LAMPIRAN

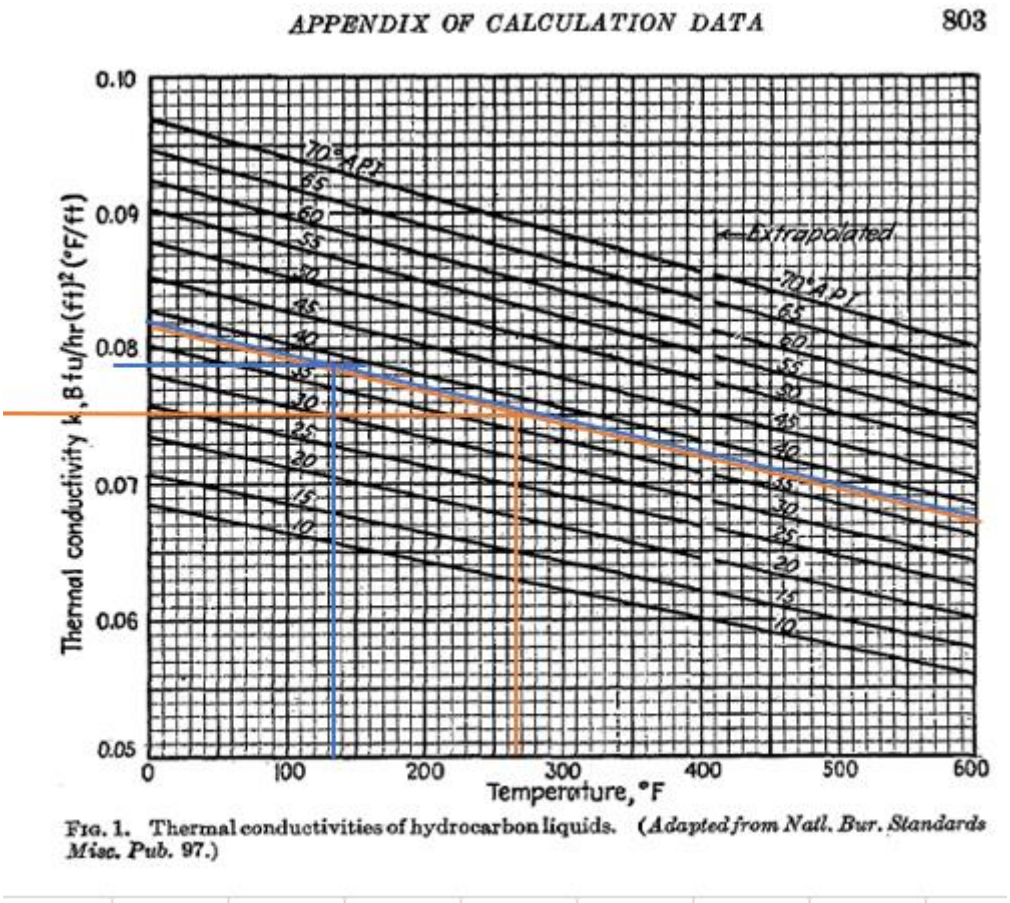
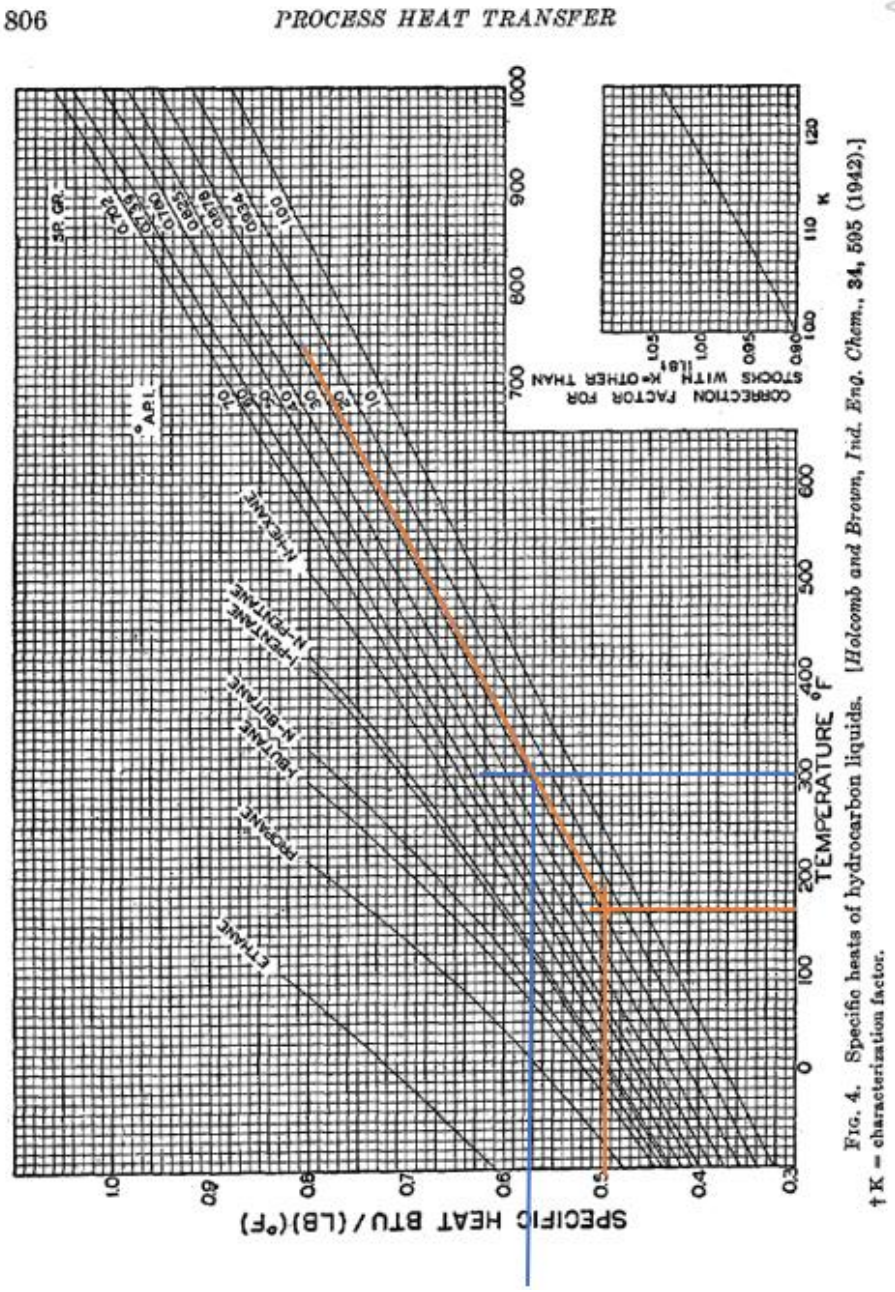
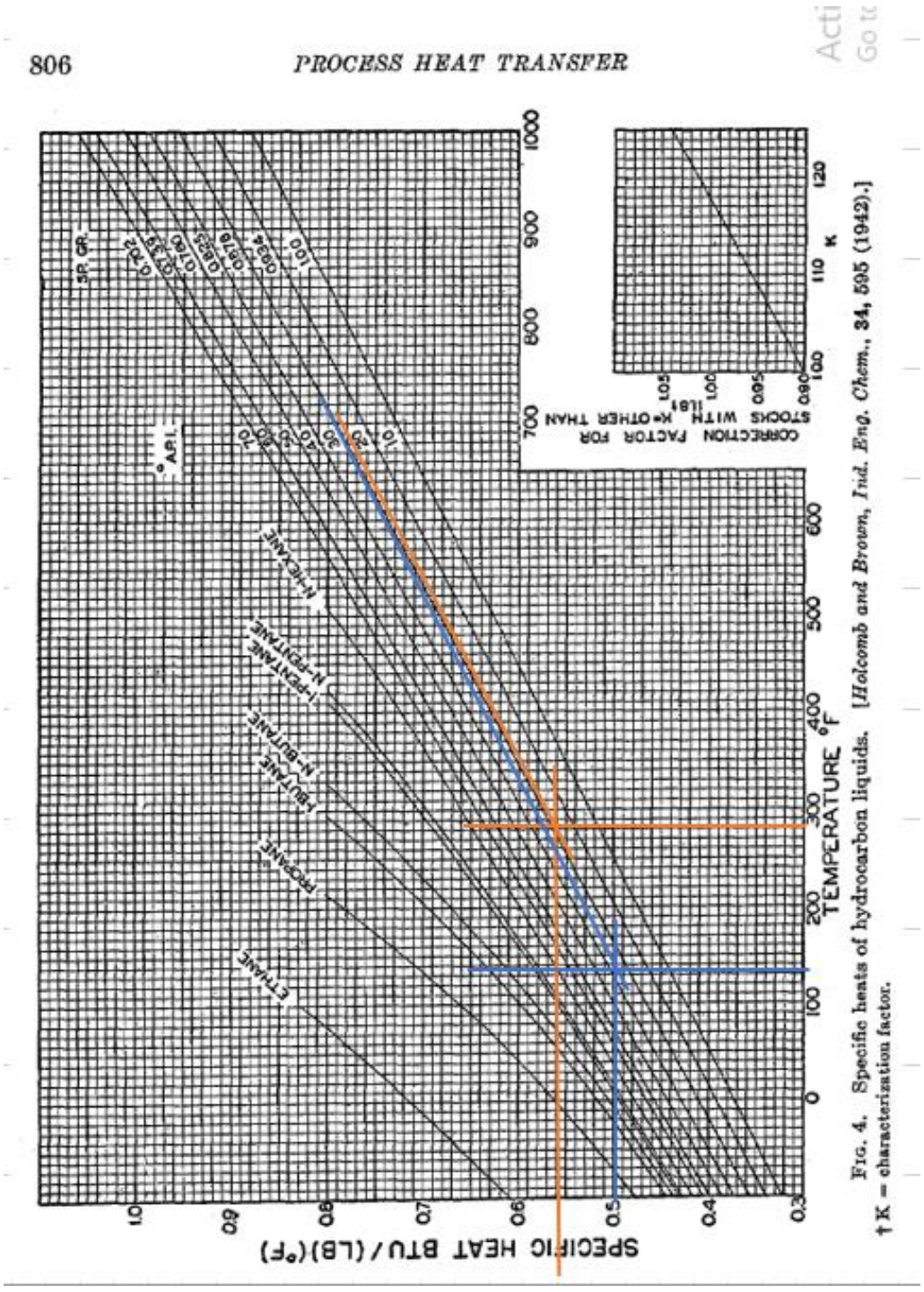


