BAB VI

PERHITUNGAN BEBAN GENERATOR

VI.1. Sistem Penerangan Dan Navigasi

Sistem penerangan dan navigasi mengetengahkan tentang lampu – lampu, baik yang berfungsi sebagai penerangan atau juga berfungsi sebagai sarana navigasi.

VI.2. lampu Untuk Sistem Navigasi

Yaitu lampu kapal yang harus dihidupkan pada waktu kapal berlayar diantara matahari terbenam dan terbit, sedemikian rupa, sehingga jenis kapal, letak adan arah kapal dapat diketahui.

Adapun yang termasuk lampu – lampu navigasi adalah :

a. Stern Light (lampu burilan)

   - Jumlah 1 unit
   - Jarak, bisa dikihat sejauh 2 mil
   - Direncanakan daya lampu (40 watt x 2)

b. Not under command light (lampu isyarat tanda komando)

   yaitu lampu navigasi yang memberikan isyarat bahwa papal dalam keadaan tidak terkendalikan.

   - Jumlah 1 unit
   - Direncanakan daya lampu (60 watt x 2)

c. Anchor light (lampu jangkar)

   yaitu lampu isyarat berwarna putih yang di pasang pada ujung haluan kapal yang memeberikan isyarat pada waktu malam hari bahwa kapal sedang lego jangkar atau berlabuh.

   - Jumlah 2 unit dan jarak bisa dilihat sejauh 2 mil
   - Direncanakan daya lampu 40 kW

d. Side light (lampu sisi)

yaitu lampu navigasi yang berwarna merah (sisi kiri) dan hijau (sisi kanan) yang dipasang disisi kapal dan dinyalakan pada waktu kapal berlayar dimalam hari.

- Jumlah 2 unit dan jarak bisa dilihat sejauh 2 mil
- Direncanakan daya lampu (60 watt x 2)

e. Masthead light (lampu tiang)

yaitu lampu berwarna putih yang dipasang dibagian depan pada tiang depan kapal

- Jumlah 2 unit dan jarak bisa dilihat sejauh 5 mil
- Direncanakan daya lampu (60 watt x 2)

f. Morse lamp (lampu morse)

yaitu lampu berwarna putih yang dipergunakan untuk mengirim isyarat morse.

- Jumlah 1 unit, daya lampu 40 watt x 2

VI.3. Lampu Untuk Penerangan

Yaitu lampu – lampu yang dipergunakan untuk memberikan penerangan ruangan – ruangan di kapal. Untuk menghitung kebutuhan penerangan dikapal diasumsikan berdasarkan besarnya ruangan yang dapat dilihat pada General Arrangement kapal.

Adapun perinciannya sebagai berikut seperti dalam tabe dibawah ini .

Ruangan	Daya	
	Watt	kW
Navigation Bridge Deck		
1. Whell House	120	0,12
2. Radio Room	40	0,04
3. Radio Officer	40	0,04
4. Chart Room	40	0,04
5. Pilot	40	0,04
6. KM / WC	20	0,02
Jumlah	**300**	**0,3**

C. Deck		
1. Owner Room	60	0,06
2. KM / WC	20	0,02
3. Office	60	0,06
4. KM / WC	20	0,02
5. Bed Room	40	0,04
6. KM / WC	20	0,02
7. Office	60	0,06
8. KM / WC	20	0,02
9. Hospital	60	0,06
10. KM / WC	20	0,02
11. Store	40	0,04
12. Laundry & Dry Room	40	0,04
13. Corridor	60	0,06
Jumlah	**500**	**0,5**

B. Deck		
1. Office	60	0,06
2. Chief Officer	40	0,04
3. KM / WC	20	0,02
4. Chief Engineer	40	0,04
5. KM / WC	20	0,02
6. Corridor	60	0,06
7. 1 st Officer	40	0,04
8. 2nd Officer	40	0,04
9. 1st Engineer	40	0,04
10. 2nd Engineer	40	0,04
Jumlah	**400**	**0,4**

A. Deck		
1. KM / WC	20	0,02
2. KM / WC	20	0,02
3. Laundry	40	0,04
4. Dry Room	40	0,04
5. Pantry	60	0,06
6. Galley	40	0,04
7. Crew Mess	80	0,08
8. Kamar – kamar 8 x 60	480	0,48
Jumlah	**780**	**0,78**

