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APPENDICES

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX A

SAMPLE OF CALCULATIONS

Data from the experiment

    working fluid : Freon-22

    outside diameter of the heat pipe, $D_O = 9.52 \times 10^{-3}$ m.

    inside diameter of the heat pipe, $D_i = 8.7 \times 10^{-3}$ m.

    outside diameter of the jacket, D = 0.0209 m.

F_c	=	72.30	cm^3/s	F_h	=	17.90	cm^3/s
T_{hi}	=	39.90	^oC	T_{ho}	=	36.77	^oC
T_{ci}	=	19.3	^oC	T_{co}	=	20.94	^oC
T_1	=	21.74	^oC	T_2	=	23.10	^oC
T_3	=	20.87	^oC	T_4	=	20.92	^oC
T_5	=	25.95	^oC	T_6	=	25.71	^oC
T_7	=	25.94	^oC	T_8	=	25.00	^oC
T_9	=	34.10	^oC	T_{10}	=	30.00	^oC

1. Calculate average heat transfer rate.

$$T_{bh} = \frac{T_{hi} + T_{ho}}{2} = \frac{39.90 + 36.77}{2} = 38.33 \ ^oC$$

Physical properties of water at 38 ^oC

$$\rho = 992.997 \quad kg/m^3$$

$$C_p = 4.1784 \quad kJ/kg\,^oC$$

$$k = 0.623 \quad W/m^{o}C$$

$$\mu = 0.6783 \times 10^{-3} \quad kg/m.s$$

$$Q_h = \rho F_h C_p \triangle T_h$$

$$F_h = 17.9 \quad cm^3/s$$

$$= 17.9 \times 10^{-6} \quad m^3/s$$

$$\triangle T_h = T_{hi} - T_{ho}$$

$$= 39.9 - 36.77 = 3.13 \quad {}^{o}C$$

$$Q_h = (992.997)(17.9 \times 10^{-6})(4.1784 \times 10^3)(3.13)$$

$$= 232.46 \quad W.$$

$$T_{bc} = \frac{T_{ci} + T_{co}}{2} = \frac{19.3 + 20.94}{2} = 20.12 \quad {}^{o}C$$

Physical properties of water at $20^{o}C$

$$\rho = 998.234 \quad kg/m^3$$

$$C_p = 4.1819 \quad kJ/kg^{o}C$$

$$k = 0.592 \quad W/m^{o}C$$

$$\mu = 1.002 \times 10^{-3} \quad kg/m.s$$

$$Q_c = \rho F_c C_p \triangle T_c$$

$$F_c = 72.3 \quad cm^3/s$$

$$= 72.3 \times 10^{-6} \quad m^3/s$$

$$\triangle T_c = T_{co} - T_{ci}$$

$$= 20.94 - 19.3$$

$$= 1.64 \quad {}^{o}C$$

$$Q_c = (998.234)(72.3 \times 10^{-6})(4.1819 \times 10^3)(1.64)$$

$$= 494.98 \quad W$$

$$Q_{av} = \frac{Q_h + Q_c}{2} = \frac{232.46 + 494.98}{2}$$

$$= 363.72 \quad W$$

2. Calculate the Reynolds number of hot and cold water

$$Re_h = \frac{\rho D_e u}{\mu}$$

$$u = \text{water velocity} = F/A$$

$$A = \frac{\pi D_o^2}{4} - \frac{\pi D_i^2}{4}$$

$$= \frac{\pi (0.0209)^2}{4} - \frac{\pi (9.52 \times 10^{-3})}{4} = 2.719 \times 10^{-4} \quad m^2$$

$$u_c = \frac{72.3 \times 10^{-6}}{2.719 \times 10^{-4}} = 0.266 \quad m/s$$

$$D_e' = \frac{4(\text{cross-sectional area})}{\text{heat transfer perimeter}}$$

$$= \frac{4(2.719 \times 10^{-4})}{\pi (9.52 \times 10^{-3})} = 0.0364 \quad m.$$

$$D_e = \frac{4(\text{cross-sectional area})}{\text{wet perimeter}}$$

$$= \frac{4(2.719 \times 10^{-4})}{\pi (9.52 \times 10^{-3} + 0.0209)} = 0.0114 \quad m.$$

$$Re_c = \frac{(998.234)(0.0114)(0.266)}{1.002 \times 10^{-3}} = 3,021$$

$$Re_c' = \frac{(998.234)(0.0364)(0.266)}{1.002 \times 10^{-3}} = 9,646$$

$$u_h = \frac{17.9 \times 10^{-6}}{2.719 \times 10^{-4}} = 0.066 \quad m/s$$

$$Re_h = \frac{(992.997)(0.0114)(0.066)}{0.6783 \times 10^{-3}} = 1,101$$

$$Re_h' = \frac{(992.997)(0.0364)(0.066)}{0.6783 \times 10^{-3}} = 3,517$$

3. Calculate the effective thermal conductivity of the heat pipe

$$T_{who} = \frac{T_7 + T_8 + T_9 + T_{10}}{4}$$

$$= \frac{25.94 + 25.0 + 34.10 + 30.0}{4} = 28.76 \ ^{o}C$$

$$T_{wco} = \frac{T_1 + T_2 + T_3 + T_4}{4}$$

$$= \frac{21.74 + 23.10 + 20.87 + 20.92}{4} = 21.66 \ ^{o}C$$

$$T_{who} - T_{wco} = 28.76 - 21.66 = 7.1 \ ^{o}C$$

$$K_{eff} = \frac{Q_{av} L_{eff}}{A_{cross} \Delta T}$$

$$A_{cross} = \frac{\pi D_o^2}{4}$$

$$= \frac{\pi (9.52 \times 10^{-3})^2}{4} = 7.118 \times 10^{-5} \ m^2$$

$$\Delta T \quad = \quad T_{who} - T_{wco} \quad = \quad 7.1 \quad ^{o}C$$

$$L_{eff} \quad = \quad 0.5 \quad m.$$

$$K_{eff} \quad = \quad \frac{(363.72)(0.5)}{(7.118 \times 10^{-5})(7.1)} \quad = \quad 359,849 \quad W/m^{o}C$$

$$K_{cu} \quad = \quad 386 \quad W/m^{o}C$$

$$\frac{K_{eff}}{K_{cu}} \quad = \quad \frac{359,849}{386} \quad = \quad 932.2$$

$$U_{hp} \quad = \quad \frac{Q_{av}}{A_h \Delta T}$$

$$U_{hp} \quad = \quad \frac{363.72}{\pi (9.52 \times 10^{-3})(0.4)(7.1)} \quad = \quad 4,282 \quad W/m^{2o}C$$

4. Calculate the thermal resistances.

$$R_t \quad = \quad \frac{T_{bh} - T_{bc}}{Q_{av}}$$

$$= \quad \frac{38.33 - 20.12}{363.72} \quad = \quad 0.05 \quad ^{o}C/W$$

$$R_{hp} \quad = \quad \frac{T_{who} - T_{wco}}{Q_{av}}$$

$$= \quad \frac{7.1}{363.72} \quad = \quad 0.0195 \quad ^{o}C/W$$

$$R_1 \quad = \quad \frac{T_{bh} - T_{who}}{Q_{av}}$$

$$= \quad \frac{38.33 - 28.76}{363.72} \quad = \quad 0.0263 \quad ^{o}C/W$$

$$R_7 \quad = \quad \frac{T_{wco} - T_{bc}}{Q_{av}}$$

$$= \quad \frac{21.66 - 20.12}{363.72} \quad = \quad 4.234 \times 10^{-3} \quad {}^{\circ}C/W$$

5. Calculate the thermal resistances using the obtained correlations.

a. Calculate outer film coefficient of the evaporator section.

$$Nu_h \quad = \quad 13.228 \ Re_h{}^{0.381}$$

$$T_{who} \quad = \quad 28.76 \quad {}^{\circ}C$$

Assume $T_{bh1} \quad = \quad 35.14 \quad {}^{\circ}C$

$$T_f \quad = \quad (28.76 + 35.14)/2 \quad = \quad 32 \quad {}^{\circ}C$$

Properties of water at 32 ${}^{\circ}C$

$$\rho \quad = \quad 995.057 \quad kg/m^3$$

$$\mu \quad = \quad 0.7647 \times 10^{-3} \quad kg/m.s$$

$$k \quad = \quad 0.609 \quad W/m{}^{\circ}C$$

$$Re_h' \quad = \quad \frac{\rho D_e u_h}{\mu}$$

$$u_h \quad = \quad 0.066 \quad m/s$$

$$D_e \quad = \quad 0.0364$$

$$Re_h' \quad = \quad \frac{(995.057)(0.0364)(0.066)}{0.7647 \times 10^{-3}}$$

$$= \quad 3,126$$

$$Nu_h \quad = \quad (13.228)(3,126)^{0.381}$$

$$= \quad 283.8$$

$$Nu_h = \frac{h_{oh} D_e}{k}$$

$$h_{oh} = \frac{(283.8)(0.609)}{0.0364} = 4,748 \quad W/m^2 {}^oC$$

$$\Delta T_h = \frac{Q_{av}}{\pi D_o L h_{oh}}$$

$$= \frac{363.72}{\pi (9.52 \times 10^{-3})(0.4)(4,748)} = 6.4 \quad {}^oC$$

$$T_{bh2} = T_{who} + \Delta T_h$$

$$= 28.76 + 6.4 = 35.16 \quad {}^oC$$

$$T_{bh1} \cong T_{bh2}$$

$$T_{bh}' = 35.14 \quad {}^oC$$

b. Calculate outer film coefficient of the condenser section.

$$T_{wco} = 21.66 \quad {}^oC$$

Assume T_{bc1} = 19.36 ${}^oC$

Properties of water at 20 ${}^oC$

$$\rho = 998.234 \quad kg/m^3$$

$$\mu = 1.002 \times 10^{-3} \quad kg/m.s$$

$$k = 0.609 \quad W/m^oC$$

$$Re_c' = \frac{\rho D_e u_c}{\mu}$$

$$u_h = 0.266 \quad m/s$$

$$D_e = 0.0364 \quad m$$

$$Re_c' = \frac{(998.234)(0.0364)(0.266)}{1.002 \times 10^{-3}}$$

$$= 9,646$$

$$Nu_c = 0.128\ Re_c'^{0.952}$$

$$= 0.128\ (9,646)^{0.952}$$

$$= 794.9$$

$$Nu_c = \frac{h_{oh}D_e}{k}$$

$$h_{oc} = \frac{(794.9)(0.609)}{0.0364} = 13,299\ W/m^2{}^oC$$

$$\Delta T_c = \frac{Q_{av}}{h_{oc}\ \pi\ D_o L}$$

$$= \frac{363.72}{(13,299)\ \pi\ (9.52 \times 10^{-3})(0.4)} = 2.29\ {}^oC$$

$$T_{bc2} = T_{wco} - \Delta T_c$$

$$= 21.66 - 2.29 = 19.37\ {}^oC$$

$$T_{bc1} \cong T_{bc2}$$

$$T_{bc}' = 19.36\ {}^oC$$

c. Calculate the heat transfer coefficient in the evaporator section.

$$T_{whi} = T_{who} - \frac{Q_{av}\ (D_o - D_i)}{2\ k\ A_{lm}}$$

$$A_{lm} = \frac{A_o - A_i}{\ln \dfrac{A_o}{A_i}}$$

$$A_o \quad = \quad \pi D_o L \quad = \quad \pi(9.52 \times 10^{-3})(0.4)$$

$$= \quad 0.0119 \qquad m^2$$

$$A_i \quad = \quad 1.4 \, \pi D_b L$$

$$= \quad 1.4 \, (\pi)(8.96 \times 10^{-3})(0.4)$$

$$= \quad 0.0158 \qquad m^2$$

$$A_{lm} \quad = \quad \frac{0.0119 - 0.0158}{\ln \frac{0.0119}{0.0158}}$$

$$= \quad 0.0138 \qquad m^2$$

$$k \text{ (copper tube)} = 386 \qquad W/m^\circ C$$

$$T_{whi} \quad = \quad \frac{28.76 - (363.72)(9.52 \times 10^{-3} - 8.7 \times 10^{-3})}{2(386)(0.0138)}$$

$$= \quad 28.73 \qquad ^\circ C$$

$$\text{Assume } T_{vh1} \quad = \quad 25.81 \qquad ^\circ C$$

$$T_f \quad = \quad 27.3 \qquad ^\circ C$$

Properties of Freon-22 at 27.3 $^\circ C$

$$\rho_v \quad = \quad 48.651 \qquad kg/m^3$$

$$\rho \quad = \quad 1.184 \times 10^3 \qquad kg/m^3$$

$$\mu \quad = \quad 2.323 \times 10^{-4} \qquad kg/m.s$$

$$\lambda \quad = \quad 179.345 \qquad kJ/kg$$

$$k \quad = \quad 0.0837 \qquad W/m.^\circ C$$

$$\sigma \quad = \quad 7.642 \times 10^{-3} \qquad N/m$$

$$C_p \quad = \quad 1.26 \qquad kJ/kg^\circ C$$

$$\frac{C_p \, (T_{whi} - T_s)}{\lambda \, Pr^{1.7}} \quad = \quad 5.654 \times 10^{-3} \left[\frac{Q/A}{\lambda \mu} \sqrt{\frac{\sigma \, g_c}{g(\rho - \rho_v)}} \right]^r$$

$$\frac{(1.26\text{x}10^3)(T_{whi}-T_s)}{(179.345\text{x}10^3)(3.497)^{1.7}} = 5.654\text{x}10^{-3}\left[\frac{363.72/0.0158}{(2.323\text{x}10^{-4})(179.345\text{x}10^3)}\right.$$

$$\left. \times \sqrt{\frac{(7.642\text{x}10^{-3})}{(9.8)(1,184-48.651)}}\right]^{1.069}$$

$$8.364\text{x}10^{-4} \ (T_{whi}-T_s) \ = \ 2.453\text{x}10^{-3}$$

$$T_{whi}-T_s \ = \ \frac{2.453\text{x}10^{-3}}{8.364\text{x}10^{-4}} \ = \ 2.93 \quad {}^{\circ}C$$

$$T_{vh2} \ = \ T_{whi}-\Delta T$$

$$= \ 28.73-2.93 \ = \ 25.8 \quad {}^{\circ}C$$

$$T_{vh1} \ \cong \ T_{vh2}$$

$$T_{vh}' \ = \ 25.81 \quad {}^{\circ}C$$

d. Calculate the heat transfer coefficient in the condenser section.

$$T_{wci} \ = \ T_{wco}+\frac{Q_{av} \ (D_o-D_i)}{2 \ \ kA_{lm}}$$

$$= \ 21.66 + \frac{(363.72)(9.52\text{x}10^{-3}-8.7\text{x}10^{-3})}{2 \ \ (386)(0.0138)}$$

$$T_{wci} \ = \ 21.69 \quad {}^{\circ}C$$

Assume $T_{vc1} \ = \ 25.6 \ {}^{\circ}C$

Properties of Freon-22 at 23.6 $\ {}^{\circ}C$

$$\rho_v \ = \ 43.532 \quad kg/m^3$$

$$\rho \ = \ 1.199\text{x}10^3 \quad kg/m^3$$

$$\mu \ = \ 2.362\text{x}10^{-4} \quad kg/m.s$$

$$\lambda \ = \ 183.169\text{x}10^3 \quad J/kg$$

$$k \quad = \quad 0.0856 \quad W/m^oC$$

$$\delta \quad = \quad 5.278 \times 10^{-3} \quad N/m$$

$$C_p \quad = \quad 1.246 \times 10^3 \quad J/kg^oC$$

$$h_{ic} \quad = \quad 5.331 \times 10^{-4} \left[\frac{g \, \rho \, (\rho - \rho_v) k^3 \lambda}{\mu \, (T_{whi} - T_s) L_h} \right]^{0.558}$$

$$h_{ic} \quad = \quad 5.331 \times 10^{-4} \left[\frac{(9.8)(1,199)(1,199-43.532)(0.0856)^3(183,169)}{(2.362 \times 10^{-4})(25.6-21.69)(0.4)} \right]^{0.558}$$

$$= \quad 5,914 \quad W/m^{2o}C$$

$$\Delta T \quad = \quad \frac{Q}{hA} \quad = \quad \frac{363.72}{(5,914)(0.0158)}$$

$$= \quad 3.89 \quad {}^oC$$

$$T_{vc2} \quad = \quad T_{wci} + \Delta T_c \quad = \quad 21.69 + 3.89$$

$$= \quad 25.58 \quad {}^oC$$

$$\cong \quad T_{vc1}$$

$$T_{vc} \quad = \quad 25.60 \quad {}^oC$$

$$T_{va} \quad = \quad \frac{T_{vc} + T_{vh}}{2} \quad = \quad \frac{25.81 + 25.60}{2}$$

$$= \quad 25.71 \quad {}^oC$$

$$h_{ih}' \quad = \quad \frac{Q}{A_i \, \Delta T}$$

$$= \quad \frac{363.72}{(0.0158)(28.73-25.71)}$$

$$= \quad 7,623 \quad W/m^{2o}C$$

$$h_{ic}' \quad = \quad \frac{363.72}{(0.0158)(25.71-21.69)}$$

$$= \quad 5,726 \quad W/m^{2o}C$$

$$R_1 = \frac{1}{h_{oh} \, A_o}$$

$$= \frac{1}{(4,748)(\pi)(9.52 \times 10^{-3})(0.4)}$$

$$= 0.01761 \quad ^\circ C/W$$

$$R_2 = \frac{(T_{who} - T_{whi})}{Q_{av}}$$

$$= \frac{(28.76 - 28.73)}{363.72}$$

$$= 8.2481 \times 10^{-5} \quad ^\circ C/W$$

$$R_3 = \frac{1}{h_{ih}' A_i}$$

$$= \frac{1}{(7,623)(0.0158)}$$

$$= 8.3027 \times 10^{-3} \quad ^\circ C/W$$

$$R_5 = \frac{1}{h_{ic}' A_i}$$

$$= \frac{1}{(5,726)(0.0158)} = 0.0111 \quad ^\circ C/W$$

$$R_6 = \frac{T_{wci} - T_{wco}}{Q_{av}}$$

$$= \frac{21.69 - 21.66}{363.72}$$

$$= 8.2481 \times 10^{-5} \quad ^\circ C/W$$

$$R_7 = \frac{1}{h_{oc}A_o}$$

$$= \frac{1}{(13,299)(\pi)(9.52 \times 10^{-3})(0.4)}$$

$$= 6.2854 \times 10^{-3} \quad {}^{o}C/W$$

$$R_{hp} = R_2 + R_3 + R_5 + R_6$$

$$= 8.2481 \times 10^{-5} + 8.3027 \times 10^{-3} + 0.0111 + 8.2481 \times 10^{-5}$$

$$= 0.0195 \quad {}^{o}C/W$$

$$R_t = R_1 + R_{hp} + R_7$$

$$= 0.01761 + 0.0195 + 6.2854 \times 10^{-3}$$

$$= 0.0434 \quad {}^{o}C/W$$
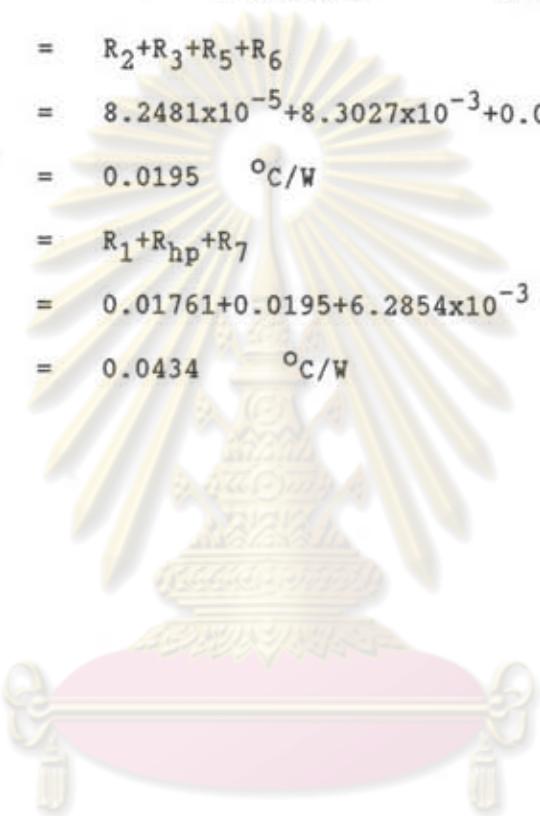
ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX B

PHYSICAL PROPERTIES

Table B-1 Properties of Freon-113, $C_2F_3Cl_3$ ($T_b = 47.68^oC$; $T_m = -36.6^oC$)

T ^oC	p bar	L kJ/kg	δ 10^{-3} N/m	ρ_v kg/m^3	ρ_1 kg/m^3	η_v N.s/m^2 x 10^3	η_1 N.s/m^2 x 10^{-7}	λ W/(m.K) x 10^{-3}
-30	0.0283	166.88	25.3	0.2639	1.687	89.4	1.670	0.0889
-10	0.0905	161.48	22.8	0.7800	1.643	94.2	1.130	0.0844
0	0.1500	158.68	21.5	1.2510	1.621	86.7	0.948	0.0822
10	0.2387	155.83	20.6	1.9300	1.598	99.0	0.780	0.0799
30	0.5420	149.93	18.1	4.1500	1.554	104.0	0.590	0.0754
50	1.0943	143.82	16.0	8.0000	1.508	108.5	0.475	0.0709
70	2.0120	137.46	13.9	14.3000	1.455	113.0	0.401	0.0664

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Table B-2 Properties of Freon-22, CHF_2Cl ($T_b = -40.8°C$; $T_m = -160°C$)

T °C	p bar	L kJ/kg	σ 10^{-3} N/m	ρ_v kg/m³	ρ_l kg/m³ × 10³	η_v N.s/m² × 10^{-7}	η_l N.s/m² × 10^{-4}	λ W/(m.K)
-100	0.0199	269.29	28.1	0.1196	1.557	80.0	6.00	0.1487
-80	0.1034	257.43	24.8	0.561	1.514	87.5	5.00	0.1385
-60	0.3752	245.42	21.5	1.865	1.465	95.0	4.14	0.1283
-40	1.0540	232.92	18.5	4.885	1.412	101.7	3.49	0.1181
-20	2.4560	219.40	15.0	10.821	1.351	110.4	3.02	0.1079
0	4.9830	204.28	11.7	21.285	1.285	118.7	2.67	0.0977
20	9.0970	186.89	8.7	38.550	1.214	126.8	2.40	0.0875
40	15.3150	166.22	5.8	66.225	1.132	134.5	2.19	0.0772
60	24.2360	139.94	3.3	111.65	1.030	142.1	2.00	0.0646

Table B-3 Properties of saturated vapor, Freon-113

Trichlorotrifluoroethane, Freon 113
Properties of Saturated Vapor

Temp. °F t	Pressure		Volume		Density		Enthalpy from −40°F.			Entropy from −40°F.		Temp. °F t
	Absolute lbs./in.² p	Gage lbs./in.² $g.p.$	Liquid ft.³/lb. v_f	Vapor ft.³/lb. v_g	Liquid lbs./ft.³ $1/v_f$	Vapor lbs./ft.³ $1/v_g$	Liquid Btu./lb. h_f	Latent Btu./lb. h_{fg}	Vapor Btu./lb. h_g	Liquid Btu./lb.°F. s_f	Vapor Btu./lb.°F. s_g	
−30	0.2987	29.31*	0.00947	82.26	105.64	0.01216	1.97	72.68	74.65	0.0047	0.1738	−30
−28	.3214	29.27*	.00948	76.81	105.50	.01302	2.36	72.57	74.93	.0056	.1737	−28
−26	.3458	29.22*	.00949	71.71	105.37	.01395	2.76	72.45	75.21	.0065	.1736	−26
−24	.3718	29.16*	.00950	66.99	105.23	.01493	3.16	72.33	75.49	.0074	.1735	−24
−22	.3995	29.11*	.00952	62.63	105.09	.01597	3.56	72.21	75.77	.0083	.1733	−22
−20	0.4288	29.05*	0.00953	58.61	104.96	0.01706	3.96	72.09	76.05	0.0092	0.1732	−20
−18	.4600	28.98*	.00954	54.88	104.82	.01822	4.36	71.98	76.34	.0101	.1731	−18
−16	.4931	28.92*	.00955	51.42	104.68	.01945	4.76	71.86	76.62	.0110	.1730	−16
−14	.5280	28.85*	.00957	48.23	104.54	.02074	5.16	71.74	76.90	.0119	.1729	−14
−12	.5652	28.77*	.00958	45.25	104.40	.02210	5.56	71.62	77.18	.0128	.1729	−12
−10	0.6046	28.69*	0.00959	42.48	104.26	0.02354	5.96	71.51	77.47	0.0137	0.1728	−10
− 8	.6462	28.60*	.00960	39.92	104.12	.02505	6.36	71.39	77.75	.0146	.1727	− 8
− 6	.6902	28.51*	.00962	37.54	103.98	.02664	6.76	71.27	78.03	.0155	.1726	− 6
− 4	.7369	28.42*	.00963	35.31	103.84	.02832	7.17	71.15	78.32	.0164	.1726	− 4
− 2	.7860	28.32*	.00964	33.24	103.70	.03009	7.57	71.03	78.60	.0173	.1725	− 2
0	0.8377	28.21*	0.00966	31.31	103.56	0.03194	7.98	70.92	78.89	0.0182	0.1725	0
2	.8924	28.10*	.00967	29.52	103.41	.03388	8.38	70.80	79.18	.0190	.1724	2
4	.9503	27.99*	.00968	27.84	103.27	.03592	8.78	70.68	79.46	.0199	.1724	4
5†	0.9802	27.92*	.00969	27.04	103.20	.03698	8.98	70.62	79.60	.0203	.1723	5†
6	1.011	27.86*	.00970	26.27	103.13	.03806	9.19	70.56	79.75	.0208	.1723	6
8	1.075	27.73*	.00971	24.81	102.98	.04031	9.59	70.44	80.03	.0216	.1723	8
10	1.142	27.60*	0.00972	23.45	102.84	0.04265	10.00	70.32	80.32	0.0225	0.1723	10
12	1.213	27.45*	.00974	22.17	102.69	.04511	10.41	70.20	80.61	.0234	.1722	12
14	1.288	27.30*	.00975	20.97	102.55	.04769	10.81	70.08	80.89	.0242	.1722	14
16	1.366	27.14*	.00977	19.84	102.40	.05040	11.22	69.96	81.18	.0251	.1722	16
18	1.448	26.97*	.00978	18.79	102.25	.05322	11.62	69.84	81.46	.0259	.1722	18
20	1.534	26.80*	0.00979	17.81	102.10	0.05616	12.03	69.72	81.75	0.0268	0.1722	20
22	1.624	26.61*	.00981	16.89	101.96	.05922	12.44	69.60	82.04	.0276	.1721	22
24	1.719	26.42*	.00982	16.02	101.81	.06243	12.85	69.48	82.33	.0285	.1721	24
26	1.818	26.22*	.00984	15.20	101.66	.06579	13.26	69.36	82.62	.0293	.1722	26
28	1.922	26.01*	.00985	14.43	101.51	.06929	13.67	69.24	82.91	.0302	.1722	28
30	2.031	25.79*	0.00987	13.71	101.36	0.07294	14.08	69.12	83.20	0.0310	0.1722	30
32	2.145	25.55*	.00988	13.03	101.21	.07675	14.49	69.00	83.49	.0318	.1722	32
34	2.264	25.31*	.00990	12.39	101.06	.08071	14.91	68.87	83.78	.0327	.1722	34
36	2.388	25.06*	.00991	11.79	100.91	.08483	15.32	68.75	84.07	.0335	.1722	36
38	2.519	24.79*	.00993	11.22	100.76	.08913	15.74	68.62	84.36	.0343	.1722	38
40	2.655	24.52*	0.00994	10.68	100.60	0.09361	16.16	68.50	84.65	0.0352	0.1723	40
42	2.797	24.23*	.00996	10.18	100.45	.09826	16.57	68.37	84.94	.0360	.1723	42
44	2.944	23.93*	.00997	9.703	100.30	.1031	16.99	68.25	85.24	.0368	.1723	44
46	3.098	23.61*	.00999	9.253	100.14	.1081	17.41	68.12	85.53	.0377	.1724	46
48	3.258	23.29*	.01000	8.830	99.99	.1133	17.82	68.00	85.82	.0385	.1724	48
50	3.427	22.94*	0.01002	8.426	99.83	0.1187	18.24	67.87	86.11	0.0393	0.1725	50
52	3.602	22.59*	.01003	8.044	99.68	.1243	18.66	67.74	86.40	.0401	.1726	52
54	3.784	22.22*	.01005	7.682	99.52	.1302	19.08	67.61	86.69	.0410	.1726	54
56	3.973	21.83*	.01006	7.342	99.37	.1362	19.50	67.48	86.98	.0418	.1727	56
58	4.170	21.43*	.01008	7.018	99.21	.1425	19.93	67.35	87.28	.0426	.1727	58
60	4.374	21.02*	0.01010	6.713	99.05	0.1490	20.35	67.22	87.57	0.0434	0.1728	60
62	4.586	20.59*	.01011	6.424	98.89	.1557	20.77	67.09	87.86	.0442	.1729	62
64	4.807	20.14*	.01013	6.149	98.73	.1626	21.19	66.96	88.15	.0450	.1729	64
66	5.036	19.67*	.01015	5.889	98.58	.1698	21.62	66.83	88.45	.0459	.1730	66
68	5.275	19.18*	.01016	5.640	98.42	.1773	22.05	66.69	88.74	.0467	.1731	68
70	5.523	18.68*	0.01018	5.404	98.26	0.1851	22.48	66.56	89.04	0.0475	0.1731	70
72	5.780	18.16*	.01019	5.180	98.10	.1931	22.90	66.43	89.33	.0483	.1732	72
74	6.042	17.62*	.01021	4.971	97.93	.2012	23.33	66.29	89.62	.0491	.1733	74
76	6.320	17.06*	.01023	4.769	97.77	.2097	23.76	66.16	89.92	.0499	.1734	76
78	6.607	16.47*	.01025	4.574	97.61	.2186	24.19	66.02	90.21	.0507	.1735	78

* Inches of mercury below one atmosphere.
† Standard ton temperatures.