FIG. 1. Thermal conductivities of hydrocarbon liquids. (*Adapted from Natl. Bur. Standards Misc. Pub.* 97.)

Gambar 1. Konduktivitas Thermal Hidrokarbon



Gambar 2. *Specific Heat* Hidrokarbon Liquida Untuk *Design* HE-03



Gambar 3. *Specific Heat* Hidrokarbon Liquida Untuk *Redesign* HE-03

VISCOSITIES OF PETROLEUM FRACTIONS
For temperature ranges employed in the text
Coordinates to be used with Fig. 14

	X	Y
76°API natural gasoline	14.4	6.4
56°API gasoline	14.0	10.5
42°API kerosene	11.6	16.0
35°API distillate	10.0	20.0
34°API mid-continent crude	10.3	21.3
28°API gas oil	10.0	23.6

VISCOSITIES OF ANIMAL AND VEGETABLE OILS*

	Acid No.	Sp gr, 20/4°C	X	Y
Almond	2.85	0.9188	6.9	28.2
Coconut	0.01	0.9226	6.9	26.9
Cod liver	.....	0.9138	7.7	27.7
Cottonseed	14.24	0.9187	7.0	28.0
Lard	3.39	0.9138	7.0	28.2
Linseed	3.42	0.9297	6.8	27.5
Mustard	.....	0.9237	7.0	28.5
Neatsfoot	13.35	0.9158	6.5	28.0
Olive	.....	0.9158	6.6	28.3
Palm kernel	9.0	0.9190	7.0	26.9
Perilla, raw	1.36	0.9297	8.1	27.2
Rapeseed	0.34	0.9114	7.0	28.8
Sardine	0.57	0.9384	7.7	27.3
Soybean	3.50	0.9228	8.3	27.5
Sperm	0.80	0.8829	7.7	26.3
Sunflower	2.76	0.9207	7.5	27.6
Whale, refined	0.73	0.9227	7.5	27.5