Poop Deck		
1. Stew Officer	40	0,04
2. Stew	40	0,04
3. Deck Store	20	0,02
4. Officer Mess	80	0,08
5. Corridor	60	0,06
6. Pantry	60	0,06
7. Galley	40	0,04
8. Suitcasses Room	40	0,04
9. Electric Room	40	0,04
10. Bay Room	40	0,04
11. Office	60	0,06
12. KM / WC	20	0,02
13. KM / WC	20	0,02
Jumlah	**500**	**0,5**

Kamar Mesin		
1. Daya lampu dikamar mesin	500	0,5
Jumlah	**500**	**0,5**

Lampu – lampu Khusus		
1. Red Light	200	0,2
2. Boat Deck Light (2 x 100)	200	0,2
3. Daylight Signal Lamp	200	0,2
4. Cargo Light	400	0,4
5. Flood Light	200	0,2
6. Berth Light (4 x 100)	400	0,4
7. Search Light	1000	1
8. Lampu Peta	60	0,06
Jumlah	**2.660**	**2,66**

VI.4. Perencanaan Perhitungan Generator

Didalam menentukan besarnya daya listrik yang harus disediakan oleh generator , sebelumnya harus dilakukan suatu analisa penggunaan daya listrik, sehingga didapat nilai yang effisien dalam pemakaian generator.

Untuk memenuhi tujuan tersebut penggunaan daya listrik khususnya dalm kapal, dapat dikategorikan pada tiga kondisi , yaitu penggunaan daya listrik pada saat kapal sedang melakuakan bongkar muat baik pada waktu siang maupun malam hari.

Adapun analisa beban generator ini dapat dilihat pada tabel beban generator.

VI.5. Pemilihan Generator

Berdasarkan tabel analisa beban generator dapat dilihat pemakaian listrik yang terbesar adalah pada saat kapal sedang berlabuh pada malam hari, yaitu sebesar **361,962 kW** . untuk itu direncanakan memakai 3 unit generator yang sama, dengan masing – masing **200 kW**, dimana salah satu dari tiga generator tersebut disiapkan sebagai generotor cadangan atau sebagai auxellary generator.

Dari hasil perkiraan perhitungan diatas, maka dipilih GEN-SET dengan data – data sebagai berikut :

Merk	**YANMAR**
Model	**6HAL2-HTN**
Type	**Vertical 4-cycle**
Daya	**200 kW**
Putaran	**1.500 rpm**
Bore & Stroke	**130 mm x 165 mm**
Frekwensi	**50 Hz**
Power Factor	**0,8**
Combastion	**DI (Direct Injection)**