Table B-3 (cont.) Properties of saturated vapor, Freon-113

PROPERTIES OF SATURATED VAPOR, FREON 113 (*Continued*)

Temp. °F. t	Pressure		Volume		Density		Enthalpy from −40°F.			Entropy from −40°F.		Temp. °F. t
	Absolute lbs./in.² p	Gage lbs./in.² g.p.	Liquid ft.³/lb. V_f	Vapor ft.³/lb. V	Liquid lbs./ft.³ 1/V_f	Vapor lbs./ft.³ 1/V	Liquid Btu./lb. h	Latent Btu./lb. L	Vapor Btu./lb. H	Liquid Btu./lb.°F. s	Vapor Btu./lb.°F. S	
80	6.902	15.87*	0.01026	4.392	97.45	0.2277	24.63	65.88	90.51	0.0515	0.1736	80
82	7.208	15.25*	.01028	4.218	97.28	.2371	25.06	65.74	90.80	.0523	.1737	82
84	7.527	14.60*	.01030	4.051	97.12	.2468	25.49	65.60	91.09	.0531	.1738	84
86†	7.856	13.93*	.01031	3.893	96.96	.2569	25.93	65.46	91.39	.0539	.1739	86†
88	8.194	13.24*	.01033	3.742	96.79	.2672	26.36	65.32	91.68	.0547	.1740	88
90	8.545	12.53*	0.01035	3.600	96.63	0.2778	26.80	65.18	91.98	0.0555	0.1741	90
92	8.908	11.79*	.01037	3.463	96.46	.2888	27.24	65.04	92.28	.0563	.1742	92
94	9.281	11.03*	.01039	3.333	96.30	.3001	27.67	64.90	92.57	.0571	.1743	94
96	9.668	10.24*	.01040	3.208	96.13	.3117	28.11	64.75	92.86	.0578	.1744	96
98	10.07	9.42*	.01042	3.089	95.96	.3237	28.55	64.60	93.15	.0586	.1745	98
100	10.48	8.59*	0.01044	2.976	95.79	0.3360	28.99	64.46	93.45	0.0594	0.1746	100
102	10.91	7.71*	.01046	2.867	95.63	.3488	29.44	64.31	93.75	.0602	.1747	102
104	11.35	6.82*	.01048	2.762	95.46	.3620	29.89	64.16	94.05	.0610	.1748	104
106	11.81	5.88*	.01050	2.662	95.29	.3756	30.33	64.01	94.34	.0618	.1750	106
108	12.28	4.93*	.01051	2.567	95.12	.3896	30.78	63.86	94.64	.0626	.1751	108
110	12.76	3.95*	0.01053	2.477	94.95	0.4038	31.22	63.71	94.93	0.0634	0.1752	110
112	13.25	2.95*	.01055	2.391	94.78	.4182	31.67	63.56	95.23	.0641	.1753	112
114	13.76	1.91*	.01057	2.308	94.61	.4333	32.12	63.40	95.52	.0649	.1755	114
116	14.29	0.83*	.01059	2.228	94.43	.4489	32.57	63.25	95.82	.0657	.1756	116
118	14.84	0.14	.01061	2.151	94.26	.4649	33.03	63.09	96.12	.0665	.1757	118
120	15.40	0.70	0.01063	2.078	94.09	0.4813	33.48	62.93	96.41	0.0673	0.1758	120
122	15.97	1.27	.01065	2.008	93.92	.4981	33.93	62.78	96.71	.0680	.1760	122
124	16.56	1.86	.01067	1.941	93.74	.5153	34.38	62.62	97.00	.0688	.1761	124
126	17.17	2.47	.01069	1.876	93.57	.5330	34.83	62.46	97.29	.0696	.1763	126
128	17.80	3.10	.01071	1.814	93.39	.5514	35.29	62.30	97.59	.0704	.1764	128
130	18.45	3.74	0.01073	1.754	93.22	0.5702	35.75	62.14	97.89	0.0712	0.1765	130
132	19.11	4.41	.01075	1.697	93.04	.5894	36.21	61.97	98.18	.0719	.1767	132
134	19.79	5.09	.01077	1.642	92.86	.6091	36.67	61.80	98.47	.0727	.1768	134
136	20.48	5.78	.01079	1.590	92.69	.6290	37.13	61.64	98.77	.0735	.1770	136
138	21.19	6.49	.01081	1.540	92.51	.6494	37.59	61.48	99.06	.0742	.1771	138
140	21.93	7.23	0.01083	1.491	92.33	0.6707	38.05	61.31	99.36	0.0750	0.1773	140
142	22.69	7.99	.01085	1.444	92.15	.6926	38.52	61.13	99.65	.0758	.1774	142
144	23.47	8.77	.01087	1.399	91.98	.7150	38.98	60.96	99.94	.0765	.1775	144
146	24.27	9.57	.01089	1.355	91.80	.7379	39.45	60.79	100.24	.0773	.1777	146
148	25.09	10.39	.01092	1.313	91.62	.7615	39.92	60.61	100.53	.0781	.1778	148
150	25.93	11.23	0.01094	1.273	91.44	0.7856	40.38	60.44	100.82	0.0789	0.1780	150
152	26.79	12.09	.01096	1.234	91.25	.8102	40.85	60.27	101.11	.0796	.1782	152
154	27.67	12.97	.01098	1.197	91.07	.8353	41.32	60.09	101.41	.0804	.1783	154
156	28.56	13.86	.01100	1.162	90.89	.8608	41.79	59.91	101.70	.0812	.1785	156
158	29.48	14.78	.01102	1.128	90.71	.8869	42.26	59.73	101.99	.0819	.1786	158
160	30.44	15.74	0.01105	1.094	90.53	0.9141	42.74	59.55	102.29	0.0827	0.1788	160
170	35.53	20.83	.01116	0.9442	89.60	1.059	45.12	58.62	103.74	.0865	.1796	170
180	41.22	26.52	.01128	.8193	88.67	1.221	47.53	57.66	105.19	.0903	.1804	180
190	47.60	32.90	.01140	.7134	87.72	1.402	49.97	56.66	106.63	.0940	.1813	190
200	54.66	39.96	.01153	.6241	86.76	1.602	52.45	55.62	108.07	.0978	.1821	200
210	62.50	47.80	.01166	.5477	85.79	1.826	54.96	54.54	109.50	.1015	.1830	210
220	71.07	56.37	0.01179	0.4827	84.80	2.072	57.49	53.43	110.92	0.1052	0.1839	220

* Inches of mercury below one atmosphere.
† Standard ton temperatures.

Table B-4   Properties of saturated vapor, Freon-22

MONOCHLORODIFLUOROMETHANE, FREON 22

PROPERTIES OF SATURATED VAPOR

Temp., °F. t	Pressure		Volume		Density		Enthalpy from −40° F.			Entropy	
	Absolute, lbs. in.² p	Gage, lbs. in.² g.p.	Liquid, ft.² lb. r_f	Vapor, ft.² lb. r_g	Liquid, lbs. ft.³ 1/r_f	Vapor, lbs. ft.³ 1/r_g	Liquid, Btu. lb. k_f	Latent, Btu. lb. l_fg	Vapor, Btu. lb. h_g	Liquid, Btu. lb. °F. s_f	Vapor, Btu./lb. °F. s_g
−155	0.19901	29.51 *	0.0102	188.13	97.67	0.0053156	−29.05	115.85	86.80	−0.08075	0.29958
−150	0.26049	29.39 *	0.0103	146.06	97.33	0.0068467	−27.77	115.15	87.38	−0.07670	.29523
−145	.33751	29.23 *	.0103	114.51	96.99	.0087329	−26.50	114.46	87.96	− .07265	.29118
−140	.43323	29.04 *	.0103	90.613	96.65	.011036	−25.23	113.78	88.55	− .06865	.28736
−135	.55106	28.80 *	.0104	72.327	96.27	.013826	−23.97	113.10	89.13	− .06471	.28372
−130	.69492	28.51 *	.0104	58.214	95.91	.017178	−22.71	112.43	89.72	− .06085	.28026
−125	0.86922	28.15 *	0.0105	47.226	95.53	0.021175	−21.45	111.76	90.31	−0.05706	0.27695
−120	1.0788	27.72 *	.0105	38.600	95.15	.025907	−20.20	111.10	90.90	− .05335	.27380
−115	1.3291	27.21 *	.0106	31.773	94.76	.031473	−18.96	110.45	91.49	− .04970	.27082
−110	1.6261	26.61 *	.0106	26.329	94.37	.037981	−17.71	109.80	92.09	− .04609	.26798
−105	1.9766	25.90 *	.0106	21.960	93.97	.045538	−16.46	109.15	92.69	− .04254	.26527
−100	2.3861	25.06 *	0.0107	18.426	93.56	0.054272	−15.21	108.50	93.29	−0.03903	0.26269
− 95	2.8649	24.09 *	.0107	15.544	93.14	.064333	−13.96	107.85	93.89	− .03557	.26023
− 90	3.4173	22.96 *	.0108	13.196	92.72	.075783	−12.71	107.20	94.49	− .03216	.25788
− 85	4.0554	21.67 *	.0108	11.256	92.29	.088813	−11.45	106.55	95.10	− .02881	.25563
− 80	4.7871	20.18 *	.0109	9.6497	91.85	.10363	−10.20	105.90	95.70	− .02551	.25347
− 75	5.6224	18.48 *	0.0109	8.3112	91.41	0.12032	− 8.94	105.24	96.30	−0.02224	0.25139
− 70	6.5711	16.55 *	.0110	7.1917	90.96	.13905	− 7.67	104.57	96.90	− .01899	.24941
− 65	7.6456	14.36 *	.0110	6.2188	90.50	.16003	− 6.41	103.91	97.50	− .01576	.24737
− 60	8.8562	11.89 *	.0111	5.4520	90.03	.18342	− 5.14	103.24	98.10	− .01256	.24580
− 55	10.224	9.11 *	.0112	4.7710	89.56	.20960	− 3.85	102.55	98.70	− .00939	.24407
− 50	11.744	6.02 *	0.0112	4.1948	89.08	0.23839	− 2.56	101.86	99.30	−0.00623	0.24245
− 45	13.428	2.59 *	.0113	3.7038	88.59	.26999	− 1.27	101.16	99.89	− .00311	.24088
− 40	15.309	0.609	.0114	3.2787	88.10	.30500	0.02	100.46	100.48	0.00000	.23942
− 35	17.391	2.691	.0114	2.9116	87.60	.34345	1.33	99.74	101.07	.00309	.23799
− 30	19.689	4.989	.0115	2.5936	87.09	.38557	2.64	99.01	101.65	.00616	.23663
− 25	22.217	7.517	0.0116	2.3170	86.58	0.43159	3.97	98.26	102.23	0.00922	0.23531
− 20	24.992	10.292	.0116	2.0755	86.06	.48181	5.31	97.50	102.81	.01227	.23406
− 15	28.031	13.331	.0117	1.8639	85.53	.53650	6.66	96.72	103.38	.01531	.23285
− 10	31.344	16.644	.0118	1.6783	84.99	.59583	8.01	95.93	103.94	.01833	.23170
− 5	34.951	20.251	.0118	1.5148	84.45	.66015	9.37	95.13	104.50	.02135	.23061
0	38.870	24.170	0.0119	1.3702	83.90	0.72980	10.74	94.30	105.04	0.02435	0.22953
5	43.118	28.418	.0120	1.2421	83.34	.80510	12.13	93.45	105.58	.02735	.22849
10	47.66	32.96	.012081	1.1295	82.778	.88532	12.89	93.02	105.91	.02884	.22692
20	58.00	43.30	.012250	0.93624	81.630	1.0683	15.68	91.27	106.95	.03468	.22498
30	69.97	55.27	.012430	.78125	80.453	1.2800	18.55	89.40	107.95	.04054	.22314
40	83.72	69.02	0.012619	0.65591	79.248	1.5246	21.52	87.39	108.91	0.04642	0.22134
50	99.40	84.70	.012818	.55371	78.015	1.8060	24.55	85.25	109.80	.05235	.21964
60	117.2	102.5	.013029	.46951	76.753	2.1299	27.65	82.95	110.60	.05833	.21797
70	137.2	122.5	.013251	.40090	75.464	2.5000	30.81	80.50	111.31	.06436	.21636
80	159.7	145.0	.013487	.34174	74.148	2.9262	34.09	77.86	111.95	.07035	.21469
90	184.8	170.1	0.013735	0.29284	72.808	3.4148	37.43	75.06	112.49	0.07630	0.21281
100	212.6	197.9	.014015	.25169	71.352	3.9731	40.80	72.08	112.88	.08221	.21102
110	243.4	228.7	.014331	.21673	69.781	4.6140	44.17	68.94	113.11	.08810	.20913
120	277.3	262.6	.014685	.18769	68.096	5.3451	47.67	65.67	113.34	.09398	.20728

Note: Values above line—February 27, 1942. Values below line—August 14, 1941.

* Inches mercury below one atmosphere.

Table B-5 Density of water

VOLUME PROPERTIES OF ORDINARY WATER

G. S. Kell

(Specific volume v, density ρ, thermal expansivity $\alpha = d \ln v/dt = -d \ln \rho/dt$, compressibility $\kappa = -d \ln v/dp = d \ln \rho/dp$)

t, °C.	v, Cc./G.	ρ, G./Ml.	$10^6\alpha$, Deg.$^{-1}$	$10^6\kappa$, Bar^{-1}	t, °C.	v, Cc./G.	ρ, G./Ml.	$10^6\alpha$, Deg.$^{-1}$	$10^6\kappa$, Bar^{-1}
−20	1.00658	0.99349	−678.48	61.94	48	1.011194	0.988957	443.95	44.15
−18	1.00532	0.99474	−580.83	60.48	49	1.011647	0.988515	450.92	44.16
−16	1.00424	0.99581	−495.74	59.11	50	1.012107	0.988066	457.81	44.17
−14	1.00332	0.99672	−420.85	57.83	51	1.012574	0.987610	464.64	44.19
−12	1.00254	0.99749	−354.33	56.64	52	1.013048	0.987148	471.40	44.21
−10	1.001895	0.998137	−294.73	55.52	53	1.013529	0.986680	478.10	44.24
−9	1.001614	0.998417	−267.18	54.99	54	1.014017	0.986205	484.74	44.26
−8	1.001359	0.998671	−240.95	54.48	55	1.014512	0.985723	491.32	44.29
−7	1.001131	0.998899	−215.94	53.98	56	1.015014	0.985236	497.84	44.33
−6	1.000926	0.999102	−192.06	53.50	57	1.015522	0.984743	504.30	44.37
−5	1.000746	0.999283	−169.22	53.04	58	1.016038	0.984243	510.71	44.41
−4	1.000587	0.999441	−147.34	52.60	59	1.016560	0.983737	517.07	44.45
−3	1.000451	0.999578	−126.36	52.17	60	1.017089	0.983226	523.38	44.50
−2	1.000334	0.999694	−106.20	51.76	61	1.017625	0.982708	529.64	44.55
−1	1.000238	9.999790	−86.81	51.36	62	1.018167	0.982185	535.85	44.61
0	1.000160	0.999868	−68.14	50.98	63	1.018716	0.981655	542.02	44.66
1	1.000101	0.999927	−50.14	50.61	64	1.019271	0.981120	548.14	44.72
2	1.000060	0.999968	−32.77	50.26	65	1.019833	0.980580	554.22	44.79
3	1.000036	0.999992	−15.98	49.92	66	1.020402	0.980034	560.26	44.85
4	1.000028	1.000000	0.26	49.59	67	1.020977	0.979482	566.26	44.92
5	1.000036	0.999992	15.98	49.28	68	1.021558	0.978924	572.22	45.00
6	1.000060	0.999968	31.23	48.98	69	1.022146	0.978361	578.15	45.07
7	1.000098	0.999930	46.01	48.69	70	1.022740	0.977793	584.04	45.15
8	1.000151	0.999877	60.37	48.41	71	1.023340	0.977219	589.89	45.23
9	1.000219	0.999809	74.33	48.15	72	1.023947	0.976640	595.72	45.32
10	1.000300	0.999728	87.90	47.89	73	1.024560	0.976056	601.51	45.40
11	1.000395	0.999634	101.12	47.65	74	1.025180	0.975466	607.27	45.49
12	1.000502	0.999526	113.99	47.42	75	1.025805	0.974871	613.00	45.59
13	1.000623	0.999406	126.54	47.19	76	1.026437	0.974271	618.71	45.68
14	1.000755	0.999273	138.78	46.98	77	1.027076	0.973665	624.39	45.78
15	1.000900	0.999129	150.73	46.78	78	1.027720	0.973055	630.04	45.88
16	1.001057	0.998972	162.41	46.59	79	1.028371	0.972439	635.67	45.99
17	1.001225	0.998804	173.82	46.40	80	1.029027	0.971819	641.27	46.10
18	1.001405	0.998625	184.99	46.23	81	1.029690	0.971193	646.86	46.21
19	1.001596	0.998435	195.91	46.06	82	1.030360	0.970562	652.42	46.32
20	1.001797	0.998234	206.61	45.91	83	1.031035	0.969926	657.96	46.44
21	1.002010	0.998022	217.10	45.76	84	1.031716	0.969286	663.48	46.56
22	1.002232	0.997801	227.37	45.62	85	1.032404	0.968640	668.98	46.68
23	1.002465	0.997569	237.45	45.48	86	1.033098	0.967990	674.47	46.81
24	1.002708	0.997327	247.34	45.36	87	1.033797	0.967335	679.94	46.94
25	1.002961	0.997075	257.05	45.24	88	1.034503	0.966674	685.40	47.07
26	1.003224	0.996814	266.59	45.13	89	1.035216	0.966009	690.84	47.20
27	1.003496	0.996544	275.96	45.02	90	1.035934	0.965340	696.26	47.34
28	1.003778	0.996264	285.17	44.93	91	1.036658	0.964665	701.68	47.48
29	1.004069	0.995976	294.23	44.84	92	1.037389	0.963986	707.08	47.63
30	1.004369	0.995678	303.14	44.75	93	1.038125	0.963302	712.48	47.77
31	1.004678	0.995372	311.92	44.67	94	1.038868	0.962613	717.86	47.93
32	1.004995	0.995057	320.55	44.60	95	1.039617	0.961920	723.24	48.08
33	1.005322	0.994734	329.06	44.54	96	1.040372	0.961222	728.60	48.24
34	1.005657	0.994403	337.44	44.48	97	1.041133	0.960519	733.96	48.40
35	1.006000	0.994063	345.71	44.42	98	1.041900	0.959812	739.32	48.56
36	1.006352	0.993716	353.85	44.37	99	1.042673	0.959100	744.67	48.73
37	1.006713	0.993360	361.89	44.33	100	1.043453	0.958384	750.01	48.90
38	1.007081	0.992997	369.81	44.29	101	1.044239	0.957662	755.36	49.07
39	1.007457	0.992626	377.64	44.25	102	1.045030	0.956937	760.70	49.25
40	1.007842	0.992247	385.36	44.22	103	1.045828	0.956207	766.03	49.43
41	1.008234	0.991861	392.99	44.20	104	1.046633	0.955472	771.37	49.62
42	1.008634	0.991467	400.52	44.18	105	1.047443	0.954733	776.71	49.80
43	1.009042	0.991067	407.97	44.16	106	1.048260	0.953989	782.05	50.00
44	1.009458	0.990659	415.33	44.15	107	1.049083	0.953240	787.39	50.19
45	1.009881	0.990244	422.60	44.15	108	1.049912	0.952488	792.73	50.39
46	1.010311	0.989822	429.80	44.14	109	1.050747	0.951730	798.07	50.59
47	1.010749	0.989393	436.91	44.15	110	1.051589	0.950968	803.42	50.80

Table B-6 Specific heat of water

SPECIFIC HEAT OF WATER

Heat Capacity of Air-free Water 0°–100°C at 1 Atmosphere Pressure
The heat capacity of air-free water is given in International steam table calories per gram and in absolute joules per gram. (1 absolute joule—0.238846 I.T. Cal.).
The enthalpy or heat content is given for air-free water in I.T. Cal. per gram and in absolute joules per gram.
From Osborne, Stimson and Ginnings; B. of S. Jour. Res. 23. 238, 1939.

Temp. °C.	Thermal Capacity		Enthalpy		Temp. °C	Thermal Capacity		Enthalpy	
	Cal./g/°C	Joules/g/°C	Cal./g	Joules/g		Cal/g/°C	Joules/g/°C	Cal/g	Joules/g
0	1.00738	4.2177	0.0245	0.1026	50	.99854	4.1807	50.0079	209.3729
1	1.00652	4.2141	1.0314	4.3184	51	.99862	4.1810	51.0065	213.5538
2	1.00571	4.2107	2.0376	8.5308	52	.99871	4.1814	52.0051	217.7350
3	1.00499	4.2077	3.0429	12.7400	53	.99878	4.1817	53.0039	221.9166
4	1.00430	4.2048	4.0475	16.9462	54	.99885	4.1820	54.0027	226.0984
5	1.00368	4.2022	5.0515	21.1498	55	.99895	4.1824	55.0016	230.2806
6	1.00313'	4.1999	6.0549	25.3508	56	.99905	4.1828	56.0006	234.4632
7	1.00260	4.1977	7.0578	29.5496	57	.99914	4.1832	56.9997	238.6462
8	1.00213	4.1957	8.0602	33.7463	58	.99924	4.1836	57.9989	242.8296
9	1.00170	4.1939	9.0621	37.9410	59	.99933	4.1840	58.9982	247.0134
10	1.00129	4.1922	10.0636	42.1341	60	.99943	4.1844	59.9975	251.1976
11	1.00093	4.1907	11.0647	46.3255	61	.99955	4.1849	60.9970	255.3822
12	1.00060	4.1893	12.0654	50.5155	62	.99964	4.1853	61.9966	259.5673
13	1.00029	4.1880	13.0659	54.7041	63	.99976	4.1858	62.9963	263.7529
14	1.00002	4.1869	14.0660	58.8916	64	.99988	4.1863	63.9962	267.9390
15	.99976	4.1858	15.0659	63.0779	65	1.00000	4.1868	64.9961	272.1256
16	.99955	4.1849	16.0655	67.2632	66	1.00014	4.1874	65.9962	276.3127
17	.99933	4.1840	17.0650	71.4476	67	1.00026	4.1879	66.9964	280.5003
18	.99914	4.1832	18.0642	75.6312	68	1.00041	4.1885	67.9967	284.6885
19	.99897	4.1825	19.0633	79.8141	69	1.00053	4.1890	68.9972	288.8772
20	.99883	4.1819	20.0622	83.9963	70	1.00067	4.1896	69.9977	293.0665
21	.99869	4.1813	21.0609	88.1778	71	1.00081	4.1902	70.9985	297.2564
22	.99857	4.1808	22.0596	92.3589	72	1.00096	4.1908	71.9994	301.4469
23	.99847	4.1804	23.0581	96.5395	73	1.00112	4.1915	73.0004	305.6381
24	.99838	4.1800	24.0565	100.7196	74	1.00127	4.1921	74.0016	309.8299
25	.99828	4.1796	25.0548	104.8994	75	1.00143	4.1928	75.0030	314.0224
26	.99821	4.1793	26.0530	109.0788	76	1.00160	4.1935	76.0045	318.2155
27	.99814	4.1790	27.0512	113.2580	77	1.00177	4.1942	77.0062	322.4094
28	.99809	4.1788	28.0493	117.4369	78	1.00194	4.1949	78.0080	326.6039
29	.99804	4.1786	29.0474	121.6157	79	1.00213	4.1957	79.0101	330.7992
30	.99802	4.1785	30.0455	125.7943	80	1.00229	4.1964	80.0123	334.9952
31	.99799	4.1784	31.0435	129.9727	81	1.00248	4.1972	81.0147	339.1920
32	.99797	4.1783	32.0414	134.1510	82	1.00268	4.1980	82.0172	343.3897
33	.99797	4.1783	33.0394	138.3293	83	1.00287	4.1988	83.0200	347.5881
34	.99795	4.1782	34.0374	142.5076	84	1.00308	4.1997	84.0230	351.7873
35	.99795	4.1782	35.0353	146.6858	85	1.00327	4.2005	85.0262	355.9874
36	.99797	4.1783	36.0333	150.8641	86	1.00349	4.2014	86.0295	360.1883
37	.99797	4.1783	37.0312	155.0423	87	1.00370	4.2023	87.0331	364.3902
38	.99799	4.1784	38.0292	159.2207	88	1.00392	4.2032	88.0369	368.5929
39	.99802	4.1785	39.0272	163.3991	89	1.00416	4.2042	89.0410	372.7966
40	.99804	4.1786	40.0253	167.5777	90	1.00437	4.2051	90.0452	377.0012
41	.99807	4.1787	41.0233	171.7563	91	1.00461	4.2061	91.0497	381.2068
42	.99811	4.1789	42.0214	175.9351	92	1.00485	4.2071	92.0545	385.4135
43	.99816	4.1791	43.0195	180.1141	93	1.00509	4.2081	93.0594	389.6211
44	.99819	4.1792	44.0177	184.2933	94	1.00535	4.2092	94.0647	393.8297
45	.99826	4.1795	45.0159	188.4726	95	1.00561	4.2103	95.0701	398.0395
46	.99830	4.1797	46.0142	192.6522	96	1.00588	4.2114	96.0759	402.2503
47	.99835	4.1799	47.0125	196.8320	97	1.00614	4.2125	97.0819	406.4622
48	.99842	4.1802	48.0109	201.0120	98	1.00640	4.2136	98.0882	410.6753
49	.99847	4.1804	49.0094	205.1923	99	1.00669	4.2148	99.0947	414.8895
					100	1.00697	4.2160	100.1015	419.1049

Table B-7   Thermal conductivity of water

THERMAL CONDUCTIVITY OF CERTAIN LIQUIDS

From NSRDS-NBS 8
R. W. Powell, C. Y. Ho, and P. E. Liley

The thermal conductivity, k, is given in the units Milliwatt cm⁻¹ °K⁻¹. To convert to Cal(gm) hr⁻¹ cm⁻¹ °K⁻¹ multiply the values listed in the table by 0.860421

T (K)	Helium	Nitrogen	Argon	Carbon tetra-chloride	Diphenyl	m-Terphenyl	Toluene	Water
2.4	0.192							
2.6	0.193							
2.8	0.197							
3.0	0.204							
3.2	0.214							
3.4	0.227							
3.6	0.241							
3.8	0.260							
4.0	0.282							
4.2	0.307							
4.4	(0.335)‡							
4.6	(0.366)‡							
4.8	(0.400)‡							
5.0	(0.437)‡							
5.2	(0.477)‡							
60		1.692†						
65		1.598						
70		1.504						
75		1.411						
80		1.320‡	1.315†					
85		1.229‡	1.258					
90		1.140‡	1.200‡					
95		1.051‡	1.141‡					
100		0.965‡	1.082‡					
105		0.879‡	1.023‡					
110		0.794‡	0.963‡					
115		0.710‡	0.903‡					
120		0.627‡	0.842‡					
125		0.544‡	0.780‡					
130			0.717‡					
135			0.654‡					
140			0.591‡					
145			0.527‡					
150			0.463‡				(1.719)†	
160							(1.694)†	
170							(1.669)†	
180							1.644	
190							1.619	
200							1.594	
210							1.569	
220							1.543	
230				(1.169)†			1.518	
240				(1.150)†			1.492	
250				1.131			1.467	5.22†
260				1.112			1.442	5.39†
270				1.093			1.416	5.55†
280				1.074			1.391	5.74
290				1.055			1.365	5.92
300				1.036			1.340	6.09
310				1.017			1.315	6.23
320				0.997			1.289	6.37
330				0.978	(1.402)†		1.264	6.48
340				0.959	(1.387)†		1.238	6.59
350				0.940	1.373	(1.361)†	1.213	6.68
360				(0.921)	1.359	(1.356)†	1.188	6.75
370				(0.902)	1.345	1.351	1.162	6.80
380				(0.882)	1.331	1.346	1.137	6.84‡
390				(0.863)	1.316	1.341	(1.112)‡	6.86‡
400				(0.844)	1.302	1.335	(1.086)‡	6.86‡
410				(0.825)	1.288	1.329	(1.061)‡	6.86‡
420				(0.806)	1.274	1.323	(1.036)‡	6.84‡
430				(0.787)	1.259	1.317	(1.013)‡	6.81‡
440				(0.768)	1.245	1.310	(0.985)‡	6.78‡
450				(0.749)	1.231	1.304	(0.959)‡	6.73‡
460					1.217	1.297	(0.933)‡	6.67‡
470					1.202	1.290	(0.908)‡	6.61‡
480					1.188	1.283	(0.885)‡	6.53‡
490					1.174	1.276	(0.862)‡	6.45‡
500					1.160	1.268	(0.839)‡	6.35‡
510					1.146	1.261		6.24‡
520					1.131	1.254		6.12‡
530					1.117‡	1.246		5.99‡
540					1.103‡	1.238		5.86‡
550					1.089‡	1.230		5.71‡
560					1.074‡	1.222		5.55‡
570					1.060‡	1.213		5.39‡
580					1.046‡	1.205		5.20‡
590					1.032‡	1.197		5.01‡
600					1.018‡	1.188		4.81‡
610						1.180		4.60‡
620						1.172		4.40‡
630						1.163‡		(4.20)‡
640						1.155‡		(4.01)‡
650						1.146‡		

† Extrapolated for the supercooled liquid. [Approximate n.m.p. in K: N₂, 63; A, 84; CCl₄, 250; C₁₂H₁₀, 342; m-C₁₈H₁₄, 361; p-C₁₈H₁₄, 486; C₇H₃₈, 178; H₂O, 273.1].

‡ Under saturation vapor pressure [Approximate n.b.p. in K: He, 4.3; N₂, 77; A, 88; CCl₄, 350; C₁₂H₁₀, 528; m-C₁₈H₁₄, 637; p-C₁₈H₁₄, 658; C₇H₃₈, 384; H₂O, 373].

Table B-8 Viscosity of water

THE VISCOSITY OF WATER 0°C TO 100°C

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°C	η(cp)	°C	η(cp)	°C	η(cp)	°C	η(cp)
0	1.787	26	0.8705	52	0.5290	78	0.3638
1	1.728	27	.8513	53	.5204	79	.3592
2	1.671	28	.8327	54	.5121	80	.3547
3	1.618	29	.8148	55	.5040	81	.3503
4	1.567	30	.7975	56	.4961	82	.3460
5	1.519	31	.7808	57	.4884	83	.3418
6	1.472	32	.7647	58	.4809	84	.3377
7	1.428	33	.7491	59	.4736	85	.3337
8	1.386	34	.7340	60	.4665	86	.3297
9	1.346	35	.7194	61	.4596	87	.3259
10	1.307	36	.7052	62	.4528	88	.3221
11	1.271	37	.6915	63	.4462	89	.3184
12	1.235	38	.6783	64	.4398	90	.3147
13	1.202	39	.6654	65	.4335	91	.3111
14	1.169	40	.6529	66	.4273	92	.3076
15	1.139	41	.6408	67	.4213	93	.3042
16	1.109	42	.6291	68	.4155	94	.3008
17	1.081	43	.6178	69	.4098	95	.2975
18	1.053	44	.6067	70	.4042	96	.2942
19	1.027	45	.5960	71	.3987	97	.2911
20	1.002	46	.5856	72	.3934	98	.2879
21	0.9779	47	.5755	73	.3882	99	.2848
22	.9548	48	.5656	74	.3831	100	.2818
23	.9325	49	.5561	75	.3781		
24	.9111	50	.5468	76	.3732		
25	.8904	51	.5378	77	.3684		

The above table was calculated from the following empirical relationships derived from measurements in viscometers calibrated with water at 20°C (and one atmosphere), modified to agree with the currently accepted value for the viscosity at 20° of 1.002 cp:

$$0° \text{ to } 20°C: \log_{10} \eta_T = \frac{1301}{998.333 + 8.1855(T-20) + 0.00585(T-20)^2} - 3.30233$$

(R. C. Hardy and R. L. Cottington, J.Res.NBS 42, 573 (1949).)

$$20° \text{ to } 100°C: \log_{10} \frac{\eta_T}{\eta_{20}} = \frac{1.3272(20-T) - 0.001053(T-20)^2}{T + 105}$$

(J. F. Swindells, NBS, unpublished results.)

