

5. LAMPIRAN

Lampiran 1: Tabel *Properties of saturated water (liquid-vapor): temperature table*

TABLE A-2

Properties of Saturated Water (Liquid–Vapor): Temperature Table

Pressure Conversions:
 1 bar = 0.1 MPa
 = 10² kPa

Temp. °C	Press. bar	Specific Volume m ³ /kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		Temp. °C
		Sat. Liquid <i>v_f</i> × 10 ³	Sat. Vapor <i>v_g</i>	Sat. Liquid <i>u_f</i>	Sat. Vapor <i>u_g</i>	Sat. Liquid <i>h_f</i>	Evap. <i>h_{fg}</i>	Sat. Vapor <i>h_g</i>	Sat. Liquid <i>s_f</i>	Sat. Vapor <i>s_g</i>	
.01	0.00611	1.0002	206.136	0.00	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	.01
4	0.00813	1.0001	157.232	16.77	2380.9	16.78	2491.9	2508.7	0.0610	9.0514	4
5	0.00872	1.0001	147.120	20.97	2382.3	20.98	2489.6	2510.6	0.0761	9.0257	5
6	0.00935	1.0001	137.734	25.19	2383.6	25.20	2487.2	2512.4	0.0912	9.0003	6
8	0.01072	1.0002	120.917	33.59	2386.4	33.60	2482.5	2516.1	0.1212	8.9501	8
10	0.01228	1.0004	106.379	42.00	2389.2	42.01	2477.7	2519.8	0.1510	8.9008	10
11	0.01312	1.0004	99.857	46.20	2390.5	46.20	2475.4	2521.6	0.1658	8.8765	11
12	0.01402	1.0005	93.784	50.41	2391.9	50.41	2473.0	2523.4	0.1806	8.8524	12
13	0.01497	1.0007	88.124	54.60	2393.3	54.60	2470.7	2525.3	0.1953	8.8285	13
14	0.01598	1.0008	82.848	58.79	2394.7	58.80	2468.3	2527.1	0.2099	8.8048	14
15	0.01705	1.0009	77.926	62.99	2396.1	62.99	2465.9	2528.9	0.2245	8.7814	15
16	0.01818	1.0011	73.333	67.18	2397.4	67.19	2463.6	2530.8	0.2390	8.7582	16
17	0.01938	1.0012	69.044	71.38	2398.8	71.38	2461.2	2532.6	0.2535	8.7351	17
18	0.02064	1.0014	65.038	75.57	2400.2	75.58	2458.8	2534.4	0.2679	8.7123	18
19	0.02198	1.0016	61.293	79.76	2401.6	79.77	2456.5	2536.2	0.2823	8.6897	19
20	0.02339	1.0018	57.791	83.95	2402.9	83.96	2454.1	2538.1	0.2966	8.6672	20
21	0.02487	1.0020	54.514	88.14	2404.3	88.14	2451.8	2539.9	0.3109	8.6450	21
22	0.02645	1.0022	51.447	92.32	2405.7	92.33	2449.4	2541.7	0.3251	8.6229	22
23	0.02810	1.0024	48.574	96.51	2407.0	96.52	2447.0	2543.5	0.3393	8.6011	23
24	0.02985	1.0027	45.883	100.70	2408.4	100.70	2444.7	2545.4	0.3534	8.5794	24
25	0.03169	1.0029	43.360	104.88	2409.8	104.89	2442.3	2547.2	0.3674	8.5580	25
26	0.03363	1.0032	40.994	109.06	2411.1	109.07	2439.9	2549.0	0.3814	8.5367	26
27	0.03567	1.0035	38.774	113.25	2412.5	113.25	2437.6	2550.8	0.3954	8.5156	27
28	0.03782	1.0037	36.690	117.42	2413.9	117.43	2435.2	2552.6	0.4093	8.4946	28
29	0.04008	1.0040	34.733	121.60	2415.2	121.61	2432.8	2554.5	0.4231	8.4739	29
30	0.04246	1.0043	32.894	125.78	2416.6	125.79	2430.5	2556.3	0.4369	8.4533	30
31	0.04496	1.0046	31.165	129.96	2418.0	129.97	2428.1	2558.1	0.4507	8.4329	31
32	0.04759	1.0050	29.540	134.14	2419.3	134.15	2425.7	2559.9	0.4644	8.4127	32
33	0.05034	1.0053	28.011	138.32	2420.7	138.33	2423.4	2561.7	0.4781	8.3927	33
34	0.05324	1.0056	26.571	142.50	2422.0	142.50	2421.0	2563.5	0.4917	8.3728	34
35	0.05628	1.0060	25.216	146.67	2423.4	146.68	2418.6	2565.3	0.5053	8.3531	35
36	0.05947	1.0063	23.940	150.85	2424.7	150.86	2416.2	2567.1	0.5188	8.3336	36
38	0.06632	1.0071	21.602	159.20	2427.4	159.21	2411.5	2570.7	0.5458	8.2950	38
40	0.07384	1.0078	19.523	167.56	2430.1	167.57	2406.7	2574.3	0.5725	8.2570	40
45	0.09593	1.0099	15.258	188.44	2436.8	188.45	2394.8	2583.2	0.6387	8.1648	45

$v_f = (\text{table value})/1000$

H₂O

Lampiran 2: Tabel *Properties of saturated water (liquid-vapor): pressure table*

TABLE A-3

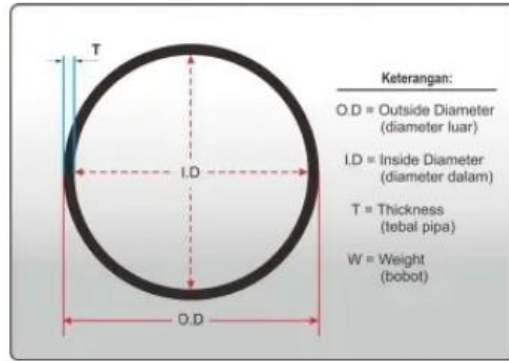
Properties of Saturated Water (Liquid–Vapor): Pressure Table

