

## DAFTAR PUSTAKA

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Lampiran 1. Tabel *Properties of miscellaneous material*853  
APPENDIX 1

TABLE A-8

Properties of miscellaneous materials

(Values are at 300 K unless indicated otherwise)

Material	Density, $\rho$ kg/m <sup>3</sup>	Thermal Conductivity, $k$ W/m · K	Specific Heat, $c_p$ J/kg · K	Material	Density, $\rho$ kg/m <sup>3</sup>	Thermal Conductivity, $k$ W/m · K	Specific Heat, $c_p$ J/kg · K
Asphalt	2115	0.062	920	Ice			
Bakelite	1300	1.4	1465	273 K	920	1.88	2040
Brick, refractory				253 K	922	2.03	1945
Chrome brick				173 K	928	3.49	1460
473 K	3010	2.3	835	Leather, sole	998	0.159	—
823 K	—	2.5	—	Linoleum	535	0.081	—
1173 K	—	2.0	—		1180	0.186	—
Fire clay, burnt				Mica	2900	0.523	—
1600 K				Paper	930	0.180	1340
773 K	2050	1.0	960	Plastics			
1073 K	—	1.1	—	Plexiglass	1190	0.19	1465
1373 K	—	1.1	—	Teflon			
Fire clay, burnt				300 K	2200	0.35	1050
1725 K				400 K	—	0.45	—
773 K	2325	1.3	960	Lexan	1200	0.19	1260
1073 K	—	1.4	—	Nylon	1145	0.29	—
1373 K	—	1.4	—	Polypropylene	910	0.12	1925
Fire clay brick				Polyester	1395	0.15	1170
478 K	2645	1.0	960	PVC, vinyl	1470	0.1	840
922 K	—	1.5	—	Porcelain	2300	1.5	—
1478 K	—	1.8	—	Rubber, natural	1150	0.28	—
Magnesite				Rubber, vulcanized			
478 K	—	3.8	1130	Soft	1100	0.13	2010
922 K	—	2.8	—	Hard	1190	0.16	—
1478 K	—	1.9	—	Sand	1515	0.2–1.0	800
Chicken meat,				Snow, fresh	100	0.60	—
white (74.4%				Snow, 273 K	500	2.2	—
water content)				Soil, dry	1500	1.0	1900
198 K	—	1.60	—	Soil, wet	1900	2.0	2200
233 K	—	1.49	—	Sugar	1600	0.58	—
253 K	—	1.35	—	Tissue, human			
273 K	—	0.48	—	Skin	—	0.37	—
293 K	—	0.49	—	Fat layer	—	0.2	—
Clay, dry	1550	0.930	—	Muscle	—	0.41	—
Clay, wet	1495	1.675	—	Vaseline	—	0.17	—
Coal, anthracite	1350	0.26	1260	Wood, cross-grain			
Concrete (stone				Balsa	140	0.055	—
mix)	2300	1.4	880	Fir	415	0.11	2720
Cork	86	0.048	2030	Oak	545	0.17	2385
Cotton	80	0.06	1300	White pine	435	0.11	—
Fat	—	0.17	—	Yellow pine	640	0.15	2805
Glass				Wood, radial			
Window	2800	0.7	750	Oak	545	0.19	2385
Pyrex	2225	1–1.4	835	Fir	420	0.14	2720
Crown	2500	1.05	—	Wool, ship	145	0.05	—
Lead	3400	0.85	—				

Source: Compiled from various sources.

Lampiran 2. Tabel *Properties of insulating material*850  
APPENDIX 1

TABLE A-6

Properties of insulating materials  
(at a mean temperature of 24°C)

Material	Thickness, $L$ mm	Density, $\rho$ kg/m <sup>3</sup>	Thermal Conductivity, $k$ W/m · K	Specific Heat, $c_p$ kJ/kg · K	$R$ -value (for listed thickness, $L/k$ ), K · m <sup>2</sup> /W
<b>Blanket and Batt</b>					
Mineral fiber (fibrous form)	50 to 70 mm	4.8–32	—	0.71–0.96	1.23
processed from rock, slag, or glass)	75 to 90 mm	4.8–32	—	0.71–0.96	1.94
	135 to 165 mm	4.8–32	—	0.71–0.96	3.32
<b>Board and Slab</b>					
Cellular glass		136	0.055	1.0	—
Glass fiber (organic bonded)		64–144	0.036	0.96	—
Expanded polystyrene (molded beads)		16	0.040	1.2	—
Expanded polyurethane ( $R$ -11 expanded)		24	0.023	1.6	—
Expanded perlite (organic bonded)		16	0.052	1.26	—
Expanded rubber (rigid)		72	0.032	1.68	—
Mineral fiber with resin binder		240	0.042	0.71	—
Cork		120	0.039	1.80	—
<b>Sprayed or Formed in Place</b>					
Polyurethane foam		24–40	0.023–0.026	—	—
Glass fiber		56–72	0.038–0.039	—	—
Urethane, two-part mixture (rigid foam)		70	0.026	1.045	—
Mineral wool granules with asbestos/inorganic binders (sprayed)		190	0.046	—	—
<b>Loose Fill</b>					
Mineral fiber (rock, slag, or glass)	~75 to 125 mm	9.6–32	—	0.71	1.94
	~165 to 222 mm	9.6–32	—	0.71	3.35
	~191 to 254 mm	—	—	0.71	3.87
	~185 mm	—	—	0.71	5.28
Silica aerogel		122	0.025	—	—
Vermiculite (expanded)		122	0.068	—	—
Perlite, expanded		32–66	0.039–0.045	1.09	—
Sawdust or shavings		128–240	0.065	1.38	—
Cellulosic insulation (milled paper or wood pulp)		37–51	0.039–0.046	—	—
<b>Roof Insulation</b>					
Cellular glass	—	144	0.058	1.0	—
Preformed, for use above deck	13 mm	—	—	1.0	0.24
	25 mm	—	—	2.1	0.49
	50 mm	—	—	3.9	0.93
<b>Reflective Insulation</b>					
Silica powder (evacuated)		160	0.0017	—	—
Aluminum foil separating fluffy glass mats; 10–12 layers (evacuated); for cryogenic applications (150 K)		40	0.00016	—	—
Aluminum foil and glass paper laminate; 75–150 layers (evacuated); for cryogenic applications (150 K)		120	0.000017	—	—