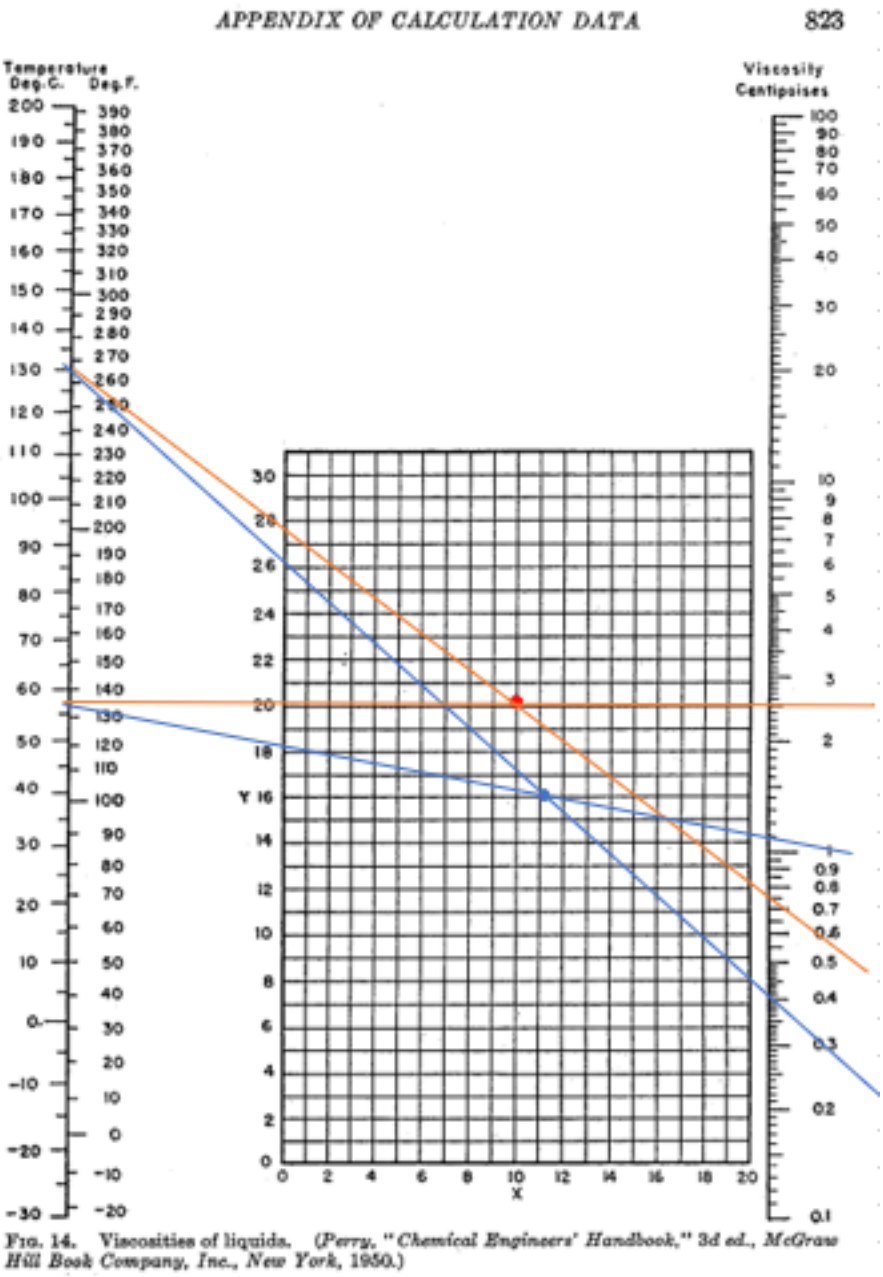
* Based on data at 100 and 210°F of A. R. Rescorla and F. L. Carnahan, *Ind. Eng. Chem.*, **28**, 1212–1213 (1936).

VISCOSITIES OF COMMERCIAL FATTY ACIDS*
250 to 400°F

	Sp gr at 300°F	X	Y
Lauric	0.792	10.1	23.1
Oleic	0.799	10.0	25.2
Palmitic	0.786	9.2	25.9
Stearic	0.789	10.5	25.5

* From data of D. Q. Kern and W. Van Nostrand, *Ind. Eng. Chem.*, **41**, 2209 (1949).