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Table B-9   Properties of air at P = 101.325 kPa   (M = 28.966)

T	ρ	μ	ν	C$_p$	k	Pr
K	kg/m^3	Ps.s	m^2/s	kJ/(kg.K)	W/(m.K)	
100	3.5985	70.60 -07	19.62 -07	1.028	92.20 -04	0.787
150	2.3673	10.38 -06	43.85 -07	1.011	13.75 -03	0.763
200	1.7690	13.36 -06	75.52 -07	1.006	18.10 -03	0.743
250	1.4119	16.06 -06	11.37 -06	1.003	22.26 -03	0.724
263	1.3421	16.70 -06	12.44 -06	1.003	23.28 -03	0.720
273	1.2930	17.20 -06	13.30 -06	1.004	24.07 -03	0.717
283	1.2473	17.69 -06	14.18 -06	1.004	24.86 -03	0.714
293	1.2017	18.17 -06	15.08 -06	1.004	25.63 -03	0.712
300	1.1766	18.53 -06	15.75 -06	1.005	26.14 -03	0.711
303	1.1650	18.64 -06	16.00 -06	1.005	26.37 -03	0.710
313	1.1277	19.11 -06	16.95 -06	1.005	27.09 -03	0.709
323	1.0928	19.57 -06	17.91 -06	1.006	27.80 -03	0.708
333	1.0600	20.02 -06	18.89 -06	1.007	28.51 -03	0.707
343	1.0291	20.47 -06	19.89 -06	1.008	29.21 -03	0.706
350	1.0085	20.81 -06	20.63 -06	1.008	29.70 -03	0.706
353	1.0000	20.91 -06	20.91 -06	1.008	29.89 -03	0.705
363	0.9724	21.34 -06	21.95 -06	1.009	30.58 -03	0.704
373	0.9463	21.77 -06	23.01 -06	1.010	31.26 -03	0.703
400	0.8825	22.94 -06	26.00 -06	1.013	33.05 -03	0.703
450	0.7844	24.93 -06	31.78 -06	1.020	36.33 -03	0.700
500	0.7060	26.82 -06	37.99 -06	1.029	39.51 -03	0.699

Table B-9 (cont.) Properties of air at P = 101.325 kPa (M = 28.966)

T	ρ	μ	ν	C_P	k	Pr
K	kg/m^3	Ps.s	m^2/s	kJ/(kg.K)	W/(m.K)	
550	0.6418	28.60 -06	44.56 -06	1.039	42.60 -03	0.698
600	0.5883	30.30 -06	51.50 -06	1.051	45.60 -03	0.699
650	0.5431	31.93 -06	58.80 -06	1.063	48.40 -03	0.701
700	0.5043	33.49 -06	66.41 -06	1.075	51.30 -03	0.702
750	0.4706	34.98 -06	74.32 -06	1.087	54.10 -03	0.703
800	0.4412	36.43 -06	82.56 -06	1.099	56.90 -03	0.703
850	0.4153	37.83 -06	91.10 -06	1.110	59.70 -03	0.703
900	0.3922	39.18 -06	99.90 -06	1.121	62.50 -03	0.702
950	0.3716	40.49 -06	10.90 -05	1.131	64.90 -03	0.705
1,000	0.3530	41.77 -06	11.83 -05	1.141	67.20 -03	0.709
1,100	0.3209	44.40 -06	13.80 -05	1.160	73.20 -03	0.705
1,200	0.2942	46.90 -06	15.90 -05	1.177	78.20 -03	0.705
1,300	0.2715	49.30 -06	18.20 -05	1.195	83.70 -03	0.705
1,400	0.2521	51.70 -06	20.50 -05	1.212	89.10 -03	0.704
1,500	0.2353	54.00 -06	22.90 -05	1.230	94.60 -03	0.704
1,600	0.2206	56.30 -06	25.50 -05	1.248	10.00 -02	0.703
1,700	0.2076	58.50 -06	28.20 -05	1.266	10.50 -02	0.702
1,800	0.1961	60.70 -06	31.00 -05	1.286	11.10 -02	0.701
1,900	0.1858	62.90 -06	33.90 -05	1.307	11.70 -02	0.700
2,000	0.1765	65.00 -06	36.80 -05	1.331	12.40 -02	0.699

Table B-9(cont.) Properties of air at P = 101.325 kPa (M = 28.966)

T	ρ	μ	ν	C_p	k	Pr
K	kg/m^3	Ps.s	m^2/s	$kJ/(kg \cdot K)$	$W/(m \cdot K)$	
2,100	0.1681	67.20 -06	40.40 -05	1.359	13.10 -02	0.696
2,200	0.1605	69.30 -06	43.20 -05	1.392	13.90 -02	0.693
2,300	0.1535	71.40 -06	46.50 -05	1.434	14.90 -02	0.688
2,400	0.1471	73.50 -06	50.00 -05	1.487	16.10 -02	0.681
2,500	0.1412	75.70 -06	53.60 -05	1.556	17.50 -02	0.673

Table B-10 Physical properties of metals

Physical properties of metals

Metal	Melting point °C	Properties at 20°C				Thermal conductivity k, W/(m·°C)								
		ρ, $\frac{kg}{m^3}$	c_p, $\frac{kJ}{kg\cdot°C}$	k, $\frac{W}{m\cdot°C}$	α, $\frac{m^2}{s}$ $\times 10^5$	$-100°C$	$0°C$	$100°C$	$200°C$	$300°C$	$400°C$	$600°C$	$800°C$	$1000°C$
Aluminum														
Pure	660	2,707	0.896	204	8.418	215	202	206	215	228	249			
Al-Cu (Duralumin), 94-96% Al, 3-5% Cu, trace Mg		2,787	0.883	164	6.676	126	159	182	194					
Al-Si (Silumin, copper-bearing), 86.5% Al, 1% Cu		2,659	0.867	137	5.933	119	137	144	152	161				
Al-Si (Alusil), 78-80% Al, 20-22% Si		2,627	0.854	161	7.172	144	157	168	175	178				
Al-Mg-Si, 97% Al, 1% Mg, 1% Si, 1% Mn		2,707	0.892	177	7.311		175	189	204					
Beryllium	1277	1,850	1.825	200	5.92									
Bismuth	272	9,780	0.122	7.86	0.66									
Cadmium	321	8,650	0.231	96.8	4.84									
Copper														
Pure	1085	8,954	0.3831	386	11.234	407	386	379	374	369	363	353		
Aluminum bronze 95% Cu, 5% Al		8,666	0.410	83	2.330									
Bronze 75% Cu, 25% Sn		8.666	0.343	26	0.859									
Red brass 85% Cu, 9% Sn, 6% Zn		8.714	0.385	61	1.804		59	71						

PROGRAM LISTING

1. Program for calculating the experimental thermal resistances.

```
10      REM PROGRAM FOR CALCULATE EXPERIMENTAL THERMAL RESISTANCE
20      INPUT " NO. OF DATA = " ; N
30      DIM FC(N), FH(N), THI(N), THO(N), TCI(N), TCO(N), T1(N), T2(N),
T3(N)
40      DIM T4(N), T5(N), T6(N), T7(N), T8(N), T9(N), T10(N), QAV(N), UA
(N), QH(N),QC(N)
50      DIM RT(N), R35(N), REXP1(N), REXP2(N), REXP6(N), REXP7(N), UHP(N
),NRH(N),NRC(N),REH(N),REC(N)
60      LE = .4 : 'm. :
70      LC = .4 :'m.
80      DO = .00952 : 'm.
90      DI = .0087 :'m.
100      D = .0209296 :'m.
110     PI = 3.141592654#
120     FOR I = 1 TO N
130        READ FC(I), FH(I), THI(I), THO(I), TCI(I), TCO(I), T1(I), T2(
I)
140        READ T3(I), T4(I), T5(I), T6(I), T7(I), T8(I), T9(I), T10(I)
150        TH = (THI(I) + THO(I))/2
160        T  = TH
170        GOSUB 910
180        DLH = DL : CPH = CP : VISH = VIS
190        QH(I) = DLH * FH(I) * CPH * (THI(I) - THO(I)) * .000001
200        DEQ = D-DO
210        A = PI * (D+DO)*(D-DO)/4
220        NRH(I) = DLH * FH(I)*DEQ / ( A * VISH * 1000!)
230        REH(I)  = ((D+DO) / DO) * NRH(I)
240        TC = (TCI(I) + TCO(I))/2
250        T = TC
260        GOSUB 910
270        DLC = DL : CPC = CP : VISC = VIS
280        QC(I) = DLC * FC(I) * CPC * (TCO(I) - TCI(I)) * .000001
290        NRC(I) = 4 * DLC * FC(I) / ( PI * (D+DO) * VISC * 1000!)
300        REC(I)  = ((D+DO) / DO) * NRC(I)
310        QAV(I)  = (QC(I) + QH(I))/2
320        TWCO = (T1(I) + T2(I) + T3(I) + T4(I))/4
330        TWHO = (T7(I) + T8(I) + T9(I) + T10(I))/4
340        UA(I)   = QAV(I)/(TWHO - TWCO)
350        REXP1(I)  = (TH - TWHO) / QAV(I)
360        REXP2(I)  = LOG(DO/DI) / ( 2 * PI * 386 * LE)
370        REXP7(I)  = (TWCO - TC) / QAV(I)
380        REXP6(I)  = REXP2(I)
390        RT(I)     = (TH - TC) / QAV(I)
400        R35(I)    = 1 / UA(I)
410        UHP(I)       = 4 * UA(I) / ( PI * DO^2 )
420     NEXT I
430     BEEP
440     WIDTH "LPT1:",132
450     LPRINT CHR$(15);
```

```
460     LPRINT CHR$(14);TAB(25);"DATA FROM THE EXPERIMENTS":LPRINT
470     LPRINT :
480     LPRINT CHR$(15);"NO. OF DATA = ";N
490     LPRINT :LPRINT "***************************************************
********************************************************************
*************"
500     LPRINT CHR$(15);:LPRINT
510     LPRINT "  FC       ";" FH       ";"  THI    ";"  THO    ";"  TCI   ";"
  TCO    ";"  T1      ";"  T2      ";"  T3      ";"  T4      ";"  T5      ";"  T6
     ";"  T7      ";"  T8      ";"  T9     ";" T10    ";
520     LPRINT :LPRINT : LPRINT "***************************************************
********************************************************************
*********************"
530     LPRINT
540     FOR I = 1 TO N
550         LPRINT USING "###.##  ";FC(I);FH(I);THI(I);THO(I);TCI(I);TCO
(I);T1(I);T2(I);T3(I);T4(I);T5(I);T6(I);T7(I);T8(I);T9(I);T10(I);
560     LPRINT
570     NEXT I
580     LPRINT : LPRINT :LPRINT :LPRINT
590 LPRINT CHR$(14); TAB(25);"EXPERIMENTAL RESULTS"
600 LPRINT :LPRINT :LPRINT CHR$(15)
610     LPRINT "***************************************************
********************************************************************
*****"
620     LPRINT
630     LPRINT "     UA       ";"     UHP        ";"    RT       ";"     R35
    ";"  REXP1      ";"  REXP2      ";"  REXP6       ";"  REXP7      "
;
640 LPRINT
650     LPRINT : LPRINT "***************************************************
********************************************************************
****************"
660 LPRINT
670 FOR I = 1 TO N
680         LPRINT USING "##.####^^^^  ";UA(I),UHP(I),RT(I),R35(I),REXP1
(I),REXP2(I),REXP6(I),REXP7(I);
690 LPRINT
700     NEXT I
710     LPRINT :LPRINT
720 LPRINT "***************************************************
********************************************************************
****"
730 LPRINT :
740 LPRINT "     QC       ";"    QH        ";"    QAV    ";"     REH
   ";"   REH'     ";"   REC      ";"   REC'    ";
750 LPRINT :LPRINT
```

```
760 LPRINT "***************************************************************
****************************************************************************
***"
770 LPRINT : LPRINT
780 FOR I = 1 TO N
790 LPRINT USING "##.####^^^^   ";QC(I);QH(I);QAV(I);NRH(I);REH(I);NRC(
I);REC(I);
800 LPRINT
810 NEXT I
820 DATA 89.7,27.7,38.8,34.77,18.3,19.03,21.57,22.04,20.98,22.36,31.32
,32.59,30.55,36,36,37.5
830 DATA 89.7,38.5,39.1,36.37,18.8,19.44,21.07,22.04,20.98,21.85,29.35
,27.71,27.04,36,38.5,39
840 DATA 89.7,53.9,39.5,38.97,19.30,19.94,21.57,23.05,20.98,22.87,31.3
2,31.61,29.55,37.5,37.5,39
850 DATA 89.7,65.8,39.9,39.47,20.11,20.54,22.08,23.56,22,22.87,31.81,3
2.59,30.55,38,38,39
860 DATA 89.7,75.6,40,39.67,18.5,19.03,20.56,22.04,19.96,21.85,29.85,3
0.63,30.55,38.5,39,38.5
870 DATA 89.7,84.5,39.3,39.17,17.2,18.13,21.07,22.04,19.96,22.36,33.29
,34.54,34.06,38.5,38.5,38
880 LPRINT :LPRINT :LPRINT CHR$(14); TAB(30); " THE END "
890 LPRINT CHR$(18);
900    END
910 REM SUBROUTINE FOR CALCULATE WATER PROPERTY
920 DL = 999.8466#  +.06340783#*T - .008427257# * T^2 +.00006389052#
* T^3-.0000003029236# *T^4
930 CPL = 75.98544#-.008254895#*T -.003420649#*T^2+.0001721228# *T^3-.
000003097828#*T^4+.00000001965672#*T^5
940 CP =(CPL*1000)/18.016
950 LOVIS = (1.3272 * (20 -T)-.001053 * (T-20)^2) / (T + 105)
960  VIS = 10^(LOVIS) * 1.002
970 RETURN
```

2. Program for calculating the constant of the condensation and pool boiling correlations.

```
10    REM PROGRAM FOR CALCULATE CONSTANT OF CORRELATIONS
20    INPUT "NO. OF DATA = ";N
30    INPUT "TYPE OF FREON : FREON NO.  ";M
40    DIM Q(N), TWHO(N), TWCO(N), TWHI(N), TWCI(N), X(N), Y(N), BR(N),
BL(N)
50    DIM CR(N), HC(N)
60    PI = 3.141592654#
70    G = 9.8 :' GRAVITY ACCELERATION (m/s^2)
80    GC = 1 :'CONVERSION FACTOR (1 kg.m/(N.s^2))
90    LE = .4 :'EVAPORATOR LENGTH (m.)
100   LC = .4 :'CONDENSER LENGTH (m.)
110   DO = .00952 :'OUTSIDE DIAMETER OF TUBE (m.)
120   DI = .0087 :'INSIDE DIAMETER OF TUBE (m.)
130   AI = PI*.00896*.4
131   AO = PI*DO*LE
132   AM = (AO-1.4*AI)/LOG(AO/(1.4*AI))
140   FOR I = 1 TO N
150       READ TWHO(I), TWCO(I), Q(I)
160       TWHI(I) = TWHO(I) - Q(I)*(DO-DI)/(2*386*AM)
170       TWCI(I) = TWCO(I) + Q(I)*(DO-DI)/(2*386*AM)
180       TS = (TWHI(I) + TWCI(I))/2
185       T = TS
190       IF M = 22 THEN GOSUB 2000 ELSE GOSUB 1000
200       PR = CPLF*VISLF/KLF
210       BL(I) = CPLF*(TWHI(I)-TS)/(LAF*PR^1.7)
220       BR(I) = (GC*SURF/(G*(DLF-DVF)))^.5*Q(I)/(1.4*AI*VISLF*LAF)
230       HC(I) = Q(I)/((TS-TWCI(I))*1.4*AI)
240       CR(I) = G*DLF*(DLF-DVF)*LAF*KLF^3/(VISLF*(TS-TWCI(I))*LC)
250   NEXT I
260   WIDTH "LPT1:",132
270   LPRINT CHR$(15);
280   LPRINT CHR$(14);TAB(25);"INPUT DATA"
290   LPRINT : LPRINT
300   LPRINT "NO. FO DATA = ";N,"TYPE OF FREON : FREON ";M
310   LPRINT
320   LPRINT "*************************************************************
*************************************************************
*****"
330   LPRINT
340   LPRINT TAB(15);"    QAV    ";"    TWHO    ";"    TWCO    ";"
TWHI    ";"    TWCI    ";"    XH    ";"    YH    ";"    XC    ";
"    YC    ";
350   LPRINT
360   LPRINT "*************************************************************
*************************************************************
***"
370   LPRINT
380   FOR I = 1 TO N
390       LPRINT TAB(15);USING "##.###^^^^   ";Q(I);TWHO(I);TWCO(I);TWHI
(I);TWCI(I);BR(I);BL(I);CR(I);HC(I);
400       LPRINT
410   NEXT I
420   LPRINT "*************************************************************
*************************************************************
***"
430   LPRINT : LPRINT
```

```
440   LPRINT CHR$(14);TAB(20);"CORRELATION OF POOL BOILING"
450   LPRINT
460   FOR I = 1 TO N
470       X(I) = BR(I)
480       Y(I) = BL(I)
490   NEXT I
500   GOSUB 3000
510   LPRINT : LPRINT
520   LPRINT CHR$(14);TAB(20);"FILM CONDENSATION CORRELATION"
530   FOR I = 1 TO N
540       X(I) = CR(I)
550       Y(I) = HC(I)
560   NEXT I
570   GOSUB 3000
580   END
1000 REM SUBPROGRAM FOR CALCULATE FREON-113 PROPERTY
1010 DLF = 1621.038#-2.171899#*T-.003504691#*T^2
1020 DVF = 1.260348#+.05430785#*T+.0007819232#*T^2+.0000995579#*T^3-.0
00003698256#*T^4+.00000004329166#*T^5
1030 LAF = 160606.6#-260.895#*T+.002443325#*T^2-.02480492#*T^3+.000231
1955#*T^4
1040 VISLF = .0009420137#-.0000145653#*T+.0000001727834#*T^2-.00000000
1864928#*T^3+1.430161D-11*T^4
1050 KLF = .1173633#-.0008310745#*T-.00004276443#*T^2+.000002891884#*T
^3-.00000005429155#*T^4+.0000000003290212#*T^5
1060 SURF = .02200656#-.0001264531#*T+.000001047079#*T^2-.000000054799
63#*T^3+.0000000007125223#*T^4+1.376073D-11*T^5-2.56327D-13*T^6
1070 CPLF1 = .1824871#+.0009191438#*(T*1.8+32)-.000007517865#*(T*1.8+3
2)^2-.00000004215532#*(T*1.8+32)^3+.0000000010574775#*(T*1.8+32)^4-4.1
829384D-12*(T*1.8+32)^5
1080 CPLF = CPLF1*4186.69
1090 RETURN
2000 REM SUBPROGRAM FOR CALCULATE FREON-22 PROPERTY
2010 DLF = 1285#-1.945733#*T-.09944414#*T^2+.00022548#*T^3+.0000480120
1#*T^4-.0000002782948#*T^5-.00000002284995#*T^6+.0000000004199209#*T^7
+5.434099D-13*T^8+4.44025D-14*T^9-1.460264D-15*T^10
2020 DVF = 21.28499#+.7253383#*T+.00383729#*T^2+.0001529189#*T^3
2030 VISLF = .0002670001#-.000001509946#*T+.000000007179722#*T^2+6.945
386D-11*T^3-1.47996D-12*T^4+2.479268D-15*T^5
2040 LAF = 204280.1#-836.2317#*T-.2807336#*T^2-.07326331#*T^3+.0002059
711#*T^4
2050 KLF = .09769995#-.0005441583#*T+.000002624762#*T^2-.0000000458314
7#*T^3
2060 SURF = .0117#-.0001121023#*T-.000002908705#*T^2+.00000004846874#*
T^3+4.495216D-11*T^4+6.411755D-12*T^5-1.551813D-13*T^6
2070 CPLF = 1168.869#+2.867799#*T+.04272785#*T^2-.001856198#*T^3+.0000
3269711#*T^4
2080 RETURN
3000 REM SUBPROGRAM FOR LINEAR LEAST SQUARE FIT
3001 X1 = 0
3002 X2 = 0
3003 X3 = 0
3004 X4 = 0
3005 X5 = 0
```

```
3006 Y1 = 0
3007 Y2 = 0
3010 FOR I = 1 TO N
3020      X1 = X1 + LOG(X(I))
3030      X2 = X2 + (LOG(X(I)))^2
3040      X3 = X3 + LOG(X(I))*LOG(Y(I))
3050      Y1 = Y1 + LOG(Y(I))
3060 NEXT I
3070 FOR I = 1 TO N
3080      X4 = X4 + (X(I)-X1/N)*(Y(I)-Y1/N)
3090      X5 = X5 + (X(I)-X1/N)^2
3100      Y2 = Y2 + (Y(I)-Y1/N)^2
3110 NEXT I
3120 R = X4/(X5*Y2)^.5
3130 B = (X3-X1*Y1/N)/(X2-X1^2/N)
3140 A = EXP((Y1-B*X1)/N)
3150 LPRINT TAB(20);" Y = A * X^B "
3160 LPRINT TAB(20);" A = ";A;TAB(40);" B = ";B;TAB(60);" R = ";R
3170 RETURN
3180 DATA 32.3,24.5,115.39
3190 DATA 32.6,24.4,159.36
3200 DATA 32.2,24.1,183.42
3210 DATA 32.8,24.2,170.85
3220 DATA 32.5,24.1,149.50
3230 DATA 32.7,24.2,144.58
```
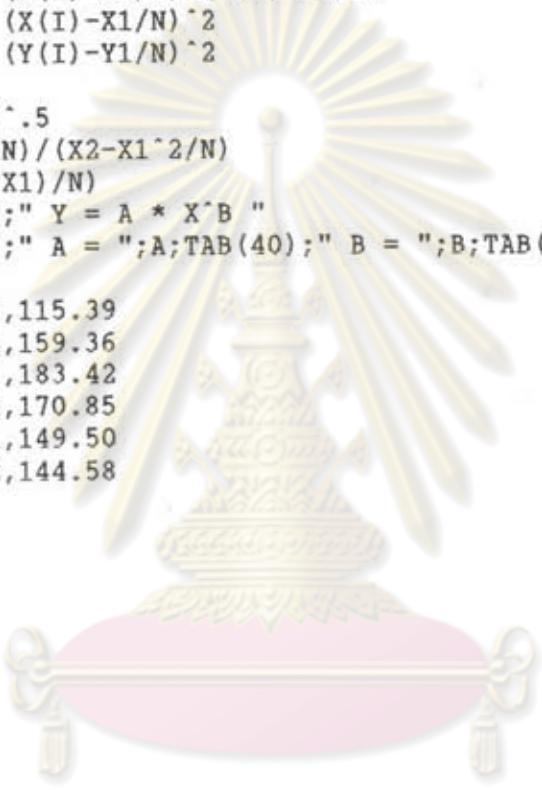
ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

3. Program for calculating the constant of outer film correlations.

```
10    REM PROGRAM FOR CALCULATE CONSTANT OF OUTER FILM CORRELATIONS
20    INPUT "NO. OF DATA = ";N
30    DIM Q(N), TWHO(N), TWCO(N), TWHI(N), TWCI(N), X(N), Y(N), THI(N),
TCI(N)
40    DIM THO(N), TCO(N), REH(N), REC(N), NUH(N), NUC(N), FC(N), FH(N)
50    PI = 3.141592654#
60    D = .0209296 :'INSIDE DIAMETER OF JACKET (m.)
70    LC = .4 :'CONDENSER LENGTH (m.)
80    LE = .4 :'EVAPORATOR LENGTH (m.)
90    D = .0209296 :'INSIDE DIAMETER OF JACKET (m.)
100   DO = .00952 :'OUTSIDE DIAMETER OF TUBE (m.)
110   DI = .0087 :'INSIDE DIAMETER OF TUBE (m.)
120   AO = PI*DO*LE
130   DEQ = (D - DO)*(D + DO)/DO
140   INPUT "Do you want to read data from file";ANS$
150   IF ANS$ = "Y" OR ANS$ = "y" THEN GOTO 370
160   INPUT "Print A for append data ; any key for reinput";B$
170   IF B$ = "A" OR B$ = "a" THEN OPEN "B:DATAF1" FOR APPEND AS #1 ELS
E GOTO 190
180   GOTO 200
190   OPEN "B:DATAF1" FOR OUTPUT AS #1
200   C = 0
210   IF T$ = "Y" OR T$ = "y" THEN CLOSE : GOTO 430
220   C = C+1
230   INPUT "FC = ", FC(C)
240   INPUT "FH = ", FH(C)
250   INPUT "THI = ", THI(C)
260   INPUT "THO = ", THO(C)
270   INPUT "TCI = ", TCI(C)
280   INPUT "TCO = ", TCO(C)
290   INPUT "TWHO = ", TWHO(C)
300   INPUT "TWCO = ", TWCO(C)
310   INPUT "Q = ", Q(C)
320   INPUT "Do you want to correct it ";A$
330   IF A$ = "Y" OR A$ = "Y" THEN GOTO 220
340   WRITE #1, FC(C), FH(C), THI(C), THO(C), TCI(C), TCO(C), TWHO(C),
TWCO(C), Q(C)
350   INPUT "Is it out of data ";T$
360   GOTO 210
370   OPEN "I",#1,"B:DATAF1"
380   C = 0
390   IF EOF(1) THEN CLOSE : GOTO 430
400   C = C+1
410   INPUT #1, FC(C), FH(C), THI(C), THO(C), TCI(C), TCO(C), TWHO(C),
TWCO(C), Q(C)
420   GOTO 390
430   N = C
440   FOR I = 1 TO N
450       TH = (THI(I)+THO(I))/2
```

```
460       TC = (TCI(I)+TCO(I))/2
470       DELTH =  TH - TWHO(I)
480       DELTC =  TWCO(I) - TC
490       HOH = Q(I)/(AO*DELTH)
500       HOC = Q(I)/(AO*DELTC)
510       T = (TH+TWHO(I))/2
520       GOSUB 1050
530       REH(I) = DLW*DEQ*FH(I)*.000001*4/(PI*(D^2-DO^2)*VISL)
540       NUH(I) = HOH*DEQ/KLW
550       T = (TC+TWCO(I))/2
560       GOSUB 1050
570       REC(I) = DLW*DEQ*FC(I)*.000001*4/(PI*(D^2-DO^2)*VISL)
580       NUC(I) = HOC*DEQ/KLW
590   NEXT I
600   WIDTH "LPT1:",132
610   LPRINT CHR$(15);
620   LPRINT CHR$(14);TAB(25);"INPUT DATA"
630   LPRINT : LPRINT
640   LPRINT "NO. FO DATA = ";N
650   LPRINT
660   LPRINT "********************************************************
**********************************************************************
*****"
670   LPRINT
680   LPRINT TAB(15);"    Fc      ";"     Fh       ";"    Thi      ";"
Tho     ";"    Tci      ";"    Tco     ";"    Twho    ";"    Twco     ";
"     Qav    ";
690   LPRINT
700   LPRINT "********************************************************
**********************************************************************
***"
710   LPRINT
720   FOR I = 1 TO N
730       LPRINT TAB(15);USING "#####.###    ";FC(I);FH(I);THI(I);THO(I)
;TCI(I);TCO(I);TWHO(I);TWCO(I);Q(I);
740       LPRINT
750   NEXT I
760   LPRINT "********************************************************
**********************************************************************
***"
770   LPRINT : LPRINT
780   LPRINT "********************************************************
**********************************************************************
*****"
790   LPRINT
800   LPRINT TAB(15);"     Nuh    ";"    Reh     ";"     Nuc     ";"
Rec    ";
810   LPRINT
820   LPRINT "********************************************************
**********************************************************************
***"
830   LPRINT
840   FOR I = 1 TO N
850       LPRINT TAB(15);USING "##.###^^^^   ";NUH(I);REH(I);NUC(I);REC(
I);
```

```
860      LPRINT
870   NEXT I
880   LPRINT "********************************************************
***********************************************************************
***"
890   LPRINT : LPRINT
900   LPRINT CHR$(14);TAB(20);"OUTER FILM CORRELATION OF EVAPORATOR"
910   LPRINT
920   FOR I = 1 TO N
930      X(I) = REH(I)
940      Y(I) = NUH(I)
950   NEXT I
960   GOSUB 1130
970   LPRINT : LPRINT
980   LPRINT CHR$(14);TAB(20);"OUTER FILM CORRELATION OF CONDENSER"
990   FOR I = 1 TO N
1000      X(I) = REC(I)
1010      Y(I) = NUC(I)
1020   NEXT I
1030   GOSUB 1130
1040   END
1050 REM SUBPROGRAM FOR CALCULATE WATER PROPERTY
1060 DLW = 999.8466+6.340783E-02*T-8.427257E-03*T^2+6.389052E-05*T^3-3
.029236E-07*T^4
1070 CPW1 = 75.97694-6.542445E-02*T+2.480525E-03*T^2-5.065634E-05*T^3+
5.740747E-07*T^4-2.703634E-09*T^5
1080 CPW = CPW1/18.016*1000
1090 LVIS = (1.3272*(20-T)-.001053*(T-20)^2)/(T+105)
1100 VISL = 10^LVIS*1.002*.001
1110 KLW = .5519998+2.750176E-03*T-2.959454E-05*T^2+2.502208E-07*T^3-1
.043016E-09*T^4
1120 RETURN
1130 REM SUBPROGRAM FOR LINEAR LEAST SQUARE FIT
1140 X1 = 0
1150 X2 = 0
1160 X3 = 0
1170 X4 = 0
1180 X5 = 0
1190 Y1 = 0
1200 Y2 = 0
1210 FOR I = 1 TO N
1220      X1 = X1 + LOG(X(I))
1230      X2 = X2 + (LOG(X(I)))^2
1240      X3 = X3 + LOG(X(I))*LOG(Y(I))
1250      Y1 = Y1 + LOG(Y(I))
1260 NEXT I
1270 FOR I = 1 TO N
1280      X4 = X4 + (X(I)-X1/N)*(Y(I)-Y1/N)
1290      X5 = X5 + (X(I)-X1/N)^2
1300      Y2 = Y2 + (Y(I)-Y1/N)^2
```

```
1300      Y2 = Y2 + (Y(I)-Y1/N)^2
1310 NEXT I
1320 R = X4/(X5*Y2)^.5
1330 B = (X3-X1*Y1/N)/(X2-X1^2/N)
1340 A = EXP((Y1-B*X1)/N)
1350 LPRINT TAB(20);" Y = A * X^B "
1360 LPRINT TAB(20);" A = ";A;TAB(40);" B = ";B;TAB(60);" R = ";R
1370 RETURN
```

