.14	1.412	1238.8	8.19	167.47	190	0.0530	6583.1	76.775	14.50	1.398	1634.6	—	—
									200	0.0519	6728.1	77.085	14.50	1.397	1652.0	—	—

[b]Saturated vapor at normal boiling point

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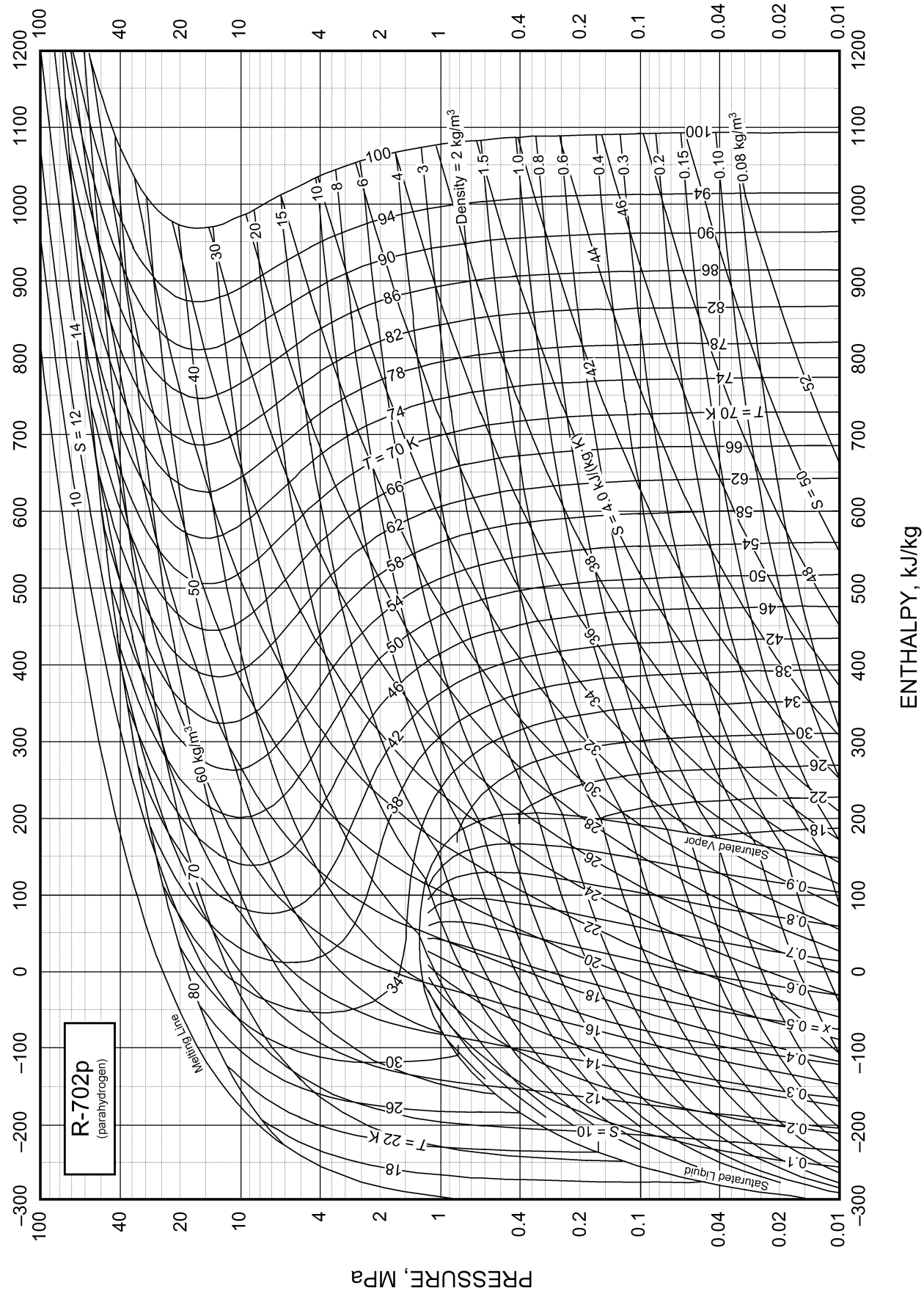

Fig. 27 Pressure-Enthalpy Diagram for Refrigerant 702p (Parahydrogen)

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Refrigerant 702p (Parahydrogen) Properties of Saturated Liquid and Saturated Vapor

Temp.,* K	Absolute Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* K
13.80[a]	0.00705	77.04	7.8437	–307.2	140.1	4.980	37.428	7.72	10.68	1.690	1373	305.0	26.0	0.65	75.3	10.46	3.124	13.80
14	0.00790	76.87	7.1198	–305.7	141.9	5.088	37.115	7.53	10.70	1.692	1364	307.0	25.3	0.67	76.9	10.65	3.086	14
15	0.01343	76.01	4.4920	–298.3	150.9	5.588	35.628	7.13	10.84	1.704	1316	316.4	22.2	0.74	84.1	11.62	2.894	15
16	0.02152	75.12	2.9640	–291.1	159.5	6.051	34.295	7.30	11.01	1.720	1269	325.1	19.8	0.81	90.0	12.60	2.705	16
17	0.03284	74.19	2.0392	–283.5	167.5	6.504	33.107	7.72	11.22	1.741	1224	333.0	17.8	0.87	94.7	13.59	2.516	17
18	0.04807	73.22	1.4541	–275.4	175.0	6.958	32.042	8.26	11.46	1.767	1183	340.3	16.2	0.94	98.3	14.60	2.330	18
19	0.06796	72.19	1.0683	–266.6	181.8	7.416	31.077	8.85	11.76	1.800	1145	346.8	14.8	1.00	101.1	15.64	2.146	19
20	0.09326	71.11	0.80448	–257.2	188.0	7.880	30.193	9.48	12.12	1.840	1109	352.6	13.6	1.06	103.0	16.71	1.963	20
20.28[b]	0.10132	70.80	0.74656	–254.4	189.5	8.009	29.960	9.66	12.23	1.853	1099	354.1	13.3	1.07	103.4	17.01	1.913	20.28
20.50	0.10818	70.54	0.70371	–252.2	190.8	8.114	29.776	9.81	12.33	1.864	1091	355.3	13.1	1.09	103.7	17.25	1.873	20.50
21	0.12474	69.96	0.61847	–247.1	193.3	8.350	29.373	10.15	12.56	1.890	1073	357.8	12.6	1.12	104.2	17.82	1.783	21
21.50	0.14305	69.35	0.54589	–241.7	195.7	8.589	28.983	10.51	12.81	1.920	1055	360.2	12.1	1.15	104.7	18.39	1.693	21.50
22	0.16320	68.73	0.48372	–236.2	197.8	8.829	28.604	10.87	13.09	1.952	1036	362.3	11.6	1.18	104.9	18.98	1.605	22
22.50	0.18529	68.08	0.43016	–230.5	199.7	9.071	28.235	11.26	13.39	1.989	1018	364.3	11.2	1.21	105.0	19.59	1.517	22.50
23	0.20942	67.42	0.38378	–224.6	201.3	9.315	27.875	11.67	13.74	2.030	999	366.2	10.8	1.25	105.0	20.21	1.429	23
23.50	0.23570	66.72	0.34340	–218.5	202.6	9.562	27.521	12.10	14.12	2.075	979	367.9	10.4	1.28	104.9	20.86	1.342	23.50
24	0.26423	66.00	0.30808	–212.1	203.6	9.811	27.174	12.56	14.56	2.127	959	369.4	10.1	1.32	104.7	21.53	1.256	24
24.50	0.29511	65.25	0.27705	–205.5	204.4	10.064	26.832	13.06	15.04	2.185	939	370.8	9.7	1.35	104.3	22.23	1.171	24.50
25	0.32845	64.47	0.24966	–198.7	204.7	10.320	26.492	13.61	15.60	2.251	918	372.1	9.4	1.39	103.8	22.95	1.086	25
26	0.40291	62.80	0.20378	–184.2	204.4	10.843	25.820	14.87	16.96	2.414	873	374.1	8.7	1.46	102.6	24.51	0.920	26
27	0.48849	60.97	0.16716	–168.4	202.3	11.385	25.145	16.47	18.81	2.635	825	375.5	8.1	1.54	100.9	26.25	0.757	27
28	0.58610	58.93	0.13744	–151.2	198.1	11.954	24.454	18.61	21.44	2.948	773	376.3	7.5	1.63	98.7	28.23	0.599	28
29	0.69673	56.60	0.11286	–132.0	191.3	12.560	23.727	21.70	25.45	3.426	716	376.4	6.9	1.74	96.0	30.57	0.445	29
30	0.82143	53.86	0.09208	–110.2	180.6	13.223	22.933	26.73	32.31	4.238	653	375.9	6.4	1.86	92.6	33.45	0.299	30
31	0.96149	50.48	0.07387	–84.4	164.1	13.981	22.011	36.68	46.58	5.916	582	374.8	5.8	2.04	88.3	37.31	0.161	31
32	1.1185	45.81	0.05667	–51.0	135.8	14.938	20.788	66.67	93.30	11.357	501	373.2	5.1	2.35	82.3	43.38	0.038	32
32.94[c]	1.2838	31.36	0.03189	40.3	40.3	17.615	17.615	∞	∞	∞	0	0.0	—	—	∞	∞	0.000	32.94

*Temperatures on IPTS-68 scale [a]Triple point [b]Normal boiling point [c]Critical point

Refrigerant 702p (Parahydrogen) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–252.9[b]	1.3395	189.5	29.960	12.23	1.853	354.1	1.07	17.01	–50	0.1100	3030.3	60.270	15.71	1.356	1118.1	7.31	164.51
–250	1.1364	223.4	31.524	11.45	1.793	385.5	1.22	19.33	–40	0.1053	3186.7	60.955	15.56	1.361	1144.9	7.53	168.14
–245	0.9088	279.1	33.703	10.91	1.744	431.8	1.47	23.27	–30	0.1010	3341.5	61.605	15.41	1.366	1171.1	7.75	171.75
–240	0.7608	333.0	35.467	10.69	1.720	472.2	1.72	27.03	–20	0.0970	3495.0	62.224	15.28	1.370	1196.8	7.97	175.31
–235	0.6557	386.2	36.960	10.58	1.706	508.7	1.95	30.58	–10	0.0933	3647.2	62.814	15.16	1.374	1221.9	8.19	178.87
–230	0.5767	438.9	38.260	10.54	1.694	542.0	2.18	33.99	0	0.0899	3798.3	63.377	15.06	1.377	1246.5	8.40	182.44
–225	0.5150	491.6	39.415	10.53	1.683	572.8	2.40	37.34	5	0.0883	3873.5	63.650	15.01	1.379	1258.6	8.50	184.23
–220	0.4655	544.3	40.456	10.57	1.672	601.2	2.60	40.72	10	0.0867	3948.5	63.917	14.97	1.381	1270.5	8.61	186.05
–215	0.4247	597.3	41.410	10.66	1.656	627.0	2.80	44.21	15	0.0852	4023.2	64.179	14.93	1.382	1282.3	8.71	187.89
–210	0.3906	651.0	42.295	10.81	1.637	650.4	2.98	47.87	20	0.0838	4097.8	64.436	14.89	1.383	1294.0	8.81	189.73
–200	0.3366	761.4	43.918	11.31	1.587	690.5	3.34	55.69	25	0.0824	4172.1	64.687	14.86	1.384	1305.6	8.92	191.58
–190	0.2958	877.9	45.409	12.01	1.532	723.9	3.67	64.19	30	0.0810	4246.4	64.934	14.83	1.386	1317.0	9.02	193.46
–180	0.2639	1002.1	46.819	12.84	1.479	753.5	3.98	73.55	35	0.0797	4320.4	65.176	14.80	1.387	1328.3	9.12	195.36
–170	0.2382	1134.8	48.171	13.69	1.435	781.3	4.28	83.79	40	0.0784	4394.3	65.414	14.77	1.388	1339.5	9.22	197.29
–160	0.2171	1275.8	49.475	14.50	1.401	808.7	4.57	94.32	45	0.0772	4468.1	65.648	14.75	1.388	1350.5	9.32	199.25
–150	0.1994	1424.3	50.732	15.17	1.376	836.2	4.85	104.41	50	0.0760	4541.8	65.878	14.72	1.389	1361.5	9.42	201.20
–140	0.1844	1578.7	51.938	15.69	1.358	864.2	5.12	113.74	55	0.0748	4615.4	66.104	14.70	1.390	1372.3	9.52	203.16
–130	0.1715	1737.6	53.088	16.05	1.347	892.4	5.38	122.26	60	0.0737	4688.9	66.326	14.69	1.391	1383.1	9.62	205.18
–120	0.1603	1899.3	54.180	16.27	1.341	920.9	5.64	129.99	65	0.0726	4762.2	66.545	14.67	1.391	1393.7	9.72	207.24
–110	0.1505	2062.6	55.213	16.37	1.338	949.5	5.89	136.76	70	0.0716	4835.6	66.760	14.65	1.392	1404.3	9.81	209.33
–100	0.1418	2226.3	56.187	16.36	1.338	978.1	6.14	142.70	75	0.0705	4908.8	66.972	14.64	1.392	1414.7	9.91	211.44
–90	0.1340	2389.6	57.104	16.29	1.340	1006.7	6.38	147.96	80	0.0695	4981.9	67.180	14.63	1.393	1425.1	10.01	213.53
–80	0.1271	2551.9	57.967	16.17	1.343	1035.1	6.62	152.62	85	0.0686	5055.1	67.386	14.62	1.393	1435.3	10.10	215.59
–70	0.1208	2712.9	58.779	16.03	1.347	1063.2	6.85	156.90	90	0.0676	5128.1	67.588	14.60	1.394	1445.5	10.20	217.63
–60	0.1152	2872.4	59.546	15.87	1.352	1090.8	7.08	160.82	95	0.0667	5201.1	67.788	14.60	1.394	1455.6	10.29	219.65
									100	0.0658	5274.1	67.985	14.59	1.394	1465.6	10.39	221.73

[b]Saturated vapor at normal boiling point

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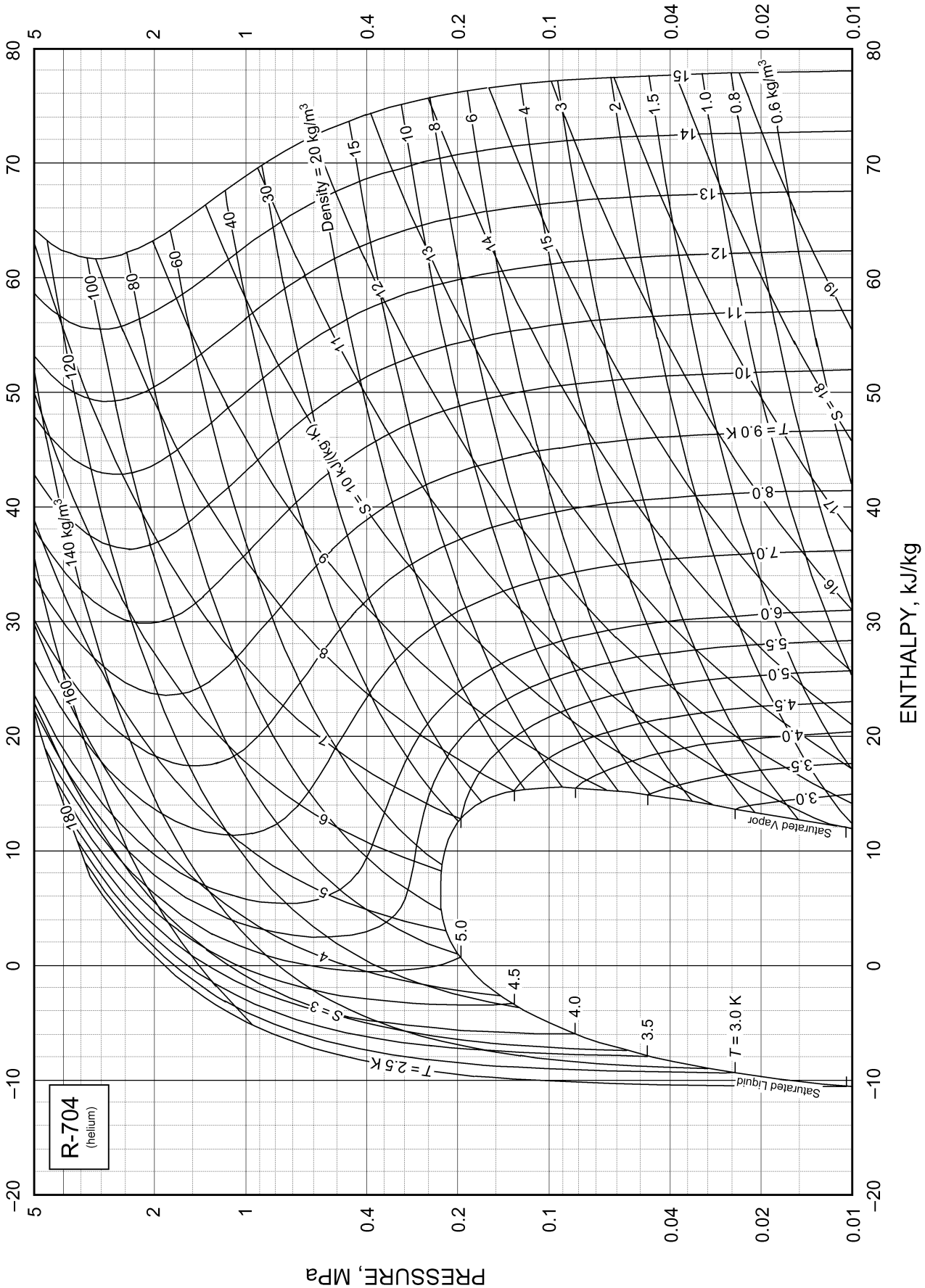

Fig. 28 Pressure-Enthalpy Diagram for Refrigerant 704 (Helium)

Note: The reference states for enthalpy and entropy differ from those in the table.

