Physical Properties of Hydrocarbons

Part 21–Halogenated Hydrocarbons

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PART 20 COVERED Fluorocarbons-11, -12, -13, and -14. This part presents the properties of four other important commercial chlorofluorohydrocarbons—Fluorocarbon-21, -22, -113, and -114. All four of these compounds are important refrigerants. Fluorocarbon-113 (trichlorotrifluoroethane) is finding increasing use as a degreasing solvent. Fluorocarbon-114 (dichlorotetrafluoroethane) is a popular choice for many aerosol formulations. As part of the one-half billion pound/year fluorocarbon business, these four compounds will continue to enjoy a steady growth.

Because of their commercial value, the physical properties of these compounds have been extensively studied.

Vapor Pressure and Critical Properties. The critical properties and vapor pressures up to the critical point are available from the literature for all four compounds.[1, 2, 3, 4, 5, 6]

Heat of Vaporization. The heat of vaporization is available for Fluorocarbon-21 from −40° to +71° C; for Fluorocarbon-22 from −100° to +71° C; for Fluorocarbon-113 from −35° to +93° C; and for Fluorocarbon-114 from −62° to +60° C.[2] The data have been extended to the critical temperature by the Kharbanda nomograph of the Watson equation[7] with a probable error of only a few percent.

Heat Capacity. The vapor heat capacity has been determined from −200° to +1,000° C for Fluorocarbon-21 and Fluorocarbon-22.[8] For Fluorocarbon-113, data are available only from 0-150° C.[9, 10] The method of Rihani and Doraiswamy[11] has been used to calculate the vapor heat capacities over the −100° to +900° C range for Fluorocarbon-113 and Fluorocarbon-114. This method usually gives errors of less than 2 percent, but when compared to experimental data on other chlorofluoro compounds, the method gave an average error of 6 percent. Estimation methods generally give poorer accuracy with halogenated hydrocarbons than any other type of compound.

Benning and McHarness[10] have measured the liquid heat capacity of Fluorocarbon-21, -22, and -113 from −20° to +70° C. Neilson and White[12] have measured the heat capacity of Fluorocarbon-22 from its melting point to −47° C. Du Pont[1] reports the 25° C heat capacity for all four compounds. The data have been extended by the equation

$$C_p = k/d^{1/2}$$

where

C_p = liquid heat capacity, calories/g −°C
k = a constant determined from experimental data
d = density, grams/milliliter

The author found much better estimation accuracy was obtained by using the square root of the density instead of the straight density, as is normally done. The fluorocarbon heat capacities change very little with temperature. Using this modified method, the average error was 2.4 percent and the maximum error was 7.4 percent, when compared to 14 experimental values.

Density. The liquid densities of Fluorocarbon-21, -22, and -113, have been measured from near their melting point up to their critical point.[2, 13] Martin[6] presents data on Fluorocarbon-114 from −77° C up to the critical point.

TABLE 21-1—Physical Properties of Halogenated Hydrocarbons

Compound	Commercial Trade Name	Boiling Point °C	Melting Point °C	Molecular Weight	CRITICAL PROPERTIES		
					T_c °C	p_c psia	d_c g/ml
Dichlorofluoro-methane	Fluorocarbon-21	8.9	−135	102.93	178.5	750	.522
Chlorodifluoro-methane	Fluorocarbon-22	−40.8	−160	86.48	96.0	722	.525
1,1,2-trichloro-1,2,2-trifluoro-ethane	Fluorocarbon-113	47.6	− 35	187.39	214.1	495	.576
1,2-dichloro-1,1,2,2-tetra-fluoroethane	Fluorocarbon-114	3.8	− 94	170.94	145.7	473	.582