Gambar 4. Viskositas Fraksi Petrolium



Gambar 5. Viskositas liquida untuk *design* HE-03

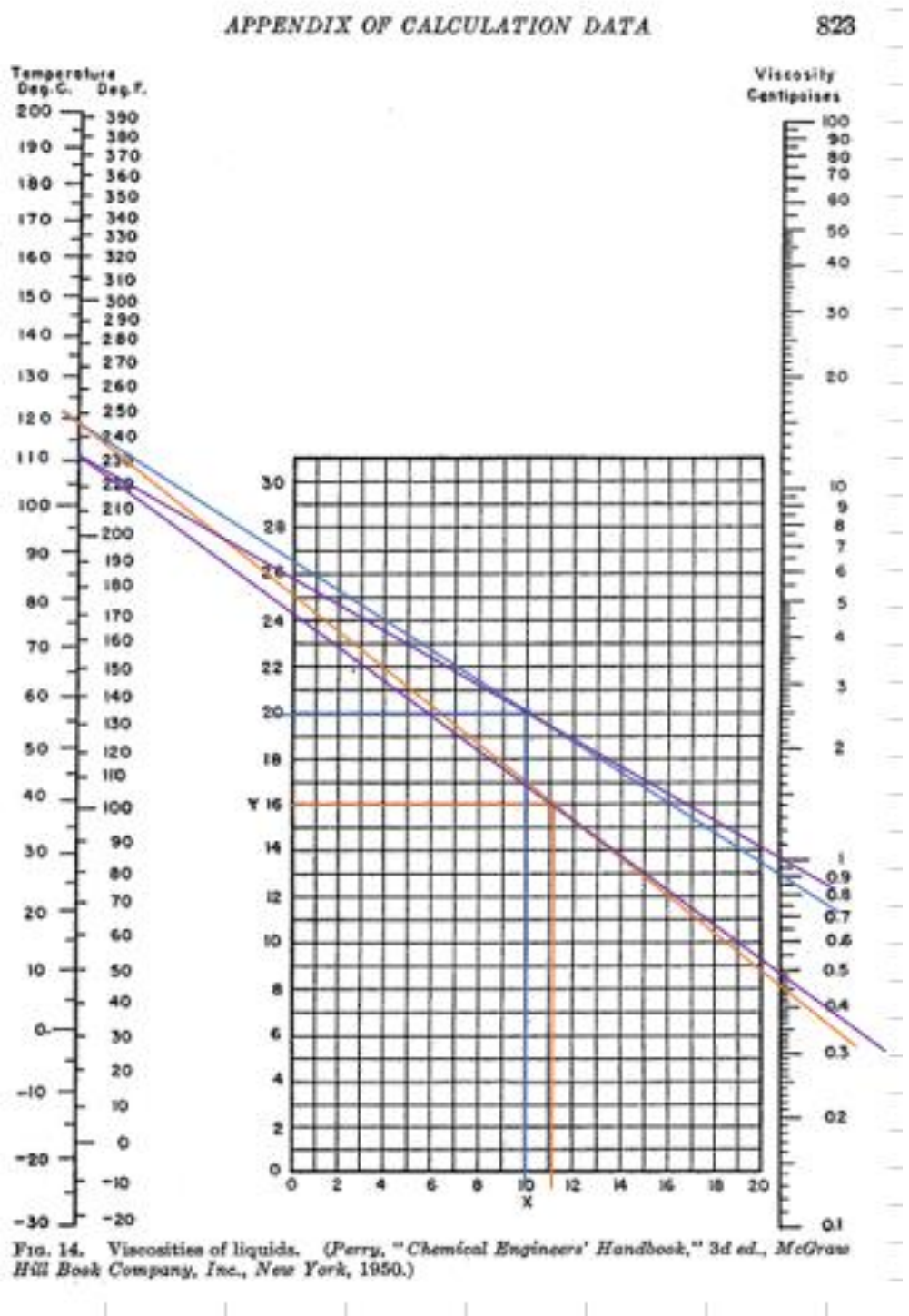
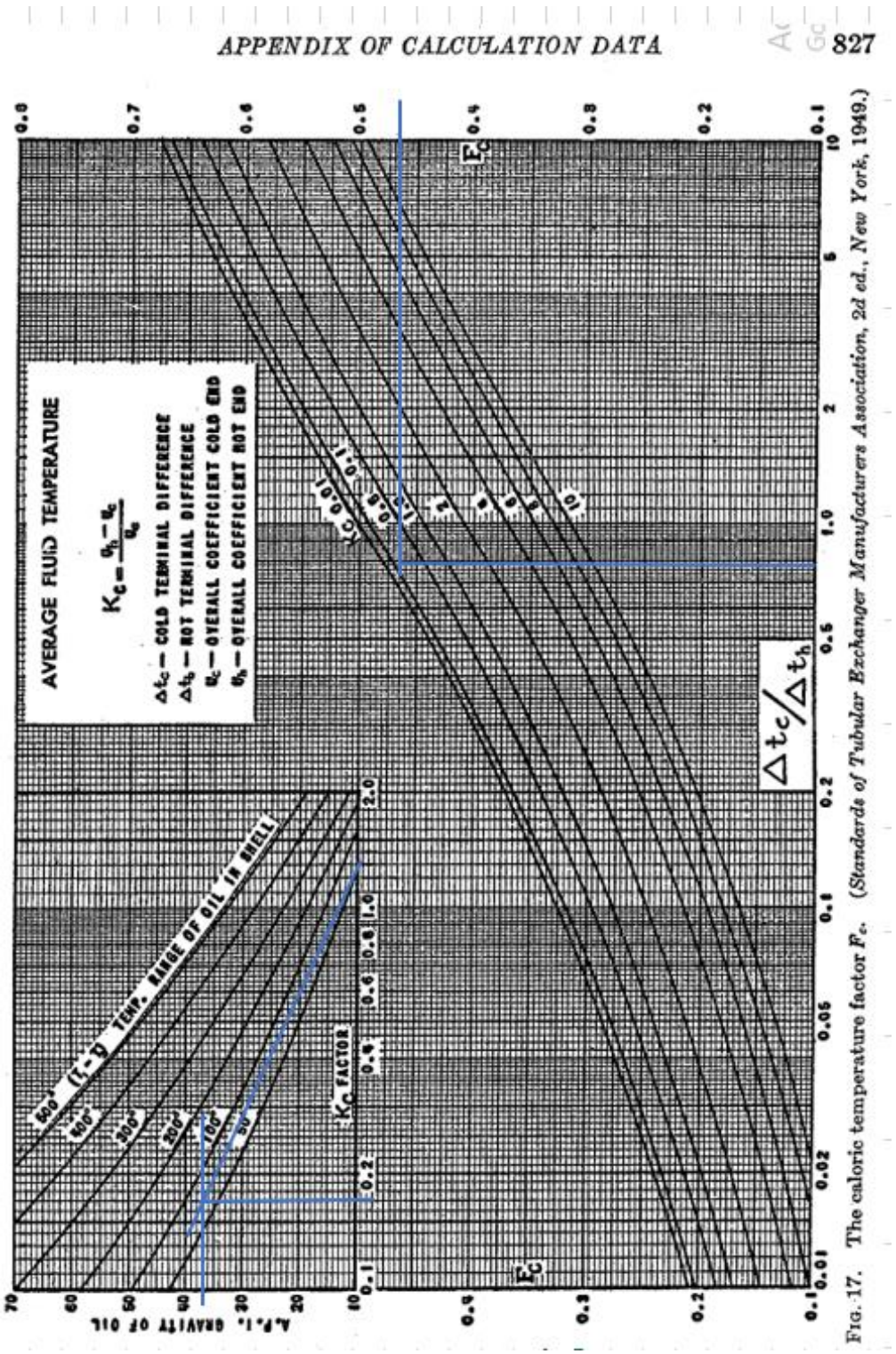