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Refrigerant 704 (Helium) Properties of Saturated Liquid and Saturated Vapor

Temp.,* K	Absolute Pressure, MPa	Density, kg/m³	Volume, m³/kg	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p, kJ/(kg·K)		c_p/c_v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m	Temp.,* K
		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		
2.18[a]	0.00486	146.24	0.87297	2.34	25.56	1.4040	12.0746	6.318	6.061	1.747	217	83.2	—	—	—	—	0.388	2.18
2.20	0.00515	146.19	0.83068	2.48	25.66	1.4682	12.0035	5.800	6.076	1.750	217	83.6	—	—	—	—	0.385	2.20
2.30	0.00653	145.87	0.67831	2.98	26.05	1.6865	11.7174	4.164	6.139	1.763	216	85.0	—	—	—	—	0.371	2.30
2.40	0.00814	145.46	0.56257	3.35	26.44	1.8414	11.4586	3.217	6.199	1.778	216	86.3	—	—	—	—	0.356	2.40
2.50	0.01000	144.96	0.47252	3.66	26.81	1.9607	11.2211	2.700	6.258	1.795	216	87.6	—	—	—	—	0.342	2.50
2.60	0.01213	144.38	0.40113	3.93	27.17	2.0604	11.0011	2.453	6.318	1.813	217	88.8	—	—	—	—	0.328	2.60
2.70	0.01454	143.72	0.34364	4.18	27.52	2.1502	10.7956	2.372	6.380	1.834	217	90.0	—	—	—	—	0.314	2.70
2.80	0.01727	143.00	0.29674	4.44	27.86	2.2356	10.6024	2.394	6.446	1.857	217	91.1	—	—	—	—	0.300	2.80
2.90	0.02032	142.21	0.25805	4.70	28.19	2.3196	10.4198	2.477	6.516	1.882	216	92.1	—	—	—	—	0.286	2.90
3.00	0.02373	141.34	0.22582	4.97	28.50	2.4039	10.2464	2.598	6.592	1.910	214	93.0	—	—	—	—	0.272	3.00
3.10	0.02750	140.42	0.19871	5.26	28.79	2.4894	10.0808	2.740	6.676	1.941	213	93.9	—	—	—	—	0.258	3.10
3.20	0.03166	139.43	0.17574	5.56	29.07	2.5765	9.9222	2.897	6.768	1.976	210	94.8	—	—	—	—	0.244	3.20
3.30	0.03622	138.38	0.15612	5.88	29.33	2.6653	9.7694	3.062	6.872	2.015	208	95.5	—	—	—	—	0.231	3.30
3.40	0.04121	137.25	0.13925	6.22	29.57	2.7559	9.6216	3.234	6.989	2.059	205	96.3	—	—	—	—	0.217	3.40
3.50	0.04664	136.06	0.12466	6.58	29.79	2.8482	9.4781	3.414	7.122	2.108	202	96.9	—	—	—	—	0.203	3.50
3.60	0.05252	134.80	0.11195	6.96	29.98	2.9422	9.3381	3.603	7.274	2.165	199	97.5	3.5	1.00	17.9	7.31	0.190	3.60
3.70	0.05888	133.45	0.10081	7.35	30.16	3.0380	9.2007	3.803	7.449	2.229	196	98.1	3.4	1.04	18.1	7.56	0.177	3.70
3.80	0.06573	132.03	0.09101	7.77	30.31	3.1355	9.0653	4.020	7.654	2.303	193	98.6	3.4	1.07	18.2	7.82	0.164	3.80
3.90	0.07310	130.51	0.08232	8.21	30.43	3.2351	8.9312	4.257	7.894	2.389	189	99.1	3.3	1.11	18.4	8.09	0.150	3.90
4.00	0.08100	128.90	0.07459	8.67	30.52	3.3367	8.7975	4.523	8.179	2.491	186	99.5	3.3	1.15	18.5	8.36	0.138	4.00
4.10	0.08945	127.17	0.06767	9.16	30.57	3.4407	8.6633	4.826	8.521	2.611	182	99.8	3.2	1.19	18.6	8.66	0.125	4.10
4.20	0.09847	125.32	0.06144	9.68	30.59	3.5475	8.5277	5.179	8.938	2.756	178	100.1	3.2	1.24	18.6	8.97	0.112	4.20
4.23[b]	0.10132	124.73	0.05967	9.84	30.59	3.5806	8.4861	5.299	9.083	2.806	176	100.2	3.2	1.25	18.7	9.06	0.108	4.23
4.30	0.10809	123.33	0.05581	10.22	30.57	3.6577	8.3896	5.600	9.455	2.934	173	100.4	3.1	1.28	18.7	9.30	0.099	4.30
4.40	0.11832	121.17	0.05067	10.80	30.50	3.7719	8.2476	6.118	10.110	3.158	169	100.6	3.1	1.33	18.8	9.66	0.087	4.40
4.50	0.12920	118.81	0.04596	11.42	30.36	3.8912	8.0999	6.776	10.964	3.448	164	100.8	3.0	1.38	18.8	10.07	0.075	4.50
4.60	0.14075	116.20	0.04161	12.09	30.16	4.0171	7.9440	7.646	12.117	3.838	159	100.9	3.0	1.43	18.8	10.54	0.063	4.60
4.70	0.15301	113.27	0.03753	12.83	29.87	4.1517	7.7767	8.863	13.754	4.388	153	101.0	2.9	1.48	18.9	11.08	0.051	4.70
4.80	0.16602	109.90	0.03367	13.64	29.45	4.2986	7.5924	10.700	16.244	5.224	147	101.1	2.8	1.55	19.0	11.76	0.040	4.80
4.90	0.17983	105.89	0.02993	14.57	28.87	4.4641	7.3821	13.813	20.464	6.637	140	101.3	2.7	1.62	19.1	12.63	0.029	4.90
5.00	0.19453	100.83	0.02617	15.69	28.02	4.6615	7.1273	20.240	29.094	9.531	133	101.6	2.6	1.70	19.3	13.86	0.018	5.00
5.10	0.21023	93.53	0.02206	17.20	26.63	4.9283	6.7774	40.770	55.866	18.545	124	102.5	2.5	1.80	19.9	15.77	0.008	5.10
5.20[c]	0.22746	69.64	0.01436	21.71	21.71	5.7639	5.7639	∞	∞	∞	0	0.0	—	—	∞	∞	0.000	5.20

*Temperatures on EPT-76 scale [a]Lower lambda point [b]Normal boiling point [c]Critical point

Refrigerant 704 (Helium) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–268.9[b]	16.758	30.59	8.4861	9.083	2.806	100.2	1.25	9.05	100	0.1307	1953.16	32.7129	5.193	1.667	1137.0	23.15	181.41
–260	3.7508	82.19	15.2748	5.327	1.708	213.6	2.72	20.17	120	0.1240	2057.02	32.9840	5.193	1.667	1167.0	24.00	188.10
–250	2.1049	134.88	18.2572	5.236	1.678	284.4	3.93	28.69	140	0.1180	2160.88	33.2417	5.193	1.667	1196.3	24.84	194.69
–240	1.4677	187.10	20.1325	5.213	1.671	340.1	4.93	35.90	160	0.1126	2264.74	33.4872	5.193	1.667	1224.9	25.67	201.19
–220	0.9155	291.20	22.5899	5.200	1.668	430.1	6.60	48.56	180	0.1076	2368.60	33.7216	5.193	1.667	1252.9	26.49	207.60
–200	0.6655	395.16	24.2500	5.196	1.667	504.3	8.04	59.86	200	0.1031	2472.46	33.9459	5.193	1.667	1280.2	27.29	213.93
–180	0.5228	499.06	25.5057	5.195	1.667	568.8	9.35	70.30	220	0.0989	2576.32	34.1609	5.193	1.667	1307.0	28.09	220.18
–160	0.4305	602.95	26.5160	5.194	1.667	626.7	10.39	80.09	240	0.0950	2680.18	34.3673	5.193	1.667	1333.2	28.88	226.35
–140	0.3659	706.82	27.3614	5.194	1.667	679.7	11.56	89.41	260	0.0915	2784.04	34.5659	5.193	1.667	1358.9	29.66	232.46
–120	0.3182	810.69	28.0882	5.193	1.666	728.8	12.68	98.32	280	0.0882	2887.90	34.7571	5.193	1.667	1384.1	30.43	238.50
–100	0.2815	914.56	28.7256	5.193	1.666	774.9	13.75	106.90	300	0.0851	2991.76	34.9416	5.193	1.667	1408.9	31.20	244.47
–80	0.2524	1018.42	29.2932	5.193	1.667	818.3	14.79	115.20	320	0.0822	3095.62	35.1197	5.193	1.667	1433.3	31.96	250.39
–60	0.2287	1122.28	29.8049	5.193	1.667	859.6	15.80	123.25	340	0.0795	3199.48	35.2919	5.193	1.667	1457.2	32.71	256.24
–40	0.2091	1226.14	30.2707	5.193	1.667	898.9	16.79	131.09	360	0.0770	3303.34	35.4586	5.193	1.667	1480.8	33.45	262.04
–20	0.1926	1330.00	30.6980	5.193	1.667	936.7	17.75	138.73	380	0.0747	3407.20	35.6201	5.193	1.667	1504.0	34.19	267.79
0	0.1785	1433.87	31.0929	5.193	1.667	972.9	18.70	146.20	400	0.0725	3511.06	35.7767	5.193	1.667	1526.8	34.92	273.48
20	0.1663	1537.73	31.4599	5.193	1.667	1007.9	19.62	153.50	420	0.0704	3614.92	35.9288	5.193	1.667	1549.3	35.65	279.13
40	0.1557	1641.58	31.8026	5.193	1.667	1041.6	20.52	160.67	440	0.0684	3718.78	36.0765	5.193	1.667	1571.5	36.37	284.73
60	0.1464	1745.44	32.1241	5.193	1.667	1074.4	21.41	167.70	460	0.0665	3822.64	36.2201	5.193	1.667	1593.4	37.08	290.28
80	0.1381	1849.30	32.4269	5.193	1.667	1106.1	22.29	174.61	480	0.0648	3926.50	36.3599	5.193	1.667	1615.0	37.79	295.78
									500	0.0631	4030.36	36.4960	5.193	1.667	1636.3	38.49	301.25

[b]Saturated vapor at normal boiling point

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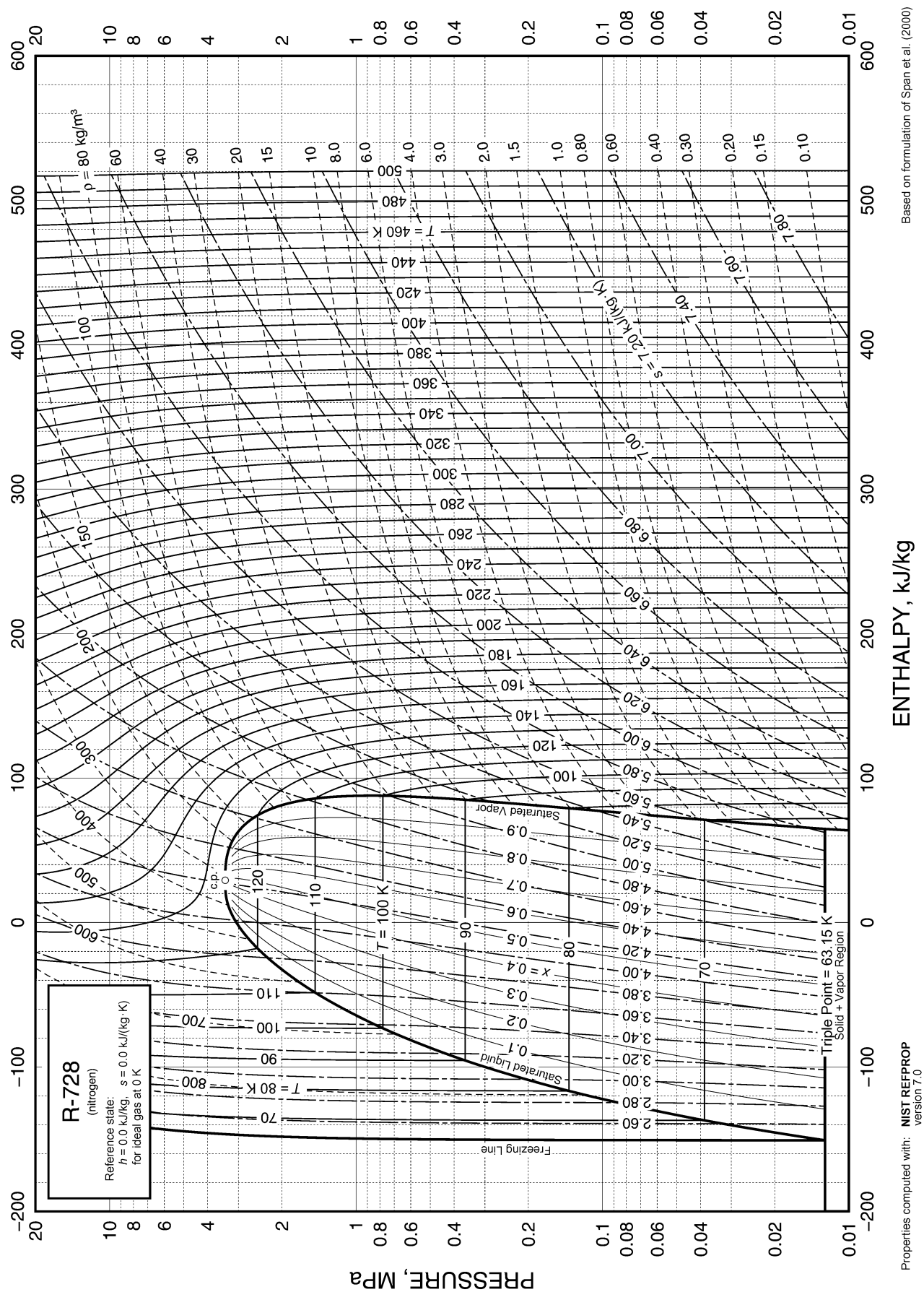