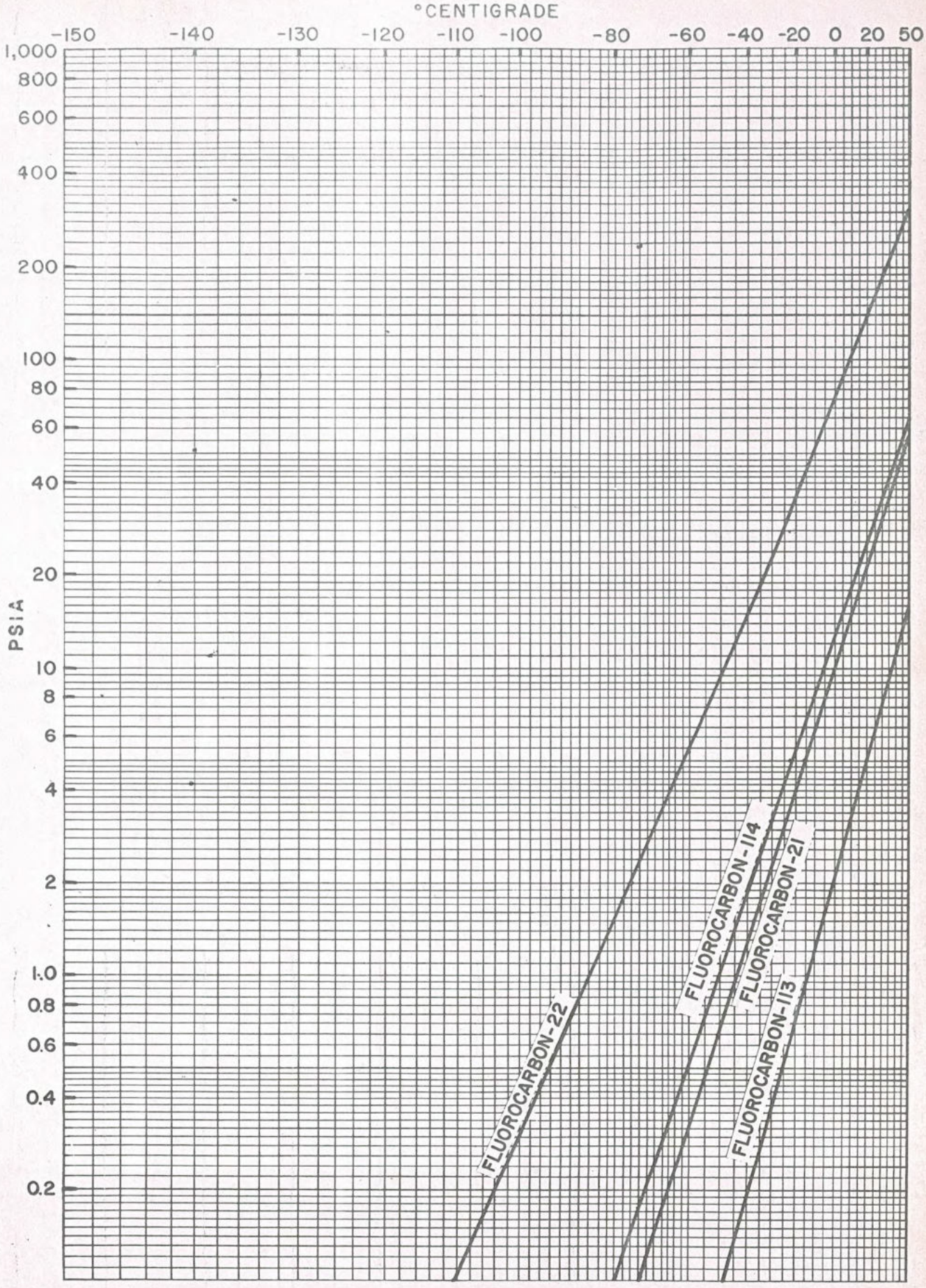

Fig. 21-1—Gives vapor pressure of halogenated hydrocarbons from — 150° C to + 50° C.

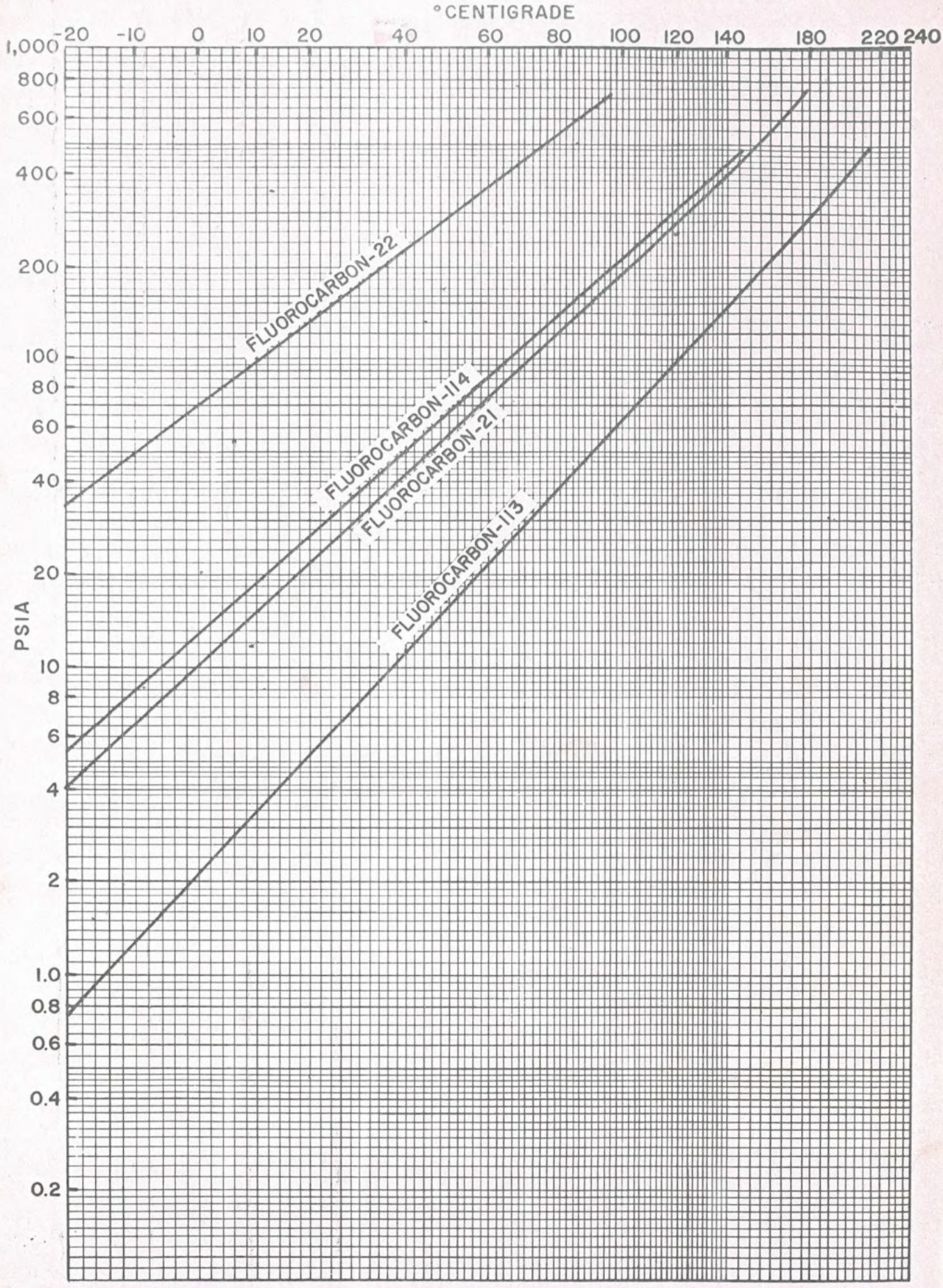

Fig. 21-2—Gives vapor pressure of halogenated hydrocarbons from — 20° C to + 220° C.