Pressure Conversions:
1 bar = 0.1 MPa
= 10² kPa

Press. bar	Temp. °C	Specific Volume m ³ /kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		Press. bar
		Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	
0.04	28.96	1.0040	34.800	121.45	2415.2	121.46	2432.9	2554.4	0.4226	8.4746	0.04
0.06	36.16	1.0064	23.739	151.53	2425.0	151.53	2415.9	2567.4	0.5210	8.3304	0.06
0.08	41.51	1.0084	18.103	173.87	2432.2	173.88	2403.1	2577.0	0.5926	8.2287	0.08
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7	0.6493	8.1502	0.10
0.20	60.06	1.0172	7.649	251.38	2456.7	251.40	2358.3	2609.7	0.8320	7.9085	0.20
0.30	69.10	1.0223	5.229	289.20	2468.4	289.23	2336.1	2625.3	0.9439	7.7686	0.30
0.40	75.87	1.0265	3.993	317.53	2477.0	317.58	2319.2	2636.8	1.0259	7.6700	0.40
0.50	81.33	1.0300	3.240	340.44	2483.9	340.49	2305.4	2645.9	1.0910	7.5939	0.50
0.60	85.94	1.0331	2.732	359.79	2489.6	359.86	2293.6	2653.5	1.1453	7.5320	0.60
0.70	89.95	1.0360	2.365	376.63	2494.5	376.70	2283.3	2660.0	1.1919	7.4797	0.70
0.80	93.50	1.0380	2.087	391.58	2498.8	391.66	2274.1	2665.8	1.2329	7.4346	0.80
0.90	96.71	1.0410	1.869	405.06	2502.6	405.15	2265.7	2670.9	1.2695	7.3949	0.90
1.00	99.63	1.0432	1.694	417.36	2506.1	417.46	2258.0	2675.5	1.3026	7.3594	1.00
1.50	111.4	1.0528	1.159	466.94	2519.7	467.11	2226.5	2693.6	1.4336	7.2233	1.50
2.00	120.2	1.0605	0.8857	504.49	2529.5	504.70	2201.9	2706.7	1.5301	7.1271	2.00
2.50	127.4	1.0672	0.7187	535.10	2537.2	535.37	2181.5	2716.9	1.6072	7.0527	2.50
3.00	133.6	1.0732	0.6058	561.15	2543.6	561.47	2163.8	2725.3	1.6718	6.9919	3.00
3.50	138.9	1.0786	0.5243	583.95	2546.9	584.33	2148.1	2732.4	1.7275	6.9405	3.50
4.00	143.6	1.0836	0.4625	604.31	2553.6	604.74	2133.8	2738.6	1.7766	6.8959	4.00
4.50	147.9	1.0882	0.4140	622.25	2557.6	623.25	2120.7	2743.9	1.8207	6.8565	4.50
5.00	151.9	1.0926	0.3749	639.68	2561.2	640.23	2108.5	2748.7	1.8607	6.8212	5.00
6.00	158.9	1.1006	0.3157	669.90	2567.4	670.56	2086.3	2756.8	1.9312	6.7600	6.00
7.00	165.0	1.1080	0.2729	696.44	2572.5	697.22	2066.3	2763.5	1.9922	6.7080	7.00
8.00	170.4	1.1148	0.2404	720.22	2576.8	721.11	2048.0	2769.1	2.0462	6.6628	8.00
9.00	175.4	1.1212	0.2150	741.83	2580.5	742.83	2031.1	2773.9	2.0946	6.6226	9.00
10.0	179.9	1.1273	0.1944	761.68	2583.6	762.81	2015.3	2778.1	2.1387	6.5863	10.0
15.0	198.3	1.1539	0.1318	843.16	2594.5	844.84	1947.3	2792.2	2.3150	6.4448	15.0
20.0	212.4	1.1767	0.09963	906.44	2600.3	908.79	1890.7	2799.5	2.4474	6.3409	20.0
25.0	224.0	1.1973	0.07998	959.11	2603.1	962.11	1841.0	2803.1	2.5547	6.2575	25.0
30.0	233.9	1.2165	0.06668	1004.8	2604.1	1008.4	1795.7	2804.2	2.6457	6.1869	30.0
35.0	242.6	1.2347	0.05707	1045.4	2603.7	1049.8	1753.7	2803.4	2.7253	6.1253	35.0
40.0	250.4	1.2522	0.04978	1082.3	2602.3	1087.3	1714.1	2801.4	2.7964	6.0701	40.0
45.0	257.5	1.2692	0.04406	1116.2	2600.1	1121.9	1676.4	2798.3	2.8610	6.0199	45.0
50.0	264.0	1.2859	0.03944	1147.8	2597.1	1154.2	1640.1	2794.3	2.9202	5.9734	50.0
60.0	275.6	1.3187	0.03244	1205.4	2589.7	1213.4	1571.0	2784.3	3.0267	5.8892	60.0
70.0	285.9	1.3513	0.02737	1257.6	2580.5	1267.0	1505.1	2772.1	3.1211	5.8133	70.0
80.0	295.1	1.3842	0.02352	1305.6	2569.8	1316.6	1441.3	2758.0	3.2068	5.7432	80.0
90.0	303.4	1.4178	0.02048	1350.5	2557.8	1363.3	1378.9	2742.1	3.2858	5.6772	90.0
100.	311.1	1.4524	0.01803	1393.0	2544.4	1407.6	1317.1	2724.7	3.3596	5.6141	100.
110.	318.2	1.4886	0.01599	1433.7	2529.8	1450.1	1255.5	2705.6	3.4295	5.5527	110.

