United States Environmental Protection Agency
Air and Energy Engineering Research Laboratory
Research Triangle Park, NC 27711

Research and Development
February 1993
EPA-600/S-93-001

EPA ENVIRONMENTAL RESEARCH BRIEF

Thermophysical Properties of HFE-125

N. Dean Smith

Thermophysical properties of HFE-125 (pentafluorodimethylether) suggest that it could serve as an alternative non-ozone depleting refrigerant for certain low temperature applications. This Brief presents the thermophysical properties of HFE-125 (Tables 1-4) which have been obtained by the Environmental Protection Agency's Air and Energy Engineering Research Laboratory.

Measured properties include boiling point, freezing point, critical temperature, critical density, heat of vaporization at the boiling point, and liquid specific heat at 40°C. The critical pressure was determined from the critical temperature and critical density. Liquid densities were measured at six temperatures over the range of approximately 10 to 60°C and were calculated from below the boiling point to the critical temperature using a least squares fit of the measured data. Vapor pressures were measured at 39 temperatures ranging from below the boiling point to the critical temperature. Vapor densities were not measured but were calculated by a modified corresponding states method using the measured critical temperature, critical density, and boiling point.

All measured properties were determined using 99.5 percent pure HFE-125 which was obtained from a commercial source and repurified. Freezing point, boiling point, and critical temperature are considered accurate to ±0.2°C. Vapor pressures measured from below the boiling point up to the boiling point are accurate to ±0.5 kPa, and vapor pressures measured above the boiling point are accurate to ±3 kPa. The heat of vaporization measured at the boiling point is accurate to ±0.1 kJ/mol. Measured liquid densities and the critical density are accurate to within 2 percent, and the liquid specific heat to within 3 percent.

Vapor densities for CFC-12 (difluorodichloromethane) determined by the modified corresponding states method were found to be within 3 percent of literature values. Therefore, this same accuracy is assumed for the calculated vapor densities of HFE-125.

Details regarding the methods utilized for determining these properties are reported by Beyerlein et al.[1] Similar property data for HFE-125 have also been reported by Salvi-Narkhede et al.[2]

TABLE 1. MEASURED PHYSICAL PROPERTIES OF HFE-125

Property	SI Units	English Units
Boiling Point (T_b)	-34.6°C	-30.3°F
Freezing Point	-156.1°C	-249.0°F
Critical Temperature	80.7°C	177.3°F
Critical Pressure*	3253 kPa	471.8 psia
Critical Density	584 kg/m³	36.4 lb/ft³
Heat of Vaporization @ T_b	161.2 kJ/kg	69.34 Btu/lb
Liquid Specific Heat @ 40°C	1.327 kJ/kg K	0.3172 Btu/lb °F

* Critical pressure determined from critical temperature and critical density

TABLE 2. MEASURED LIQUID DENSITIES OF HFE-125

Temperature, °C (°F)	Liquid Density, kg/m³ (lb/ft³)
9.7 (49.5)	1362 (85.00)
22.4 (72.3)	1298 (81.05)
32.1 (89.8)	1254 (78.32)
42.2 (108.0)	1196 (74.68)
51.4 (124.4)	1133 (70.72)
60.8 (141.5)	1051 (65.62)

TABLE 3. MEASURED VAPOR PRESSURES OF HFE-125

Temperature, °C (°F)	Vapor Pressure, kPa (psia)
-104.4 (-155.7)	0.83 (0.120)
-95.7 (-140.3)	1.53 (0.222)
-85.8 (-122.4)	4.20 (0.609)
-74.6 (-102.3)	10.16 (1.474)
-73.4 (-100.1)	10.80 (1.566)
-65.3 (-85.5)	19.47 (2.823)
-63.4 (-82.1)	21.73 (3.152)
-55.6 (-68.1)	34.80 (5.047)
-54.6 (-66.3)	36.00 (5.221)
-53.9 (-65.0)	38.40 (5.569)
-49.5 (-56.4)	49.73 (7.213)
-48.6 (-55.5)	50.73 (7.358)
-44.8 (-48.6)	61.72 (8.953)
-44.4 (-44.9)	63.46 (9.204)
-39.3 (-38.7)	80.53 (11.68)
-38.9 (-38.0)	83.06 (12.05)
-38.6 (-37.5)	83.99 (12.18)
-36.9 (-34.4)	90.53 (13.13)
-34.6 (-30.3)	100.9 (14.63)
-34.3 (-29.7)	102.3 (14.83)
-34.2 (-29.6)	102.7 (14.89)

(Continued)

Table 3 Continued

Temperature, °C (°F)	Vapor Pressure, kPa (psia)
5.4 (41.7)	499.9 (72.50)
10.1 (50.2)	580.6 (84.21)
14.8 (58.6)	668.9 (97.02)
20.0 (68.0)	776.6 (112.6)
24.8 (76.6)	889.3 (129.0)
30.4 (86.7)	1034 (150.0)
34.7 (94.5)	1160 (168.2)
40.0 (104.0)	1327 (192.4)
45.3 (113.5)	1508 (218.8)
50.4 (122.7)	1703 (247.0)
54.9 (130.8)	1881 (272.8)
59.9 (139.8)	2100 (304.6)
65.9 (150.6)	2393 (347.1)
70.0 (158.0)	2610 (378.6)
74.8 (166.6)	2892 (419.5)
78.0 (172.4)	3087 (447.8)
80.0 (176.0)	3203 (464.6)
80.7 (177.3)	3253 (471.8)