4. Program for calculating the theoretical thermal resistances.

```
10      REM PROGRAM FOR CALCULATE THE THEORETICAL THERMAL RESISTANCE
20      INPUT " NO. OF DATA = " ; N
30      INPUT " TYPE OF FREON : FREON NO.   " ; M
40      DIM FC(N),FH(N),THI(N),THO(N),TCI(N),TCO(N),TWHO(N),TWCO(N),Q(N)
50      DIM TWHI(N),TWCI(N),TVH(N),TVC(N),TBH(N),TBHN(N),TBC(N),TBCN(N)
60      DIM R1(N),R2(N),R3(N),R3N(N),R5(N),R6(N),R7(N),R5N(N),RT(N),RTN(
N),RHP(N)
70      DIM HOH(N),HOC(N),HIH(N),HIC(N),HIHN(N),HICN(N),RHPN(N)
80      DIM DELE1(N),DELE2(N),DELE3(N),DELE4(N),DELE5(N),DELE6(N)
90      PI = 3.141592654#
100      G = 9.8 : 'GRAVITATIONAL ACCELERATION, m/s^2
110      GC = 1  : 'CONVERSION FACTOR, 1 kg.m/(N.s^2)
120     LE = .4 : 'EVAPORATOR LENGTH, m.
130     LC  = .4 : 'CONDENSER LENGTH, m.
140     DO = .00952 : 'OUTSIDE DIAMETER OF TUBE, m.
150     DI  = .0087 : 'INSIDE DIAMETER OF TUBE, m.
160     D = .0209296 : 'INSIDE DIAMETER OF JACKET, m.
170     AI = PI*.00896*.4
180     AO = PI*DO*LE
190     AM = (AO-1.4*AI)/LOG(AO/(1.4*AI))
200     OPEN "B:DATAT1" FOR INPUT AS #1
210     C = 0
220     IF EOF(1) THEN CLOSE : GOTO 260
230     C = C+1
240     INPUT #1, FC(C), FH(C), THI(C), THO(C), TCI(C), TCO(C), TWHO(C),
    TWCO(C), Q(C)
250     GOTO 220
260     FOR I = 1 TO N
270         TBH(I) = (THI(I)+THO(I))/2
280         TBH1 = TBH(I)
290         A = 13.22788
300         B = .3808254
310         T = (TBH1 + TWHO(I))/2
320         GOSUB 1680
330         DEQ = (D-DO)*(D+DO)/DO
340         REHP(I) = 4*DEQ*DLW*FH(I)*.000001/(PI*(D+DO)*(D-DO)*VISL)
350         NUH = A*REHP(I)^B
360         HOH(I) = NUH*KLW/DEQ
370         DELTMH = Q(I)/(HOH(I)*PI*DO*LE)
380         TBH2 = TWHO(I) + DELTMH
390         E1 = ABS(TBH1 - TBH2)/TBH1
400         IF E1 <= .001 THEN GOTO 430
410         TBH1 = (TBH1+TBH2)/2
420         GOTO 310
430         TBHN(I) = TBH1
440         REH(I) = DO/(DO+D)*REHP(I)
450         TBC(I) = (TCI(I) + TCO(I))/2
460         TBC1 = TBC(I)
470         A = .1280409
480         B = .9516121
490         T = (TBC1 + TWCO(I))/2
500         GOSUB 1680
```

```
510      RECP(I) = 4*DEQ*DLW*FC(I)*.000001/(PI*(D+DO)*(D-DO)*VISL)
520      NUC = A*RECP(I)^B
530      HOC(I) = NUC*KLW/DEQ
540      DELTMC = Q(I)/(HOC(I)*PI*DO*LC)
550      TBC2 = TWCO(I) -  DELTMC
560      E2 = ABS(TBC1-TBC2)/TBC1
570      IF E2 <= .001 THEN GOTO 600
580      TBC1 = (TBC1+TBC2)/2
590      GOTO 490
600      TBCN(I) = TBC1
610      REC(I) = DO/(DO+D)*RECP(I)
620      TWHI(I) = TWHO(I) - (Q(I)*(DO-DI)/(2*386*AM))
630      TWCI(I) = TWCO(I) + (Q(I)*(DO-DI)/(2*386*AM))
640      TVH1 = (TWHI(I)+TWCI(I))/2
650      T = (TWHI(I)+TVH1)/2
660      IF M = 22 THEN GOTO 710
670      GOSUB 1760
680      CSF = 7.020683E-03
690      R = .9621316
700      GOTO 740
710      GOSUB 1860
720      CSF = 5.65438E-03
730      R = 1.06921
740      B1 = Q(I)/(1.4*AI*LAF*VISLF)*(GC*SURF/(G*(DLF-DVF)))^.5
750      DELTH = CSF*LAF*(CPLF*VISLF/KLF)^1.7*B1^R/CPLF
760      TVH2 = TWHI(I) - DELTH
770      E3  = ABS(TVH1-TVH2)/TVH1
780      IF E3 <= .001 THEN GOTO 810
790      TVH1 = (TVH1+TVH2)/2
800      GOTO 650
810      TVH(I) = TVH1
820      HIH(I) = Q(I)/((TWHI(I)-TVH(I))*1.4*AI)
830      TVC1 = TVH1
840      T = (TWCI(I)+TVC1)/2
850      IF M = 22 THEN GOTO 900
860      GOSUB 1760
870      C1 = 1.705018E-06
880      C2 = .7437863
890      GOTO 930
900      GOSUB 1860
910      C1 = 5.331091E-04
920      C2 = .5580585
930      B2 = G*DLF*(DLF-DVF)*LAF*KLF^3/(VISLF*ABS(TVC1-TWCI(I))*LC)
940      HIC(I) = C1*B2^C2
950      TVC2 = TWCI(I) + Q(I)/(HIC(I)*1.4*AI)
960      PRINT"TVC2 = ";TVC2
970      E4 = ABS(TVC1-TVC2)/TVC1
980      IF E4 <= .001 THEN GOTO 1010
990      TVC1 = (TVC1+TVC2)/2
1000     GOTO 840
```

```
1010        TVC(I) = TVC1
1020        PRINT"TVC = ";TVC(I)
1030        IF TVC(I) = TVH(I) THEN GOTO 1180
1050        TVA(I) = (TVC(I)+TVH(I))/2
1060        DELE5(I) = (TVH(I) - TVA(I))/TVA(I)*100
1070        DELE6(I) = (TVC(I) - TVA(I))/TVA(I)*100
1080        HIHN(I) = Q(I)/(1.4*AI*(TWHI(I)-TVA(I)))
1090        HICN(I) = Q(I)/(1.4*AI*(TVA(I)-TWCI(I)))
1100        R3N(I) = 1/(HIHN(I)*1.4*AI)
1110        R5N(I) = 1/(HICN(I)*1.4*AI)
1140        DELE1(I) = (TBHN(I)-TBH(I))/TBH(I)*100
1150        DELE2(I) = (TBH(I)-TWHO(I))/(TBHN(I)-TWHO(I))*100
1160        DELE3(I) = (TBCN(I)-TBC(I))/TBC(I)*100
1170        DELE4(I) = (TWCO(I)-TBC(I))/(TWCO(I)-TBCN(I))*100
1180        R1(I) = 1/(HOH(I)*PI*DO*LE)
1190        R2(I) = (TWHO(I)-TWHI(I))/Q(I)
1200        R3(I) = 1/(HIH(I)*1.4*AI)
1210        R5(I) = 1/(HIC(I)*1.4*AI)
1220        R6(I) = (TWCI(I)-TWCO(I))/Q(I)
1230        R7(I) = 1/(HOC(I)*PI*DO*LE)
1240        RHP(I) = R2(I)+R3(I)+R5(I)+R6(I)
1250        RT(I) = R1(I)+R2(I)+R3(I)+R5(I)+R6(I)+R7(I)
1251        RHPN(I) = R2(I)+R3N(I)+R5N(I)+R6(I)
1252        PRINT "RHPN = ";RHPN(I)
1253        RTN(I) = R1(I)+R2(I)+R3N(I)+R5N(I)+R6(I)+R7(I)
1254        PRINT "RTN = ";RTN(I)
1260    NEXT I
1270    BEEP
1280    STOP
1290    WIDTH "LPT1:",240
1300    LPRINT CHR$(27);"N";CHR$(3)
1310    LPRINT CHR$(15);
1320    LPRINT CHR$(14);TAB(25);"DATA FROM THE EXPERIMENTS"
1330    LPRINT : LPRINT
1340    LPRINT "NO. OF DATA = ";N;"   TYPE OF FREON : FREON ";M
1350    LPRINT:LPRINT:LPRINT
1360    LPRINT "************************************************************
*******************************************************************
*************************"
1370    LPRINT
1380    LPRINT "      FC   ";"    FH   ";"   THI    ";"   THO    ";"
TCI    ";"   TCO    ";"  TWHO   ";"  TWCO   ";"  TWHI   ";"   TWCI
   ";"   QAV   ";"   REH'  ";"   REH   ";"   REC'  ";"   REC   ";
1390    LPRINT
1400    LPRINT "************************************************************
*******************************************************************
*************************"
1410    LPRINT
```

```
1420   FOR I = 1 TO N
1430      LPRINT USING "#####.##   ";FC(I);FH(I);THI(I);THO(I);TCI(I);T
CO(I);TWHO(I);TWCO(I);TWHI(I);TWCI(I);Q(I);REHP(I);REH(I);RECP(I);REC(
I)
1440   NEXT I
1450   LPRINT : LPRINT : LPRINT : LPRINT
1460   LPRINT CHR$(14);TAB(40)"THEORETICAL THERMAL RESISTANCE"
1470   LPRINT : LPRINT : LPRINT
1480   LPRINT "******************************************************************
***********************************************************************
***********************************************************************
********************"
1490   LPRINT
1500   LPRINT TAB(4);"RT";TAB(16);"RT'";TAB(28);"RHP";TAB(40);"RHP'";TA
B(52);"R1";TAB(64);"R2";TAB(76);"R3";TAB(88);"R3'";TAB(100);"R5";TAB(1
12);"R5'";TAB(124);"R6";TAB(136);"R7";TAB(148);"HOH";TAB(160);"HOC";TA
B(172);"HIH";TAB(184);"HIH'";TAB(196);"HIC"
1510   LPRINT
1520   LPRINT "******************************************************************
***********************************************************************
***********************************************************************
********************"
1530   LPRINT
1540   FOR I = 1 TO N
1550      LPRINT USING "##.####^^^^ ";RT(I);RTN(I);RHP(I);RHPN(I);R1(
I);R2(I);R3(I);R3N(I);R5(I);R5N(I);R6(I);R7(I);HOH(I);HOC(I);HIH(I);HI
HN(I);HIC(I);HICN(I)
1560   NEXT I
1570   LPRINT:LPRINT
1580   LPRINT "******************************************************************
***********************************************************************
***********************************************************************
********************"
1590   LPRINT
1600   LPRINT TAB(4);"Tbh";TAB(16);"Tbh'";TAB(28);"Tbc";TAB(40);"Tbc'";
TAB(52);"Tvh";TAB(64);"Tvc";TAB(76);"Tva";TAB(88);"Tbh'-Tbh";TAB(100);
"DELTH/DELTH'";TAB(112);"Tbc'-Tbc";TAB(124);"DELTC/DELTC'";TAB(136);"T
vh-Tva";TAB(148);"Tvc-Tva";
1610   LPRINT
1620   LPRINT "******************************************************************
***********************************************************************
***********************************************************************
********************"
1630   LPRINT
1640   FOR I = 1 TO N
1650      LPRINT USING "  ####.##   ";TBH(I);TBHN(I);TBC(I);TBCN(I);TV
H(I);TVC(I);TVA(I);DELE1(I);DELE2(I);DELE3(I);DELE4(I);DELE5(I);DELE6(
I)
1660   NEXT I
1670   END
1680   REM SUBROUTINE FOR CALCULATE WATER PROPERTY
1690   DLW = 999.8466+6.340783E-02*T-8.427257E-03*T^2+6.389052E-05*T^3-
3.029236E-07*T^4
1700   CPW1 = 75.97694-6.542445E-02*T+2.480525E-03*T^2-5.065634E-05*T^3
+5.740747E-07*T^4-2.703634E-09*T^5
```

```
1710   CPLW = CPW1/18.016*1000!
1720   LVIS = (1.3272*(20-T)-.001053*(T-20)^2)/(T+105)
1730   VISL = 10^LVIS*1.002*.001
1740   KLW = .5519998+2.750176E-03*T-2.959454E-05*T^2+2.502208E-07*T^3-
1.043016E-09*T^4
1750   RETURN
1760   REM SUBROUTINE FOR CALCULATE FREON-113 PROPERTY
1770   DLF = 1621.038-2.171899*T-3.504691E-03*T^2
1780   DVF = 1.260348+5.430785E-02*T+7.819232E-04*T^2+9.95579E-05*T^3-3
.698256E-06*T^4+4.329166E-08*T^5
1790   LAF = 160606.6-260.895*T+2.443325E-03*T^2-2.480492E-02*T^3+2.311
955E-04*T^4
1800   VISLF = 9.420137E-04-1.45653E-05*T+1.727834E-07*T^2-1.864928E-09
*T^3+1.430161E-11*T^4
1810   KLF = .1173633-8.310745E-04*T-4.276443E-05*T^2+2.891884E-06*T^3-
5.429155E-08*T^4+3.290212E-10*T^5
1820   SURF = 2.200656E-02-1.264531E-04*T+1.047079E-06*T^2-5.479963E-08
*T^3+7.125223E-10*T^4+1.376073E-11*T^5-2.56327E-13*T^6
1830   CPLF1 = .1824871+9.191438E-04*(T*1.8+32)-7.517865E-06*(T*1.8+32)
^2-4.215532E-08*(T*1.8+32)^3+.0000000010574775#*(T*1.8+32)^4-4.1829384
D-12*(T*1.8+32)^5
1840   CPLF = CPLF1*4186.69
1850   RETURN
1860   REM SUBROUTINE FOR CALCULATE FREON-22 PROPERTY
1870   DLF = 1285!-1.945733*T-9.944414E-02*T^2+2.2548E-04*T^3+4.801201E
-05*T^4-2.782948E-07*T^5-2.284995E-08*T^6+4.199209E-10*T^7+5.434099E-1
3*T^8+4.44025E-14*T^9-1.460264E-15*T^10
1880   DVF = 21.28499+.7253383*T+3.83729E-03*T^2+1.529189E-04*T^3
1890   VISLF = 2.670001E-04-1.509946E-06*T+7.179722E-09*T^2+6.945386E-1
1*T^3-1.47996E-12*T^4+2.479268E-15*T^5
1900   LAF = 204280.1-836.2317*T-.2807336*T^2-7.326331E-02*T^3+2.059711
E-04*T^4
1910   KLF = 9.769995E-02-5.441583E-04*T+2.624762E-06*T^2-4.583147E-08*
T^3
1920   SURF = .0117-1.121023E-04*T-2.908705E-06*T^2+4.846874E-08*T^3+4.
495216E-11*T^4+6.411755E-12*T^5-1.551813E-13*T^6
1930   CPLF = 1168.869+2.867799*T+4.272785E-02*T^2-1.856198E-03*T^3+3.2
69711E-05*T^4
1940   RETURN
```

5. Program for calculating the required number of heat pipe in heat
exchanger design.

```
10    REM PROGRAM FOR CALCULATE HEAT PIPE HEAT EXCHANGER AREA
20    REM WORKING FLUID OF HEAT PIPE : FREON-113 OR FREON-22
30    REM INPUT THE CHARACTERISTIC OF HEAT PIPE
40    INPUT "Type of Freon (Freon-113 or Freon-22) : Freon No. ",M
50    INPUT "Outside diameter of heat pipe (m.) : ",DO
60    INPUT "Inside diameter of heat pipe (m.) : ",DI
70    INPUT "Length of evaporator (m.) : ",LE
80    INPUT "Length of condenser (m.) : ",LC
90    INPUT "Effective surface area of evaporator (m.) : ",AOH
100   INPUT "Effective surface area of condenser (m.) : ",AOC
110   INPUT "Thermal conductivity of heat pipe tube (W/m.C) : ",K
120   INPUT "Outer film coefficient of evaporator (W/m^2.C) : ",HOH
130   INPUT "Outer film coefficient of condenser (W/m^2.C) : ",HOC
140   REM INPUT THE PROPERTY OF TRANSFER FLUID
150   INPUT "Inlet temperature of hot fluid (C): ",THI
160   INPUT "Outlet temperature of hot fluid (C) : ",THO
170   INPUT "Inlet temperature of cold fluid (C) : ",TCI
180   INPUT "Outlet temperature of cold fluid (C) : ",TCO
190   INPUT "Mass flow rate of hot fluid (kg/sec) : ",MH
200   INPUT "Mass flow rate of cold fluid (kg/sec) : ",MC
210   INPUT "Heat capacity of hot fluid (J/kg) : ",CPH
220   INPUT "Heat capacity of cold fluid (J/kg) : ",CPC
230   DT1 = THI-TCO
240   DT2 = THO-TCI
250   IF DT1 = DT2 THEN GOTO 280
260   LMTD = ((THI-TCO)-(THO-TCI))/LOG((THI-TCO)/(THO-TCI))
270   GOTO 290
280   LMTD = (DT1+DT2)/2
290   QT = MH*CPH*(THI-THO)
300   TBH = (THI+THO)/2
310   TBC = (TCI+TCO)/2
320   DT = TBH-TBC
330   UAF = 1/(1/(HOH*AOH)+LOG(DO/DI)/(2*3.141592654#*LE*K)+LOG(DO/DI)/
(2*3.141592654#*LC*K)+1/(HOC*AOC))
340   QP1 = (UAF*DT)/2
350   TWHI = TBH-QP1*LOG(DO/DI)/(2*3.141562654#*K*LE)-QP1/(HOH*AOH)
360   PRINT "QP1 = ";QP1
370   TWCI = TBC+QP1*LOG(DO/DI)/(2*3.141562654#*K*LC)+QP1/(HOC*AOC)
380   TS = (TWCI+TWHI)/2
390   T = (TS+TWHI)/2
400   IF M = 22 THEN GOTO 450
410   GOSUB 940
420   CSF = 7.020683E-03
430   R = .9621316
440   GOTO 480
450   GOSUB 1040
460   CSF = 5.65438E-03
470   R = 1.06921
480   B1 = QP1/(3.141592654#*DI*LE*LAF*VISLF)*(SURF/(9.8*(DLF-DVF)))^.5
490   DELTH = CSF*LAF*(CPLF*VISLF/KLF)^1.7*B1^R/CPLF
500   TR = TWHI - DELTH
```

```
510   IF ABS(TS-TR)/TS <= .001 THEN GOTO 540
520   TS = (TS+TR)/2
530   GOTO 390
540   HIH = QP1/((TWHI-TS)*3.141592654#*DI*LE)
550   T = (TWCI+TS)/2
560   IF M = 22 THEN GOTO 610
570   GOSUB 940
580   C1 = 1.705018E-06
590   C2 = .7437863
600   GOTO 640
610   GOSUB 1040
620   C1 = 5.331091E-04
630   C2 = .5580585
640   B2 = 9.8*DLF*(DLF-DVF)*LAF*KLF^3/(VISLF*(TS-TWCI)*LC)
650   HIC = C1*B2^C2
660   DELTC = QP1/(HIC*3.141596254#*DI*LC)
670   TSP = TWCI + DELTC
680   IF ABS(TSP-TS)/TS =< .001 THEN GOTO 710
690   TS = (TSP+TS)/2
700   GOTO 550
710   R3 = 1/(HIH*3.141592654#*DI*LE)
720   R5 = 1/(HIC*3.141592654#*DI*LC)
730   UA = 1/(1/UAF+R3+R5)
740   QP2 = UA*LMTD
750   IF ABS(QP2-QP1)/QP1 =< .001 THEN GOTO 780
760   QP1 = (QP1+QP2)/2
770   GOTO 350
780   N= QT/QP1
790   R1 = 1/(HOH*AOH)
800   R7 = 1/(HOC*AOC)
810   R2 = LOG(DO/DI)/(2*3.141596254#*LE*K)
820   R6 = LOG(DO/DI)/(2*3.141596254#*LC*K)
830   PRINT "Number of heat pipe = ";N
840   LPRINT "Number of heat pipe = ";N
850   PRINT "Thermal Resistance of Heat Pipe"
860   LPRINT "Thermal Resistance of Heat Pipe"
870   PRINT "R1 = ";R1,"R7 = ";R7
880   LPRINT "R1 = ";R1,"R7 = ";R7
890   PRINT "R2 = ";R2,"R6 = ";R6
900   LPRINT "R2 = ";R2,"R6 = ";R6
910   PRINT "R3 = ";R3,"R5 = ";R5
920 LPRINT "R3 = ";R3,"R5 = ";R5
930 END
940   REM SUBROUTINE FOR CALCULATE FREON-113 PROPERTY
950   DLF = 1621.038-2.171899*T-3.504691E-03*T^2
```

```
960   DVF = 1.260348+5.430785E-02*T+7.819232E-04*T^2+9.95579E-05*T^3-3.
698256E-06*T^4+4.329166E-08*T^5
970   LAF = 160606.6-260.895*T+2.443325E-03*T^2-2.480492E-02*T^3+2.3119
55E-04*T^4
980   VISLF = 9.420137E-04-1.45653E-05*T+1.727834E-07*T^2-1.864928E-09*
T^3+1.430161E-11*T^4
990   KLF = .1173633-8.310745E-04*T-4.276443E-05*T^2+2.891884E-06*T^3-5
.429155E-08*T^4+3.290212E-10*T^5
1000   SURF = 2.200656E-02-1.264531E-04*T+1.047079E-06*T^2-5.479963E-08
*T^3+7.125223E-10*T^4+1.376073E-11*T^5-2.56327E-13*T^6
1010   CPLF1 = .1824871+9.191438E-04*(T*1.8+32)-7.517865E-06*(T*1.8+32)
^2-4.215532E-08*(T*1.8+32)^3+.0000000010574775#*(T*1.8+32)^4-4.1829384
D-12*(T*1.8+32)^5
1020   CPLF = CPLF1*4186.69
1030   RETURN
1040   REM SUBROUTINE FOR CALCULATE FREON-22 PROPERTY
1050   DLF = 1285!-1.945733*T-9.944414E-02*T^2+2.2548E-04*T^3+4.801201E
-05*T^4-2.782948E-07*T^5-2.284995E-08*T^6+4.199209E-10*T^7+5.434099E-1
3*T^8+4.44025E-14*T^9-1.460264E-15*T^10
1060   DVF = 21.28499+.7253383*T+3.83729E-03*T^2+1.529189E-04*T^3
1070   VISLF = 2.670001E-04-1.509946E-06*T+7.179722E-09*T^2+6.945386E-1
1*T^3-1.47996E-12*T^4+2.479268E-15*T^5
1080   LAF = 204280.1-836.2317*T-.2807336*T^2-7.326331E-02*T^3+2.059711
E-04*T^4
1090   KLF = 9.769995E-02-5.441583E-04*T+2.624762E-06*T^2-4.583147E-08*
T^3
1100   SURF = .0117-1.121023E-04*T-2.908705E-06*T^2+4.846874E-08*T^3+4.
495216E-11*T^4+6.411755E-12*T^5-1.551813E-13*T^6
1110   CPLF = 1168.869+2.867799*T+4.272785E-02*T^2-1.856198E-03*T^3+3.2
69711E-05*T^4
1120   RETURN
```

APPENDIX D

HEAT TRANSFER CORRELATIONS

1. Outer Film Correlations

INPUT DATA

NO. FG DATA = 197

Pc	Fa	Thi	Tho	Tci	Tco	Twho	Twco	Qav	Nun	Ran	Nuc	Rec
39.700	27.700	38.800	34.300	18.300	19.000	25.000	21.700	368.530	1.003E+03	5.712E+03	4.171E+02	1.200E+04
39.700	38.800	39.100	38.400	18.800	19.400	25.100	21.500	338.010	6.244E+02	7.218E+03	7.130E+02	1.234E+04
39.700	53.700	39.500	39.000	19.200	19.900	25.900	22.100	179.170	2.611E+02	1.047E+04	1.452E+02	1.220E+04
39.700	65.300	39.700	39.520	20.100	20.500	26.400	22.800	137.210	2.925E+02	1.219E+04	2.379E+02	1.227E+04
39.700	75.300	40.000	39.700	18.500	19.000	26.800	21.100	151.080	2.257E+02	1.436E+04	2.236E+02	1.172E+04
39.700	84.500	39.550	39.200	17.200	19.100	27.300	21.400	197.230	4.731E+02	1.362E+04	2.691E+02	1.181E+04
70.200	53.700	40.200	39.000	16.700	17.800	28.100	22.100	274.920	8.395E+02	1.372E+04	2.832E+02	9.368E+03
70.200	65.800	39.500	38.700	17.500	17.500	28.600	22.000	205.090	7.142E+02	1.322E+04	2.455E+02	9.251E+03
70.200	75.300	40.800	40.100	17.200	18.000	28.900	22.000	228.240	7.408E+02	1.527E+04	2.715E+02	9.208E+03
70.200	84.500	40.700	40.100	17.000	17.700	29.100	22.300	281.710	9.785E+02	1.711E+04	2.779E+02	9.259E+03
57.300	27.700	40.700	36.250	17.900	18.300	26.500	22.400	372.970	9.225E+02	5.570E+03	4.416E+02	7.771E+03
57.300	38.500	41.200	37.100	17.700	18.600	27.400	22.200	450.080	1.219E+03	7.081E+03	5.672E+02	7.704E+03
57.300	53.700	41.500	40.500	17.400	18.400	27.500	22.500	284.500	8.115E+02	1.102E+04	3.155E+02	7.738E+03
57.300	65.800	41.800	40.800	17.700	18.500	27.800	23.000	240.730	7.737E+02	1.291E+04	2.506E+02	7.304E+03
57.300	75.300	42.000	41.200	18.000	18.800	29.600	23.300	214.520	6.075E+02	1.554E+04	2.252E+02	7.360E+03
57.300	84.500	42.400	41.500	17.500	18.700	29.700	23.100	263.990	6.222E+02	1.747E+04	2.775E+02	7.832E+03
57.300	27.700	40.300	37.200	19.200	20.900	34.000	20.200	372.050	4.398E+02	5.291E+03	6.214E+02	7.729E+03
57.300	38.500	40.100	37.200	19.500	20.300	34.500	20.200	327.330	7.314E+02	7.229E+03	5.572E+02	7.710E+03
57.300	53.700	40.500	39.300	19.300	20.100	35.100	20.500	216.510	2.114E+02	1.047E+04	1.282E+02	7.720E+03
57.300	65.300	40.600	39.700	20.000	20.800	35.300	20.700	200.960	1.981E+02	1.283E+04	3.417E+02	7.304E+03
57.300	75.300	41.100	40.500	20.100	20.800	35.300	20.700	186.320	1.657E+02	1.482E+04	3.812E+02	7.309E+03
41.700	27.700	40.600	35.500	17.100	17.500	37.500	22.900	322.290	2.945E+03	5.890E+03	3.031E+02	5.565E+03
41.700	38.500	40.200	35.900	17.700	18.700	36.900	22.800	435.510	1.850E+03	7.462E+03	5.052E+02	5.610E+03
41.700	53.700	40.400	39.500	17.990	18.700	38.400	23.200	193.700	6.981E+02	1.379E+04	2.015E+02	5.871E+03
41.700	65.300	40.200	39.400	17.700	18.900	38.600	24.000	234.090	9.112E+02	1.318E+04	2.091E+02	5.712E+03
41.700	75.600	42.100	41.400	18.100	19.100	39.900	23.900	204.110	5.350E+02	1.366E+04	1.760E+02	5.772E+03
41.700	84.500	42.400	41.500	18.100	19.100	40.100	24.000	252.570	6.617E+02	1.705E+04	2.281E+02	5.722E+03
30.500	27.700	41.500	39.500	20.500	21.500	36.500	22.200	404.350	5.188E+02	5.412E+03	1.714E+03	1.114E+04
30.500	38.500	41.000	38.500	19.600	20.500	35.400	21.600	359.990	5.241E+02	7.548E+03	1.164E+03	1.394E+04
30.500	53.700	41.200	40.100	15.900	20.700	37.100	21.700	278.320	3.738E+02	1.073E+04	1.014E+03	1.095E+04
30.500	65.300	41.500	40.800	19.900	20.800	37.400	21.500	257.550	3.341E+02	1.319E+04	1.050E+03	1.099E+04
30.500	75.600	40.500	39.500	18.500	17.200	39.900	22.900	237.540	3.294E+03	1.556E+04	2.005E+02	1.067E+04
30.500	84.500	41.500	41.000	19.900	20.900	39.900	21.400	234.920	2.618E+02	1.666E+04	1.084E+03	1.095E+04
57.300	23.500	30.900	20.600	24.500	25.000	18.100	24.800	115.570	2.171E+02	6.705E+03	2.882E+03	3.602E+03
57.300	37.700	35.400	33.400	24.700	25.400	22.000	25.300	205.920	4.331E+02	4.737E+03	4.146E+03	3.490E+03
57.300	38.500	35.500	33.500	24.550	25.000	32.400	25.300	245.470	6.081E+02	6.493E+03	1.982E+03	3.651E+03
57.300	53.700	35.500	33.300	24.200	24.900	32.500	25.400	148.470	1.793E+02	9.770E+03	8.797E+02	3.651E+03
57.300	65.300	35.500	35.400	24.250	25.000	32.500	25.300	106.310	1.784E+02	1.152E+04	8.283E+02	3.651E+03
57.300	75.300	35.500	35.300	24.200	24.900	32.600	25.300	125.250	2.202E+02	1.270E+04	8.412E+02	3.641E+03
57.300	84.500	33.800	35.500	24.300	25.000	32.600	25.300	159.990	2.747E+02	1.632E+04	1.145E+03	3.646E+03
57.300	27.700	30.400	30.200	24.800	25.900	15.100	25.700	76.920	1.112E+02	4.256E+03	8.856E+02	3.739E+03
57.300	53.900	29.500	29.300	25.600	16.500	17.100	26.200	103.880	1.081E+02	8.712E+03	2.062E+03	8.366E+03
57.300	65.500	29.500	29.500	23.300	16.200	27.500	25.000	106.760	7.603E+02	1.065E+04	6.344E+02	8.573E+03
57.300	75.600	30.400	30.300	24.250	24.700	28.000	25.300	109.590	2.023E+02	1.240E+04	7.280E+02	6.541E+03
57.300	84.500	30.050	29.300	24.400	25.100	27.000	24.500	111.790	1.394E+02	1.366E+04	1.127E+04	3.612E+03
57.300	27.700	35.600	33.400	24.200	24.350	52.600	24.600	170.990	4.681E+02	4.349E+03	6.616E+03	9.556E+03
57.300	38.500	32.200	34.330	24.500	25.100	31.400	24.700	159.440	3.272E+02	6.720E+03	8.052E+03	8.026E+03
57.300	43.900	35.900	35.550	24.850	25.200	35.000	25.100	181.120	7.088E+02	1.005E+04	5.091E+03	3.865E+03
57.300	27.700	35.300	36.800	24.800	25.500	31.330	25.700	125.540	1.125E+02	5.019E+03	9.738E+02	9.727E+03
57.300	38.500	35.900	36.730	24.250	25.000	32.600	25.400	119.570	1.599E+02	7.073E+03	7.827E+02	3.656E+03
57.300	53.500	35.300	36.100	24.150	24.950	32.700	25.600	121.920	1.783E+02	9.953E+03	5.210E+02	3.865E+03