FIG. 14. Viscosities of liquids. (*Perry, "Chemical Engineers' Handbook," 3d ed., McGraw Hill Book Company, Inc., New York, 1950.*)

Gambar 6. Viskositas Liquida untuk *Redesign* HE-03



Gambar 7. Faktor *Caloric Temperature*

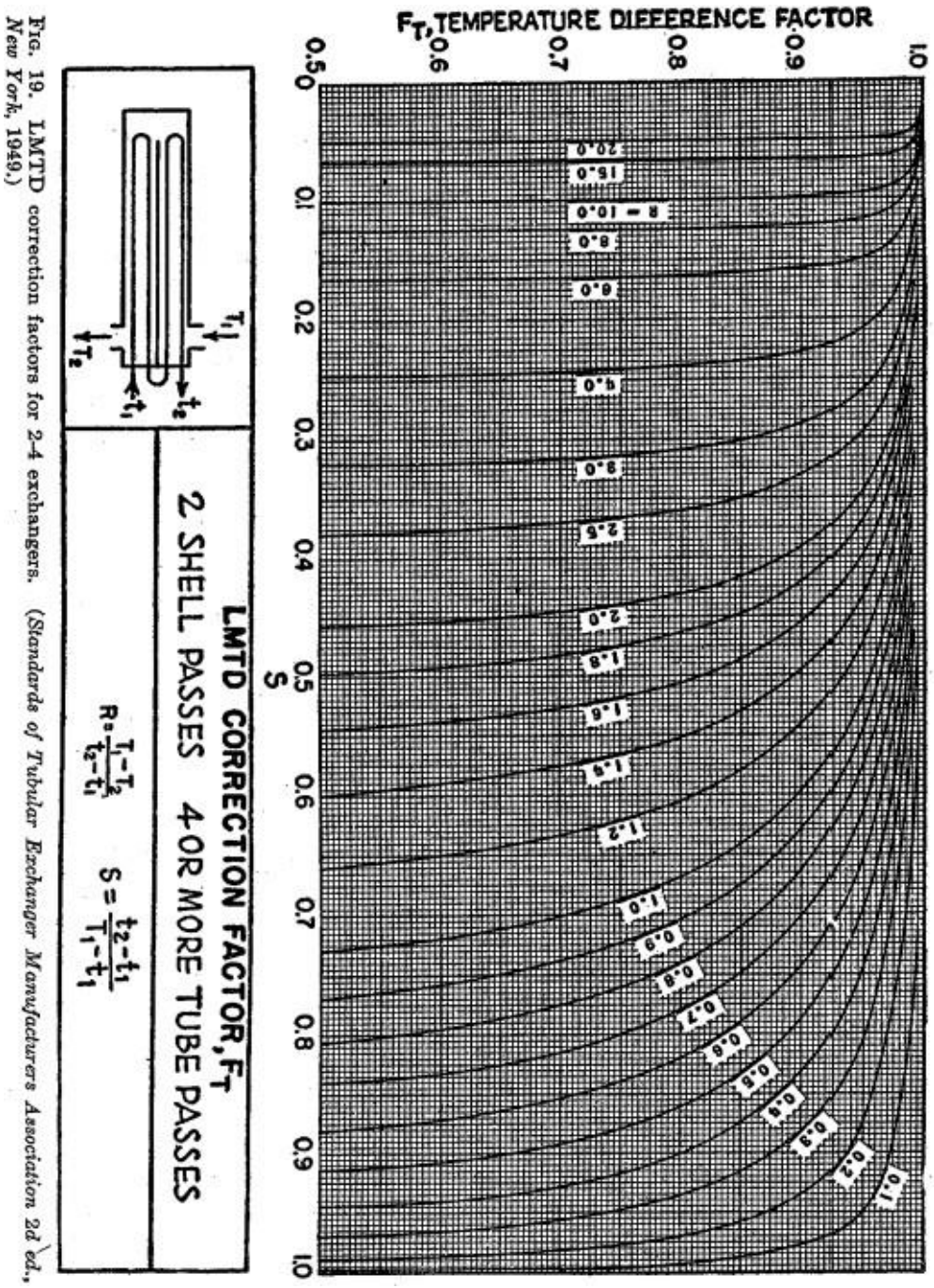


FIG. 19. LMTD correction factors for 2-4 exchangers. (*Standards of Tubular Exchanger Manufacturers Association 2d ed., New York*, 1949.)