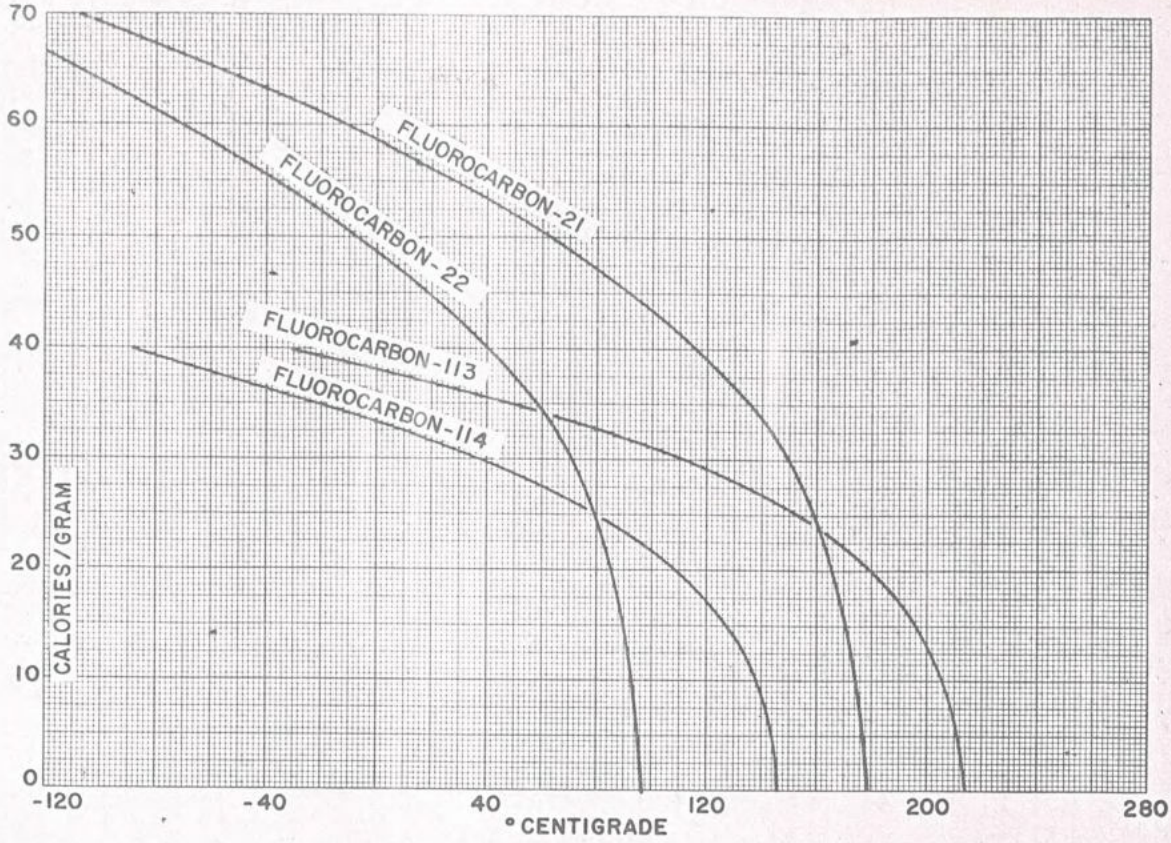

Fig. 21-3—Gives heat of vaporization of halogenated hydrocarbons from — 120° C to + 200° C.

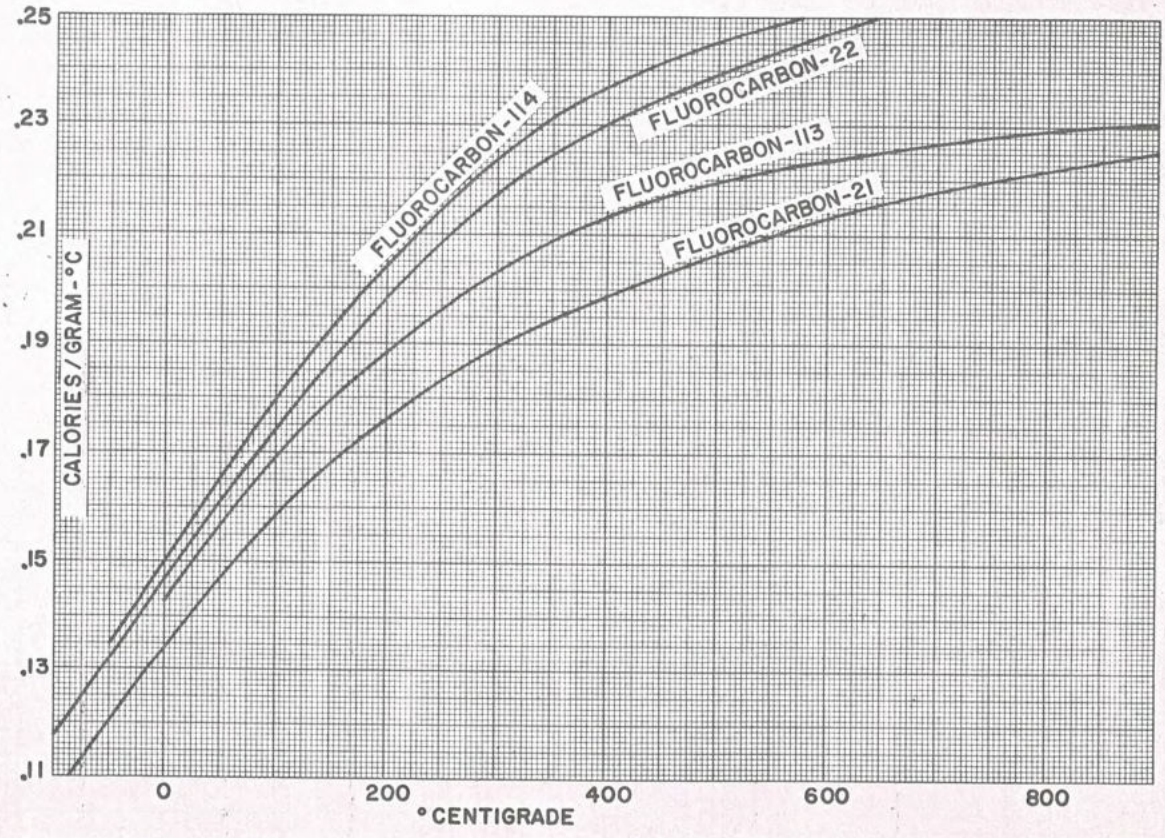

Fig. 21-4—Gives vapor heat capacity of halogenated hydrocarbons from —100° C to +900° C.