$v_f = (\text{table value})/1000$

Lampiran 3: Tabel dimensi pipa SCH 40 ASME B36.10



TABEL PIPA SCHEDULE 40
 ASME B36.10
 Welded & Seamless Wrought Steel Pipe

NPS	O.D	I.D	T	W
INCH	MM	MM	MM	KG / M
1/8	10,3	6,84	1,73	0,37
1/4	13,7	9,22	2,24	0,63
1/2	21,3	15,76	2,77	1,27
3/4	25,7	20,96	2,87	1,69
1	33,4	26,64	3,38	2,5
1.1/4	42,2	35,08	3,56	3,39
1.1/2	43,3	40,94	3,68	4,05
2	60,3	52,48	3,91	5,44
2.1/2	73	62,68	5,16	8,63
3	88,9	77,92	5,49	11,29
4	114,3	108,28	6,02	16,08
5	141,3	128,20	6,55	21,77
6	168,3	154,08	7,11	28,26
8	219,1	202,74	8,18	42,55
10	273	254,46	9,27	60,29
12	323,28	303,18	10,31	79,71
14	355,6	333,34	11,13	94,55

TABLE A.6 Continued

Temperature, T (K)	Pressure, p (bars) ^b	Specific Volume (m ³ /kg)		Heat of Vaporization, h_{fg} (kJ/kg)	Specific Heat (kJ/kg·K)		Viscosity (N·s/m ²) $\mu_f \cdot 10^6$	Thermal Conductivity (W/m·K)		Prandtl Number		Surface Tension, $\sigma_f \cdot 10^3$ (N/m)	Expansion Coefficient, $\beta_f \cdot 10^6$ (K ⁻¹)	Temperature, T (K)
		$v_f \cdot 10^3$	v_g		$c_{p,f}$	$c_{p,g}$		$k_f \cdot 10^3$	$k_g \cdot 10^3$	Pr_f	Pr_g			
440	7.333	1.110	0.261	2059	4.36	2.46	162	682	31.7	1.04	1.12	45.1	—	440
450	9.319	1.123	0.208	2024	4.40	2.56	152	678	33.1	0.99	1.14	42.9	—	450
460	11.71	1.137	0.167	1989	4.44	2.68	143	673	34.6	0.95	1.17	40.7	—	460
470	14.55	1.152	0.136	1951	4.48	2.79	136	667	36.3	0.92	1.20	38.5	—	470
480	17.90	1.167	0.111	1912	4.53	2.94	129	660	38.1	0.89	1.23	36.2	—	480
490	21.83	1.184	0.0922	1870	4.59	3.10	124	651	40.1	0.87	1.25	33.9	—	490
500	26.40	1.203	0.0766	1825	4.66	3.27	118	642	42.3	0.86	1.28	31.6	—	500
510	31.66	1.222	0.0631	1779	4.74	3.47	113	631	44.7	0.85	1.31	29.3	—	510
520	37.70	1.244	0.0525	1730	4.84	3.70	108	621	47.5	0.84	1.35	26.9	—	520
530	44.58	1.268	0.0445	1679	4.95	3.96	104	608	50.6	0.85	1.39	24.5	—	530
540	52.38	1.294	0.0375	1622	5.08	4.27	101	594	54.0	0.86	1.43	22.1	—	540
550	61.19	1.323	0.0317	1564	5.24	4.64	97	580	58.3	0.87	1.47	19.7	—	550
560	71.08	1.355	0.0269	1499	5.43	5.09	94	563	63.7	0.90	1.52	17.3	—	560
570	82.16	1.392	0.0228	1429	5.68	5.67	91	548	76.7	0.94	1.59	15.0	—	570
580	94.51	1.433	0.0193	1353	6.00	6.40	88	528	76.7	0.99	1.68	12.8	—	580
590	108.3	1.482	0.0163	1274	6.41	7.35	84	513	84.1	1.05	1.84	10.5	—	590
600	123.5	1.541	0.0137	1176	7.00	8.75	81	497	92.9	1.14	2.15	8.4	—	600
610	137.3	1.612	0.0115	1068	7.85	11.1	77	467	103	1.30	2.60	6.3	—	610
620	159.1	1.705	0.0094	941	9.35	15.4	72	444	114	1.52	3.46	4.5	—	620
625	169.1	1.778	0.0085	858	10.6	18.3	70	430	121	1.65	4.20	3.5	—	625
630	179.7	1.856	0.0075	781	12.6	22.1	67	412	130	2.0	4.8	2.6	—	630
635	190.9	1.935	0.0066	683	16.4	27.6	64	392	141	2.7	6.0	1.5	—	635
640	202.7	2.075	0.0057	560	26	42	59	367	155	4.2	9.6	0.8	—	640
645	215.2	2.351	0.0045	361	90	—	54	331	178	12	26	0.1	—	645
647.3 ^c	221.2	3.170	0.0032	0	∞	∞	45	238	238	∞	∞	0.0	—	647.3 ^c

^aAdapted from Reference 22.

^b1 bar = 10⁵ N/m².

^cCritical temperature.

Lampiran 5 : *Thermophysical properties of air at atmospheric pressure*

Table B.2 Thermophysical properties of air at atmospheric pressure

T(K)	ρ (kg/m ³)	c_p (J/kg·K)	$\mu \times 10^7$ (kg/m·s)	$\nu \times 10^6$ (m ² /s)	$k \times 10^3$ (W/m·K)	$a \times 10^6$ (m ² /s)	Pr
200	1.7458	1.007	132.5	7.59	18.10	10.30	0.737
250	1.3947	1.006	159.6	11.44	22.30	15.90	0.720
300	1.1614	1.007	184.6	15.89	26.30	22.50	0.707
350	0.9950	1.009	208.2	20.92	30.00	29.90	0.700
400	0.8711	1.014	230.1	26.41	33.80	38.30	0.690
450	0.7740	1.021	250.7	32.39	37.30	47.20	0.686
500	0.6964	1.030	270.1	38.79	40.70	56.70	0.684
550	0.6329	1.040	288.4	45.57	43.90	66.70	0.683
600	0.5804	1.051	305.8	52.69	46.90	76.90	0.685
650	0.5356	1.063	322.5	60.21	49.70	87.30	0.690
700	0.4975	1.075	338.8	68.10	52.40	98.00	0.695
750	0.4643	1.087	354.6	76.37	54.90	109.00	0.702
800	0.4354	1.099	369.8	84.93	57.30	120.00	0.709
850	0.4097	1.110	384.3	93.80	59.60	131.00	0.716
900	0.3868	1.121	398.1	102.90	62.00	143.00	0.720
950	0.3666	1.131	411.3	112.20	64.30	155.00	0.723

Source: I. Dincer, *Heat Transfer in Food Cooling Applications*, Taylor & Francis, Washington, DC. (1997); and C. Borgnakke and R.E. Sonntag, *Thermodynamic and Transport Properties*, Wiley, New York (1997).

