Lampiran 1. Tabel A-1 *Properties Tables and Charts (S1 units) Appendix 1*

TABLE A – 1

Molar mass, gas constant, and critical-point properties

Substance	Formula	Molar mass, M kg/kmol	Gas constant, R kJ/kg · K*	Critical-point properties: Temperature, K	Pressure, MPa	Volume, m^3/kmol
Air		28.97	0.2870	132.5	3.77	0.0883
Ammonia	NH_3	17.03	0.4882	405.5	11.28	0.0724
Argon	Ar	39.948	0.2081	151	4.86	0.0749
Benzene	C_6H_6	78.115	0.1064	562	4.92	0.2603
Bromine	Br_2	159.808	0.0520	584	10.34	0.1355
n-Butane	C_4H_{10}	58.124	0.1430	425.2	3.80	0.2547
Carbon dioxide	CO_2	44.01	0.1889	304.2	7.39	0.0943
Carbon monoxide	CO	28.011	0.2968	133	3.50	0.0930
Carbon tetrachloride	CCl_4	153.82	0.05405	556.4	4.56	0.2759
Chlorine	Cl_2	70.906	0.1173	417	7.71	0.1242
Chloroform	$CHCl_3$	119.38	0.06964	536.6	5.47	0.2403
Dichlorodifluoromethane (R-12)	CCl_2F_2	120.91	0.06876	384.7	4.01	0.2179
Dichlorofluoromethane (R-21)	$CHCl_2F$	102.92	0.08078	451.7	5.17	0.1973
Ethane	C_2H_6	30.070	0.2765	305.5	4.48	0.1480
Ethyl alcohol	C_2H_5OH	46.07	0.1805	516	6.38	0.1673
Ethylene	C_2H_4	28.054	0.2964	282.4	5.12	0.1242
Helium	He	4.003	2.0769	5.3	0.23	0.0578
n-Hexane	C_6H_{14}	86.179	0.09647	507.9	3.03	0.3677
Hydrogen (normal)	H_2	2.016	4.1240	33.3	1.30	0.0649
Krypton	Kr	83.80	0.09921	209.4	5.50	0.0924
Methane	CH_4	16.043	0.5182	191.1	4.64	0.0993
Methyl alcohol	CH_3OH	32.042	0.2595	513.2	7.95	0.1180
Methyl chloride	CH_3Cl	50.488	0.1647	416.3	6.68	0.1430
Neon	Ne	20.183	0.4119	44.5	2.73	0.0417
Nitrogen	N_2	28.013	0.2968	126.2	3.39	0.0899
Nitrous oxide	N_2O	44.013	0.1889	309.7	7.27	0.0961
Oxygen	O_2	31.999	0.2598	154.8	5.08	0.0780
Propane	C_3H_8	44.097	0.1885	370	4.26	0.1998
Propylene	C_3H_6	42.081	0.1976	365	4.62	0.1810
Sulfur dioxide	SO_2	64.063	0.1298	430.7	7.88	0.1217
Tetrafluoroethane (R-134a)	CF_3CH_2F	102.03	0.08149	374.2	4.059	0.1993
Trichlorofluoromethane (R-11)	CCl_3F	137.37	0.06052	471.2	4.38	0.2478
Water	H_2O	18.015	0.4615	647.1	22.06	0.0560
Xenon	Xe	131.30	0.06332	289.8	5.88	0.1186

*The unit kJ/kg · K is equivalent to kPa · m³/kg · K. The gas constant is calculated from $R = R_u/M$, where R_u = 8.31447 kJ/kmol · K and M is the molar mass.

Source: K. A. Kobe and R. E. Lynn, Jr., *Chemical Review* 52 (1953), pp. 117–236; and ASHRAE, *Handbook of Fundamentals* (Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1993), pp. 16.4 and 36.1.

Lampiran 2. Tabel A-2a *Properties Tables and Charts (S1 units) Appendix 1*

TABLE A–2

Ideal-gas specific heats of various common gases

(*a*) At 300 K

Gas	Formula	Gas constant, *R* kJ/kg · K	c_p kJ/kg · K	c_v kJ/kg · K	*k*
Air	—	0.2870	1.005	0.718	1.400
Argon	Ar	0.2081	0.5203	0.3122	1.667
Butane	C_4H_{10}	0.1433	1.7164	1.5734	1.091
Carbon dioxide	CO_2	0.1889	0.846	0.657	1.289
Carbon monoxide	CO	0.2968	1.040	0.744	1.400
Ethane	C_2H_6	0.2765	1.7662	1.4897	1.186
Ethylene	C_2H_4	0.2964	1.5482	1.2518	1.237
Helium	He	2.0769	5.1926	3.1156	1.667
Hydrogen	H_2	4.1240	14.307	10.183	1.405
Methane	CH_4	0.5182	2.2537	1.7354	1.299
Neon	Ne	0.4119	1.0299	0.6179	1.667
Nitrogen	N_2	0.2968	1.039	0.743	1.400
Octane	C_8H_{18}	0.0729	1.7113	1.6385	1.044
Oxygen	O_2	0.2598	0.918	0.658	1.395
Propane	C_3H_8	0.1885	1.6794	1.4909	1.126
Steam	H_2O	0.4615	1.8723	1.4108	1.327

Note: The unit kJ/kg · K is equivalent to kJ/kg · °C.

Source: Chemical and Process Thermodynamics 3/E by Kyle, B. G., © 2000. Adapted by permission of Pearson Education, Inc., Upper Saddle River, NJ.

