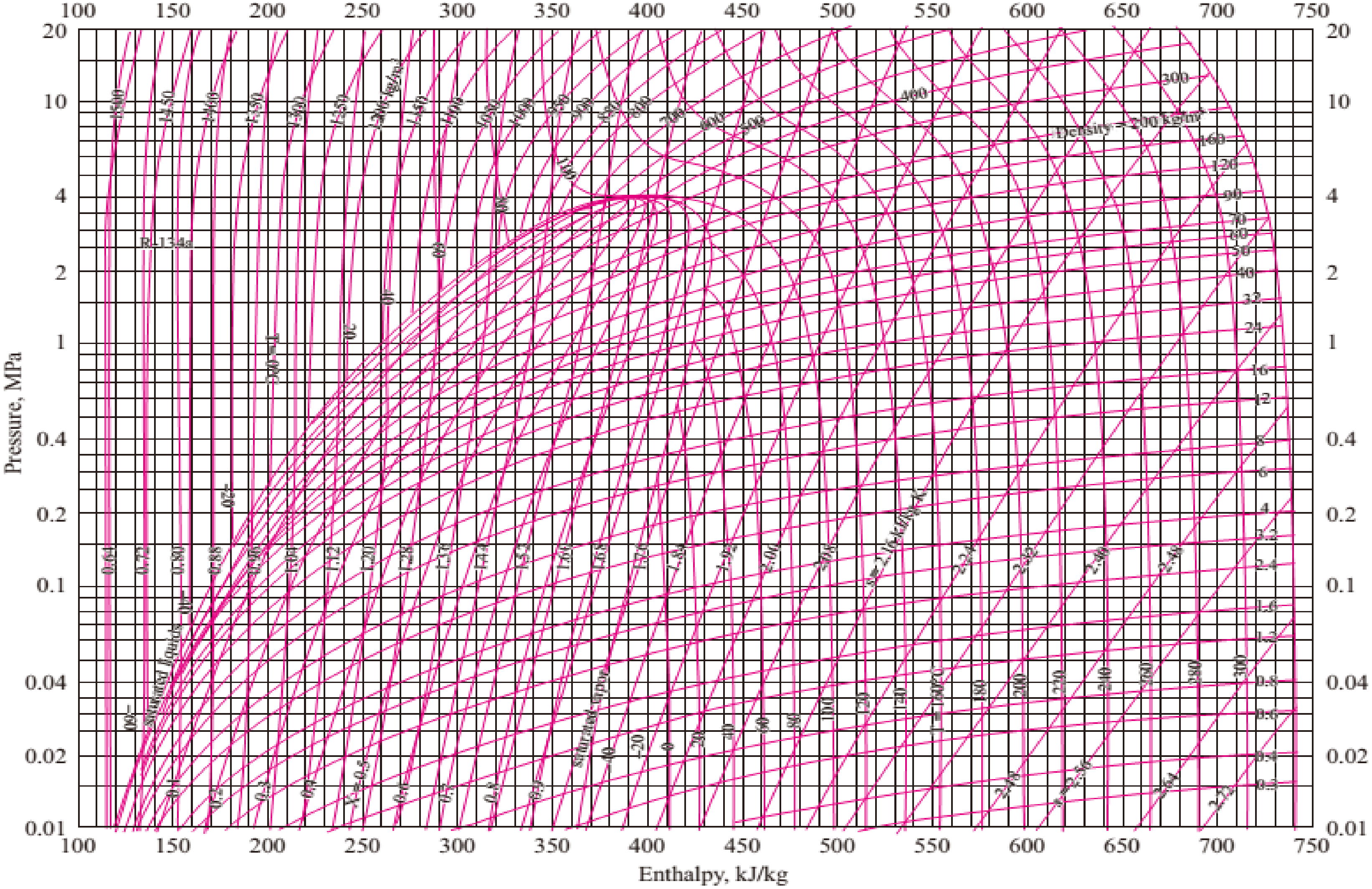
LAMPIRAN 1. Diagram P-h Refrigeran R-134a