TABEL ANALISA BEBAN GENERATOR

No	NAMA ALAT	DAYA			BERLABUH				BONGKAR MUAT				BERLAYAR				MANUVER			
					SIANG		MALAM		SIANG		MALAM		SIANG		MALAM		SIANG		MALAM	
		Watt	jml	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW
1	Steering Engine	28,467	2	56,934	-	-	-	-	-	-	-	-	0.8	45,547	0.8	45,547	1	56,934	1	56,934
2	Windlass	44,000	1	44	0.8	35.2	0.8	35.2	-	-	-	-	-	-	-	-	1	44	1	44
3	Capstan	8,581	1	8,581	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Cooling S.W.Pump	5,400	2	10.8	-	-	-	-	0.8	8.64	0.8	8.64	0.8	8.64	0.8	8.64	1	10.8	1	10.8
5	S.W.Serv.Pp(for refre)	5,400	1	5,4	-	-	-	-	0.8	4,32	0.8	4,32	0.8	4,32	0.8	4,32	1	5,4	1	5,4
6	Fire & GS.Pump	9,340	1	9.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Cool.S.W.Pp(for D/G)	1,000	2	2	-	-	-	-	0,8	1.6	0,8	1.6	0,8	1.6	0,8	1.6	1	2	1	2
8	D.O Purifier	1,500	1	1,5	-	-	-	-	0.4	0,6	-	-	0,2	0,3	0,2	0,3	1	1,5	1	1,5
9	Main Compressor	9,000	2	18	-	-	-	-	0,8	14,4	0,8	14,4	0,8	14,4	0,8	14,4	1	18	1	18
10	Emerg. Main air comp.	1,800	1	1,8	-	-	-	-	0.4	0,72	0.4	0,72	0,8	1,44	0,8	1,44	1	1,8	1	1,8
11	Electric welder	8.000	1	8,0	-	-	-	-	0,8	6,4	0,8	6,4	0,8	6,4	0,8	6,4	-	-	-	-
12	Incinerator	6,000	1	6	-	-	-	-	0,8	4,8	0,8	4,8	0,8	4,8	0,8	4,8	-	-	-	-
13	Grinder	1.150	1	1.15	-	-	-	-	0,4	0,46	0,8	0,92	0,8	0,92	0,8	0,92	-	-	-	-
14	Main L.O.Pump	7,100	2	14,2	-	-	-	-	0,6	8,52	0,6	8,52	0,8	11,36	0,8	11,36	1	14,2	1	14,2
15	L.O.Trans.Pump	1,150	1	1.15	-	-	-	-	0.8	0,92	0.8	0,92	0.8	0,92	0.8	0.92	1	1.15	1	1.15
16	D.O.Serv.Pump	0.102	2	0.204	-	-	-	-	0.8	0,163	0.8	0,163	0.8	0,163	0.8	0.163	1	0.204	1	0.204
17	L.O.Purifier	7,500	1	7,5	-	-	-	-	0.8	6	0.8	6	0.8	6	0.8	6	1	7,5	1	7,5
18	Cargo Oil Pump	28,500	2	57	-	-	-	-	0.8	45,6	0.8	45,6	0.8	45,6	0.8	45,6	1	57	1	57
19	Cargo Winches	13,600	2	27,2	-	-	-	-	0.8	21,76	0.8	21,76	-	-	-	-	-	-	-	-
20	Ballast Pump	1,460	1	1,46	0.4	0,584	0.4	0,584	0.6	0,876	0.6	0,876	0.8	1,168	0.8	1,168	1	1,46	1	1,46
21	DO Transfer Pump	1,280	1	2.56	-	-	-	-	0.8	1,024	0.8	1,024	0.8	1,024	0.8	1,024	1	2.56	1	1,28
22	Sanitary S.W pump	2,040	2	4.08	-	-	-	-	0.8	3,264	0.8	3,264	0.8	3,264	0.8	3,264	1	4.08	1	4.08
23	Oily Water Separator	2,500	1	2,5	-	-	-	-	0.8	2	0.8	2	0.8	2	0.8	2	1	4,3	1	4,3
24	Lathe Machine	3.800	1	3,8	-	-	-	-	0.9	3,42	0,9	3,42	0,9	3,42	0,9	3,42	1	3,8	1	3,8
25	Jacket Cool F.W.Pump	6,250	2	12.5	-	-	-	-	0,8	10	0,8	10	0,8	10	0,8	10	1	12.5	1	12.5
26	Stripping Pump	17,000	2	34	-	-	-	-	0.8	27,2	0.8	27,2	0.8	27,2	0.8	27,2	1	34	1	34
27	Tank Cleaning Pump	37,000	1	37	-	-	-	-	0.8	29,6	0.8	29,6	0.8	29,6	0.8	29,6	1	37	1	37
28	Hot W.Circ.Pump	102	1	0,102	-	-	-	-	0,8	0,082	0,8	0,082	0,8	0,082	0,8	0,082	1	1,3	1	1,3
29	Bilge Pump.	2,010	1	2,01	0.2	0,402	0.2	0,402	0,6	1,206	0.6	1,206	0,8	1,608	0,8	1,608	1	2,01	1	2,01
30	Drill	1.050	1	1,15	0,2	0,23	0,2	0,23	0,6	0,69	0,6	0,69	0,2	0,23	0,2	0,23	-	-	-	-
31	Cargo Pp RM Ex.Fan	1.675	1	1,6	0,2	0,32	0,2	0,32	0,4	0,64	0,4	0,64	0,2	0,32	0,2	0,32	-	-	-	-
32	Drink W.sterilizer	0,500	1	0,5	0,2	0,1	0,2	0,1	0,2	0,1	-	-	-	-	0,5	0.25	-	-	-	-
33	Boat winch	3.000	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	Emergency Fire Pump	11,000	1	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No	NAMA ALAT	DAYA			BERLABUH				BONGKAR MUAT				BERLAYAR				MANUVER			
					SIANG		MALAM		SIANG		MALAM		SIANG		MALAM		SIANG		MALAM	
		Watt	jml	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW
35	San & Dom.FW Pp	652	2	1.304	0.8	1,043	0.8	1,043	0.8	1,043	0.8	1,043	0.8	1,043	0.8	1,043	1	1,043	1	1,043
36	Sewage Pump	220	2	0.44	0.8	0,176	0.8	0,176	0.8	0,176	0.8	0,176	-	-	-	-	-	-	-	-
37	Exhaust Fan	450	3	1.35	0.4	0.54	0.4	0.54	0.8	1.08	0.8	1.08	0.8	1.08	0.8	1.08	1	1.35	1	1.35
38	Supply Fan	350	3	1.05	0.4	0.42	0.4	0.42	0.8	0.84	0.8	0.84	0.8	0.84	0.8	0.84	1	1.05	1	1.05
39	Cold Storage	11.500	1	11.5	0.6	6.9	0.6	6.9	0.6	6.9	0.6	6.9	0.6	6.9	0.6	6.9	0.6	6.9	0.6	6.9
40	Stern Light	80	1	0.08	-	-	-	-	-	-	0.8	0.064	-	-	0.8	0.064	0.8	0.064	0.8	0.064
41	N.U.C.L	120	1	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	Wheel House	120	2	0.24	-	-	0.8	0.192	-	-	0.4	0.096	-	-	0.8	0.192	0.8	0.192	0.8	0.192
43	Radio Room	40	2	0.08	-	-	0.4	0.032	-	-	0.8	0.064	-	-	0.6	0.048	0.6	0.048	0.6	0.048
44	Radio Officer	40	2	0.08	-	-	0.8	0.064	-	-	0.8	0.064	-	-	0.8	0.064	0.8	0.064	0.8	0.064
45	Morse Lamp	80	1	0.08	-	-	-	-	-	-	0.4	0.032	-	-	0.4	0.032	-	-	-	-
46	Chart Room	40	-	0.04	-	-	0.2	0.008	-	-	0.2	0.008	-	-	0.2	0.008	-	-	0.2	0.008
47	Pilot	40	-	0.04	0.4	0.016	0.6	0.024	0.4	0.016	0.8	0.032	0.4	0.016	0.8	.0.032	0.4	0.016	0.8	0.032
48	KM/ WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
49	Pilot	40	-	0.04	0.4	0.016	0.6	0.024	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032
50	KM/ WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
51	Owner Room	40	-	0.04	0.4	0.024	0.6	0.024	0.4	0.016	0.8	0.024	0.4	0.016	0.8	0.024	0.4	0.016	0.8	0.024
52	KM/ WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
53	Office	60	-	0.06	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048
54	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
55	Bed Room	40	-	0.04	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032
56	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
57	Office	60	-	0.06	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048
58	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
59	Hospital	60	-	0.06	-	-	0.6	0.036	-	-	0.6	0.036	-	-	0.6	0.036	-	-	0.6	0.036
60	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
61	Storage	40	-	0.04	-	-	0.4	0.016	-	-	0.4	0.016	-	-	0.4	0.016	-	-	0.4	0.016
62	Laundry & Dry Room	40	-	0.04	0.2	0.008	0.6	0.024	0.2	0.008	0.6	0.024	0.2	0.008	0.6	0.024	0.2	0.008	0.6	0.024
63	Corridor	60	-	0.06	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036
64	Office	60	-	0.06	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048
65	Chief Officer	40	-	0.04	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032
66	Chief Engineer	40	-	0.04	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032
67	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
68	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008