Lampiran 3. Tabel *Properties of air at 1 atm pressure.*860  
APPENDIX 1

TABLE A-15

Properties of air at 1 atm pressure

Temp. $T, ^\circ\text{C}$	Density $\rho, \text{kg/m}^3$	Specific Heat $c_p, \text{J/kg} \cdot \text{K}$	Thermal Conductivity $k, \text{W/m} \cdot \text{K}$	Thermal Diffusivity $\alpha, \text{m}^2/\text{s}^2$	Dynamic Viscosity $\mu, \text{kg/m} \cdot \text{s}$	Kinematic Viscosity $\nu, \text{m}^2/\text{s}$	Prandtl Number Pr
-150	2.866	983	0.01171	$4.158 \times 10^{-6}$	$8.636 \times 10^{-6}$	$3.013 \times 10^{-6}$	0.7246
-100	2.038	966	0.01582	$8.036 \times 10^{-6}$	$1.189 \times 10^{-5}$	$5.837 \times 10^{-6}$	0.7263
-50	1.582	999	0.01979	$1.252 \times 10^{-5}$	$1.474 \times 10^{-5}$	$9.319 \times 10^{-6}$	0.7440
-40	1.514	1002	0.02057	$1.356 \times 10^{-5}$	$1.527 \times 10^{-5}$	$1.008 \times 10^{-5}$	0.7436
-30	1.451	1004	0.02134	$1.465 \times 10^{-5}$	$1.579 \times 10^{-5}$	$1.087 \times 10^{-5}$	0.7425
-20	1.394	1005	0.02211	$1.578 \times 10^{-5}$	$1.630 \times 10^{-5}$	$1.169 \times 10^{-5}$	0.7408
-10	1.341	1006	0.02288	$1.696 \times 10^{-5}$	$1.680 \times 10^{-5}$	$1.252 \times 10^{-5}$	0.7387
0	1.292	1006	0.02364	$1.818 \times 10^{-5}$	$1.729 \times 10^{-5}$	$1.338 \times 10^{-5}$	0.7362
5	1.269	1006	0.02401	$1.880 \times 10^{-5}$	$1.754 \times 10^{-5}$	$1.382 \times 10^{-5}$	0.7350
10	1.246	1006	0.02439	$1.944 \times 10^{-5}$	$1.778 \times 10^{-5}$	$1.426 \times 10^{-5}$	0.7336
15	1.225	1007	0.02476	$2.009 \times 10^{-5}$	$1.802 \times 10^{-5}$	$1.470 \times 10^{-5}$	0.7323
20	1.204	1007	0.02514	$2.074 \times 10^{-5}$	$1.825 \times 10^{-5}$	$1.516 \times 10^{-5}$	0.7309
25	1.184	1007	0.02551	$2.141 \times 10^{-5}$	$1.849 \times 10^{-5}$	$1.562 \times 10^{-5}$	0.7296
30	1.164	1007	0.02588	$2.208 \times 10^{-5}$	$1.872 \times 10^{-5}$	$1.608 \times 10^{-5}$	0.7282
35	1.145	1007	0.02625	$2.277 \times 10^{-5}$	$1.895 \times 10^{-5}$	$1.655 \times 10^{-5}$	0.7268
40	1.127	1007	0.02662	$2.346 \times 10^{-5}$	$1.918 \times 10^{-5}$	$1.702 \times 10^{-5}$	0.7255
45	1.109	1007	0.02699	$2.416 \times 10^{-5}$	$1.941 \times 10^{-5}$	$1.750 \times 10^{-5}$	0.7241
50	1.092	1007	0.02735	$2.487 \times 10^{-5}$	$1.963 \times 10^{-5}$	$1.798 \times 10^{-5}$	0.7228
60	1.059	1007	0.02808	$2.632 \times 10^{-5}$	$2.008 \times 10^{-5}$	$1.896 \times 10^{-5}$	0.7202
70	1.028	1007	0.02881	$2.780 \times 10^{-5}$	$2.052 \times 10^{-5}$	$1.995 \times 10^{-5}$	0.7177
80	0.9994	1008	0.02953	$2.931 \times 10^{-5}$	$2.096 \times 10^{-5}$	$2.097 \times 10^{-5}$	0.7154
90	0.9718	1008	0.03024	$3.086 \times 10^{-5}$	$2.139 \times 10^{-5}$	$2.201 \times 10^{-5}$	0.7132
100	0.9458	1009	0.03095	$3.243 \times 10^{-5}$	$2.181 \times 10^{-5}$	$2.306 \times 10^{-5}$	0.7111
120	0.8977	1011	0.03235	$3.565 \times 10^{-5}$	$2.264 \times 10^{-5}$	$2.522 \times 10^{-5}$	0.7073
140	0.8542	1013	0.03374	$3.898 \times 10^{-5}$	$2.345 \times 10^{-5}$	$2.745 \times 10^{-5}$	0.7041
160	0.8148	1016	0.03511	$4.241 \times 10^{-5}$	$2.420 \times 10^{-5}$	$2.975 \times 10^{-5}$	0.7014
180	0.7788	1019	0.03646	$4.593 \times 10^{-5}$	$2.504 \times 10^{-5}$	$3.212 \times 10^{-5}$	0.6992
200	0.7459	1023	0.03779	$4.954 \times 10^{-5}$	$2.577 \times 10^{-5}$	$3.455 \times 10^{-5}$	0.6974
250	0.6746	1033	0.04104	$5.890 \times 10^{-5}$	$2.760 \times 10^{-5}$	$4.091 \times 10^{-5}$	0.6946
300	0.6158	1044	0.04418	$6.871 \times 10^{-5}$	$2.934 \times 10^{-5}$	$4.765 \times 10^{-5}$	0.6935
350	0.5664	1056	0.04721	$7.892 \times 10^{-5}$	$3.101 \times 10^{-5}$	$5.475 \times 10^{-5}$	0.6937
400	0.5243	1069	0.05015	$8.951 \times 10^{-5}$	$3.261 \times 10^{-5}$	$6.219 \times 10^{-5}$	0.6948
450	0.4880	1081	0.05298	$1.004 \times 10^{-4}$	$3.415 \times 10^{-5}$	$6.997 \times 10^{-5}$	0.6965
500	0.4565	1093	0.05572	$1.117 \times 10^{-4}$	$3.563 \times 10^{-5}$	$7.806 \times 10^{-5}$	0.6986
600	0.4042	1115	0.06093	$1.352 \times 10^{-4}$	$3.846 \times 10^{-5}$	$9.515 \times 10^{-5}$	0.7037
700	0.3627	1135	0.06581	$1.598 \times 10^{-4}$	$4.111 \times 10^{-5}$	$1.133 \times 10^{-4}$	0.7092
800	0.3289	1153	0.07037	$1.855 \times 10^{-4}$	$4.362 \times 10^{-5}$	$1.326 \times 10^{-4}$	0.7149
900	0.3008	1169	0.07465	$2.122 \times 10^{-4}$	$4.600 \times 10^{-5}$	$1.529 \times 10^{-4}$	0.7206
1000	0.2772	1184	0.07868	$2.398 \times 10^{-4}$	$4.826 \times 10^{-5}$	$1.741 \times 10^{-4}$	0.7260
1500	0.1990	1234	0.09599	$3.908 \times 10^{-4}$	$5.817 \times 10^{-5}$	$2.922 \times 10^{-4}$	0.7478
2000	0.1553	1264	0.11113	$5.664 \times 10^{-4}$	$6.630 \times 10^{-5}$	$4.270 \times 10^{-4}$	0.7539

Note: For ideal gases, the properties  $c_p$ ,  $k$ ,  $\mu$ , and Pr are independent of pressure. The properties  $\rho$ ,  $\nu$ , and  $\alpha$  at a pressure  $P$  (in atm) other than 1 atm are determined by multiplying the values of  $\rho$  at the given temperature by  $P$  and by dividing  $\nu$  and  $\alpha$  by  $P$ .

Source: Data generated from the EES software developed by S. A. Klein and F. L. Alvarado. Original sources: Keenan, Chao, Keyes, Gas Tables, Wiley, 198; and Thermophysical Properties of Matter, Vol. 3: Thermal Conductivity, Y. S. Touloukian, P. E. Liley, S. C. Saxena, Vol. 11: Viscosity, Y. S. Touloukian, S. C. Saxena, and P. Hestermans, IFI/Plenum, NY, 1970, ISBN 0-306067020-8.