Lampiran 3. Tabel A-2b *Properties Tables and Charts (S1 units) Appendix 1*

TABLE A–2

Ideal-gas specific heats of various common gases (*Continued*)

(b) At various temperatures

Temperature, K	c_p kJ/kg · K	c_v kJ/kg · K	k	c_p kJ/kg · K	c_v kJ/kg · K	k	c_p kJ/kg · K	c_v kJ/kg · K	k
		Air			*Carbon dioxide, CO_2*			*Carbon monoxide, CO*	
250	1.003	0.716	1.401	0.791	0.602	1.314	1.039	0.743	1.400
300	1.005	0.718	1.400	0.846	0.657	1.288	1.040	0.744	1.399
350	1.008	0.721	1.398	0.895	0.706	1.268	1.043	0.746	1.398
400	1.013	0.726	1.395	0.939	0.750	1.252	1.047	0.751	1.395
450	1.020	0.733	1.391	0.978	0.790	1.239	1.054	0.757	1.392
500	1.029	0.742	1.387	1.014	0.825	1.229	1.063	0.767	1.387
550	1.040	0.753	1.381	1.046	0.857	1.220	1.075	0.778	1.382
600	1.051	0.764	1.376	1.075	0.886	1.213	1.087	0.790	1.376
650	1.063	0.776	1.370	1.102	0.913	1.207	1.100	0.803	1.370
700	1.075	0.788	1.364	1.126	0.937	1.202	1.113	0.816	1.364
750	1.087	0.800	1.359	1.148	0.959	1.197	1.126	0.829	1.358
800	1.099	0.812	1.354	1.169	0.980	1.193	1.139	0.842	1.353
900	1.121	0.834	1.344	1.204	1.015	1.186	1.163	0.866	1.343
1000	1.142	0.855	1.336	1.234	1.045	1.181	1.185	0.888	1.335
		Hydrogen, H_2			*Nitrogen, N_2*			*Oxygen, O_2*	
250	14.051	9.927	1.416	1.039	0.742	1.400	0.913	0.653	1.398
300	14.307	10.183	1.405	1.039	0.743	1.400	0.918	0.658	1.395
350	14.427	10.302	1.400	1.041	0.744	1.399	0.928	0.668	1.389
400	14.476	10.352	1.398	1.044	0.747	1.397	0.941	0.681	1.382
450	14.501	10.377	1.398	1.049	0.752	1.395	0.956	0.696	1.373
500	14.513	10.389	1.397	1.056	0.759	1.391	0.972	0.712	1.365
550	14.530	10.405	1.396	1.065	0.758	1.387	0.988	0.728	1.358
600	14.546	10.422	1.396	1.075	0.778	1.382	1.003	0.743	1.350
650	14.571	10.447	1.395	1.086	0.789	1.376	1.017	0.758	1.343
700	14.604	10.480	1.394	1.098	0.801	1.371	1.031	0.771	1.337
750	14.645	10.521	1.392	1.110	0.813	1.365	1.043	0.783	1.332
800	14.695	10.570	1.390	1.121	0.825	1.360	1.054	0.794	1.327
900	14.822	10.698	1.385	1.145	0.849	1.349	1.074	0.814	1.319
1000	14.983	10.859	1.380	1.167	0.870	1.341	1.090	0.830	1.313

Source: Kenneth Wark, *Thermodynamics*, 4th ed. (New York: McGraw-Hill, 1983), p. 783, Table A–4M. Originally published in *Tables of Thermal Properties of Gases*, NBS Circular 564, 1955.

Lampiran 4. Tabel A-2c *Properties Tables and Charts (S1 units) Appendix 1*

TABLE A–2

Ideal-gas specific heats of various common gases (*Concluded*)

(c) As a function of temperature

$$\bar{c}_p = a + bT + cT^2 + dT^3$$

(T in K, c_p in kJ/kmol · K)

Substance	Formula	a	b	c	d	Temperature range, K	% error Max.	% error Avg.
Nitrogen	N_2	28.90	-0.1571×10^{-2}	0.8081×10^{-5}	-2.873×10^{-9}	273–1800	0.59	0.34
Oxygen	O_2	25.48	1.520×10^{-2}	-0.7155×10^{-5}	1.312×10^{-9}	273–1800	1.19	0.28
Air		28.11	0.1967×10^{-2}	0.4802×10^{-5}	-1.966×10^{-9}	273–1800	0.72	0.33
Hydrogen	H_2	29.11	-0.1916×10^{-2}	0.4003×10^{-5}	-0.8704×10^{-9}	273–1800	1.01	0.26
Carbon monoxide	CO	28.16	0.1675×10^{-2}	0.5372×10^{-5}	-2.222×10^{-9}	273–1800	0.89	0.37
Carbon dioxide	CO_2	22.26	5.981×10^{-2}	-3.501×10^{-5}	7.469×10^{-9}	273–1800	0.67	0.22
Water vapor	H_2O	32.24	0.1923×10^{-2}	1.055×10^{-5}	-3.595×10^{-9}	273–1800	0.53	0.24
Nitric oxide	NO	29.34	-0.09395×10^{-2}	0.9747×10^{-5}	-4.187×10^{-9}	273–1500	0.97	0.36
Nitrous oxide	N_2O	24.11	5.8632×10^{-2}	-3.562×10^{-5}	10.58×10^{-9}	273–1500	0.59	0.26
Nitrogen dioxide	NO_2	22.9	5.715×10^{-2}	-3.52×10^{-5}	7.87×10^{-9}	273–1500	0.46	0.18
Ammonia	NH_3	27.568	2.5630×10^{-2}	0.99072×10^{-5}	-6.6909×10^{-9}	273–1500	0.91	0.36
Sulfur	S_2	27.21	2.218×10^{-2}	-1.628×10^{-5}	3.986×10^{-9}	273–1800	0.99	0.38
Sulfur dioxide	SO_2	25.78	5.795×10^{-2}	-3.812×10^{-5}	8.612×10^{-9}	273–1800	0.45	0.24
Sulfur trioxide	SO_3	16.40	14.58×10^{-2}	-11.20×10^{-5}	32.42×10^{-9}	273–1300	0.29	0.13
Acetylene	C_2H_2	21.8	9.2143×10^{-2}	6.527×10^{-5}	18.21×10^{-9}	273–1500	1.46	0.59
Benzene	C_6H_6	−36.22	48.475×10^{-2}	-31.57×10^{-5}	77.62×10^{-9}	273–1500	0.34	0.20
Methanol	CH_4O	19.0	9.152×10^{-2}	-1.22×10^{-5}	-8.039×10^{-9}	273–1000	0.18	0.08
Ethanol	C_2H_6O	19.9	20.96×10^{-2}	-10.38×10^{-5}	20.05×10^{-9}	273–1500	0.40	0.22
Hydrogen chloride	HCl	30.33	-0.7620×10^{-2}	1.327×10^{-5}	-4.338×10^{-9}	273–1500	0.22	0.08
Methane	CH_4	19.89	5.024×10^{-2}	1.269×10^{-5}	-11.01×10^{-9}	273–1500	1.33	0.57
Ethane	C_2H_6	6.900	17.27×10^{-2}	6.406×10^{-5}	7.285×10^{-9}	273–1500	0.83	0.28
Propane	C_3H_8	4.04	30.48×10^{-2}	15.72×10^{-5}	31.74×10^{-9}	273–1500	0.40	0.12
n-Butane	C_4H_{10}	3.96	37.15×10^{-2}	-18.34×10^{-5}	35.00×10^{-9}	273–1500	0.54	0.24
i-Butane	C_4H_{10}	−7.913	41.60×10^{-2}	-23.01×10^{-5}	49.91×10^{-9}	273–1500	0.25	0.13
n-Pentane	C_5H_{12}	6.774	45.43×10^{-2}	-22.46×10^{-5}	42.29×10^{-9}	273–1500	0.56	0.21
n-Hexane	C_6H_{14}	6.938	55.22×10^{-2}	-28.65×10^{-5}	57.69×10^{-9}	273–1500	0.72	0.20
Ethylene	C_2H_4	3.95	15.64×10^{-2}	-8.344×10^{-5}	17.67×10^{-9}	273–1500	0.54	0.13
Propylene	C_3H_6	3.15	23.83×10^{-2}	-12.18×10^{-5}	24.62×10^{-9}	273–1500	0.73	0.17