Fig. 29 Pressure-Enthalpy Diagram for Refrigerant 728 (Nitrogen)

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Refrigerant 728 (Nitrogen) Properties of Saturated Liquid and Saturated Vapor

Temp.,* K	Absolute Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* K
63.15[a]	0.01252	867.2	1.48310	–150.73	64.78	2.4257	5.8383	2.000	1.058	1.411	995	161.1	311.6	4.38	173.2	5.62	12.24	63.15
64	0.01460	863.7	1.28720	–149.03	65.59	2.4524	5.8059	2.002	1.061	1.413	987	162.1	297.5	4.44	171.5	5.71	12.03	64
66	0.02062	855.4	0.93698	–145.02	67.47	2.5140	5.7336	2.005	1.066	1.417	966	164.3	267.8	4.59	167.5	5.92	11.55	66
68	0.02848	847.0	0.69642	–141.00	69.31	2.5739	5.6667	2.010	1.073	1.421	946	166.4	242.3	4.73	163.5	6.14	11.07	68
70	0.03854	838.5	0.52743	–136.97	71.10	2.6321	5.6045	2.014	1.082	1.427	926	168.4	220.2	4.88	159.5	6.35	10.59	70
72	0.05121	829.9	0.40625	–132.93	72.83	2.6889	5.5466	2.020	1.091	1.433	906	170.3	201.1	5.03	155.5	6.58	10.12	72
74	0.06691	821.1	0.31772	–128.87	74.50	2.7442	5.4925	2.027	1.102	1.441	885	172.1	184.3	5.19	151.5	6.80	9.65	74
76	0.08610	812.2	0.25192	–124.79	76.11	2.7983	5.4417	2.035	1.114	1.450	865	173.8	169.6	5.34	147.5	7.03	9.19	76
77.35[b]	0.10132	806.1	0.21682	–122.02	77.16	2.8342	5.4090	2.041	1.124	1.457	851	174.8	160.7	5.44	144.8	7.19	8.87	77.35
78	0.10926	803.1	0.20226	–120.70	77.64	2.8511	5.3939	2.045	1.129	1.461	845	175.3	156.6	5.49	143.5	7.26	8.73	78
80	0.13687	793.9	0.16422	–116.58	79.10	2.9028	5.3487	2.056	1.145	1.473	824	176.7	145.1	5.65	139.5	7.51	8.27	80
82	0.16947	784.6	0.13470	–112.43	80.47	2.9534	5.3059	2.068	1.163	1.487	804	178.0	134.8	5.81	135.6	7.76	7.83	82
84	0.20757	775.0	0.11152	–108.26	81.75	3.0031	5.2651	2.083	1.184	1.503	783	179.2	125.6	5.97	131.6	8.01	7.38	84
86	0.25174	765.2	0.09310	–104.05	82.93	3.0520	5.2262	2.099	1.208	1.521	762	180.2	117.2	6.14	127.7	8.29	6.94	86
88	0.30251	755.2	0.07831	–99.81	84.01	3.1000	5.1888	2.119	1.235	1.542	741	181.0	109.7	6.31	123.7	8.57	6.51	88
90	0.36046	745.0	0.06632	–95.52	84.97	3.1473	5.1527	2.141	1.266	1.567	719	181.8	102.8	6.48	119.8	8.87	6.09	90
92	0.42616	734.5	0.05651	–91.18	85.81	3.1940	5.1178	2.166	1.300	1.594	697	182.4	96.5	6.66	115.9	9.19	5.67	92
94	0.50020	723.8	0.04842	–86.79	86.52	3.2401	5.0839	2.196	1.341	1.626	675	182.8	90.7	6.84	111.9	9.53	5.25	94
96	0.58316	712.7	0.04169	–82.34	87.10	3.2858	5.0507	2.231	1.387	1.664	652	183.1	85.4	7.03	108.0	9.89	4.84	96
98	0.67565	701.2	0.03605	–77.81	87.51	3.3311	5.0181	2.271	1.440	1.707	629	183.3	80.4	7.23	104.0	10.29	4.44	98
100	0.77827	689.4	0.03129	–73.21	87.77	3.3761	4.9858	2.318	1.503	1.758	605	183.3	75.8	7.43	100.1	10.73	4.05	100
105	1.08330	657.5	0.02224	–61.27	87.56	3.4882	4.9055	2.479	1.714	1.931	543	182.5	65.3	7.98	90.3	12.04	3.10	105
110	1.46580	621.5	0.01598	–48.49	85.84	3.6015	4.8226	2.743	2.062	2.221	476	180.8	56.0	8.63	80.4	13.83	2.21	110
115	1.93700	578.7	0.01146	–34.39	81.91	3.7198	4.7311	3.240	2.749	2.778	403	177.7	47.3	9.44	70.6	16.58	1.39	115
120	2.51060	523.4	0.00799	–17.87	74.17	3.8514	4.6185	4.508	4.631	4.216	317	172.6	38.4	10.62	61.0	21.72	0.66	120
125	3.20690	426.1	0.00487	6.40	55.03	4.0373	4.4263	16.720	23.740	16.930	195	160.3	26.9	13.33	56.4	41.54	0.08	125
126.19[c]	3.39580	313.3	0.00319	29.23	29.23	4.2149	4.2149	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	126.19

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

Refrigerant 728 (Nitrogen) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–195.8[b]	4.6121	77.16	5.4090	1.124	1.457	174.8	5.44	7.19
–180	3.7571	94.51	5.6133	1.081	1.432	194.0	6.51	8.72
–160	3.0593	115.90	5.8213	1.061	1.419	215.2	7.81	10.63
–140	2.5858	137.02	5.9932	1.052	1.412	234.2	9.06	12.49
–120	2.2414	158.02	6.1402	1.048	1.409	251.6	10.27	14.28
–100	1.9789	178.95	6.2687	1.045	1.406	267.9	11.42	16.03
–90	1.8696	189.40	6.3273	1.045	1.405	275.6	11.99	16.88
–80	1.7719	199.85	6.3829	1.044	1.405	283.1	12.54	17.71
–70	1.6839	210.28	6.4355	1.043	1.404	290.4	13.08	18.54
–60	1.6043	220.71	6.4857	1.043	1.404	297.5	13.61	19.35
–50	1.5320	231.14	6.5335	1.042	1.403	304.4	14.14	20.15
–40	1.4659	241.56	6.5791	1.042	1.403	311.2	14.65	20.94
–30	1.4053	251.98	6.6229	1.042	1.403	317.9	15.16	21.72
–20	1.3496	262.40	6.6649	1.042	1.402	324.4	15.66	22.49
–10	1.2981	272.82	6.7053	1.042	1.402	330.7	16.15	23.25
0	1.2504	283.23	6.7441	1.041	1.402	337.0	16.63	24.00
10	1.2061	293.65	6.7815	1.041	1.402	343.1	17.10	24.74
20	1.1648	304.06	6.8177	1.041	1.401	349.1	17.57	25.47
30	1.1263	314.47	6.8526	1.041	1.401	355.0	18.03	26.20
40	1.0903	324.89	6.8864	1.041	1.401	360.8	18.49	26.91
50	1.0565	335.30	6.9191	1.042	1.401	366.5	18.94	27.62
60	1.0247	345.72	6.9509	1.042	1.400	372.1	19.38	28.32
70	0.9948	356.14	6.9817	1.042	1.400	377.7	19.82	29.01
80	0.9666	366.56	7.0117	1.042	1.400	383.1	20.25	29.69
90	0.9399	376.99	7.0408	1.043	1.400	388.5	20.68	30.37
100	0.9147	387.42	7.0691	1.043	1.399	393.7	21.10	31.04
110	0.8908	397.85	7.0967	1.044	1.399	398.9	21.52	31.70
120	0.8681	408.30	7.1236	1.044	1.398	404.0	21.93	32.36
130	0.8466	418.74	7.1498	1.045	1.398	409.1	22.34	33.01
140	0.8261	429.20	7.1755	1.046	1.397	414.1	22.74	33.66
150	0.8065	439.66	7.2005	1.047	1.397	419.0	23.14	34.30
160	0.7879	450.14	7.2249	1.048	1.396	423.8	23.53	34.93
170	0.7701	460.62	7.2489	1.049	1.396	428.6	23.92	35.56
180	0.7531	471.12	7.2723	1.050	1.395	433.3	24.31	36.18
190	0.7368	481.62	7.2952	1.051	1.394	438.0	24.69	36.80
200	0.7212	492.14	7.3177	1.053	1.394	442.6	25.07	37.42
210	0.7063	502.67	7.3397	1.054	1.393	447.1	25.44	38.03
220	0.6920	513.22	7.3613	1.055	1.392	451.6	25.81	38.63
230	0.6782	523.78	7.3825	1.057	1.391	456.0	26.18	39.23
240	0.6650	534.36	7.4033	1.059	1.390	460.4	26.54	39.83
250	0.6523	544.95	7.4238	1.060	1.389	464.7	26.90	40.42
260	0.6401	555.56	7.4439	1.062	1.389	468.9	27.26	41.01
270	0.6283	566.19	7.4636	1.064	1.388	473.2	27.62	41.59
280	0.6169	576.84	7.4831	1.066	1.387	477.3	27.97	42.17
290	0.6060	587.50	7.5022	1.068	1.386	481.5	28.32	42.75
300	0.5954	598.19	7.5210	1.070	1.385	485.5	28.66	43.32
310	0.5852	608.90	7.5395	1.072	1.384	489.6	29.00	43.89
320	0.5753	619.62	7.5577	1.074	1.383	493.6	29.35	44.46
330	0.5658	630.37	7.5757	1.076	1.381	497.5	29.68	45.02
340	0.5565	641.14	7.5934	1.078	1.380	501.4	30.02	45.58
350	0.5476	651.93	7.6109	1.080	1.379	505.3	30.35	46.13
360	0.5390	662.74	7.6281	1.082	1.378	509.1	30.68	46.69
370	0.5306	673.58	7.6451	1.085	1.377	512.9	31.01	47.23
380	0.5225	684.44	7.6618	1.087	1.376	516.7	31.34	47.78
390	0.5146	695.32	7.6783	1.089	1.375	520.4	31.66	48.33
400	0.5069	706.22	7.6947	1.092	1.374	524.1	31.98	48.87
420	0.4923	728.10	7.7267	1.096	1.371	531.4	32.62	49.94
440	0.4785	750.08	7.7580	1.101	1.369	538.6	33.24	51.00
460	0.4655	772.15	7.7885	1.106	1.367	545.6	33.87	52.06
480	0.4531	794.32	7.8183	1.111	1.365	552.6	34.48	53.10
500	0.4414	816.59	7.8475	1.116	1.363	559.4	35.08	54.14

[b]Saturated vapor at normal boiling point

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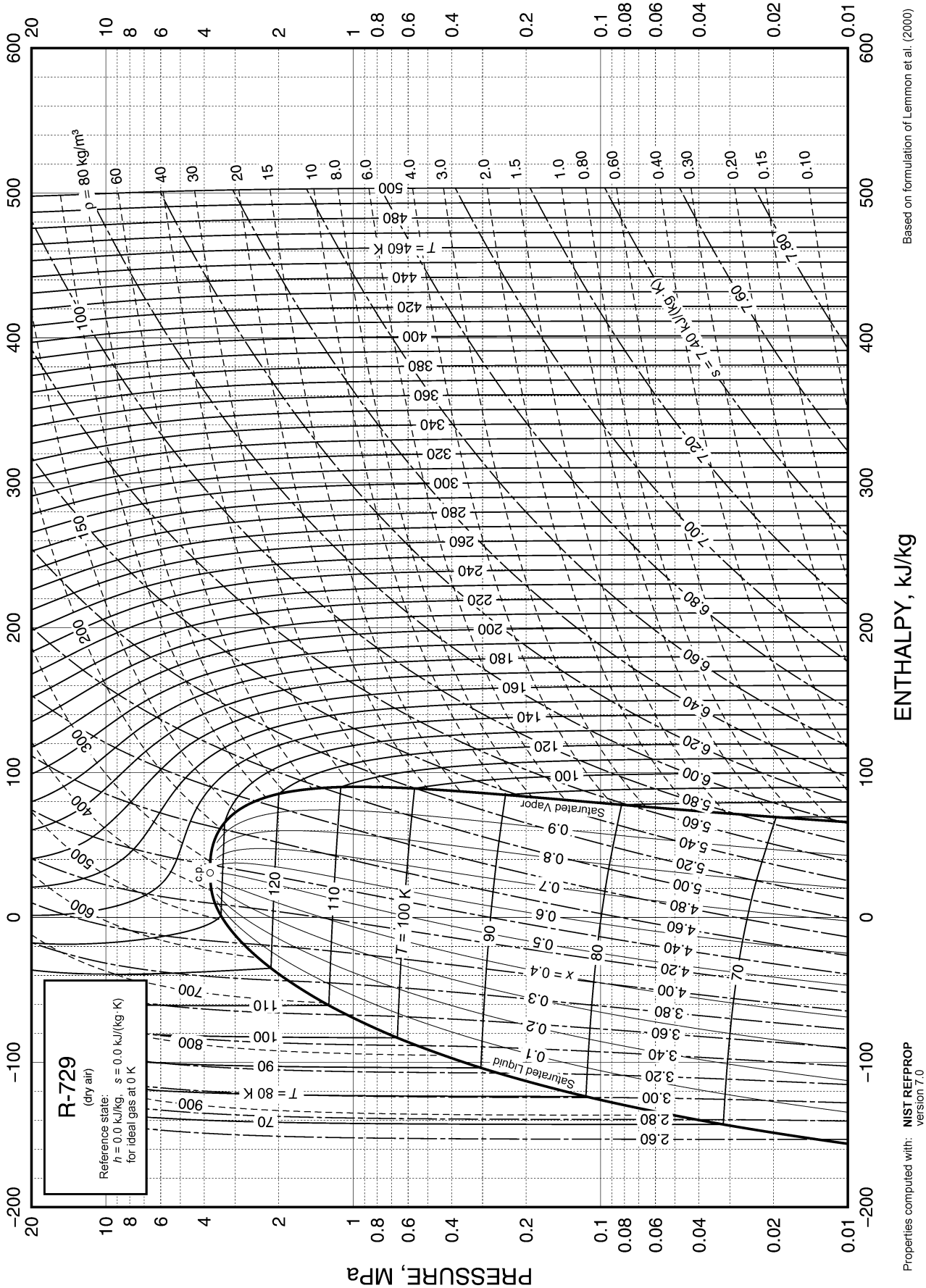

Fig. 30 Pressure-Enthalpy Diagram for Refrigerant 729 (Air)

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Refrigerant 729 (Air) Properties of Liquid on the Bubble Line and Vapor on the Dew Line