LAMPIRAN 2. Tabel Persamaan Regresi Termokopel

Termokopel ke-	Persamaan Regresi	Termokopel ke-	Persamaan Regresi
T_1	y = 0.9787x + 0.3965	T_{11}	y = 0.9726x + 0.7888
T_2	y = 0.9733x + 0.5087	T_{12}	y = 0.9709x + 0.773
T_3	y = 0.9718x + 0.5279	T_{13}	y = 0.9804x + 0.7632
T_4	y = 0.9717x + 0.4745	T_{14}	y = 0.9756x + 0.9866
T_5	y = 0.9848x - 0.3787	T_{15}	y = 0.9732x + 0.9362
T_6	y = 0.9824x - 0.3608	T_{16}	y = 0.9722x + 0.8744
T_7	y = 0.9976x - 0.6447	T_{17}	y = 0.9797x - 0.0533
T_8	y = 0.9843x - 0.4043	T_{18}	y = 0.9754x + 0.0219
T_9	y = 0.9783x + 0.6538	T_{19}	y = 0.9755x - 0.0445
T_{10}	y = 0.9722x + 0.8294	T_{20}	y = 0.9748x - 0.0637

Keterangan:

T_1 = Temperatur aliran refrigerant pada sisi masuk seksi uji
$T_{2, 3, 4}$ = Temperatur dinding pada sisi masuk seksi uji
T_5 = Temperatur udara sebelum masuk seksi uji
T_6 = Temperatur udara setelah masuk seksi uji
T_7 = Temperatur aliran sisi hisap kompresor
T_8 = Temperatur aliran sisi tekan kompresor
T_9 = Temperatur aliran refrigerant pada sisi keluar seksi uji

$T_{10, 11, 12}$	= Temperatur dinding pada sisi keluar seksi uji
T_{13}	= Temperatur aliran masuk katup ekspansi
T_{14}	= Temperatur aliran keluar katup ekspansi
T_{15}	= Temperatur aliran air keluar evaporator
T_{16}	= Temperatur aliran air masuk evaporator
T_{17}	= Temperatur aliran air keluar kondensor
T_{18}	= Temperatur aliran air masuk kondensor
T_{19}	= Temperatur air pada tangki campur
T_{20}	= Temperatur air pada tangki utama

Indeks x adalah temperatur yang terbaca pada *termoreader*, temperatur yang terbaca tersebut disubstitusikan ke persamaan regresi pada masing-masing temperatur untuk mendapatkan temperatur hasil kalibrasi. Temperatur hasil kalibrasi diberi indeks y.