Lampiran 4. Tabel *Properties of saturated water*854  
APPENDIX 1

TABLE A-9

Properties of saturated water

Temp. <i>T</i> , °C	Saturation Pressure <i>P</i> <sub>sat</sub> , kPa	Density $\rho$ , kg/m <sup>3</sup>		Enthalpy of Vaporization <i>h</i> <sub>fg</sub> , kJ/kg	Specific Heat <i>c</i> <sub>p</sub> , J/kg · K		Thermal Conductivity <i>k</i> , W/m · K		Dynamic Viscosity $\mu$ , kg/m · s		Prandtl Number Pr		Volume Expansion Coefficient $\beta$ , 1/K
		Liquid	Vapor		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792 × 10 <sup>-3</sup>	0.922 × 10 <sup>-5</sup>	13.5	1.00	-0.068 × 10 <sup>-3</sup>
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519 × 10 <sup>-3</sup>	0.934 × 10 <sup>-5</sup>	11.2	1.00	0.015 × 10 <sup>-3</sup>
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307 × 10 <sup>-3</sup>	0.946 × 10 <sup>-5</sup>	9.45	1.00	0.733 × 10 <sup>-3</sup>
15	1.7051	999.1	0.0128	2466	4185	1863	0.589	0.0179	1.138 × 10 <sup>-3</sup>	0.959 × 10 <sup>-5</sup>	8.09	1.00	0.138 × 10 <sup>-3</sup>
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002 × 10 <sup>-3</sup>	0.973 × 10 <sup>-5</sup>	7.01	1.00	0.195 × 10 <sup>-3</sup>
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891 × 10 <sup>-3</sup>	0.987 × 10 <sup>-5</sup>	6.14	1.00	0.247 × 10 <sup>-3</sup>
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798 × 10 <sup>-3</sup>	1.001 × 10 <sup>-5</sup>	5.42	1.00	0.294 × 10 <sup>-3</sup>
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720 × 10 <sup>-3</sup>	1.016 × 10 <sup>-5</sup>	4.83	1.00	0.337 × 10 <sup>-3</sup>
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653 × 10 <sup>-3</sup>	1.031 × 10 <sup>-5</sup>	4.32	1.00	0.377 × 10 <sup>-3</sup>
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596 × 10 <sup>-3</sup>	1.046 × 10 <sup>-5</sup>	3.91	1.00	0.415 × 10 <sup>-3</sup>
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547 × 10 <sup>-3</sup>	1.062 × 10 <sup>-5</sup>	3.55	1.00	0.451 × 10 <sup>-3</sup>
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504 × 10 <sup>-3</sup>	1.077 × 10 <sup>-5</sup>	3.25	1.00	0.484 × 10 <sup>-3</sup>
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467 × 10 <sup>-3</sup>	1.093 × 10 <sup>-5</sup>	2.99	1.00	0.517 × 10 <sup>-3</sup>
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433 × 10 <sup>-3</sup>	1.110 × 10 <sup>-5</sup>	2.75	1.00	0.548 × 10 <sup>-3</sup>
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404 × 10 <sup>-3</sup>	1.126 × 10 <sup>-5</sup>	2.55	1.00	0.578 × 10 <sup>-3</sup>
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378 × 10 <sup>-3</sup>	1.142 × 10 <sup>-5</sup>	2.38	1.00	0.607 × 10 <sup>-3</sup>
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355 × 10 <sup>-3</sup>	1.159 × 10 <sup>-5</sup>	2.22	1.00	0.633 × 10 <sup>-3</sup>
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333 × 10 <sup>-3</sup>	1.176 × 10 <sup>-5</sup>	2.08	1.00	0.670 × 10 <sup>-3</sup>
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315 × 10 <sup>-3</sup>	1.193 × 10 <sup>-5</sup>	1.96	1.00	0.702 × 10 <sup>-3</sup>
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297 × 10 <sup>-3</sup>	1.210 × 10 <sup>-5</sup>	1.85	1.00	0.716 × 10 <sup>-3</sup>
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282 × 10 <sup>-3</sup>	1.227 × 10 <sup>-5</sup>	1.75	1.00	0.750 × 10 <sup>-3</sup>
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255 × 10 <sup>-3</sup>	1.261 × 10 <sup>-5</sup>	1.58	1.00	0.798 × 10 <sup>-3</sup>
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232 × 10 <sup>-3</sup>	1.296 × 10 <sup>-5</sup>	1.44	1.00	0.858 × 10 <sup>-3</sup>
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213 × 10 <sup>-3</sup>	1.330 × 10 <sup>-5</sup>	1.33	1.01	0.913 × 10 <sup>-3</sup>
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197 × 10 <sup>-3</sup>	1.365 × 10 <sup>-5</sup>	1.24	1.02	0.970 × 10 <sup>-3</sup>
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183 × 10 <sup>-3</sup>	1.399 × 10 <sup>-5</sup>	1.16	1.02	1.025 × 10 <sup>-3</sup>
160	617.8	907.4	3.256	2083	4340	2420	0.680	0.0331	0.170 × 10 <sup>-3</sup>	1.434 × 10 <sup>-5</sup>	1.09	1.05	1.145 × 10 <sup>-3</sup>
170	791.7	897.7	4.119	2050	4370	2490	0.677	0.0347	0.160 × 10 <sup>-3</sup>	1.468 × 10 <sup>-5</sup>	1.03	1.05	1.178 × 10 <sup>-3</sup>
180	1,002.1	887.3	5.153	2015	4410	2590	0.673	0.0364	0.150 × 10 <sup>-3</sup>	1.502 × 10 <sup>-5</sup>	0.983	1.07	1.210 × 10 <sup>-3</sup>
190	1,254.4	876.4	6.388	1979	4460	2710	0.669	0.0382	0.142 × 10 <sup>-3</sup>	1.537 × 10 <sup>-5</sup>	0.947	1.09	1.280 × 10 <sup>-3</sup>
200	1,553.8	864.3	7.852	1941	4500	2840	0.663	0.0401	0.134 × 10 <sup>-3</sup>	1.571 × 10 <sup>-5</sup>	0.910	1.11	1.350 × 10 <sup>-3</sup>
220	2,318	840.3	11.60	1859	4610	3110	0.650	0.0442	0.122 × 10 <sup>-3</sup>	1.641 × 10 <sup>-5</sup>	0.865	1.15	1.520 × 10 <sup>-3</sup>
240	3,344	813.7	16.73	1767	4760	3520	0.632	0.0487	0.111 × 10 <sup>-3</sup>	1.712 × 10 <sup>-5</sup>	0.836	1.24	1.720 × 10 <sup>-3</sup>
260	4,688	783.7	23.69	1663	4970	4070	0.609	0.0540	0.102 × 10 <sup>-3</sup>	1.788 × 10 <sup>-5</sup>	0.832	1.35	2.000 × 10 <sup>-3</sup>
280	6,412	750.8	33.15	1544	5280	4835	0.581	0.0605	0.094 × 10 <sup>-3</sup>	1.870 × 10 <sup>-5</sup>	0.854	1.49	2.380 × 10 <sup>-3</sup>
300	8,581	713.8	46.15	1405	5750	5980	0.548	0.0695	0.086 × 10 <sup>-3</sup>	1.965 × 10 <sup>-5</sup>	0.902	1.69	2.950 × 10 <sup>-3</sup>
320	11,274	667.1	64.57	1239	6540	7900	0.509	0.0836	0.078 × 10 <sup>-3</sup>	2.084 × 10 <sup>-5</sup>	1.00	1.97	
340	14,586	610.5	92.62	1028	8240	11,870	0.469	0.110	0.070 × 10 <sup>-3</sup>	2.255 × 10 <sup>-5</sup>	1.23	2.43	
360	18,651	528.3	144.0	720	14,690	25,800	0.427	0.178	0.060 × 10 <sup>-3</sup>	2.571 × 10 <sup>-5</sup>	2.06	3.73	
374.14	22,090	317.0	317.0	0	—	—	—	—	0.043 × 10 <sup>-3</sup>	4.313 × 10 <sup>-5</sup>			

Note 1: Kinematic viscosity  $\nu$  and thermal diffusivity  $\alpha$  can be calculated from their definitions,  $\nu = \mu/\rho$  and  $\alpha = k/\rho c_p = \nu/Pr$ . The temperatures 0.01°C, 100°C, and 374.14°C are the triple-, boiling-, and critical-point temperatures of water, respectively. The properties listed above (except the vapor density) can be used at any pressure with negligible error except at temperatures near the critical-point value.

Note 2: The unit kJ/kg · °C for specific heat is equivalent to kJ/kg · K, and the unit W/m · °C for thermal conductivity is equivalent to W/m · K.

Source: Viscosity and thermal conductivity data are from J. V. Sengers and J. T. R. Watson, *Journal of Physical and Chemical Reference Data* 15 (1986), pp. 1291–1322. Other data are obtained from various sources or calculated.

Lampiran 5. Tabel Pengambilan Data ETC Standar (1)