Source: B. G. Kyle, *Chemical and Process Thermodynamics* (Englewood Cliffs, NJ: Prentice Hall, 1984). Used with permission.

Lampiran 5. Tabel A-3a *Properties Tables and Charts (S1 units) Appendix 1*

TABLE A–3

Properties of common liquids, solids, and foods

(*a*) Liquids

	Boiling data at 1 atm		Freezing data		Liquid properties		
Substance	Normal boiling point, °C	Latent heat of vaporization h_{fg}, kJ/kg	Freezing point, °C	Latent heat of fusion h_{if}, kJ/kg	Temperature, °C	Density ρ, kg/m³	Specific heat c_p, kJ/kg · K
Ammonia	−33.3	1357	−77.7	322.4	−33.3	682	4.43
					−20	665	4.52
					0	639	4.60
					25	602	4.80
Argon	−185.9	161.6	−189.3	28	−185.6	1394	1.14
Benzene	80.2	394	5.5	126	20	879	1.72
Brine (20% sodium chloride by mass)	103.9	—	−17.4	—	20	1150	3.11
n-Butane	−0.5	385.2	−138.5	80.3	−0.5	601	2.31
Carbon dioxide	−78.4*	230.5 (at 0°C)	−56.6		0	298	0.59
Ethanol	78.2	838.3	−114.2	109	25	783	2.46
Ethyl alcohol	78.6	855	−156	108	20	789	2.84
Ethylene glycol	198.1	800.1	−10.8	181.1	20	1109	2.84
Glycerine	179.9	974	18.9	200.6	20	1261	2.32
Helium	−268.9	22.8	—	—	−268.9	146.2	22.8
Hydrogen	−252.8	445.7	−259.2	59.5	−252.8	70.7	10.0
Isobutane	−11.7	367.1	−160	105.7	−11.7	593.8	2.28
Kerosene	204–293	251	−24.9	—	20	820	2.00
Mercury	356.7	294.7	−38.9	11.4	25	13,560	0.139
Methane	−161.5	510.4	−182.2	58.4	−161.5	423	3.49
					−100	301	5.79
Methanol	64.5	1100	−97.7	99.2	25	787	2.55
Nitrogen	−195.8	198.6	−210	25.3	−195.8	809	2.06
					−160	596	2.97
Octane	124.8	306.3	−57.5	180.7	20	703	2.10
Oil (light)					25	910	1.80
Oxygen	−183	212.7	−218.8	13.7	−183	1141	1.71
Petroleum	—	230–384			20	640	2.0
Propane	−42.1	427.8	−187.7	80.0	−42.1	581	2.25
					0	529	2.53
					50	449	3.13
Refrigerant-134a	−26.1	217.0	−96.6	—	−50	1443	1.23
					−26.1	1374	1.27
					0	1295	1.34
					25	1207	1.43
Water	100	2257	0.0	333.7	0	1000	4.22
					25	997	4.18
					50	988	4.18
					75	975	4.19
					100	958	4.22

* Sublimation temperature. (At pressures below the triple-point pressure of 518 kPa, carbon dioxide exists as a solid or gas. Also, the freezing-point temperature of carbon dioxide is the triple-point temperature of −56.5°C.)

Lampiran 6. Tabel A-26 *Properties Tables and Charts (S1 units) Appendix 2*

TABLE A–26E

Enthalpy of formation, Gibbs function of formation, and absolute entropy at 77°F, 1 atm