LANJUTAN LAMPIRAN 2. Tabel Kalibrasi Termokopel

No	T Standard (°C)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	T_{17}	T_{18}	T_{19}	T_{20}
1	6	6	5.8	5.8	5.8	6.7	6.7	6.8	6.7	5.8	5.5	5.5	5.5	5.6	5.3	5.3	5.4	6.2	6.4	6.7	6.3
2	10	9.9	9.8	9.8	10	10.7	10.6	10.7	10.7	9.6	9.5	9.6	9.7	9.3	9.3	9.5	9.5	10.3	10.4	10.4	10.4
3	12	12.1	12	12	12.1	12.7	12.7	12.9	12.8	11.7	11.6	11.6	11.7	11.5	11.4	11.5	11.6	12.5	12.5	12.5	12.6
4	15	15.2	15.2	15.2	15.2	15.9	15.9	15.9	15.9	14.8	14.8	14.9	14.9	14.7	14.5	14.7	14.7	15.6	15.6	15.7	15.7
5	17	17	17	17	17.1	17.8	17.7	17.8	17.8	16.7	16.7	16.7	16.8	16.7	16.4	16.6	16.6	17.5	17.5	17.6	17.6
7	20	20.1	20	20.1	20.1	20.7	20.7	20.8	20.8	19.8	19.7	19.8	19.9	19.6	19.5	19.6	19.6	20.5	20.5	20.5	20.6
8	22	22.2	22.2	22.2	22.3	22.8	22.8	22.9	23	21.8	21.9	21.9	22	21.7	21.7	21.8	21.8	22.6	22.6	22.6	22.7
9	25	25	25.1	25.1	25.2	25.7	25.8	25.8	25.8	24.7	24.8	24.8	24.9	24.6	24.6	24.7	24.7	25.5	25.5	25.6	25.6
10	27	26.9	26.9	26.9	27	27.5	27.5	27.6	26.5	26.6	26.7	26.7	26.4	26.4	26.4	26.5	26.5	27.2	27.3	27.4	27.4
11	29	29	29.1	29.1	29.2	29.7	29.7	29.5	29.8	28.7	28.8	28.9	28.9	28.6	28.6	28.7	28.7	29.4	29.5	29.5	29.6
12	31	31.2	31.3	31.4	31.4	31.9	31.9	31.8	31.9	31	31	31.1	31.3	30.8	30.7	30.9	31	31.7	31.7	31.8	31.8
13	33	33.5	33.8	33.7	33.8	34.3	34.1	33.5	34.5	33.2	33.4	33.4	33.4	33.3	33	33.1	34.4	34	33.9	34	34
14	36	36.2	36.3	36.3	36.4	36.7	36.8	36.6	36.8	35.9	36.6	36.1	36.1	35.8	35.8	35.9	36	36.6	36.8	36.8	36.8
15	39	39.2	39.3	39.4	39.4	39.6	39.8	39.6	39.8	38.9	39	39	39.2	38.9	38.8	38.9	38.9	39.6	39.7	39.8	39.8
16	41	41.2	41.4	41.5	41.6	41.8	41.9	41.6	41.9	41.1	41.2	41.2	41.3	40.9	40.9	41.1	41.1	41.8	41.9	41.9	42
17	44	44.3	44.4	44.5	44.5	44.8	44.9	44.5	44.9	44.1	44.2	44.2	44.3	43.9	43.9	44.1	44.1	44.8	44.9	44.9	45
19	48	48.3	48.5	48.5	48.6	48.8	48.8	48.5	48.9	48	48.2	48.2	48.2	47.9	47.9	48	48.1	48.7	48.8	48.9	49
20	51	51.5	51.7	51.7	51.8	51.9	52	51.7	52.1	51.3	51.4	51.5	51.6	51.1	51.1	51.4	51.4	51.9	52.1	52.1	52.2
21	53	53.7	53.9	54	54	54.1	54.1	53.6	54.2	53.5	53.7	53.8	53.8	53.3	53.3	53.6	53.7	54.3	54.3	54.5	54.5
22	56	56.5	56.7	56.8	56.8	56.9	57	56.6	57	56.3	56.4	56.5	56.6	56	56.1	56.4	56.4	56.9	57.1	57.2	57.2
23	59	60	60.4	60.5	60.7	60.6	60.8	59.9	60.4	59.8	60.2	60.3	60.4	59.6	59.6	60.1	60.1	60.5	60.8	60.8	61
24	61	61.8	61.9	61.9	62.2	62.2	62.2	61.7	62.5	61.4	61.7	61.6	61.8	61.2	61.4	61.5	61.6	62.2	62.4	62.5	62.3
25	64	65.1	65.1	65.4	65.4	65.4	65.5	64.9	65.8	64.8	64.7	64.6	65.1	64.6	64.7	64.5	64.9	65.5	65.6	65.6	65.8
26	67	67.9	67.9	68.2	68	68.1	68.3	67.8	68.5	67.7	67.6	67.7	68	67.4	67.5	67.3	67.5	68.2	68.3	68.4	68.5
27	69	70.5	70.8	70.8	70.6	70.7	71	70.3	70.8	70.3	70.3	70.4	70.6	70	70.1	70.2	70.4	70.8	71.1	71.1	71.2
28	71	72.6	72.9	72.9	73.1	73.1	73.3	72.2	72.8	72.4	72.7	72.7	72.7	71.8	72.1	72.5	72.5	72.7	73.2	73.2	73.3
29	73	74.8	75	75	75.3	75.1	75.1	74.3	74.8	74.6	74.8	74.8	74.8	74.2	74.1	74.6	74.6	74.9	75.2	75.3	75.2