ETC Standar (1)								
t	IN (Ti)C	OUT (To)C	Absorber (TP1)C	Kaca Dalam (Tc- dalam)C	Kaca Luar (Tc- Luar)C	Tanki (T.Tangki)C	Ling (Ta)C	Ilum (I) Kw
0	26,81	26,86	27,40	27,70	27,70	26,10	27,29	0,000
5	26,51	28,36	54,36	57,42	59,56	26,10	27,23	1,070
10	26,64	29,73	62,22	68,66	67,02	26,26	27,31	1,080
15	26,76	30,19	63,98	70,92	69,42	26,40	27,33	1,094
20	26,87	30,44	64,40	71,56	69,84	26,62	27,42	1,060
25	27,08	30,71	65,56	73,26	71,60	26,84	27,83	1,064
30	27,13	30,90	65,98	73,42	70,44	27,08	27,79	1,061
35	27,29	31,04	66,24	74,08	72,26	27,32	27,96	1,060
40	27,40	31,11	66,18	74,02	72,00	27,44	28,11	1,045
45	27,71	31,48	66,24	74,48	73,32	27,74	28,56	1,040
50	27,83	31,69	66,54	74,10	72,12	28,02	28,73	1,038
55	27,95	31,85	66,64	74,78	72,76	28,16	28,86	1,033
60	28,08	32,00	66,94	74,66	72,82	28,34	28,98	1,039
65	28,19	32,13	66,98	74,90	72,24	28,54	29,19	1,031
70	28,32	32,29	67,18	74,94	72,68	28,68	29,33	1,032
75	28,43	32,43	67,30	75,46	73,28	28,98	29,44	1,040
80	28,54	32,58	67,42	75,54	73,60	29,06	29,49	1,054
85	28,60	32,67	67,40	75,56	72,88	29,32	29,46	1,053
90	28,66	32,74	67,50	76,04	74,34	29,48	29,40	1,054
95	28,74	32,82	67,56	76,26	74,56	29,48	29,33	1,051
100	28,84	32,88	67,62	75,86	73,60	29,64	29,42	1,052
105	28,98	33,02	67,80	75,88	72,58	29,84	29,55	1,050
110	29,14	33,18	68,04	76,06	73,28	29,98	29,50	1,057
115	29,26	33,30	68,12	76,20	73,76	30,10	29,51	1,057
120	29,37	33,46	68,48	76,72	73,72	30,20	29,54	1,064
125	29,48	33,58	68,58	76,98	73,56	30,38	29,64	1,060
130	29,56	33,66	68,76	76,92	73,88	30,50	29,67	1,065
135	29,67	33,76	69,00	77,50	75,22	30,60	29,68	1,067
140	29,73	33,86	69,08	77,30	73,94	30,78	29,73	1,072
145	29,81	33,99	69,36	77,72	74,06	30,78	29,76	1,075
150	29,89	34,05	69,40	77,68	74,06	31,02	29,83	1,069
155	29,94	34,11	69,48	77,84	74,26	31,08	29,80	1,068
160	29,97	34,13	69,44	78,12	75,14	31,20	29,78	1,066
165	30,03	34,22	69,50	77,82	73,84	31,30	29,79	1,067
170	30,10	34,35	69,54	77,68	73,82	31,44	29,74	1,066
175	30,12	34,45	69,62	77,78	73,66	31,50	29,73	1,066
180	30,14	34,44	69,62	78,02	73,86	31,54	29,74	1,065
185	29,98	32,29	43,00	49,92	42,88	31,60	29,67	0



190	29,85	30,81	34,72	37,60	34,62	31,44	29,59	0
195	29,93	30,46	32,68	34,24	32,68	31,28	29,51	0
200	29,92	30,31	31,86	32,86	31,68	31,10	29,43	0
205	29,85	30,14	31,36	32,14	31,08	30,94	29,36	0
210	29,77	30,00	30,94	31,58	30,78	30,78	29,32	0
215	29,72	29,86	30,52	31,16	30,28	30,62	29,25	0
220	29,65	29,74	30,24	30,84	30,14	30,52	29,21	0
225	29,56	29,67	30,08	30,56	29,88	30,38	29,19	0
230	29,51	29,56	29,90	30,34	29,70	30,30	29,17	0
235	29,43	29,46	29,68	30,06	29,52	30,10	29,14	0
240	29,37	29,39	29,54	29,90	29,52	30,06	29,17	0

Lampiran 6. Tabel Pengambilan Data ETC Standar (2)

ETC Standar (2)								
t	IN (Ti)C	OUT (To)C	Absorber (TP1)C	Kaca Dalam (Tc- dalam)C	Kaca Luar (Tc- Luar)C	Tanki (T.Tangki)C	Ling (Ta)C	Ilum (I) Kw
0	26,81	26,86	27,40	27,50	27,60	26,70	27,29	0,000
5	26,94	29,02	54,80	57,00	59,00	26,80	26,99	1,032
10	26,97	30,53	62,62	69,50	65,84	26,90	27,08	1,044
15	27,02	30,94	64,12	71,60	67,54	27,04	27,20	1,044
20	27,11	31,19	64,92	72,72	67,62	27,06	27,30	1,049
25	27,21	31,33	65,08	73,04	65,32	27,30	27,32	1,048
30	27,32	31,47	65,22	73,12	64,32	27,40	27,34	1,049
35	27,42	31,62	65,54	73,94	68,44	27,48	27,53	1,051
40	27,80	31,61	65,96	75,00	72,46	27,56	28,09	1,051
45	28,17	32,28	66,50	75,22	71,42	27,78	28,50	1,047
50	28,34	32,50	66,74	75,32	71,26	27,94	28,75	1,047
55	28,53	32,74	66,68	75,40	70,40	28,10	29,01	1,040
60	28,69	32,89	66,88	75,40	70,94	28,24	29,31	1,049
65	28,85	33,14	68,06	76,62	71,80	28,38	29,46	1,085
70	28,98	33,36	68,54	77,12	72,02	28,54	29,56	1,083
75	29,02	33,45	67,52	76,92	74,32	28,72	29,63	1,093
80	29,12	33,43	64,48	74,32	74,42	28,82	29,71	1,053
85	28,98	33,22	63,22	70,12	69,36	29,12	29,14	1,069
90	28,76	33,19	68,16	76,48	68,78	29,24	28,68	1,083
95	28,68	33,07	68,02	76,42	68,96	29,38	28,50	1,088
100	28,65	32,93	68,02	76,94	68,24	29,52	28,32	1,062
105	28,64	32,89	67,98	77,56	69,32	29,56	28,23	1,065
110	28,69	32,89	67,96	76,56	67,78	29,68	28,17	1,076
115	28,76	32,91	67,92	77,02	69,04	29,68	28,14	1,087
120	28,80	32,98	68,18	77,26	68,90	29,82	28,07	1,091
125	28,87	33,02	68,10	77,16	66,78	29,84	28,02	1,087
130	28,90	33,21	68,86	77,20	69,20	29,88	27,99	1,112
135	28,93	33,33	69,10	76,96	66,98	30,06	27,94	1,105
140	28,95	33,33	68,78	76,70	68,30	30,00	27,96	1,078
145	28,96	33,33	68,64	76,72	69,60	30,08	27,99	1,075
150	29,01	33,44	68,54	77,14	72,24	30,12	27,94	1,063
155	29,10	33,48	68,34	76,72	70,80	30,12	27,98	1,054
160	29,24	33,57	68,24	76,60	71,04	30,20	28,27	1,051
165	29,41	33,71	68,18	76,44	68,74	30,20	28,81	1,046
170	29,58	33,89	68,22	76,60	70,44	30,26	29,19	1,044
175	29,72	34,07	68,62	77,20	71,68	30,34	29,45	1,062
180	29,75	34,20	69,08	77,54	73,56	30,48	29,43	1,068
185	29,48	32,01	42,36	49,82	41,56	30,56	29,24	0

190	29,35	30,36	33,98	37,06	32,58	30,50	29,34	0
195	29,43	29,98	32,02	33,82	30,86	30,42	29,41	0
200	29,45	29,83	31,24	32,36	30,68	30,28	29,45	0
205	29,44	29,73	30,70	31,64	29,94	30,22	29,56	0
210	29,42	29,66	30,44	31,28	29,68	30,20	29,58	0
215	29,42	29,57	30,14	30,78	29,68	30,10	29,58	0
220	29,34	29,48	29,94	30,40	29,58	30,04	29,51	0
225	29,17	29,29	29,58	30,06	29,14	30,02	29,29	0
230	28,95	29,04	29,30	29,80	28,84	29,96	28,90	0
235	28,79	28,85	29,04	29,52	28,42	29,84	28,51	0
240	28,67	28,71	28,80	29,26	28,32	29,74	28,29	0

Lampiran 7. Tabel Pengambilan Data ETC Standar (3)