INPUT DATA

NO. FG DATA = 197

****

Fc	Fh	Thi	Tho	Tci	Tco	Twho	Twco	Qav	Nuh	Reh	Nuc	Rec

17.700	83.700	40.550	38.770	19.190	21.440	36.125	30.000	286.710	1.429E+02	4.937E+03	1.309E+02	3.436E+03
23.000	83.700	40.300	38.570	18.200	20.140	36.375	29.125	459.930	1.534E+02	6.382E+03	7.325E+02	3.447E+03
29.700	83.700	41.300	40.070	18.300	20.440	37.000	28.625	426.090	1.698E+02	7.159E+03	1.309E+03	5.471E+03
56.100	83.700	41.300	39.370	19.800	21.340	36.750	29.125	445.370	4.052E+02	6.927E+03	4.803E+02	1.005E+04
68.700	83.700	41.200	39.470	18.930	20.040	36.375	28.250	483.770	4.729E+02	6.392E+03	1.361E+02	1.225E+04
79.300	83.700	40.500	38.370	19.100	20.140	36.625	27.875	489.360	4.893E+02	7.028E+03	3.615E+02	1.227E+04
88.700	83.700	41.500	39.470	18.400	19.440	36.375	25.875	527.310	4.664E+02	7.047E+03	1.086E+03	1.426E+04
17.700	83.700	41.200	39.970	19.700	24.950	37.625	31.275	565.640	7.735E+02	7.022E+03	1.091E+03	9.338E+03
28.300	83.700	41.100	39.170	21.210	25.850	37.225	30.750	598.270	7.092E+02	7.071E+03	1.370E+03	1.258E+04
39.700	83.700	40.900	38.970	20.610	25.150	36.750	29.375	710.340	1.192E+03	7.063E+03	1.512E+03	1.432E+04
56.100	83.700	41.200	39.270	20.010	24.140	37.000	28.500	759.730	7.033E+02	7.242E+03	7.894E+02	1.601E+04
68.700	83.700	41.500	39.570	20.410	22.340	37.000	29.000	683.270	1.406E+03	6.295E+03	1.254E+03	1.612E+04
79.300	83.700	40.200	37.770	18.400	19.940	36.750	28.250	578.960	1.408E+02	7.390E+03	4.374E+02	1.292E+04
88.700	83.700	40.300	37.770	19.200	20.740	36.875	29.275	775.570	4.428E+02	1.289E+04	1.327E+03	1.607E+04
28.000	83.700	40.800	38.570	22.010	26.380	39.000	32.750	449.220	5.099E+02	1.603E+04	1.585E+03	1.905E+04
39.700	83.700	40.600	39.270	22.210	25.950	38.750	31.625	522.760	5.425E+02	6.972E+03	4.214E+02	3.074E+04
56.100	83.700	40.400	39.270	21.610	24.240	37.375	29.250	515.220	2.876E+02	6.774E+03	6.366E+02	6.605E+03
68.700	83.700	40.100	38.370	21.110	21.740	37.125	27.875	303.790	2.804E+02	6.993E+03	7.999E+02	9.869E+03
79.300	83.700	40.200	39.170	20.710	22.740	36.375	27.625	532.050	3.433E+02	6.363E+03	1.268E+03	1.273E+04
88.700	83.700	40.000	38.470	18.100	19.740	35.000	26.000	569.550	4.201E+02	6.939E+03	1.470E+03	1.597E+04
17.700	83.700	40.000	38.970	20.910	25.250	39.000	32.750	542.850	4.774E+02	3.184E+03	1.351E+03	1.591E+04
39.700	83.700	39.700	38.270	20.610	23.140	38.000	30.250	389.150	4.700E+02	6.252E+03	1.268E+03	1.614E+04
56.100	83.700	39.300	38.270	20.710	22.140	37.000	28.125	546.240	3.418E+02	9.262E+03	1.171E+03	1.603E+04
68.700	83.700	39.400	38.270	20.710	21.740	37.375	28.250	543.860	3.433E+02	1.274E+04	1.375E+03	1.608E+04
79.300	83.700	39.500	37.970	20.610	21.240	37.250	27.625	331.750	3.799E+02	1.592E+04	1.227E+03	1.615E+04
28.700	83.700	39.200	37.770	20.110	20.740	35.750	25.750	364.940	4.659E+02	6.346E+03	1.150E+03	3.755E+03
58.700	16.700	40.500	35.760	18.300	19.640	29.000	23.375	412.590	2.942E+02	6.373E+03	6.482E+02	6.351E+03
38.700	26.500	40.600	36.270	19.100	20.440	32.125	26.250	480.780	4.011E+02	6.855E+03	6.446E+02	9.744E+03
38.700	37.400	40.200	36.270	18.300	19.540	34.000	26.900	553.280	5.100E+02	6.534E+03	7.346E+02	1.298E+04
38.700	53.000	40.400	36.270	18.300	19.640	35.750	26.750	367.810	6.340E+02	6.343E+03	9.363E+02	1.612E+04
38.700	64.300	40.450	37.270	18.400	19.340	35.625	27.125	674.710	4.760E+02	3.179E+03	8.939E+02	1.617E+04
38.700	74.900	40.200	37.270	19.100	20.440	35.625	27.375	672.270	7.628E+02	6.180E+03	3.146E+02	1.622E+04
88.700	83.700	40.500	38.270	19.700	21.240	34.500	26.250	637.560	3.544E+02	9.203E+03	9.447E+02	1.624E+04
72.500	17.300	39.900	36.770	19.300	20.940	28.760	21.160	563.900	5.200E+02	1.263E+04	7.680E+02	1.626E+04
72.500	32.400	40.300	37.570	19.500	21.240	31.350	22.700	426.000	5.758E+02	1.375E+04	6.916E+02	1.654E+04
72.500	48.400	39.300	37.270	19.300	21.140	33.810	23.170	501.700	1.311E+02	6.366E+03	5.274E+02	3.421E+03
72.500	63.600	40.100	39.170	18.900	20.640	32.850	22.640	385.400	2.515E+02	6.379E+03	7.293E+02	9.275E+03
72.500	79.200	39.900	29.170	19.960	20.540	33.610	23.125	587.700	1.359E+02	6.795E+03	1.970E+03	7.324E+03
24.300	54.600	40.200	37.370	19.600	22.140	34.830	27.500	361.700	2.130E+02	6.395E+03	1.676E+03	1.290E+04
48.300	54.500	40.200	37.370	19.300	21.540	33.410	24.330	409.900	1.968E+02	6.849E+03	4.499E+03	1.537E+04
72.500	54.600	40.300	37.870	18.900	20.540	31.290	22.440	436.400	1.674E+02	6.904E+03	1.703E+03	5.343E+03
95.500	54.300	40.000	37.170	19.300	20.340	31.420	21.630	432.400	1.780E+02	6.893E+03	3.248E+02	1.432E+03
20.200	38.500	35.400	34.770	27.210	30.860	33.300	31.470	119.700	1.954E+03	6.599E+03	6.653E+02	6.684E+03
39.700	38.500	35.300	34.770	29.710	29.860	32.870	30.840	62.470	1.640E+03	6.795E+03	1.227E+03	9.768E+03
57.800	38.500	35.400	34.670	28.910	30.160	32.270	29.910	208.700	2.691E+02	6.826E+03	1.562E+03	1.258E+04
76.500	38.500	35.200	34.470	28.910	30.060	32.010	29.560	241.400	2.344E+02	6.912E+03	1.800E+03	1.611E+04
20.200	38.500	35.800	34.970	27.410	30.980	33.100	31.420	118.900	1.833E+03	6.183E+03	3.213E+03	1.534E+04
39.700	58.500	35.600	35.170	29.510	30.980	33.150	30.890	177.300	2.306E+02	9.087E+03	4.052E+02	1.594E+04
57.800	22.500	35.600	35.170	29.810	30.760	32.540	30.345	165.500	2.206E+02	1.296E+04	2.792E+03	1.579E+04
76.500	43.500	35.900	35.270	29.710	30.710	32.370	30.250	217.400	2.135E+02	1.549E+04	2.417E+03	1.550E+04
57.800	17.900	35.590	35.770	29.610	30.560	31.390	30.290	182.200	2.773E+02	3.210E+03	9.262E+02	1.597E+04

INPUT DATA

NO. FO DATA = 197

Fc	Fa	Thi	Tho	Tci	Tco	Twho	Twco	Qav	Nur	Reh	Nuc	Rec
95.500	51.200	25.300	34.570	29.610	30.460	30.710	30.250	202.950	2.440E+02	9.051E+03	3.215E+03	1.301E+04
95.500	69.900	25.700	35.570	29.610	30.560	31.655	30.540	207.570	2.566E+02	1.257E+04	1.357E+03	1.607E+04
95.500	86.900	25.300	35.570	30.010	30.750	31.310	30.780	212.150	2.362E+02	1.567E+04	2.125E+03	1.617E+04
20.200	38.500	25.700	34.270	29.010	30.260	32.190	31.160	166.350	2.941E+02	6.718E+03	5.422E+02	3.401E+03
39.700	38.500	25.700	34.270	29.510	30.750	32.140	31.540	184.770	3.145E+02	6.719E+03	7.231E+02	6.752E+03
57.900	38.500	25.400	33.570	30.010	30.860	31.770	31.490	216.510	3.663E+02	3.369E+03	1.015E+03	9.646E+03
76.500	38.500	25.200	33.370	29.510	30.250	31.440	31.050	241.600	3.052E+02	9.335E+03	1.395E+03	1.290E+04
95.500	38.500	25.700	34.470	28.610	29.550	31.250	29.920	205.060	4.121E+02	9.389E+03	1.506E+03	1.578E+04
17.700	83.700	42.400	41.970	21.210	22.740	38.375	33.630	131.060	1.670E+04	1.710E+04	5.320E+01	2.320E+03
28.000	83.700	42.400	41.970	20.110	21.640	38.875	32.900	163.990	2.404E+02	1.719E+04	7.374E+01	4.330E+03
39.700	83.700	42.300	41.370	19.300	21.220	39.375	30.750	193.100	3.456E+02	1.724E+04	9.484E+01	6.030E+03
56.100	83.700	42.400	41.770	20.210	21.640	38.625	30.500	285.000	3.715E+02	1.712E+04	1.296E+02	8.541E+03
68.700	83.700	42.500	41.570	19.600	20.740	38.275	29.230	272.790	3.287E+02	1.711E+04	1.492E+02	1.014E+04
79.200	83.700	42.300	41.570	18.500	19.740	38.625	29.750	298.120	4.207E+02	1.711E+04	1.448E+02	1.175E+04
88.700	83.700	42.300	41.770	18.100	19.230	39.250	29.750	301.390	5.250E+02	1.721E+04	1.372E+02	1.305E+04
57.800	27.700	25.400	35.100	24.100	25.000	31.100	25.200	170.150	5.375E+02	1.635E+04	2.001E+02	2.659E+03
57.800	38.500	25.700	35.400	23.100	24.300	31.100	24.200	138.470	6.990E+02	1.633E+04	2.234E+02	4.115E+03
57.800	55.700	25.800	35.400	23.700	24.150	31.500	24.400	148.150	5.295E+02	1.669E+04	2.445E+02	6.223E+03
70.200	38.500	25.900	34.500	24.700	25.400	32.200	25.200	223.560	5.443E+02	1.662E+04	2.578E+02	9.355E+03
89.700	38.500	25.500	34.000	24.900	25.600	32.000	25.900	263.650	5.709E+02	1.650E+04	2.868E+02	1.002E+04
20.200	38.500	36.000	34.470	28.710	29.360	33.520	30.270	170.640	6.040E+02	1.627E+04	2.999E+02	1.154E+04
29.700	38.500	36.200	34.770	29.210	30.060	33.540	30.500	184.500	5.731E+02	1.613E+04	3.349E+02	1.251E+04
57.900	38.500	35.700	34.170	29.910	30.360	33.740	31.460	236.520	1.993E+03	1.666E+04	3.120E+02	2.762E+03
76.500	38.500	36.400	34.370	29.510	30.460	33.740	30.650	273.460	9.932E+02	1.666E+04	4.052E+02	4.395E+03
95.500	38.500	36.100	34.470	30.110	31.060	33.970	31.630	318.770	1.086E+03	1.649E+04	5.494E+02	5.097E+03
95.500	17.970	35.400	35.970	29.210	30.260	32.270	30.700	202.150	1.144E+03	1.658E+04	6.189E+02	5.479E+03
95.500	34.600	35.500	35.970	29.510	30.460	33.690	31.080	298.840	9.413E+02	1.662E+04	6.661E+02	1.036E+04
95.500	51.200	35.400	36.170	29.210	29.960	33.440	30.270	67.160	1.478E+03	1.635E+04	3.766E+02	1.153E+04
95.500	69.900	35.400	35.970	29.510	30.560	33.620	30.900	231.240	1.930E+03	1.634E+04	4.177E+02	1.219E+04
95.500	86.900	36.400	35.970	29.410	30.360	33.620	30.750	266.280	1.845E+03	1.588E+04	2.576E+02	4.518E+03
20.200	38.500	34.600	36.270	28.310	29.960	32.920	31.470	202.840	1.060E+03	1.681E+04	3.464E+02	6.332E+03
39.700	38.500	35.500	36.470	28.510	29.860	32.240	30.630	204.230	1.021E+03	1.657E+04	4.123E+02	8.613E+03
57.900	38.500	35.200	36.670	29.010	29.950	32.270	30.750	211.700	1.275E+03	1.648E+04	2.374E+02	1.021E+04
76.500	38.500	35.100	36.870	28.610	29.750	31.940	30.370	276.650	7.724E+02	1.640E+04	4.545E+02	1.179E+04
95.500	38.500	35.500	34.570	29.110	29.750	31.890	30.600	315.140	6.572E+02	1.612E+04	4.080E+02	1.252E+04
95.500	17.990	35.600	34.570	29.310	29.860	31.660	30.400	271.610	3.437E+02	1.777E+04	1.780E+02	2.829E+03
95.500	34.600	36.200	34.570	29.510	30.460	32.290	31.210	312.990	1.671E+03	1.656E+04	2.361E+02	3.695E+03
95.500	51.200	36.600	35.370	29.510	30.160	32.690	30.780	246.440	9.465E+02	1.635E+04	2.604E+02	8.335E+03
95.500	69.900	36.200	35.370	29.610	30.550	32.490	30.750	251.990	1.149E+03	1.642E+04	2.467E+02	1.023E+04
95.500	86.500	36.500	35.075	29.610	30.560	32.160	31.160	266.250	1.255E+03	1.657E+04	2.669E+02	1.169E+04
20.200	38.500	37.200	33.970	27.910	29.150	32.390	30.910	150.590	6.522E+02	1.612E+04	3.472E+02	1.272E+04
39.740	38.500	35.400	34.070	23.110	28.950	31.790	30.070	175.740	2.227E+02	3.060E+03	4.767E+02	1.216E+04
57.800	38.500	35.100	35.670	29.510	30.060	31.870	31.260	204.520	3.710E+02	4.926E+03	3.757E+02	1.269E+04
76.580	38.500	34.700	33.470	29.510	30.150	31.770	31.620	249.610	6.468E+02	7.064E+03	3.936E+02	1.252E+04
95.500	38.500	34.700	32.570	29.410	30.250	32.050	31.220	275.220	1.012E+03	1.016E+04	4.339E+02	1.215E+04
95.500	17.900	35.000	33.370	29.610	30.460	31.810	31.310	227.440	1.011E+03	1.253E+04	4.287E+02	1.273E+04
95.500	34.600	35.100	33.370	29.510	30.360	32.340	31.770	293.180	9.924E+02	1.447E+04	4.470E+02	1.286E+04
95.500	51.200	35.300	33.870	29.510	30.460	32.620	31.770	340.760	6.566E+02	1.605E+04	5.500E+02	1.250E+04
95.500	69.900	35.400	34.870	29.510	30.560	32.620	31.200	265.630	1.873E+02	3.214E+03	1.204E+03	9.542E+03
95.500	85.900	35.400	34.870	29.010	30.460	32.850	32.150	264.460	3.050E+02	6.031E+03	9.299E+02	9.994E+03
20.200	38.500	35.100	34.779	28.610	30.060	31.490	31.540	112.520	4.842E+02	9.146E+03	8.665E+02	1.093E+04

INPUT DATA

NO. FO DATA = 197

Fc	Fh	Thi	Tho	Tci	Tco	Twho	Twci	Qav	Nur	Reh	Nuc	Rec
39.700	38.500	35.300	34.570	28.910	30.060	31.670	30.530	150.340	2.782E+02	1.204E+04	6.809E+02	9.916E+02
57.800	38.500	34.800	34.370	29.210	30.160	30.800	30.060	148.610	2.037E+02	1.511E+04	5.502E+02	9.967E+02
76.500	38.500	35.630	35.170	29.510	30.360	31.466	30.250	169.830	4.473E+02	6.622E+02	3.598E+02	3.550E+02
95.500	38.500	35.300	35.070	29.310	30.080	30.990	29.870	167.380	2.630E+02	6.542E+02	4.711E+02	6.921E+02
37.600	38.500	35.700	35.170	28.910	30.060	31.540	29.990	133.320	2.342E+02	6.455E+02	8.171E+02	9.887E+02
26.200	38.500	35.200	34.470	29.310	30.660	31.970	31.690	115.690	1.440E+02	4.457E+03	1.185E+03	1.305E+04
39.700	38.500	35.400	34.870	29.310	30.460	31.740	30.910	157.340	2.395E+02	7.002E+02	4.138E+02	3.426E+02
57.800	38.500	36.300	35.570	29.610	30.780	32.270	30.980	194.590	1.258E+02	6.968E+03	3.631E+02	6.648E+03
76.500	38.500	35.200	34.770	29.210	29.530	30.860	29.580	217.450	3.718E+02	6.927E+03	1.768E+03	5.544E+03
95.500	38.500	35.700	35.370	29.710	30.650	31.820	30.800	223.070	4.212E+02	6.895E+03	4.863E+03	1.268E+04
95.500	34.600	35.800	35.470	29.210	29.980	30.590	29.810	173.710	2.617E+02	7.013E+03	4.259E+02	6.424E+02
95.500	51.200	35.100	34.770	29.510	30.260	31.000	30.080	184.070	3.591E+02	7.027E+02	1.222E+03	6.703E+02
95.500	69.900	35.500	35.270	29.010	29.760	31.310	29.710	182.350	3.152E+02	6.977E+02	1.058E+03	9.734E+03
95.500	86.900	35.200	35.070	29.010	29.760	31.260	29.746	171.470	2.549E+02	6.974E+03	8.637E+03	1.235E+04
95.500	17.400	35.800	34.870	29.010	29.960	31.840	30.680	223.310	3.214E+02	3.197E+03	1.124E+03	5.749E+03
57.800	34.600	34.900	33.370	29.210	30.160	32.970	31.110	224.200	9.483E+02	6.213E+03	7.812E+02	5.751E+03
57.800	51.200	35.700	34.370	29.410	30.460	32.900	31.640	167.800	1.155E+03	9.363E+03	7.785E+02	5.610E+03
57.800	69.900	35.800	35.270	30.010	30.860	32.850	31.740	175.850	4.616E+02	1.282E+04	6.935E+03	5.876E+03
57.800	86.900	35.700	35.570	29.510	30.860	32.709	31.670	173.700	4.653E+02	1.594E+04	6.701E+02	9.859E+03
57.800	17.900	35.600	33.770	29.210	30.260	31.790	30.360	194.700	2.509E+02	3.196E+03	1.545E+03	6.660E+03
57.800	34.600	35.600	34.670	28.910	30.160	32.473	30.290	217.100	4.012E+02	6.244E+03	1.429E+03	5.632E+03
57.800	51.200	35.800	32.870	29.010	30.260	32.940	30.540	227.900	4.494E+02	9.311E+03	1.251E+03	9.688E+03
57.800	69.900	35.900	32.670	28.510	30.160	32.670	30.260	195.200	3.191E+02	1.272E+04	1.259E+03	9.629E+03
57.800	86.900	35.900	32.870	28.910	30.210	32.740	30.290	203.800	3.292E+02	1.583E+04	1.458E+03	9.636E+03
20.300	38.500	35.300	33.770	24.810	26.750	31.790	25.250	213.800	6.007E+02	8.929E+03	3.156E+02	5.217E+03
41.700	38.500	35.400	33.570	24.610	26.250	31.730	27.590	258.800	4.286E+02	6.868E+03	5.962E+02	6.458E+02
64.200	38.500	35.500	34.170	24.510	25.550	31.169	26.640	245.560	5.314E+02	6.838E+03	7.661E+02	9.775E+02
85.200	38.500	35.500	34.270	24.610	24.750	30.900	26.900	115.200	1.409E+02	6.926E+03	2.606E+02	1.299E+04
97.900	38.500	35.500	34.370	24.410	25.750	30.880	26.650	283.100	2.433E+02	6.824E+03	1.895E+03	1.474E+04
26.200	38.500	35.500	34.470	24.710	26.650	32.340	29.166	164.400	2.062E+02	6.929E+03	2.363E+03	3.207E+02
41.700	38.500	35.700	34.170	24.610	26.250	31.760	28.020	273.500	4.247E+02	6.885E+03	5.397E+02	6.493E+03
64.200	35.500	35.700	33.970	24.210	25.550	31.510	26.640	304.200	4.512E+02	6.861E+03	8.939E+02	9.785E+03
85.200	38.500	35.700	33.670	23.910	25.150	31.080	25.990	366.500	4.861E+02	6.808E+03	1.283E+03	1.283E+04
95.500	38.500	35.700	33.970	23.910	24.950	30.930	25.860	345.300	4.364E+02	6.821E+03	1.215E+03	1.438E+04
64.200	17.900	35.800	33.570	24.710	26.050	30.030	26.490	254.700	2.782E+02	3.135E+03	1.155E+03	9.817E+03
64.200	34.600	35.400	34.170	24.210	25.850	30.980	26.650	267.700	2.471E+02	6.130E+03	6.152E+02	9.789E+03
64.200	51.200	35.500	34.570	24.410	25.850	31.780	25.860	291.500	4.414E+02	9.167E+02	6.462E+02	9.830E+03
64.200	69.900	35.700	33.270	24.710	26.150	31.510	26.790	285.000	3.161E+02	1.254E+04	9.414E+02	9.855E+03
64.200	61.900	35.600	33.070	24.560	25.950	31.510	26.660	282.200	5.167E+02	1.555E+04	6.898E+02	9.819E+03
97.900	17.900	35.800	33.870	24.310	25.250	29.520	25.000	255.800	2.553E+02	3.118E+03	5.949E+03	1.462E+04
97.500	34.600	35.500	34.070	24.610	25.450	30.830	25.760	274.100	2.421E+02	6.121E+03	1.889E+03	1.479E+04
97.900	51.200	35.800	34.770	24.110	24.950	30.050	25.210	255.760	2.498E+02	9.922E+03	1.924E+03	1.462E+04
97.500	69.900	35.500	35.170	24.110	25.050	31.150	26.100	275.700	2.624E+02	1.247E+04	7.934E+03	1.477E+04
97.900	86.900	35.500	35.170	24.410	24.750	31.280	25.730	223.800	1.565E+02	1.595E+04	5.642E+02	1.471E+04

OUTER FILM CORRELATION OF EVAPORATOR

$Y = A * X^B$

$A = 13.22769$ $B = .3808254$ $R = .7541345$

OUTER FILM CORRELATION OF CONDENSER

$Y = A * X^B$

$A = .1230409$ $B = .9516121$ $R = .6244151$

2. Heat Transfer Correlations Inside the Evaporator and Condenser
Sections

a. For Freon-113, tilt angle 50 degrees, fill ratio 30%

INPUT DATA

NO. FO DATA = 57   TYPE OF FREON : FREON 113

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GAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC

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3.685E+02	3.500E+01	2.170E+01	3.497E+01	2.173E+01	2.665E-01	1.890E-03	1.921E+12	3.531E+03
3.380E+02	3.510E+01	2.150E+01	3.507E+01	2.153E+01	2.443E-01	1.922E-03	1.878E+12	3.166E+03
1.792E+02	3.590E+01	2.210E+01	3.589E+01	2.211E+01	1.306E-01	1.980E-03	1.850E+12	1.651E+03
1.392E+02	3.640E+01	2.260E+01	3.639E+01	2.261E+01	1.021E-01	2.000E-03	1.852E+12	1.262E+03
1.511E+02	3.660E+01	2.110E+01	3.659E+01	2.111E+01	1.099E-01	2.218E-03	1.646E+12	1.239E+03
1.972E+02	3.730E+01	2.140E+01	3.728E+01	2.142E+01	1.444E-01	2.297E-03	1.607E+12	1.577E+03
2.740E+02	3.810E+01	2.210E+01	3.808E+01	2.212E+01	2.024E-01	2.343E-03	1.603E+12	2.179E+03
2.351E+02	3.860E+01	2.200E+01	3.858E+01	2.202E+01	1.740E-01	2.442E-03	1.545E+12	1.801E+03
2.362E+02	3.890E+01	2.200E+01	3.888E+01	2.202E+01	1.752E-01	2.494E-03	1.518E+12	1.777E+03
2.819E+02	3.910E+01	2.260E+01	3.908E+01	2.262E+01	2.101E-01	2.453E-03	1.558E+12	2.173E+03
3.726E+02	3.650E+01	2.240E+01	3.647E+01	2.243E+01	2.731E-01	2.036E-03	1.817E+12	3.367E+03
4.501E+02	3.740E+01	2.220E+01	3.737E+01	2.223E+01	3.312E-01	2.209E-03	1.688E+12	3.774E+03
2.842E+02	3.950E+01	2.250E+01	3.948E+01	2.252E+01	2.122E-01	2.534E-03	1.513E+12	2.127E+03
2.407E+02	3.980E+01	2.300E+01	3.978E+01	2.302E+01	1.806E-01	2.525E-03	1.533E+12	1.822E+03
2.146E+02	3.960E+01	2.330E+01	3.958E+01	2.332E+01	1.611E-01	2.453E-03	1.580E+12	1.674E+03
2.631E+02	3.990E+01	2.310E+01	3.988E+01	2.312E+01	1.976E-01	2.530E-03	1.534E+12	1.992E+03
3.721E+02	3.440E+01	2.030E+01	3.437E+01	2.033E+01	2.658E-01	1.957E-03	1.809E+12	3.362E+03
3.274E+02	3.450E+01	2.020E+01	3.447E+01	2.023E+01	2.339E-01	1.985E-03	1.782E+12	2.915E+03
2.165E+02	3.510E+01	2.050E+01	3.508E+01	2.052E+01	1.555E-01	2.047E-03	1.745E+12	1.886E+03
2.010E+02	3.530E+01	2.070E+01	3.528E+01	2.072E+01	1.447E-01	2.055E-03	1.745E+12	1.750E+03
1.868E+02	3.530E+01	2.070E+01	3.529E+01	2.071E+01	1.345E-01	2.055E-03	1.745E+12	1.627E+03
3.323E+02	3.750E+01	2.290E+01	3.747E+01	2.293E+01	2.457E-01	2.141E-03	1.758E+12	2.998E+03
4.356E+02	3.690E+01	2.260E+01	3.687E+01	2.263E+01	3.204E-01	2.076E-03	1.795E+12	3.883E+03
1.937E+02	3.840E+01	2.330E+01	3.839E+01	2.331E+01	1.444E-01	2.246E-03	1.702E+12	1.631E+03
2.341E+02	3.860E+01	2.400E+01	3.858E+01	2.402E+01	1.754E-01	2.190E-03	1.764E+12	2.039E+03
2.041E+02	3.990E+01	2.390E+01	3.988E+01	2.392E+01	1.540E-01	2.430E-03	1.613E+12	1.622E+03
2.525E+02	4.010E+01	2.400E+01	4.008E+01	2.402E+01	1.909E-01	2.451E-03	1.605E+12	1.995E+03
4.046E+02	3.630E+01	2.220E+01	3.627E+01	2.223E+01	2.957E-01	2.028E-03	1.817E+12	3.656E+03
3.600E+02	3.640E+01	2.160E+01	3.637E+01	2.163E+01	2.624E-01	2.120E-03	1.728E+12	3.098E+03
2.786E+02	3.710E+01	2.170E+01	3.708E+01	2.172E+01	2.041E-01	2.225E-03	1.661E+12	2.302E+03
2.576E+02	3.740E+01	2.160E+01	3.738E+01	2.162E+01	1.889E-01	2.288E-03	1.619E+12	2.073E+03
2.373E+02	3.980E+01	2.250E+01	3.978E+01	2.292E+01	1.779E-01	2.538E-03	1.524E+12	1.786E+03
2.340E+02	3.690E+01	2.140E+01	3.688E+01	2.142E+01	1.709E-01	2.229E-03	1.649E+12	1.920E+03
1.156E+02	2.810E+01	2.480E+01	2.809E+01	2.481E+01	8.166E-02	4.498E-04	7.733E+12	4.468E+03
2.059E+02	3.200E+01	2.530E+01	3.198E+01	2.532E+01	1.495E-01	9.522E-04	3.818E+12	3.918E+03

INPUT DATA

TYPE OF FREON : FREON 113

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QAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC