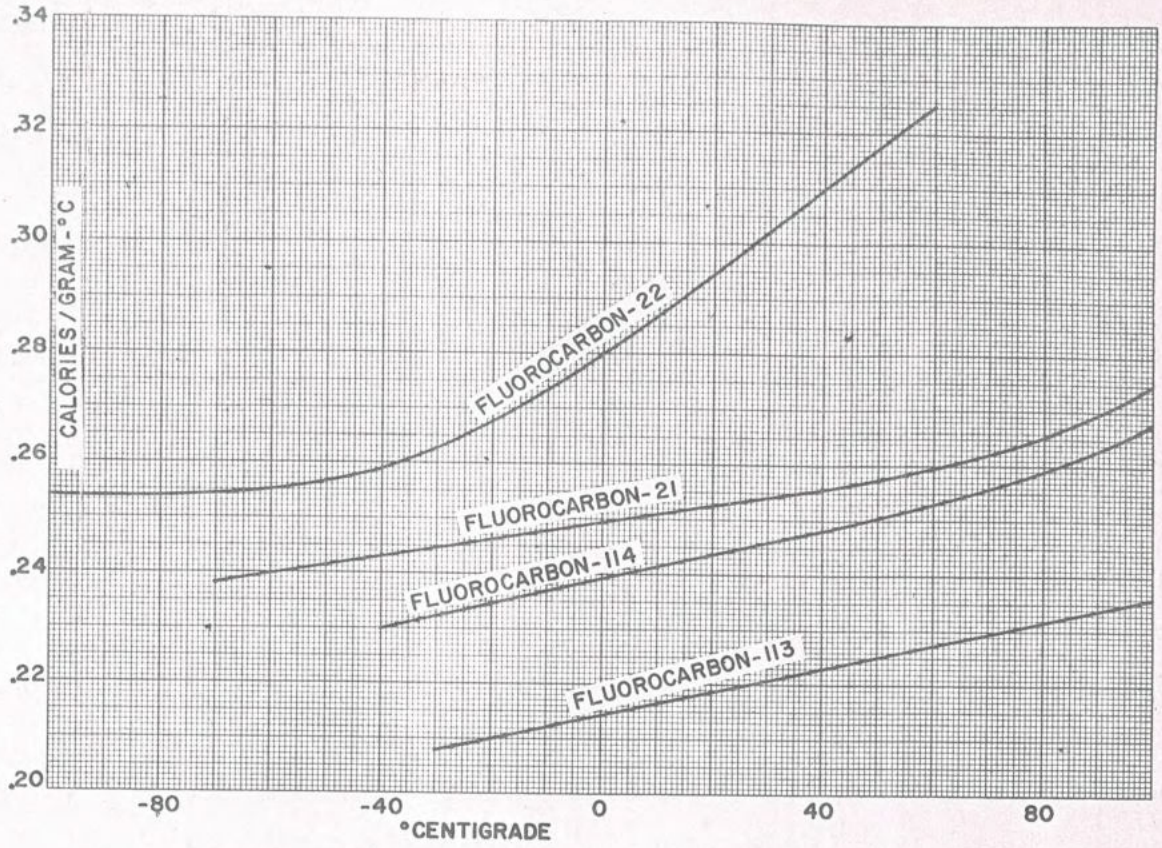

Fig. 21-5—Gives liquid heat capacity of halogenated hydrocarbons from — 100° C to + 100° C.

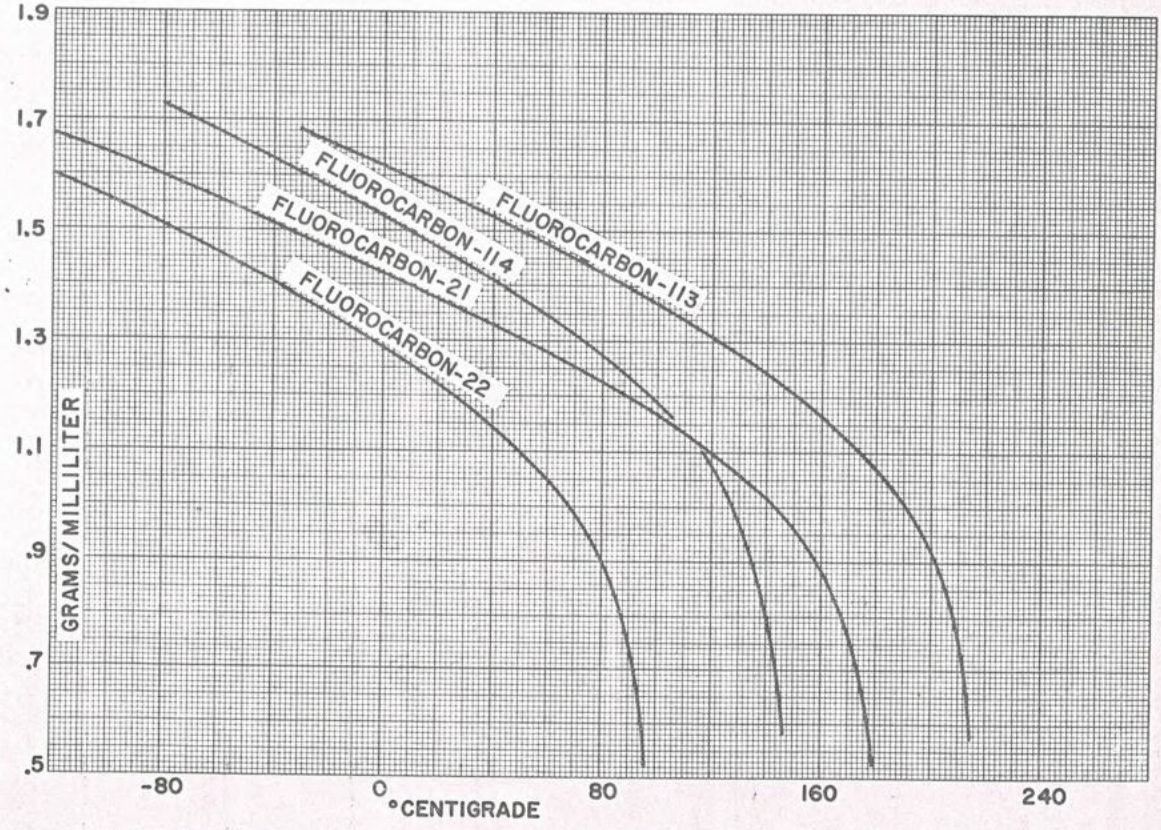

Fig. 21-6—Gives liquid density of halogenated hydrocarbons from — 120° C to + 210° C.