ETC Standar (3)								
t	IN (Ti)C	OUT (To)C	Absorber (TP1)C	Kaca Dalam (Tc- dalam)C	Kaca Luar (Tc- Luar)C	Tanki (T.Tangki)C	Ling (Ta)C	Illum (I) Kw
0	26,81	26,86	27,70	28,30	28,00	26,90	27,29	0,000
5	26,91	28,92	54,90	56,48	47,16	26,86	26,89	1,037
10	26,97	30,17	61,98	67,96	55,96	26,94	26,88	1,039
15	27,03	30,53	63,70	70,32	58,38	27,06	26,91	1,048
20	27,09	30,68	64,44	71,10	59,28	27,18	26,94	1,053
25	27,16	30,81	64,80	71,92	60,04	27,32	26,98	1,056
30	27,24	30,95	65,14	72,28	60,60	27,44	26,97	1,054
35	27,31	31,54	65,42	72,62	60,88	27,46	27,02	1,055
40	27,34	31,31	65,82	72,92	61,28	27,48	27,04	1,055
45	27,41	31,52	65,86	73,46	61,40	27,50	27,13	1,053
50	27,51	31,70	65,94	73,68	61,50	27,50	27,16	1,052
55	27,79	31,94	66,12	74,24	62,00	27,46	27,49	1,052
60	27,91	32,12	66,44	74,32	62,12	27,54	27,60	1,054
65	28,10	32,45	66,60	74,38	62,02	27,56	27,63	1,054
70	28,10	32,56	66,92	75,00	62,38	27,64	27,86	1,060
75	28,41	32,51	67,16	74,68	59,16	27,70	27,68	1,061
80	28,54	32,58	67,20	75,40	58,54	27,68	27,84	1,057
85	28,60	32,67	67,36	75,30	58,64	27,78	27,72	1,058
90	28,66	32,74	67,58	75,38	58,74	27,86	27,58	1,062
95	28,74	32,82	67,92	75,86	59,12	27,82	27,93	1,063
100	28,84	32,88	67,62	75,98	59,32	27,86	28,19	1,056
105	28,98	33,02	67,52	75,50	59,16	27,96	28,14	1,041
110	29,14	33,18	67,32	75,04	58,92	28,00	28,17	1,046
115	29,26	33,30	67,46	74,60	59,12	28,06	28,26	1,044
120	29,37	33,46	67,48	74,58	59,10	28,18	28,08	1,050
125	29,48	33,58	67,76	76,08	59,22	28,10	28,22	1,053
130	29,56	33,66	67,92	75,78	59,16	28,18	28,18	1,052
135	29,67	33,76	67,82	74,72	59,22	28,18	28,01	1,049
140	29,73	33,86	67,72	75,58	59,34	28,16	28,26	1,047
145	29,81	33,99	67,92	74,94	59,22	28,20	28,17	1,044
150	29,89	34,05	67,70	74,66	59,36	28,24	28,10	1,040
155	29,94	34,11	67,64	75,92	59,22	28,26	28,32	1,035
160	29,97	34,13	67,52	74,42	59,18	28,28	28,21	1,031
165	30,03	34,22	67,62	75,64	59,22	28,28	28,40	1,031
170	30,10	34,35	67,70	74,70	59,14	28,40	28,20	1,029
175	30,12	34,45	67,68	75,04	59,30	28,42	28,05	1,034
180	30,09	34,44	67,64	75,44	59,16	28,40	27,95	1,041
185	29,98	32,29	41,32	49,22	46,50	28,36	28,28	0

190	29,85	30,81	33,48	36,26	37,58	28,36	28,23	0
195	29,93	30,46	31,58	32,80	34,06	28,30	28,37	0
200	29,92	30,31	30,72	31,46	32,46	28,32	28,46	0
205	29,85	30,14	30,18	30,82	31,54	28,28	28,55	0
210	29,77	30,00	29,88	30,44	31,08	28,28	28,69	0
215	29,72	29,86	29,62	30,06	30,58	28,32	28,48	0
220	29,65	29,74	29,26	29,68	30,12	28,36	28,21	0
225	29,56	29,67	28,96	29,44	29,76	28,36	28,01	0
230	29,51	29,56	28,66	29,18	29,42	28,38	27,80	0
235	29,43	29,46	28,52	28,92	29,14	28,48	27,65	0
240	29,37	29,39	28,30	28,70	28,86	28,44	27,52	0

Lampiran 8. Tabel Pengambilan Data ETC Dengan penambahan PCM (1)

ETC PCM (1)									
t	IN (Ti)C	OUT (To)C	PCM C	Absorber (TPI)C	Kaca Dalam (Tc- dalam)C	Kaca Luar (Tc- Luar)C	Tanki (T.Tangki)C	Ling (Ta)C	Ilum (I) Kw
0	26,29	26,98	27,1	26,90	27,30	27,40	26,90	28,32	0,000
5	26,73	28,77	34,9	46,72	54,20	43,14	26,76	27,96	1,050
10	27,11	30,70	39,86	52,76	65,62	53,66	27,00	28,12	1,056
15	27,20	31,34	41,5	54,78	68,50	56,82	27,38	28,21	1,051
20	27,31	31,65	42,28	55,98	69,84	58,10	27,72	28,30	1,043
25	27,40	31,85	42,56	55,86	70,12	58,62	28,20	28,41	1,041
30	27,50	32,05	42,8	56,04	70,70	59,06	28,46	28,53	1,042
35	27,53	32,20	43,02	56,28	70,94	59,40	28,74	28,60	1,041
40	27,57	32,23	43,24	56,56	71,24	59,42	29,00	28,60	1,034
45	27,77	32,44	43,42	56,82	71,02	58,82	29,02	28,64	1,035
50	27,98	32,69	43,68	57,12	71,54	59,16	29,12	28,70	1,032
55	28,12	32,86	43,96	57,42	71,88	59,62	29,24	28,81	1,030
60	28,20	33,02	44,2	57,60	72,08	59,80	29,34	28,95	1,024
65	28,31	33,16	44,16	57,68	72,02	59,86	29,50	29,05	1,024
70	28,43	33,28	44,32	57,80	72,50	60,16	29,76	29,10	1,021
75	28,54	33,44	44,5	58,02	72,80	60,44	30,04	29,17	1,021
80	28,68	33,61	44,66	58,26	72,96	60,72	30,26	29,25	1,018
85	28,78	33,68	44,8	58,34	73,10	60,68	30,52	29,24	1,002
90	28,88	33,75	44,84	58,40	72,88	60,66	30,76	29,27	0,997
95	28,97	33,80	44,9	58,50	73,20	60,86	30,82	29,31	0,992
100	29,13	33,95	45,16	58,80	73,56	61,08	31,02	29,42	1,021
105	29,29	34,14	45,32	58,92	73,74	61,42	31,16	29,39	1,021
110	29,38	34,29	45,44	59,00	73,72	61,54	31,34	29,39	1,021
115	29,45	34,40	45,54	59,18	73,72	61,58	31,52	29,35	1,019
120	29,53	34,44	45,56	59,10	73,40	61,42	31,70	29,35	1,018
125	29,61	34,51	45,68	59,22	73,66	61,48	31,86	29,22	1,017
130	29,82	34,66	45,74	59,38	74,16	61,82	32,00	29,15	1,021
135	30,00	34,86	45,84	59,38	73,68	61,68	32,12	29,14	1,020
140	30,07	34,99	45,96	59,46	73,94	61,70	32,22	29,14	1,020
145	30,11	35,07	46,04	59,62	74,26	61,96	32,40	29,10	1,022
150	30,16	35,15	46,08	59,68	74,24	61,94	32,44	29,09	1,021
155	30,21	35,19	46,14	59,70	74,10	61,84	32,58	29,10	1,027
160	30,25	35,21	46,22	59,78	74,46	62,08	32,66	29,07	1,030
165	30,26	35,24	46,38	59,92	74,40	62,30	32,82	29,09	1,034
170	30,38	35,32	46,52	60,14	74,34	62,30	32,88	29,16	1,033
175	30,46	35,42	46,64	60,24	74,56	62,44	32,96	29,12	1,036
180	30,43	35,46	46,7	60,38	74,88	62,56	33,08	29,11	1,036
185	30,34	34,73	39,5	42,42	50,84	49,04	33,04	29,00	0

190	29,95	32,17	33,72	34,66	37,04	36,48	32,86	28,33	0
195	29,53	30,63	31,76	32,22	33,48	33,18	32,62	27,64	0
200	29,34	29,90	30,78	31,04	31,86	31,70	32,26	27,69	0
205	29,23	29,62	30,2	30,34	30,56	30,64	31,92	27,50	0
210	29,06	29,32	29,88	29,90	29,90	30,10	31,68	27,54	0
215	28,92	29,09	29,58	29,60	29,18	29,48	31,38	27,29	0
220	28,89	28,83	29,34	29,28	28,96	29,26	31,22	26,91	0
225	28,76	28,67	29,1	29,00	28,36	28,78	30,92	26,81	0
230	28,59	28,49	28,82	28,72	28,00	28,46	30,66	26,67	0
235	28,55	28,40	28,68	28,46	27,52	28,06	30,50	26,61	0
240	28,55	28,41	28,46	28,24	27,06	27,68	30,32	26,61	0