Absolute Pressure, MPa	Temperature,* K		Density, kg/m³	Volume, m³/kg	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p, kJ/(kg·K)		c_p/c_v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m
	Bubble	Dew	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	
0.00526	59.75	63.09	957.8	3.42745	–162.40	62.73	2.4517	6.1507	1.895	1.014	1.405	1056	158.9	424.8	4.47	185.2	5.83	14.95
0.008	61.83	65.12	949.2	2.32401	–158.45	64.67	2.5165	6.0614	1.897	1.017	1.407	1035	161.3	377.9	4.62	181.2	6.04	14.41
0.01	63.00	66.27	944.4	1.88990	–156.22	65.75	2.5522	6.0142	1.899	1.019	1.408	1023	162.6	354.6	4.70	179.0	6.16	14.11
0.015	65.27	68.47	934.9	1.29870	–151.92	67.82	2.6193	5.9293	1.902	1.023	1.411	1001	165.0	315.3	4.87	174.7	6.38	13.54
0.02	66.99	70.15	927.6	0.99558	–148.64	69.35	2.6687	5.8697	1.904	1.026	1.414	984	166.8	289.6	4.99	171.4	6.55	13.11
0.03	69.58	72.68	916.5	0.68481	–143.68	71.62	2.7412	5.7866	1.909	1.033	1.420	959	169.4	256.4	5.18	166.5	6.80	12.46
0.04	71.57	74.61	907.9	0.52523	–139.88	73.30	2.7948	5.7282	1.913	1.039	1.425	940	171.3	234.8	5.33	162.7	7.00	11.97
0.05	73.19	76.19	900.8	0.42756	–136.77	74.63	2.8378	5.6832	1.917	1.044	1.430	925	172.8	219.0	5.45	159.7	7.16	11.57
0.06	74.58	77.53	894.7	0.36139	–134.10	75.75	2.8738	5.6467	1.921	1.050	1.434	911	174.0	206.8	5.55	157.0	7.29	11.24
0.08	76.89	79.78	884.3	0.27713	–129.64	77.55	2.9323	5.5893	1.928	1.060	1.443	889	175.9	188.7	5.72	152.7	7.52	10.68
0.1	78.79	81.62	875.7	0.22550	–125.95	78.96	2.9794	5.5450	1.936	1.070	1.452	871	177.3	175.6	5.86	149.1	7.71	10.22
0.10132[b]	78.90	81.73	875.1	0.22277	–125.73	79.05	2.9822	5.5424	1.936	1.071	1.452	869	177.4	174.8	5.87	148.9	7.72	10.20
0.15	82.51	85.23	858.4	0.15488	–118.68	81.55	3.0688	5.4648	1.953	1.094	1.471	834	179.9	153.5	6.15	142.1	8.07	9.35
0.2	85.39	88.02	844.6	0.11849	–113.01	83.38	3.1357	5.4079	1.969	1.117	1.409	806	181.6	139.3	6.37	136.8	8.37	8.68
0.3	89.82	92.32	822.7	0.08100	–104.17	85.84	3.2353	5.3272	2.002	1.162	1.527	762	183.7	120.9	6.72	128.5	8.88	7.67
0.4	93.26	95.65	805.0	0.06165	–97.17	87.42	3.3104	5.2691	2.034	1.207	1.564	727	184.9	108.9	7.00	122.1	9.37	6.90
0.5	96.12	98.42	789.7	0.04977	–91.26	88.49	3.3715	5.2231	2.068	1.253	1.601	697	185.6	100.1	7.25	116.8	9.82	6.28
0.6	98.59	100.80	776.0	0.04169	–86.07	89.22	3.4235	5.1848	2.102	1.299	1.639	670	186.0	93.3	7.47	112.2	10.24	5.75
0.8	102.76	104.83	751.9	0.03136	–77.12	89.99	3.5098	5.1221	2.176	1.398	1.721	625	186.3	83.0	7.86	104.4	11.03	4.88
1	106.23	108.18	730.4	0.02500	–69.40	90.12	3.5811	5.0708	2.258	1.506	1.813	585	186.0	75.3	8.21	98.0	11.81	4.18
1.5	113.15	114.83	682.6	0.01623	–53.12	88.65	3.7230	4.9678	2.515	1.844	2.101	500	184.2	61.9	9.00	85.2	13.87	2.85
2	118.58	120.02	638.2	0.01162	–39.06	85.27	3.8379	4.8805	2.899	2.359	2.538	427	181.4	52.5	9.79	75.2	16.31	1.89
2.5	123.11	124.32	592.9	0.00869	–25.82	80.04	3.9407	4.7966	3.558	3.27	3.286	359	177.8	44.8	10.68	66.9	19.55	1.16
3	127.03	127.99	541.8	0.00658	–12.26	72.34	4.0419	4.7056	5.008	5.303	4.895	290	173.4	37.7	11.82	60.0	24.56	0.59
3.78781[c]	132.53	132.53	342.6	0.00292	29.38	29.38	4.3479	4.3479	—	—	—	—	—	—	—	—	—	0.00

*Temperatures on ITS-90 scale [b]Bubble and dew points at one standard atmosphere [c]Critical point

Refrigerant 729 (Air) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–191.4[d]	4.4889	79.05	5.5424	1.071	1.452	177.4	5.87	7.72	150	0.8338	424.81	7.2142	1.017	1.394	411.7	24.11	34.75
–180	3.8887	91.09	5.6804	1.044	1.435	190.8	6.68	8.84	160	0.8145	434.99	7.2379	1.019	1.394	416.4	24.52	35.39
–160	3.1648	111.75	5.8814	1.025	1.421	211.7	8.04	10.76	170	0.7961	445.18	7.2612	1.020	1.393	421.1	24.93	36.04
–140	2.6744	132.15	6.0474	1.016	1.414	230.4	9.35	12.63	180	0.7785	455.39	7.2840	1.022	1.392	425.7	25.34	36.67
–120	2.3178	152.43	6.1893	1.012	1.410	247.6	10.61	14.45	190	0.7617	465.62	7.3063	1.023	1.391	430.2	25.74	37.31
–100	2.0462	172.63	6.3133	1.009	1.408	263.5	11.82	16.20	200	0.7456	475.86	7.3282	1.025	1.390	434.7	26.13	37.93
–90	1.9332	182.71	6.3699	1.008	1.407	271.1	12.41	17.06	210	0.7302	486.12	7.3497	1.027	1.389	439.1	26.53	38.56
–80	1.8321	192.79	6.4235	1.007	1.406	278.5	12.99	17.91	220	0.7154	496.40	7.3707	1.029	1.388	443.5	26.92	39.17
–70	1.7411	202.86	6.4743	1.007	1.406	285.7	13.55	18.74	230	0.7011	506.70	7.3914	1.031	1.387	447.8	27.30	39.79
–60	1.6588	212.93	6.5227	1.007	1.405	292.7	14.11	19.56	240	0.6875	517.02	7.4117	1.033	1.386	452.0	27.69	40.40
–50	1.5840	222.99	6.5688	1.006	1.405	299.5	14.66	20.37	250	0.6743	527.35	7.4317	1.035	1.385	456.2	28.06	41.00
–40	1.5156	233.06	6.6130	1.006	1.404	306.2	15.20	21.17	260	0.6617	537.71	7.4513	1.037	1.384	460.4	28.44	41.60
–30	1.4530	243.11	6.6552	1.006	1.404	312.7	15.73	21.96	270	0.6495	548.09	7.4705	1.039	1.383	464.5	28.81	42.20
–20	1.3953	253.17	6.6957	1.006	1.404	319.1	16.25	22.74	280	0.6378	558.49	7.4895	1.041	1.381	468.6	29.18	42.80
–10	1.3421	263.23	6.7347	1.006	1.403	325.4	16.76	23.51	290	0.6264	568.91	7.5082	1.043	1.380	472.6	29.55	43.39
0	1.2927	273.29	6.7722	1.006	1.403	331.5	17.27	24.27	300	0.6155	579.35	7.5266	1.045	1.379	476.6	29.91	43.97
10	1.2469	283.35	6.8084	1.006	1.402	337.5	17.77	25.02	310	0.6049	589.82	7.5447	1.048	1.378	480.5	30.27	44.56
20	1.2043	293.41	6.8433	1.006	1.402	343.4	18.26	25.77	320	0.5947	600.30	7.5625	1.050	1.377	484.4	30.63	45.14
30	1.1644	303.48	6.8771	1.007	1.402	349.2	18.75	26.50	330	0.5849	610.81	7.5801	1.052	1.376	488.3	30.98	45.71
40	1.1272	313.55	6.9098	1.007	1.401	354.9	19.22	27.22	340	0.5753	621.35	7.5974	1.055	1.375	492.1	31.34	46.29
50	1.0922	323.62	6.9414	1.008	1.401	360.5	19.70	27.94	350	0.5661	631.90	7.6145	1.057	1.373	495.9	31.69	46.86
60	1.0594	333.70	6.9721	1.008	1.400	366.0	20.16	28.65	360	0.5572	642.48	7.6313	1.059	1.372	499.7	32.03	47.42
70	1.0284	343.79	7.0020	1.009	1.400	371.4	20.62	29.36	370	0.5485	653.09	7.6479	1.062	1.371	503.4	32.38	47.99
80	0.9993	353.88	7.0310	1.010	1.399	376.7	21.08	30.05	380	0.5401	663.71	7.6643	1.064	1.370	507.1	32.72	48.55
90	0.9717	363.98	7.0592	1.011	1.399	381.9	21.52	30.74	390	0.5320	674.37	7.6805	1.066	1.369	510.7	33.06	49.11
100	0.9456	374.09	7.0866	1.011	1.398	387.1	21.97	31.42	400	0.5241	685.04	7.6965	1.069	1.368	514.3	33.40	49.66
110	0.9209	384.21	7.1134	1.012	1.397	392.1	22.41	32.10	420	0.5089	706.47	7.7279	1.074	1.365	521.5	34.06	50.76
120	0.8975	394.34	7.1395	1.014	1.397	397.1	22.84	32.77	440	0.4947	727.98	7.7585	1.078	1.363	528.5	34.72	51.86
130	0.8752	404.49	7.1650	1.015	1.396	402.1	23.27	33.43	460	0.4812	749.60	7.7884	1.083	1.361	535.4	35.37	52.94
140	0.8540	414.64	7.1899	1.016	1.395	406.9	23.69	34.09	480	0.4684	771.31	7.8176	1.088	1.359	542.3	36.02	54.01
									500	0.4563	793.12	7.8461	1.093	1.357	549.0	36.65	55.08

[d]Saturated vapor at dew-point temperature

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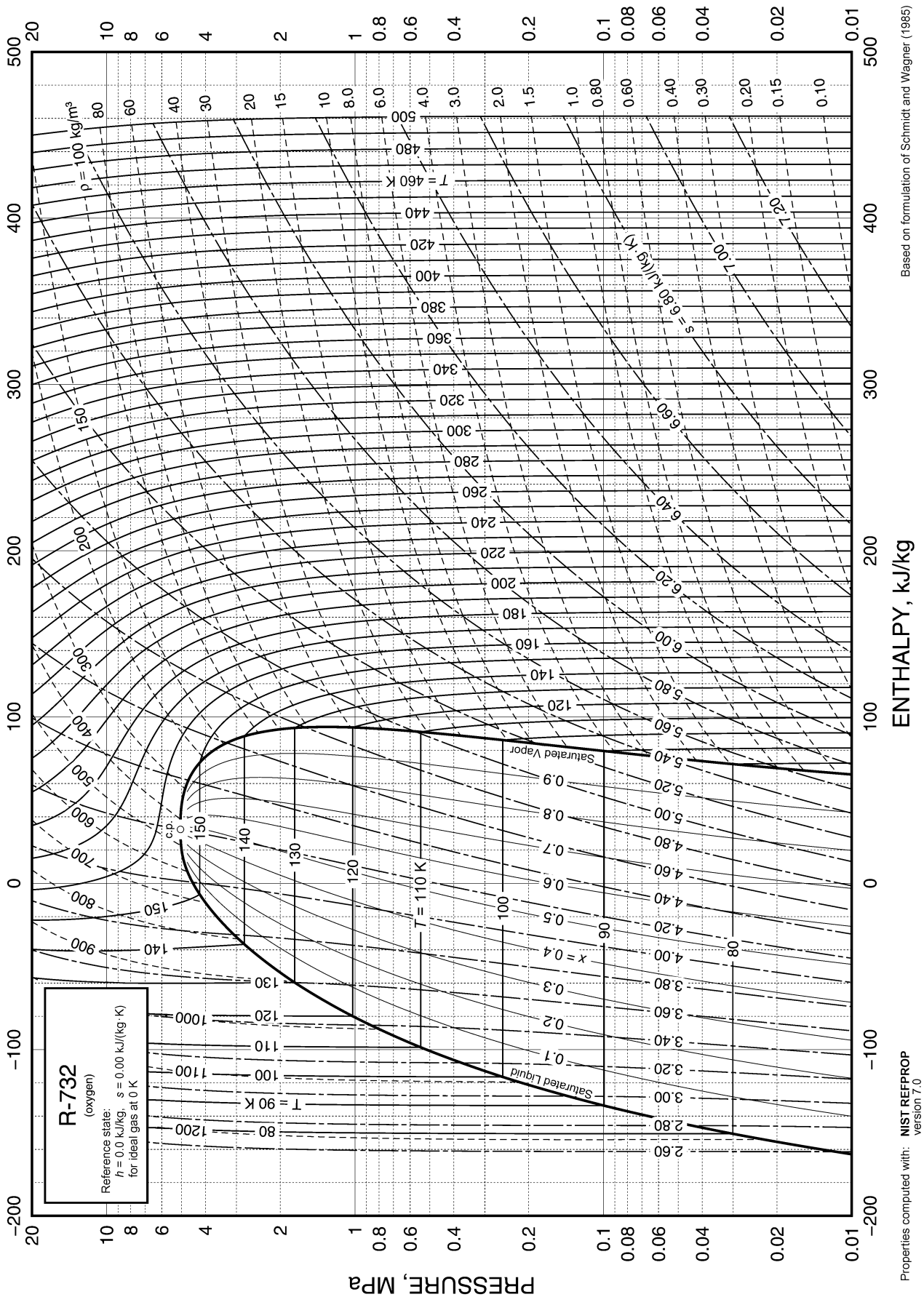

Fig. 31 Pressure-Enthalpy Diagram for Refrigerant 732 (Oxygen)

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Refrigerant 732 (Oxygen) Properties of Saturated Liquid and Saturated Vapor