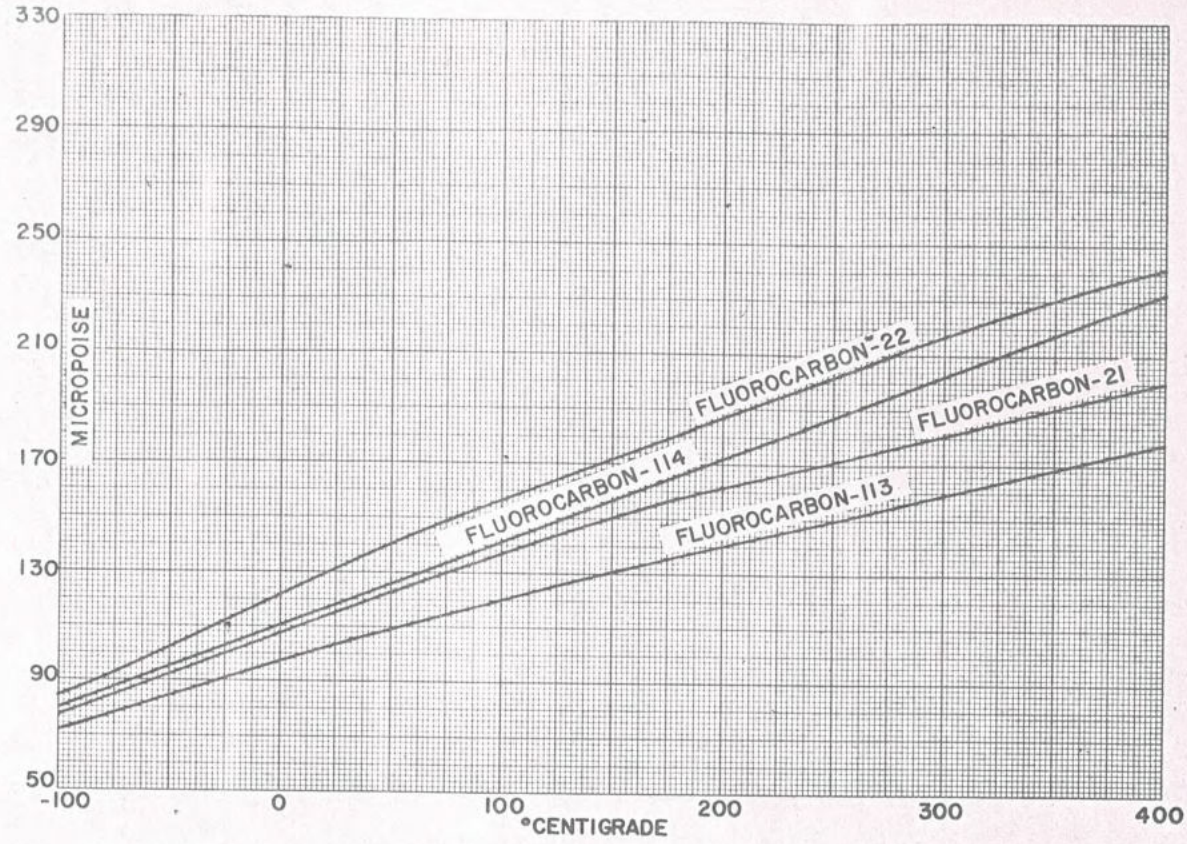

Fig. 21-7—Gives vapor viscosity of halogenated hydrocarbons from — 100° C to +400° C.

