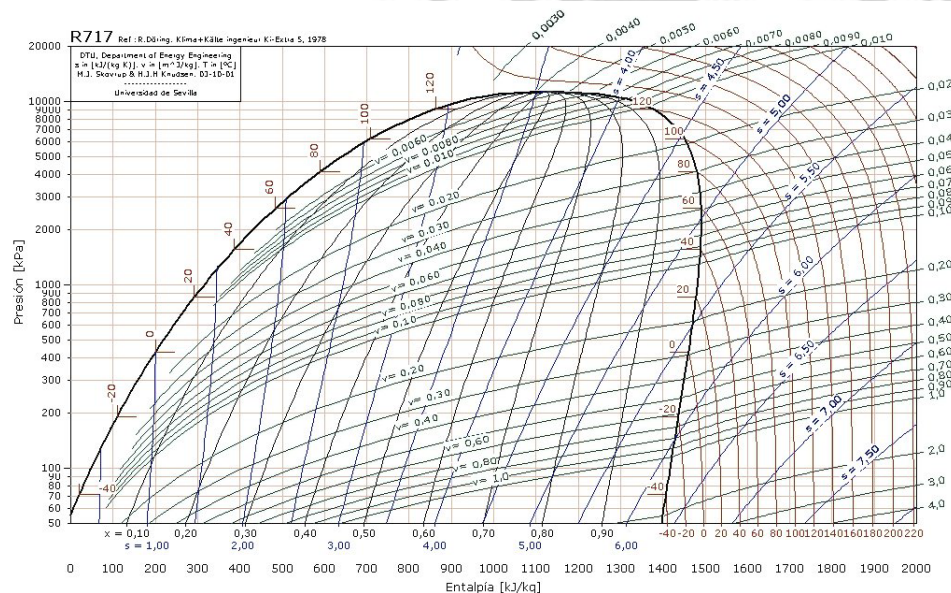


Colección de Tablas y Gráficas de Tecnología Frigorífica

Versión 3.1 (septiembre de 2004)



Autor: Juan Francisco Coronel Toro
Profesor asociado del Grupo de Termotecnia
Dpto. de Ingeniería Energética y mecánica de Fluidos
Universidad de Sevilla

Este documento está basado en versiones anteriores desarrolladas por:

- ☐ D. Ramón Velázquez Vila
- ☐ D. José Guerra Macho
- ☐ D. Servando Álvarez Domínguez
- ☐ D. José Luis Molina Félix
- ☐ D. David Velázquez Alonso
- ☐ D. Luis Pérez-Lombard
- ☐ D. Juan F. Coronel Toro

Todos ellos pertenecientes al Grupo de Termotecnia.

Parte de la información ha sido tomada de las siguientes referencias:

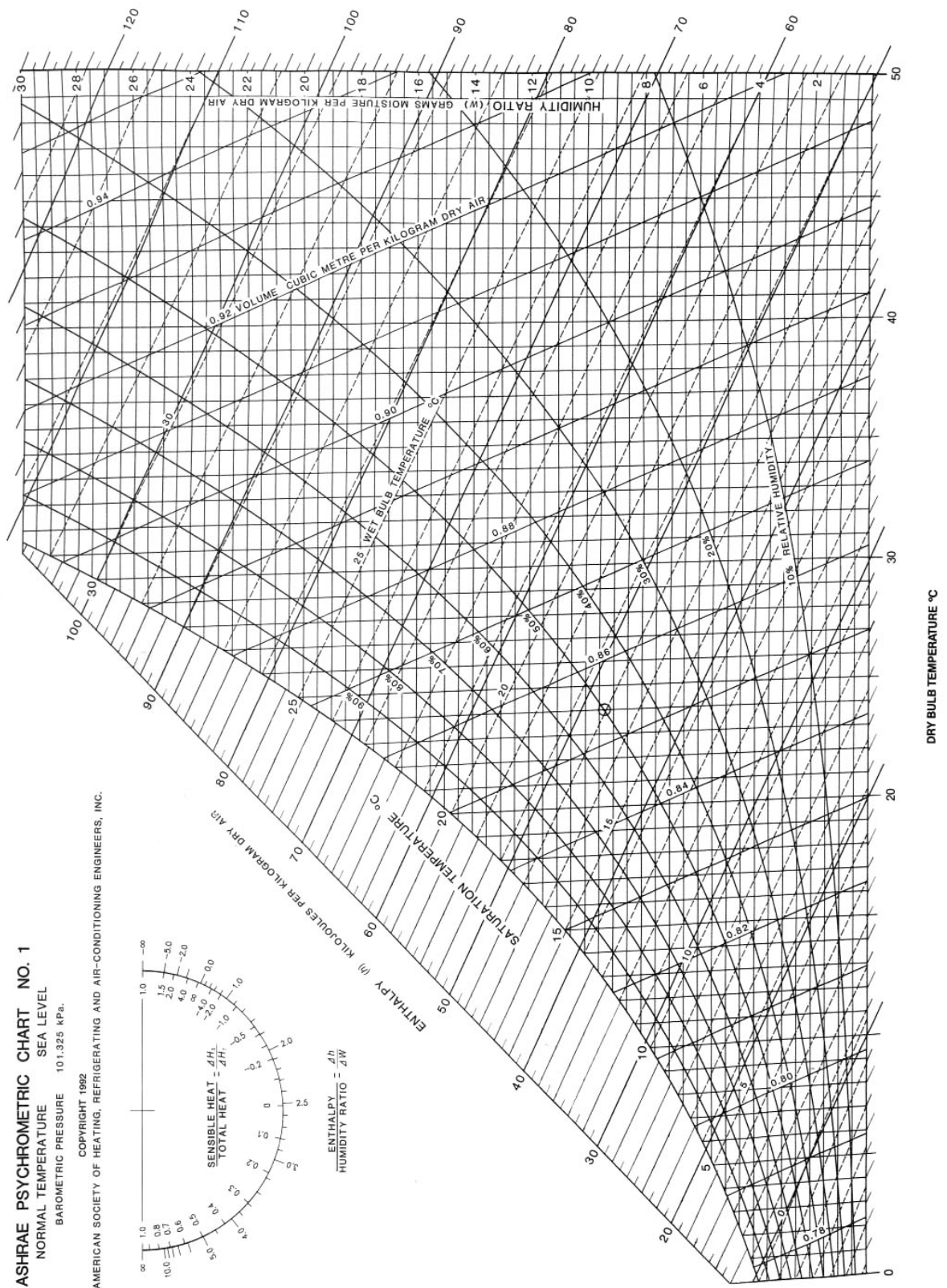
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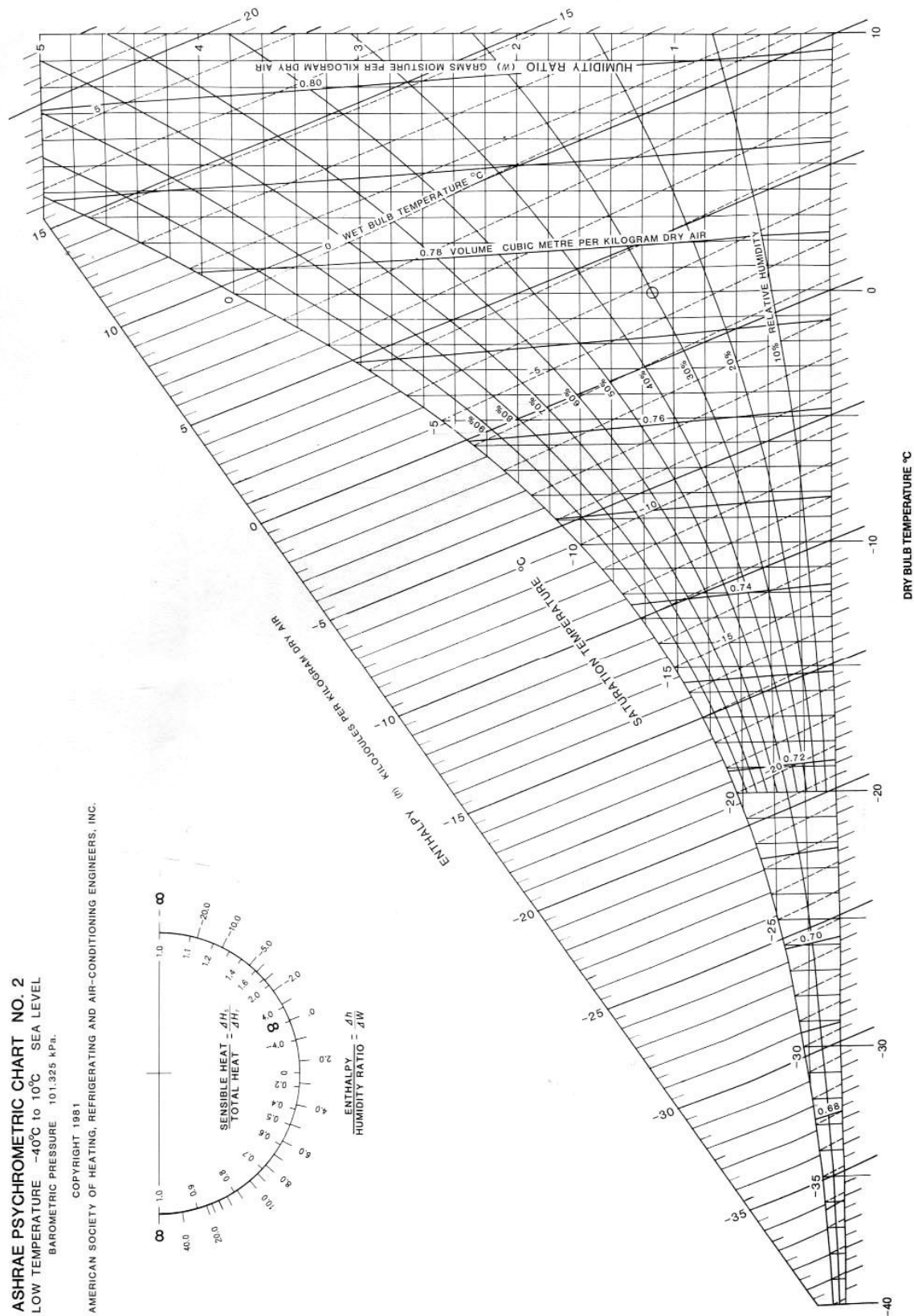
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1. Diagramas Psicrométricos

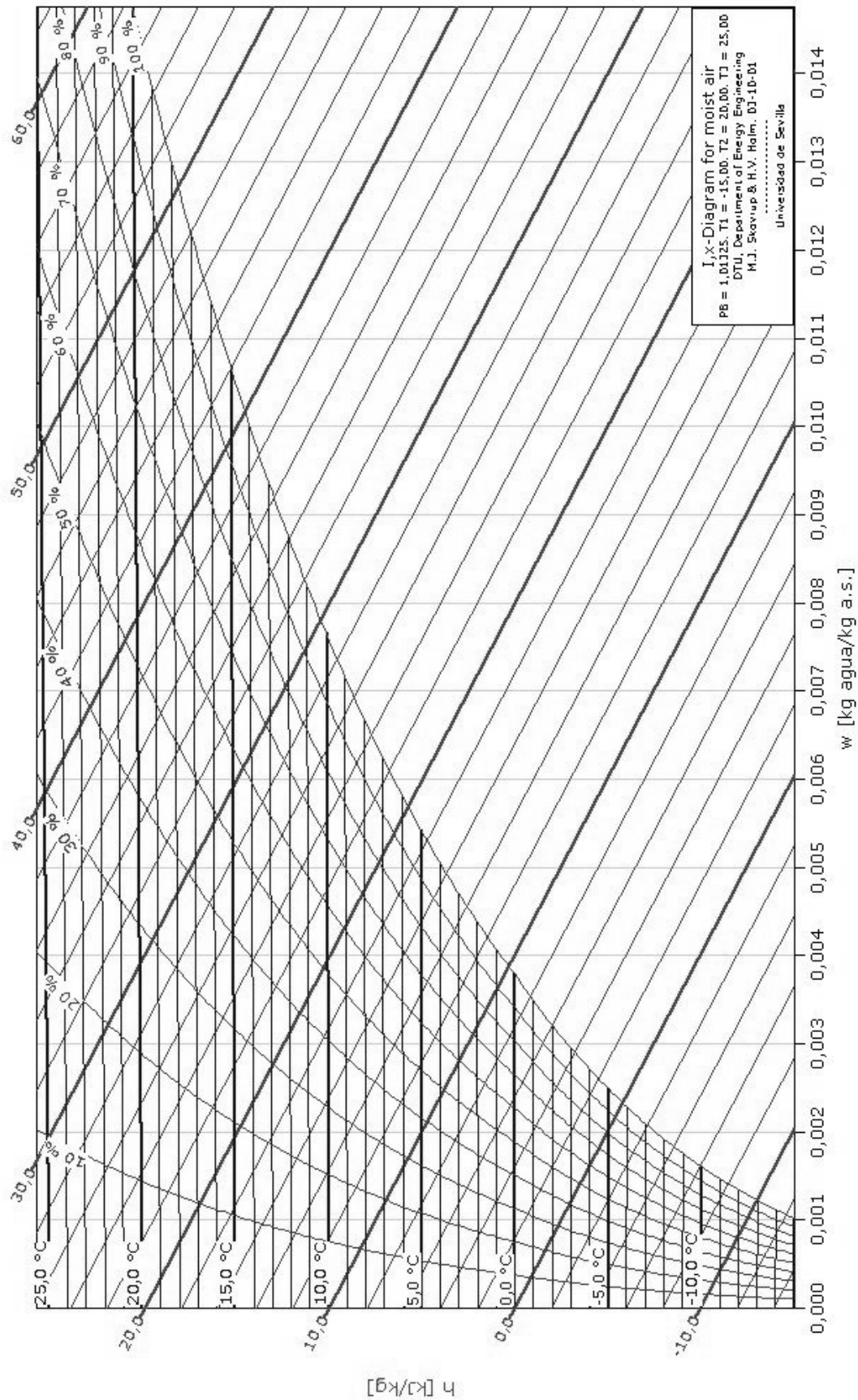
Gráfica 1.1: Diagrama Psicrométrico ASHRAE



Gráfica 1.2: Diagrama Psicrométrico ASHRAE para bajas temp.