Lampiran 6 : tabel *properties of ASTM A516 Gr 70*

ASTM A516 Carbon Steel, Grade 70




Categories: [Metal](#); [Ferrous Metal](#); [Alloy Steel](#); [Low Alloy Steel](#); [ASTM Steel](#); [Carbon Steel](#); [Low Carbon Steel](#)


Material: Carbon steel plate for moderate and lower temperature service.

Notes: Pressure vessel quality

Key Words: SA516, ASTM A285

Vendors: No vendors are listed for this material. Please [click here](#) if you are a supplier and would like information on how to add your listing to this material.

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Physical Properties	Metric	English	Comments
Density	7.80 g/cc	0.282 lb/in ³	Typical of ASTM Steel

Mechanical Properties	Metric	English	Comments
Tensile Strength, Ultimate	485 - 620 MPa	70300 - 89900 psi	
Tensile Strength, Yield	260 MPa	37700 psi	
Elongation at Break	17 %	17 %	in 200mm
	21 %	21 %	in 50mm
Modulus of Elasticity	200 GPa	29000 ksi	Typical Carbon Steel
Bulk Modulus	160 GPa	23200 ksi	Typical for Steel
Poissons Ratio	0.29	0.29	Typical Carbon Steel
Shear Modulus	80.0 GPa	11600 ksi	Typical for Steel

Electrical Properties	Metric	English	Comments
Electrical Resistivity	0.0000170 ohm-cm	0.0000170 ohm-cm	Typical Carbon Steel

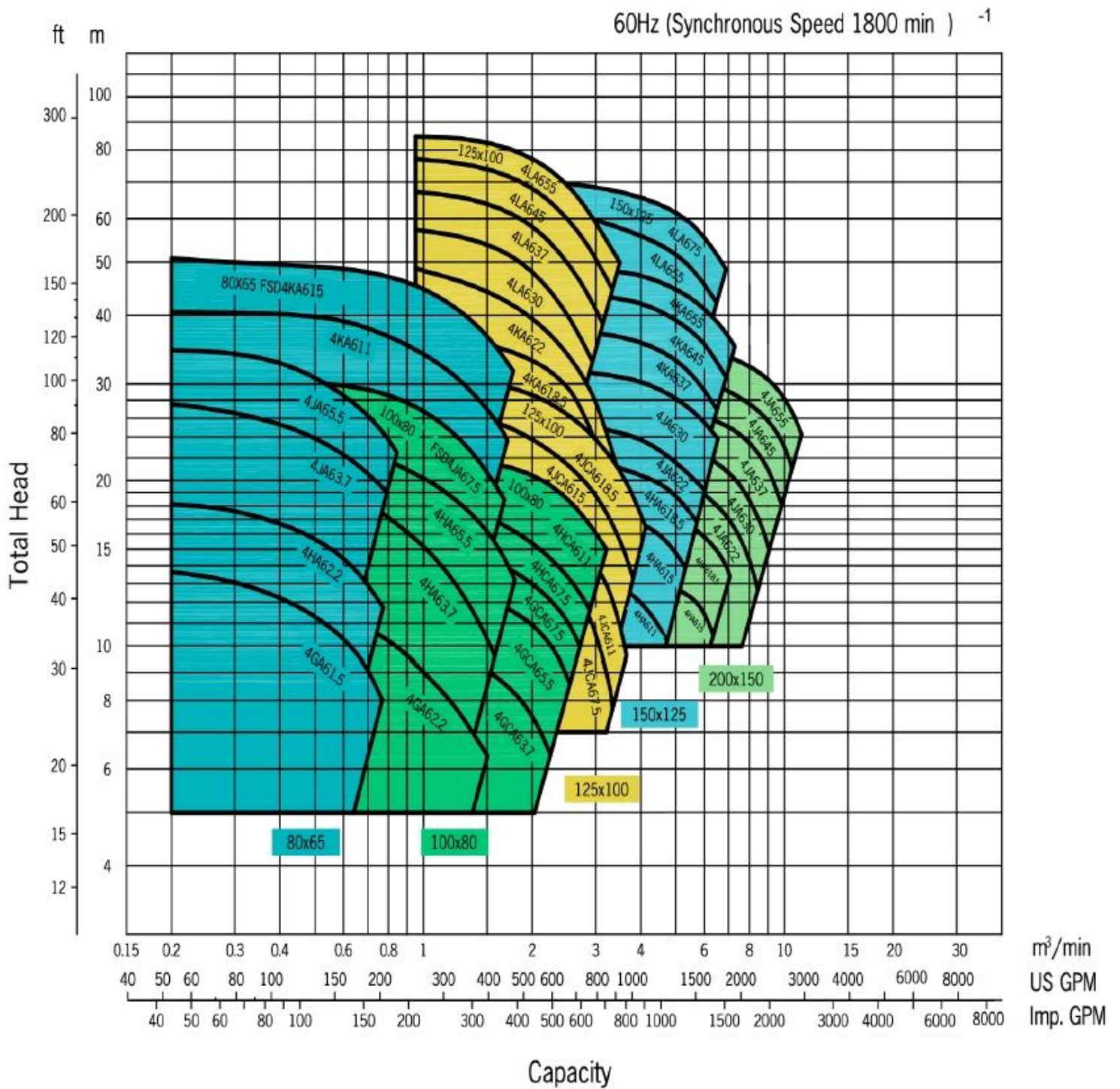
Thermal Properties	Metric	English	Comments
CTE, linear	12.0 $\mu\text{m}/\text{m}\cdot^\circ\text{C}$	6.67 $\mu\text{in}/\text{in}\cdot^\circ\text{F}$	Typical Carbon Steel
Specific Heat Capacity	0.470 J/g $\cdot^\circ\text{C}$	0.112 BTU/lb $\cdot^\circ\text{F}$	Typical Carbon Steel
Thermal Conductivity	52.0 W/m-K	361 BTU-in/hr-ft ² $\cdot^\circ\text{F}$	Typical Carbon Steel