Temp.,* K	Absolute Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* K
54.36[a]	0.00015	1306.1	96.54300	–193.61	49.11	2.0921	6.5571	1.673	0.926	1.395	1123	140.3	773.6	4.10	201.9	4.42	22.68	54.36
55	0.00018	1303.5	80.00900	–192.55	49.68	2.1117	6.5159	1.672	0.928	1.394	1127	141.1	747.5	4.15	201.0	4.48	22.50	55
60	0.00073	1282.0	21.46200	–184.19	54.19	2.2571	6.2301	1.673	0.948	1.390	1127	147.0	578.1	4.55	193.9	4.98	21.12	60
65	0.00233	1259.7	7.21880	–175.81	58.66	2.3912	5.9985	1.677	0.967	1.387	1102	152.6	457.9	4.96	186.8	5.49	19.76	65
70	0.00626	1237.0	2.89250	–167.42	63.09	2.5156	5.8086	1.678	0.978	1.387	1066	158.1	371.8	5.36	179.7	5.99	18.41	70
75	0.01455	1213.9	1.32930	–159.02	67.45	2.6313	5.6510	1.679	0.979	1.392	1027	163.3	308.7	5.75	172.6	6.51	17.09	75
80	0.03012	1190.5	0.68099	–150.61	71.69	2.7397	5.5185	1.682	0.974	1.402	987	168.4	261.2	6.15	165.4	7.03	15.78	80
85	0.05683	1166.6	0.38047	–142.18	75.75	2.8417	5.4055	1.688	0.969	1.417	947	173.1	224.6	6.54	158.3	7.57	14.49	85
90	0.09935	1142.1	0.22794	–133.69	79.55	2.9383	5.3076	1.699	0.970	1.436	906	177.3	195.6	6.94	151.0	8.12	13.22	90
90.19[b]	0.10133	1141.2	0.22386	–133.37	79.69	2.9419	5.3042	1.699	0.971	1.437	904	177.5	194.7	6.95	150.8	8.15	13.17	90.19
95	0.16308	1116.9	0.14450	–125.12	83.04	3.0303	5.2215	1.715	0.982	1.460	864	181.0	172.1	7.33	143.8	8.71	11.98	95
100	0.25400	1090.9	0.09592	–116.45	86.16	3.1185	5.1445	1.738	1.006	1.491	822	184.1	152.6	7.73	136.6	9.34	10.75	100
105	0.37853	1063.8	0.06612	–107.64	88.85	3.2033	5.0746	1.767	1.046	1.528	779	186.4	135.9	8.13	129.2	10.01	9.56	105
110	0.54340	1035.5	0.04699	–98.64	91.05	3.2855	5.0100	1.807	1.101	1.576	735	188.1	121.5	8.55	121.9	10.75	8.39	110
115	0.75559	1005.6	0.03424	–89.42	92.72	3.3657	4.9495	1.858	1.177	1.638	689	189.1	108.8	8.98	114.6	11.57	7.25	115
120	1.02230	973.9	0.02544	–79.90	93.75	3.4444	4.8915	1.927	1.276	1.721	642	189.4	97.4	9.43	107.2	12.51	6.14	120
125	1.35090	939.7	0.01919	–70.02	94.06	3.5222	4.8349	2.021	1.411	1.835	592	189.0	87.1	9.91	99.9	13.61	5.07	125
130	1.74910	902.5	0.01463	–59.66	93.47	3.6001	4.7780	2.153	1.600	2.000	540	187.8	77.6	10.45	92.6	14.94	4.04	130
135	2.22500	861.0	0.01120	–48.65	91.74	3.6791	4.7191	2.354	1.886	2.252	484	185.7	68.7	11.06	85.4	16.64	3.05	135
140	2.78780	813.2	0.00856	–36.70	88.47	3.7612	4.6552	2.691	2.370	2.682	423	182.8	60.2	11.82	78.2	18.98	2.13	140
145	3.44770	755.1	0.00646	–23.22	82.83	3.8498	4.5812	3.368	3.369	3.561	355	178.8	51.9	12.88	71.1	22.58	1.27	145
150	4.21860	675.5	0.00465	–6.67	72.56	3.9546	4.4828	5.464	6.625	6.315	274	172.8	42.9	14.72	64.2	29.67	0.51	150
154.58[c]	5.04300	436.1	0.00229	32.42	32.42	4.2008	4.2008	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	154.58

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

Refrigerant 732 (Oxygen) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)	Temp.,* °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–183.0[b]	4.4671	79.69	5.3042	0.971	1.437	177.5	6.95	8.15	150	0.9215	387.55	6.7333	0.948	1.379	389.3	26.96	35.69
–180	4.3120	82.52	5.3352	0.948	1.439	181.1	7.18	8.43	160	0.9002	397.05	6.7555	0.951	1.377	393.7	27.43	36.41
–160	3.5050	101.23	5.5171	0.931	1.422	201.0	8.71	10.34	170	0.8799	406.58	6.7772	0.954	1.375	398.0	27.90	37.11
–140	2.9596	119.78	5.6681	0.924	1.414	218.8	10.18	12.22	180	0.8605	416.14	6.7986	0.957	1.373	402.2	28.37	37.81
–120	2.564	138.20	5.7970	0.919	1.409	235.2	11.59	14.07	190	0.8419	425.72	6.8195	0.961	1.372	406.4	28.83	38.51
–100	2.2629	156.56	5.9096	0.916	1.407	250.4	12.96	15.88	200	0.8241	435.35	6.8400	0.964	1.370	410.5	29.28	39.21
–90	2.1378	165.72	5.9611	0.916	1.406	257.6	13.62	16.76	210	0.8070	445.00	6.8602	0.967	1.368	414.5	29.73	39.89
–80	2.0258	174.87	6.0097	0.915	1.405	264.6	14.28	17.64	220	0.7906	454.68	6.8801	0.970	1.367	418.5	30.18	40.58
–70	1.9251	184.02	6.0559	0.915	1.404	271.5	14.92	18.51	230	0.7749	464.40	6.8996	0.973	1.365	422.5	30.63	41.26
–60	1.8340	193.16	6.0998	0.914	1.404	278.1	15.55	19.37	240	0.7598	474.14	6.9188	0.976	1.363	426.4	31.06	41.94
–50	1.7512	202.30	6.1418	0.914	1.403	284.6	16.17	20.22	250	0.6743	527.35	7.4345	1.035	1.385	456.2	27.56	40.55
–40	1.6756	211.45	6.1818	0.914	1.402	290.9	16.78	21.06	260	0.7313	493.73	6.9562	0.983	1.360	434.2	31.93	43.28
–30	1.6063	220.59	6.2202	0.915	1.401	297.1	17.39	21.90	270	0.7178	503.58	6.9745	0.986	1.359	438.0	32.36	43.94
–20	1.5425	229.74	6.2571	0.915	1.401	303.1	17.98	22.72	280	0.7048	513.45	6.9925	0.989	1.357	441.7	32.78	44.61
–10	1.4836	238.90	6.2926	0.916	1.400	309.0	18.57	23.54	290	0.6923	523.36	7.0103	0.992	1.355	445.4	33.20	45.27
0	1.4290	248.06	6.3268	0.917	1.399	314.8	19.14	24.35	300	0.6802	533.29	7.0278	0.995	1.354	449.1	33.62	45.92
10	1.3784	257.23	6.3597	0.918	1.398	320.5	19.71	25.15	310	0.6686	543.26	7.0450	0.998	1.352	452.8	34.04	46.57
20	1.3312	266.41	6.3916	0.919	1.397	326.0	20.27	25.95	320	0.6573	553.26	7.0620	1.001	1.351	456.4	34.45	47.22
30	1.2871	275.61	6.4225	0.920	1.396	331.4	20.83	26.73	330	0.6464	563.28	7.0788	1.004	1.350	460.0	34.85	47.87
40	1.2459	284.82	6.4524	0.922	1.395	336.7	21.37	27.51	340	0.6358	573.34	7.0953	1.007	1.348	463.6	35.26	48.51
50	1.2073	294.05	6.4814	0.924	1.394	342.0	21.91	28.29	350	0.6256	583.43	7.1116	1.010	1.347	467.1	35.66	49.15
60	1.1709	303.29	6.5095	0.926	1.392	347.1	22.44	29.05	360	0.6157	593.54	7.1277	1.013	1.345	470.6	36.06	49.78
70	1.1367	312.56	6.5369	0.928	1.391	352.1	22.97	29.82	370	0.6062	603.68	7.1436	1.016	1.344	474.1	36.46	50.42
80	1.1045	321.85	6.5636	0.930	1.390	357.0	23.49	30.57	380	0.5969	613.86	7.1593	1.019	1.343	477.5	36.85	51.05
90	1.0740	331.16	6.5896	0.932	1.388	361.9	24.00	31.32	390	0.5879	624.05	7.1748	1.021	1.342	480.9	37.24	51.68
100	1.0452	340.49	6.6150	0.935	1.387	366.6	24.51	32.06	400	0.5792	634.28	7.1901	1.024	1.340	484.3	37.63	52.30
110	1.0179	349.85	6.6397	0.937	1.385	371.3	25.01	32.80	420	0.5624	654.81	7.2202	1.029	1.338	491.0	38.39	53.54
120	0.9919	359.23	6.6639	0.940	1.384	375.9	25.50	33.53	440	0.5467	675.45	7.2495	1.034	1.336	497.6	39.15	54.78
130	0.9673	368.64	6.6875	0.943	1.382	380.5	25.99	34.26	460	0.5318	696.19	7.2782	1.039	1.334	504.2	39.90	56.00
140	0.9439	378.08	6.7107	0.945	1.38	384.9	26.48	34.98	480	0.5176	717.02	7.3062	1.044	1.332	510.6	40.64	57.21
									500	0.5042	737.95	7.3336	1.049	1.330	517.0	41.36	58.42

*Temperatures on IPTS-68 scale

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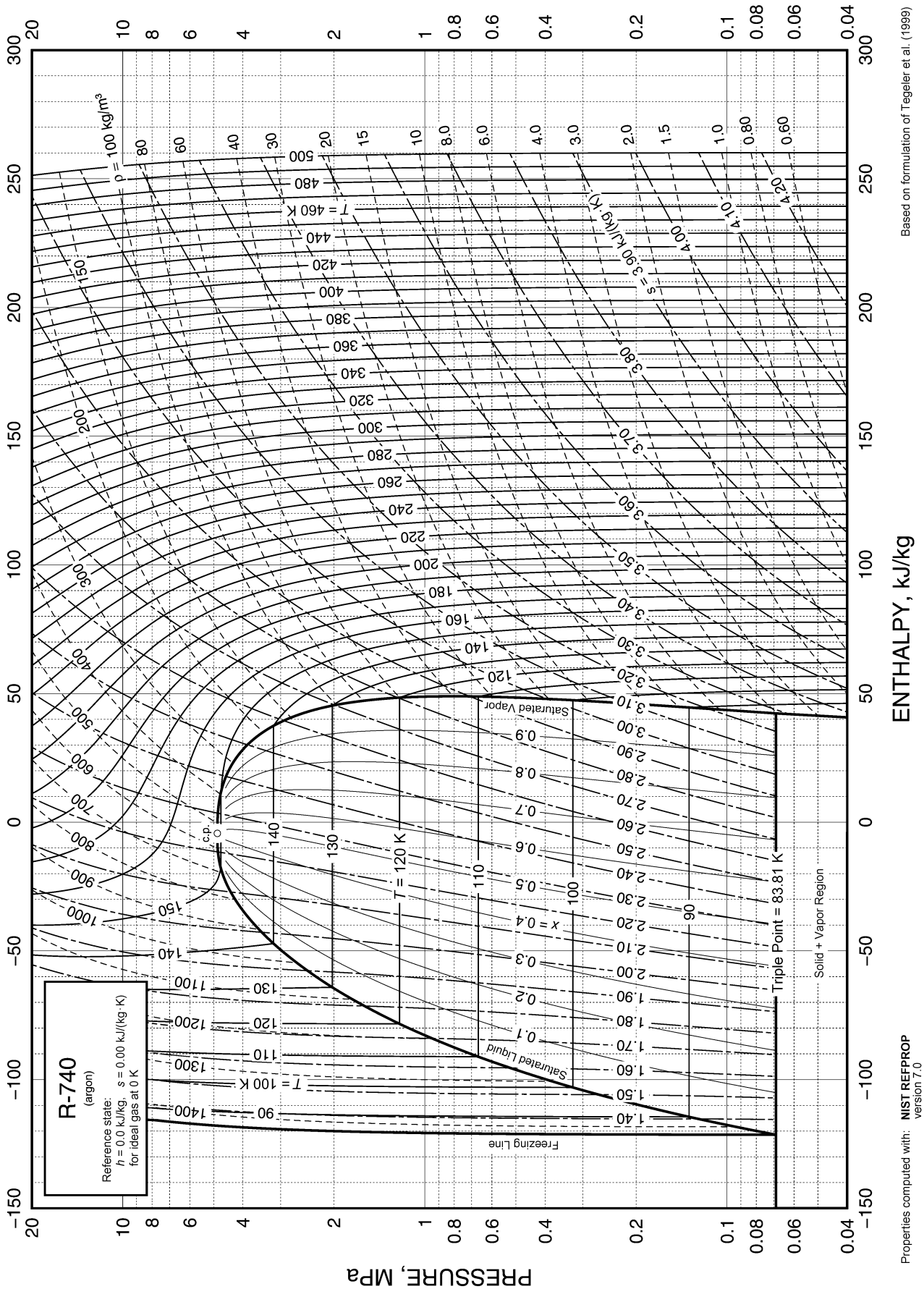

Fig. 32 Pressure-Enthalpy Diagram for Refrigerant 740 (Argon)

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Refrigerant 740 (Argon) Properties of Saturated Liquid and Saturated Vapor

Temp.,* K	Absolute Pressure, MPa	Density, kg/m³ Liquid	Volume, m³/kg Vapor	Enthalpy, kJ/kg Liquid	Enthalpy, kJ/kg Vapor	Entropy, kJ/(kg·K) Liquid	Entropy, kJ/(kg·K) Vapor	Specific Heat c_p, kJ/(kg·K) Liquid	Specific Heat c_p, kJ/(kg·K) Vapor	c_p/c_v Vapor	Velocity of Sound, m/s Liquid	Velocity of Sound, m/s Vapor	Viscosity, μPa·s Liquid	Viscosity, μPa·s Vapor	Thermal Cond., mW/(m·K) Liquid	Thermal Cond., mW/(m·K) Vapor	Surface Tension, mN/m	Temp.,* K
83.81[a]	0.06889	1416.8	0.24663	–121.44	42.28	1.3295	3.2830	1.116	0.555	1.709	862	168.1	290.2	6.86	133.6	5.36	13.42	83.81
84	0.07045	1415.6	0.24164	–121.22	42.36	1.3321	3.2794	1.116	0.556	1.710	861	168.3	288.4	6.87	133.3	5.37	13.37	84
86	0.08811	1403.4	0.19687	–118.98	43.13	1.3583	3.2433	1.116	0.562	1.719	847	169.9	270.9	7.05	130.4	5.52	12.86	86
87.30[b]	0.10132	1395.4	0.17320	–117.52	43.62	1.3750	3.2208	1.117	0.566	1.725	838	170.9	260.3	7.17	128.5	5.62	12.53	87.3
88	0.10901	1391.1	0.16198	–116.74	43.87	1.3839	3.2090	1.118	0.568	1.728	833	171.4	254.8	7.23	127.4	5.68	12.35	88
90	0.13351	1378.6	0.13448	–114.49	44.57	1.4090	3.1763	1.121	0.576	1.740	819	172.8	240.0	7.41	124.5	5.83	11.85	90
92	0.16199	1366.0	0.11258	–112.23	45.23	1.4335	3.1451	1.125	0.584	1.752	805	174.2	226.4	7.60	121.6	6.00	11.36	92
94	0.19485	1353.2	0.09496	–109.96	45.85	1.4577	3.1152	1.131	0.593	1.766	791	175.5	213.8	7.78	118.7	6.16	10.86	94
96	0.23249	1340.3	0.08067	–107.68	46.41	1.4814	3.0865	1.137	0.603	1.782	776	176.7	202.2	7.97	115.8	6.33	10.38	96
98	0.27532	1327.1	0.06897	–105.38	46.93	1.5048	3.0590	1.145	0.614	1.800	762	177.8	191.3	8.16	113.0	6.51	9.89	98
100	0.32377	1313.7	0.05932	–103.06	47.40	1.5278	3.0324	1.154	0.627	1.820	747	178.9	181.3	8.35	110.2	6.69	9.42	100
102	0.37825	1300.1	0.05129	–100.72	47.81	1.5505	3.0068	1.164	0.641	1.842	732	179.9	172.0	8.54	107.4	6.88	8.94	102
104	0.43920	1286.2	0.04458	–98.37	48.17	1.5730	2.9819	1.175	0.656	1.867	717	180.8	163.3	8.74	104.6	7.08	8.48	104
106	0.50706	1272.0	0.03892	–95.98	48.46	1.5952	2.9578	1.188	0.673	1.894	701	181.6	155.2	8.95	101.9	7.28	8.02	106
108	0.58226	1257.6	0.03413	–93.57	48.68	1.6172	2.9343	1.202	0.691	1.926	685	182.4	147.6	9.15	99.1	7.50	7.56	108
110	0.66526	1242.8	0.03004	–91.13	48.84	1.6390	2.9114	1.218	0.712	1.960	669	183.0	140.4	9.37	96.4	7.73	7.11	110
112	0.75650	1227.6	0.02654	–88.65	48.92	1.6606	2.8890	1.235	0.736	2.000	653	183.6	133.7	9.59	93.7	7.98	6.67	112
114	0.85644	1212.1	0.02351	–86.14	48.93	1.6821	2.8669	1.255	0.762	2.044	636	184.1	127.4	9.81	91.0	8.24	6.23	114
116	0.96553	1196.2	0.02090	–83.59	48.85	1.7035	2.8452	1.278	0.791	2.094	619	184.5	121.4	10.04	88.4	8.52	5.80	116
118	1.08420	1179.7	0.01862	–81.00	48.68	1.7248	2.8238	1.303	0.825	2.151	602	184.8	115.7	10.29	85.7	8.82	5.38	118
120	1.21300	1162.8	0.01663	–78.35	48.41	1.7461	2.8025	1.332	0.863	2.216	584	185.1	110.2	10.54	83.1	9.15	4.96	120
125	1.58230	1117.9	0.01263	–71.49	47.27	1.7995	2.7495	1.425	0.986	2.426	538	185.3	97.6	11.23	76.7	10.14	3.95	125
130	2.02550	1068.1	0.00966	–64.16	45.30	1.8538	2.6957	1.564	1.172	2.741	488	184.8	85.9	12.03	70.4	11.45	3.00	130
135	2.55090	1011.5	0.00739	–56.18	42.21	1.9102	2.6390	1.790	1.482	3.262	433	183.7	74.7	13.02	64.2	13.34	2.10	135
140	3.16820	943.7	0.00559	–47.16	37.47	1.9712	2.5757	2.225	2.104	4.258	372	181.5	63.6	14.32	58.1	16.39	1.29	140
145	3.88960	854.3	0.00409	–36.19	29.76	2.0425	2.4973	3.399	3.896	6.880	297	176.6	52.1	16.27	52.0	22.53	0.58	145
150	4.73460	680.4	0.00253	–17.88	11.52	2.1589	2.3550	23.580	35.470	43.160	175	157.0	36.8	21.18	57.6	55.88	0.04	150
150.69[c]	4.86300	535.6	0.00187	–4.33	–4.33	2.2476	2.2476	∞	∞	∞	0	0.0	—	—	∞	∞	0.00	150.69