Gráfica 1.3: Diagrama Psicrométrico Mollier



2. Propiedades de los principales refrigerantes

Tabla 2.1: Propiedades del líquido y vapor saturados para el R-22

R-22, CHClF₂, Clorodifluorometano

t (°C)	P (kPa)	v _l (dm ³ /kg)	v _g (m ³ /kg)	h _l (kJ/kg)	h _g (kJ/kg)	s _l (kJ/kg·K)	s _g (kJ/kg·K)
-50	64.39	0.6952	0.32461	144.94	383.93	0.7791	1.8501
-48	71.28	0.698	0.29526	147.01	384.88	0.7883	1.8448
-46	78.75	0.7008	0.26907	149.09	385.82	0.7975	1.8397
-44	86.82	0.7036	0.24564	151.19	386.76	0.8066	1.8347
-42	95.55	0.7064	0.22464	153.29	387.69	0.8157	1.8298
-40	104.95	0.7093	0.20578	155.4	388.62	0.8248	1.8251
-38	115.07	0.7123	0.18881	157.52	389.54	0.8339	1.8205
-36	125.94	0.7153	0.17351	159.66	390.45	0.8429	1.8161
-34	137.61	0.7183	0.15969	161.8	391.36	0.8518	1.8117
-32	150.11	0.7214	0.14719	163.96	392.26	0.8608	1.8075
-30	163.48	0.7245	0.13586	166.13	393.15	0.8697	1.8034
-28	177.76	0.7277	0.12558	168.31	394.03	0.8786	1.7993
-26	192.99	0.7309	0.11623	170.5	394.91	0.8874	1.7954
-24	209.22	0.7342	0.10772	172.7	395.77	0.8963	1.7916
-22	226.48	0.7375	0.09995	174.91	396.63	0.905	1.7879
-20	244.83	0.7409	0.09286	177.13	397.48	0.9138	1.7842
-18	264.29	0.7443	0.08637	179.37	398.31	0.9226	1.7807
-16	284.93	0.7478	0.08042	181.61	399.14	0.9313	1.7772
-14	306.78	0.7514	0.07497	183.87	399.96	0.9399	1.7738
-12	329.89	0.755	0.06996	186.14	400.77	0.9486	1.7705
-10	354.3	0.7587	0.06535	188.42	401.56	0.9572	1.7672
-8	380.06	0.7625	0.0611	190.71	402.35	0.9658	1.764
-6	407.23	0.7663	0.05719	193.02	403.12	0.9744	1.7609
-4	435.84	0.7703	0.05357	195.33	403.88	0.983	1.7578
-2	465.94	0.7742	0.05023	197.66	404.63	0.9915	1.7548
0	497.59	0.7783	0.04714	200	405.37	1	1.7519
2	530.83	0.7825	0.04427	202.35	406.09	1.0085	1.749
4	565.71	0.7867	0.04162	204.72	406.8	1.0169	1.7461
6	602.28	0.791	0.03915	207.09	407.5	1.0254	1.7433
8	640.59	0.7955	0.03685	209.48	408.18	1.0338	1.7405
10	680.7	0.8	0.03472	211.88	408.84	1.0422	1.7378
12	722.65	0.8046	0.03273	214.3	409.49	1.0506	1.7351
14	766.5	0.8094	0.03087	216.7	410.13	1.0589	1.7325
16	812.29	0.8142	0.02914	219.15	410.75	1.0672	1.7299
18	860.08	0.8192	0.02752	221.6	411.35	1.0756	1.7273
20	909.93	0.8243	0.02601	224.07	411.93	1.0839	1.7247
22	961.89	0.8295	0.02459	226.56	412.49	1.0922	1.7221
24	1016.01	0.8349	0.02326	229.05	413.03	1.1005	1.7196
26	1072.34	0.8404	0.02201	231.57	413.56	1.1087	1.7171
28	1130.95	0.8461	0.02084	234.1	414.06	1.117	1.7146
30	1191.88	0.8519	0.01974	236.65	414.54	1.1253	1.7121
32	1255.2	0.8579	0.01871	239.22	415	1.1335	1.7096
34	1320.97	0.8641	0.01774	241.8	415.43	1.1418	1.7071
36	1389.24	0.8705	0.01682	244.41	415.84	1.15	1.7046
38	1460.06	0.8771	0.01595	247.03	416.22	1.1583	1.7021
40	1533.52	0.8839	0.01514	249.67	416.57	1.1666	1.6995
42	1609.65	0.8909	0.01437	252.34	416.89	1.1748	1.697
44	1688.53	0.8983	0.01364	255.03	417.18	1.1831	1.6944
46	1770.23	0.9058	0.01295	257.74	417.44	1.1914	1.6918
48	1854.8	0.9137	0.01229	260.49	417.66	1.1998	1.6892
50	1942.31	0.9219	0.01167	263.25	417.85	1.2081	1.6865
52	2032.84	0.9304	0.01108	266.05	417.99	1.2165	1.6838
54	2126.46	0.9394	0.01052	268.88	418.09	1.2249	1.681
56	2223.23	0.9487	0.00999	271.74	418.15	1.2333	1.6781
58	2323.24	0.9585	0.00948	274.64	418.15	1.2418	1.6752
60	2426.57	0.9687	0.009	277.58	418.1	1.2504	1.6722
62	2533.29	0.9796	0.00854	280.57	417.99	1.259	1.669
64	2643.49	0.991	0.0081	283.6	417.81	1.2677	1.6658
66	2757.26	1.0031	0.00768	286.68	417.56	1.2765	1.6624
68	2874.7	1.0161	0.00728	289.82	417.24	1.2854	1.6588
70	2995.9	1.0298	0.00689	293.03	416.82	1.2944	1.6551

Fuente: R.C.Downing. ASHRAE Transactions 1974. Paper No. 2313.

Tabla 2.1: Propiedades del líquido y vapor saturados para el R-134a

R-134a, CH₂F-CF₃, 1,1,1,2-Tetrafluoretano

t (°C)	P (kPa)	v _l (dm ³ /kg)	v _g (m ³ /kg)	h _l (kJ/kg)	h _g (kJ/kg)	s _l (kJ/kg·K)	s _g (kJ/kg·K)
-50	29.9	0.6917	0.5957	138.42	366.54	0.7524	1.7747
-48	33.5	0.6944	0.53549	140.7	367.81	0.7626	1.7713
-46	37.45	0.6971	0.48239	142.99	369.07	0.7727	1.768
-44	41.77	0.6998	0.43545	145.3	370.33	0.7828	1.7648
-42	46.5	0.7026	0.39385	147.63	371.59	0.7929	1.7618
-40	51.64	0.7055	0.35692	149.97	372.85	0.803	1.7589
-38	57.24	0.7083	0.32405	152.33	374.11	0.813	1.7562
-36	63.32	0.7113	0.29474	154.7	375.37	0.8231	1.7535
-34	69.91	0.7142	0.26855	157.09	376.62	0.8331	1.751
-32	77.04	0.7172	0.24511	159.49	377.87	0.8431	1.7486
-30	84.74	0.7202	0.22408	161.91	379.11	0.853	1.7463
-28	93.05	0.7233	0.20518	164.35	380.35	0.863	1.7441
-26	101.99	0.7264	0.18817	166.8	381.59	0.8729	1.742
-24	111.6	0.7296	0.17282	169.26	382.82	0.8828	1.74
-22	121.92	0.7328	0.15896	171.74	384.05	0.8927	1.738
-20	132.99	0.7361	0.14641	174.24	385.28	0.9025	1.7362
-18	144.83	0.7394	0.13504	176.75	386.5	0.9124	1.7345
-16	157.48	0.7428	0.12471	179.27	387.71	0.9222	1.7328
-14	170.99	0.7463	0.11533	181.81	388.92	0.932	1.7312
-12	185.4	0.7498	0.10678	184.36	390.12	0.9418	1.7297
-10	200.73	0.7533	0.09898	186.93	391.32	0.9515	1.7282
-8	217.04	0.7569	0.09186	189.52	392.51	0.9613	1.7269
-6	234.36	0.7606	0.08535	192.12	393.7	0.971	1.7255
-4	252.74	0.7644	0.07938	194.73	394.87	0.9807	1.7243
-2	272.21	0.7682	0.07391	197.36	396.04	0.9903	1.7231
0	292.82	0.7721	0.06889	200	397.2	1	1.722
2	314.62	0.776	0.06427	202.66	398.36	1.0096	1.7209
4	337.65	0.7801	0.06001	205.33	399.5	1.0192	1.7199
6	361.95	0.7842	0.05609	208.02	400.64	1.0288	1.7189
8	387.56	0.7884	0.05248	210.72	401.77	1.0384	1.7179
10	414.55	0.7927	0.04913	213.44	402.89	1.048	1.717
12	442.94	0.7971	0.04604	216.17	404	1.0575	1.7162
14	472.8	0.8016	0.04318	218.92	405.1	1.067	1.7154
16	504.16	0.8062	0.04052	221.68	406.18	1.0765	1.7146
18	537.08	0.8109	0.03806	224.44	407.26	1.0859	1.7139
20	571.6	0.8157	0.03577	227.23	408.33	1.0954	1.7132
22	607.78	0.8206	0.03365	230.05	409.38	1.1049	1.7125
24	645.66	0.8257	0.03166	232.87	410.42	1.1143	1.7118
26	685.3	0.8309	0.02982	235.72	411.45	1.1237	1.7112
28	726.75	0.8362	0.02809	238.58	412.47	1.1332	1.7106
30	770.06	0.8416	0.02648	241.46	413.47	1.1426	1.71
32	815.28	0.8473	0.02498	244.36	414.45	1.152	1.7094
34	862.47	0.853	0.02357	247.28	415.42	1.1614	1.7088
36	911.68	0.859	0.02225	250.22	416.37	1.1708	1.7082
38	962.98	0.8651	0.02102	253.18	417.3	1.1802	1.7077
40	1016.4	0.8714	0.01986	256.16	418.21	1.1896	1.7071
42	1072.02	0.8779	0.01877	259.16	419.11	1.199	1.7065
44	1129.9	0.8847	0.01774	262.19	419.98	1.2084	1.7059
46	1190.08	0.8917	0.01678	265.24	420.83	1.2178	1.7053
48	1252.63	0.8989	0.01588	268.32	421.65	1.2273	1.7047
50	1317.62	0.9064	0.01502	271.42	422.44	1.2367	1.7041
52	1385.1	0.9142	0.01421	274.55	423.21	1.2462	1.7034
54	1455.15	0.9223	0.01345	277.71	423.95	1.2557	1.7027
56	1527.83	0.9308	0.01273	280.9	424.66	1.2652	1.7019
58	1603.2	0.9396	0.01205	284.13	425.32	1.2747	1.7011
60	1681.34	0.9488	0.01141	287.39	425.96	1.2843	1.7003
62	1762.33	0.9585	0.01079	290.68	426.54	1.294	1.6994
64	1846.22	0.9687	0.01021	294.02	427.09	1.3037	1.6983
66	1933.11	0.9794	0.00966	297.4	427.58	1.3134	1.6973
68	2023.07	0.9907	0.00914	300.83	428.02	1.3232	1.6961
70	2116.2	1.0027	0.00864	304.31	428.4	1.3331	1.6947

Fuente: D.P.Wilson & R.S.Basu, ASHRAE Transactions 1988, Vol. 94 part 2.

Tabla 2.3: Propiedades del líquido y vapor saturados para el R-717

R-717, NH₃, Amoníaco

t (°C)	P (kPa)	v _l (dm ³ /kg)	v _g (m ³ /kg)	h _l (kJ/kg)	h _g (kJ/kg)	s _l (kJ/kg·K)	s _g (kJ/kg·K)
-50	40.85	1.4242	2.62482	-23.77	1391.02	0.0981	6.4382
-48	45.92	1.429	2.35264	-14.99	1394.34	0.1372	6.3967
-46	51.51	1.434	2.11333	-6.2	1397.63	0.176	6.3562
-44	57.64	1.4389	1.90242	2.6	1400.87	0.2146	6.3166
-42	64.36	1.444	1.71612	11.42	1404.08	0.2529	6.2778
-40	71.71	1.4491	1.55117	20.25	1407.25	0.2909	6.2398
-38	79.73	1.4542	1.4048	29.1	1410.38	0.3286	6.2026
-36	88.47	1.4594	1.27465	37.97	1413.46	0.3661	6.1662
-34	97.97	1.4647	1.15868	46.84	1416.51	0.4033	6.1305
-32	108.28	1.4701	1.05513	55.74	1419.5	0.4403	6.0956
-30	119.46	1.4755	0.96249	64.64	1422.46	0.477	6.0613
-28	131.54	1.481	0.87945	73.57	1425.36	0.5135	6.0277
-26	144.6	1.4865	0.80488	82.5	1428.22	0.5497	5.9947
-24	158.67	1.4921	0.73779	91.45	1431.04	0.5857	5.9623
-22	173.82	1.4978	0.67733	100.42	1433.8	0.6214	5.9305
-20	190.11	1.5036	0.62274	109.4	1436.51	0.657	5.8994
-18	207.6	1.5094	0.57338	118.39	1439.17	0.6923	5.8687
-16	226.34	1.5154	0.52866	127.4	1441.78	0.7273	5.8386
-14	246.41	1.5214	0.4881	136.43	1444.34	0.7622	5.8091
-12	267.85	1.5275	0.45123	145.46	1446.84	0.7968	5.78
-10	290.75	1.5336	0.41769	154.52	1449.29	0.8312	5.7514
-8	315.17	1.5399	0.38712	163.58	1451.68	0.8653	5.7233
-6	341.17	1.5463	0.35921	172.66	1454.01	0.8993	5.6957
-4	368.83	1.5527	0.33371	181.76	1456.29	0.9331	5.6685
-2	398.22	1.5593	0.31037	190.87	1458.51	0.9666	5.6417
0	429.41	1.5659	0.28898	200	1460.66	1	5.6153
2	462.48	1.5727	0.26935	209.14	1462.76	1.0332	5.5893
4	497.5	1.5795	0.25131	218.3	1464.8	1.0661	5.5637
6	534.54	1.5865	0.23471	227.47	1466.77	1.0989	5.5384
8	573.7	1.5936	0.21943	236.67	1468.68	1.1315	5.5135
10	615.04	1.6008	0.20533	245.87	1470.52	1.1639	5.489
12	658.64	1.6081	0.19232	255.1	1472.3	1.1961	5.4647
14	704.59	1.6155	0.18029	264.34	1474.02	1.2281	5.4408
16	752.98	1.6231	0.16916	273.6	1475.66	1.26	5.4172
18	803.88	1.6308	0.15885	282.89	1477.24	1.2917	5.3939
20	857.38	1.6386	0.14929	292.19	1478.74	1.3232	5.3708
22	913.56	1.6466	0.14041	301.51	1480.17	1.3546	5.3481
24	972.52	1.6547	0.13216	310.86	1481.53	1.3859	5.3255
26	1034.34	1.663	0.12449	320.23	1482.82	1.4169	5.3033
28	1099.11	1.6714	0.11734	329.62	1484.03	1.4479	5.2812
30	1166.93	1.68	0.11069	339.04	1485.16	1.4787	5.2594
32	1237.88	1.6888	0.10447	348.48	1486.21	1.5093	5.2377
34	1312.06	1.6978	0.09867	357.96	1487.19	1.5398	5.2163
36	1389.55	1.7069	0.09327	367.33	1488.09	1.5699	5.1952
38	1470.47	1.7162	0.0882	376.86	1488.89	1.6002	5.1741
40	1554.89	1.7257	0.08345	386.43	1489.61	1.6303	5.1532
42	1642.93	1.7355	0.079	396.02	1490.25	1.6604	5.1325
44	1734.67	1.7454	0.07483	405.66	1490.79	1.6904	5.1119
46	1830.22	1.7556	0.07092	415.34	1491.23	1.7203	5.0914
48	1929.68	1.766	0.06724	425.06	1491.59	1.7501	5.0711
50	2033.14	1.7767	0.06378	434.82	1491.84	1.7798	5.0508
52	2140.72	1.7876	0.06053	444.63	1491.99	1.8095	5.0307
54	2252.52	1.7988	0.05747	454.5	1492.04	1.8391	5.0106
56	2368.64	1.8103	0.05458	464.42	1491.98	1.8687	4.9906
58	2489.19	1.8221	0.05186	474.39	1491.81	1.8983	4.9707
60	2614.27	1.8343	0.04929	484.43	1491.52	1.9278	4.9508
62	2744.01	1.8467	0.04687	494.54	1491.12	1.9573	4.9309
64	2878.5	1.8595	0.04458	504.71	1490.58	1.9869	4.911
66	3017.86	1.8727	0.04241	514.96	1489.93	2.0164	4.8911
68	3162.22	1.8863	0.04036	525.29	1489.13	2.046	4.8713
70	3311.68	1.9003	0.03841	535.71	1488.2	2.0756	4.8513