Gambar 8. Faktor Koreksi LMTD

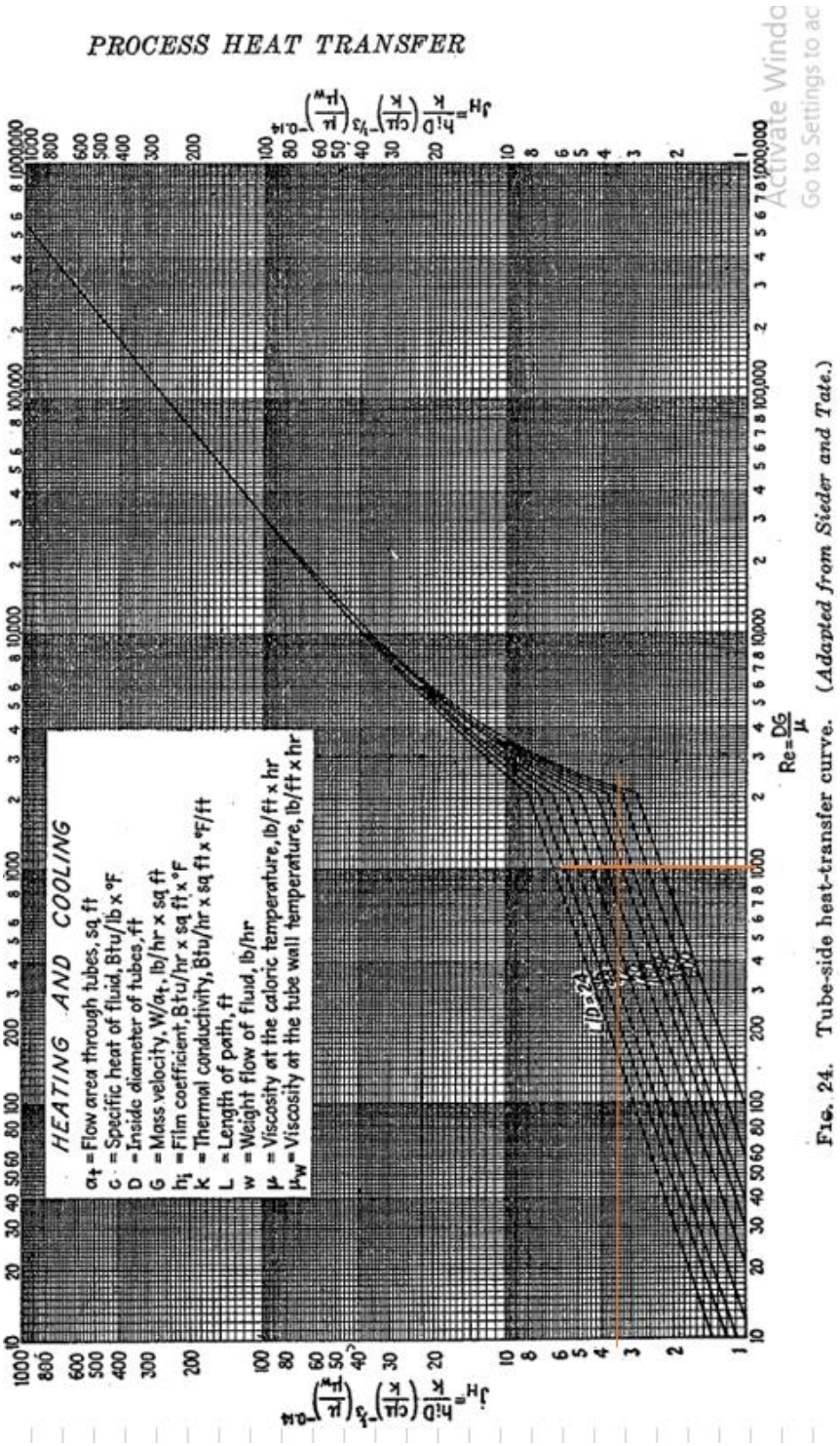
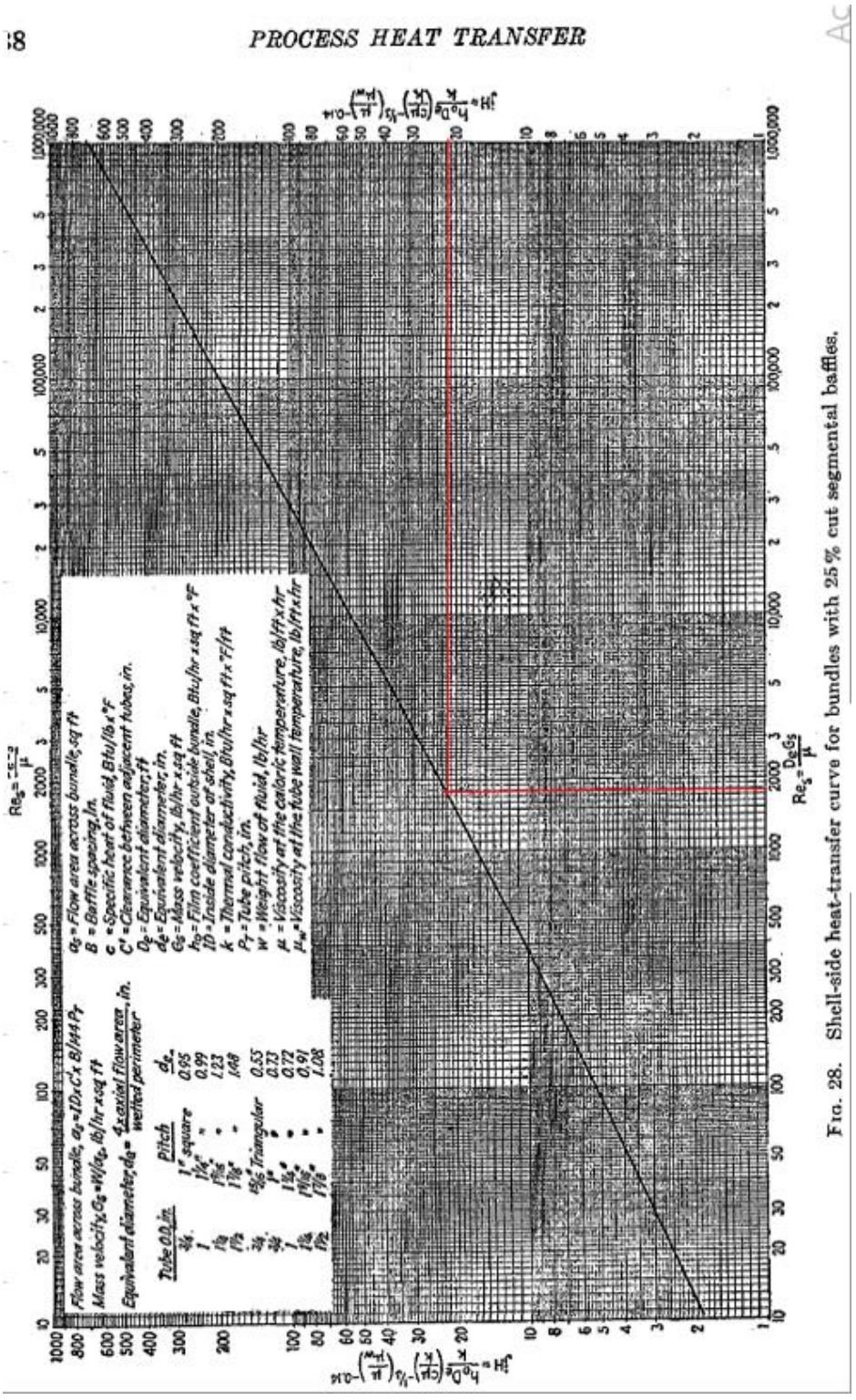
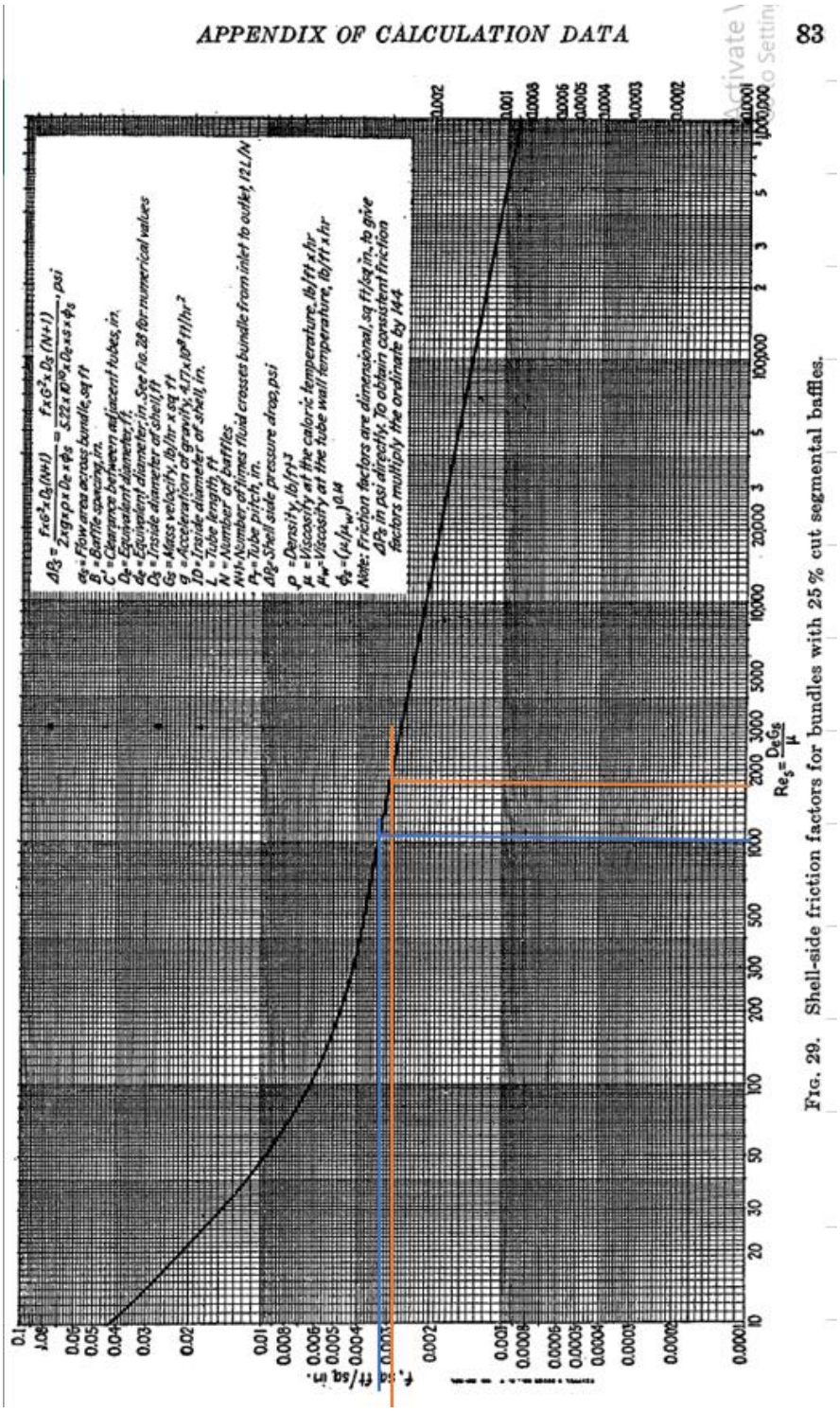