No	NAMA ALAT	DAYA			BERLABUH				BONGKAR MUAT				BERLAYAR				MANUVER			
					SIANG		MALAM		SIANG		MALAM		SIANG		MALAM		SIANG		MALAM	
		Watt	jml	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW
69	Corridor	60	-	0.06	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036	0.6	0.036
70	I.Officer	40	-	0.04	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032
71	II.Officer	40	-	0.04	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032
72	I.Engineer	40	-	0.04	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032
73	II.Engineer	40	-	0.04	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032
74	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
75	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
76	Pantry	60	-	0.06	0.2	0.012	0.6	0.036	0.2	0.012	0.6	0.036	0.2	0.012	0.6	0.036	0.2	0.012	0.6	0.036
77	Galley	40	-	0.04	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032	0.2	0.008	0.8	0.032
78	Crew Mess	80	-	0.08	0.4	0.032	0.8	0.064	0.4	0.032	0.8	0.064	0.4	0.032	0.8	0.064	0.4	0.032	0.8	0.064
79	Kamar-kamar	480	-	0.48	0.4	0.192	0.6	0.288	0.4	0.192	0.6	0.288	0.4	0.192	0.6	0.288	0.4	0.192	0.6	0.288
80	Stew Officer	40	-	0.04	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032	0.4	0.016	0.8	0.032
81	Deck Store	40	-	0.04	-	-	0.4	0.016	-	-	0.4	0.016	-	-	0.4	0.016	-	-	0.4	0.016
82	Officer Mess	80	-	0.08	0.4	0.032	0.8	0.064	0.4	0.032	0.8	0.064	0.4	0.032	0.8	0.064	0.4	0.032	0.8	0.064
83	Corridor	40	-	0.04	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024	0.6	0.024
84	Pantry	60	-	0.06	0.2	0.012	0.6	0.036	0.2	0.012	0.6	0.036	0.2	0.012	0.6	0.036	0.2	0.012	0.6	0.036
85	Galley	60	-	0.06	0.2	0.012	0.8	0.048	0.2	0.012	0.8	0.048	0.2	0.012	0.8	0.048	0.2	0.012	0.8	0.048
86	Suitcases Room	40	-	0.04	0.2	0.008	0.4	0.016	0.2	0.008	0.4	0.016	0.2	0.008	0.4	0.016	0.2	0.008	0.4	0.016
87	Electric Room	40	-	0.04	0.4	0.016	0.6	0.024	0.4	0.016	0.6	0.024	0.4	0.016	0.6	0.024	0.4	0.016	0.6	0.024
88	Bay Room	40	-	0.04	0.2	0.008	0.6	0.024	0.2	0.008	0.6	0.024	0.2	0.008	0.6	0.024	0.2	0.008	0.6	0.024
89	Officer	60	-	0.06	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048
90	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
91	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
92	Lampu2 di km mesin	500	-	0.5	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4
93	Officer	60	-	0.06	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048	0.4	0.024	0.8	0.048
94	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
95	KM/WC	20	-	0.02	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008	0.2	0.004	0.4	0.008
96	Lampu2 di km mesin	500	-	0.5	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4
97	Red Light	200	1	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98	Boat Deck Light	200	2	0.4	-	-	0.2	0.08	-	-	0.6	0.24	-	-	0.6	0.24	-	-	0.6	0.24
99	Day Light Sign. Lamp	200	1	0.2	-	-	0.2	0.04	-	-	0.6	0.12	-	-	0.6	0.12	-	-	0.6	0.12
100	Cargo Light	400	4	1.6	-	-	0.8	1.28	-	-	-	-	-	-	0.4	0.64	-	-	0.4	0.64
101	Flood Light	200	1	0.2	-	-	0.8	0.16	-	-	-	-	-	-	0.4	0.08	-	-	0.4	0.08
102	Berth Light	400	4	1.6	-	-	0.8	1.28	-	-	-	-	-	-	0.8	1.28	-	-	0.8	1.28
103	Search Light	1000	1	1	-	-	-	-	-	-	0.6	0.6	-	-	0.8	0.8	-	-	0.8	0.8
104	Lampu Peta	60	1	0.06	-	-	-	-	-	-	0.8	0.48	-	-	0.6	0.36	-	-	0.6	0.36