Fuente: R.Döring. Klima+Kälte ingenieur Ki-Extra 5, 1978.

Tabla 2.4: Entalpía del líquido subenfriado y el vapor sobrecalentado para el R-717

h (kJ/kg), R-717, NH₃, Amoniaco

t _{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	3312	-21.8	21.95	66.21	110.9	156.2	201.9	248.1	294.9	342.5	391	440.6	491.8		1527	1566	1601
65	2948	-22.13	21.64	65.91	110.7	155.9	201.6	247.9	294.8	342.4	390.9	440.6	491.9	1509	1547	1582	1615
60	2614	-22.43	21.35	65.64	110.4	155.7	201.4	247.7	294.6	342.3	390.8	440.6		1529	1564	1597	1628
55	2310	-22.7	21.09	65.39	110.2	155.4	201.2	247.5	294.5	342.2	390.8	440.6	1510	1546	1579	1609	1639
50	2033	-22.95	20.85	65.16	110	155.2	201	247.4	294.3	342.1	390.7		1527	1560	1591	1621	1649
45	1782	-23.17	20.63	64.96	109.8	155.1	200.9	247.2	294.2	342	390.7	1509	1542	1573	1602	1630	1658
40	1555	-23.37	20.44	64.77	109.6	154.9	200.7	247.1	294.1	341.9		1523	1554	1584	1612	1639	1665
35	1351	-23.56	20.26	64.6	109.4	154.8	200.6	247	294	341.8	1505	1536	1565	1593	1620	1646	1672
30	1167	-23.72	20.11	64.45	109.3	154.6	200.5	246.9	293.9		1517	1546	1574	1601	1627	1653	1678
25	1003	-23.87	19.97	64.32	109.2	154.5	200.4	246.8	293.9	1499	1528	1556	1582	1608	1634	1659	1683
20	857.8	-24	19.84	64.2	109.1	154.4	200.3	246.7		1509	1537	1563	1589	1614	1639	1664	1688
15	728.8	-24.11	19.73	64.1	109	154.3	200.2	246.6	1491	1518	1545	1570	1595	1620	1644	1668	1692
10	615.3	-24.22	19.63	64.01	108.9	154.2	200.1		1500	1526	1551	1576	1600	1624	1648	1672	1696
5	516	-24.3	19.55	63.92	108.8	154.2	200.1	1481	1507	1532	1557	1581	1605	1628	1652	1675	1699
0	429.6	-24.38	19.48	63.85	108.7	154.1		1488	1513	1538	1562	1585	1609	1632	1655	1678	1701
-5	354.9	-24.45	19.41	63.79	108.7	154.1	1470	1495	1519	1542	1566	1589	1612	1635	1658	1681	1703
-10	290.8	-24.5	19.36	63.74	108.6		1476	1500	1523	1546	1569	1592	1615	1637	1660	1683	1705
-15	236.2	-24.55	19.31	63.7	108.6	1457	1481	1504	1527	1550	1572	1595	1617	1639	1662	1684	1707
-20	190.1	-24.59	19.27	63.66		1462	1485	1507	1530	1552	1575	1597	1619	1641	1663	1686	1708
-25	151.5	-24.63	19.24	63.63	1442	1465	1488	1510	1533	1555	1577	1599	1621	1643	1665	1687	1710
-30	119.4	-24.66	19.21		1446	1469	1491	1513	1535	1556	1578	1600	1622	1644	1666	1688	1711
-35	93.07	-24.68	19.19	1427	1449	1471	1493	1515	1536	1558	1580	1601	1623	1645	1667	1689	1711
-40	71.66	-24.7		1430	1452	1473	1495	1516	1538	1559	1581	1602	1624	1646	1668	1690	1712
-45	54.47	-24.72	1411	1432	1454	1475	1496	1518	1539	1560	1582	1603	1625	1646	1668	1690	1712
-50	40.82		1413	1434	1455	1476	1497	1519	1540	1561	1582	1604	1625	1647	1669	1691	1713

Fuente: Tillner-Roth, Harms-Watzenberg, and Baehr, "Eine neue Fundamentalgleichung für Ammoniak", DKV-Tagungsbericht 20:167-181, 1993.

Tabla 2.5: Entropía del líquido subenfriado y el vapor sobrecalentado para el R-717

s (kJ/kg·K), R-717, NH₃, Amoníaco

t _{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	3312	0.087	0.279	0.464	0.645	0.82	0.99	1.157	1.319	1.479	1.636	1.792	1.948		4.97	5.07	5.17
65	2948	0.088	0.279	0.465	0.646	0.821	0.992	1.158	1.321	1.48	1.638	1.794	1.95	4.96	5.07	5.17	5.26
60	2614	0.088	0.28	0.466	0.647	0.822	0.993	1.159	1.322	1.482	1.639	1.796		5.06	5.16	5.26	5.34
55	2310	0.089	0.281	0.467	0.648	0.823	0.994	1.16	1.323	1.483	1.641	1.797	5.057	5.16	5.26	5.34	5.42
50	2033	0.09	0.282	0.468	0.648	0.824	0.995	1.161	1.324	1.484	1.642		5.16	5.26	5.35	5.43	5.51
45	1782	0.09	0.282	0.469	0.649	0.825	0.996	1.162	1.325	1.485	1.643	5.158	5.259	5.35	5.43	5.51	5.59
40	1555	0.091	0.283	0.469	0.65	0.825	0.996	1.163	1.326	1.486		5.26	5.354	5.44	5.52	5.6	5.67
35	1351	0.091	0.284	0.47	0.65	0.826	0.997	1.164	1.327	1.487	5.262	5.359	5.448	5.53	5.61	5.68	5.75
30	1167	0.092	0.284	0.47	0.651	0.827	0.998	1.164	1.328		5.364	5.456	5.541	5.62	5.7	5.77	5.84
25	1003	0.092	0.284	0.471	0.651	0.827	0.998	1.165	1.328	5.37	5.465	5.552	5.633	5.71	5.78	5.85	5.92
20	857.8	0.093	0.285	0.471	0.652	0.828	0.999	1.165		5.474	5.563	5.647	5.725	5.8	5.87	5.94	6.01
15	728.8	0.093	0.285	0.471	0.652	0.828	0.999	1.166	5.484	5.576	5.662	5.742	5.818	5.89	5.96	6.03	6.09
10	615.3	0.093	0.285	0.472	0.653	0.828	0.999		5.59	5.678	5.761	5.838	5.912	5.98	6.05	6.12	6.18
5	516	0.093	0.286	0.472	0.653	0.829	1	5.605	5.696	5.78	5.86	5.936	6.008	6.08	6.15	6.21	6.27
0	429.6	0.094	0.286	0.472	0.653	0.829		5.715	5.802	5.884	5.961	6.035	6.106	6.18	6.24	6.31	6.37
-5	354.9	0.094	0.286	0.472	0.653	0.829	5.735	5.825	5.909	5.988	6.064	6.137	6.207	6.28	6.34	6.4	6.47
-10	290.8	0.094	0.286	0.473	0.654		5.85	5.936	6.018	6.095	6.17	6.241	6.31	6.38	6.44	6.51	6.57
-15	236.2	0.094	0.286	0.473	0.654	5.876	5.965	6.049	6.129	6.205	6.278	6.349	6.417	6.48	6.55	6.61	6.67
-20	190.1	0.094	0.286	0.473		5.996	6.083	6.165	6.243	6.318	6.39	6.46	6.527	6.59	6.66	6.72	6.78
-25	151.5	0.094	0.287	0.473	6.03	6.119	6.203	6.284	6.36	6.434	6.506	6.575	6.642	6.71	6.77	6.83	6.89
-30	119.4	0.094	0.287		6.158	6.245	6.327	6.406	6.482	6.555	6.626	6.694	6.761	6.83	6.89	6.95	7.01
-35	93.07	0.094	0.287	6.199	6.289	6.374	6.455	6.533	6.608	6.68	6.751	6.819	6.885	6.95	7.01	7.08	7.14
-40	71.66	0.094		6.336	6.424	6.508	6.588	6.665	6.739	6.811	6.881	6.949	7.015	7.08	7.14	7.2	7.26
-45	54.47	0.094	6.386	6.477	6.564	6.647	6.726	6.802	6.876	6.947	7.017	7.084	7.15	7.21	7.28	7.34	7.4
-50	40.82		6.535	6.624	6.709	6.791	6.87	6.946	7.019	7.09	7.159	7.227	7.292	7.36	7.42	7.48	7.54

Fuente: Tillner-Roth, Harms-Watzenberg, and Baehr, "Eine neue Fundamentalgleichung für Ammoniak", DKV-Tagungsbericht 20:167-181, 1993.

Tabla 2.6: Volumen específico del líquido subenfriado y el vapor sobrecalentado para el R-717

 v (m³/kg), R-717, NH₃, Amoníaco

t_{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	3312	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		0.04	0.04	0.05
65	2948	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.04	0.05	0.05	0.05
60	2614	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		0.05	0.06	0.06	0.06
55	2310	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.057	0.06	0.06	0.07	0.07
50	2033	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002		0.067	0.07	0.07	0.08	0.08
45	1782	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.075	0.079	0.08	0.09	0.09	0.09
40	1555	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002		0.088	0.092	0.1	0.1	0.1	0.11
35	1351	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.098	0.104	0.109	0.11	0.12	0.12	0.13
30	1167	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002		0.117	0.122	0.128	0.13	0.14	0.14	0.15
25	1003	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.132	0.138	0.144	0.151	0.16	0.16	0.17	0.17
20	857.8	0.001	0.001	0.001	0.002	0.002	0.002	0.002		0.157	0.164	0.171	0.178	0.18	0.19	0.2	0.2
15	728.8	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.179	0.188	0.196	0.204	0.212	0.22	0.23	0.23	0.24
10	615.3	0.001	0.001	0.001	0.002	0.002	0.002		0.216	0.225	0.235	0.244	0.253	0.26	0.27	0.28	0.29
5	516	0.001	0.001	0.001	0.002	0.002	0.002	0.249	0.261	0.272	0.283	0.294	0.304	0.31	0.32	0.33	0.34
0	429.6	0.001	0.001	0.001	0.002	0.002		0.303	0.317	0.33	0.343	0.355	0.368	0.38	0.39	0.4	0.42
-5	354.9	0.001	0.001	0.001	0.002	0.002	0.355	0.371	0.387	0.402	0.417	0.432	0.447	0.46	0.48	0.49	0.51
-10	290.8	0.001	0.001	0.001	0.002		0.438	0.457	0.476	0.494	0.513	0.53	0.548	0.57	0.58	0.6	0.62
-15	236.2	0.001	0.001	0.001	0.002	0.521	0.544	0.567	0.59	0.612	0.634	0.656	0.678	0.7	0.72	0.74	0.76
-20	190.1	0.001	0.001	0.001		0.653	0.681	0.709	0.737	0.764	0.791	0.818	0.845	0.87	0.9	0.92	0.95
-25	151.5	0.001	0.001	0.001	0.79	0.825	0.86	0.895	0.929	0.963	0.996	1.03	1.063	1.1	1.13	1.16	1.2
-30	119.4	0.001	0.001		1.009	1.053	1.097	1.14	1.183	1.225	1.267	1.309	1.351	1.39	1.44	1.48	1.52
-35	93.07	0.001	0.001	1.246	1.302	1.358	1.413	1.468	1.522	1.576	1.63	1.683	1.737	1.79	1.84	1.9	1.95
-40	71.66	0.001		1.627	1.699	1.77	1.841	1.911	1.981	2.051	2.12	2.19	2.259	2.33	2.4	2.47	2.53
-45	54.47	0.001	2.056	2.15	2.244	2.337	2.429	2.52	2.612	2.703	2.794	2.885	2.975	3.07	3.16	3.25	3.34
-50	40.82		2.755	2.879	3.003	3.125	3.247	3.369	3.49	3.612	3.732	3.853	3.974	4.09	4.22	4.34	4.46

Fuente: Tillner-Roth, Harms-Watzenberg, and Baehr, "Eine neue Fundamentalgleichung für Ammoniak", DKV-Tagungsbericht 20:167-181, 1993.