Substance	Formula	$\bar{h}_f^\circ$ Btu/lbmol	$\bar{g}_f^\circ$ Btu/lbmol	$\bar{s}^\circ$ Btu/lbmol·R
Carbon	$C(s)$	0	0	1.36
Hydrogen	$H_2(g)$	0	0	31.21
Nitrogen	$N_2(g)$	0	0	45.77
Oxygen	$O_2(g)$	0	0	49.00
Carbon monoxide	$CO(g)$	−47,540	−59,010	47.21
Carbon dioxide	$CO_2(g)$	−169,300	−169,680	51.07
Water vapor	$H_2O(g)$	−104,040	−98,350	45.11
Water	$H_2O(\ell)$	−122,970	−102,040	16.71
Hydrogen peroxide	$H_2O_2(g)$	−58,640	−45,430	55.60
Ammonia	$NH_3(g)$	−19,750	−7,140	45.97
Methane	$CH_4(g)$	−32,210	−21,860	44.49
Acetylene	$C_2H_2(g)$	+97,540	+87,990	48.00
Ethylene	$C_2H_4(g)$	+22,490	+29,306	52.54
Ethane	$C_2H_6(g)$	−36,420	−14,150	54.85
Propylene	$C_3H_6(g)$	+8,790	+26,980	63.80
Propane	$C_3H_8(g)$	−44,680	−10,105	64.51
n-Butane	$C_4H_{10}(g)$	−54,270	−6,760	74.11
n-Octane	$C_8H_{18}(g)$	−89,680	+7,110	111.55
n-Octane	$C_8H_{18}(\ell)$	−107,530	+2,840	86.23
n-Dodecane	$C_{12}H_{26}(g)$	−125,190	+21,570	148.86
Benzene	$C_6H_6(g)$	+35,680	+55,780	64.34
Methyl alcohol	$CH_3OH(g)$	−86,540	−69,700	57.29
Methyl alcohol	$CH_3OH(\ell)$	−102,670	−71,570	30.30
Ethyl alcohol	$C_2H_5OH(g)$	−101,230	−72,520	67.54
Ethyl alcohol	$C_2H_5OH(\ell)$	−119,470	−75,240	38.40
Oxygen	$O(g)$	+107,210	+99,710	38.47
Hydrogen	$H(g)$	+93,780	+87,460	27.39
Nitrogen	$N(g)$	+203,340	+195,970	36.61
Hydroxyl	$OH(g)$	+16,790	+14,750	43.92

Source: From JANAF, *Thermochemical Tables* (Midland, MI: Dow Chemical Co., 1971), *Selected Values of Chemical Thermodynamic Properties*, NBS Technical Note 270-3, 1968; and *API Research Project 44* (Carnegie Press, 1953).

Lampiran 7. Spesifikasi stainless steel tipe 316 *(aksteel, 2009)*

P R O D U C T D A T A S H E E T

316/316L

STAINLESS STEEL

UNS S31600 AND UNS S31603

AK Steel

Type 316 is an austenitic chromium-nickel stainless steel containing molybdenum. This addition increases general corrosion resistance, improves resistance to pitting from chloride ion solutions, and provides increased strength at elevated temperatures. Properties are similar to those of Type 304 except that this alloy is somewhat stronger at elevated temperatures. Corrosion resistance is improved, particularly against sulfuric, hydrochloric, acetic, formic and tartaric acids; acid sulfates and alkaline chlorides.

Type 316L is an extra-low carbon version of Type 316 that minimizes harmful carbide precipitation due to welding.

Typical uses include exhaust manifolds, furnace parts, heat exchangers, jet engine parts, pharmaceutical and photographic equipment, valve and pump trim, chemical equipment, digesters, tanks, evaporators, pulp, paper and textile processing equipment, parts exposed to marine atmospheres and tubing. Type 316L is used extensively for weldments where its immunity to carbide precipitation due to welding assures optimum corrosion resistance.

COMPOSITION

	Type 316 %	Type 316L %
Carbon	0.08 max.	0.03 max.
Manganese	2.00 max.	2.00 max.
Phosphorus	0.045 max.	0.045 max.
Sulfur	0.030 max.	0.03 max.
Silicon	0.75 max.	0.75 max.
Chromium	16.00 - 18.00	16.00 - 18.00
Nickel	10.00 - 14.00	10.00 - 14.00
Molybdenum	2.00 - 3.00	2.00 - 3.00
Nitrogen	0.10 max.	0.10 max
Iron	Balance	Balance

AVAILABLE FORMS

AK Steel produces Types 316 and 316L Stainless Steels in thicknesses from 0.01" to 0.25" (0.25 to 6.35 mm) max. and widths up to 48" (1219 mm). For other thicknesses and widths, inquire.

MECHANICAL PROPERTIES

Typical Room Temperature Properties

	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell
Type 316	84 (579)	42 (290)	50	B79
Type 316L	81 (558)	42 (290)	50	B79

Lampiran 7. Spesifikasi stainless steel tipe 316 (lanjutan)

AK STEEL 316/316L STAINLESS STEEL DATA SHEET

SPECIFICATIONS

Types 316 and 316L Stainless Steel sheet and strip are covered by the following specifications:

Type 316	Type 316L
AMS 5524	AMS 5507
ASTM A 240	ASTM A 240
ASTM A 666	ASTM A 666

PHYSICAL PROPERTIES

Density, 0.29 lbs/in^3
7.99 g/cm^3

Electrical Resistivity, microhm-in (microhm-cm) 68°F (20°C) – 29.4 (74)

Specific Heat, BTU/lb/°F (kJ/kg•K) 32 - 212°F (0-100°C) – 0.12 (0.50)

Thermal Conductivity, BTU/hr/ft^2/ft/°F (W/m•K)
at 212°F (100°C) – 9.4 (16.2)
at 932°F (500°C) – 12.4 (21.4)

Modulus of Elasticity, ksi (MPa)
28.0 x 10^3 (193 x 10^3) in tension
11.2 x 10^3 (77 x 10^3) in torsion

Mean Coefficient of Thermal Expansion, in/in/°F (μm/m•K)
32 - 212°F (0 - 100°C) – 8.9 x 10^{-6} (16.0)
32 - 600°F (0 - 315°C) – 9.0 x 10^{-6} (16.2)
32 - 1000°F (0 - 538°C) – 9.7 x 10^{-6} (17.5)
32 - 1200°F (0 - 649°C) – 10.3 x 10^{-6} (18.5)
32 - 1500°F (0 - 871°C) – 11.1 x 10^{-6} (19.9)

Magnetic Permeability, H = 200 Oersteds, Annealed – 1.02 max.

Melting Range, °F (°C) – 2500 - 2550 (1371 - 1399)

CORROSION RESISTANCE

Types 316 and 316L Stainless Steels exhibit better corrosion resistance than Type 304. They provide excellent pitting resistance and good resistance to most chemicals involved in the paper, textile and photographic industries.

HEAT TREATMENTS

Types 316 and 316L are non-hardenable by heat treatment.