*Temperatures on ITS-90 scale [a]Triple point [b]Normal boiling point [c]Critical point

Refrigerant 740 (Argon) Properties of Gas at 0.101 325 MPa (one standard atmosphere)

Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	c_p, kJ/(kg·K)	c_p/c_v	Vel. of Sound, m/s	Visc., μPa·s	Thermal Cond., mW/(m·K)
–185.8[b]	5.7736	43.62	3.2208	0.566	1.725	170.9	7.17	5.62	150	1.1504	220.08	4.0554	0.521	1.668	383.3	29.99	23.53
–180	5.3774	46.90	3.2571	0.556	1.715	177.2	7.66	6.01	160	1.1239	225.28	4.0676	0.521	1.668	387.8	30.54	23.96
–160	4.3721	57.80	3.3632	0.538	1.696	196.6	9.32	7.30	170	1.0985	230.49	4.0795	0.521	1.668	392.2	31.09	24.38
–140	3.6930	68.48	3.4501	0.531	1.686	214.0	10.93	8.56	180	1.0742	235.70	4.0911	0.521	1.668	396.6	31.62	24.80
–120	3.2000	79.06	3.5242	0.527	1.681	229.9	12.50	9.79	190	1.0510	240.91	4.1025	0.521	1.668	401.0	32.16	25.22
–100	2.8246	89.58	3.5887	0.525	1.677	244.7	14.02	10.99	200	1.0288	246.12	4.1136	0.521	1.668	405.3	32.68	25.64
–90	2.6684	94.83	3.6182	0.525	1.676	251.8	14.77	11.57	210	1.0075	251.32	4.1245	0.521	1.668	409.6	33.21	26.04
–80	2.5287	100.08	3.6461	0.524	1.675	258.6	15.50	12.15	220	0.9870	256.53	4.1351	0.521	1.668	413.8	33.73	26.45
–70	2.4031	105.31	3.6725	0.524	1.674	265.3	16.22	12.72	230	0.9674	261.74	4.1456	0.521	1.668	418.0	34.24	26.85
–60	2.2894	110.55	3.6977	0.523	1.673	271.8	16.94	13.28	240	0.9485	266.94	4.1558	0.521	1.667	422.1	34.75	27.25
–50	2.1861	115.78	3.7217	0.523	1.672	278.1	17.64	13.83	250	0.9304	272.15	4.1659	0.521	1.667	426.2	35.25	27.65
–40	2.0917	121.00	3.7446	0.523	1.672	284.3	18.33	14.38	260	0.9129	277.36	4.1758	0.521	1.667	430.2	35.75	28.04
–30	2.0052	126.23	3.7665	0.522	1.671	290.4	19.02	14.91	270	0.8961	282.56	4.1854	0.521	1.667	434.2	36.25	28.43
–20	1.9256	131.45	3.7876	0.522	1.671	296.3	19.69	15.44	280	0.8799	287.77	4.1949	0.521	1.667	438.2	36.74	28.81
–10	1.8520	136.67	3.8078	0.522	1.671	302.2	20.36	15.97	290	0.8643	292.98	4.2043	0.521	1.667	442.2	37.23	29.19
0	1.7840	141.89	3.8273	0.522	1.670	307.9	21.02	16.48	300	0.8492	298.18	4.2134	0.521	1.667	446.1	37.71	29.57
10	1.7207	147.11	3.8460	0.522	1.670	313.5	21.67	16.99	310	0.8346	303.39	4.2224	0.521	1.667	450.0	38.20	29.95
20	1.6618	152.33	3.8641	0.522	1.670	319.0	22.31	17.50	320	0.8206	308.59	4.2313	0.521	1.667	453.8	38.67	30.32
30	1.6068	157.54	3.8816	0.522	1.669	324.4	22.94	17.99	330	0.8069	313.80	4.2400	0.521	1.667	457.6	39.15	30.69
40	1.5554	162.76	3.8985	0.521	1.669	329.7	23.56	18.48	340	0.7938	319.01	4.2485	0.521	1.667	461.4	39.61	31.06
50	1.5071	167.97	3.9149	0.521	1.669	334.9	24.18	18.97	350	0.7810	324.21	4.2570	0.521	1.667	465.1	40.08	31.42
60	1.4618	173.18	3.9308	0.521	1.669	340.1	24.79	19.45	360	0.7687	329.42	4.2652	0.521	1.667	468.8	40.54	31.78
70	1.4191	178.39	3.9462	0.521	1.669	345.1	25.40	19.92	370	0.7567	334.62	4.2734	0.521	1.667	472.5	41.00	32.14
80	1.3788	183.61	3.9612	0.521	1.669	350.1	25.99	20.39	380	0.7452	339.83	4.2814	0.521	1.667	476.2	41.46	32.50
90	1.3408	188.82	3.9758	0.521	1.669	355.1	26.58	20.85	390	0.7339	345.03	4.2893	0.521	1.667	479.8	41.91	32.85
100	1.3048	194.03	3.9899	0.521	1.668	359.9	27.17	21.31	400	0.7230	350.24	4.2971	0.521	1.667	483.4	42.36	33.20
110	1.2707	199.24	4.0037	0.521	1.668	364.7	27.74	21.76	420	0.7022	360.65	4.3124	0.521	1.667	490.5	43.25	33.90
120	1.2383	204.45	4.0171	0.521	1.668	369.4	28.32	22.21	440	0.6825	371.06	4.3272	0.520	1.667	497.6	44.13	34.58
130	1.2076	209.66	4.0302	0.521	1.668	374.1	28.88	22.66	460	0.6638	381.47	4.3416	0.520	1.667	504.5	45.00	35.26
140	1.1783	214.87	4.0430	0.521	1.668	378.7	29.44	23.09	480	0.6462	391.88	4.3556	0.520	1.667	511.3	45.86	35.93
									500	0.6295	402.29	4.3692	0.520	1.667	518.1	46.70	36.59

[b]Saturated vapor at normal boiling point

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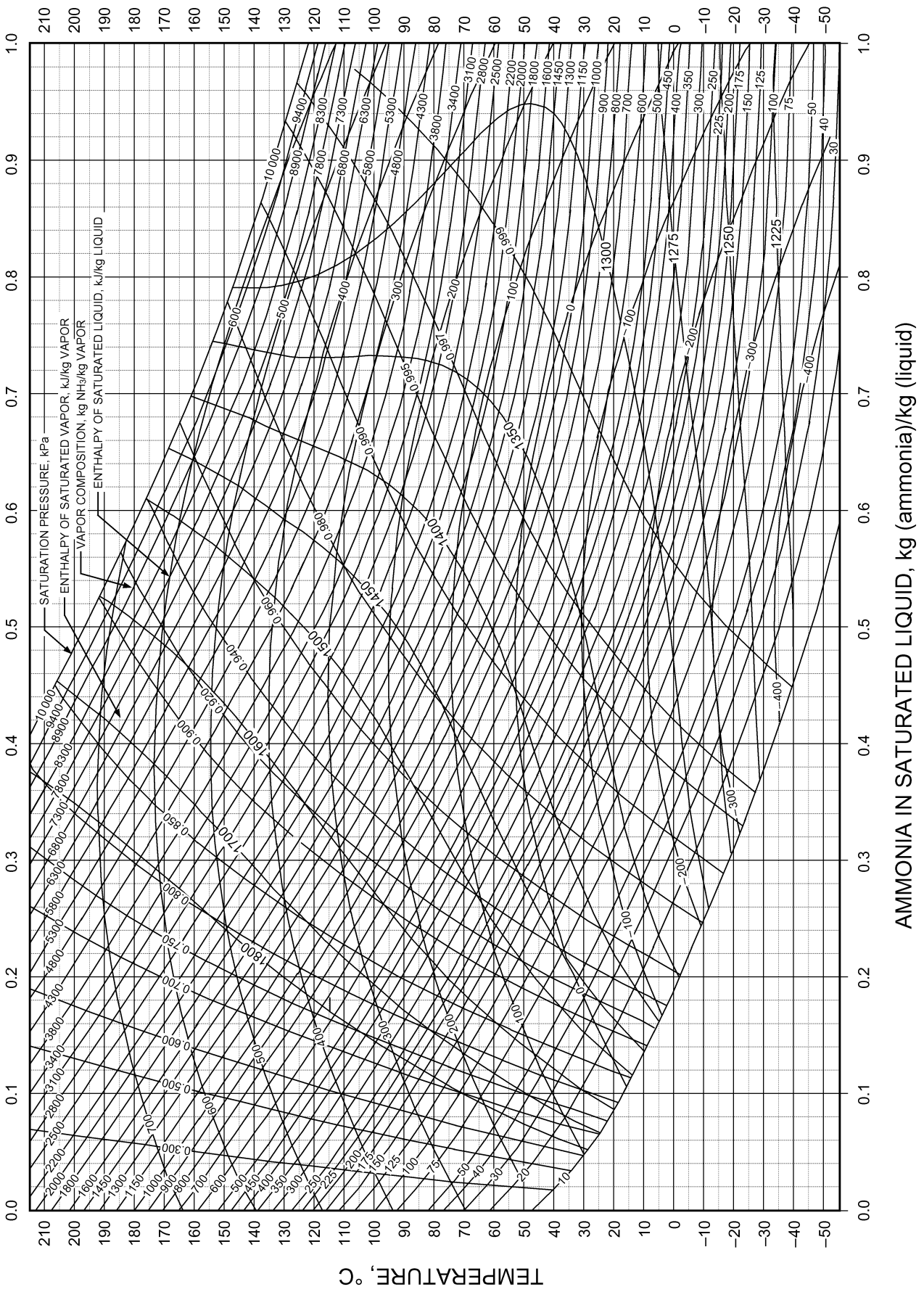

Fig. 33 Enthalpy-Concentration Diagram for Ammonia/Water Solutions

Prepared by Kwang Kim and Keith Herold, Center for Environmental Energy Engineering, University of Maryland at College Park

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Specific Volume of Saturated Ammonia Solutions, m^3/kg

Temp., °C	Concentration, Ammonia (Mass basis) 0	10	20	30	40	50	60	70	80	90	100	Temp., °C
–10	0.00100	0.00103	0.00106	0.00109	0.00114	0.00118	0.00122	0.00128	0.00135	0.00142	0.00151	–10
0	0.00100	0.00103	0.00107	0.00110	0.00114	0.00119	0.00124	0.00130	0.00137	0.00146	0.00156	0
10	0.00100	0.00104	0.00107	0.00111	0.00115	0.00120	0.00125	0.00132	0.00139	0.00149	0.00160	10
20	0.00100	0.00104	0.00108	0.00112	0.00116	0.00121	0.00127	0.00133	0.00142	0.00152	0.00164	20
30	0.00100	0.00105	0.00108	0.00113	0.00117	0.00123	0.00128	0.00135	0.00145	0.00156	0.00168	30
40	0.00101	0.00105	0.00109	0.00114	0.00119	0.00124	0.00130	0.00138	0.00148	0.00159	0.00173	40
50	0.00101	0.00106	0.00110	0.00115	0.00120	0.00125	0.00132	0.00140	0.00151	0.00163	0.00177	50
60	0.00102	0.00106	0.00111	0.00116	0.00121	0.00127	0.00134	0.00143	0.00154	0.00167	0.00183	60
70	0.00102	0.00107	0.00112	0.00117	0.00122	0.00129	0.00136	0.00146	0.00158	0.00172	0.00190	70
80	0.00103	0.00108	0.00113	0.00118	0.00124	0.00130	0.00139	0.00149	0.00162	0.00178	0.00198	80
90	0.00104	0.00109	0.00114	0.00119	0.00125	0.00132	0.00141	0.00153	0.00167	0.00184	0.00208	90
100	0.00104	0.00110	0.00115	0.00121	0.00127	0.00135	0.00145	0.00157	0.00172	0.00191	0.00219	100

Prepared under ASHRAE research project RP-271, sponsored by TC 8.3.
Data reference: B.H. Jennings, Ammonia water properties (paper presented at ASHRAE meeting, January 1965).