TABLE 4. CALCULATED LIQUID DENSITY, VAPOR DENSITY, AND HEAT OF VAPORIZATION OF HFE-125

Temperature °C (°F)	Liquid Density kg/m^3 (lb/ft^3)	Vapor Density kg/m^3 (lb/ft^3)	Heat of Vaporization kJ/kg (Btu/lb)
-54.6 (-66.3)	1603 (100.1)	2.79 (0.174)	167.5 (72.06)
-50.6 (-59.1)	1590 (99.24)	3.44 (0.215)	166.2 (71.52)
-46.6 (-51.9)	1576 (98.39)	4.21 (0.263)	165.0 (70.98)
-42.6 (-44.7)	1562 (97.54)	5.11 (0.319)	163.7 (70.44)
-38.6 (-37.5)	1549 (96.67)	6.16 (0.384)	162.5 (69.90)
-34.6 (-30.3)	1535 (95.80)	7.32 (0.457)	161.2 (69.34)
-30.0 (-22.0)	1518 (94.78)	8.94 (0.558)	158.6 (68.26)
-25.4 (-13.7)	1502 (93.74)	10.83 (0.676)	156.1 (67.16)
-20.8 (-5.4)	1485 (92.68)	13.01 (0.812)	153.4 (66.02)
-16.2 (2.9)	1467 (91.60)	15.53 (0.970)	150.7 (64.85)
-11.5 (11.2)	1450 (90.50)	18.43 (1.150)	147.9 (63.65)
-6.9 (19.5)	1432 (89.37)	21.73 (1.356)	145.0 (62.41)
-2.3 (27.8)	1413 (88.22)	25.49 (1.591)	142.1 (61.13)
2.3 (36.1)	1394 (87.03)	29.75 (1.857)	139.0 (59.81)
6.9 (44.4)	1375 (85.81)	34.58 (2.159)	135.8 (58.43)
11.5 (52.7)	1351 (84.37)	40.03 (2.499)	132.5 (57.01)
16.1 (61.0)	1333 (83.23)	46.19 (2.884)	129.0 (55.52)
20.7 (69.3)	1313 (81.96)	53.15 (3.318)	125.4 (53.96)
25.4 (77.6)	1291 (80.58)	61.03 (3.810)	121.6 (52.33)
30.0 (85.9)	1267 (79.07)	69.94 (4.366)	117.6 (50.62)
34.6 (94.2)	1240 (77.44)	80.08 (4.999)	113.4 (48.80)
39.2 (102.6)	1212 (75.68)	91.67 (5.723)	109.0 (46.87)

(Continued)

Table 4 Continued

Temperature °C (°F)	Liquid Density kg/m³ (lb/ft³)	Vapor Density kg/m³ (lb/ft³)	Heat of Vaporization kJ/kg (Btu/lb)
43.8 (110.8)	1182 (73.81)	105.0 (6.554)	104.1 (44.80)
48.4 (119.2)	1150 (71.81)	120.4 (7.518)	98.96 (42.56)
53.0 (127.4)	1116 (69.69)	138.6 (8.649)	93.22 (40.12)
57.6 (135.8)	1080 (67.45)	160.1 (9.994)	86.97 (37.41)
62.2 (144.0)	1046 (65.29)	186.2 (11.62)	79.84 (34.35)
66.9 (152.4)	999 (62.36)	218.4 (13.63)	71.46 (30.76)
71.5 (160.7)	943 (58.87)	259.4 (16.20)	61.17 (26.33)
76.1 (169.0)	874 (54.54)	314.1 (19.61)	46.90 (20.19)
80.7 (177.3)	584 (36.43)	583.6 (36.43)	0.00 (0.00)

Equation for liquid density in kg/m³ is:

$D_l = 1388.6 + (-2.698E+00)C + (-4.597E-02)C^2$ C = temperature in °C

Range is 9.7 to 60.8°C.

Equation for liquid density in lb/ft³ is:

$D_l = 88.777 + (-3.687E-02)F + (-8.857E-04)F^2$ F = temperature in °F

Range is 49.5 to 141.5°F.

Vapor density was calculated by a modified corresponding states method.[1,3]

Heat of vaporization was calculated by the method of Thek and Stiel[4] with the Viswanath modification.[5]

References:

1. Beyerlein, A. L., et al., "Physical Properties of Fluorinated Propane and Butane Derivatives as Alternative Refrigerants," Technical Paper No. 3658, presented at American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Winter Meeting, Chicago, January 23-27, 1993.

2. Salvi-Narkhede, M., et al., "Vapor Pressures, Liquid Molar Volumes, Vapor Nonideality, and Critical Properties of Some Partially Fluorinated Ethers ($CF_3OCF_2CF_2H$, CF_3OCF_2H, and CF_3OCH_3), Some Perfluoroethers ($CF_3OCF_2OCF_3$, c-$CF_2OCF_2OCF_2$, and c-$CF_2CF_2CF_2O$), and CHF_2Br and CF_3CFHCF_3," J. Chem. Thermodynamics, 25, 1993 (in press).

3. Reid, R. C., J. M. Prausnitz, and B. E. Poling, The Properties of Gases and Liquids, 4th ed., McGraw-Hill, New York, 1984.

4. Thek, R. E. and L. I. Stiel, "A New Reduced Vapor Pressure Equation," AIChE J., 12, 599 (1966); Addendum, 13, 626 (1967).

5. Viswanath, D. S. and N. R. Kuloor, "On a Generalized Watson's Relation for Latent Heat of Vaporization," Can. J. Chem. Eng., 45, 29, 1967.