LAMPIRAN 3. Kalibrasi Orifice

Percobaan	$\dot{V}_{air}$	$\dot{V}_{air}$	Pembacaan Manometer			ΔP	v_1 (orifice)	Re	$\dot{V}_{air,ideal}$	$\dot{V}_{air,actual}$	Koefisien Curah (C)
	(LPM)	(m^3/s)	z_{kiri} (cm)	z_{kanan} (cm)	Δz (cm)	(N/m^2)	(m/s)		(m^3/dt)	(m^3/s)	
1	0	0	74,5	74,5	0	0	0	0	0	0	0
2	1	1,66667 x10^{-5}	82,3	66,7	15,6	20.812,9	0,131568	1,671	2,02752 x10^{-5}	1,66667 x10^{-5}	0,82202
3	1,2	0,00002	86,4	62,6	23,8	31.753	0,157882	2,005	2,50433 x10^{-5}	0,00002	0,79862
4	1,4	2,33333 x10^{-5}	91	58	33	44.027,3	0,184196	2,339	2,9489 x10^{-5}	2,33333 x10^{-5}	0,79126
5	1,6	2,66667 x10^{-5}	97	52	45	60.037,2	0,210509	2,673	3,44357 x10^{-5}	2,66667 x10^{-5}	0,77439
6	1,8	0,00003	104	45	59	78.715,4	0,236823	3,008	3,94302 x10^{-5}	0,00003	0,76084
7	2	3,33333 x10^{-5}	107	42	65	86.720,4	0,263137	3,342	4,13865 x10^{-5}	3,33333 x10^{-5}	0,80541

Keterangan:

$\dot{V}_{air}$ = Debit air masuk saluran (m^3/s)
Δz = Beda tinggi air raksa (cm)
ΔP = Beda tekanan sisi masuk dan keluar orfice (N/m^2)/(Pa)
v_1 = Kecepatan alir air masuk saluran (m/s)
$\dot{V}_{air,\ ideal}$ = Debit air masuk ideal (m^3/s)
$\dot{V}_{air,\ aktual}$ = Debit air masuk aktual (m^3/s)
Re = Angka Reynolds

C = Koefisien curah

Diameter pipa tembaga, D_1 = 0,0127 m
Diameter lubang orifice, D_2 = 0,002 m
Luas penampang aliran, A_1 = 0,00013 m^2
Luas penampang lubang orifice, A_2 = 0,00013 m^2
Viskositas dinamik air, μ_{air} = 0,001 $N.s/m^2$
Massa jenis air, ρ_{air} = 1.000 kg/m^3

LAMPIRAN 4. Perhitungan laju aliran massa refrigeran ($\dot{m}_r$)