Component Elements Properties	Metric	English	Comments
Carbon, C	0.31 %	0.31 %	may vary with plate thickness
Iron, Fe	98.315 %	98.315 %	as balance
Manganese, Mn	0.85 - 1.2 %	0.85 - 1.2 %	
Phosphorus, P	0.035 %	0.035 %	

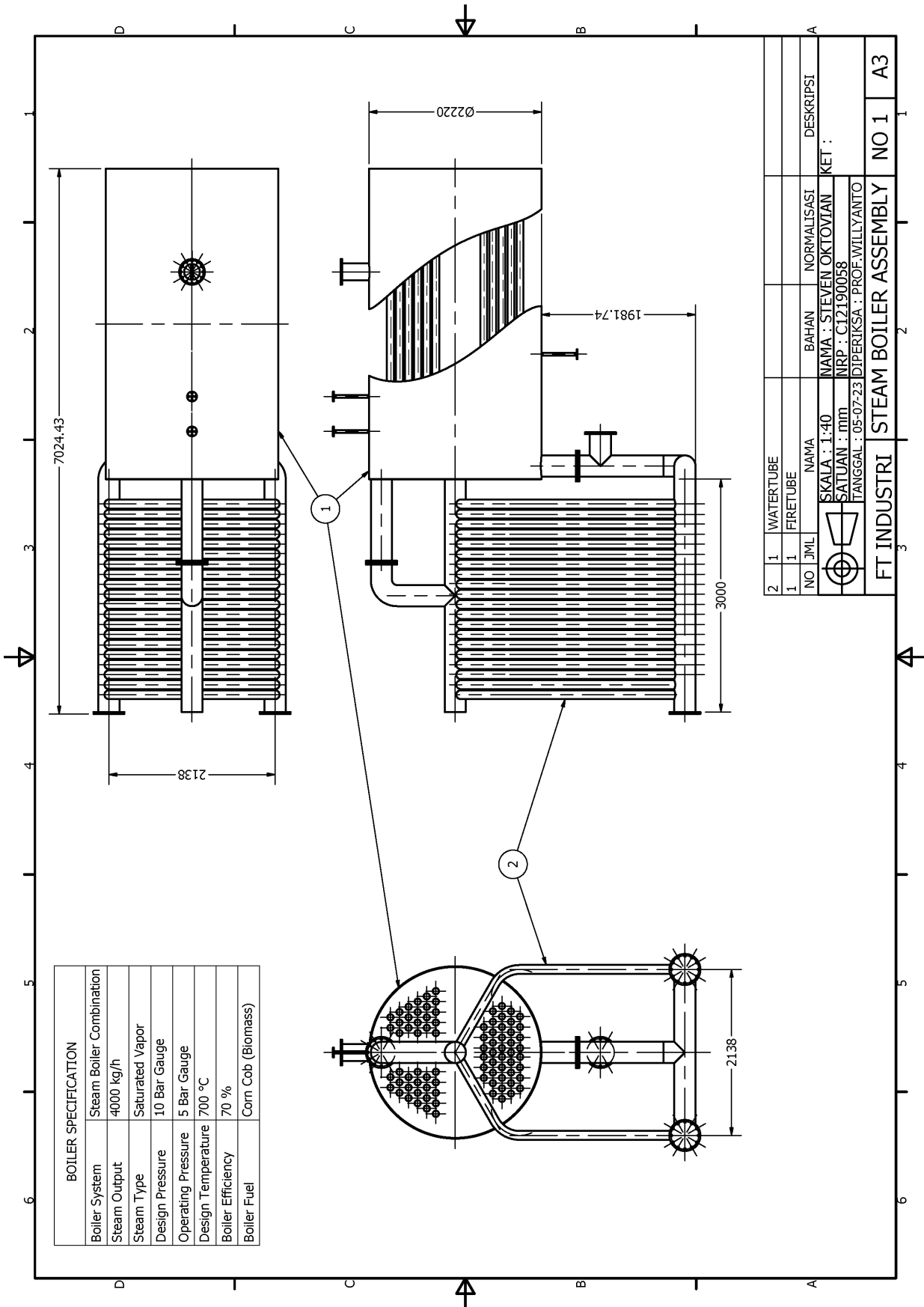
Lampiran 7: Spesifikasi pompa air Ebara type FSDA 60 Hz

Description		Standard	Option
Liquid handled	Type of Liquid	Fresh Water	
	Temperature	0 - 80 °C (32 - 176°F)	
		10 bar	16 bar
Synchronous speed		1800 min ⁻¹	
Location		Indoor	Outdoor
Covering Range	Suction Dia.	80 to 200 mm	
	Flow rate	0.2 to 12 m ³ /min	
	Power	1.5 to 75 kW	
Construction	Pump Type	End Suction Volute Pump	
	Casing split	Back Pull Out	
	Impeller	Enclosed	
	Shaft seal	Mechanical Seal	
	Shaft	Stub Shaft	
	Sealing	Self flushing	
Material	Casing	Cast Iron	Ductile cast iron
	Impeller	Bronze (CAC406)	Cast Iron
	Shaft	316 Stainless steel	
	Mech. Seal	Ceramic/Carbon	SiC/Carbon; SiC/SiC
Flanges	Suction & Discharge	JIS 10K RF	JIS 16 KRF; ANSI 250
Motor	Type	IEC Standard, Flange Mounted type (B5)	NEMA Standard, Flange Mounted type (B5)
	No. of pole	4	
	Synch. Speed	1800 min ⁻¹	
	Insulation class	F	
	Protection	IP 55	IP55W
	Volt/ Phase/ Hz	380V-660V/ 3 Ph. / 60 Hz	