Annealing: Heat to 1900 - 2100°F (1038 - 1149°C), then rapidly quench.

FORMABILITY

Types 316 and 316L can be readily formed and drawn.

WELDABILITY

The austenitic class of stainless steels is generally considered to be weldable by the common fusion and resistance techniques. Special consideration is required to avoid weld "hot cracking" by assuring formation of ferrite in the weld deposit. These particular alloys are generally considered to have poorer weldability than Types 304 and 304L. A major difference is the higher nickel content for these alloys which requires slower arc welding speed and more care to avoid hot cracking. When a weld filler is needed, AWS E/ER 316L and 16-8-2 are most often specified. Types 316 and its low-carbon "L" version are well known in reference literature and more information can be obtained in this way.

METRIC CONVERSION

Data in this publication are presented in U.S. customary units. Approximate metric equivalents may be obtained by performing the following calculations:

Length (inches to millimeters) – Multiply by 25.4

Strength (ksi to megapascals or meganewtons per square meter) – Multiply by 6.8948

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Lampiran 8. Perhitungan kalorimeter aliran baru dan kalorimeter aliran lama

1. **Kalorimeter aliran baru**

$LHV_{C_3H_8}$ = [$\dot{m}_{w,out}$. $Cp_{w,out}$. (T_{st2} –T_{st1}) + {($\dot{m}_{CO_2}$. Cp_{CO_2} + $\dot{m}_{H_2O}$. Cp_{H_2O} + $\dot{m}_{N_2}$. Cp_{N_2}) . T_{st4}} – ($\dot{m}_{C_3H_8}$. $Cp_{C_3H_8}$. T_{st3} + $\dot{m}_{u,in}$. $Cp_{u,in}$. T_{st3})] . $\frac{1}{\dot{m}_{C_3H_8}}$

$LHV_{C_3H_8}$ = [0,01667 kg/dtk . 4,19 kJ/kg.K . (67,51°C - 35,09°C) + {(0,000588 kg/dtk . 0,978 kJ/kg.K + 0,000320727 kg/dtk . 3,224 kJ/kg.K + 0,002344873 kg/dtk . 1,049 kJ/kg.K) . 497,83 K} – (0,000196 kJ/dtk . 1,6794 kJ/kg.K . 304,01 K + 0,0030576 kg/dtk . 1.005 kJ/kg.K . 304,01 K)] . $\frac{1}{0,0 \quad k\ /d}$