Tabla 2.7: Entalpía del líquido subenfriado y el vapor sobrecalentado para el R-22

h (kJ/kg), R-22, CHClF₂, Clorodifluorometano

t _{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	2998	144.7	155.6	166.6	177.7	189.1	200.6	212.3	224.3	236.7	249.5	262.9	277.2		430	442	452
65	2702	144.6	155.5	166.5	177.7	189	200.5	212.2	224.3	236.7	249.5	263	277.5	424	436	446	456
60	2428	144.5	155.4	166.4	177.6	188.9	200.4	212.2	224.2	236.7	249.6	263.2		429	440	450	459
55	2176	144.4	155.3	166.3	177.5	188.8	200.4	212.1	224.2	236.7	249.6	263.3	423.4	434	444	453	462
50	1943	144.3	155.2	166.2	177.4	188.8	200.3	212.1	224.2	236.7	249.7		428	438	447	456	465
45	1730	144.2	155.1	166.2	177.3	188.7	200.3	212.1	224.2	236.7	249.7	422.1	431.7	441	450	458	467
40	1534	144.1	155.1	166.1	177.3	188.6	200.2	212	224.2	236.7		425.9	434.9	444	452	461	469
35	1355	144.1	155	166	177.2	188.6	200.2	212	224.2	236.7	420	429	437.5	446	454	462	471
30	1192	144	154.9	166	177.2	188.6	200.1	212	224.2		423.1	431.6	439.8	448	456	464	472
25	1044	144	154.9	165.9	177.1	188.5	200.1	212	224.2	417.4	425.7	433.8	441.8	450	458	466	474
20	910.3	143.9	154.8	165.9	177.1	188.5	200.1	212		419.9	427.9	435.8	443.6	451	459	467	475
15	789.6	143.9	154.8	165.8	177.1	188.4	200.1	211.9	414.2	422.1	429.8	437.5	445.1	453	460	468	476
10	681.2	143.8	154.7	165.8	177	188.4	200		416.3	423.9	431.4	438.9	446.4	454	462	469	477
5	584.3	143.8	154.7	165.8	177	188.4	200	410.6	418.1	425.5	432.9	440.2	447.6	455	463	470	478
0	498.1	143.7	154.7	165.7	177	188.4		412.4	419.6	426.8	434.1	441.3	448.6	456	463	471	478
-5	421.9	143.7	154.7	165.7	176.9	188.4	406.7	413.8	420.9	428	435.1	442.3	449.5	457	464	472	479
-10	354.9	143.7	154.6	165.7	176.9		408.1	415.1	422	429	436	443.1	450.3	458	465	472	480
-15	296.3	143.7	154.6	165.7	176.9	402.5	409.3	416.1	423	429.9	436.8	443.8	450.9	458	465	473	480
-20	245.4	143.6	154.6	165.7		403.7	410.3	417	423.8	430.6	437.5	444.4	451.5	459	466	473	481
-25	201.5	143.6	154.6	165.6	398.1	404.6	411.2	417.8	424.5	431.2	438.1	445	452	459	466	474	481
-30	163.9	143.6	154.6		399	405.4	411.9	418.4	425.1	431.8	438.5	445.4	452.4	460	467	474	481
-35	132	143.6	154.5	393.4	399.7	406.1	412.5	419	425.5	432.2	438.9	445.8	452.7	460	467	474	482
-40	105.2	143.6		394.1	400.4	406.6	413	419.4	425.9	432.6	439.3	446.1	453	460	467	474	482
-45	82.91	143.6	388.6	394.7	400.9	407.1	413.4	419.8	426.3	432.9	439.6	446.4	453.3	460	467	475	482
-50	64.52		389.2	395.2	401.3	407.5	413.7	420.1	426.6	433.1	439.8	446.6	453.5	461	468	475	482

Fuente: Wagner, W., Marx, V., Prob, A., "A New Equation of State for Chlorodifluoromethane covering the entire fluid region from 116 K to 550 K at pressures up to 200 MPa, Int. J. Refrig, 16:373, 1993.

Tabla 2.8: Entropía del líquido subenfriado y el vapor sobrecalentado para el R-22

s (kJ/kg·K), R-22, CHClF₂, Clorodifluormetano

t _{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	2998	0.769	0.817	0.863	0.908	0.952	0.995	1.037	1.079	1.12	1.162	1.204	1.248		1.69	1.73	1.75
65	2702	0.77	0.818	0.864	0.909	0.953	0.996	1.038	1.08	1.121	1.163	1.205	1.249	1.68	1.72	1.75	1.77
60	2428	0.77	0.818	0.864	0.909	0.953	0.996	1.038	1.08	1.122	1.164	1.206		1.71	1.74	1.76	1.79
55	2176	0.771	0.818	0.865	0.91	0.954	0.997	1.039	1.081	1.123	1.165	1.208	1.696	1.73	1.76	1.78	1.81
50	1943	0.771	0.819	0.865	0.91	0.954	0.997	1.039	1.081	1.123	1.165		1.717	1.75	1.77	1.8	1.82
45	1730	0.771	0.819	0.865	0.91	0.954	0.998	1.04	1.082	1.124	1.166	1.708	1.737	1.76	1.79	1.81	1.84
40	1534	0.771	0.819	0.866	0.911	0.955	0.998	1.04	1.083	1.125		1.729	1.756	1.78	1.81	1.83	1.85
35	1355	0.772	0.82	0.866	0.911	0.955	0.998	1.041	1.083	1.125	1.72	1.748	1.774	1.8	1.82	1.85	1.87
30	1192	0.772	0.82	0.866	0.911	0.955	0.999	1.041	1.083		1.74	1.767	1.792	1.82	1.84	1.86	1.88
25	1044	0.772	0.82	0.866	0.912	0.956	0.999	1.042	1.084	1.732	1.759	1.784	1.809	1.83	1.86	1.88	1.9
20	910.3	0.772	0.82	0.867	0.912	0.956	0.999	1.042		1.751	1.777	1.802	1.826	1.85	1.87	1.89	1.91
15	789.6	0.772	0.82	0.867	0.912	0.956	0.999	1.042	1.744	1.771	1.796	1.82	1.843	1.87	1.89	1.91	1.93
10	681.2	0.773	0.821	0.867	0.912	0.956	1		1.764	1.789	1.814	1.837	1.86	1.88	1.9	1.93	1.95
5	584.3	0.773	0.821	0.867	0.912	0.957	1	1.757	1.783	1.808	1.832	1.855	1.877	1.9	1.92	1.94	1.96
0	498.1	0.773	0.821	0.867	0.912	0.957		1.777	1.802	1.826	1.85	1.873	1.895	1.92	1.94	1.96	1.98
-5	421.9	0.773	0.821	0.867	0.913	0.957	1.771	1.797	1.821	1.845	1.868	1.891	1.913	1.93	1.96	1.98	2
-10	354.9	0.773	0.821	0.868	0.913		1.792	1.817	1.841	1.864	1.887	1.909	1.931	1.95	1.97	1.99	2.01
-15	296.3	0.773	0.821	0.868	0.913	1.787	1.812	1.837	1.861	1.884	1.906	1.928	1.95	1.97	1.99	2.01	2.03
-20	245.4	0.773	0.821	0.868		1.808	1.833	1.857	1.881	1.903	1.926	1.948	1.969	1.99	2.01	2.03	2.05
-25	201.5	0.773	0.821	0.868	1.804	1.83	1.854	1.878	1.901	1.924	1.946	1.968	1.989	2.01	2.03	2.05	2.07
-30	163.9	0.773	0.821		1.827	1.852	1.876	1.9	1.922	1.945	1.967	1.989	2.01	2.03	2.05	2.07	2.09
-35	132	0.773	0.821	1.824	1.85	1.875	1.898	1.922	1.944	1.967	1.989	2.01	2.031	2.05	2.07	2.09	2.11
-40	105.2	0.773		1.848	1.874	1.898	1.922	1.945	1.967	1.989	2.011	2.033	2.054	2.08	2.1	2.12	2.14
-45	82.91	0.773	1.847	1.873	1.898	1.922	1.946	1.968	1.991	2.013	2.035	2.056	2.077	2.1	2.12	2.14	2.16
-50	64.52		1.873	1.899	1.923	1.947	1.97	1.993	2.016	2.038	2.059	2.081	2.102	2.12	2.14	2.16	2.18

Fuente: Wagner, W., Marx, V., Prob, A., "A New Equation of State for Chlorodifluoromethane covering the entire fluid region from 116 K to 550 K at pressures up to 200 MPa, Int. J. Refrig, 16:373, 1993.

Tabla 2.9: Volumen específico del líquido subenfriado y el vapor sobrecalentado para el R-22

 v (m³/kg), R-22, CHClF₂, Clorodifluorometano

t_{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	2998	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	1E-03		0.01	0.01	0.01
65	2702	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	1E-03	0.01	0.01	0.01	0.01
60	2428	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04		0.01	0.01	0.01	0.01
55	2176	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	0.011	0.01	0.01	0.01	0.01
50	1943	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04		0.013	0.01	0.01	0.02	0.02
45	1730	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	0.014	0.015	0.02	0.02	0.02	0.02
40	1534	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	9E-04		0.016	0.017	0.02	0.02	0.02	0.02
35	1355	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	9E-04	0.018	0.019	0.02	0.02	0.02	0.02	0.02
30	1192	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04		0.021	0.022	0.023	0.02	0.03	0.03	0.03
25	1044	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	0.023	0.025	0.026	0.027	0.03	0.03	0.03	0.03
20	910.3	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04		0.028	0.029	0.03	0.032	0.03	0.03	0.04	0.04
15	789.6	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	0.031	0.033	0.034	0.036	0.037	0.04	0.04	0.04	0.04
10	681.2	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04		0.037	0.038	0.04	0.042	0.044	0.05	0.05	0.05	0.05
5	584.3	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	0.041	0.044	0.046	0.048	0.05	0.052	0.05	0.06	0.06	0.06
0	498.1	7E-04	7E-04	7E-04	7E-04	8E-04		0.05	0.052	0.054	0.057	0.059	0.061	0.06	0.07	0.07	0.07
-5	421.9	7E-04	7E-04	7E-04	7E-04	8E-04	0.057	0.06	0.062	0.065	0.068	0.07	0.073	0.08	0.08	0.08	0.08
-10	354.9	7E-04	7E-04	7E-04	7E-04		0.069	0.072	0.075	0.078	0.081	0.084	0.087	0.09	0.09	0.1	0.1
-15	296.3	7E-04	7E-04	7E-04	7E-04	0.079	0.083	0.087	0.091	0.094	0.098	0.101	0.105	0.11	0.11	0.12	0.12
-20	245.4	7E-04	7E-04	7E-04		0.097	0.102	0.106	0.111	0.115	0.119	0.123	0.127	0.13	0.14	0.14	0.14
-25	201.5	7E-04	7E-04	7E-04	0.114	0.12	0.125	0.13	0.136	0.141	0.146	0.151	0.156	0.16	0.17	0.17	0.18
-30	163.9	7E-04	7E-04		0.142	0.149	0.155	0.161	0.168	0.174	0.18	0.186	0.192	0.2	0.2	0.21	0.22
-35	132	7E-04	7E-04	0.17	0.178	0.186	0.194	0.202	0.209	0.217	0.224	0.232	0.239	0.25	0.25	0.26	0.27
-40	105.2	7E-04		0.215	0.225	0.235	0.244	0.254	0.264	0.273	0.283	0.292	0.301	0.31	0.32	0.33	0.34
-45	82.91	7E-04	0.263	0.275	0.287	0.3	0.312	0.324	0.336	0.348	0.36	0.371	0.383	0.4	0.41	0.42	0.43
-50	64.52		0.34	0.355	0.371	0.387	0.402	0.417	0.433	0.448	0.463	0.478	0.493	0.51	0.52	0.54	0.55

Fuente: Wagner, W., Marx, V., Prob, A., "A New Equation of State for Chlorodifluoromethane covering the entire fluid region from 116 K to 550 K at pressures up to 200 MPa, Int. J. Refrig, 16:373, 1993.

Tabla 2.10: Entalpía del líquido subenfriado y el vapor sobrecalentado para el R-134a

h (kJ/kg), R-134a, CH₂F-CF₃, 1,1,1,2-Tetrafluoretano

t _{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	2118	136.5	148.9	161.5	174.3	187.2	200.4	213.9	227.6	241.7	256.2	271.3	287.2		443	456	469
65	1891	136.4	148.8	161.4	174.2	187.2	200.4	213.8	227.6	241.7	256.3	271.4	287.3	435	448	460	472
60	1683	136.3	148.7	161.3	174.1	187.1	200.3	213.8	227.6	241.7	256.3	271.5		440	452	463	475
55	1492	136.2	148.7	161.3	174.1	187.1	200.3	213.8	227.6	241.7	256.3	271.5	431.5	444	455	466	477
50	1319	136.2	148.6	161.2	174	187	200.2	213.7	227.5	241.7	256.4		435.4	447	458	469	479
45	1161	136.1	148.6	161.2	174	187	200.2	213.7	227.5	241.7	256.4	427.3	438.6	449	460	471	481
40	1017	136.1	148.5	161.1	173.9	186.9	200.2	213.7	227.5	241.7		430.5	441.2	452	462	473	483
35	887.5	136	148.5	161.1	173.9	186.9	200.1	213.7	227.5	241.7	422.6	433.2	443.5	454	464	474	485
30	770.6	136	148.4	161	173.8	186.9	200.1	213.6	227.5		425.2	435.4	445.4	456	466	476	486
25	665.8	135.9	148.4	161	173.8	186.8	200.1	213.6	227.5	417.4	427.4	437.3	447.1	457	467	477	487
20	572.1	135.9	148.3	161	173.8	186.8	200.1	213.6		419.6	429.3	438.9	448.6	458	468	478	488
15	488.7	135.9	148.3	160.9	173.7	186.8	200	213.6	411.9	421.4	430.8	440.3	449.8	459	469	479	489
10	414.9	135.8	148.3	160.9	173.7	186.8	200		413.7	422.9	432.2	441.5	450.9	460	470	480	490
5	349.9	135.8	148.3	160.9	173.7	186.7	200	406.1	415.1	424.2	433.3	442.5	451.8	461	471	480	490
0	293	135.8	148.2	160.9	173.7	186.7		407.5	416.4	425.3	434.3	443.4	452.6	462	471	481	491
-5	243.5	135.8	148.2	160.8	173.7	186.7	400	408.7	417.4	426.2	435.1	444.2	453.3	463	472	482	491
-10	200.7	135.7	148.2	160.8	173.6		401.2	409.7	418.3	427	435.9	444.8	453.9	463	473	482	492
-15	164	135.7	148.2	160.8	173.6	393.8	402.1	410.5	419.1	427.7	436.5	445.4	454.4	464	473	483	492
-20	132.8	135.7	148.2	160.8		394.7	402.9	411.2	419.7	428.2	437	445.8	454.8	464	473	483	492
-25	106.5	135.7	148.2	160.8	387.4	395.5	403.6	411.8	420.2	428.7	437.4	446.2	455.2	464	474	483	493
-30	84.43	135.7	148.1		388.1	396.1	404.1	412.3	420.6	429.1	437.7	446.5	455.5	465	474	483	493
-35	66.19	135.7	148.1	381	388.7	396.6	404.5	412.7	421	429.4	438	446.8	455.7	465	474	484	493
-40	51.25	135.7		381.5	389.2	397	404.9	413	421.2	429.7	438.3	447	455.9	465	474	484	493
-45	39.15	135.7	374.5	382	389.5	397.3	405.2	413.2	421.5	429.9	438.4	447.2	456.1	465	474	484	493
-50	29.48		374.9	382.3	389.8	397.5	405.4	413.4	421.7	430	438.6	447.3	456.2	465	475	484	493

Fuente: R. Tillner-Roth and H.D. Baehr, An International Standard Formulation for the Thermodynamic Properties of 1,1,1,2-Tetrafluoroethane (HFC-134a) for Temperatures from 170 K to 455 K and Pressures up to 70 MPa, J. Phys. Chem, Ref. Data, Vol. 23, No. 5, 1994.