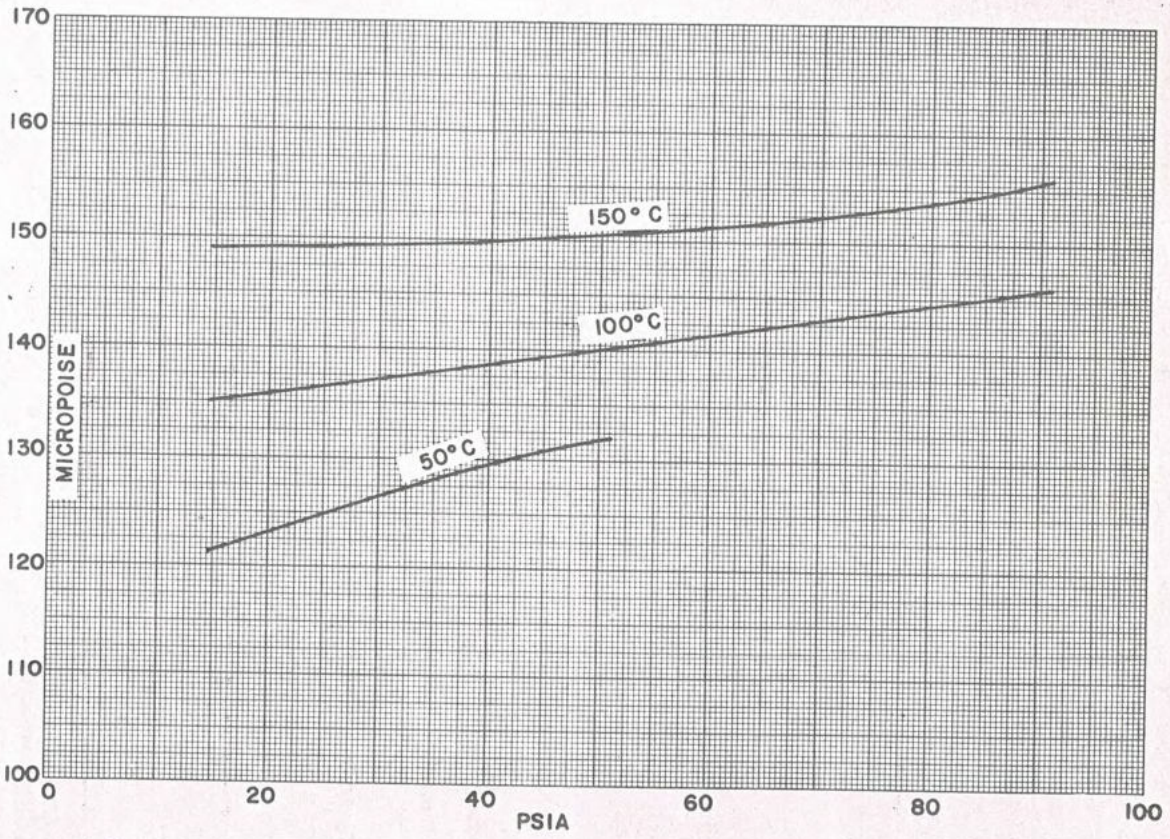

Fig. 21-8—Gives pressure effect on vapor viscosity of Fluorocarbon-21 from 0 to 100 psia.

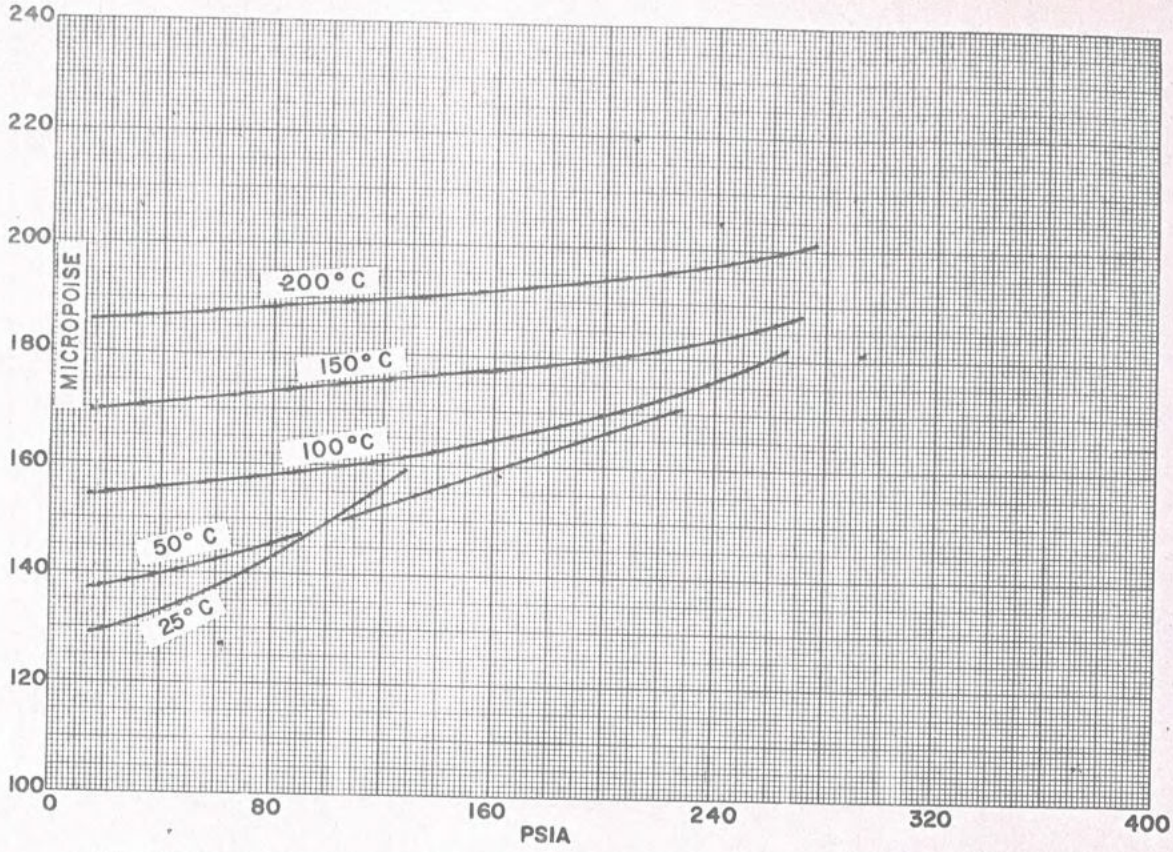

Fig. 21-9—Gives pressure effect on vapor viscosity of Fluorocarbon-22 from 0 to 400 psia.