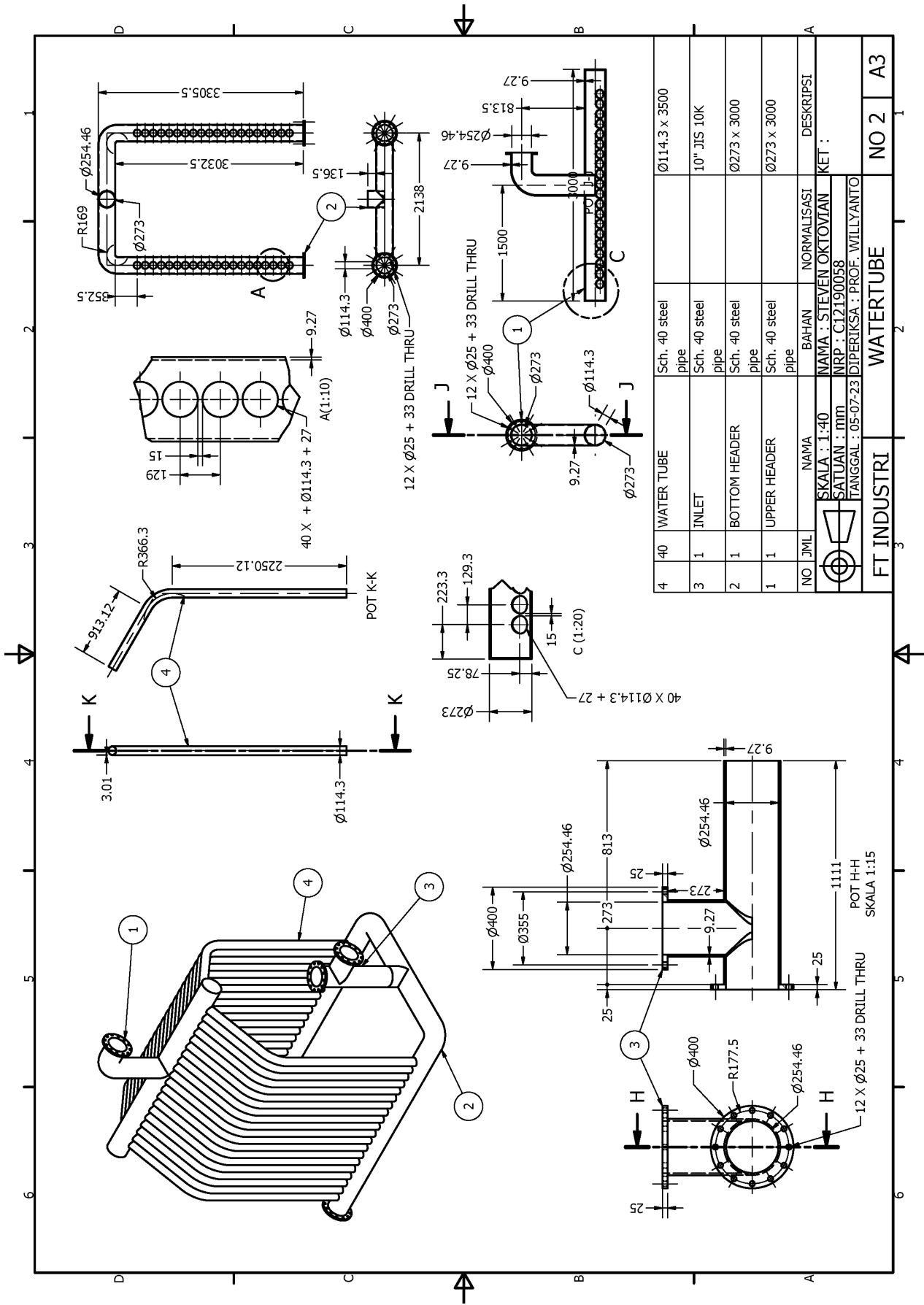
Lampiran 8 Performance chart pompa air Ebara Type FSDA 60 Hz