Tabla 2.11: Entropía del líquido subenfriado y el vapor sobrecalentado para el R-134a

s (kJ/kg·K), R-134a, CH₂F-CF₃, 1,1,1,2-Tetrafluoretano

t _{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	2118	0.738	0.793	0.846	0.897	0.947	0.996	1.045	1.092	1.14	1.187	1.234	1.283		1.74	1.77	1.81
65	1891	0.739	0.793	0.846	0.897	0.948	0.997	1.045	1.093	1.14	1.188	1.235	1.284	1.72	1.76	1.79	1.82
60	1683	0.739	0.793	0.846	0.898	0.948	0.997	1.046	1.094	1.141	1.188	1.236		1.74	1.78	1.81	1.84
55	1492	0.739	0.794	0.847	0.898	0.948	0.998	1.046	1.094	1.141	1.189	1.237	1.724	1.76	1.79	1.82	1.85
50	1319	0.739	0.794	0.847	0.898	0.949	0.998	1.046	1.094	1.142	1.189		1.744	1.78	1.81	1.84	1.87
45	1161	0.74	0.794	0.847	0.899	0.949	0.998	1.047	1.095	1.142	1.19	1.727	1.762	1.79	1.82	1.85	1.88
40	1017	0.74	0.794	0.847	0.899	0.949	0.999	1.047	1.095	1.143		1.746	1.778	1.81	1.84	1.87	1.9
35	887.5	0.74	0.794	0.847	0.899	0.949	0.999	1.047	1.095	1.143	1.73	1.763	1.795	1.83	1.85	1.88	1.91
30	770.6	0.74	0.795	0.848	0.899	0.95	0.999	1.048	1.096		1.748	1.78	1.811	1.84	1.87	1.9	1.93
25	665.8	0.74	0.795	0.848	0.899	0.95	0.999	1.048	1.096	1.733	1.766	1.797	1.826	1.86	1.88	1.91	1.94
20	572.1	0.74	0.795	0.848	0.9	0.95	0.999	1.048		1.751	1.782	1.813	1.842	1.87	1.9	1.93	1.95
15	488.7	0.74	0.795	0.848	0.9	0.95	1	1.048	1.736	1.768	1.799	1.829	1.858	1.89	1.91	1.94	1.97
10	414.9	0.741	0.795	0.848	0.9	0.95	1		1.754	1.786	1.816	1.845	1.874	1.9	1.93	1.96	1.98
5	349.9	0.741	0.795	0.848	0.9	0.95	1	1.741	1.772	1.803	1.832	1.861	1.889	1.92	1.95	1.97	2
0	293	0.741	0.795	0.848	0.9	0.951		1.759	1.79	1.82	1.849	1.878	1.906	1.93	1.96	1.99	2.01
-5	243.5	0.741	0.795	0.848	0.9	0.951	1.746	1.777	1.808	1.837	1.866	1.894	1.922	1.95	1.98	2	2.03
-10	200.7	0.741	0.795	0.848	0.9		1.765	1.796	1.826	1.855	1.883	1.912	1.939	1.97	1.99	2.02	2.05
-15	164	0.741	0.795	0.849	0.9	1.753	1.784	1.814	1.844	1.873	1.901	1.929	1.957	1.98	2.01	2.04	2.06
-20	132.8	0.741	0.796	0.849		1.773	1.803	1.833	1.863	1.891	1.92	1.948	1.975	2	2.03	2.06	2.08
-25	106.5	0.741	0.796	0.849	1.762	1.793	1.823	1.853	1.882	1.911	1.939	1.966	1.994	2.02	2.05	2.07	2.1
-30	84.43	0.741	0.796		1.783	1.814	1.844	1.873	1.902	1.93	1.958	1.986	2.013	2.04	2.07	2.09	2.12
-35	66.19	0.741	0.796	1.773	1.804	1.835	1.865	1.894	1.923	1.951	1.979	2.006	2.034	2.06	2.09	2.11	2.14
-40	51.25	0.741		1.796	1.827	1.857	1.886	1.916	1.944	1.972	2	2.028	2.055	2.08	2.11	2.14	2.16
-45	39.15	0.741	1.788	1.819	1.85	1.88	1.909	1.938	1.967	1.995	2.023	2.05	2.077	2.1	2.13	2.16	2.18
-50	29.48		1.812	1.843	1.874	1.904	1.933	1.962	1.99	2.018	2.046	2.074	2.101	2.13	2.15	2.18	2.21

Fuente: R. Tillner-Roth and H.D. Baehr, An International Standard Formulation for the Thermodynamic Properties of 1,1,1,2-Tetrafluoroethane (HFC-134a) for Temperatures from 170 K to 455 K and Pressures up to 70 MPa, J. Phys. Chem, Ref. Data, Vol. 23, No. 5, 1994.

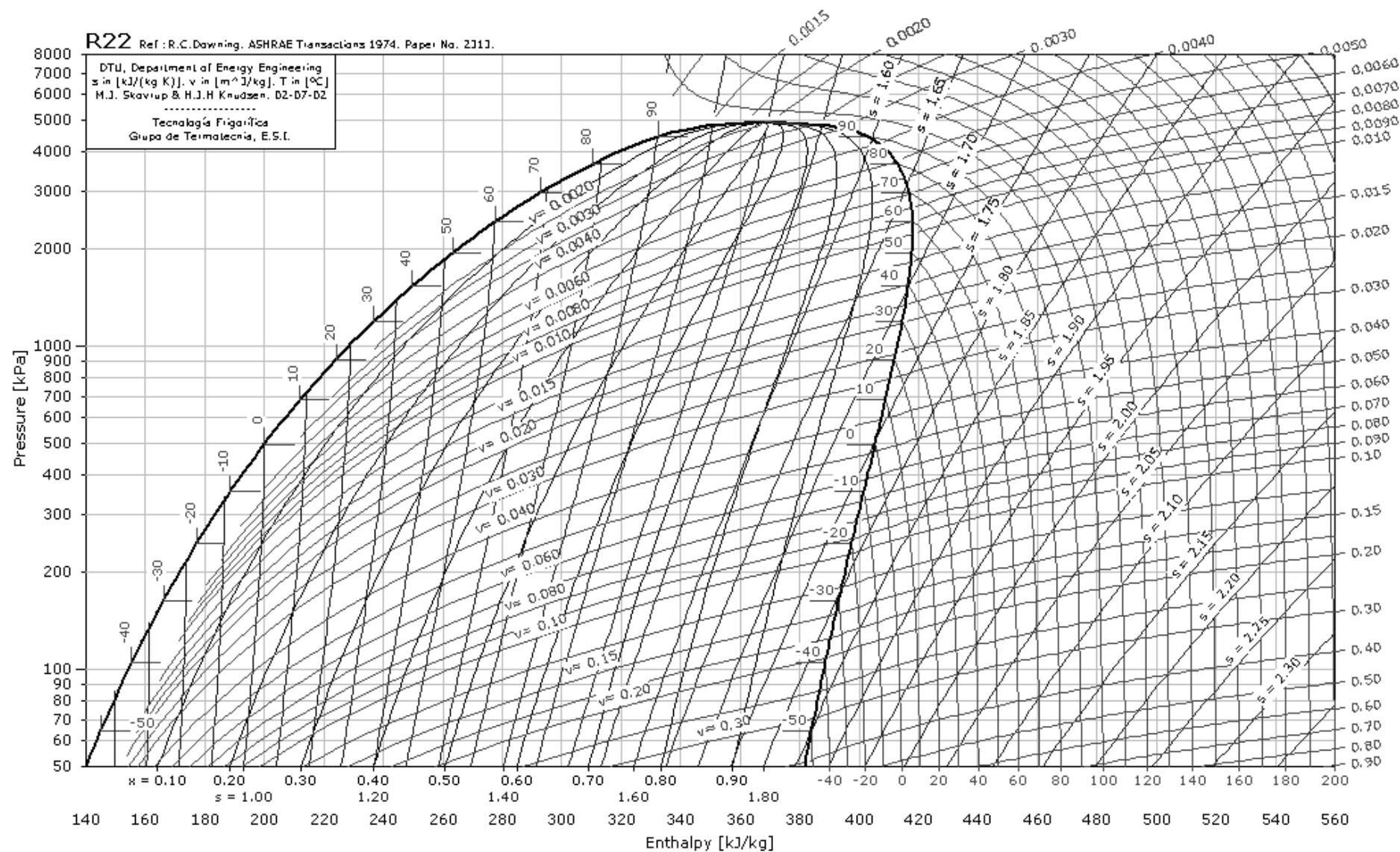
Tabla 2.12: Volumen específico del líquido subenfriado y el vapor sobrecalentado para el R-134a

 v (m³/kg), R-134a, CH₂F-CF₃, 1,1,1,2-Tetrafluoretano

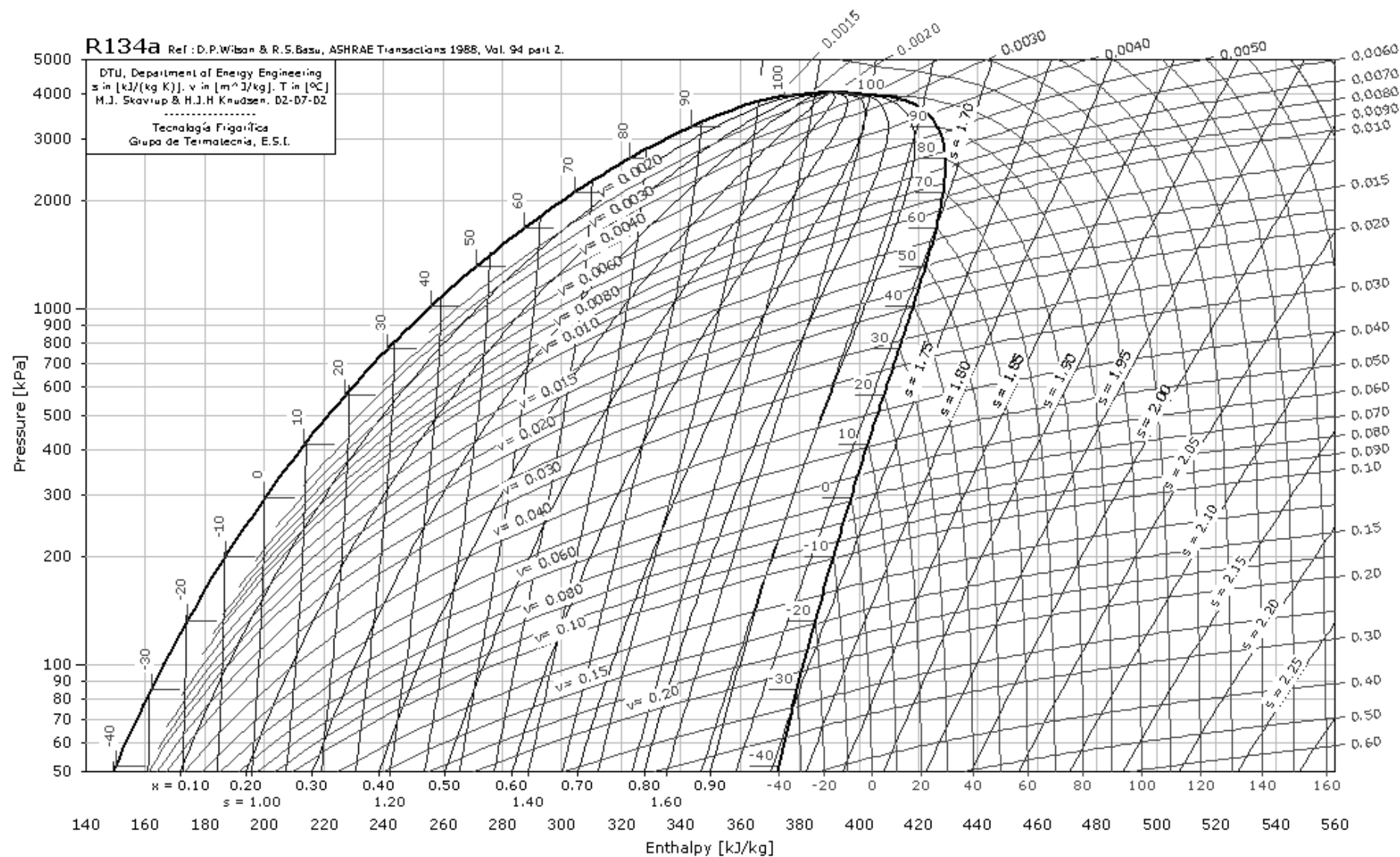
t_{sat} (°C)	P (kPa)	t (°C)															
		-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
70	2118	7E-04	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	9E-04		0.01	0.01	0.01
65	1891	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	9E-04	0.01	0.01	0.01	0.01
60	1683	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04		0.01	0.01	0.01	0.02
55	1492	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	9E-04	0.014	0.01	0.02	0.02	0.02
50	1319	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04		0.016	0.02	0.02	0.02	0.02
45	1161	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	9E-04	0.018	0.019	0.02	0.02	0.02	0.02
40	1017	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04		0.021	0.023	0.02	0.02	0.03	0.03
35	887.5	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	8E-04	0.024	0.025	0.027	0.03	0.03	0.03	0.03
30	770.6	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04		0.028	0.03	0.031	0.03	0.03	0.04	0.04
25	665.8	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	8E-04	0.032	0.034	0.035	0.037	0.04	0.04	0.04	0.04
20	572.1	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04		0.038	0.04	0.042	0.044	0.05	0.05	0.05	0.05
15	488.7	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	8E-04	0.043	0.045	0.048	0.05	0.052	0.05	0.06	0.06	0.06
10	414.9	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04		0.052	0.055	0.057	0.059	0.062	0.06	0.07	0.07	0.07
5	349.9	7E-04	7E-04	7E-04	7E-04	8E-04	8E-04	0.06	0.063	0.066	0.068	0.071	0.074	0.08	0.08	0.08	0.08
0	293	7E-04	7E-04	7E-04	7E-04	8E-04		0.073	0.076	0.079	0.083	0.086	0.089	0.09	0.1	0.1	0.1
-5	243.5	7E-04	7E-04	7E-04	7E-04	8E-04	0.085	0.089	0.093	0.097	0.1	0.104	0.108	0.11	0.12	0.12	0.12
-10	200.7	7E-04	7E-04	7E-04	7E-04		0.104	0.109	0.114	0.118	0.123	0.127	0.132	0.14	0.14	0.14	0.15
-15	164	7E-04	7E-04	7E-04	7E-04	0.124	0.129	0.135	0.14	0.146	0.151	0.157	0.162	0.17	0.17	0.18	0.18
-20	132.8	7E-04	7E-04	7E-04		0.154	0.161	0.168	0.175	0.181	0.188	0.194	0.201	0.21	0.21	0.22	0.23
-25	106.5	7E-04	7E-04	7E-04	0.186	0.194	0.203	0.211	0.219	0.227	0.235	0.243	0.251	0.26	0.27	0.28	0.28
-30	84.43	7E-04	7E-04		0.237	0.247	0.257	0.268	0.278	0.288	0.298	0.308	0.318	0.33	0.34	0.35	0.36
-35	66.19	7E-04	7E-04	0.291	0.304	0.317	0.33	0.343	0.356	0.369	0.381	0.394	0.407	0.42	0.43	0.44	0.46
-40	51.25	7E-04		0.378	0.395	0.412	0.428	0.445	0.461	0.477	0.494	0.51	0.526	0.54	0.56	0.57	0.59
-45	39.15	7E-04	0.476	0.498	0.519	0.541	0.562	0.584	0.605	0.626	0.648	0.669	0.69	0.71	0.73	0.75	0.77
-50	29.48		0.635	0.664	0.692	0.721	0.749	0.777	0.805	0.833	0.861	0.889	0.917	0.95	0.97	1	1.03