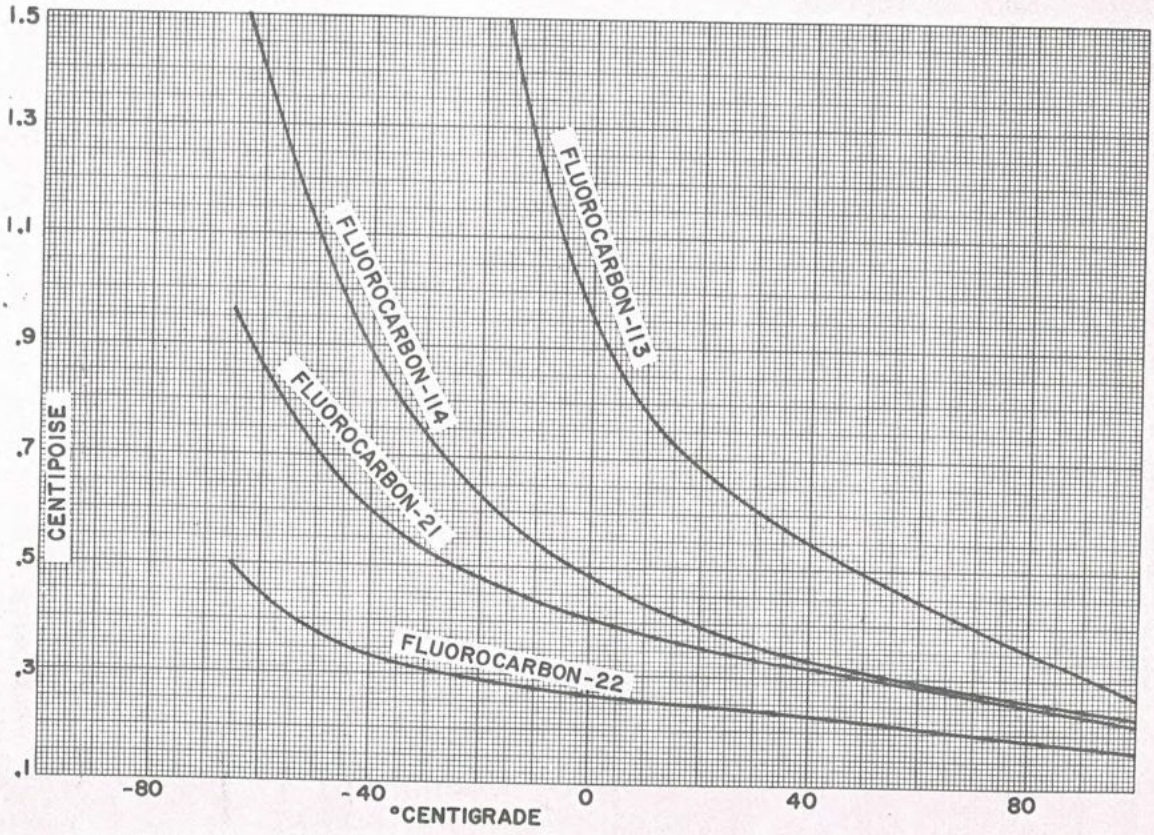

Fig. 21-10—Gives liquid viscosity of halogenated hydrocarbons from — 60° C to + 100° C.

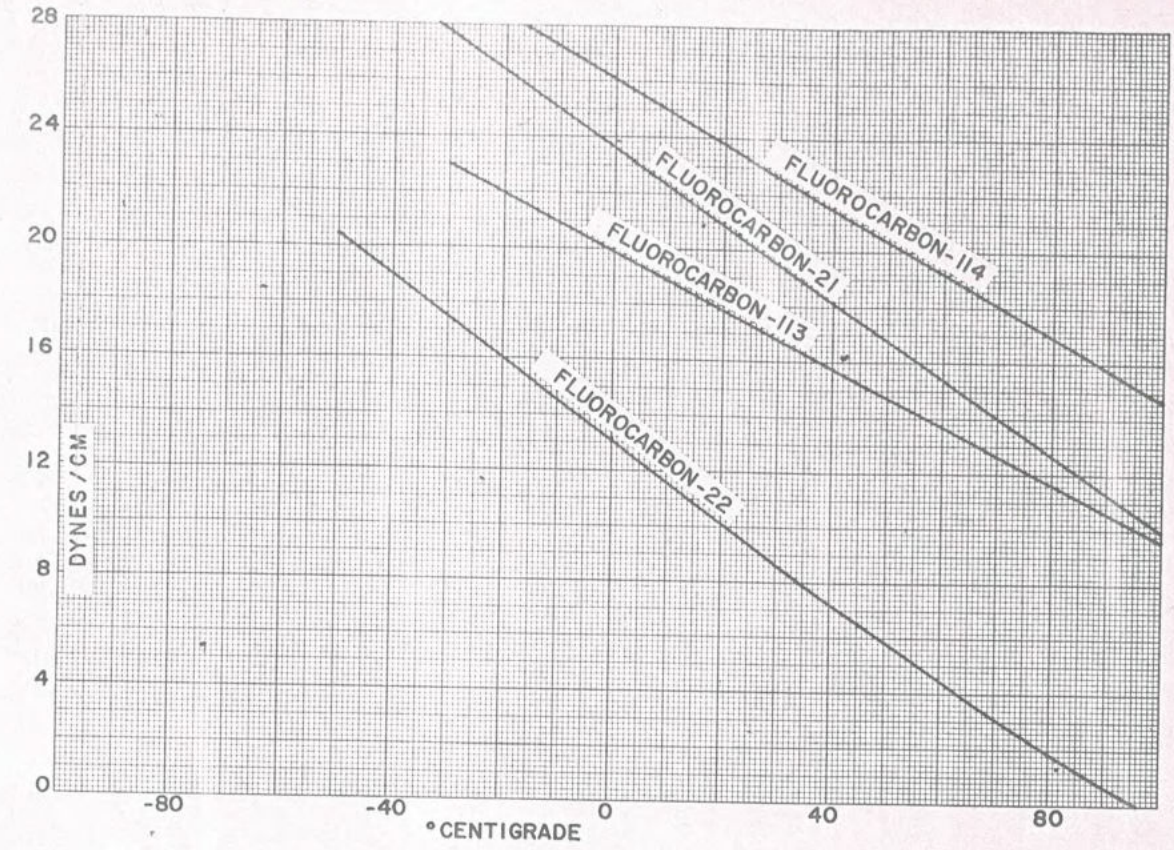

Fig. 21-11—Gives surface tension of halogenated hydrocarbons from — 50° C to + 100° C.