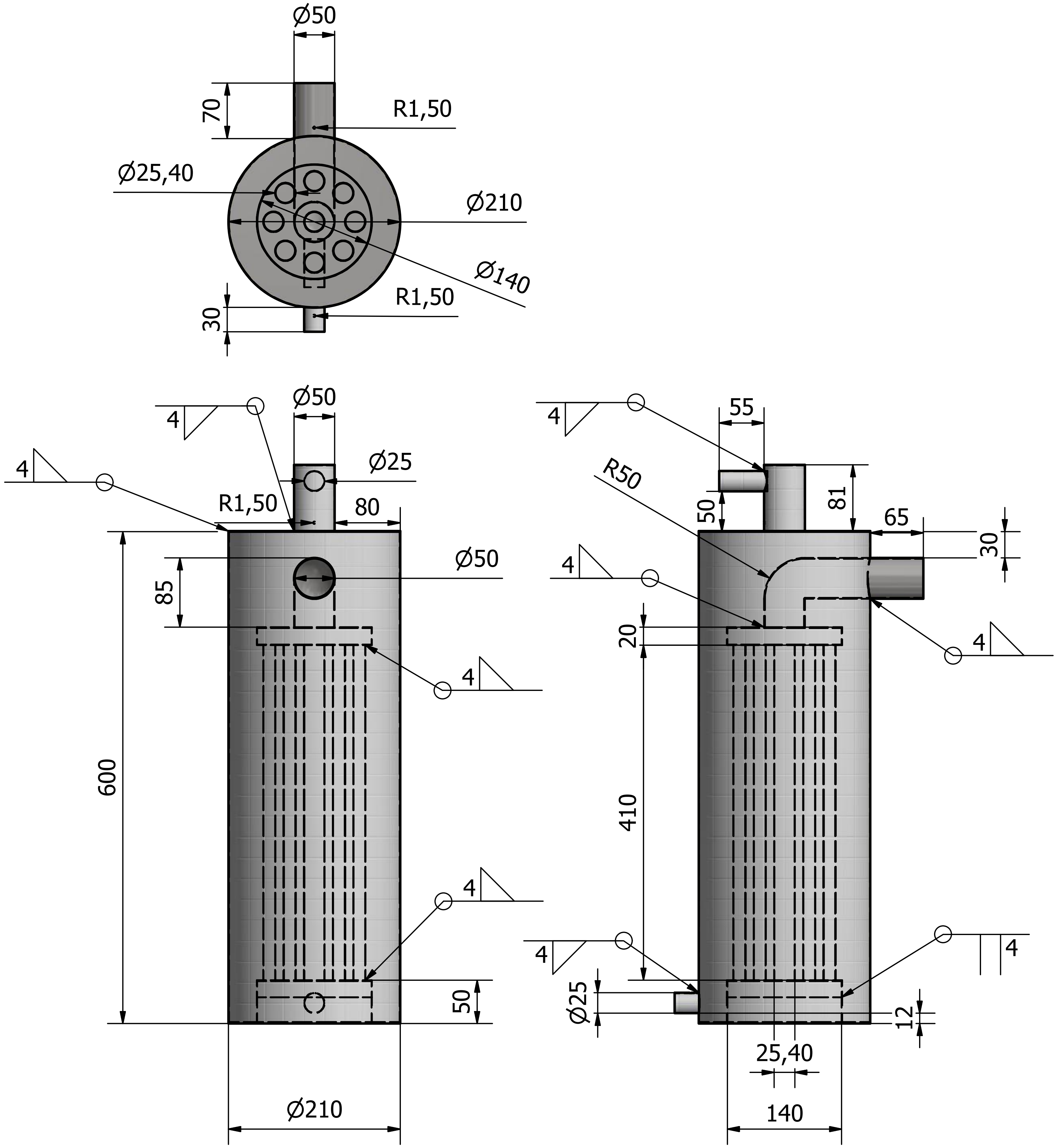
$LHV_{C_3H_8}$ = **47.876,46 kJ/kg**

2. **Kalorimeter aliran lama**

$LHV_{C_3H_8}$ = [$\dot{m}_{w,out}$. $Cp_{w,out}$. (T_2 –T_1) + {($\dot{m}_{CO_2}$. Cp_{CO_2} + $\dot{m}_{H_2O}$. Cp_{H_2O} + $\dot{m}_{N_2}$. Cp_{N_2}) . T_4} – ($\dot{m}_{C_3H_8}$. $Cp_{C_3H_8}$. T_3 + $\dot{m}_{u,in}$. $Cp_{u,in}$. T_3)] . $\frac{1}{\dot{m}_{C_3H_8}}$

$LHV_{C_3H_8}$ = [0,01667 kg/dtk . 4,19 kJ/kg.K . (68,1°C - 28,8°C) + {(0,0006 kg/dtk . 1,204 kJ/kg.K + 0,000327273 kg/dtk . 3,224 kJ/kg.K + 0,002392727 kg/dtk . 1,145 kJ/kg.K) . 893,95 K} – (0,0002 kJ/dtk . 1,6794 kJ/kg.K . 304,05 K + 0,0030576 kg/dtk . 1.005 kJ/kg.K . 304,05 K)] . $\frac{1}{0,0 \quad k\ /d}$

$LHV_{C_3H_8}$ = **48.003,01 kJ/kg**



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	Satuan : mm	Jurusan : Teknik Mesin	
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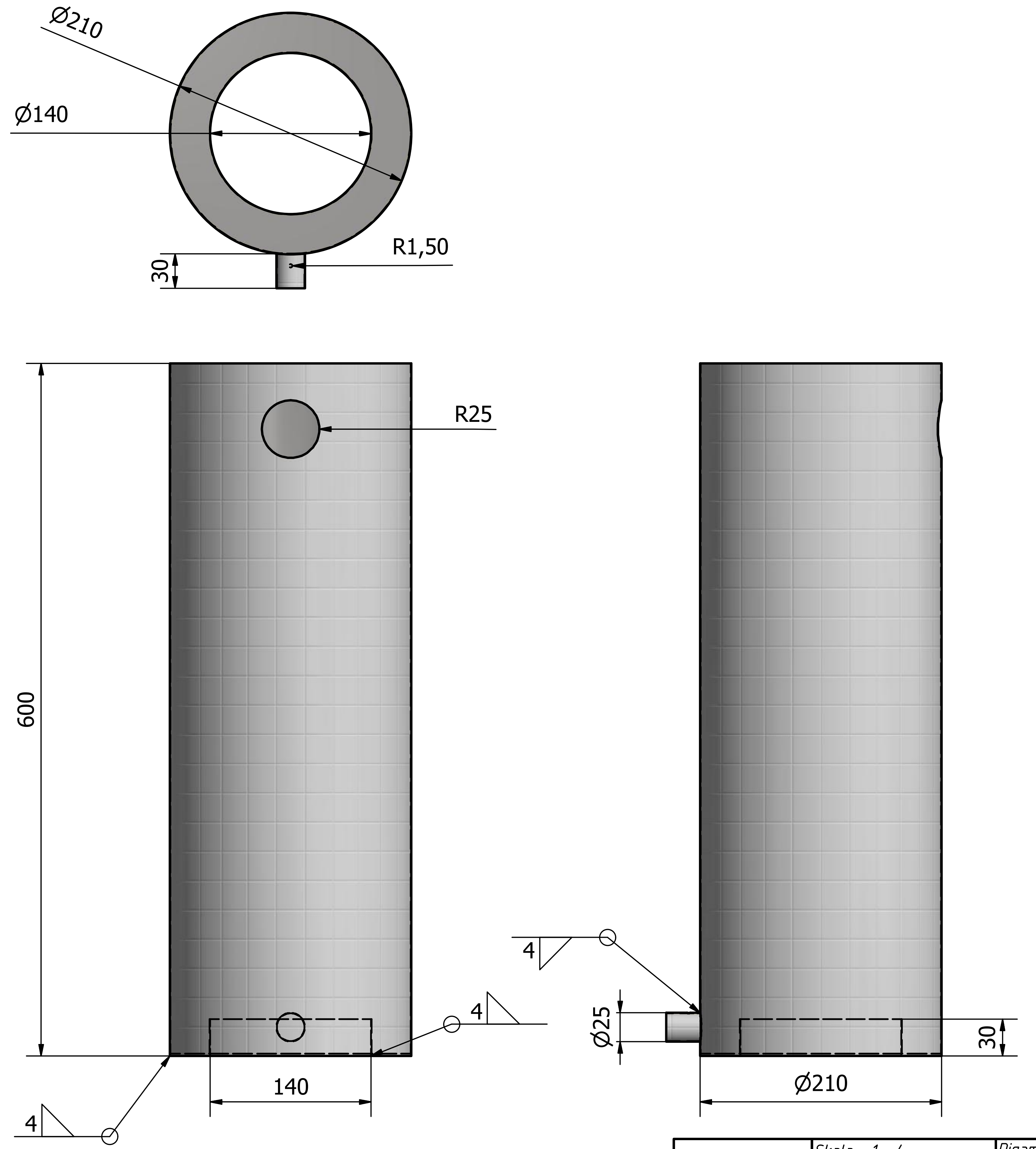
Universitas Muhammadiyah Yogyakarta	Tabung kalorimeter	No. 1/TA/2017	A3