Fig. 24. Tube-side heat-transfer curve. (*Adapted from Sieder and Tate.*)

Gambar 9. Kurva *Tube-Side Heat-Transfer*



Gambar 10. Kurva *Shell-Side Heat-Transfer*



Gambar 11. Faktor Friksi *Shell-Side*

TABLE 8. APPROXIMATE OVERALL DESIGN COEFFICIENTS

Values include total dirt factors of 0.003 and allowable pressure drops of 5 to 10 psi on the controlling stream

Coolers

Hot fluid	Cold fluid	Overall U_D
Water	Water	250–500§
Methanol	Water	250–500§
Ammonia	Water	250–500§
Aqueous solutions	Water	250–500§
Light organics*	Water	75–150
Medium organics†	Water	50–125
Heavy organics‡	Water	5–75‖
Gases	Water	2–50¶
Water	Brine	100–200
Light organics	Brine	40–100

Heaters

Hot fluid	Cold fluid	Overall U_D
Steam	Water	200–700§
Steam	Methanol	200–700§
Steam	Ammonia	200–700§
Steam	Aqueous solutions:	
Steam	Less than 2.0 cp	200–700
Steam	More than 2.0 cp	100–500§
Steam	Light organics	100–200
Steam	Medium organics	50–100
Steam	Heavy organics	6–60
Steam	Gases	5–50¶

Exchangers

Hot fluid	Cold fluid	Overall U_D
Water	Water	250–500§
Aqueous solutions	Aqueous solutions	250–500§
Light organics	Light organics	40–75
Medium organics	Medium organics	20–60
Heavy organics	Heavy organics	10–40
Heavy organics	Light organics	30–60
Light organics	Heavy organics	10–40

* *Light organics* are fluids with viscosities of less than 0.5 centipoise and include benzene, toluene, acetone, ethanol, methyl ethyl ketone, gasoline, light kerosene, and naphtha.

† *Medium organics* have viscosities of 0.5 to 1.0 centipoise and include kerosene, straw oil, hot gas oil, hot absorber oil, and some crudes.

‡ *Heavy organics* have viscosities above 1.0 centipose and include cold gas oil, lube oils, fuel oils, reduced crude oils, tars, and asphalts.

§ Dirt factor 0.001.

‖ Pressure drop 20 to 30 psi.

¶ These rates are greatly influenced by the operating pressure.