Lampiran 9. Tabel Pengambilan Data ETC Dengan penambahan PCM (2)

ETC PCM (2)									
t	IN (Ti)C	OUT (To)C	PCM C	Absorber (TPI)C	Kaca Dalam (Tc- dalam)C	Kaca Luar (Tc- Luar)C	Tanki (T.Tangki)C	Ling (Ta)C	Ilum (I) Kw
0	26,29	26,98	27,80	25,60	26,00	26,10	26,10	26,71	0,000
5	26,53	28,26	31,42	41,00	60,54	60,48	26,10	26,70	0,984
10	26,69	30,13	34,65	48,66	75,08	68,08	26,18	26,75	0,998
15	26,90	30,78	36,31	51,08	79,20	68,94	26,22	27,16	1,004
20	27,16	31,25	37,39	52,48	81,70	71,14	26,32	27,58	1,011
25	27,39	31,59	38,29	53,30	83,28	72,08	26,38	28,01	1,008
30	27,48	31,81	38,98	53,62	82,70	72,08	26,46	28,00	0,998
35	27,52	31,93	39,57	54,22	84,16	72,68	26,52	28,17	1,025
40	27,57	31,81	40,06	54,70	84,52	73,18	26,64	28,23	1,029
45	27,67	32,29	40,49	55,12	85,20	73,48	26,70	28,25	1,024
50	27,72	32,41	40,89	55,36	85,30	73,64	26,80	28,33	1,036
55	27,78	32,67	41,34	56,04	86,30	74,50	26,90	28,37	1,056
60	27,85	32,84	41,78	56,48	86,88	75,40	27,00	28,44	1,054
65	27,94	32,93	42,05	56,66	86,94	74,60	27,10	28,46	1,053
70	28,00	33,02	42,31	56,74	87,24	74,78	27,22	28,51	1,052
75	28,08	33,04	42,65	56,94	87,62	74,58	27,28	28,60	1,051
80	28,16	33,06	42,96	57,16	88,02	75,38	27,36	28,67	1,050
85	28,19	33,14	43,23	57,28	87,90	74,86	27,46	28,67	1,052
90	28,22	33,21	43,46	57,42	88,20	75,32	27,66	28,67	1,053
95	28,30	33,34	43,73	57,52	88,46	75,00	27,78	28,76	1,054
100	28,37	33,55	43,97	57,68	88,58	75,40	27,98	28,77	1,046
105	28,42	33,53	44,19	57,70	88,40	75,14	28,22	28,79	1,044
110	28,49	33,57	44,43	57,78	88,74	74,88	28,42	28,93	1,043
115	28,57	33,61	44,57	57,80	88,86	75,02	28,58	28,87	1,042
120	28,63	33,65	44,75	57,76	88,78	74,78	28,76	28,83	1,042
125	28,72	33,69	44,92	57,78	89,04	74,72	29,04	28,90	1,040
130	28,83	33,88	45,07	57,86	89,12	74,30	28,96	28,92	1,039
135	29,07	34,10	45,31	57,90	89,20	74,34	29,44	28,95	1,034
140	29,52	34,43	45,63	58,04	89,20	74,30	30,10	28,91	1,032
145	29,71	34,68	45,61	58,02	89,48	73,82	30,48	28,92	1,037
150	29,74	34,79	45,78	58,34	89,70	74,22	30,70	28,98	1,037
155	29,79	34,84	45,85	58,56	89,56	74,72	30,80	28,94	1,035
160	29,86	34,88	46,02	58,58	89,24	74,62	30,88	28,98	1,032
165	29,86	34,92	46,20	58,62	89,36	74,52	31,02	28,97	1,029
170	29,85	34,90	46,33	58,60	88,96	74,10	31,10	28,95	1,026
175	29,82	34,89	46,37	58,48	89,20	74,08	31,46	28,95	1,027
180	29,94	34,94	46,39	58,54	89,40	74,18	31,82	28,97	1,027
185	29,85	33,18	43,18	43,50	55,38	41,66	31,82	28,94	0



190	29,75	31,20	39,79	35,66	41,16	34,42	31,70	28,84	0
195	29,74	30,44	38,28	33,02	36,76	32,42	31,42	28,78	0
200	29,69	30,10	37,09	31,94	34,70	31,28	31,14	28,81	0
205	29,57	29,87	36,11	31,22	33,34	30,62	30,94	28,86	0
210	29,51	29,73	35,22	30,72	32,62	30,24	30,78	28,89	0
215	29,45	29,61	34,37	30,38	32,04	29,82	30,62	28,88	0
220	29,36	29,49	33,72	30,02	31,52	29,54	30,50	28,87	0
225	29,15	29,29	33,04	29,70	31,02	29,12	30,38	28,84	0
230	29,08	29,13	32,55	29,30	30,60	28,88	30,20	28,88	0
235	29,09	29,08	32,09	29,28	30,30	28,92	30,10	28,88	0
240	29,07	29,04	31,63	29,12	30,02	28,78	30,00	28,85	0

Lampiran 10. Tabel Pengambilan Data ETC Dengan penambahan PCM (3)

ETC PCM (3)									
t	IN (Ti)C	OUT (To)C	PCM C	Absorber (TP1)C	Kaca Dalam (Tc- dalam)C	Kaca Luar (Tc- Luar)C	Tanki (T.Tangki)C	Ling (Ta)C	Ilum (I) Kw
0	26,30	26,44	26,70	26,20	25,70	25,70	26,90	28,32	0,000
5	26,34	28,48	35,78	46,80	53,80	57,76	26,76	28,51	0,992
10	27,07	30,50	40,80	53,68	67,28	67,84	27,00	28,81	1,000
15	27,35	31,29	42,24	55,64	70,18	69,14	27,38	29,02	1,007
20	27,51	31,72	43,00	56,68	71,48	70,18	27,72	29,33	1,014
25	27,54	31,89	43,46	57,38	72,28	71,02	28,20	29,54	1,022
30	27,62	32,01	43,78	57,78	72,68	70,70	28,46	29,74	1,020
35	27,66	32,12	44,34	58,24	72,72	70,62	28,74	29,79	1,021
40	27,76	32,01	44,70	58,68	73,08	71,32	29,00	29,87	1,020
45	27,92	32,55	44,96	59,02	73,50	71,10	29,02	29,84	1,021
50	28,05	32,77	45,14	59,18	73,66	70,94	29,12	29,89	1,020
55	28,19	32,99	45,26	59,42	73,72	71,22	29,24	30,07	1,021
60	28,31	33,15	45,38	59,58	74,12	71,44	29,34	30,17	1,021
65	28,43	33,17	45,50	59,80	74,44	71,46	29,50	30,27	1,021
70	28,42	33,15	45,64	60,02	74,82	71,42	29,76	30,39	1,019
75	28,48	33,26	45,76	60,30	74,98	71,86	30,04	30,42	1,020
80	28,70	33,55	45,84	60,36	74,80	72,04	30,26	30,54	1,019
85	28,72	33,56	45,98	60,56	74,62	71,56	30,52	30,56	1,017
90	28,72	33,56	46,00	60,64	74,88	71,80	30,76	30,72	1,020
95	28,77	33,58	46,04	60,66	74,98	72,18	30,82	30,87	1,017
100	28,92	33,68	46,10	60,82	75,14	72,02	31,02	30,89	1,019
105	29,02	33,81	46,18	60,84	75,34	72,06	31,16	30,91	1,020
110	29,09	33,95	46,20	60,88	75,34	72,18	31,34	30,91	1,019
115	29,14	34,01	46,30	61,04	75,30	71,42	31,52	31,00	1,018
120	29,14	34,05	46,38	61,10	75,20	71,92	31,70	30,93	1,015
125	29,27	34,16	46,50	61,14	75,54	71,96	31,86	30,92	1,015
130	29,45	34,26	46,56	61,22	75,90	71,74	32,00	30,90	1,014
135	29,50	34,41	46,64	61,26	75,40	71,96	32,12	30,99	1,014
140	29,58	34,46	46,74	61,40	75,78	72,36	32,22	31,01	1,010
145	29,54	34,52	46,78	61,46	75,66	72,62	32,40	30,60	1,005
150	29,57	34,59	46,90	61,60	76,06	72,32	32,44	30,40	1,006
155	29,68	34,66	47,06	61,66	76,00	72,64	32,58	30,32	1,008
160	29,75	34,76	47,12	61,78	75,96	72,28	32,66	30,33	1,008
165	30,09	34,88	47,16	61,84	76,02	72,32	32,82	30,28	1,006
170	30,18	35,06	47,20	61,78	76,28	72,64	32,88	30,17	1,008
175	30,26	35,20	47,32	61,98	76,06	72,96	32,96	29,79	1,007
180	30,30	35,29	47,38	62,00	76,14	72,60	33,08	29,57	1,007
185	30,24	33,38	39,38	42,22	49,20	41,90	33,04	29,74	0