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2.435E+02	3.240E+01	2.530E+01	3.238E+01	2.532E+01	1.771E-01	1.012E-03	3.607E+12	4.374E+03
1.485E+02	3.280E+01	2.540E+01	3.279E+01	2.541E+01	1.083E-01	1.063E-03	3.455E+12	2.554E+03
1.069E+02	3.250E+01	2.530E+01	3.249E+01	2.531E+01	7.783E-02	1.031E-03	3.547E+12	1.888E+03
1.253E+02	3.260E+01	2.530E+01	3.259E+01	2.531E+01	9.123E-02	1.046E-03	3.500E+12	2.183E+03
1.591E+02	3.260E+01	2.530E+01	3.259E+01	2.531E+01	1.159E-01	1.045E-03	3.502E+12	2.774E+03
9.662E+01	2.810E+01	2.570E+01	2.809E+01	2.571E+01	6.864E-02	3.296E-04	1.064E+13	5.140E+03
1.037E+02	2.710E+01	2.620E+01	2.709E+01	2.621E+01	7.343E-02	1.216E-04	2.871E+13	1.488E+04
1.070E+02	2.750E+01	2.500E+01	2.749E+01	2.501E+01	7.539E-02	3.391E-04	1.022E+13	5.464E+03
1.096E+02	2.800E+01	2.530E+01	2.799E+01	2.531E+01	7.762E-02	3.691E-04	9.460E+12	5.182E+03
1.120E+02	2.700E+01	2.480E+01	2.699E+01	2.481E+01	7.859E-02	2.962E-04	1.163E+13	6.510E+03
2.386E+02	3.220E+01	2.530E+01	3.218E+01	2.532E+01	1.733E-01	9.819E-04	3.711E+12	4.410E+03
2.686E+02	3.200E+01	2.560E+01	3.198E+01	2.562E+01	1.953E-01	9.106E-04	4.006E+12	5.360E+03
1.706E+02	3.352E+01	3.027E+01	3.351E+01	3.028E+01	1.288E-01	4.905E-04	7.991E+12	6.716E+03
1.845E+02	3.354E+01	3.050E+01	3.353E+01	3.051E+01	1.394E-01	4.593E-04	8.558E+12	7.773E+03
2.365E+02	3.374E+01	3.146E+01	3.372E+01	3.148E+01	1.800E-01	3.462E-04	1.152E+13	1.338E+04
2.735E+02	3.374E+01	3.085E+01	3.372E+01	3.087E+01	2.073E-01	4.367E-04	9.062E+12	1.218E+04
3.190E+02	3.397E+01	3.163E+01	3.395E+01	3.165E+01	2.433E-01	3.549E-04	1.129E+13	1.767E+04
2.022E+02	3.327E+01	3.070E+01	3.325E+01	3.072E+01	1.527E-01	3.870E-04	1.015E+13	1.010E+04
2.986E+02	3.369E+01	3.108E+01	3.367E+01	3.110E+01	2.267E-01	3.939E-04	1.007E+13	1.478E+04
6.716E+01	3.344E+01	3.027E+01	3.343E+01	3.028E+01	5.065E-02	4.803E-04	8.151E+12	2.697E+03
2.312E+02	3.362E+01	3.080E+01	3.360E+01	3.082E+01	1.751E-01	4.263E-04	9.265E+12	1.054E+04
2.663E+02	3.362E+01	3.073E+01	3.360E+01	3.075E+01	2.016E-01	4.359E-04	9.053E+12	1.186E+04

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CORRELATION OF POOL BOILING

Y = A * I^B
A = 7.020683E-03   B = .9621316   R = .9994775

FILM CONDENSATION CORRELATION

Y = A * I^B
A = 1.705019E-06   B = .7437863   R = .9023314

f. For Freon-22, tilt angle 50 degrees, fill ratio 16.4%

INPUT DATA

NO. FO DATA = 47   TYPE OF FREON : FREON 22

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QAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC

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QAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC
3.639E+02	2.876E+01	2.166E+01	2.873E+01	2.169E+01	4.533E-01	2.952E-03	4.513E+12	6.555E+03
4.260E+02	3.195E+01	2.270E+01	3.192E+01	2.273E+01	5.334E-01	3.859E-03	3.265E+12	5.885E+03
5.017E+02	3.361E+01	2.317E+01	3.357E+01	2.321E+01	6.298E-01	4.360E-03	2.808E+12	6.143E+03
3.854E+02	3.285E+01	2.264E+01	3.282E+01	2.267E+01	4.830E-01	4.266E-03	2.920E+12	4.817E+03
3.677E+02	3.361E+01	2.312E+01	3.358E+01	2.315E+01	4.615E-01	4.389E-03	2.791E+12	4.472E+03
3.617E+02	3.483E+01	2.760E+01	3.480E+01	2.763E+01	4.573E-01	3.026E-03	3.741E+12	6.397E+03
4.098E+02	3.341E+01	2.483E+01	3.338E+01	2.486E+01	5.154E-01	3.586E-03	3.347E+12	6.105E+03
4.364E+02	3.228E+01	2.244E+01	3.225E+01	2.247E+01	5.464E-01	4.107E-03	3.065E+12	5.666E+03
4.324E+02	3.242E+01	2.163E+01	3.239E+01	2.166E+01	5.410E-01	4.505E-03	2.820E+12	5.116E+03
1.197E+02	3.330E+01	3.147E+01	3.329E+01	3.148E+01	1.518E-01	7.646E-04	1.432E+13	8.384E+03
6.249E+01	3.269E+01	3.054E+01	3.269E+01	3.054E+01	7.909E-02	9.029E-04	1.240E+13	3.704E+03
2.087E+02	3.227E+01	2.991E+01	3.225E+01	2.993E+01	2.638E-01	9.817E-04	1.157E+13	1.138E+04
2.414E+02	3.201E+01	2.966E+01	3.199E+01	2.968E+01	3.049E-01	9.752E-04	1.173E+13	1.324E+04
1.189E+02	3.315E+01	3.142E+01	3.314E+01	3.143E+01	1.508E-01	7.224E-04	1.520E+13	8.813E+03
1.778E+02	3.315E+01	3.089E+01	3.314E+01	3.090E+01	2.253E-01	9.421E-04	1.174E+13	1.010E+04
1.866E+02	3.254E+01	3.064E+01	3.253E+01	3.065E+01	2.387E-01	7.893E-04	1.419E+13	1.279E+04
2.174E+02	3.239E+01	3.036E+01	3.237E+01	3.038E+01	2.750E-01	8.421E-04	1.338E+13	1.382E+04
1.822E+02	3.189E+01	3.089E+01	3.188E+01	3.090E+01	2.305E-01	4.100E-04	2.748E+13	2.379E+04
2.242E+02	3.297E+01	3.111E+01	3.295E+01	3.113E+01	2.841E-01	7.703E-04	1.436E+13	1.558E+04
2.676E+02	3.390E+01	3.164E+01	3.388E+01	3.166E+01	3.397E-01	9.366E-04	1.156E+13	1.530E+04
1.756E+02	3.365E+01	3.174E+01	3.364E+01	3.175E+01	2.229E-01	7.948E-04	1.365E+13	1.183E+04
1.737E+02	3.370E+01	3.167E+01	3.367E+01	3.168E+01	2.205E-01	8.456E-04	1.284E+13	1.100E+04
1.943E+02	3.179E+01	3.036E+01	3.178E+01	3.037E+01	2.456E-01	5.904E-04	1.925E+13	1.761E+04
2.171E-02	3.247E+01	3.029E+01	3.245E+01	3.031E+01	2.746E-01	9.054E-04	1.244E+13	1.283E+04
2.279E+02	3.294E+01	3.054E+01	3.292E+01	3.056E+01	2.985E-01	9.977E-04	1.118E+13	1.223E+04
1.982E+02	3.267E+01	3.026E+01	3.265E+01	3.029E+01	2.508E-01	1.004E-03	1.120E+13	1.057E+04
2.038E+02	3.274E+01	3.028E+01	3.272E+01	3.030E+01	2.579E-01	1.024E-03	1.096E+13	1.065E+04
2.128E+02	3.279E+01	2.925E+01	3.277E+01	2.927E+01	2.689E-01	1.479E-03	7.697E+12	7.698E+03
2.568E+02	3.173E+01	2.759E+01	3.171E+01	2.761E+01	3.234E-01	1.727E-03	6.846E+12	7.946E+03
2.455E+02	3.118E+01	2.664E+01	3.116E+01	2.666E+01	3.086E-01	1.895E-05	6.370E+12	6.919E+03
1.152E+02	3.090E+01	2.690E+01	3.089E+01	2.691E+01	1.448E-01	1.676E-03	7.203E+12	3.670E+03
2.821E+02	3.088E+01	2.563E+01	3.086E+01	2.565E+01	3.540E-01	2.190E-03	5.611E+12	6.875E+03

INPUT DATA

TYPE OF FREON : FREON 22

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QAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC
1.644E+02	3.234E+01	2.916E+01	3.233E+01	2.917E+01	2.076E-01	1.330E-03	8.624E+12	6.612E+03
2.735E+02	3.176E+01	2.802E+01	3.174E+01	2.804E+01	3.446E-01	1.558E-03	7.541E+12	7.384E+03
3.042E+02	3.151E+01	2.664E+01	3.149E+01	2.666E+01	3.825E-01	2.031E-03	5.916E+12	8.002E+03
3.665E+02	3.108E+01	2.599E+01	3.105E+01	2.602E+01	4.602E-01	2.119E-03	5.758E+12	9.238E+03
3.453E+02	3.093E+01	2.586E+01	3.090E+01	2.589E+01	4.335E-01	2.111E-03	5.800E+12	8.733E+03
2.547E+02	3.003E+01	2.649E+01	3.001E+01	2.651E+01	3.156E-01	1.473E-03	8.344E+12	9.231E+03
2.677E+02	3.098E+01	2.663E+01	3.096E+01	2.665E+01	3.364E-01	1.814E-03	6.675E+12	7.883E+03
2.915E+02	3.178E+01	2.686E+01	3.176E+01	2.688E+01	3.668E-01	2.053E-03	5.814E+12	7.587E+03
2.550E+02	3.151E+01	2.679E+01	3.149E+01	2.681E+01	3.207E-01	1.971E-03	6.085E+12	6.912E+03
2.522E+02	3.151E+01	2.666E+01	3.149E+01	2.668E+01	3.171E-01	2.026E-03	5.931E+12	6.651E+03
2.598E+02	2.952E+01	2.500E+01	2.950E+01	2.502E+01	3.252E-01	1.882E-03	6.705E+12	7.358E+03
2.741E+02	3.083E+01	2.576E+01	3.081E+01	2.578E+01	3.440E-01	2.115E-03	5.804E+12	6.917E+03
2.597E+02	3.005E+01	2.521E+01	3.003E+01	2.523E+01	3.254E-01	2.018E-03	6.194E+12	6.865E+03
2.357E+02	3.115E+01	2.610E+01	3.113E+01	2.612E+01	3.011E-01	2.110E-03	5.767E+12	6.067E+03
1.289E+02	3.128E+01	2.573E+01	3.127E+01	2.574E+01	1.619E-01	2.327E-03	5.245E+12	2.957E+03

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CORRELATION OF POOL BOILING

$Y = A * X^B$
A = 5.85438E-03   B = 1.06921   R = .9970072

FILM CONDENSATION CORRELATION

$Y = A * X^B$
A = 5.331091E-04   B = .5560585   R = .9656718

b. For Freon-113, tilt angle 50 degrees, fill ratio 18.5%

INPUT DATA

NO. FO DATA = 15   TYPE OF FREON : FREON 113

##

GAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC
2.028E+02	3.252E+01	3.147E+01	3.250E+01	3.149E+01	1.532E-01	1.553E-04	2.530E+13	2.526E+04
2.042E+02	3.224E+01	3.063E+01	3.222E+01	3.065E+01	1.533E-01	2.380E-04	1.629E+13	1.642E+04
2.117E+02	3.227E+01	3.075E+01	3.225E+01	3.077E+01	1.590E-01	2.246E-04	1.729E+13	1.806E+04
2.767E+02	3.194E+01	3.037E+01	3.192E+01	3.035E+01	2.069E-01	2.290E-04	1.681E+13	2.298E+04
3.151E+02	3.189E+01	3.060E+01	3.187E+01	3.062E+01	2.360E-01	1.865E-04	2.069E+13	3.221E+04
2.717E+02	3.169E+01	3.040E+01	3.167E+01	3.042E+01	2.029E-01	1.867E-04	2.056E+13	2.761E+04
3.130E+02	3.229E+01	3.121E+01	3.227E+01	3.123E+01	2.358E-01	1.565E-04	2.495E+13	3.849E+04
2.464E+02	3.269E+01	3.078E+01	3.267E+01	3.080E+01	1.856E-01	2.839E-04	1.373E+13	1.670E+04
2.511E+02	3.249E+01	3.075E+01	3.247E+01	3.077E+01	1.886E-01	2.574E-04	1.512E+13	1.873E+04
2.863E+02	3.284E+01	3.116E+01	3.282E+01	3.118E+01	2.012E-01	2.499E-04	1.572E+13	2.061E+04
1.669E+02	3.219E+01	3.116E+01	3.218E+01	3.117E+01	1.256E-01	1.521E-04	2.562E+13	2.108E+04
1.948E+02	3.214E+01	3.154E+01	3.213E+01	3.155E+01	1.393E-01	8.686E-05	4.506E+13	4.102E+04
2.165E+02	3.177E+01	3.149E+01	3.175E+01	3.151E+01	1.629E-01	3.732E-05	1.043E+14	1.114E+05
2.416E+02	3.144E+01	3.103E+01	3.142E+01	3.105E+01	1.809E-01	5.597E-05	6.691E+13	6.224E+04
3.031E+02	3.156E+01	2.992E+01	3.154E+01	2.994E+01	2.256E-01	2.369E-04	1.609E+13	2.414E+04

##

CORRELATION OF POOL BOILING

$Y = A * X^B$
A = 8.265365E-04   B = .957011   R = .9998452

FILM CONDENSATION CORRELATION

$Y = A * X^B$
A = 2.849737E-08   B = .8968566   R = 1.893394

c. For Freon-113, tilt angle 50 degrees, fill ratio 9.3%

INPUT DATA

NO. FO DATA = 10   TYPE OF FREON : FREON 113

****

QAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC

****

QAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC
1.509E+02	3.299E+01	3.091E+01	3.298E+01	3.092E+01	1.139E-01	3.133E-04	1.253E+13	9.308E+03
1.757E+02	3.179E+01	3.007E+01	3.178E+01	3.008E+01	1.311E-01	2.527E-04	1.515E+13	1.317E+04
2.045E+02	3.187E+01	3.126E+01	3.185E+01	3.128E+01	1.537E-01	8.744E-05	4.447E+13	4.486E+04
2.496E+02	3.177E+01	3.162E+01	3.175E+01	3.164E+01	1.879E-01	1.690E-05	2.308E+14	2.840E+05
2.752E+02	3.205E+01	3.122E+01	3.203E+01	3.124E+01	2.070E-01	1.192E-04	3.267E+13	4.434E+04
2.294E+02	3.181E+01	3.131E+01	3.179E+01	3.133E+01	1.724E-01	7.022E-05	5.536E+13	6.266E+04
2.932E+02	3.234E+01	3.172E+01	3.232E+01	3.174E+01	2.216E-01	8.769E-05	4.484E+13	6.472E+04
3.408E+02	3.262E+01	3.177E+01	3.259E+01	3.180E+01	2.580E-01	1.221E-04	3.235E+13	5.422E+04
2.656E+02	3.262E+01	3.180E+01	3.260E+01	3.182E+01	2.012E-01	1.193E-04	3.311E+13	4.326E+04
2.645E+02	3.289E+01	3.213E+01	3.287E+01	3.215E+01	2.010E-01	1.108E-04	3.592E+13	4.665E+04

****

CORRELATION OF POOL BOILING

$Y = A * X^B$
A = 9.999117E-06   B = -1.361575   R = .9997676

FILM CONDENSATION CORRELATION
$Y = A * X^B$
A = 1.811136E-11   B = 1.137221   R = 6.174495

d. For Freon-113, tilt angle 50 degrees, fill ratio 4.9%

INPUT DATA

NO. FO DATA = 18   TYPE OF FREON : FREON 113

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GAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC
1.966E+02	3.227E+01	3.098E+01	3.225E+01	3.100E+01	1.479E-01	1.906E-04	2.042E+13	1.980E+04
1.533E+02	3.167E+01	3.053E+01	3.166E+01	3.054E+01	1.146E-01	1.872E-04	2.300E+13	1.743E+04
1.486E+02	3.080E+01	3.006E+01	3.079E+01	3.007E+01	1.102E-01	1.060E-04	3.570E+13	2.629E+04
1.696E+02	3.146E+01	3.025E+01	3.145E+01	3.026E+01	1.264E-01	1.764E-04	2.166E+13	1.318E+04
1.674E+02	3.099E+01	2.987E+01	3.098E+01	2.988E+01	1.241E-01	1.617E-04	2.340E+13	1.941E+04
1.323E+02	3.154E+01	2.999E+01	3.153E+01	3.000E+01	9.851E-02	2.276E-04	1.676E+13	1.098E+04
1.151E+02	3.197E+01	3.169E+01	3.196E+01	3.170E+01	8.678E-02	3.985E-05	9.820E+13	5.568E+04
1.373E+02	3.174E+01	3.091E+01	3.173E+01	3.092E+01	1.029E-01	1.217E-04	3.177E+13	2.154E+04
2.175E+02	3.086E+01	2.958E+01	3.084E+01	2.960E+01	1.608E-01	1.835E-04	2.052E+13	2.213E+04
2.231E+02	3.162E+01	3.080E+01	3.160E+01	3.082E+01	1.670E-01	1.179E-04	3.269E+13	3.603E+04
1.727E+02	3.099E+01	2.981E+01	3.098E+01	2.982E+01	1.280E-01	1.704E-04	2.220E+13	1.900E+04
1.841E+02	3.100E+01	3.008E+01	3.099E+01	3.009E+01	1.367E-01	1.321E-04	2.873E+13	2.619E+04
1.824E+02	3.131E+01	2.971E+01	3.130E+01	2.972E+01	1.354E-01	2.327E-04	1.629E+13	1.472E+04
1.725E+02	3.126E+01	2.974E+01	3.125E+01	2.975E+01	1.280E-01	2.210E-04	1.715E+13	1.465E+04
2.233E+02	3.164E+01	3.068E+01	3.162E+01	3.070E+01	1.670E-01	1.388E-04	2.774E+13	3.061E+04
2.039E+02	3.071E+01	3.035E+01	3.069E+01	3.037E+01	1.514E-01	4.865E-05	7.756E+13	7.875E+04
2.078E+02	3.165E+01	3.064E+01	3.163E+01	3.066E+01	1.552E-01	1.466E-04	2.625E+13	2.693E+04
2.121E+02	3.181E+01	3.098E+01	3.179E+01	3.100E+01	1.591E-01	1.201E-04	3.224E+13	3.376E+04

****

CORRELATION OF POOL BOILING

Y = A * X^B
A = 3.578661E-04   B = .4701016   R = .9999404

FILM CONDENSATION CORRELATION

Y = A * X^B
A = 1.07898E-08   B = .9186567   R = 1.610236

e. For Freon-22, tilt angle 50 degrees, fill ratio 30%

INPUT DATA

NO. FO DATA = 7   TYPE OF FREON : FREON 22

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DAV	TWHO	TWCO	TWHI	TWCI	XH	YH	XC	YC

****

5.634E+02	3.763E+01	3.138E+01	3.758E+01	3.142E+01	7.189E-01	2.603E-03	3.954E+12	1.160E+04
5.883E+02	3.725E+01	3.075E+01	3.720E+01	3.080E+01	7.495E-01	2.707E-03	3.859E+12	1.165E+04
7.108E+02	3.875E+01	2.938E+01	3.870E+01	2.943E+01	9.032E-01	3.067E-03	3.500E+12	1.241E+04
7.597E+02	3.700E+01	2.850E+01	3.694E+01	2.856E+01	9.645E-01	3.539E-03	3.062E+12	1.150E+04
6.832E+02	3.700E+01	2.900E+01	3.695E+01	2.905E+01	8.680E-01	3.333E-03	3.227E+12	1.098E+04
5.770E+02	3.875E+01	2.825E+01	3.870E+01	2.830E+01	8.588E-01	3.544E-03	3.079E+12	1.023E+04
7.754E+02	3.688E+01	2.938E+01	3.682E+01	2.943E+01	9.854E-01	3.116E-03	3.439E+12	1.333E+04

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CORRELATION OF POOL BOILING

$Y = A * I^B$

A = 3.498025E-03   B = .7725898   R = .9958382

FILM CONDENSATION CORRELATION

$Y = A * I^B$

A = 1.243539   B = .3167939   R = .9949496

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX E

CALCULATED THERMAL RESISTANCES
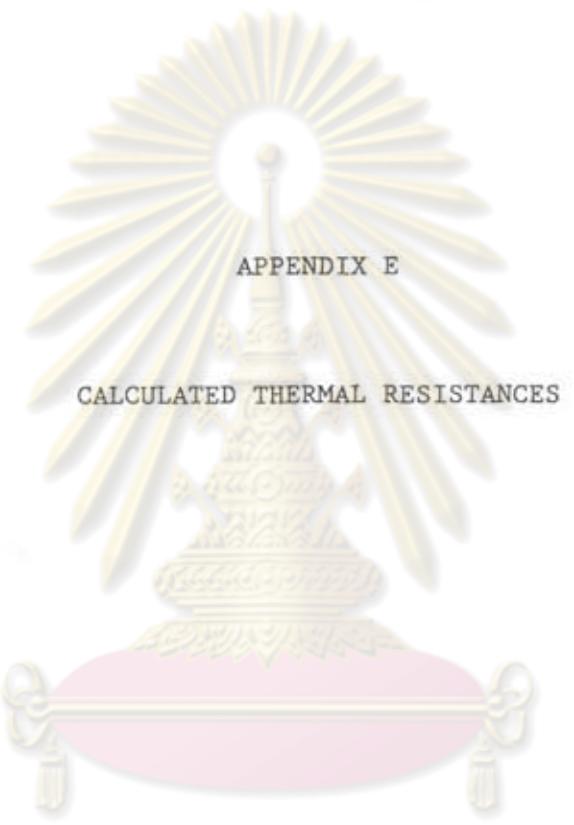
ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c = 40\text{-}20\ ^{\circ}C.$

DATA FROM THE EXPERIMENTS

NO. OF DATA = 6   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
89.70	27.70	38.80	34.80	18.30	19.00	35.00	21.70	34.97	21.73	368.53	5379.33	1681.84	12167.75	3804.22
89.70	38.50	39.10	36.40	18.80	19.40	35.10	21.50	35.07	21.53	338.01	7422.13	2320.51	12131.43	3792.86
89.70	53.70	39.50	39.00	19.30	19.90	35.90	22.10	35.89	22.11	179.17	10332.59	3230.46	12430.59	3886.40
89.70	65.80	39.90	39.50	20.10	20.50	36.40	22.60	36.39	22.61	139.21	12668.96	3960.92	12609.32	3942.27
89.70	75.60	40.00	39.70	18.50	19.00	36.60	21.10	36.59	21.11	151.08	14616.61	4569.85	12155.83	3800.49
89.70	84.50	39.30	39.20	17.20	18.10	37.30	21.40	37.28	21.42	197.23	16611.84	5193.66	12209.50	3817.27

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
1.1863E-01	5.5257E-02	9.9459E-02	3.6089E-02	1.4009E-02	7.7105E-05	1.8272E-02	-1.3351E-02	8.1032E-02	4.9286E-02	7.7105E-05	5.1585E-03	5.9667E+03	1.6204E+04	3.4719E+03	-4.7517E+03	7.8288E+02 1.2872E+03
1.0282E-01	5.7814E-02	8.5243E-02	4.0235E-02	1.2404E-02	7.7104E-05	1.8382E-02	-4.0632E-03	6.6706E-02	4.4144E-02	7.7104E-05	5.1752E-03	6.7392E+03	1.6152E+04	3.4511E+03	-1.5613E+04	9.5102E+02 1.4371E+03
4.6118E-02	9.3005E-02	3.0134E-02	7.7022E-02	1.0943E-02	7.7116E-05	1.8579E-02	4.1961E-02	1.1401E-02	3.4907E-02	7.7105E-05	5.0411E-03	7.6391E+03	1.6582E+04	3.4146E+03	1.5119E+03	5.5641E+03 1.8174E+03
3.9574E-02	1.1422E-01	2.4489E-02	9.9131E-02	1.0120E-02	7.7111E-05	1.8576E-02	5.5814E-02	5.7589E-03	4.3182E-02	7.7097E-05	4.9642E-03	8.2599E+03	1.6838E+04	3.4150E+03	1.1366E+03	1.1016E+04 1.4698E+03
4.0410E-02	1.1734E-01	2.5667E-02	1.0259E-01	9.5790E-03	7.7112E-05	1.8513E-02	5.6905E-02	7.0002E-03	4.5535E-02	7.7099E-05	5.1640E-03	8.7264E+03	1.6187E+04	3.4267E+03	1.1148E+03	9.0625E+03 1.3932E+03
4.7554E-02	9.4862E-02	3.3308E-02	8.0617E-02	9.1059E-03	7.7114E-05	1.8239E-02	4.1831E-02	1.4915E-02	3.8631E-02	7.7104E-05	5.1395E-03	9.1797E+03	1.6264E+04	3.4783E+03	1.5165E+03	4.2533E+03 1.6422E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'Tbc'-Tbc	DELTC/DELTC'Tvh-Tva	Tvc-Tva
36.80	40.14	18.65	19.79	28.24	51.55	39.39	9.08	35.02	6.10	159.56	-29.21	29.21
37.75	39.27	19.10	19.74	28.86	44.33	36.45	4.03	63.54	3.35	136.31	-20.82	20.82
39.25	37.88	19.60	21.18	32.56	24.18	28.37	-3.49	169.08	8.08	272.75	14.77	-14.77
39.70	37.24	20.30	21.90	33.80	23.44	28.62	-4.69	229.56	7.86	326.56	18.11	-18.11
39.85	38.07	18.75	20.51	33.79	22.19	27.99	-4.46	220.43	8.30	296.27	20.72	-20.72
39.25	39.13	17.65	20.37	33.69	24.38	29.03	-0.30	105.52	15.44	365.72	16.03	-16.03

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c = 40\text{-}20\ ^\circ$C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 4   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
70.20	53.90	40.20	39.00	16.70	17.60	38.10	22.10	38.08	22.12	274.02	10863.62	3396.49	9629.34	3010.59
70.20	65.30	40.60	39.60	16.70	17.50	38.60	22.00	38.58	22.02	235.09	13310.71	4161.56	9635.19	3012.42
70.20	75.60	40.80	40.10	17.20	18.00	38.90	22.00	38.88	22.02	236.24	15359.31	4802.06	9634.58	3012.23
70.20	84.50	40.90	40.10	17.00	17.90	39.10	22.60	39.08	22.62	281.91	17280.73	5402.78	9740.86	3045.46

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
7.4017E-02	7.2500E-02	5.6907E-02	5.8390E-02	1.0674E-02	7.7110E-05	1.7996E-02	1.8682E-02	3.8755E-02	3.9554E-02	7.7103E-05	6.4359E-03	7.8312E+03	1.2988E+04	3.5248E+03	3.3958E+03	1.6369E+03 1.6039E+03
5.9370E-02	8.6918E-02	4.3063E-02	7.0611E-02	9.8752E-03	7.7109E-05	1.7948E-02	3.1666E-02	2.4960E-02	3.8791E-02	7.7100E-05	6.4317E-03	8.4646E+03	1.2996E+04	3.5346E+03	2.0034E+03	2.5416E+03 1.6354E+03
5.9159E-02	8.7316E-02	4.3380E-02	7.1537E-02	9.3467E-03	7.7105E-05	1.7902E-02	3.1924E-02	2.5323E-02	3.9460E-02	7.7105E-05	6.4322E-03	8.9433E+03	1.2996E+04	3.5436E+03	1.9872E+03	2.5052E+03 1.6077E+03
7.4473E-02	7.3816E-02	5.9186E-02	5.8529E-02	8.9297E-03	7.7103E-05	1.7836E-02	1.7562E-02	4.1196E-02	4.0813E-02	7.7103E-05	6.3566E-03	9.3609E+03	1.3150E+04	3.5567E+03	3.6122E+03	1.5399E+03 1.5544E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'Tbc'-Tbc		DELTC/DELTC'Tvh-Tva		Tvc-Tva
39.60	41.00	17.15	20.32	33.15	32.77	32.96	3.55	51.65	18.49	278.38	0.57	-0.57
40.20	40.90	17.10	20.47	34.56	27.71	31.14	1.74	69.57	19.72	320.85	10.36	-10.36
40.45	41.07	17.60	20.47	34.65	28.03	31.34	1.53	71.49	16.29	287.13	10.57	-10.57
40.50	41.58	17.45	20.79	34.05	34.30	34.13	2.68	56.36	19.16	284.94	-0.23	0.23

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c = 40-20 \, ^{\circ}C$.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 6   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
57.80	27.70	40.70	36.20	17.90	18.80	36.50	22.40	36.47	22.43	372.63	5532.54	1729.74	7877.67	2462.94
57.80	38.50	41.30	37.10	17.70	18.60	37.40	22.20	37.37	22.23	450.08	7839.22	2450.92	7778.15	2431.82
57.80	53.90	41.90	40.50	17.40	18.40	39.50	22.50	39.48	22.52	284.20	11151.59	3486.52	7964.01	2489.95
57.80	65.80	41.80	40.80	17.70	18.50	39.80	23.00	39.78	23.02	240.73	13609.86	4255.09	8093.37	2530.37
57.80	75.60	42.00	41.30	18.00	18.80	39.60	23.30	39.58	23.32	214.62	15535.93	4857.59	8170.90	2554.61
57.80	84.50	42.40	41.50	17.90	18.70	39.90	23.10	39.88	23.12	263.09	17505.35	5473.01	8096.46	2531.34