Fuente: R. Tillner-Roth and H.D. Baehr, An International Standard Formulation for the Thermodynamic Properties of 1,1,1,2-Tetrafluoroethane (HFC-134a) for Temperatures from 170 K to 455 K and Pressures up to 70 MPa, J. Phys. Chem, Ref. Data, Vol. 23, No. 5, 1994.

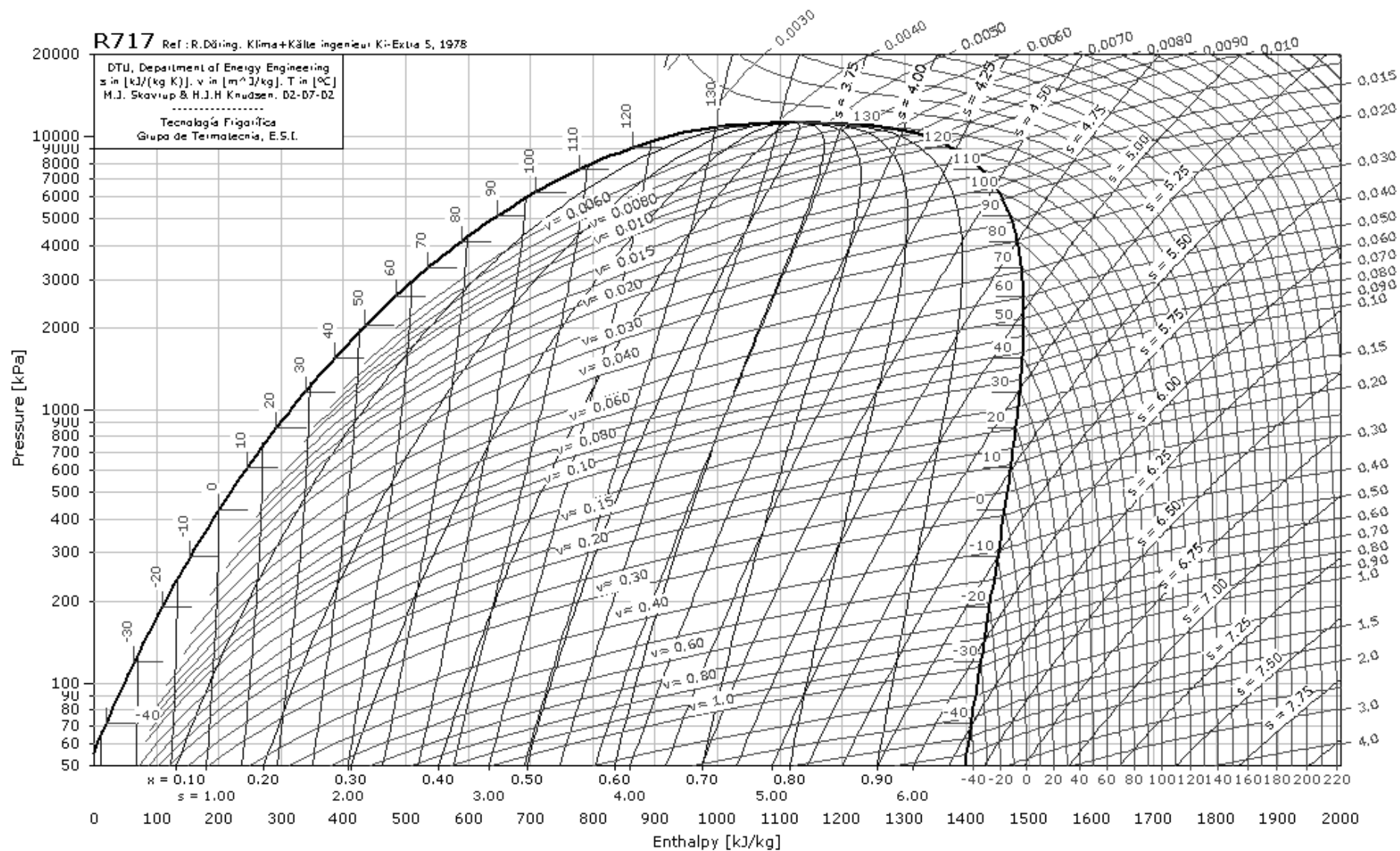
Gráfica 2.1: Diagrama p-h del R-22



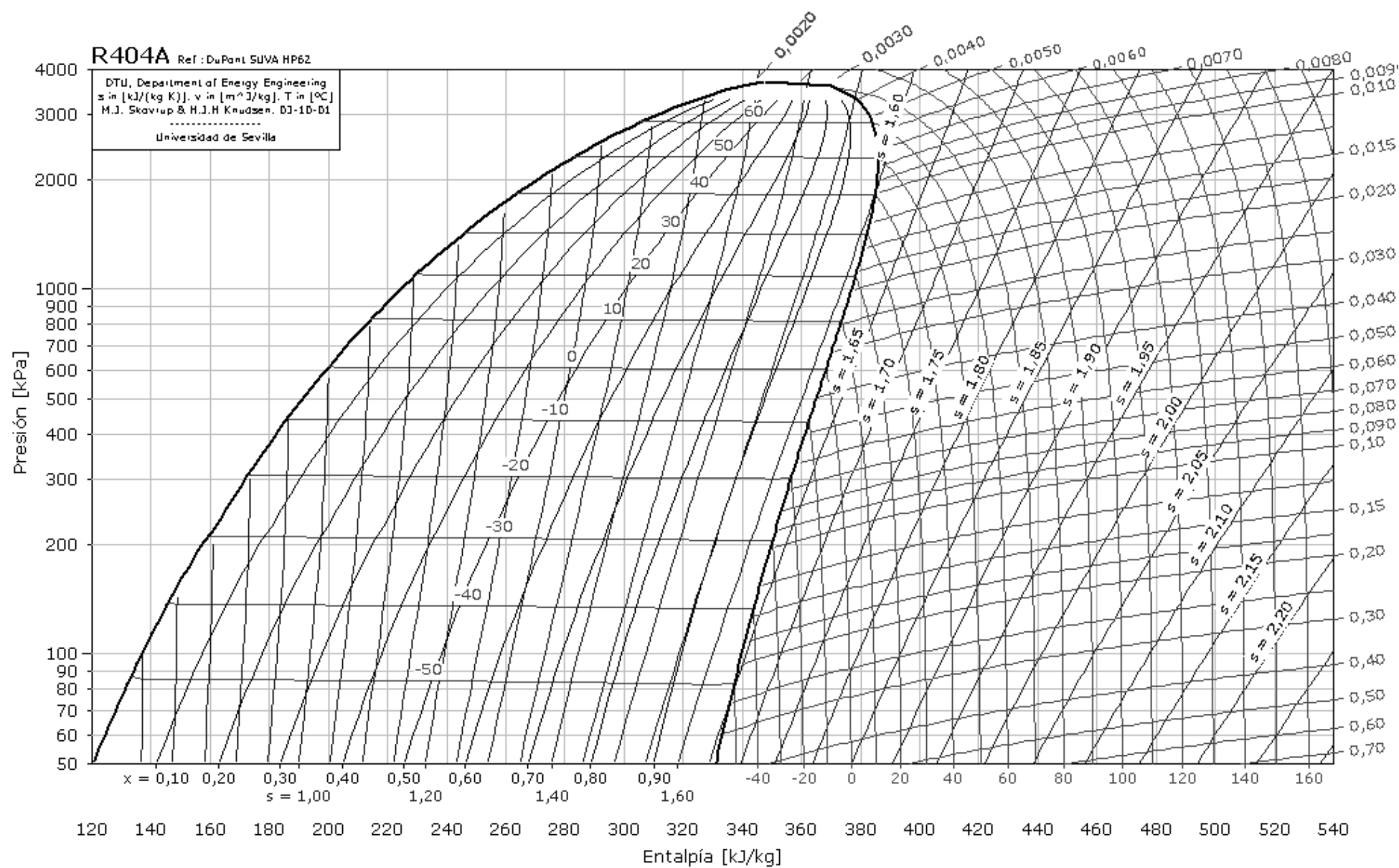
Gráfica 2.2: Diagrama p-h del R-134a



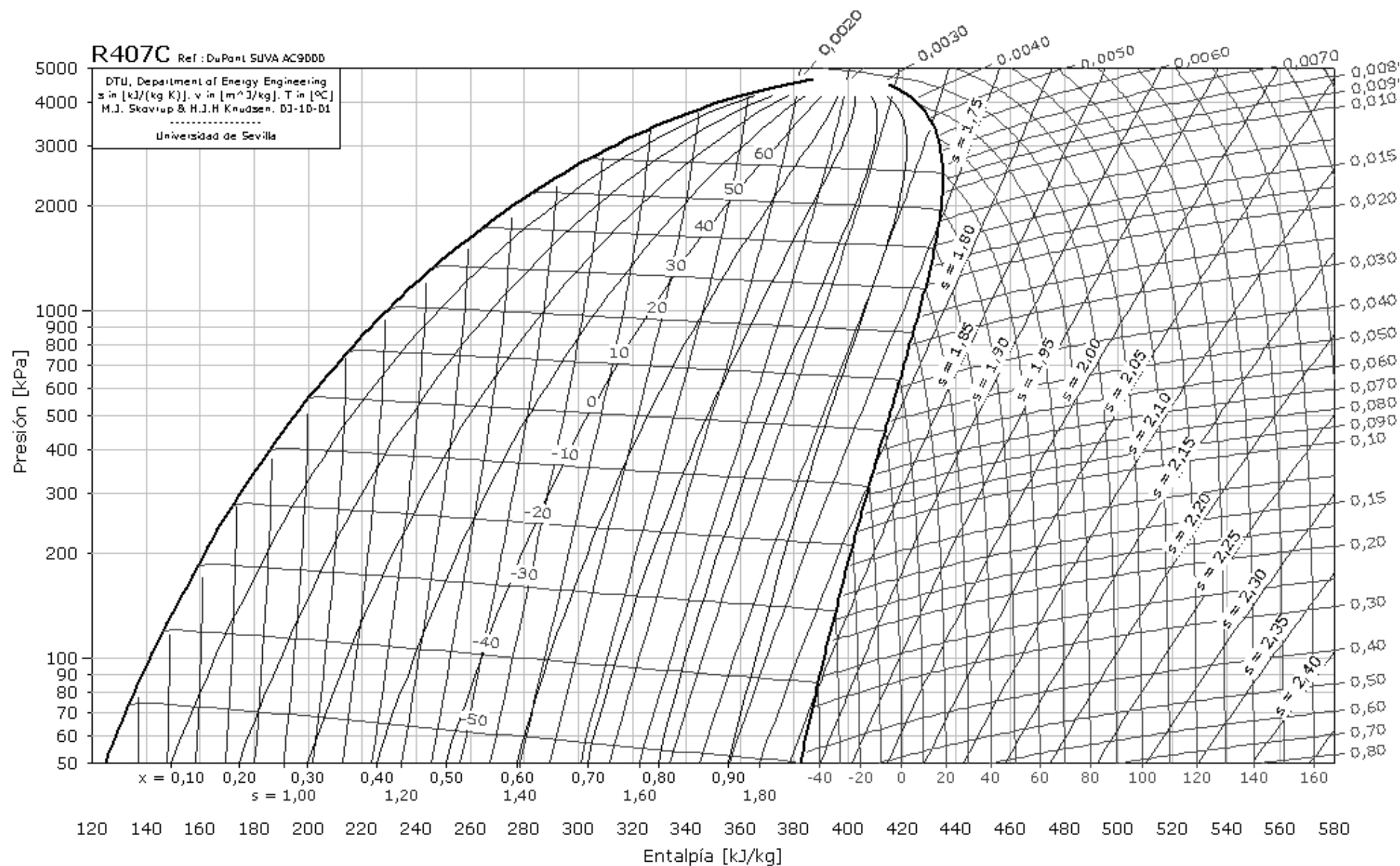
Gráfica 2.3: Diagrama p-h del R-717



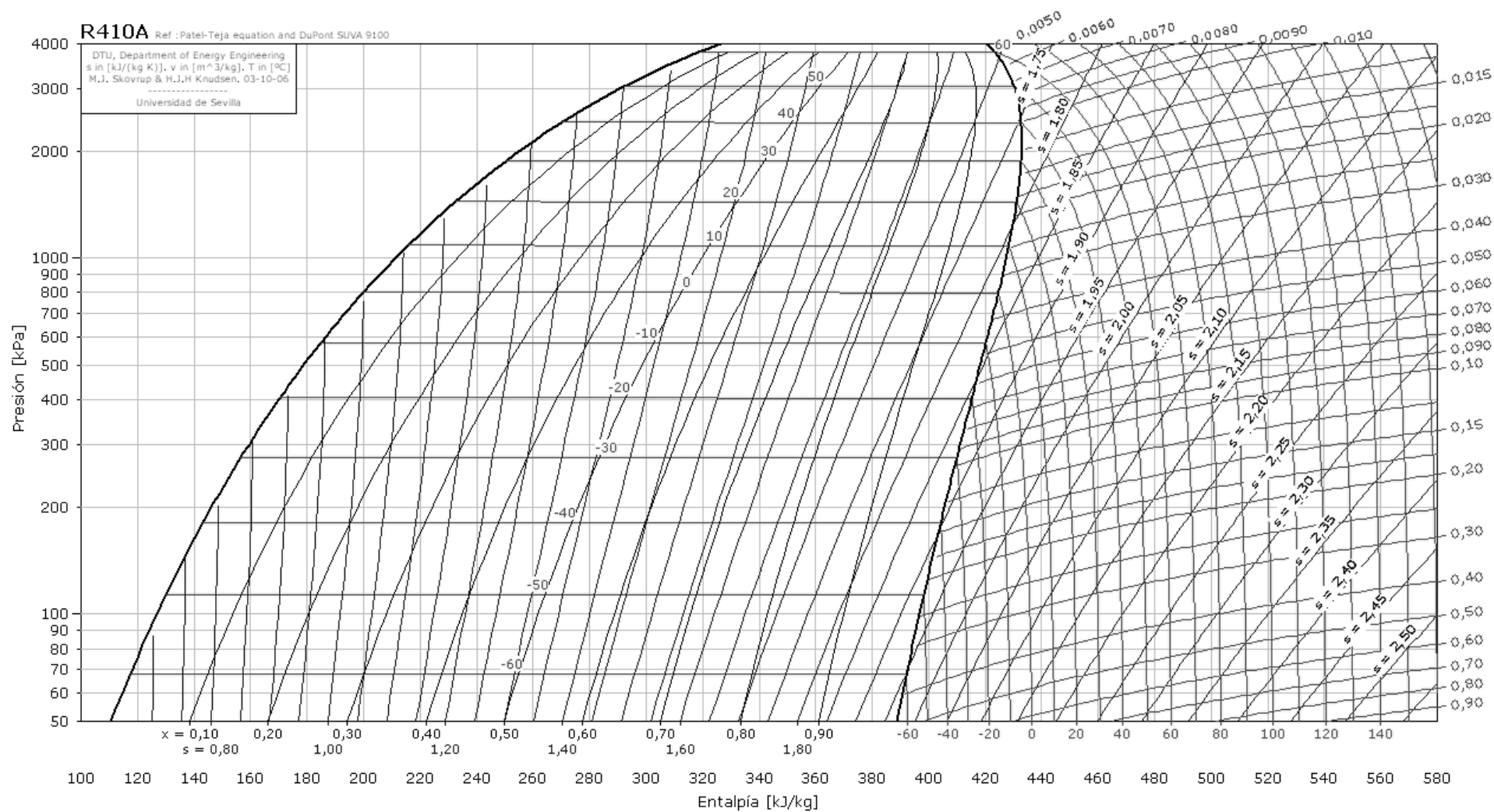
Gráfica 2.4: Diagrama p-h del R-404A



Gráfica 2.5: Diagrama p-h del R-407C



Gráfica 2.6: Diagrama p-h del R-410A



3. Tuberías y accesorios para refrigerantes

Tabla 3.1: Dimensiones normalizadas en tuberías comerciales de cobre para refrigerantes

Medida	Dext (pulgada)	Dext (mm)	Rollo de tubo				Barra de tubo			
			esp (pulgada)	esp (mm)	Dint (pulgada)	Dint (mm)	esp (pulgada)	esp (mm)	Dint (pulgada)	Dint (mm)
3/16"	0.1875	4.763	0.030	0.762	0.1275	3.239				
1/4"	0.2500	6.350	0.030	0.762	0.1900	4.826				
5/16"	0.3125	7.938	0.030	0.762	0.2525	6.414				
3/8"	0.3750	9.525	0.030	0.762	0.3150	8.001	0.030	0.762	0.315	8.001