190	30,03	31,47	33,98	34,92	36,98	34,50	32,86	29,79	0
195	29,75	30,45	32,46	32,92	34,24	32,50	32,62	29,87	0
200	29,55	29,94	31,80	32,10	33,02	31,80	32,26	29,84	0
205	29,44	29,67	31,46	31,60	32,32	31,16	31,92	29,89	0
210	29,37	29,49	31,26	31,22	31,76	30,68	31,68	30,29	0
215	29,29	29,32	31,06	31,02	31,32	30,44	31,38	30,35	0
220	29,16	29,18	31,00	30,82	31,04	30,16	31,22	30,32	0
225	29,03	29,00	30,76	30,58	30,64	29,98	30,92	30,30	0
230	28,90	28,85	30,68	30,50	30,46	29,70	30,66	30,21	0
235	28,79	28,70	30,56	30,26	30,08	29,50	30,50	29,88	0
240	28,66	28,56	30,48	30,10	30,06	29,44	30,32	29,54	0

Lampiran 11. Tabel Hasil Perhitungan ETC Standar (1), (2) dan (3)

ETC Standar (1)				ETC Standar (2)				ETC Standar (3)			
t	V (m <sup>3</sup> /s)	Qu (Watt)	η (%)	t	V (m <sup>3</sup> /s)	Qu (Watt)	η (%)	t	V (m <sup>3</sup> /s)	Qu (Watt)	η (%)
0	2,33E-06	0,00	0%	0	2,33E-06	0	0%	0	2,33E-06	0,00	0%
5	2,33E-06	18,06	22%	5	2,33E-06	20,24	26%	5	2,33E-06	19,50	25%
10	2,33E-06	29,97	37%	10	2,33E-06	34,64	44%	10	2,33E-06	31,17	40%
15	2,33E-06	33,38	41%	15	2,33E-06	38,15	49%	15	2,33E-06	34,05	43%
20	2,33E-06	34,70	44%	20	2,33E-06	39,70	50%	20	2,33E-06	34,92	44%
25	2,33E-06	35,23	44%	25	2,33E-06	40,03	51%	25	2,33E-06	35,54	45%
30	2,33E-06	36,57	46%	30	2,33E-06	40,36	51%	30	2,33E-06	35,98	45%
35	2,33E-06	36,49	46%	35	2,33E-06	40,84	52%	35	2,33E-06	38,98	49%
40	2,33E-06	37,29	48%	40	2,33E-06	39,24	50%	40	2,33E-06	38,91	51%
45	2,33E-06	36,64	47%	45	2,33E-06	39,89	51%	45	2,33E-06	39,86	50%
50	2,33E-06	37,51	48%	50	2,33E-06	40,40	51%	50	2,33E-06	40,72	52%
55	2,33E-06	37,88	49%	55	2,33E-06	40,85	52%	55	2,33E-06	40,34	51%
60	2,33E-06	38,00	49%	60	2,33E-06	40,78	52%	60	2,33E-06	40,86	52%
65	2,33E-06	38,25	49%	65	2,33E-06	41,66	51%	65	2,33E-06	40,28	53%
70	2,33E-06	38,60	50%	70	2,33E-06	42,54	52%	70	2,33E-06	40,08	54%
75	2,33E-06	38,85	50%	75	2,33E-06	43,00	52%	75	2,33E-06	39,74	50%
80	2,33E-06	39,21	50%	80	2,33E-06	41,79	53%	80	2,33E-06	39,22	49%
85	2,33E-06	39,47	50%	85	2,33E-06	41,17	51%	85	2,33E-06	39,47	50%
90	2,33E-06	39,54	50%	90	2,33E-06	43,07	53%	90	2,33E-06	39,55	50%
95	2,33E-06	39,56	50%	95	2,33E-06	42,55	52%	95	2,33E-06	39,56	50%
100	2,33E-06	39,20	50%	100	2,33E-06	41,52	52%	100	2,33E-06	39,20	49%
105	2,33E-06	39,23	50%	105	2,33E-06	41,27	52%	105	2,33E-06	39,24	50%
110	2,33E-06	39,16	49%	110	2,33E-06	40,78	50%	110	2,33E-06	39,16	50%
115	2,33E-06	39,23	49%	115	2,33E-06	40,38	49%	115	2,33E-06	39,23	50%
120	2,33E-06	39,64	50%	120	2,33E-06	40,50	49%	120	2,33E-06	39,64	50%
125	2,33E-06	39,80	50%	125	2,33E-06	40,26	49%	125	2,33E-06	39,81	50%
130	2,33E-06	39,75	50%	130	2,33E-06	41,81	50%	130	2,33E-06	39,76	50%
135	2,33E-06	39,69	50%	135	2,33E-06	42,76	52%	135	2,33E-06	39,69	50%
140	2,33E-06	40,01	50%	140	2,33E-06	42,55	53%	140	2,33E-06	40,02	51%
145	2,33E-06	40,59	50%	145	2,33E-06	42,44	53%	145	2,33E-06	40,60	52%
150	2,33E-06	40,36	50%	150	2,33E-06	42,98	54%	150	2,33E-06	40,37	52%
155	2,33E-06	40,44	50%	155	2,33E-06	42,47	54%	155	2,33E-06	40,45	52%
160	2,33E-06	40,35	50%	160	2,33E-06	41,99	53%	160	2,33E-06	40,36	52%
165	2,33E-06	40,57	51%	165	2,33E-06	41,80	53%	165	2,33E-06	40,58	52%
170	2,33E-06	41,32	52%	170	2,33E-06	41,84	53%	170	2,33E-06	41,33	53%
175	2,33E-06	42,01	52%	175	2,33E-06	42,19	53%	175	2,33E-06	42,03	54%
180	2,33E-06	41,71	52%	180	2,33E-06	43,20	54%	180	2,33E-06	42,15	54%
185	2,33E-06	22,49	0%	185	2,33E-06	24,57	0%	185	2,33E-06	22,49	0%
190	2,33E-06	9,24	0%	190	2,33E-06	9,79	0%	190	2,33E-06	9,24	0%
195	2,33E-06	5,12	0%	195	2,33E-06	5,35	0%	195	2,33E-06	5,12	0%

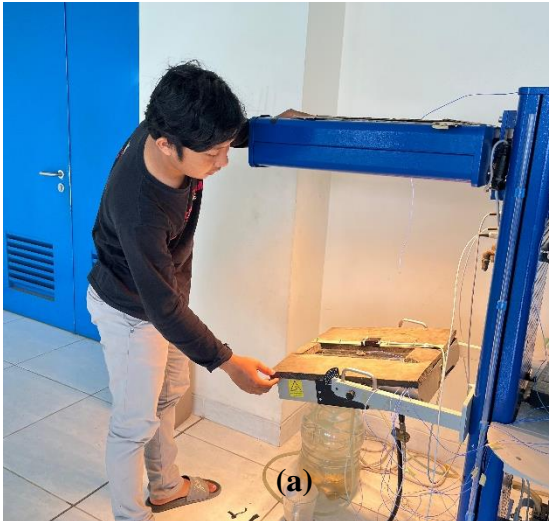
200	2,33E-06	3,73	0%	200	2,33E-06	3,62	0%	200	2,33E-06	3,73	0%
205	2,33E-06	2,83	0%	205	2,33E-06	2,81	0%	205	2,33E-06	2,83	0%
210	2,33E-06	2,26	0%	210	2,33E-06	2,30	0%	210	2,33E-06	2,26	0%
215	2,33E-06	1,43	0%	215	2,33E-06	1,49	0%	215	2,33E-06	1,43	0%
220	2,33E-06	0,87	0%	220	2,33E-06	1,43	0%	220	2,33E-06	0,87	0%
225	2,33E-06	1,07	0%	225	2,33E-06	1,19	0%	225	2,33E-06	1,07	0%
230	2,33E-06	0,47	0%	230	2,33E-06	0,90	0%	230	2,33E-06	0,47	0%
235	2,33E-06	0,37	0%	235	2,33E-06	0,53	0%	235	2,33E-06	0,37	0%
240	2,33E-06	0,18	0%	240	2,33E-06	0,36	0%	240	2,33E-06	0,18	0%