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
1.2224E-01	5.9452E-02	1.0062E-01	3.7839E-02	1.3816E-02	7.7107E-05	1.8133E-02	-1.3191E-02	8.2338E-02	5.0876E-02	7.7102E-05	7.7973E-03	6.0503E+03	1.0720E+04	3.4986E+03	-4.8094E+03	7.7047E+02	1.2469E+03
2.5568E-01	5.3749E-02	2.5570E-01	3.3772E-02	1.2072E-02	7.7103E-05	1.7874E-02	-8.2960E-02	2.1767E-01	1.1658E-01	7.7103E-05	7.9048E-03	6.9242E+03	1.0575E+04	3.5493E+03	-7.6469E+02	2.9144E+03	5.4417E+02
7.8317E-02	7.8060E-02	6.0074E-02	5.9817E-02	1.0537E-02	7.7099E-05	1.7780E-02	1.7708E-02	4.2141E-02	4.1955E-02	7.7106E-05	7.7062E-03	7.9332E+03	1.0847E+04	3.5681E+03	3.5824E+03	1.5054E+03	1.5121E+03
6.2042E-02	8.7129E-02	4.4701E-02	6.9788E-02	9.7673E-03	7.7108E-05	1.7757E-02	3.0242E-02	2.6789E-02	3.9392E-02	7.7101E-05	7.5737E-03	8.5582E+03	1.1037E+04	3.5726E+03	2.0977E+03	2.3680E+03	1.6104E+03
5.4049E-02	9.2738E-02	3.7259E-02	7.5948E-02	9.2937E-03	7.7104E-05	1.7843E-02	3.7131E-02	1.9262E-02	3.8663E-02	7.7104E-05	7.4964E-03	8.9943E+03	1.1151E+04	3.5555E+03	1.7085E+03	3.2935E+03	1.6408E+03
6.8780E-02	8.0300E-02	5.2337E-02	6.3856E-02	8.8729E-03	7.7109E-05	1.7761E-02	2.3467E-02	3.3421E-02	4.0235E-02	7.7102E-05	7.5706E-03	9.4208E+03	1.1041E+04	3.5718E+03	2.7033E+03	1.8430E+03	1.5767E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
38.45	41.63	18.35	19.48	29.71	53.06	41.39	8.26	38.04	6.18	138.86	-28.20	28.20
39.20	42.31	18.15	18.62	29.32	120.09	74.70	9.21	33.28	2.61	113.25	-60.75	60.75
41.20	42.46	17.90	20.30	34.43	34.47	34.45	3.05	57.51	13.40	208.94	-0.06	0.06
41.30	42.13	18.10	21.16	35.51	29.50	32.50	2.00	64.49	16.92	266.69	9.25	-9.25
41.65	41.62	18.40	21.88	35.75	27.47	31.61	-0.07	101.38	17.81	301.78	13.09	-13.09
41.95	42.20	18.50	21.10	35.21	32.20	33.71	0.60	89.15	15.27	239.42	4.45	-4.45

For Freon-113, tilt angle 50 degrees, fill ratio 30 %, $T_h - T_c = 40-20\ ^\circ C$

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
57.80	27.70	40.30	37.30	19.20	20.80	34.40	20.30	34.37	20.33	372.05	5322.03	1663.92	7473.15	2336.46
57.80	38.50	40.10	37.30	19.50	20.30	34.50	20.20	34.47	20.23	327.38	7333.24	2292.72	7489.07	2341.44
57.80	53.90	40.60	39.60	19.30	20.10	35.10	20.50	35.08	20.52	216.51	10216.06	3194.03	7633.09	2386.47
57.80	65.60	40.60	39.90	20.00	20.80	35.30	20.70	35.28	20.72	200.96	12479.82	3901.79	7682.62	2401.95
57.80	75.60	41.10	40.50	20.10	20.80	35.30	20.70	35.29	20.71	186.82	14306.13	4472.78	7693.33	2405.30

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HDH	HDC	HIH	HIH'	HIC
1.2512E-01	6.0236E-02	1.0279E-01	3.7898E-02	1.4084E-02	7.7104E-05	1.8475E-02	-1.3909E-02	8.4156E-02	5.1653E-02	7.7104E-05	8.2534E-03	5.9351E+03	1.0128E+04	3.4337E+03	-4.5611E+03	7.5382E+02	1.2282E+03
1.0197E-01	6.4393E-02	8.1254E-02	4.3680E-02	1.2478E-02	7.7103E-05	1.8484E-02	-2.4928E-04	6.2616E-02	4.3775E-02	7.7103E-05	8.2344E-03	6.6990E+03	1.0151E+04	3.4321E+03	-2.5449E+05	1.0131E+03	1.4492E+03
5.7137E-02	8.6504E-02	3.9066E-02	6.7433E-02	1.1004E-02	7.7101E-05	1.8591E-02	3.3224E-02	1.9321E-02	3.4055E-02	7.7101E-05	8.0669E-03	7.5962E+03	1.0362E+04	3.4123E+03	1.9094E+03	3.2835E+03	1.8628E+03
5.3351E-02	9.0358E-02	3.4344E-02	7.2651E-02	1.0196E-02	7.7166E-05	1.8610E-02	3.7708E-02	1.5580E-02	3.4790E-02	7.7136E-05	8.0109E-03	8.1985E+03	1.0435E+04	3.4086E+03	1.6824E+03	4.0719E+03	1.8235E+03
4.9015E-02	9.5831E-02	3.1334E-02	7.8150E-02	9.6816E-03	7.7103E-05	1.8575E-02	4.192E-02	1.2605E-02	3.6070E-02	7.7103E-05	7.9988E-03	8.6339E+03	1.0456E+04	3.4152E+03	1.5131E+03	5.0330E+03	1.7568E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
38.80	39.62	20.00	17.24	27.50	51.59	39.55	2.10	84.35	-13.78	9.82	-30.47	30.47
38.70	38.61	19.90	17.52	28.42	40.69	34.56	-0.22	102.11	-11.98	11.18	-17.75	17.75
40.10	37.50	19.70	18.77	31.06	24.72	27.89	-6.48	208.19	-4.72	46.24	11.36	-11.36
40.25	37.37	20.40	19.10	31.54	23.87	27.71	-7.15	239.09	-6.76	18.77	13.85	-13.85
40.80	37.14	20.45	19.22	31.82	23.09	27.45	-8.98	269.55	-6.03	16.85	15.89	-15.89

For Freon-113, tilt angle 50 degrees, fill ratio 30 %, $T_h - T_c$ = 40-20 $^\circ$C

DATA FROM THE EXPERIMENTS

NO. OF DATA = 6   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH*	REH	REC*	REC
41.70	27.70	40.60	35.50	17.10	17.50	37.50	22.90	37.47	22.93	332.28	5605.18	1752.45	5709.77	1785.15
41.70	38.50	40.20	35.70	17.70	18.70	36.90	22.60	36.87	22.63	435.61	7756.47	2425.04	5589.32	1747.49
41.70	53.90	40.40	39.50	17.90	18.90	38.40	23.30	38.39	23.31	193.70	10816.93	3388.14	5868.74	1834.85
41.70	65.60	40.30	39.40	17.70	18.90	38.60	24.00	38.58	24.02	234.09	13308.27	4160.80	5938.53	1856.67
41.70	75.60	42.10	41.40	18.10	19.10	39.90	23.90	39.88	23.92	204.11	15600.75	4877.54	5945.98	1859.00
41.70	84.50	42.40	41.50	18.10	19.10	40.10	24.00	40.08	24.02	252.57	17555.40	5488.66	5925.31	1852.53

THEORETICAL THERMAL RESISTANCE

RT	RT*	RHP	RHP*	R1	R2	R3	R3*	R5	R5*	R6	R7	HOH	HOC	HIH	HIH*	HIC
1.0540E-01	6.3251E-02	8.1089E-02	4.3939E-02	1.3727E-02	7.7102E-05	1.8013E-02	-5.0204E-04	6.2922E-02	4.4287E-02	7.7102E-05	1.0585E-02	6.0895E+03	7.8967E+03	3.5219E+03	-1.2636E+05	1.0082E+03	1.4325E+03
2.5487E-01	5.5795E-02	2.3190E-01	3.2828E-02	1.2136E-02	7.7107E-05	1.7935E-02	-8.1498E-02	2.1381E-01	1.1417E-01	7.7102E-05	1.0831E-02	6.8879E+03	7.7174E+03	3.5371E+03	-7.7841E+02	2.9670E+02	5.5564E+02
5.3675E-02	9.8919E-02	3.2711E-02	7.7956E-02	1.0687E-02	7.7101E-05	1.8156E-02	4.0715E-02	1.4399E-02	3.7086E-02	7.7101E-05	1.0277E-02	7.8216E+03	8.1338E+03	3.4937E+03	1.5581E+03	4.4059E+03	1.7106E+03
6.2888E-02	8.2392E-02	4.2865E-02	6.2369E-02	9.8761E-03	7.7112E-05	1.7988E-02	2.7678E-02	2.4722E-02	3.4537E-02	7.7104E-05	1.0147E-02	8.4638E+03	8.2379E+03	3.5266E+03	2.2920E+03	2.5660E+03	1.8368E+03
5.4143E-02	9.7797E-02	3.4735E-02	7.8389E-02	9.2748E-03	7.7113E-05	1.7824E-02	3.9584E-02	1.6757E-02	1.8651E-02	7.7103E-05	1.0133E-02	9.0125E+03	8.2490E+03	3.5592E+03	1.6026E+03	3.7858E+03	1.6413E+03
6.7533E-02	8.2776E-02	4.8501E-02	6.3745E-02	8.8604E-03	7.7103E-05	1.7744E-02	2.5307E-02	3.0603E-02	3.3283E-02	7.7103E-05	1.0171E-02	9.4341E+03	8.2182E+03	3.5751E+03	2.5067E+03	2.0730E+03	1.6571E+03

Tbh	Tbh*	Tbc	Tbc*	Tvh	Tvc	Tva	Tbh*-Tbh	DELTH/DELTH*	Tbc*-Tbc	DELTC/DELTC*	Tvh-Tva	Tvc-Tva
38.05	47.03	17.30	19.27	31.49	43.79	37.64	10.47	12.13	11.97	158.71	-16.34	16.34
38.05	42.16	16.20	17.89	29.05	115.68	72.37	10.80	21.87	-1.68	93.50	-59.85	59.85
39.95	40.44	13.40	21.50	34.87	26.13	30.50	1.22	76.04	15.74	244.49	14.33	-14.33
39.35	40.39	18.30	21.61	34.37	29.85	32.10	2.58	54.82	18.08	238.37	7.07	-7.07
41.75	41.77	18.50	21.82	36.25	27.36	31.30	0.05	98.84	17.29	254.59	13.97	-13.97
41.95	42.31	18.60	21.42	35.60	31.78	33.69	0.87	83.55	15.15	209.08	5.67	-5.67

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c$ = 40-20 $^{\circ}$C

DATA FROM THE EXPERIMENTS

NO. OF DATA = 6   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
80.50	27.70	41.50	37.50	20.50	21.50	36.30	22.20	36.27	22.23	404.55	5534.04	1730.20	11003.26	3440.15
80.50	38.50	41.00	38.50	19.60	20.50	36.40	21.60	36.37	21.63	359.99	7621.67	2382.90	10875.57	3400.22
80.50	53.90	41.30	40.10	19.90	20.70	37.10	21.70	37.08	21.72	278.62	10676.26	3337.91	10964.00	3427.87
80.50	65.60	41.50	40.60	19.90	20.80	37.40	21.60	37.38	21.62	257.56	13053.83	4081.25	10953.57	3424.61
80.50	75.60	40.50	39.50	16.50	17.30	39.80	22.90	39.78	22.92	237.34	15615.12	4682.03	11313.02	3536.99
80.50	84.50	41.50	41.00	19.90	20.70	36.90	21.40	36.88	21.42	234.02	16539.08	5170.91	10918.31	3413.59

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
1.3752E-01	5.4339E-02	1.1604E-01	3.4854E-02	1.3814E-02	7.7105E-05	1.8047E-02	-2.3470E-02	9.9839E-02	5.8170E-02	7.7105E-05	5.6713E-03	6.0511E+03	1.4739E+04	3.5153E+03	-2.7029E+03	6.3541E+02	1.0906E+03
1.1331E-01	5.9097E-02	9.5321E-02	4.1112E-02	1.2242E-02	7.7101E-05	1.8145E-02	-8.9011E-03	7.7022E-02	4.9859E-02	7.7101E-05	5.7431E-03	6.8284E+03	1.4555E+04	3.4962E+03	-7.1271E+03	8.2364E+02	1.2724E+03
7.4777E-02	7.1732E-02	5.8317E-02	5.5272E-02	1.0766E-02	7.7110E-05	1.8136E-02	1.6669E-02	4.0027E-02	3.8449E-02	7.7103E-05	5.6932E-03	7.7640E+03	1.4682E+04	3.4979E+03	3.8057E+03	1.5849E+03	1.6500E+03
6.6448E-02	7.7015E-02	5.0778E-02	6.1345E-02	9.9709E-03	7.7106E-05	1.8139E-02	2.3370E-02	3.2484E-02	3.7821E-02	7.7106E-05	5.6990E-03	8.3833E+03	1.4667E+04	3.4975E+03	2.714E+03	1.9529E+03	1.6775E+03
5.8374E-02	8.5931E-02	4.3619E-02	7.1206E-02	9.2704E-03	7.7101E-05	1.7765E-02	3.1504E-02	2.5700E-02	3.9548E-02	7.7101E-05	5.5043E-03	9.0166E+03	1.5186E+04	3.5710E+03	2.0137E+03	2.4685E+03	1.6041E+03
5.7791E-02	8.1078E-02	4.2946E-02	6.6254E-02	9.1256E-03	7.7102E-05	1.8271E-02	2.9864E-02	2.4521E-02	3.6215E-02	7.7102E-05	5.7189E-03	9.1598E+03	1.4611E+04	3.4721E+03	2.1242E+03	2.5871E+03	1.7517E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
39.50	41.36	21.00	19.93	28.97	62.56	45.76	5.96	57.60	-5.12	52.76	-36.70	36.70
39.75	40.78	20.05	19.55	29.84	49.31	39.58	2.58	76.55	-2.49	75.63	-24.60	24.60
40.70	40.14	20.30	20.13	32.03	32.84	32.43	-1.39	118.59	-0.86	88.95	-1.26	1.26
41.15	40.00	20.35	20.15	32.71	30.01	31.36	-2.79	144.05	-1.00	86.00	4.30	-4.30
40.15	41.97	16.85	21.57	35.57	29.04	32.30	4.54	16.11	28.03	455.85	10.09	-10.39
41.25	39.07	20.30	20.38	32.61	27.18	29.89	-5.29	200.60	-1.10	83.17	9.08	-9.08

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c$ = 35-25 °C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 6   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
57.80	27.70	35.40	33.40	24.70	25.40	32.00	25.30	31.78	25.32	205.92	4968.03	1555.24	8573.33	2680.43
57.80	38.50	35.50	33.60	24.30	25.00	32.40	25.30	32.38	25.32	243.47	6967.67	2178.43	8546.63	2672.09
57.80	53.90	35.50	35.00	24.20	24.90	32.80	25.40	32.77	25.41	143.47	9697.71	3031.97	8632.57	2698.95
57.80	65.80	35.50	35.40	24.30	25.00	32.50	25.30	32.49	25.31	106.91	11703.31	3859.01	8641.82	2701.85
57.80	75.60	35.50	35.30	24.20	24.90	32.60	25.30	32.59	25.31	125.25	13489.57	4217.49	8629.47	2697.98
57.80	84.50	35.60	35.30	24.20	25.00	32.60	25.30	32.59	25.31	159.09	15117.96	4726.60	8605.54	2690.50

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
5.7126E-02	5.4230E-02	3.5435E-02	3.2537E-02	1.4574E-02	7.7102E-05	1.8876E-02	1.7494E-02	1.6402E-02	1.4889E-02	7.7102E-05	7.1186E-03	5.7354E+03	1.1742E+04	3.3608E+03	3.6263E+03	3.8677E+03 4.2608E+03
6.5569E-02	4.9103E-02	4.5648E-02	2.9162E-02	1.2799E-02	7.7102E-05	1.8766E-02	1.0586E-02	2.6727E-02	1.8421E-02	7.7102E-05	7.1425E-03	6.5309E+03	1.1703E+04	3.3805E+03	5.9925E+03	2.3736E+03 3.4438E+03
4.4693E-02	6.8201E-02	2.6334E-02	4.9842E-02	1.1293E-02	7.7106E-05	1.9190E-02	3.0856E-02	2.9897E-03	1.8932E-02	7.7106E-05	7.0661E-03	7.4020E+03	1.1830E+04	3.3058E+03	2.0560E+03	9.0760E+03 3.3687E+03
4.0266E-02	8.3931E-02	2.2675E-02	6.7346E-02	1.0527E-02	7.7107E-05	1.9457E-02	4.1682E-02	3.0639E-03	2.5510E-02	7.7107E-05	7.0580E-03	7.9406E+03	1.1843E+04	3.2605E+03	1.5220E+03	2.0705E+04 2.4868E+03
4.0787E-02	7.5321E-02	2.3951E-02	5.8283E-02	9.9687E-03	7.7116E-05	1.9282E-02	3.6345E-02	4.5151E-03	2.1784E-02	7.7101E-05	7.0689E-03	8.3852E+03	1.1825E+04	3.2901E+03	1.7455E+03	1.4050E+04 2.9121E+03
4.4306E-02	6.2518E-02	2.7674E-02	4.5886E-02	9.5424E-03	7.7114E-05	1.9123E-02	2.8149E-02	8.3969E-03	1.7583E-02	7.7102E-05	7.0900E-03	8.7599E+03	1.1790E+04	3.3174E+03	2.2537E+03	7.5550E+03 3.6079E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'Tbc'-Tbc		DELTC/DELTC'Tvh-Tva	Tvc-Tva
34.40	34.98	25.05	23.85	28.10	28.67	28.38	1.70	80.44	-4.77	17.30 -1.00	1.00
34.55	35.49	24.65	23.58	27.81	31.80	29.80	2.71	69.63	-4.34	37.79 -6.68	6.68
35.25	34.50	24.55	24.36	29.94	26.48	28.21	-2.13	144.12	-0.76	82.03 6.14	-6.14
35.45	33.85	24.65	24.56	30.41	25.66	28.04	-5.07	255.82	-0.37	87.69 8.48	-8.48
35.40	33.87	24.55	24.43	30.18	25.90	28.04	-4.32	220.11	-0.49	86.40 7.62	-7.62
35.45	34.14	24.60	24.19	29.55	26.67	28.11	-3.70	185.29	-1.58	62.85 5.11	-5.11

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c = 30-25$ °C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 6   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
57.80	27.70	30.40	30.30	24.80	25.50	29.10	25.70	28.09	25.71	96.62	4513.47	1411.13	8727.96	2728.78
57.80	38.50	30.90	30.60	24.30	25.00	28.10	24.80	28.09	24.81	115.57	6278.18	1962.86	8538.46	2669.53
57.80	53.70	29.90	29.80	25.60	26.30	27.10	26.20	27.09	26.21	103.68	8574.19	2680.70	8821.85	2758.13
57.80	65.80	29.60	29.50	23.80	24.50	27.50	25.00	27.49	25.01	106.96	10551.73	3298.97	8579.33	2682.31
57.80	75.60	30.40	30.30	24.20	24.90	28.00	25.30	27.99	25.31	109.59	12247.98	3829.30	8640.97	2701.58
57.80	84.50	30.00	29.90	24.40	25.10	27.00	24.80	26.99	24.81	111.99	13397.48	4188.69	8540.02	2670.02

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIN'	HIC
4.4630E-02	4.7112E-02	2.2357E-02	2.4840E-02	1.5290E-02	7.7107E-05	1.9699E-02	2.0808E-02	2.5033E-03	3.8774E-03	7.7107E-05	6.9832E-03	5.4671E+03	1.1970E+04	3.2203E+03	3.0488E+03	2.5342E+04	1.6361E+04
4.4107E-02	4.9187E-02	2.3474E-02	2.8554E-02	1.3483E-02	7.7106E-05	1.9651E-02	2.2089E-02	3.6689E-03	6.3106E-03	7.7106E-05	7.1499E-03	6.1998E+03	1.1691E+04	3.2282E+03	2.8719E+03	1.7291E+04	1.0053E+04
3.9091E-02	2.7593E-02	2.0178E-02	8.6806E-03	1.2009E-02	7.7100E-05	1.9900E-02	1.4191E-02	1.2584E-04	-5.6643E-03	7.7100E-05	6.9034E-03	6.9603E+03	1.2108E+04	3.1878E+03	4.4704E+03	5.1228E+05	-1.1200E+04
4.1231E-02	4.1575E-02	2.3031E-02	2.3373E-02	1.1086E-02	7.7107E-05	1.9824E-02	1.9887E-02	3.0534E-03	3.3318E-03	7.7107E-05	7.1133E-03	7.5401E+03	1.1751E+04	3.2001E+03	3.1899E+03	2.0776E+04	1.9040E+04
4.3679E-02	4.2157E-02	2.3159E-02	2.4637E-02	1.0461E-02	7.7102E-05	1.9755E-02	2.0385E-02	3.2498E-03	4.0979E-03	7.7102E-05	7.0588E-03	7.9903E+03	1.1842E+04	3.2112E+03	3.1120E+03	1.9521E+04	1.5481E+04
3.7540E-02	3.6929E-02	2.0355E-02	1.9645E-02	1.0136E-02	7.7101E-05	1.9826E-02	1.9597E-02	2.7495E-04	-1.0641E-04	7.7101E-05	7.1485E-03	8.2465E+03	1.1693E+04	3.1998E+03	3.2372E+03	2.3073E+05	-5.9616E+05

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'Tbc'-Tbc		DELTC/DELTC'Tvh-Tva	Tvc-Tva
30.35	29.60	25.15	25.04	26.19	25.97	26.08	-2.47	149.95	-0.43	83.48	0.41	-0.41
30.75	29.67	24.65	24.00	25.82	25.26	25.54	-3.50	168.30	-2.65	18.65	1.10	-1.10
29.85	28.37	25.95	25.50	25.03	26.21	25.62	-4.97	216.90	-1.74	35.68	-2.31	2.31
27.55	28.71	24.15	24.22	25.37	25.36	25.36	-2.84	169.13	0.28	108.50	0.03	-0.03
30.35	29.18	24.55	24.55	25.83	25.69	25.76	-3.91	201.77	0.00	100.00	0.27	-0.27
29.75	28.16	24.75	24.01	24.77	24.82	24.80	-5.97	253.73	-3.98	6.34	-0.10	0.10

For Freon-113, tilt angle 50 degrees, fill ratio 30%.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 7   TYPE OF FREON : FREON 113

FC	FW	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
70.20	38.50	35.90	34.30	24.70	25.40	32.20	25.30	32.18	25.32	258.56	6936.68	2168.74	10419.01	3257.48
89.70	38.50	35.60	34.00	24.90	25.60	32.00	25.60	31.98	25.62	268.63	6935.75	2168.45	13427.91	4198.21
20.20	38.50	36.00	34.47	28.71	29.86	33.52	30.27	33.51	30.28	170.64	7057.68	2206.57	3286.76	1027.60
39.70	38.50	36.20	34.77	29.21	30.06	33.54	30.50	33.53	30.51	184.50	7072.82	2211.30	6585.71	2058.38
57.80	38.50	35.70	34.17	29.91	30.86	33.74	31.46	33.72	31.48	236.52	7145.70	2234.09	9801.08	3064.29
76.50	38.50	36.40	34.87	29.51	30.46	33.74	30.85	33.72	30.87	273.46	7178.11	2244.22	12828.72	4010.87
95.50	38.50	36.10	34.47	30.11	31.06	33.97	31.63	33.95	31.65	318.97	7249.53	2266.55	16292.05	5093.67

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
6.2936E-02	4.7664E-02	4.4196E-02	2.8924E-02	1.2828E-02	7.7106E-05	1.8802E-02	1.1224E-02	3.5240E-02	1.7545E-02	7.7106E-05	5.9127E-03	6.5164E+03	1.4137E+04	3.3741E+03	5.6520E+03	2.5134E+03	3.6157E+03
7.1546E-02	4.1293E-02	5.4080E-02	2.3825E-02	1.2628E-02	7.7109E-05	1.8804E-02	3.7397E-03	3.5122E-02	1.9931E-02	7.7102E-05	4.6395E-03	6.5159E+03	1.8017E+04	3.3737E+03	1.6964E+04	1.8063E+03	3.1830E+03
5.7935E-02	4.9292E-02	2.7689E-02	1.9046E-02	1.2718E-02	7.7103E-05	1.8655E-02	1.4425E-02	8.8794E-03	4.4668E-03	7.7105E-05	1.7529E-02	6.5727E+03	4.7688E+03	3.4006E+03	4.3978E+03	7.1445E+03	1.4202E+04
5.1827E-02	3.3210E-02	3.0094E-02	1.6477E-02	1.2704E-02	7.7100E-05	1.8683E-02	1.1959E-02	1.1256E-02	4.3638E-03	7.7100E-05	9.0293E-03	6.5797E+03	9.2577E+03	3.3954E+03	5.3047E+03	5.6360E+03	1.4537E+04
6.0336E-02	2.8446E-02	4.1529E-02	9.6398E-03	1.2640E-02	7.7110E-05	1.8519E-02	2.6512E-03	2.2856E-02	6.8344E-03	7.7102E-05	6.1668E-03	6.6133E+03	1.3555E+04	3.4256E+03	2.3928E+04	2.7756E+03	9.2823E+03
7.0463E-02	2.7959E-02	5.3072E-02	1.0569E-02	1.2611E-02	7.7100E-05	1.8531E-02	-2.6526E-03	3.4387E-02	1.3067E-02	7.7100E-05	4.7795E-03	6.6282E+03	1.7489E+04	3.4233E+03	-2.3915E+04	1.9449E+03	4.8550E+03
8.5943E-02	2.3685E-02	6.9594E-02	7.3361E-03	1.2549E-02	7.7102E-05	1.8443E-02	-1.2620E-02	5.0998E-02	1.9802E-02	7.7102E-05	3.7995E-03	6.6605E+03	2.2000E+04	3.4398E+03	-5.0269E+03	1.2440E+03	3.2037E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
35.10	35.24	25.05	23.91	27.70	31.31	29.50	0.40	95.37	-4.55	17.98	-6.13	6.13
34.80	35.43	25.25	24.37	26.93	35.02	30.97	1.80	81.70	-3.49	28.43	-13.06	13.06
35.24	35.66	29.29	27.30	30.32	31.77	31.05	1.21	80.04	-6.78	33.14	-2.33	2.33
35.49	35.86	29.63	26.86	30.08	32.56	31.32	1.06	83.34	-2.41	52.78	-3.96	3.96
34.95	36.73	30.39	30.03	29.34	36.85	33.09	5.06	40.22	-1.18	75.00	-11.34	11.34
35.64	37.17	29.99	29.57	28.65	40.24	34.44	4.30	55.31	-1.38	67.68	-16.82	16.82
35.29	37.95	30.59	30.44	28.06	47.88	37.97	7.56	33.01	-0.48	87.78	-26.09	26.09

For Freon-113, tilt angle 50 degrees, fill ratio 30%, $T_h - T_c = 35\text{-}30\ ^\circ$C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 113

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
95.50	17.90	35.40	33.97	29.31	30.06	33.27	30.70	33.25	30.72	202.16	3305.93	1033.59	16043.02	5015.82
95.50	34.80	35.50	33.97	29.51	30.46	33.69	31.08	33.67	31.10	298.64	6474.23	2024.15	16118.50	5039.41
95.50	51.20	35.40	36.17	29.21	29.96	33.44	30.27	33.47	30.28	67.16	9246.57	2890.92	15986.60	4998.18
95.50	69.90	36.40	35.97	29.51	30.36	33.62	30.80	33.60	30.82	231.24	12867.42	4022.97	16067.47	5023.46
95.50	86.90	36.40	35.97	29.41	30.36	33.62	30.73	33.60	30.75	266.28	16017.71	5007.90	16020.26	5008.70

THEORETICAL THERMAL RESISTANCE

RT	RT	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
5.4371E-02	3.3537E-02	3.3547E-02	1.2713E-02	1.6961E-02	7.7102E-05	1.8670E-02	8.3333E-03	1.4723E-02	4.2252E-03	7.7102E-05	3.8626E-03	4.9282E+03	2.1641E+04	3.3979E+03	7.6126E+03	4.3089E+03 1.5015E+04
7.8861E-02	2.5694E-02	6.1907E-02	9.7396E-03	1.3111E-02	7.7101E-05	1.8508E-02	-8.0081E-03	4.3245E-02	1.6593E-02	7.7101E-05	3.8433E-03	6.3754E+03	2.1750E+04	3.4277E+03	-7.9218E+03	1.4670E+03 3.8231E+03
3.6521E-02	6.2572E-02	2.1150E-02	4.7301E-02	1.1494E-02	7.7078E-05	1.7611E-02	3.2423E-02	1.3845E-03	1.4424E-02	7.7106E-05	3.8772E-03	7.2722E+03	2.1559E+04	3.2349E+03	1.9566E+03	4.5821E+04 4.3381E+03
5.4353E-02	2.6164E-02	4.0384E-02	1.2195E-02	1.0113E-02	7.7106E-05	1.8558E-02	4.5375E-03	2.1671E-02	7.5034E-03	7.7106E-05	3.8564E-03	8.2658E+03	2.1676E+04	3.4184E+03	1.3981E+04	2.9273E+03 8.4547E+03
6.3970E-02	2.4024E-02	5.0800E-02	1.0853E-02	9.3021E-03	7.7102E-05	1.8560E-02	-1.3489E-03	3.2086E-02	1.2048E-02	7.7102E-05	3.8685E-03	8.9861E+03	2.1608E+04	3.4181E+03	-4.7031E+04	1.9771E+03 5.2655E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
34.69	36.67	29.69	29.89	29.48	33.66	31.57	5.72	41.62	0.69	125.20	-6.62	6.62
34.74	37.53	29.99	29.96	28.14	42.98	36.06	8.21	26.83	-0.09	97.66	-21.96	21.96
35.79	34.24	29.59	29.98	32.12	30.40	31.76	-4.33	294.57	1.34	238.53	2.75	-2.75
36.19	35.99	29.94	29.94	29.51	35.80	32.55	-0.55	108.41	0.00	100.00	-9.96	9.96
36.19	36.12	29.89	29.72	28.66	39.26	33.96	-0.18	102.66	-0.54	83.96	-15.61	15.61

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 40\text{-}20\ ^\circ C.$

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
72.30	17.90	39.90	36.77	19.30	20.94	28.76	21.66	28.73	21.69	363.90	3111.81	972.90	9751.86	3048.90
72.30	32.40	40.00	37.57	19.50	21.24	31.95	22.70	31.92	22.73	426.00	5969.84	1866.46	9957.01	3113.04
72.30	48.40	39.80	37.57	19.30	21.14	33.61	23.17	33.57	23.21	501.70	9202.22	2877.05	10014.67	3131.06
72.30	63.80	40.10	39.17	18.90	20.64	32.85	22.64	32.82	22.67	385.40	11725.01	3665.80	9969.79	3117.03
72.30	79.30	39.90	39.17	18.90	20.54	33.61	23.12	33.58	23.15	367.70	14766.55	4616.73	10099.99	3157.74