Refrigerant Temperature (t' = °C) and Enthalpy (h = kJ/kg) of Lithium Bromide Solutions

Temp., (t = °C)		Percent LiBr 0	10	20	30	40	45	50	55	60	65	70
20	t'	20.0	19.1	17.7	15.0	9.8	5.8	–0.4	–7.7	–15.8	–23.4#	–29.3#
	h	84.0	67.4	52.6	40.4	33.5	33.5	38.9	53.2	78.0	111.0#	145.0#
30	t'	30.0	29.0	27.5	24.6	19.2	15.0	8.6	1.0	–7.3	–15.2#	–21.6#
	h	125.8	103.3	84.0	68.6	58.3	56.8	60.5	73.5	96.8	128.4#	161.7#
40	t'	40.0	38.9	37.3	34.3	28.5	24.1	17.5	9.8	1.3	–7.0#	–14.0#
	h	167.6	139.5	115.8	96.0	82.5	79.7	82.2	93.5	115.4	146.0#	178.3#
50	t'	50.0	48.8	47.2	44.0	37.9	33.3	26.5	18.5	9.9	1.3	–6.3#
	h	209.3	175.2	147.0	123.4	106.7	102.6	103.8	114.0	134.5	163.5	195.0#
60	t'	60.0	58.8	57.0	53.6	47.3	42.5	35.5	27.3	18.4	9.5	1.4#
	h	251.1	211.7	179.1	151.4	131.7	125.8	125.8	134.7	153.7	181.4	211.9#
70	t'	70.0	68.7	66.8	63.3	56.6	51.6	44.4	36.1	27.0	17.7	9.0#
	h	293.0	247.7	210.5	178.8	155.7	148.9	148.0	155.6	173.2	199.4	228.8#
80	t'	80.0	78.6	76.7	73.0	66.0	60.8	53.4	44.8	35.6	26.0	16.7#
	h	334.9	287.8	243.6	207.3	181.0	172.8	170.0	176.2	192.6	217.2	245.7#
90	t'	90.0	88.6	86.5	82.6	75.4	70.0	62.3	53.6	44.1	34.2	24.3#
	h	376.9	321.1	275.6	235.4	206.1	195.8	192.3	197.1	212.2	235.6	262.9#
100	t'	100.0	98.5	96.3	92.3	84.7	79.1	71.3	62.4	52.7	42.4	32.0
	h	419.0	357.6	307.9	263.8	231.0	219.9	214.6	218.2	231.5	253.5	279.7
110	t'	110.0	108.4	106.2	101.9	94.1	88.3	80.2	71.1	61.3	50.6	39.7
	h	461.3	394.3	340.1	292.4	255.9	243.3	236.8	239.1	251.0	271.4	296.3
120	t'	120.0*	118.3*	116.0*	111.6	103.4	97.5	89.2	79.9	69.8	58.9	47.3
	h	503.7*	431.0*	372.5*	320.9	281.0	267.0	259.0	260.0	270.2	289.5	313.4
130	t'	130.0*	128.3*	125.8*	121.3*	112.8	106.7	92.8	88.7	78.4	67.1	55.0
	h	546.5*	468.4*	404.5*	349.6*	306.2	290.7	281.0	280.4	289.1	306.9	330.2
140	t'	140.0*	138.2*	135.7*	130.9*	122.2*	115.8	107.1	97.4	87.0	75.3	62.7
	h	589.1*	505.6*	437.8*	377.9*	331.3*	314.2	303.2	301.1	308.1	324.7	346.9
150	t'	150.0*	148.1*	145.5*	140.6*	131.5*	125.0*	116.1*	106.2	95.5	83.5	70.3
	h	632.2*	542.7*	470.5*	406.8*	356.6*	337.8*	325.5*	321.6	327.3	342.7	363.6
160	t'	160.0*	158.1*	155.3*	150.3*	140.9*	134.2*	125.0*	115.0	104.1	91.8	78.9
	h	675.6*	580.8*	503.1*	435.4*	381.9*	361.2*	347.7*	342.2	346.1	360.3	380.1
170	t'	170.0*	168.0*	165.2*	159.9*	150.3*	143.3*	134.0*	123.7	112.7	100.0	85.7
	h	719.2*	618.9*	536.1*	464.3*	406.8*	384.9*	369.9*	362.9	365.4	378.3	396.0
180	t'	180.0*	177.9*	175.0*	169.6*	159.6*	152.5*	142.9*	132.5*	121.2*	108.2	93.3
	h	763.2*	657.1*	569.4*	493.4*	432.1*	408.8*	392.1*	383.4*	384.3*	395.8	411.3

*Extensions of data above 115°C are well above the original data and should be used with care.
#Supersaturated solution.

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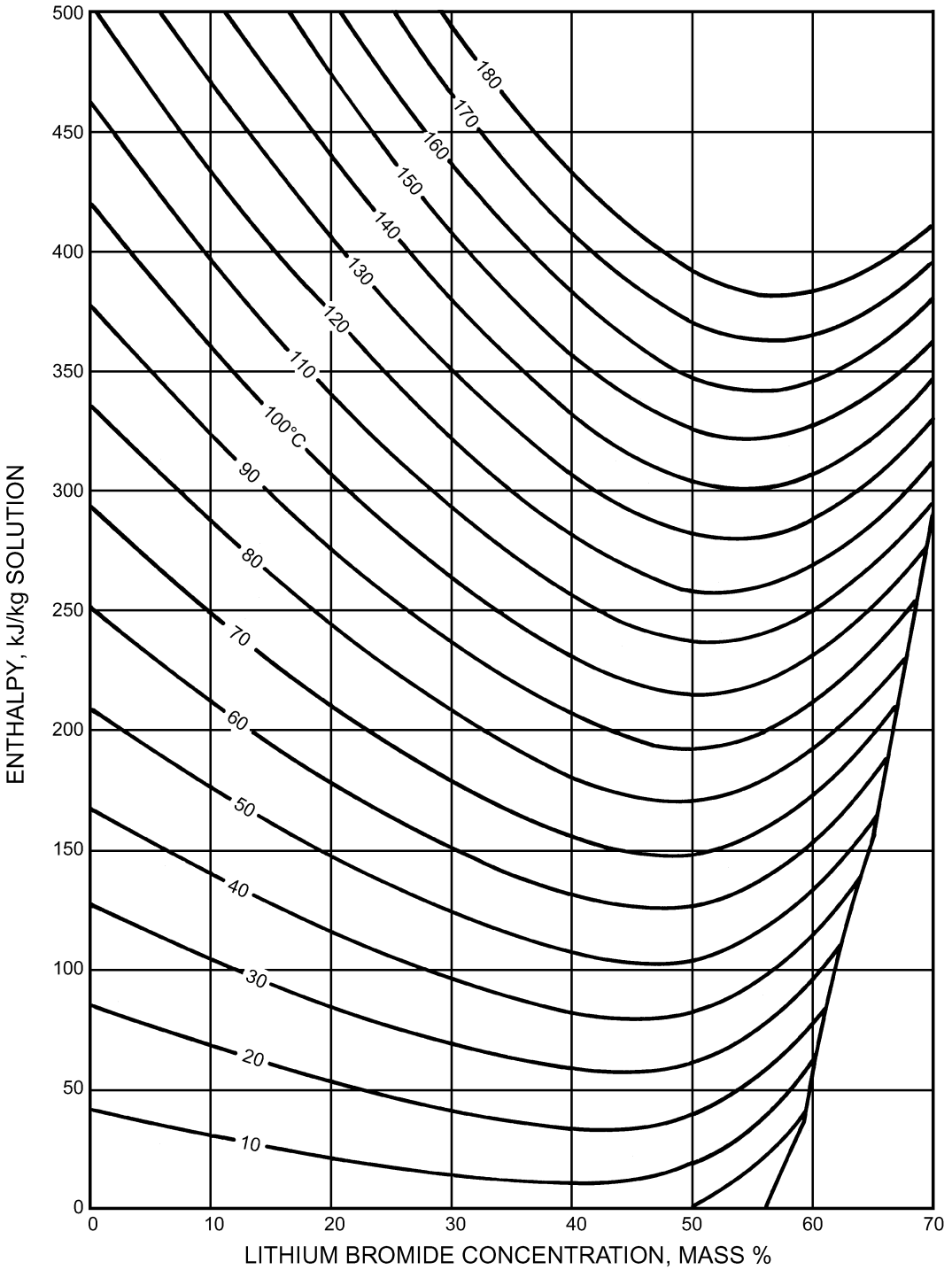

EQUATIONS **CONCENTRATION RANGE 40 < X < 70% LiBr** **TEMPERATURE RANGE 15 < t < 165°C**

$h = \Sigma_0^4 A_n X^n + t\Sigma_0^4 B_n X^n + t^2\Sigma_0^4 C_n X^n$ in kJ/kg, where t = °C and X = %LiBr

A_0 = –2024.33	B_0 = 18.2829	C_0 = –3.7008214 E-2
A_1 = 163.309	B_1 = –1.1691757	C_1 = 2.8877666 E-3
A_2 = –4.88161	B_2 = 3.248041 E-2	C_2 = –8.1313015 E-5
A_3 = 6.302948 E-2	B_3 = –4.034184 E-4	C_3 = 9.9116628 E-7
A_4 = –2.913705 E-4	B_4 = 1.8520569 E-6	C_4 = –4.4441207 E-9

Fig. 34 Enthalpy-Concentration Diagram for Water/Lithium Bromide Solutions

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EQUATIONS

1. $t = \Sigma_0^3 B_n X^n + t' \Sigma_0^3 A_n X^n$ Solution Temperature, °C
2. $t' = (t - \Sigma_0^3 B_n X^n) / \Sigma_0^3 A_n X^n$ Refrigerant Temperature, °C
3. $\log P = C + D/T' + E/T'^2$ P = kPa; T' = K
4. $T' = \dfrac{-2E}{D + [D^2 - 4E(C - \log P)]^{0.5}}$

A_0 = –2.007 55	B_0 = 124.937	C = 7.05
A_1 = 0.169 76	B_1 = –7.716 49	D = –1596.49
A_2 = –3.133 362 E-03	B_2 = 0.152 286	E = –104 095.5
A_3 = 1.976 68 E-05	B_3 = –7.950 90 E-04	

RANGE: $-15 < t' < 110$°C
$5 < t < 175$°C
$45 < X < 70$% LiBr

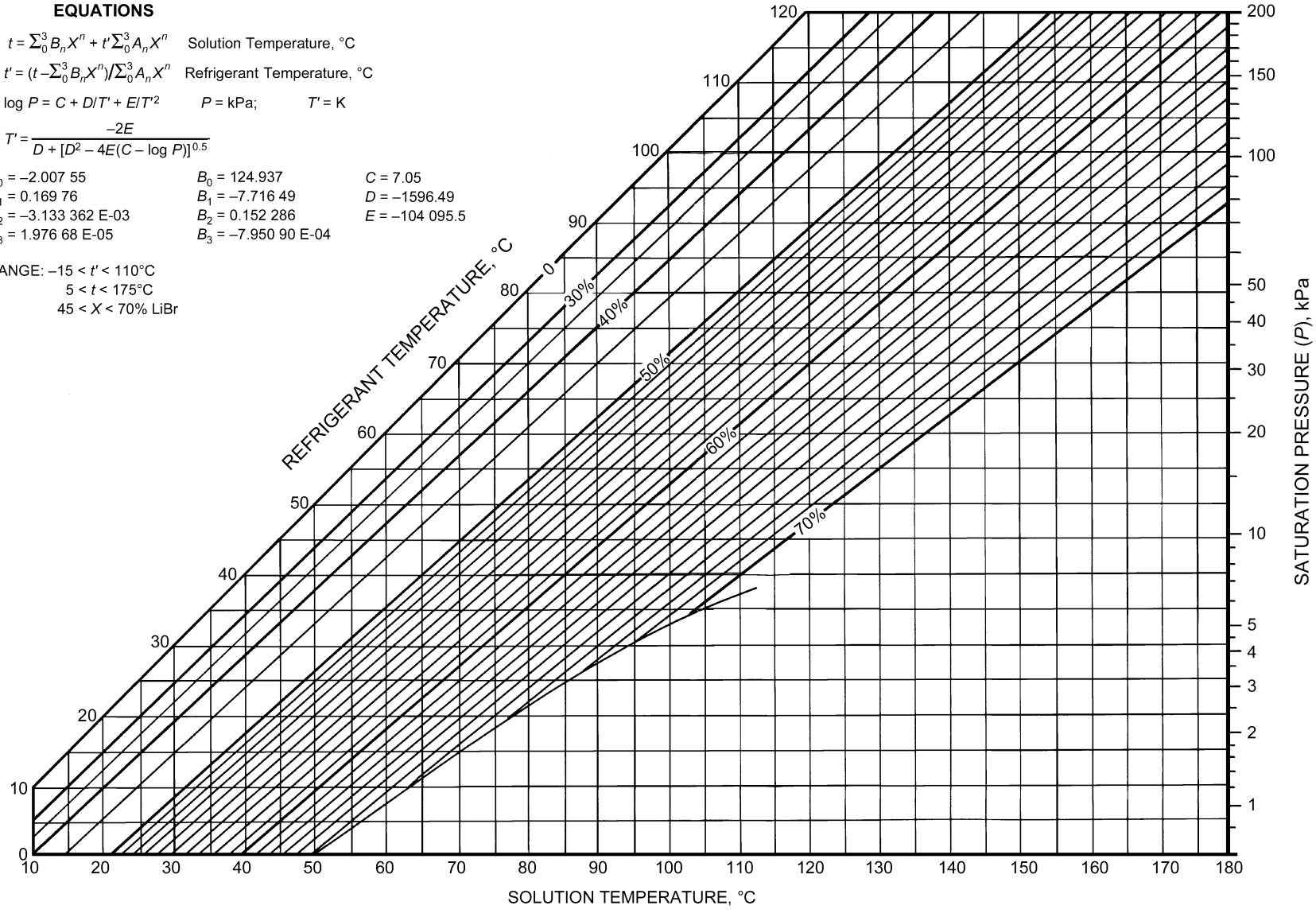

Fig. 35 Equilibrium Chart for Aqueous Lithium Bromide Solutions
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Tables revised for this edition (R-125, R-170, R-245fa, R-290, R-600, and R-600a) have been calculated using

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Many tables (indicated with a ‡ after the fluid name) have not changed from the 2005 *ASHRAE Handbook—Fundamentals*. These tables were calculated using

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Tables for R-702, R-702p, and R-704 have not changed from the 1997 *ASHRAE Handbook—Fundamentals*; these tables were calculated using the programs noted for each fluid.

The underlying sources for these computer packages are listed as follows by fluid and property. The reference listed under "Equation of state" was used for vapor pressure, liquid density, vapor volume, enthalpy, entropy, specific heat, and velocity of sound.

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Equation of state

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Surface tension

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Equation of state

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R-134a†

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Viscosity

Huber et al. 2003. op. cit. (See R-32.)

Thermal conductivity

Perkins, R.A., A. Laesecke, J. Howley, M.L.V. Ramires, A.N. Gurova, and L. Cusco. 2000. Experimental thermal conductivity values for the IUPAC round-robin sample of 1,1,1,2-tetrafluoroethane (R134a). NISTIR 6605.

Surface tension

Okada, M. and Y. Higashi. 1994. Surface tension correlation of HFC-134a and HCFC-123. *CFCs, the Day After: Proceedings of Joint Meeting of IIR Commissions B1, B2, E1, and E2*, 541-548.

R-143a†

Equation of state

Lemmon, E.W. and R.T. Jacobsen. 2001. An international standard formulation for the thermodynamic properties of 1,1,1-trifluoroethane (HFC- 143a) for temperatures from 161 to 500 K and pressures to 60 MPa. *Journal of Physical and Chemical Reference Data* 29(4):521-552.

Viscosity

Klein et al. 1997. op. cit. (See R-12.)

Thermal conductivity

McLinden et al. 2000b. op. cit. (See R-12.)

Surface tension

Schmidt, J.W., E. Carrillo-Nava, and M.R. Moldover. 1996. Partially halogenated hydrocarbons $CHFCl\text{-}CF_3$, $CF_3\text{-}CH_3$, $CF_3\text{-}CHF\text{-}CHF_2$, $CF_3\text{-}CH_2\text{-}CF_3$, $CHF_2\text{-}CF_2\text{-}CH_2F$, $CF_3\text{-}CH_2\text{-}CHF_2$, $CF_3\text{-}O\text{-}CHF_2$: Critical temperature, refractive indices, surface tension and estimates of liquid, vapor and critical densities. *Fluid Phase Equilibria* 122:187-206.

R-152a‡

Equation of state

Outcalt, S.L. and M.O. McLinden. 1996. A modified Benedict-Webb-Rubin equation of state for the thermodynamic properties of R-152a (1,1-difluoroethane). *Journal of Physical and Chemical Reference Data* 25(2):605-636.

Viscosity

Klein et al. 1997. op. cit. (see R-12), ECS model of McLinden et al. (2000b) correlated to data as implemented in NIST REFPROP.

Thermal conductivity

Krauss, R., V.C. Weiss, T.A. Edison, J.V. Sengers, and K. Stephan. 1996. Transport properties of 1,1-difluoroethane (R-152a). *International Journal of Thermophysics* 17:731-757.

Surface tension

Okada and Higashi. 1995. op. cit. (See R-32.)

R-245fa

Equation of state

Extended corresponding states model of

Lemmon, E.W. and R. Span. 2006. Short fundamental equations of state for 20 industrial fluids. *Journal of Chemical & Engineering Data* 51(3):785-850.