Frek. Inverter (Hz)	Debit Air Evap. (LPM)	$\Delta h_{Air Raksa}$ (cm)	ΔP (Pa)	Re	C	$\rho_{R\text{-}134a}$ (kg/m³)	$\dot{V}_{ideal}$ (m³/s)	$\dot{V}_{aktual}$ (m³/s)	$\dot{m}_r$ (kg/s)	$\dot{m}_r$ (g/s)
16	1	4	5336,64	6827,49	0,847354035	1169	$9{,}49566 x10^{-6}$	$8{,}04619\ x10^{-6}$	0,009405991	9,405991403
	1,2	4,5	6003,72	6908,97	0,846088309	1168	$1{,}0076 x10^{-5}$	$8{,}52517\ x10^{-6}$	0,009957396	9,9573964
	1,4	4,5	6003,72	6908,97	0,846088309	1167	$1{,}00803\ x10^{-5}$	$8{,}52882\ x10^{-6}$	0,009953133	9,953132903
	1,6	4,8	6403,96	6957,86	0,845336915	1166	$1{,}04153\ x10^{-5}$	$8{,}80448\ x10^{-6}$	0,010266021	10,2660211
	1,8	4,8	6403,96	6957,86	0,845336915	1166	$1{,}04153\ x10^{-5}$	$8{,}80448\ x10^{-6}$	0,010266021	10,2660211
	2	4,8	6403,96	6957,86	0,845336915	1165	$1{,}04198\ x10^{-5}$	$8{,}80826\ x10^{-6}$	0,010261618	10,26161792
18	1	4,5	6003,72	6908,97	0,846088309	1164	$1{,}00933\ x10^{-5}$	$8{,}5398\ x10^{-6}$	0,009940331	9,94033144
	1,2	4,6	6137,13	6925,27	0,845837181	1163	$1{,}02092\ x10^{-5}$	$8{,}63532\ x10^{-6}$	0,010042873	10,04287296
	1,4	4,8	6403,96	6957,86	0,845336915	1162	$1{,}04333\ x10^{-5}$	$8{,}81962\ x10^{-6}$	0,010248397	10,24839702
	1,6	5	6670,80	6990,46	0,84483928	1162	$1{,}06484\ x10^{-5}$	$8{,}99619\ x10^{-6}$	0,010453569	10,45356896
	1,8	5,2	6937,63	7023,05	0,844344252	1161	$1{,}0864\ x10^{-5}$	$9{,}17292\ x10^{-6}$	0,010649758	10,64975844
	2	5,5	7337,88	7071,94	0,843606539	1161	$1{,}11729\ x10^{-5}$	$9{,}42557\ x10^{-6}$	0,010943086	10,9430861
20	1	4,3	5736,88	6876,38	0,846592572	1160	$9{,}88343\ x10^{-5}$	$8{,}36724\ x10^{-6}$	0,009705996	9,705995829
	1,2	5,4	7204,46	7055,64	0,843851804	1160	$1{,}10757\ x10^{-5}$	$9{,}34623\ x10^{-6}$	0,010841628	10,84162751
	1,4	5,5	7337,88	7071,94	0,843606539	1159	$1{,}11826\ x10^{-5}$	$9{,}4337\ x10^{-6}$	0,010933656	10,93365647
	1,6	5,5	7337,88	7071,94	0,843606539	1158	$1{,}11874\ x10^{-5}$	$9{,}43777\ x10^{-6}$	0,010928939	10,9289386
	1,8	5,7	7604,71	7104,53	0,843117914	1157	$1{,}13939\ x10^{-5}$	$9{,}60642\ x10^{-6}$	0,011114626	11,11462587
	2	6,5	8672,04	7234,91	0,841188346	1156	$1{,}21725\ x10^{-5}$	$1{,}02394\ x10^{-5}$	0,011836717	11,83671707
22	1	6,1	8138,37	7169,72	0,842148191	1156	$1{,}1792\ x10^{-5}$	$9{,}93063\ x10^{-6}$	0,011479812	11,47981208
	1,2	6,2	8271,79	7186,02	0,841907311	1156	$1{,}18883\ x10^{-5}$	$1{,}00088\ x10^{-5}$	0,011570216	11,57021601
	1,4	6,5	8672,04	7234,91	0,841188346	1155	$1{,}21778\ x10^{-5}$	$1{,}02438\ x10^{-5}$	0,011831596	11,83159628

Lanjutan LAMPIRAN 4. Perhitungan laju aliran massa refrigeran ($\dot{m}_r$)

Frek. Inverter (Hz)	**Debit Air Evap. (LPM)**	**$\Delta h_{Air\ Raksa}$ (cm)**	**ΔP (Pa)**	**Re**	**C**	**$\rho_{R\text{-}134a}$ (kg/m^3)**	**$\dot{V}_{ideal}$ (m^3/s)**	**$\dot{V}_{aktual}$ (m^3/s)**	**$\dot{m}_r$ (kg/s)**	**$\dot{m}_r$ (g/s)**
22	1,6	6,5	8672,04	7234,91	0,841188346	1155	1,21778 x10^{-5}	1,02438 x10^{-5}	0,011831596	11,83159628
	1,8	6,5	8672,04	7234,91	0,841188346	1155	1,21778 x10^{-5}	1,02438 x10^{-5}	0,011831596	11,83159628
	2	7	9339,12	7316,39	0,840002143	1154	1,2643 x10^{-5}	1,06201 x10^{-5}	0,012255605	12,25560465
24	1	7,5	10006,20	7397,87	0,838830723	1154	1,30867 x10^{-5}	1,09775 x10^{-5}	0,012668065	12,66806517
	1,2	7,5	10006,20	7397,87	0,838830723	1153	1,30924 x10^{-5}	1,09823 x10^{-5}	0,012662575	12,66257522
	1,4	7,5	10006,20	7397,87	0,838830723	1153	1,30924 x10^{-5}	1,09823 x10^{-5}	0,012662575	12,66257522
	1,6	7,5	10006,20	7397,87	0,838830723	1152	1,30981 x10^{-5}	1,09871 x10^{-5}	0,012657083	12,65708288
	1,8	7,5	10006,20	7397,87	0,838830723	1152	1,30981 x10^{-5}	1,09871 x10^{-5}	0,012657083	12,65708288
	2	8,25	11006,82	7520,10	0,837100561	1152	1,37374 x10^{-5}	1,14995 x10^{-5}	0,01324748	13,24747996