THEORETICAL THERMAL RESISTANCE

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RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
4.2716E-02	4.3364E-02	1.8865E-02	1.9511E-02	1.7480E-02	7.7106E-05	8.0296E-03	8.3240E-03	1.0679E-02	1.1033E-02	7.7101E-05	6.3725E-03	4.7819E+03	1.3117E+04	7.9006E+03	7.6212E+03	5.9403E+03
4.1861E-02	4.1492E-02	2.2084E-02	2.1714E-02	1.3547E-02	7.7104E-05	8.1443E-03	7.9899E-03	1.3785E-02	1.3570E-02	7.7104E-05	6.2311E-03	6.1704E+03	1.3415E+04	7.7894E+03	7.9399E+03	4.6020E+03	4.6751E+03
4.4323E-02	3.8449E-02	2.6684E-02	2.0809E-02	1.1447E-02	7.7100E-05	8.2497E-03	5.3432E-03	1.8280E-02	1.5312E-02	7.7104E-05	6.1925E-03	7.3024E+03	1.3499E+04	7.6898E+03	1.1873E+04	3.4704E+03	4.1431E+03
3.6971E-02	4.3190E-02	2.0273E-02	2.6492E-02	1.0475E-02	7.7106E-05	8.1037E-03	1.1184E-02	1.2015E-02	1.5154E-02	7.7106E-05	6.2225E-03	7.9796E+03	1.3433E+04	7.8283E+03	5.6724E+03	5.2799E+03	4.1863E+03
3.5407E-02	4.4248E-02	1.9687E-02	2.8529E-02	9.5834E-03	7.7103E-05	8.1004E-03	1.2490E-02	1.1433E-02	1.5884E-02	7.7103E-05	6.1362E-03	8.7224E+03	1.3622E+04	7.8316E+03	5.0790E+03	5.5488E+03	3.9938E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH	Tbc'-Tbc	DELTC/DELTC	Tvh-Tva	Tvc-Tva
38.34	35.14	20.12	19.56	25.81	25.60	25.70	-8.33	150.04	-3.80	66.82	0.43	-0.42
38.79	37.75	20.37	20.06	28.45	28.58	28.51	-2.47	117.83	-1.54	88.16	-0.23	0.23
58.68	39.31	20.22	20.07	29.43	32.35	30.89	1.63	88.96	-0.72	95.29	-4.72	4.72
39.63	36.91	19.77	20.23	29.70	27.32	28.51	-6.88	167.27	2.30	118.85	4.16	-4.16
39.54	37.17	19.72	20.84	30.60	27.37	28.97	-5.99	166.52	5.70	149.33	5.57	-5.57

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 40\text{-}20\ ^\circ C$.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 4   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
24.20	34.60	40.20	37.37	19.00	22.14	34.83	27.60	34.80	27.83	361.70	6666.63	2084.31	3595.47	1124.12
48.80	34.60	40.20	37.67	19.30	21.54	33.41	24.83	33.38	24.86	409.80	6531.96	2042.20	6988.12	2184.82
72.30	34.60	40.00	37.37	18.90	20.54	32.28	22.44	32.25	22.47	436.40	6415.68	2005.85	9865.32	3090.62
96.30	34.60	40.00	37.17	19.20	20.34	32.42	21.63	32.39	21.66	432.40	6428.95	2010.00	13015.18	4069.17

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
5.0511E-02	4.9183E-02	2.1317E-02	1.9989E-02	1.2922E-02	7.7106E-05	8.1259E-03	7.5012E-03	1.3037E-02	1.2334E-02	7.7106E-05	1.6272E-02	6.4688E+03	5.1370E+03	7.8070E+03	8.4571E+03	4.8661E+03 5.1436E+03
4.4176E-02	4.2676E-02	2.2437E-02	2.0937E-02	1.3054E-02	7.7104E-05	8.1772E-03	7.4831E-03	1.4106E-02	1.3320E-02	7.7104E-05	8.6852E-03	6.4036E+03	9.6244E+03	7.7580E+03	8.5003E+03	4.4973E+03 4.7627E+03
4.2010E-02	1.9605E-02	2.2560E-02	1.5421E-04	1.3171E-02	7.7107E-05	8.1683E-03	0.0000E+00	1.4238E-02	0.0000E+00	7.7103E-05	6.2798E-03	6.3467E+03	1.3311E+04	7.7664E+03	0.0000E+00	4.4557E+03 0.0000E+00
4.0058E-02	4.2951E-02	2.2060E-02	2.4954E-02	1.3157E-02	7.7106E-05	8.1841E-03	9.5993E-03	1.3722E-02	1.5200E-02	7.7106E-05	4.8406E-03	6.3532E+03	1.7268E+04	7.7514E+03	6.6087E+03	4.6232E+03 4.1735E+03

Tbh	Tbh'	Ttc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
38.79	39.48	20.57	21.70	31.86	32.31	32.09	1.80	84.99	5.50	119.17	-0.70	0.70
38.93	38.78	20.42	21.25	30.03	30.61	30.32	-0.40	102.88	4.09	123.33	-0.97	0.97
38.58	38.07	19.72	19.71	28.68	28.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38.59	38.14	19.77	19.55	28.35	27.62	28.24	-1.16	107.85	-1.10	89.54	2.17	-2.17

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35-30$ °C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 4   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
26.20	38.50	35.40	34.77	29.21	30.86	33.30	31.47	33.29	31.48	119.70	6986.65	2184.36	3405.86	1064.83
39.70	38.50	35.50	34.77	29.71	29.66	32.69	30.54	32.69	30.54	62.49	6851.72	2142.17	6663.24	2083.25
57.80	38.50	35.40	34.67	28.91	30.16	32.27	29.91	32.25	29.93	208.70	6922.83	2154.41	9498.96	2969.83
76.50	38.50	35.20	34.47	28.91	30.06	32.01	29.66	31.99	29.68	241.40	6912.30	2161.11	12525.22	3915.98

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
4.1146E-02	4.4943E-02	1.1492E-02	1.5286E-02	1.2782E-02	7.7091E-05	7.5670E-03	9.3351E-03	3.7705E-03	5.7989E-03	7.7107E-05	1.6873E-02	6.5397E+03	4.9541E+03	8.3856E+03	6.7957E+03	1.6825E+04	1.0940E+04
3.1316E-02	5.6226E-02	9.4953E-03	3.4405E-02	1.2907E-02	7.7100E-05	7.4416E-03	1.9680E-02	1.2995E-03	1.4572E-02	7.7100E-05	8.9139E-03	6.4765E+03	9.3775E+03	8.5249E+03	3.2236E+03	3.3397E+04	4.3536E+03
3.3494E-02	3.0526E-02	1.4277E-02	1.1388E-02	1.2840E-02	7.7116E-05	7.5988E-03	6.1863E-03	8.5238E-03	4.9676E-03	7.7107E-05	6.3771E-03	6.5099E+03	1.3108E+04	8.3485E+03	1.0255E+04	9.7242E+03	1.2770E+04
3.3551E-02	2.7489E-02	1.5797E-02	9.7549E-03	1.2850E-02	7.7100E-05	7.7110E-03	4.7349E-03	7.9518E-03	4.8458E-03	7.7100E-05	4.9036E-03	6.5050E+03	1.7047E+04	8.2270E+03	1.3398E+04	7.9980E+03	1.3092E+04

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'Tbc'-Tbc	DELTC/DELTC'Tvh-Tva	Tvc-Tva	
35.09	34.86	30.04	29.47	32.39	31.96	32.17	-0.64	114.32	-1.88	71.76	0.66	-0.66
35.14	33.52	29.69	29.96	32.22	30.69	31.46	-4.59	294.00	0.94	148.44	2.43	-2.43
35.04	34.97	29.54	28.60	30.67	31.26	30.96	-0.18	102.38	-3.18	28.52	-0.95	0.95
34.84	35.08	29.49	28.49	30.13	31.57	30.85	0.70	92.06	-3.36	15.00	-2.33	2.33

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35-30\ {}^\circ$C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 4   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
20.20	38.50	35.80	34.97	29.41	30.66	33.15	31.42	33.14	31.43	118.90	6964.61	2177.47	5402.76	1063.87
39.70	38.50	36.00	35.17	29.51	30.86	33.15	30.89	33.14	30.90	177.80	7016.51	2193.64	6842.40	2076.73
57.80	38.50	35.80	35.17	29.61	30.76	32.54	30.64	32.53	30.65	188.60	6942.86	2170.67	9662.49	3020.96
76.50	38.50	35.90	35.27	29.71	30.76	32.39	30.56	32.37	30.38	217.40	6947.10	2171.99	12730.22	3980.07

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
4.0757E-02	4.4241E-02	1.1066E-02	1.4550E-02	1.2802E-02	7.7096E-05	7.1979E-03	8.8193E-03	3.7135E-03	5.5766E-03	7.7096E-05	1.6889E-02	6.5294E+03	4.9493E+03	8.8135E+03	7.1932E+03	1.7083E+04	1.1576E+04
3.4784E-02	3.4410E-02	1.3085E-02	1.2711E-02	1.2755E-02	7.7109E-05	7.4925E-03	7.5825E-03	5.4383E-03	5.1741E-03	7.7099E-05	8.9438E-03	6.5535E+03	9.3461E+03	8.4669E+03	8.5930E+03	1.1665E+04	1.2261E+04
3.2686E-02	2.9158E-02	1.3602E-02	1.0074E-02	1.2822E-02	7.7103E-05	7.6002E-03	5.9081E-03	5.8481E-03	4.0119E-03	7.7103E-05	6.2615E-03	6.5193E+03	1.3350E+04	8.3470E+03	1.0738E+04	1.0848E+04	1.5813E+04
3.2489E-02	2.6975E-02	1.4852E-02	9.3376E-03	1.2818E-02	7.7101E-05	7.6579E-03	4.9648E-03	7.0397E-03	4.2166E-03	7.7101E-05	4.8191E-03	6.5212E+03	1.7346E+04	8.2841E+03	1.2778E+04	9.0116E+03	1.5038E+04

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH	Tbc'-Tbc	DELTC/DELTC	Tvh-Tva	Tvc-Tva
35.59	34.67	30.04	29.43	32.29	31.90	32.09	-1.95	144.78	-2.00	69.71	0.60	-0.60
35.59	35.44	30.19	29.31	31.80	31.84	31.82	-0.41	106.41	-2.68	44.76	-0.06	0.06
35.49	34.99	30.19	29.48	31.09	31.73	31.41	-1.40	120.21	-2.33	39.33	-1.02	1.02
35.59	35.20	30.24	29.33	30.71	31.88	31.29	-1.08	113.66	-3.00	12.11	-1.87	1.87

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35-30$ °C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
57.80	17.90	35.60	33.77	29.61	30.56	31.89	30.89	31.88	30.90	182.20	3207.60	1002.85	9717.74	3038.23
57.80	34.60	34.90	33.37	29.21	30.16	32.97	31.11	32.95	31.13	224.20	6324.30	1977.28	9732.31	3042.79
57.80	51.30	35.70	34.37	29.41	30.46	33.90	31.64	33.88	31.66	267.60	9536.19	2981.47	9812.96	3068.00
57.80	69.90	35.80	35.37	30.01	30.96	33.65	31.74	33.64	31.75	175.60	12803.27	4002.91	9892.69	3092.93
57.80	86.90	35.70	35.37	29.91	30.86	33.70	31.67	33.69	31.68	173.70	15908.96	4973.90	9878.89	3088.61

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
3.6693E-02	2.8930E-02	1.3251E-02	5.4885E-03	1.7218E-02	7.7110E-05	7.5011E-03	3.7062E-03	5.5957E-03	1.6281E-03	7.7100E-05	6.2234E-03	4.8547E+03	1.3431E+04	8.4573E+03	1.7117E+04	1.1337E+04	3.8965E+04
-3.4851E-02	2.7774E-02	1.5373E-02	8.2962E-03	1.3265E-02	7.7111E-05	7.6673E-03	4.1952E-03	7.5515E-03	3.9467E-03	7.7102E-05	6.2134E-03	6.5016E+03	1.3453E+04	8.2739E+03	1.5122E+04	8.4008E+03	1.6074E+04
3.5280E-02	2.5924E-02	1.7802E-02	8.4454E-03	1.1320E-02	7.7106E-05	7.7766E-03	3.1578E-03	9.8708E-03	5.1335E-03	7.7106E-05	6.1588E-03	7.5846E+03	1.3572E+04	8.1576E+03	2.0090E+04	6.4269E+03	1.2356E+04
2.9414E-02	2.7121E-02	1.3170E-02	1.0877E-02	1.0138E-02	7.7119E-05	7.5249E-03	6.4683E-03	3.4911E-03	4.2545E-03	7.7109E-05	6.1057E-03	8.2453E+03	1.3691E+04	8.4305E+03	9.8077E+03	1.1553E+04	1.4911E+04
2.8548E-02	2.7135E-02	1.3099E-02	1.1687E-02	9.3337E-03	7.7107E-05	7.5457E-03	6.9280E-03	5.3995E-03	4.6046E-03	7.7107E-05	6.1148E-03	8.9557E+03	1.3670E+04	8.4073E+03	9.1569E+03	1.1749E+04	1.3777E+04

Tth	Tbh'	Tbc	Tbc'	Tvb	Tvc	Tva	Tbh'-Tth	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
34.68	35.01	30.09	29.78	30.51	31.89	31.20	0.93	89.68	-1.02	72.36	-2.22	2.22
34.14	35.92	29.69	29.70	31.23	32.79	32.01	5.22	39.52	0.05	101.12	-2.43	2.43
35.04	36.90	29.94	29.96	31.80	34.27	33.01	5.33	37.81	0.09	101.68	-3.74	3.74
35.59	35.45	30.49	30.64	32.32	32.69	32.50	-0.38	107.55	0.52	114.55	-0.57	0.57
35.54	35.35	30.39	30.58	32.38	32.59	32.48	-0.53	111.38	0.64	117.81	-0.33	0.33

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35\text{-}30\ °C.$

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
57.80	17.90	35.60	33.77	29.21	30.26	31.79	30.36	31.78	30.37	194.30	3207.67	1002.87	9600.90	3001.70
57.80	34.60	35.60	34.67	28.91	30.16	32.47	30.29	32.45	30.31	217.10	6256.84	1956.19	9571.84	2992.62
57.30	51.20	35.80	35.07	29.01	30.26	32.94	30.54	32.92	30.56	227.90	9319.05	2913.58	9615.92	3006.40
57.80	69.90	35.90	35.57	28.91	30.16	32.67	30.26	32.65	30.28	198.20	12588.68	3935.82	9577.63	2994.42
57.80	86.90	35.90	35.67	28.91	30.26	32.74	30.28	32.72	30.30	203.80	15655.61	4894.69	9578.32	2994.64

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
3.7238E-02	3.0892E-02	1.3716E-02	7.3598E-03	1.7218E-02	7.7099E-05	7.5609E-03	4.4630E-03	6.0008E-03	2.7425E-03	7.7099E-05	6.3045E-03	4.8548E+03	1.3259E+04	8.3903E+03	1.4214E+04	1.0572E+04	2.3131E+04
3.4491E-02	2.9702E-02	1.4830E-02	1.0041E-02	1.3336E-02	7.7102E-05	7.6694E-03	5.3395E-03	7.0064E-03	4.5477E-03	7.7102E-05	6.3251E-03	6.2681E+03	1.3216E+04	8.2716E+03	1.1881E+04	9.0544E+03	1.3949E+04
3.3166E-02	2.8275E-02	1.5422E-02	1.0531E-02	1.1450E-02	7.7114E-05	7.7096E-03	5.3283E-03	7.5586E-03	5.0464E-03	7.7104E-05	6.2940E-03	7.3005E+03	1.3281E+04	8.2285E+03	1.1906E+04	8.3929E+03	1.2566E+04
3.0485E-02	2.6704E-02	1.3941E-02	1.2159E-02	1.0224E-02	7.7102E-05	7.6065E-03	6.7822E-03	6.1799E-03	5.2230E-03	7.7102E-05	6.3210E-03	8.1762E+03	1.3224E+04	8.3401E+03	9.3536E+03	1.0265E+04	1.2148E+04
2.9934E-02	2.7800E-02	1.4205E-02	1.2071E-02	9.4086E-03	7.7099E-05	7.6185E-03	6.6138E-03	6.4326E-03	5.3026E-03	7.7108E-05	6.3205E-03	8.8944E+03	1.3225E+04	8.3269E+03	9.5918E+03	9.8620E+03	1.1964E+04

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
34.68	35.11	29.74	29.15	30.31	31.51	30.91	1.22	87.23	-1.95	51.86	-1.95	1.95
35.13	35.34	29.54	28.94	30.79	31.80	31.29	0.58	92.94	-2.02	55.82	-1.62	1.62
35.43	35.52	29.64	29.12	31.17	32.25	31.71	0.24	96.66	-1.73	63.88	-1.71	1.71
35.74	34.73	29.54	29.02	31.15	31.47	31.31	-2.82	148.97	-1.73	58.69	-0.52	0.52
35.79	34.69	29.59	29.01	31.17	31.58	31.38	-3.06	156.04	-1.94	54.79	-0.65	0.65

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35-25\ °C$.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
20.30	38.50	35.30	33.77	24.81	26.95	32.79	29.25	32.77	29.27	212.80	6994.18	2186.72	3201.67	1000.99
41.70	38.50	35.40	33.57	24.61	26.25	31.73	27.59	31.71	27.61	256.80	6888.53	2153.68	6443.28	2014.48
64.20	38.50	35.50	34.17	24.51	25.55	31.18	26.64	31.16	26.66	245.50	6807.31	2128.29	9801.70	3064.48
85.20	38.50	35.50	34.37	24.61	24.75	30.90	26.90	30.89	26.91	115.20	6653.74	2080.28	13228.45	4135.84
97.90	38.50	35.50	34.37	24.41	25.35	30.88	25.63	30.86	25.65	282.10	6798.47	2125.53	14672.52	4587.33

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
4.5749E-02	4.7450E-02	1.4935E-02	1.6635E-02	1.2775E-02	7.7101E-05	7.8734E-03	8.6536E-03	6.9073E-03	7.8275E-03	7.7101E-05	1.8039E-02	6.5432E+03	4.6338E+03	8.0573E+03	7.3309E+03	9.1843E+03	8.1046E+03
3.8319E-02	2.2322E-02	1.6151E-02	1.5421E-04	1.2872E-02	7.7104E-05	7.9078E-03	0.0000E+00	8.0693E-03	0.0000E+00	7.7104E-05	9.2953E-03	6.4938E+03	8.9927E+03	8.0223E+03	0.0000E+00	7.8423E+03	0.0000E+00
3.4762E-02	3.7586E-02	1.5569E-02	1.8493E-02	1.2949E-02	7.7102E-05	7.8851E-03	9.2937E-03	7.5298E-03	9.0450E-03	7.7102E-05	6.2448E-03	6.4555E+03	1.3385E+04	8.0454E+03	6.8260E+03	8.4250E+03	7.0137E+03
2.8557E-02	3.2504E-02	1.0775E-02	3.4722E-02	1.3097E-02	7.7105E-05	7.5595E-03	1.9419E-02	3.0614E-03	1.5149E-02	7.7105E-05	4.6852E-03	6.3825E+03	1.7841E+04	8.3919E+03	3.2666E+03	2.0722E+04	4.1877E+03
3.4041E-02	3.5831E-02	1.6821E-02	1.8610E-02	1.2957E-02	7.7105E-05	7.9531E-03	8.8030E-03	8.7132E-03	9.6532E-03	7.7105E-05	4.2636E-03	6.4514E+03	1.9605E+04	7.9766E+03	7.2065E+03	7.2808E+03	6.5718E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC'	Tvh-Tva	Tvc-Tva
34.54	35.48	25.88	25.43	31.10	30.77	30.93	2.74	64.88	-1.74	88.19	0.54	-0.54
34.69	35.01	25.43	25.22	29.68	29.68	29.68	0.00	0.00	0.00	0.00	0.00	0.00
34.34	34.39	25.03	25.09	29.23	28.53	28.88	-1.29	113.96	0.23	103.69	1.20	-1.20
34.93	32.43	24.68	26.35	30.02	27.29	28.65	-7.18	264.14	6.75	401.18	4.77	-4.77
34.93	34.56	24.38	24.44	28.61	28.14	28.37	-1.08	110.23	-1.76	63.14	0.84	-0.84

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c$ = 35-25 $^{\circ}$C.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
20.30	38.50	35.50	34.47	24.71	26.45	32.34	29.16	32.33	29.17	164.40	6894.24	2155.47	3225.41	1008.42
41.70	38.50	35.70	34.17	24.61	26.35	31.76	28.02	31.74	28.04	273.50	6907.25	2159.54	6492.55	2029.88
64.20	38.50	35.70	33.97	24.31	25.55	31.51	26.64	31.49	26.66	304.20	6899.13	2157.00	9764.49	3052.85
85.20	38.50	35.70	33.87	23.91	25.15	31.08	25.99	31.05	26.02	366.50	6895.56	2155.88	12790.54	3998.93
95.50	38.50	35.70	33.97	23.91	24.95	30.93	25.86	30.90	25.89	345.30	6856.64	2143.71	14338.99	4483.05

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HDH	HDC	HIH	HIH'	HIC
4.3617E-02	5.0107E-02	1.2854E-02	1.9343E-02	1.2867E-02	7.7106E-05	7.7335E-03	1.0905E-02	4.9660E-03	8.2836E-03	7.7106E-05	1.7897E-02	6.4965E+03	4.8707E+03	8.2031E+03	5.8172E+03	1.2775E+04	7.6584E+03
3.8899E-02	3.5749E-02	1.6825E-02	1.3675E-02	1.2855E-02	7.7103E-05	7.7973E-03	6.2679E-03	8.8735E-03	7.2525E-03	7.7103E-05	9.2197E-03	6.5026E+03	9.0665E+03	8.1360E+03	1.0121E+04	7.1492E+03	8.7471E+03
3.6995E-02	3.5142E-02	1.7860E-02	1.6009E-02	1.2862E-02	7.7103E-05	7.9275E-03	7.0439E-03	9.7785E-03	8.8111E-03	7.7103E-05	6.2704E-03	6.4988E+03	1.3331E+04	8.0024E+03	9.0062E+03	6.4876E+03	7.1998E+03
3.8300E-02	3.1611E-02	2.0577E-02	1.3883E-02	1.2866E-02	7.7106E-05	7.9396E-03	4.6316E-03	1.2483E-02	9.1023E-03	7.7106E-05	4.8576E-03	6.4971E+03	1.7208E+04	7.9901E+03	1.3697E+04	5.0819E+03	6.9695E+03
3.6728E-02	3.1942E-02	1.9469E-02	1.4683E-02	1.2902E-02	7.7106E-05	7.9325E-03	5.5748E-03	1.1383E-02	8.9519E-03	7.7106E-05	4.3570E-03	6.4768E+03	1.9185E+04	7.9973E+03	1.1375E+04	5.5733E+03	7.0866E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'Tbc'-Tbc		DELTC/DELTC'Tvh-Tva		Tvc-Tva
34.99	34.49	25.68	26.20	31.06	30.01	30.53	-1.42	123.17	2.02	117.51	1.71	-1.71
34.93	35.26	25.48	25.48	29.61	30.44	30.02	0.92	90.33	0.00	100.00	-1.39	1.39
34.84	35.29	24.93	24.75	29.08	29.61	29.34	1.59	85.74	-0.74	90.27	-0.92	0.92
34.79	35.77	24.55	24.33	28.14	30.57	29.35	3.82	79.06	-1.22	83.00	-4.13	4.13
34.84	35.26	24.43	24.37	28.16	29.79	28.58	1.49	88.29	-0.23	96.27	-2.81	2.81

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35-25\ ^{\circ}C$.

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
64.20	17.90	35.60	33.57	24.71	26.05	30.03	26.49	30.01	26.51	254.70	3131.71	979.12	9765.99	3053.32
64.20	34.60	35.40	34.17	24.31	25.65	30.98	26.63	30.96	26.65	267.70	6119.34	1913.20	9788.92	3060.48
64.20	51.20	35.50	34.57	24.41	25.85	31.78	26.86	31.76	26.88	291.50	9174.65	2868.50	9823.39	3071.26
64.20	69.90	35.70	35.27	24.71	26.15	31.51	26.79	31.49	26.81	255.00	12372.01	3868.08	9832.33	3074.06
64.20	86.90	35.60	35.27	24.51	25.95	31.51	26.66	31.49	26.68	252.20	15345.17	4797.63	9805.77	3065.75

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
3.5191E-02	3.7593E-02	1.5497E-02	1.3899E-02	1.7425E-02	7.7103E-05	7.7456E-03	6.9917E-03	7.5973E-03	6.7528E-03	7.7103E-05	6.2693E-03	4.7971E+03	1.3333E+04	8.1903E+03	9.0734E+03	8.3502E+03	9.3945E+03
3.6051E-02	1.9892E-02	1.6313E-02	1.5421E-04	1.3484E-02	7.7106E-05	7.9450E-03	0.0000E+00	8.2136E-03	0.0000E+00	7.7106E-05	6.2536E-03	6.1991E+03	1.3367E+04	7.9847E+03	0.0000E+00	7.7236E+03	0.0000E+00
3.5170E-02	3.4647E-02	1.7401E-02	1.6878E-02	1.1539E-02	7.7105E-05	7.9570E-03	7.7375E-03	9.2893E-03	8.9865E-03	7.7105E-05	6.2300E-03	7.2440E+03	1.3417E+04	7.9726E+03	8.1988E+03	6.8292E+03	7.0594E+03
3.2542E-02	3.5046E-02	1.6006E-02	1.8510E-02	1.0312E-02	7.7102E-05	7.9090E-03	9.1140E-03	7.9429E-03	9.2416E-03	7.7102E-05	6.2239E-03	8.1058E+03	1.3430E+04	8.0211E+03	6.9606E+03	7.9868E+03	6.8645E+03
3.1617E-02	3.4976E-02	1.5873E-02	1.9231E-02	9.5029E-03	7.7103E-05	7.9259E-03	9.5560E-03	7.7919E-03	9.5186E-03	7.7103E-05	6.2421E-03	8.7962E+03	1.3391E+04	6.0040E+03	6.6372E+03	8.1416E+03	6.6847E+03

Tbh	Tbh'	Tbc	Tbc'	Twh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH	Tbc'-Tbc	DELTC/DELTC	Tvh-Tva	Tvc-Tva
34.59	34.53	25.78	24.91	28.04	28.42	28.23	-0.26	101.96	-1.85	70.24	-0.68	0.68
34.75	34.61	24.96	24.98	28.83	22.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.04	25.12	25.15	25.07	29.44	29.57	29.50	0.23	97.54	-0.25	96.43	-0.22	0.22
25.49	34.16	25.43	25.22	29.47	28.84	29.17	-3.74	150.04	-0.83	86.51	1.05	-1.05
25.43	33.93	25.23	25.10	29.49	28.67	29.08	-4.25	162.35	-0.50	91.93	1.42	-1.42

For Freon-22, tilt angle 50 degrees, fill ratio 16.4%, $T_h - T_c = 35-25\ ^\circ C.$

DATA FROM THE EXPERIMENTS

NO. OF DATA = 5   TYPE OF FREON : FREON 22

FC	FH	THI	THO	TCI	TCO	TWHO	TWCO	TWHI	TWCI	QAV	REH'	REH	REC'	REC
97.90	17.90	35.50	33.67	24.31	25.25	29.52	25.00	29.50	25.02	259.80	3102.79	970.08	14477.94	4526.49
97.90	34.60	35.50	34.07	24.61	25.45	30.83	25.78	30.81	25.78	274.10	6106.81	1909.28	14721.72	4602.71
97.90	51.20	35.60	34.77	24.11	24.95	30.05	25.21	30.03	25.23	259.70	8835.53	2762.41	14547.95	4548.39
97.90	69.90	35.50	35.17	24.11	25.05	31.15	26.10	31.13	26.12	239.70	12264.44	3834.45	14855.05	4644.40
97.90	86.90	35.50	35.17	24.41	24.75	31.28	25.73	31.27	25.74	128.90	15093.85	4719.04	14808.90	4629.97

THEORETICAL THERMAL RESISTANCE

RT	RT'	RHP	RHP'	R1	R2	R3	R3'	R5	R5'	R6	R7	HOH	HOC	HIH	HIH'	HIC
3.7518E-02	3.9229E-02	1.5687E-02	1.7398E-02	1.7506E-02	7.7102E-05	7.9086E-03	8.7220E-03	7.6240E-03	8.5218E-03	7.7102E-05	4.3252E-03	4.7750E+03	1.9326E+04	8.0215E+03	7.2734E+03	8.3209E+03	7.4443E+03
3.4268E-02	3.6243E-02	1.6522E-02	1.8497E-02	1.3498E-02	7.7108E-05	7.9348E-03	8.8751E-03	8.4329E-03	9.4695E-03	7.7101E-05	4.2483E-03	6.1927E+03	1.9678E+04	7.9950E+03	7.1495E+03	7.5228E+03	6.6992E+03
3.1793E-02	3.4698E-02	1.5732E-02	1.8637E-02	1.1758E-02	7.7102E-05	7.9025E-03	9.3136E-03	7.6751E-03	9.1691E-03	7.7102E-05	4.3029E-03	7.1092E+03	1.9427E+04	8.0277E+03	6.8114E+03	8.2655E+03	6.9188E+03
2.9727E-02	3.5633E-02	1.5182E-02	2.1088E-02	1.0357E-02	7.7106E-05	7.8699E-03	1.0777E-02	7.1378E-03	1.0136E-02	7.7106E-05	4.2074E-03	8.0706E+03	1.9867E+04	8.0609E+03	5.6863E+03	8.8877E+03	6.2585E+03
2.4937E-02	5.6860E-02	1.1134E-02	4.3057E-02	9.5815E-03	7.7108E-05	7.6858E-03	2.3564E-02	3.2944E-03	1.9338E-02	7.7108E-05	4.2215E-03	8.7241E+03	1.9801E+04	8.2540E+03	2.6922E+03	1.9256E+04	3.2805E+03

Tbh	Tbh'	Tbc	Tbc'	Tvh	Tvc	Tva	Tbh'-Tbh	DELTH/DELTH'	Tbc'-Tbc	DELTC/DELTC	Tvh-Tva	Tvc-Tva
34.59	34.10	24.78	23.89	27.45	27.02	27.23	-1.41	110.64	-3.59	19.85	0.78	-0.78
34.79	34.56	25.03	24.61	28.63	28.12	28.38	-0.65	106.02	-1.68	63.47	0.91	-0.91
35.16	33.13	24.53	24.11	27.98	27.24	27.61	-5.83	166.53	-1.72	61.85	1.33	-1.33
35.34	33.68	24.58	25.07	29.25	27.85	28.55	-4.75	166.69	2.01	148.25	2.44	-2.44
35.34	32.54	24.58	25.17	34.28	26.19	28.23	-7.92	223.78	2.39	204.05	7.25	-7.25

BIOGRAPHY

Chutima Jarusiripot was born on March 29, 1961, in Nakhon Pathom, Thailand. She graduated from Chulalongkorn University with a Bachelor of Science degree in Chemical Technology in March 1984. She entered the course of Master in Chemical Engineering at Chulalongkorn University in June 1986.