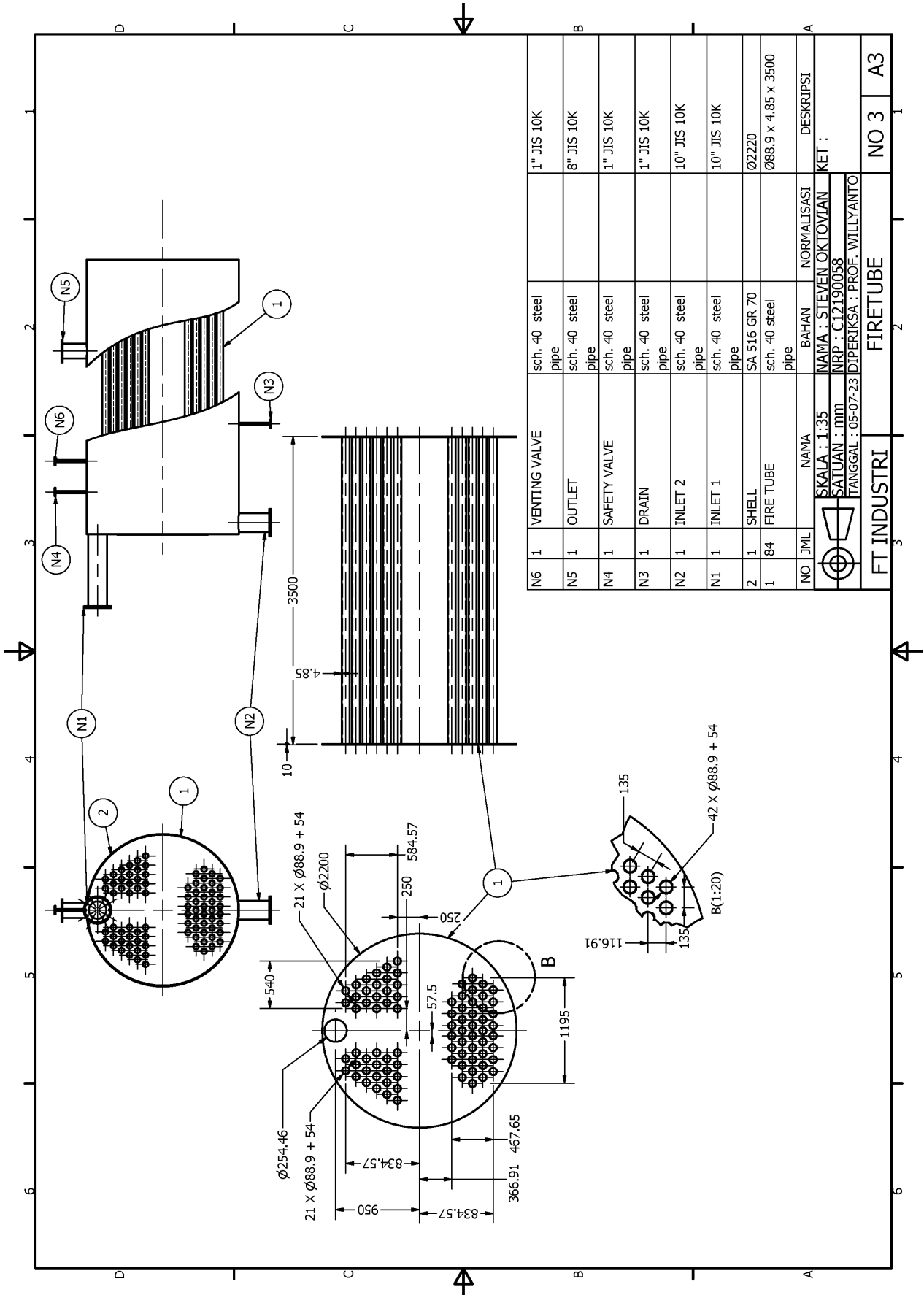
Lampiran 9: Sketch desain boiler



Lampiran 9: (lanjutan)

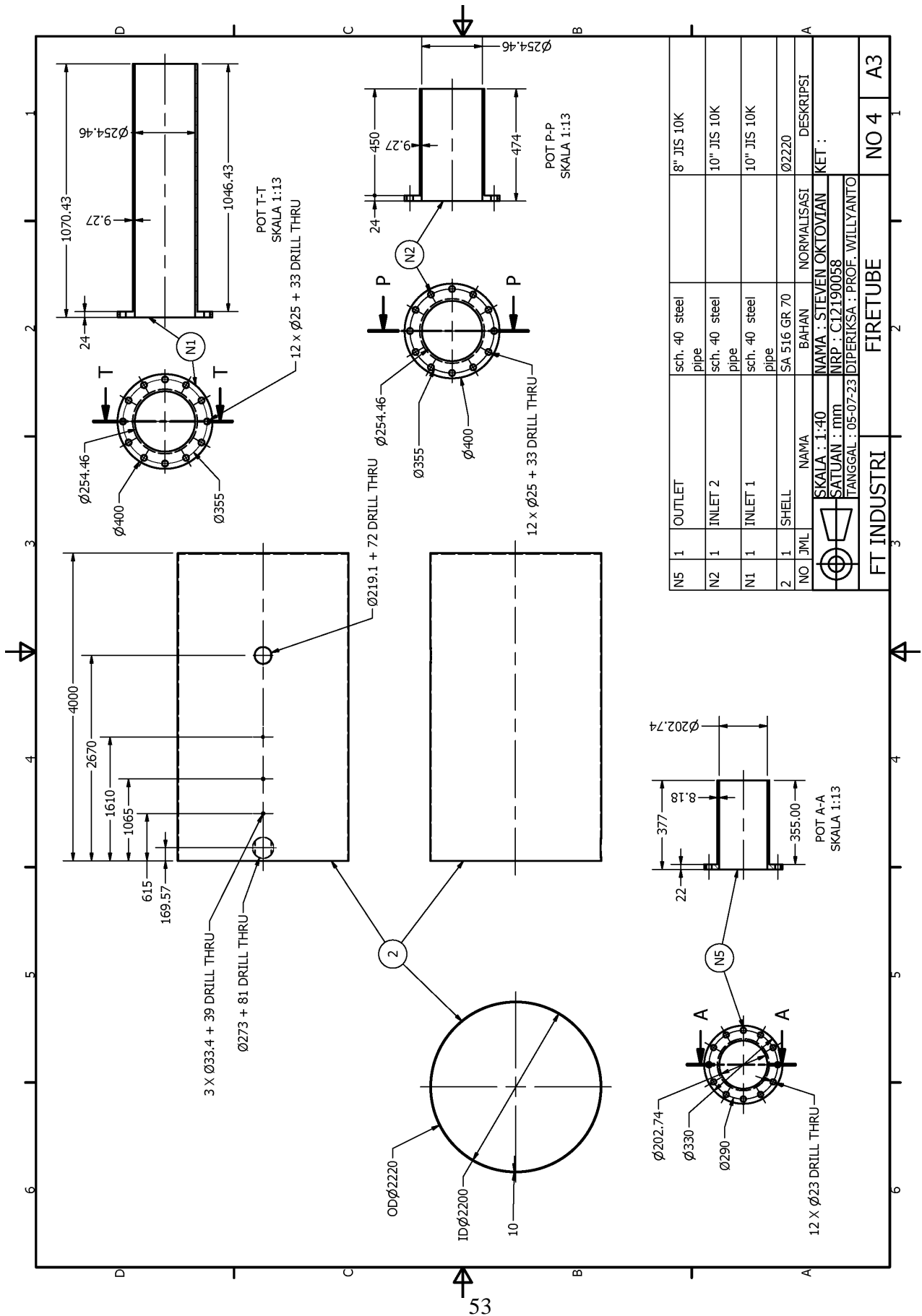


Lampiran 9: (lanjutan)