Viscosity and thermal conductivity

Huber, M.L., A. Laesecke, and R.A. Perkins. 2003. Model for the viscosity and thermal conductivity of refrigerants, including a new correlation for the viscosity of R-134a. *Industrial & Engineering Chemistry Research* 42(13):3163-3178.

Surface tension

Schmidt et al. 1996. op. cit. (See R-143a.)

Pressure-enthalpy diagram based on data of

Defibaugh, D.R. and M.R. Moldover. 1997. Compressed and saturated liquid densities for 18 halogenated organic compounds. *Journal of Chemical and Engineering Data* 42:160-168.

R-404A‡

Equation of state

Lemmon, E.W. and R.T. Jacobsen. 2004a. Equations of state for mixtures of R-32, R-125, R-134a, R-143a, and R-152a. *Journal of Physical and Chemical Reference Data* 33(2):593-620.

Viscosity

Klein et al. 1997. op. cit. (See R-12.)

Thermal conductivity

McLinden et al. 2000b. op. cit. (See R-12.)

Surface tension

Moldover, M.R. and J.C. Rainwater. 1988. Interfacial tension and vapor-liquid equilibria in the critical region of mixtures. *Journal of Chemical Physics* 88:7772-7780.

R-407C‡

Equation of state

Lemmon and Jacobsen. 2004a. op. cit. (See R-404A.)

Viscosity

Klein et al. 1997. op. cit. (See R-12.)

Thermal conductivity

McLinden et al. 2000b. op. cit. (See R-12.)

Surface tension

Moldover and Rainwater. 1988. op. cit. (See R-404A.)

R-410A‡

Equation of state

Lemmon and Jacobsen. 2004a. op. cit. (See R-404A.)

Viscosity

Klein et al. 1997. op. cit. (See R-12.)

Thermal conductivity

McLinden et al. 2000b. op. cit. (See R-12.)

Surface tension

Moldover and Rainwater. 1988. op. cit. (See R-404A.)

R-507A‡

Equation of state

Lemmon and Jacobsen. 2004a. op. cit. (See R-404A.)

Viscosity

Klein et al. 1997. op. cit. (See R-12.)

Thermal conductivity

McLinden et al. 2000b. op. cit. (See R-12.)

Surface tension

Moldover and Rainwater. 1988. op. cit. (See R-404A.)

R-717 (Ammonia)†

Equation of state

Tillner-Roth, R., F. Harms-Watzenberg, and H.D. Baehr. 1993. Eine neue Fundamentalgleichung für Ammoniak. *DKV-Tagungsbericht* 20(II): 167181.

Viscosity

Fenghour, A., W.A. Wakeham, V. Vesovic, J.T.R. Watson, J. Millat, and E. Vogel. 1995a. The viscosity of ammonia. *Journal of Physical and Chemical Reference Data* 24:1649-1667.

Thermal conductivity

Tufeu, R., D.Y. Ivanov, Y. Garrabos, and B. Le Neindre. 1984. Thermal conductivity of ammonia in a large temperature and pressure range including the critical region. *Berichte der Bunsen-Gesellschaft—Physical Chemistry* 88:422-427.

Surface tension

Stairs, R.A. and M.J. Sienko. 1956. Surface tension of ammonia and of solutions of alkalai halides in ammonia. *Journal of American Chemical Society* 78:920-923.

R-718 (Water/Steam)†

Data computed using

Harvey, A.H., S.A. Klein, and A.P. Peskin. 1999. *NIST Standard Reference Database* 10. NIST/ASME steam properties database, v. 2.2. Standard Reference Data Program.

Equation of state

Wagner, W. and A. Pruss. 2002. The IAPWS formulation 1995 for the thermodynamic properties of ordinary water substance for general and scientific use. *Journal of Physical and Chemical Reference Data* 31:387-535.

Viscosity and thermal conductivity

Kestin, J., J.V. Sengers, B. Kamgar-Parsi, and J.M.H. Levelt Sengers. 1984. Thermophysical properties of fluid H_2O. *Journal of Physical and Chemical Reference Data* 13:175.

Surface tension

IAPWS. 1995. Physical chemistry of aqueous systems: Meeting the needs of industry. *Proceedings of the 12th International Conference on the Properties of Water and Steam*, Orlando. Begell House, Inc., A139-A142. International Association for the Properties of Steam.

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R-744 (Carbon Dioxide)†

Equation of state

Span, R. and W. Wagner. 1996. A new equation of state for carbon dioxide covering the fluid region from the triple-point temperature to 1100 K at pressures up to 800 MPa. *Journal of Physical and Chemical Reference Data* 26:1509-1596.

Viscosity

Fenghour, A., W.A. Wakeham, and V. Vesovic. 1995b. The viscosity of carbon dioxide. *Journal of Physical and Chemical Reference Data* 27: 31-44.

Thermal conductivity

Vesovic, V., W.A. Wakeham, G.A. Olchowy, J.V. Sengers, J.T.R. Watson, and J. Millat. 1990. The transport properties of carbon dioxide. *Journal of Physical and Chemical Reference Data* 19:763-808.

Surface tension

Rathjen, W. and J. Straub. 1977. *Heat transfer in boiling*, Chapter 18, Temperature dependence of surface tension, coexistence curve, and vapor pressure of CO_2, $CClF_3$, $CBrF_3$, and SF_6. Academic Press, New York.

R-50 (Methane)†

Equation of state

Setzmann, U. and W. Wagner. 1991. A new equation of state and tables of thermodynamic properties for methane covering the range from the melting line to 625 K at pressures to 1000 MPa. *Journal of Physical and Chemical Reference Data* 20:1061-1151.

Viscosity

Younglove, B.A. and J.F. Ely. 1987. Thermophysical properties of fluids. II. Methane, ethane, propane, isobutane and normal butane. *Journal of Physical and Chemical Reference Data* 16:577-798.

Thermal conductivity

Friend, D.G., J.F. Ely, and H. Ingham. 1989. Thermophysical properties of methane. *Journal of Physical and Chemical Reference Data* 18(2): 583-638.

Surface tension

Somayajulu, G.R. 1988. A generalized equation for surface tension from the triple point to the critical point. *International Journal of Thermophysics* 9:559-566.

R-170 (Ethane)

Equation of state,

Bücker, D. and W. Wagner. 2006. A reference equation of state for the thermodynamic properties of ethane for temperatures from the melting line to 675 K and pressures up to 900 MPa. *Journal of Physical and Chemical Reference Data* 35:205.

Viscosity, and thermal conductivity

Friend, D.G., H. Ingham, and J.F. Ely. 1991. Thermophysical properties of ethane. *Journal of Physical and Chemical Reference Data* 20(2): 275-347.

Surface tension

Soares, V.A.M., B.d.J.V.S. Almeida, I.A. McLure, and R.A. Higgins. 1986. Surface tension of pure and mixed simple substances at low temperature. *Fluid Phase Equilibria* 32:9-16.

Pressure-enthalpy diagram based on data of

Friend, D.G., H. Ingham, and J.F. Ely. 1991. Thermophysical properties of ethane. *Journal of Physical and Chemical Reference Data* 20(2): 275-347.

R-290 (Propane)

Equation of state

Lemmon, E.W., W. Wagner, and M.O. McLinden. 2009. Thermodynamic properties of propane, IV: Equation of state. *Journal of Chemical & Engineering Data* (submitted for publication).

Viscosity

Vogel, E., C. Küchenmeister, E. Bich, and A. Laesecke. 1998. Reference correlation of the viscosity of propane. *Journal of Physical and Chemical Reference Data* 27:947-970.

Thermal conductivity

Marsh, K., R. Perkins, and M.L.V. Ramires. 2002. Measurement and correlation of the thermal conductivity of propane from 86 to 600 K at pressures to 70 MPa. *Journal of Chemical & Engineering Data* 47:932-940.

Surface tension

Baidakov, V.G. and I.I. Sulla. 1985. Surface tension of propane and isobutane at near-critical temperatures. *Russian Journal of Physical Chemistry* 59:551-554.

Pressure-enthalpy diagram based on data of

Miyamoto, H. and K. Watanabe. 2000. A thermodynamic property model for fluid-phase propane. *International Journal of Thermophysics* 21:1045-1072.

R-600 (*n*-Butane)

Equation of state

Bücker, D. and W. Wagner. 2006. Reference equations of state for the thermodynamic properties of fluid phase *n*-butane and isobutane. *Journal of Physical and Chemical Reference Data* 35:929.

Viscosity

Vogel, E., C. Kuchenmeister, and E. Bich. 1999. Viscosity for *n*-butane in the fluid region. *High Temperatures—High Pressures* 31:173-186.

Thermal conductivity

Perkins, R.A., M.L.V. Ramires, C.A. Nieto de Castro, and L. Cusco. 2002. Measurement and correlation of the thermal conductivity of butane. *Journal of Chemical and Engineering Data* 47:1263-1271.

Surface tension

Calado, J.C.G., I.A. McLure, and V.A.M. Soares. 1978. Surface tension for octafluorocyclobutane, *n*-butane and their mixtures from 233 K to 254 K, and vapour pressure, excess Gibbs function and excess volume for the mixture at 233 K. *Fluid Phase Equilibria* 2:199-213.

Coffin, C.C. and O. Maass. 1928. The preparation and physical properties of α-, β- and γ-butylene and normal and isobutane. *Journal of the American Chemical Society* 50(5):1427-1437.

Pressure-enthalpy diagram based on data of

Miyamoto, H. and K. Watanabe. 2001. Thermodynamic property model for fluid-phase *n*-butane. *International Journal of Thermophysics* 22:459-475.

R-600a (Isobutane)

Equation of state

Bücker, D. and W. Wagner. 2006. op cit. (See R-600.)

Viscosity

Vogel, E., C. Küchenmeister, and E. Bich. 2000. Viscosity correlation for isobutane over wide ranges of the fluid region. *International Journal of Thermophysics* 21:343-356.

Thermal conductivity

Perkins, R.A. 2002. Measurement and correlation of the thermal conductivity of isobutane. *Journal of Chemical Engineering Data* 47: 1272-1279.

Surface tension

Baidakov and Sulla. 1985. op. cit. (See R-290.)

Pressure-enthalpy diagram based on data of

Miyamoto, H. and K. Watanabe. 2002. A thermodynamic property model for fluid-phase isobutane. *International Journal of Thermophysics* 23:477-499.

R-1150 (Ethylene)†

Equation of state

Smukala, J., R. Span, and W. Wagner. 2000. A new equation of state for ethylene covering the fluid region for temperatures from the melting line to 450 K and pressures up to 300 MPa. *Journal of Physical and Chemical Reference Data* 29:1053-1122.

Viscosity and thermal conductivity

Holland, P.M., B.E. Eaton, and H.J.M. Hanley. 1983. A correlation of the viscosity and thermal conductivity data of gaseous and liquid ethylene. *Journal of Physical and Chemical Reference Data* 12:917-932.

Surface tension

Soares et al. op. cit. (See R-170.)

R-1270 (Propylene)‡

Equation of state

Angus, S., B. Armstrong, and K.M. de Reuck. 1980. *International thermodynamic tables of the fluid state—7: Propylene*. Pergamon Press, Oxford, U.K.

Viscosity and thermal conductivity

Huber et al. 2003. op. cit. (See R-32.)

Surface tension

Maass, O. and C.H. Wright. 1921. Some physical properties of hydrocarbons containing two and three carbon atoms. *Journal of the American Chemical Society* 43:1098-1111.

R-702 (Hydrogen)

Thermodynamic data computed using the ALLPROPS database, v. 4.0:

Lemmon, E.W., R.T. Jacobsen, S.G. Penoncello, and S.W. Beyerlein. 1994. Computer programs for the calculation of thermodynamic properties of cryogens and other fluids. *Advances in Cryogenic Engineering* 39:1891-1897.

Transport data computed using the NIST 12 database, v. 3.0:

Friend, D.G., R.D. McCarty, and V. Arp. 1992. *NIST thermophysical properties of pure fluids database*, v. 3.0. Standard Reference Data Program.

Equation of state, viscosity, and thermal conductivity

McCarty, R.D. 1975. *Hydrogen: Technology survey—Thermophysical properties*. NASA SP-3089.

Surface tension

Liley, P.E. and P.D. Desai. 1993. *ASHRAE thermophysical properties of refrigerants*.

R-702p (Parahydrogen)

Thermodynamic data computed using the ALLPROPS database, v. 4.0:

Lemmon et al. 1994. op. cit. (See R-702.)

Transport data computed using the NIST12 database, v. 3.0:

Friend et al. 1992. op. cit. (See R-702.)

Equation of state, viscosity, and thermal conductivity

Younglove, B.A. 1982. Thermophysical properties of fluids. I. Argon, ethylene, parahydrogen, nitrogen, nitrogen trifluoride, and oxygen. *Journal of Physical and Chemical Reference Data* 11(Supplement No. 1).

Surface tension

Liley and Desai. 1993. op. cit. (See R-702.)

R-704 (Helium)

Thermodynamic data computed using the ALLPROPS database, v. 4.0:

Lemmon et al. 1994. op. cit. (See R-702.)

Transport data computed using the NIST12 database, v. 3.0:

Friend et al. 1992. op. cit. (See R-702.)

Equation of state

Arp, V.D., R.D. McCarty, and D.G. Friend. 1995. Thermophysical properties of helium-4 from 0.8 to 1500 K with pressures to 2000 MPa. NIST *Technical Note* 1334 (revised).

Surface tension

Liley and Desai. 1993. op. cit. (See R-702.)

R-728 (Nitrogen)‡

Equation of state, viscosity, and thermal conductivity

Span, R., E.W. Lemmon, R.T. Jacobsen, W. Wagner, and A. Yokozeki. 2000. A reference equation of state for the thermodynamic properties of nitrogen for temperatures from 63.151 to 1000 K and pressures to 2200 MPa. *Journal of Physical and Chemical Reference Data* 29:1361-1433.

Viscosity and thermal conductivity

Lemmon, E.W. and R.T. Jacobsen. 2004b. Viscosity and thermal conductivity equations for nitrogen, oxygen, argon, and air. *International Journal of Thermophysics* 25:21-69.

Surface tension

Lemmon, E.W. and S.G. Penoncello. 1994. The surface tension of air and air component mixtures. *Advances in Cryogenic Engineering* 39:1927-1934.

R-729 (Air)‡

Equation of state

Lemmon, E.W., R.T. Jacobsen, S.G. Penoncello, and D.G. Friend. 2000. Thermodynamic properties of air and mixtures of nitrogen, argon, and oxygen from 60 to 2000 K at pressures to 2000 MPa. *Journal of Physical and Chemical Reference Data* 29:331-385.

Viscosity and thermal conductivity

Lemmon and Jacobsen. 2004b. op. cit. (See R-728.)

Surface tension

Lemmon and Penoncello. 1994. op. cit. (See R-728.)

R-732 (Oxygen)‡

Equation of state

Schmidt, R. and W. Wagner. 1985. A new form of the equation of state for pure substances and its application to oxygen. *Fluid Phase Equilibria* 19:175-200.

Viscosity and thermal conductivity

Lemmon and Jacobsen. 2004b. op. cit. (See R-728)

Surface tension

Lemmon and Penoncello. 1994. op. cit. (See R-728.)

R-740 (Argon)‡

Equation of state

Tegeler, C., R. Span, and W. Wagner. 1999. A new equation of state for argon covering the fluid region for temperatures from the melting line to 700 K at pressures up to 1000 MPa. *Journal of Physical and Chemical Reference Data* 28:779-850.

Viscosity and thermal conductivity

Lemmon and Jacobsen. 2004b. op. cit. (See R-728.)

Surface tension

Lemmon and Penoncello. 1994. op. cit. (See R-728.)

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