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	Satuan : mm	Jurusan : Teknik Mesin	
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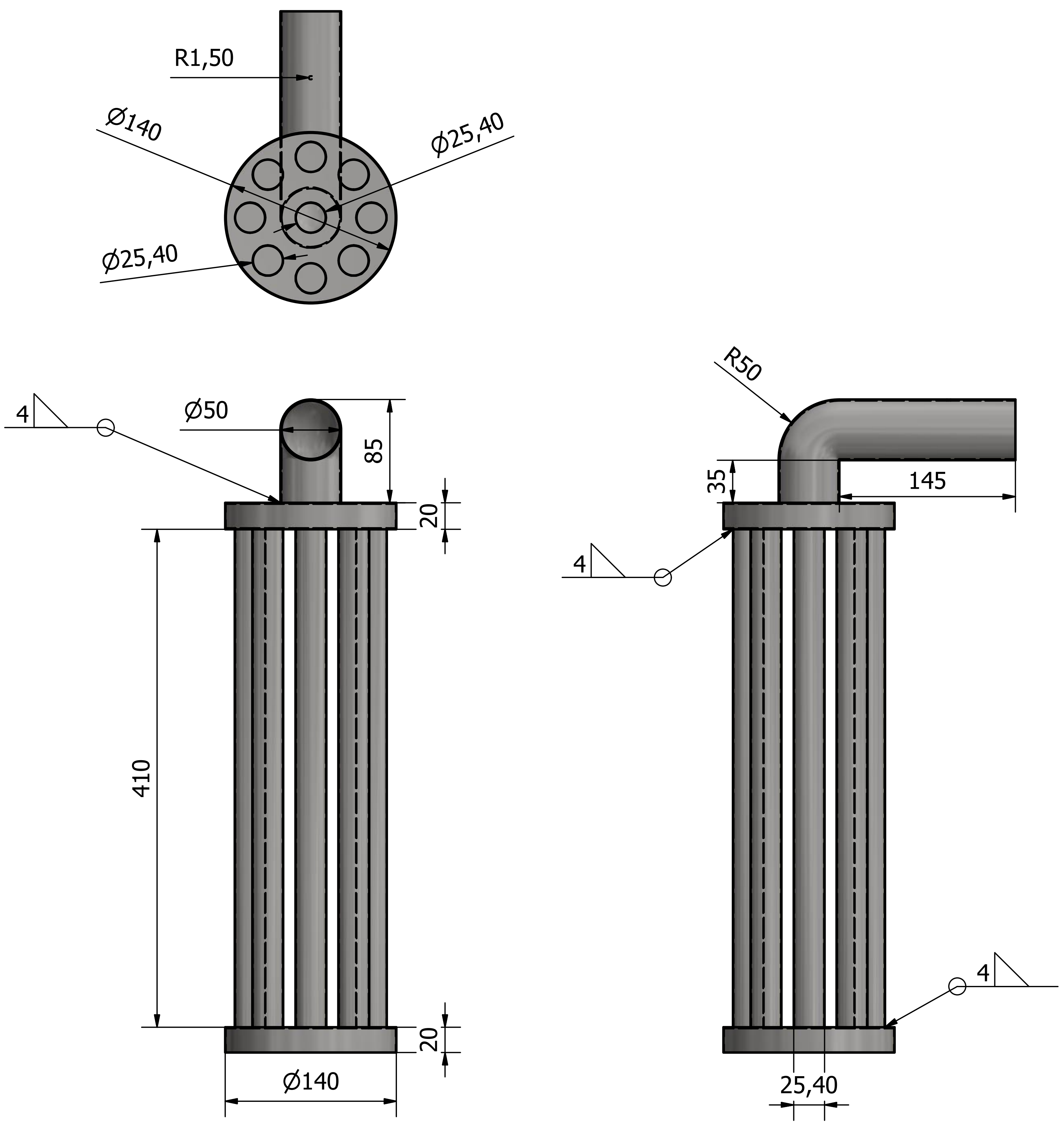
Universitas Muhammadiyah Yogyakarta	Part 1 tabung kalorimeter	No. 3/TA/2017	A3



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	Satuan : mm	Jurusan : Teknik Mesin	Lampiran 11
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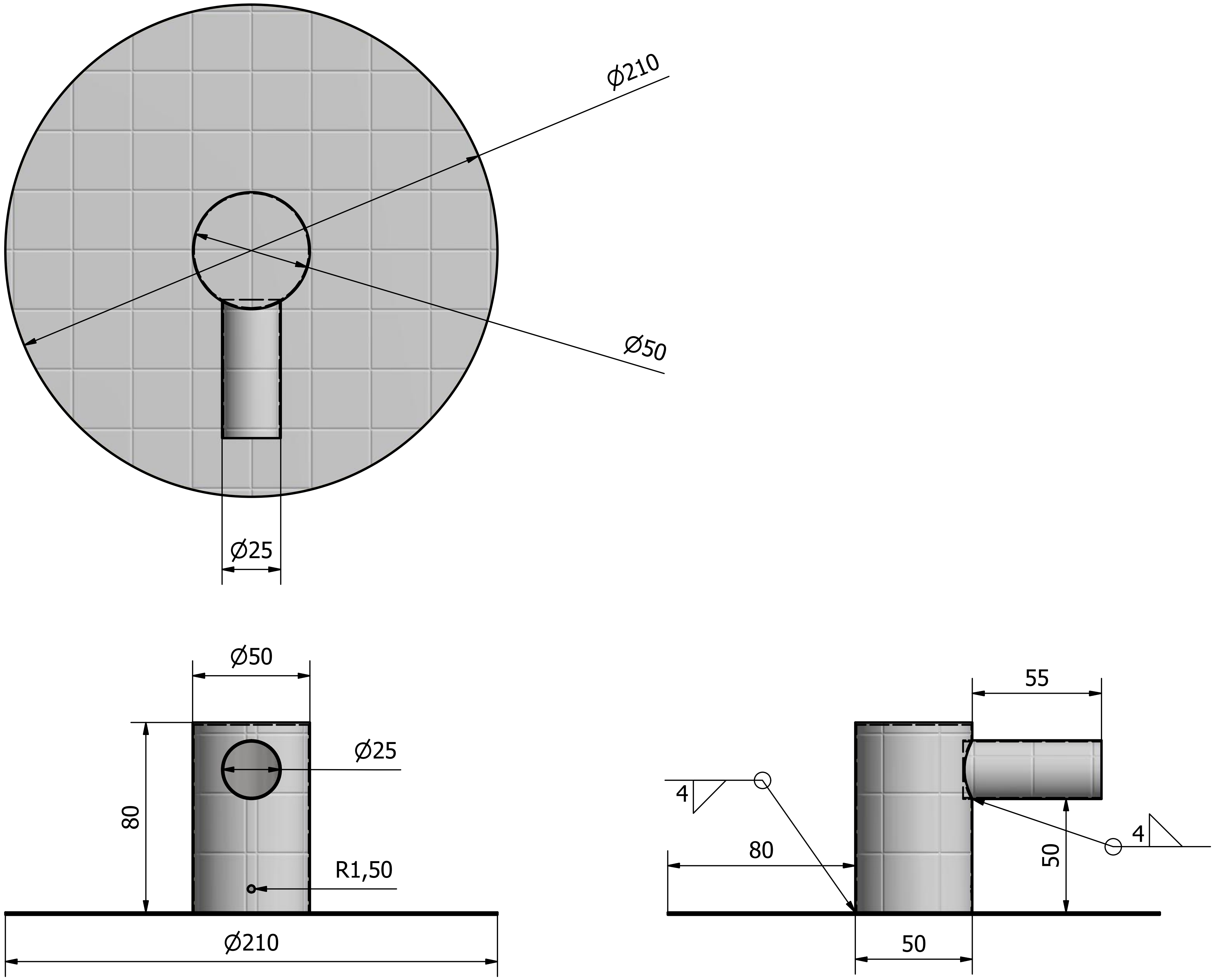
Universitas Muhammadiyah Yogyakarta	Part 2 tabung kalorimeter	No. 4/TA/2017	A3