1/2"	0.5000	12.700	0.030	0.762	0.4400	11.176	0.030	0.762	0.440	11.176
5/8"	0.6250	15.875	0.032	0.813	0.5610	14.249	0.030	0.762	0.565	14.351
3/4"	0.7500	19.050	0.035	0.889	0.6800	17.272	0.032	0.813	0.686	17.424
7/8"	0.8750	22.225	0.035	0.889	0.8050	20.447	0.032	0.813	0.811	20.599
1"	1.0000	25.400					0.035	0.889	0.930	23.622
1-1/8"	1.1250	28.575					0.040	1.016	1.045	26.543
1-3/8"	1.3750	34.925					0.042	1.067	1.291	32.791
1-5/8"	1.6250	41.275					0.050	1.270	1.525	38.735
2-1/8"	2.1250	53.975					0.060	1.524	2.005	50.927
2-5/8"	2.6250	66.675					0.071	1.803	2.483	63.068
3-1/8"	3.1250	79.375					0.071	1.803	2.983	75.768
3-5/8"	3.6250	92.075					0.080	2.032	3.465	88.011

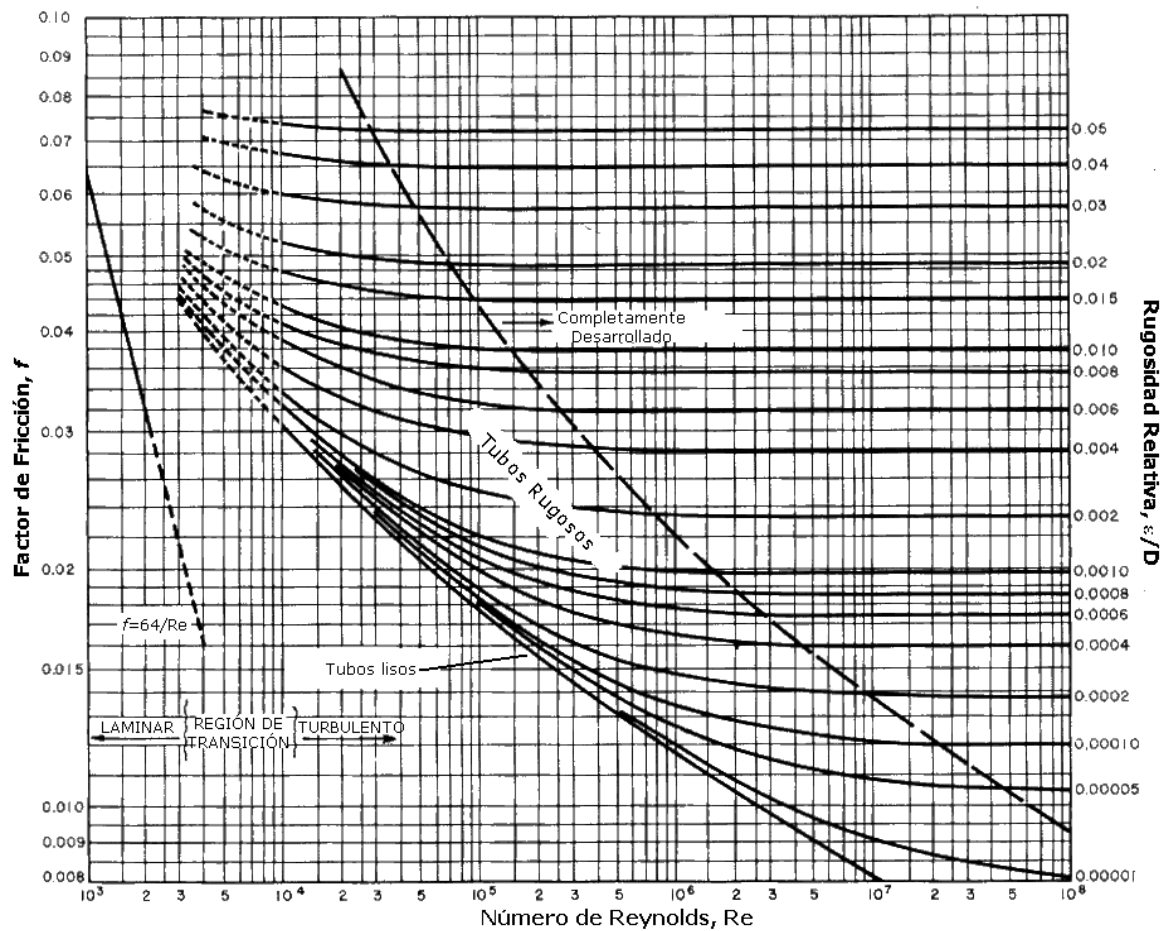
Fuente: Tarifas Salvador Escoda S.A., Mayo 2001

Tabla 3.2: Dimensiones normalizadas en tuberías comerciales de acero para refrigerantes

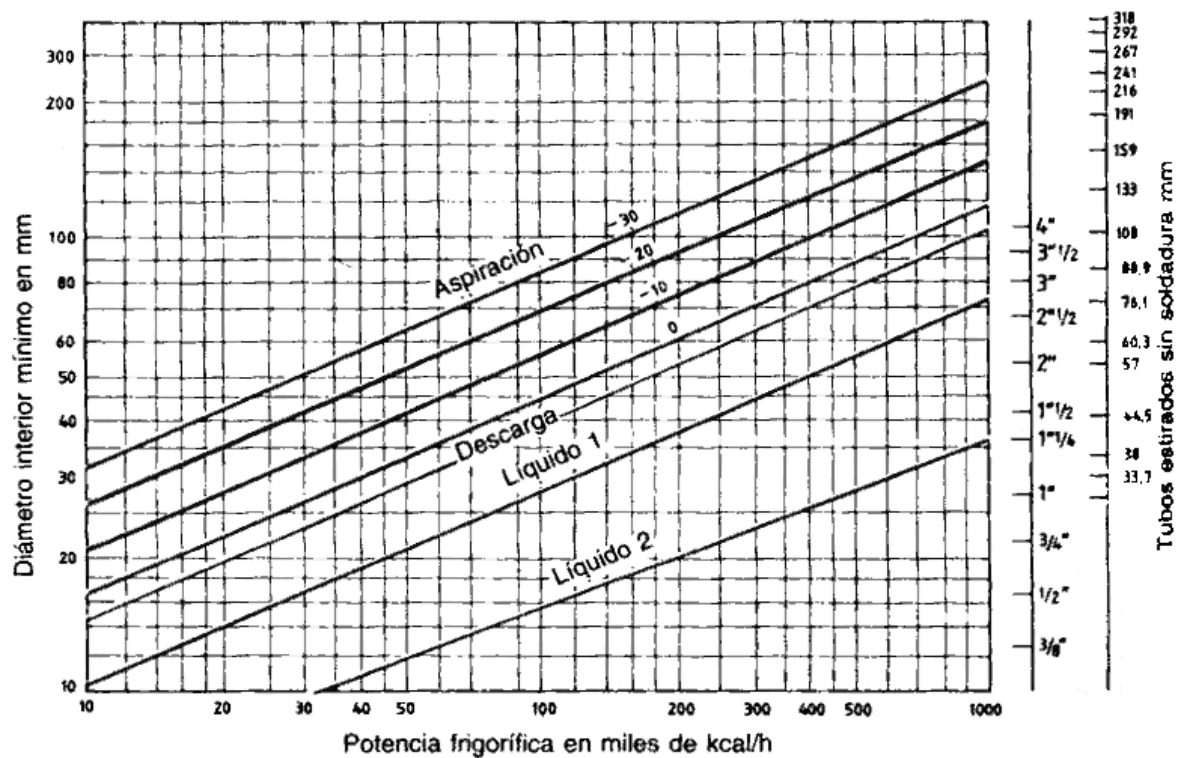
Medida	Dext (mm)	esp (mm)	Dint (mm)
1/8"	10.2	2.00	6.2
1/4"	13.5	2.35	8.8
3/8"	17.2	2.35	12.5
1/2"	21.3	2.65	16.0
3/4"	26.9	2.65	21.6
1"	33.7	3.25	27.2
1-1/4"	42.4	3.25	35.9
1-1/2"	48.3	3.25	41.8
2"	60.3	3.65	53.0
2-1/2"	76.1	3.65	68.8
3"	88.9	4.05	80.8
3-1/2"	101.6	4.05	93.5
4"	114.3	4.50	105.3
5"	139.7	4.85	130.0
6"	165.1	4.85	155.4