Keterangan:

$\Delta h_{air\ raksa}$ = Selisih tinggi air raksa pada manometer sisi masuk dan keluar (cm)
ΔP = Beda tekanan pada sisi masuk dan keluar orifice (Pa)
Re = Angka Reynolds
C = Koefisien curah
$\rho_{R\text{-}134a}$ = Massa jenis refrigeran (kg/m^3)
$\dot{V}_{ideal}$ = Kecepatan aliran refrigeran ideal (m^3/s)
$\dot{V}_{aktual}$ = Kecepatan aliran refrigeran aktual (m^3/s)
$\dot{m}_r$ = Laju aliran massa refrigeran (kg/s)/(g/s)

LAMPIRAN 5. Data Kualitas Uap Refrigeran Setelah Keluar Katup Ekspansi

Perhitungan Kualitas					
$P_{in,exp}$	**P_{eva}**	**h_f**	**h_{fg}**	**h_4**	**x**
1,134214	0,5033435	221,4	414,4	250,5	0,070222
1,134214	0,5033435	221,4	414,4	250,7	0,0707046
1,134214	0,5067908	221,5	414,5	250,9	0,0709288
1,2031616	0,5136856	221,9	414,9	251,6	0,0715835
1,2031616	0,5274751	222,1	414,1	251,7	0,0714803
1,21005636	0,5309225	222,2	414,2	252,3	0,0726702
1,21695112	0,5033435	221,4	414,4	252,6	0,0752896
1,22384588	0,5033435	221,4	414,4	253	0,0762548
1,2721092	0,5067908	221,5	414,5	253,5	0,0772014
1,2721092	0,5067908	221,5	414,5	253,8	0,0779252
1,2721092	0,5136856	221,9	414,9	254,1	0,0776091
1,3410568	0,5205804	222	414	254,5	0,0785024
1,4100044	0,4998961	221,4	414,4	255,5	0,0822876
1,4100044	0,5067908	221,5	414,5	255,6	0,0822678
1,4100044	0,5067908	221,5	414,5	255,7	0,082509
1,42379392	0,5205804	222	414	256	0,0821256
1,4444782	0,5309225	222,2	414,2	256,5	0,0828102
1,478952	0,5378173	222,4	414,4	257	0,0834942
1,5134258	0,5136856	221,9	414,9	258	0,0870089
1,5134258	0,5205804	222	414	258,3	0,0876812
1,5478996	0,5205804	222	414	258,5	0,0881643
1,5478996	0,5309225	222,2	414,2	258,6	0,0878803
1,5823734	0,5378173	222,4	414,4	258,9	0,0880792
1,6168472	0,5481594	222,6	414,6	259	0,0877955
1,6857948	0,5343699	222,3	414,3	258,8	0,0881004
1,651321	0,5343699	222,3	414,3	259	0,0885832
1,6857948	0,544712	222,5	414,5	259,5	0,0892642
1,6857948	0,5481594	222,6	414,6	260,2	0,0906898
1,7547424	0,5585015	222,8	414,8	260,5	0,0908872
1,7547424	0,5688437	223	415	261	0,0915663

Keterangan:

$P_{in,exp}$ = Tekanan masuk katup ekspansi (MPa)

P_{eva} = Tekanan evaporasi pada sisi keluar katup ekspansi (MPa)

h_f = Entalpi cair jenuh pada tekanan masuk katup ekspansi (kJ/kg)

h_{fg} = Entalpi yang dibutuhkan untuk mengubah refrigeran dari cair jenuh menjadi uap jenuh (kJ/kg)

h_4 = Entalpi pada titik keluar katup ekspansi (kJ/kg)