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	Satuan : mm	Jurusan : Teknik Mesin	Lampiran 12
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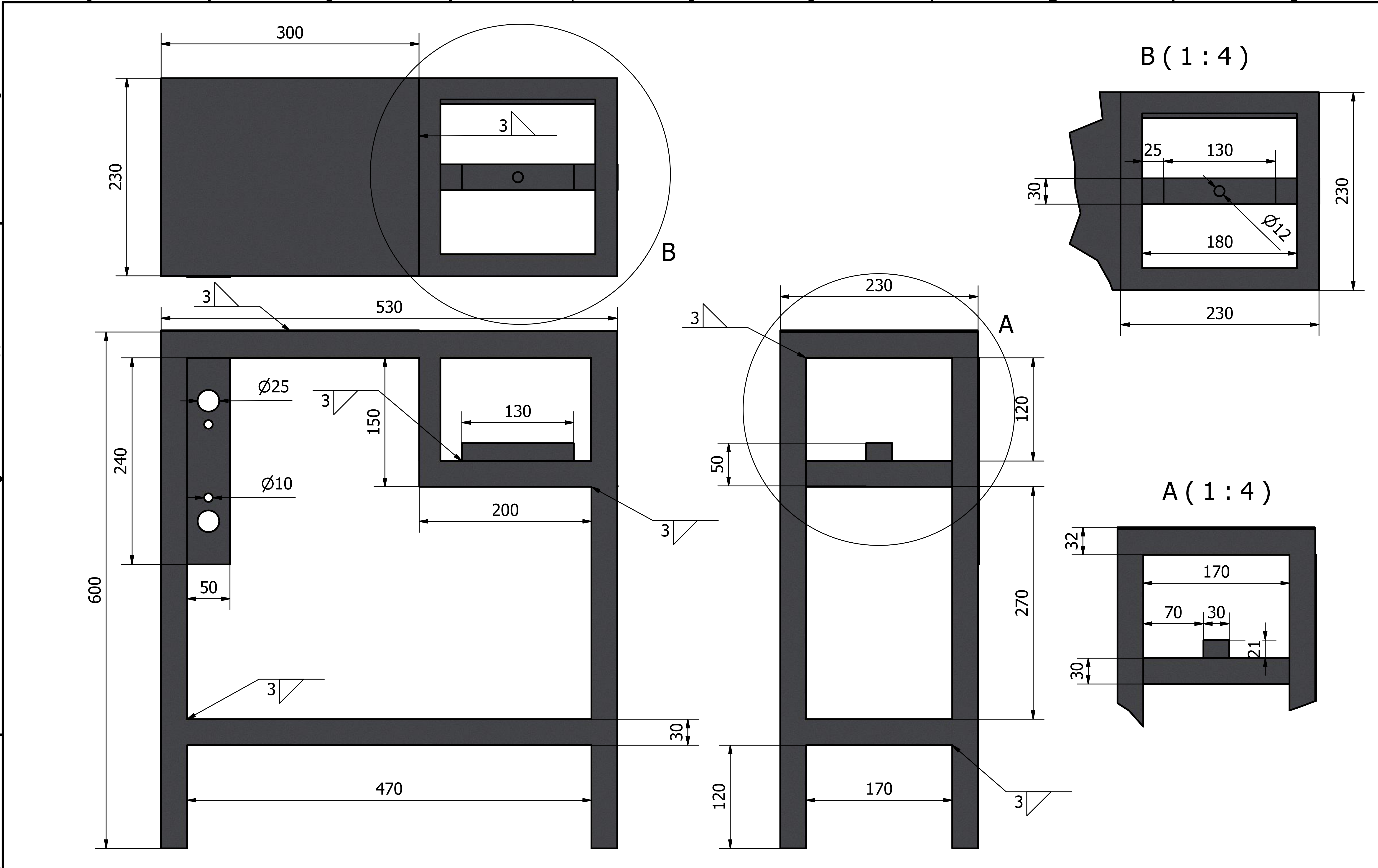
Universitas Muhammadiyah Yogyakarta	Part 3 tabung kalorimeter	No. 5/TA/2017	A3



	Skala : 1 : 4	*Digambar : Ichwano Rahardi*	*Keterangan :* Lampiran 13
	Satuan : mm	*Jurusan : Teknik Mesin*	
	Tanggal :	*Diperiksa :*	
Universitas Muhammadiyah Yogyakarta	Meja	No. 2/TA/2017	A3