Gambar 12. Perkiraan Koefisien *Overall Design*

TABLE 9. TUBE-SHEET LAYOUTS (TUBE COUNTS).—(*Continued*)
Triangular Pitch

Shell ID, in.	1-P	2-P	4-P	6-P	8-P
¾ in. OD tubes on 15/16-in. triangular pitch					
8	36	32	26	24	18
10	62	56	47	42	36
12	109	98	86	82	78
13¼	127	114	96	90	86
15¼	170	160	140	136	128
17¼	239	224	194	188	178
19¼	301	282	252	244	234
21¼	361	342	314	306	290
23¼	442	420	386	378	364
25	532	506	468	446	434
27	637	602	550	536	524
29	721	692	640	620	594
31	847	822	766	722	720
33	974	938	878	852	826
35	1102	1068	1004	988	958
37	1240	1200	1144	1104	1072
39	1377	1330	1258	1248	1212
¾ in. OD tubes on 1-in. triangular pitch					
8	37	30	24	24	
10	61	52	40	36	
12	92	82	76	74	70
13¼	109	106	86	82	74
15¼	151	138	122	118	110
17¼	203	196	178	172	166
19¼	262	250	226	216	210
21¼	316	302	278	272	260
23¼	384	376	352	342	328
25	470	452	422	394	382
27	559	534	488	474	464
29	630	604	556	538	508
31	745	728	678	666	640
33	856	830	774	760	732
35	970	938	882	864	848
37	1074	1044	1012	986	870
39	1206	1176	1128	1100	1078
1 in. OD tubes on 1¼-in. triangular pitch					
8	21	16	16	14	
10	32	32	26	24	
12	55	52	48	46	44
13¼	68	66	58	54	50
15¼	91	86	80	74	72
17¼	131	118	106	104	94
19¼	163	152	140	136	128
21¼	199	188	170	164	160
23¼	241	232	212	212	202
25	294	282	256	252	242
27	349	334	302	296	286
29	397	376	338	334	316
31	472	454	430	424	400
33	538	522	486	470	454
35	608	592	562	546	532
37	674	664	632	614	598
39	766	736	700	688	672
1¼ in. OD tubes on 1 9/16-in. triangular pitch					
10	20	18	14		
12	32	30	26	22	20
13¼	38	36	32	28	26
15¼	54	51	45	42	38
17¼	69	66	62	58	54
19¼	95	91	86	78	69
21¼	117	112	105	101	95
23¼	140	136	130	123	117
25	170	164	155	150	140
27	202	196	185	179	170
29	235	228	217	212	202
31	275	270	255	245	235
33	315	305	297	288	275
35	357	348	335	327	315
37	407	390	380	374	357
39	449	436	425	419	407
1½ in. OD tubes on 1⅞-in. triangular pitch					
12	18	14	14	12	12
13¼	27	22	18	16	14
15¼	36	34	32	30	27
17¼	48	44	42	38	36
19¼	61	58	55	51	48
21¼	76	72	70	66	61
23¼	95	91	86	80	76
25	115	110	105	98	95
27	136	131	125	118	115
29	160	154	147	141	136
31	184	177	172	165	160
33	215	206	200	190	184
35	246	238	230	220	215
37	275	268	260	252	246
39	307	299	290	284	275

Gambar 13. Susunan *Tube-Sheet*

TABLE 10. HEAT EXCHANGER AND CONDENSER TUBE DATA

Tube OD, in.	BWG	Wall thickness, in.	ID, in.	Flow area per tube, in.²	Surface per lin ft, ft²		Weight per lin ft, lb steel
					Outside	Inside	
½	12	0.109	0.282	0.0625	0.1309	0.0748	0.493
	14	0.083	0.334	0.0876		0.0874	0.403
	16	0.065	0.370	0.1076		0.0969	0.329
	18	0.049	0.402	0.127		0.1052	0.258
	20	0.035	0.430	0.145		0.1125	0.190
¾	10	0.134	0.482	0.182	0.1963	0.1263	0.965
	11	0.120	0.510	0.204		0.1335	0.884
	12	0.109	0.532	0.223		0.1393	0.817
	13	0.095	0.560	0.247		0.1466	0.727
	14	0.083	0.584	0.268		0.1529	0.647
	15	0.072	0.606	0.289		0.1587	0.571
	16	0.065	0.620	0.302		0.1623	0.520
	17	0.058	0.634	0.314		0.1660	0.469
	18	0.049	0.652	0.334		0.1707	0.401
1	8	0.165	0.670	0.355	0.2618	0.1754	1.61
	9	0.148	0.704	0.389		0.1843	1.47
	10	0.134	0.732	0.421		0.1916	1.36
	11	0.120	0.760	0.455		0.1990	1.23
	12	0.109	0.782	0.479		0.2048	1.14
	13	0.095	0.810	0.515		0.2121	1.00
	14	0.083	0.834	0.546		0.2183	0.890
	15	0.072	0.856	0.576		0.2241	0.781
	16	0.065	0.870	0.594		0.2277	0.710
	17	0.058	0.884	0.613		0.2314	0.639
	18	0.049	0.902	0.639		0.2361	0.545
1¼	8	0.165	0.920	0.665	0.3271	0.2409	2.09
	9	0.148	0.954	0.714		0.2498	1.91
	10	0.134	0.982	0.757		0.2572	1.75
	11	0.120	1.01	0.800		0.2644	1.58
	12	0.109	1.03	0.836		0.2701	1.45
	13	0.095	1.06	0.884		0.2775	1.28
	14	0.083	1.08	0.923		0.2839	1.13
	15	0.072	1.11	0.960		0.2896	0.991
	16	0.065	1.12	0.985		0.2932	0.900
	17	0.058	1.13	1.01		0.2969	0.808
	18	0.049	1.15	1.04		0.3015	0.688
1½	8	0.165	1.17	1.075	0.3925	0.3063	2.57
	9	0.148	1.20	1.14		0.3152	2.34
	10	0.134	1.23	1.19		0.3225	2.14
	11	0.120	1.26	1.25		0.3299	1.98
	12	0.109	1.28	1.29		0.3356	1.77
	13	0.095	1.31	1.35		0.3430	1.56
	14	0.083	1.33	1.40		0.3492	1.37
	15	0.072	1.36	1.44		0.3555	1.20
	16	0.065	1.37	1.47		0.3587	1.09
	17	0.058	1.38	1.50		0.3623	0.978
	18	0.049	1.40	1.54		0.3670	0.831

Gambar 14. Data *Heat Exchanger* dan *Condensor Tube*