Lampiran 12. Tabel Hasil Perhitungan ETC dengan penambahan PCM (1), (2) dan (3)

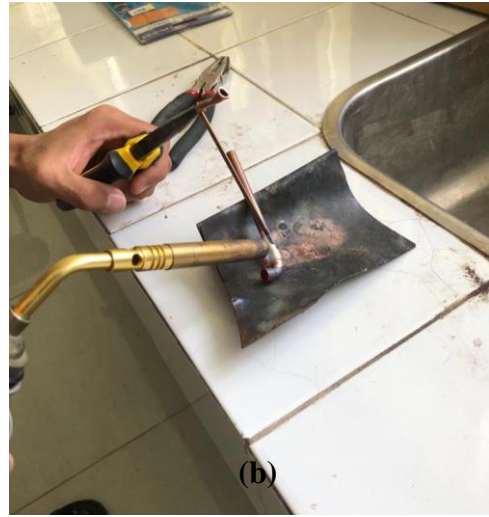
ETC PCM(1)				ETC PCM (2)				ETC PCM (3)			
t	V (m <sup>3</sup> /s)	Qu (Watt)	η (%)	t	V (m <sup>3</sup> /s)	Qu (Watt)	η (%)	t	V (m <sup>3</sup> /s)	Qu (Watt)	η (%)
0	2,33E-06	0,00	0%	0	2,33E-06	0,00	0%	0	2,33E-06	0,00	0%
5	2,33E-06	19,88	25%	5	2,33E-06	16,88	23%	5	2,33E-06	20,82	28%
10	2,33E-06	34,92	44%	10	2,33E-06	33,34	44%	10	2,33E-06	33,33	44%
15	2,33E-06	40,18	51%	15	2,33E-06	37,64	50%	15	2,33E-06	38,32	51%
20	2,33E-06	42,10	54%	20	2,33E-06	39,67	52%	20	2,33E-06	40,92	54%
25	2,33E-06	43,16	55%	25	2,33E-06	40,79	54%	25	2,33E-06	42,28	55%
30	2,33E-06	44,18	56%	30	2,33E-06	42,03	56%	30	2,33E-06	42,70	56%
35	2,33E-06	45,39	58%	35	2,33E-06	42,89	56%	35	2,33E-06	43,28	56%
40	2,33E-06	45,08	58%	40	2,33E-06	44,10	57%	40	2,33E-06	44,45	58%
45	2,33E-06	45,31	58%	45	2,33E-06	44,85	58%	45	2,33E-06	44,90	59%
50	2,33E-06	45,71	59%	50	2,33E-06	45,57	59%	50	2,33E-06	45,81	60%
55	2,33E-06	46,00	59%	55	2,33E-06	47,49	60%	55	2,33E-06	46,61	61%
60	2,33E-06	46,74	61%	60	2,33E-06	48,47	61%	60	2,33E-06	46,94	61%
65	2,33E-06	47,06	61%	65	2,33E-06	48,47	61%	65	2,33E-06	46,07	60%
70	2,33E-06	47,14	61%	70	2,33E-06	48,77	62%	70	2,33E-06	45,98	60%
75	2,33E-06	47,57	62%	75	2,33E-06	48,13	61%	75	2,33E-06	46,32	60%
80	2,33E-06	47,84	63%	80	2,33E-06	47,57	60%	80	2,33E-06	47,02	61%
85	2,33E-06	47,61	63%	85	2,33E-06	48,07	61%	85	2,33E-06	47,05	62%
90	2,33E-06	47,26	63%	90	2,33E-06	48,45	61%	90	2,33E-06	47,05	61%
95	2,33E-06	46,95	63%	95	2,33E-06	48,95	62%	95	2,33E-06	46,66	61%
100	2,33E-06	46,71	61%	100	2,33E-06	50,33	64%	100	2,33E-06	46,11	60%
105	2,33E-06	47,08	61%	105	2,33E-06	49,62	63%	105	2,33E-06	46,52	61%
110	2,33E-06	47,68	62%	110	2,33E-06	49,27	63%	110	2,33E-06	47,20	62%
115	2,33E-06	48,03	63%	115	2,33E-06	48,93	63%	115	2,33E-06	47,31	62%
120	2,33E-06	47,66	62%	120	2,33E-06	48,65	62%	120	2,33E-06	47,71	63%
125	2,33E-06	47,55	62%	125	2,33E-06	48,26	62%	125	2,33E-06	47,44	62%
130	2,33E-06	46,91	61%	130	2,33E-06	49,07	63%	130	2,33E-06	46,65	61%
135	2,33E-06	47,08	61%	135	2,33E-06	48,83	63%	135	2,33E-06	47,61	63%
140	2,33E-06	47,64	62%	140	2,33E-06	47,59	61%	140	2,33E-06	47,42	63%
145	2,33E-06	48,09	63%	145	2,33E-06	48,25	62%	145	2,33E-06	48,28	64%
150	2,33E-06	48,35	63%	150	2,33E-06	48,96	63%	150	2,33E-06	48,70	64%
155	2,33E-06	48,34	63%	155	2,33E-06	49,00	63%	155	2,33E-06	48,32	64%
160	2,33E-06	48,19	62%	160	2,33E-06	48,67	63%	160	2,33E-06	48,61	64%
165	2,33E-06	48,34	62%	165	2,33E-06	49,14	64%	165	2,33E-06	46,50	62%
170	2,33E-06	47,98	62%	170	2,33E-06	49,00	64%	170	2,33E-06	47,38	63%
175	2,33E-06	48,17	62%	175	2,33E-06	49,16	64%	175	2,33E-06	47,97	63%
180	2,33E-06	48,78	63%	180	2,33E-06	48,52	63%	180	2,33E-06	48,46	64%
185	2,33E-06	42,57	0%	185	2,33E-06	32,30	0%	185	2,33E-06	30,43	0%
190	2,33E-06	21,51	0%	190	2,33E-06	14,13	0%	190	2,33E-06	13,94	0%
195	2,33E-06	10,69	0%	195	2,33E-06	6,78	0%	195	2,33E-06	6,82	0%

200	2,33E-06	5,42	0%	200	2,33E-06	4,05	0%	200	2,33E-06	3,78	0%
205	2,33E-06	3,81	0%	205	2,33E-06	2,92	0%	205	2,33E-06	2,23	0%
210	2,33E-06	2,54	0%	210	2,33E-06	2,10	0%	210	2,33E-06	1,15	0%
215	2,33E-06	1,56	0%	215	2,33E-06	1,59	0%	215	2,33E-06	0,36	0%
220	2,33E-06	-0,54	0%	220	2,33E-06	1,28	0%	220	2,33E-06	0,20	0%
225	2,33E-06	-0,95	0%	225	2,33E-06	1,35	0%	225	2,33E-06	-0,24	0%
230	2,33E-06	-1,00	0%	230	2,33E-06	0,50	0%	230	2,33E-06	-0,46	0%
235	2,33E-06	-1,52	0%	235	2,33E-06	-0,06	0%	235	2,33E-06	-0,90	0%
240	2,33E-06	-1,38	0%	240	2,33E-06	-0,27	0%	240	2,33E-06	-0,95	0%

## Lampiran 13. Dokumentasi



(a)



(b)



(c)



(d)



(e)



(f)

Keterangan :

- (a) Proses Pengambilan data
- (b) Proses *welding* pipa tembaga
- (c) Proses penambahan PCM ke dalam ETC

- (d) Proses pengolahan data pada komputer
- (e) Proses ETC yang sedang diuji
- (f) Model alat setelah dibuat