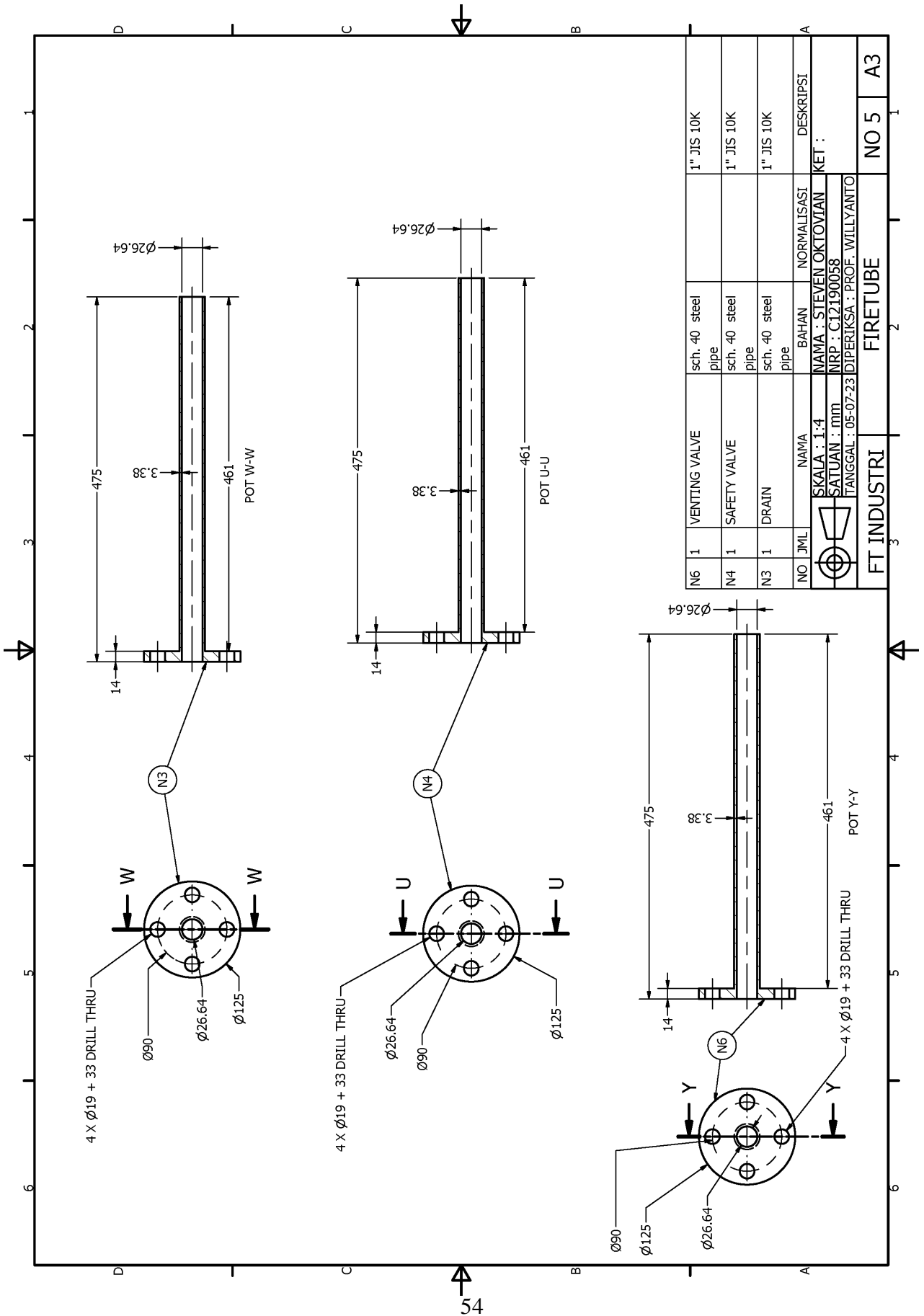
N6	1	VENTING VALVE	sch. 40 steel pipe	1" JIS 10K	
N5	1	OUTLET	sch. 40 steel pipe	8" JIS 10K	
N4	1	SAFETY VALVE	sch. 40 steel pipe	1" JIS 10K	
N3	1	DRAIN	sch. 40 steel pipe	1" JIS 10K	
N2	1	INLET 2	sch. 40 steel pipe	10" JIS 10K	
N1	1	INLET 1	sch. 40 steel pipe	10" JIS 10K	
2	1	SHELL	SA 516 GR. 70	Ø2220	
1	84	FIRE TUBE	sch. 40 steel pipe	Ø88.9 x 4.85 x 3500	
NO	JM/L	NAMA	BAHAN	NORMALISASI	
		SKALA : 1:35		NAMA : STEVEN OKTOVIAN	
		SATUAN : mm		NRP : C12190058	
		TANGGAL : 05-07-23		DIPERIKSA : PROF. WILLYANTO	
FT INDUSTRI				FIRETUBE	NO 3 A3

Lampiran 9: (lanjutan)



N5	1	OUTLET	sch. 40 steel pipe	8" JIS 10K	
N2	1	INLET 2	sch. 40 steel pipe	10" JIS 10K	
N1	1	INLET 1	sch. 40 steel pipe	10" JIS 10K	
	2	SHELL	SA 516 GR 70	Ø2220	
NO	JML	NAMA	BAHAN	NORMALISASI	
		SKALA : 1:40	NAMA : STEVEN OKTOVIAN	DESKRIPSI	
		SATUAN : mm	NRP : C.12190058	KET :	
		TANGGAL : 05-07-23	DIPERIKSA : PROF. WILLYANTO		
FT INDUSTRI				NO 4	A3

Lampiran 9: (lanjutan)



N6	1	VENTING VALVE	sch. 40 steel pipe	1" JIS 10K	
N4	1	SAFETY VALVE	sch. 40 steel pipe	1" JIS 10K	
N3	1	DRAIN	sch. 40 steel pipe	1" JIS 10K	
NO	JML	NAMA	BAHAN	NORMALISASI	
⊕		SKALA : 1:4	NAMA : STEVEN OKTOVIAN	DESKRIPSI	
		SATUAN : mm	MRP : C12190058	KET :	
		TANGGAL : 05-07-23	DIPERIKSA : PROF. WILLYANTO		
FT INDUSTRI				FIRETUBE	
				NO 5	A3