Fuente: Acero norma DIN 2440

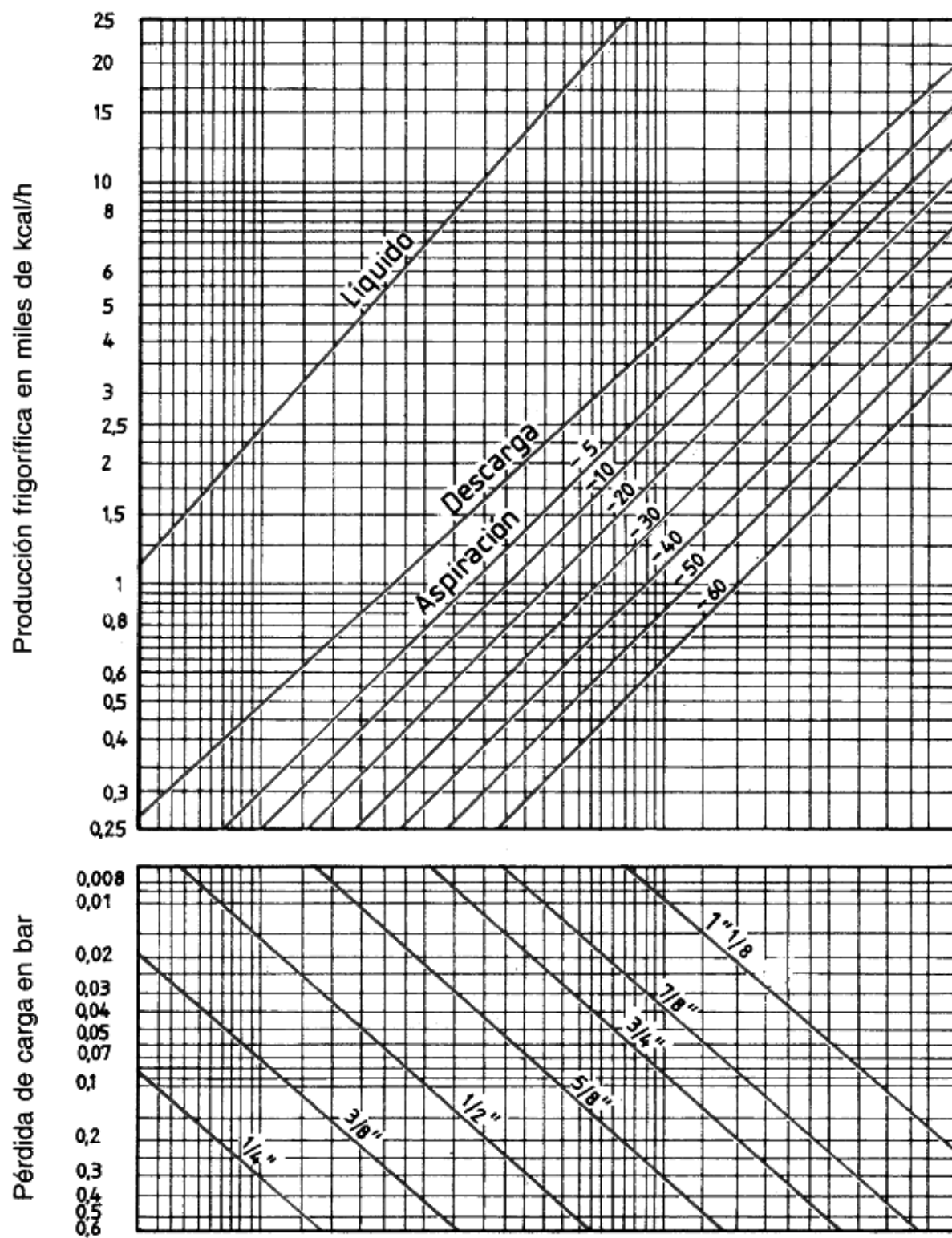
Gráfica 3.1: Ábaco de Moody



Gráfica 3.2: Ábaco para dimensionado de tuberías de amoníaco. $L=30$ m



Gráfica 3.3: Ábaco para dimensionado de tuberías de halogenados.
L=10 m



Gráfica 3.4: Ábaco para dimensionado de tuberías de halogenados. L = 30 m

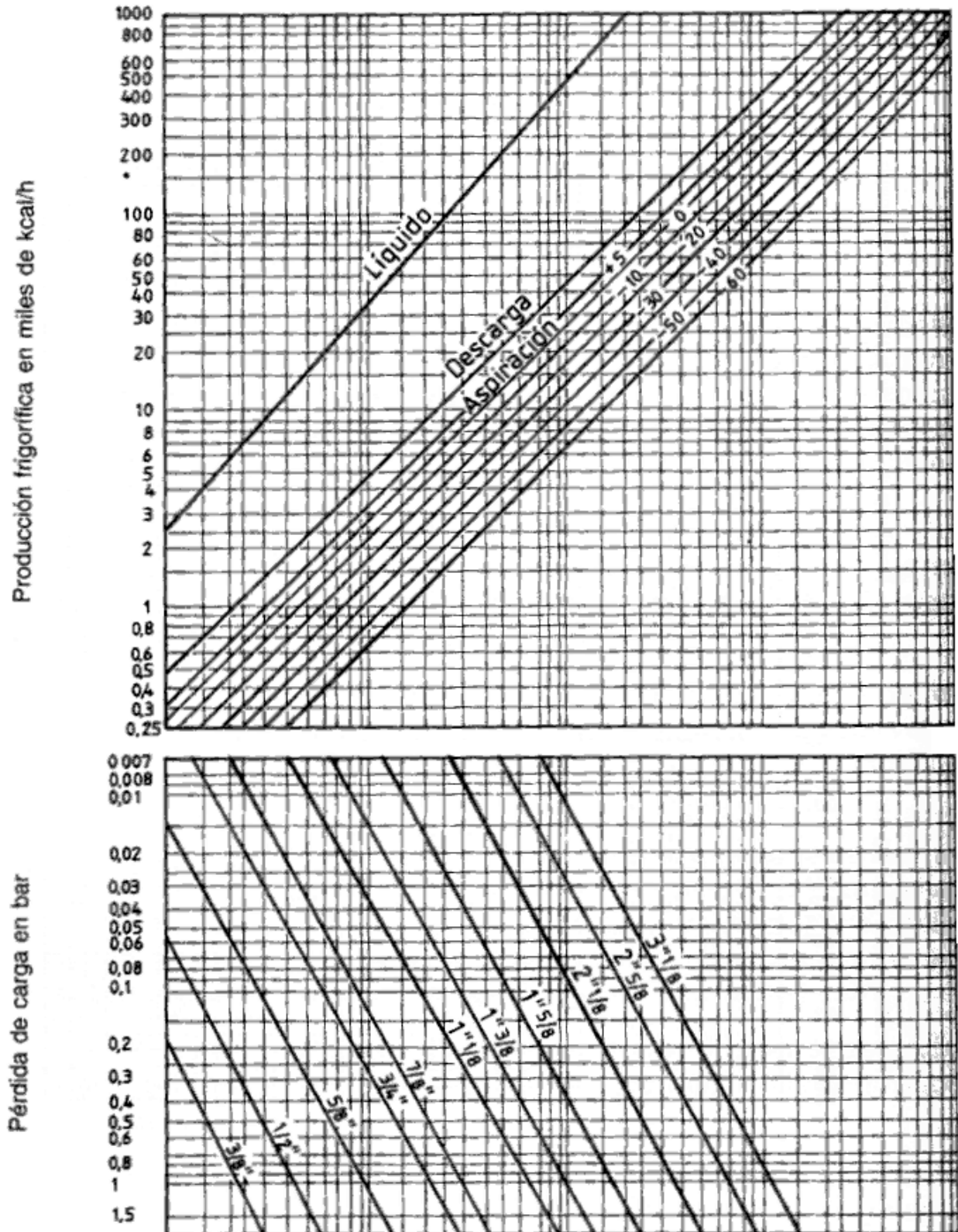


Tabla 3.3: Coeficiente K de pérdida de presión en válvulas y accesorios

Tuberías roscadas

Diámetro nóminal (mm)	Codo 90°	Curva 90°	Codo 45°	Codo doble 180°	T en ramas alineadas	T en ramas de derivación	Válvula esférica	Válvula de compuerta	Válvula de ángulo	Válvula de retención
10	2.50	-	0.38	2.50	0.90	2.70	20.00	0.40	-	8.00
15	2.10	-	0.37	2.10	0.90	2.40	14.00	0.33	-	5.50
20	1.70	0.92	0.35	1.70	0.90	2.10	10.00	0.28	6.10	3.70
25	1.50	0.78	0.34	1.50	0.90	1.80	9.00	0.24	4.60	3.00
32	1.30	0.65	0.33	1.30	0.90	1.70	8.50	0.22	3.60	2.70
40	1.20	0.54	0.32	1.20	0.90	1.60	8.00	0.19	2.90	2.50
50	1.00	0.42	0.31	1.00	0.90	1.40	7.00	0.17	2.10	2.30
65	0.85	0.35	0.30	0.85	0.90	1.30	6.50	0.16	1.60	2.20
80	0.80	0.31	0.29	0.80	0.90	1.20	6.00	0.14	1.30	2.10
100	0.70	0.24	0.28	0.70	0.90	1.10	5.70	0.12	1.00	2.00

Tuberías soldadas

Diámetro nóminal (mm)	Codo 90°	Curva 90°	Curva 45°	Codo doble 180°	T en ramas alineadas	T en ramas de derivación	Válvula esférica	Válvula de compuerta	Válvula de ángulo	Válvula de retención
25	0.43	0.41	0.22	0.43	0.26	1.00	13.00	-	4.80	2.00
32	0.41	0.37	0.22	0.41	0.25	0.95	12.00	-	3.70	2.00
40	0.40	0.35	0.21	0.40	0.23	0.90	10.00	-	3.00	2.00
50	0.38	0.30	0.20	0.38	0.20	0.84	9.00	0.34	2.50	2.00
65	0.35	0.28	0.19	0.35	0.18	0.79	8.00	0.27	2.30	2.00
80	0.34	0.25	0.18	0.34	0.17	0.76	7.00	0.22	2.20	2.00
100	0.31	0.22	0.18	0.31	0.15	0.70	6.50	0.16	2.10	2.00
150	0.29	0.18	0.17	0.29	0.12	0.62	6.00	0.10	2.10	2.00
200	0.27	0.16	0.17	0.27	0.10	0.58	5.70	0.08	2.10	2.00
250	0.25	0.14	0.16	0.25	0.09	0.53	5.70	0.06	2.10	2.00
300	0.24	0.13	0.16	0.24	0.08	0.50	5.70	0.05	2.10	2.00

Fuente: Fundamentals ASHRAE - 1997, Capítulo 33.

Tabla 3.4: Longitudes equivalentes (m) de pérdida de presión en válvulas y accesorios

Tuberías de acero comercial

Diámetro nóminal (mm)	Codo 90°	Curva 90°	Codo 45°	Codo doble 180°	T en ramas alineadas	T en ramas de derivación	Válvula esférica	Válvula de compuerta	Válvula de ángulo	Válvula de retención
1/2"	0.48	0.24	0.25	0.80	0.33	0.98	5.44	0.13	2.40	1.60
3/4"	0.65	0.32	0.35	1.08	0.44	1.33	7.34	0.17	3.24	2.15
1"	0.82	0.41	0.43	1.36	0.55	1.64	9.25	0.22	4.08	2.72
1-1/4"	1.01	0.54	0.57	1.80	0.74	2.22	12.21	0.29	5.39	3.59
1-1/2"	1.25	0.63	0.67	2.09	0.86	2.57	14.21	0.33	6.27	4.18
2"	1.59	0.79	0.85	2.65	1.04	3.12	18.02	0.42	7.95	5.30
2-1/2"	2.06	1.03	1.10	3.44	1.36	4.08	23.39	0.55	10.32	6.87
3"	2.42	1.21	1.29	4.04	1.66	4.98	27.47	0.65	12.12	8.07
4"	3.16	1.58	1.68	5.27	2.17	6.51	35.80	0.84	15.80	10.52
5"	3.90	1.95	2.08	6.50	2.64	7.92	44.20	1.04	19.50	13.00
6"	4.66	2.33	2.49	7.70	3.07	9.22	52.84	1.24	23.31	15.54

Tuberías de cobre

Diámetro nóminal (mm)	Codo 90°	Curva 90°	Curva 45°	Codo doble 180°	T en ramas alineadas	T en ramas de derivación	Válvula esférica	Válvula de compuerta	Válvula de ángulo	Válvula de retención
1/2"	0.33	0.17	0.10	0.56	0.22	0.67	3.79	0.09	1.67	1.12
5/8"	0.43	0.22	0.13	0.72	0.29	0.87	4.92	0.12	2.17	1.45
7/8"	0.62	0.31	0.19	1.04	0.42	1.25	7.07	0.17	3.12	2.08
1-1/8"	0.83	0.41	0.26	1.38	0.55	1.66	9.39	0.22	4.14	2.76
1-3/8"	1.01	0.51	0.31	1.69	0.68	2.03	11.49	0.27	5.07	3.38
1-5/8"	1.21	0.60	0.37	2.02	0.81	2.42	13.72	0.32	6.05	4.03
2-1/8"	1.61	0.80	0.49	2.68	1.07	3.21	18.21	0.43	8.03	5.35
2-5/8"	2.01	1.00	0.62	3.35	1.34	4.02	22.78	0.54	10.05	6.70

Fuente: "Cálculos en Instalaciones Frigoríficas", J.M. Pinazo Ojer, Universidad Politécnica de Valencia

Tabla 3.5: Velocidades máximas recomendadas (m/s) en depósitos de separación líquido/vapor

Refrigerante	Distancia Vertical (m)	Temperatura de saturación (°C)				
		-57	-40	-23	-7	10
R-22	0.25	0.33	0.21	0.14	0.10	0.07
	0.61	1.36	0.88	0.61	0.44	0.31
	0.91	1.57	1.04	0.72	0.52	0.39
Amoniaco	0.25	0.80	0.48	0.31	0.21	0.15
	0.61	3.30	1.99	1.29	0.88	0.64
	0.91	3.54	2.17	1.43	0.99	0.71

Nota: La distancia vertical es la distancia en vertical entre la entrada al depósito y la salida del mismo

Fuente: ASHRAE Handbook, Refrigeration Systems and Applications

Gráfica 3.5: Variación de la presión asociada a la variación de temperatura de saturación en refrigerantes