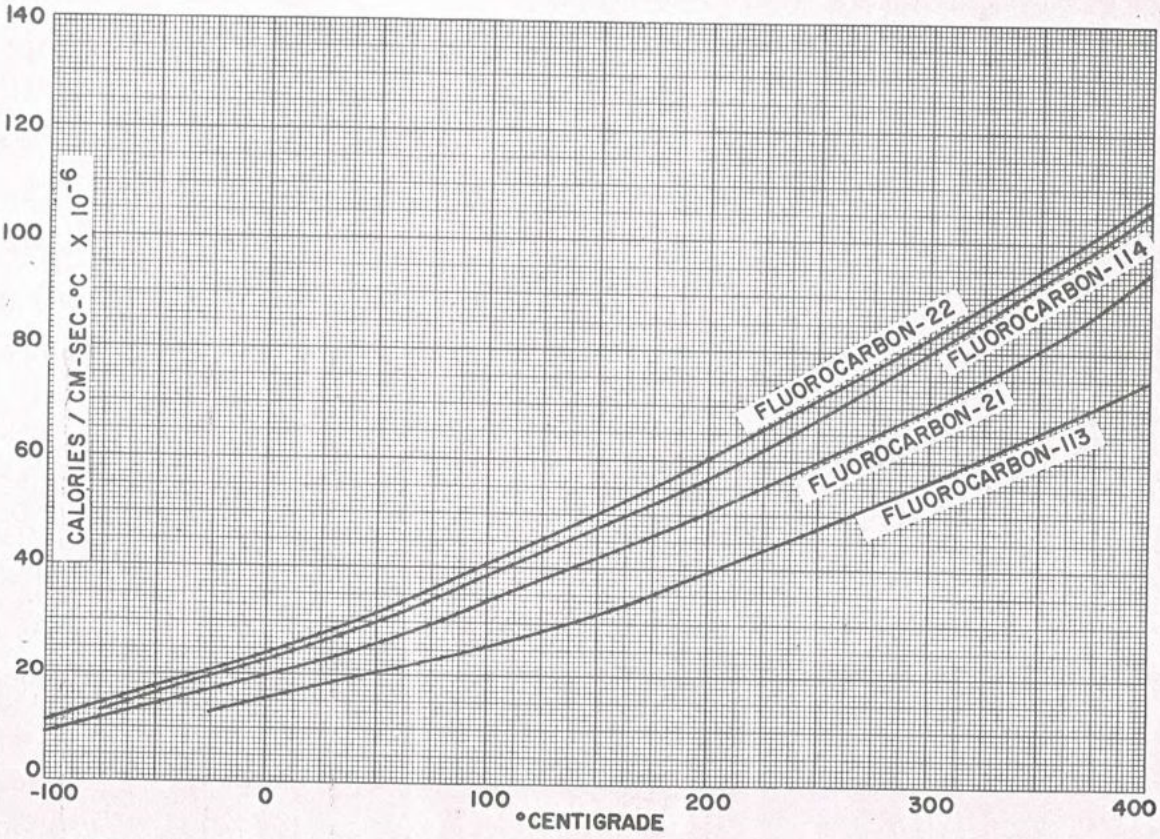

Fig. 21-12—Gives vapor thermal conductivity of halogenated hydrocarbons from — 100° C to + 400° C.

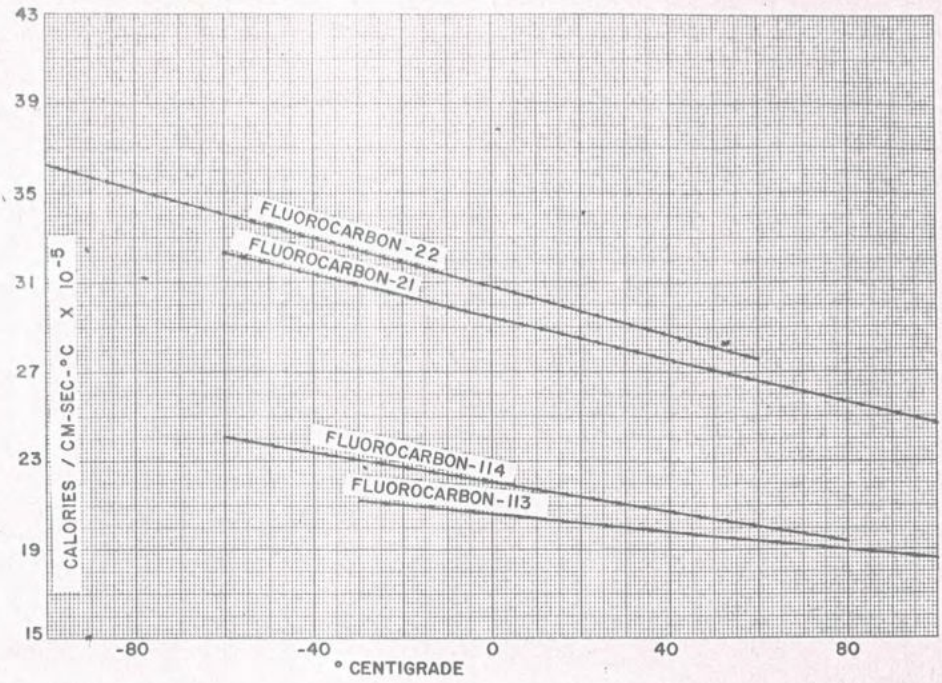

Fig. 21-13—Gives liquid thermal conductivity of halogenated hydrocarbons from — 100° C to + 100° C.

Viscosity. The vapor viscosity of all four compounds is available from the literature.[9,14] In addition, Makita[15] has studied the effect of pressure on the vapor viscosity. Fig. 21-8 presents data for the pressure effect on Fluorocarbon-21 and Fig. 21-9 shows the effect on Fluorocarbon-22.

Data for the liquid viscosity over a wide temperature range are available for the four compounds from the literature.[1,9,14]

Surface Tension. Du Pont[1] reports the surface tension of all four compounds at 25° C. Hovorka and Geiger[4] have measured the surface tension of Fluorocarbon-113 from 0-40° C and Fluorocarbon-114 from 30° to 80° C. These data have been extrapolated over a wide temperature range by the method proposed by Kharbanda,[16] with a probable error of ±10 percent.

Thermal Conductivity. The only data available on the thermal conductivities are at 25° C.[1] Consequently, the method of Owens and Thodos[17] has been used to estimate the vapor thermal conductivity and the method of Robbins and Kingrea[18] has been used for the liquid thermal conductivity. The error is probably ±5 percent for the vapor and ±10 percent for the liquid.

About the author

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Indexing Terms: Chlorinated Hydrocarbons-9, Chlorodifluoromethane-9, Computations-4, Dichlorofluoromethane-9, 1,1,2-Dichloro-1,2,2-Trifluoroethane-9, Fluorinated Hydrocarbons-9, Heat-7, Halogenated Hydrocarbons-9, Liquid Phase-5, Physical Properties-7, Pressure-6, Properties/Characteristics/-7, Temperature-6, 1,1,2-Trichloro-1,2,2-Trifluoroethane-9, Vapor Phase-5.

Part 22 "Fluorinated Hydrocarbons" will appear in an early issue.