	NAMA ALAT	DAYA			BERLABUH				BONGKAR MUAT				BERLAYAR				MANUVER			
					SIANG		MALAM		SIANG		MALAM		SIANG		MALAM		SIANG		MALAM	
		Watt	jml	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW	pf	kW
105	Compass	1000	1	1	-	-	-	-	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
106	Flood Light	200	1	0.2	-	-	0.8	0.16	-	-	-	-	-	-	0.4	0.08	-	-	0.4	0.08
107	Berth Light	400	4	1.6	-	-	0.8	1.28	-	-	-	-	-	-	0.8	1.28	-	-	0.8	1.28
108	Search Light	1000	1	1	-	-	-	-	-	-	0.6	0.6	-	-	0.8	0.8	-	-	0.8	0.8
109	Lampu Peta	60	1	0.06	-	-	-	-	-	-	0.8	0.48	-	-	0.6	0.36	-	-	0.6	0.36
110	Compass	1000	1	1	-	-	-	-	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
111	Radio	1000	1	1	0.6	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
112	Radar	3000	1	4	0.4	1.6	0.4	1.6	0.8	3.2	0.8	3.2	0.8	3.2	0.8	3.2	0.8	3.2	0.8	3.2
113	Telephone System	1000	1	1	0.4	0.4	0.4	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
114	Battery Charger	10000	1	10	0.4	4	0.4	4	0.4	4	0.4	4	0.4	4	0.4	4	0.4	4	0.4	4
115	Air Conditioner	12000	1	12	0.6	7.2	0.6	7.2	0.8	9.6	0.8	9.6	0.8	9.6	0.8	9.6	0.8	9.6	0.8	9.6
116	Peralatan Bengkel	3000	-	3	0.4	1.2	0.4	1.2	0.4	1.2	0.4	1.2	-	-	-	-	-	-	-	-
117	Peralatan Dapur	1000	-	1	0.6	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Jumlah						**63,061**		**68,399**		**238,57**		**241,97**		**264,12**		**127,61**		**355,12**		**361,962**

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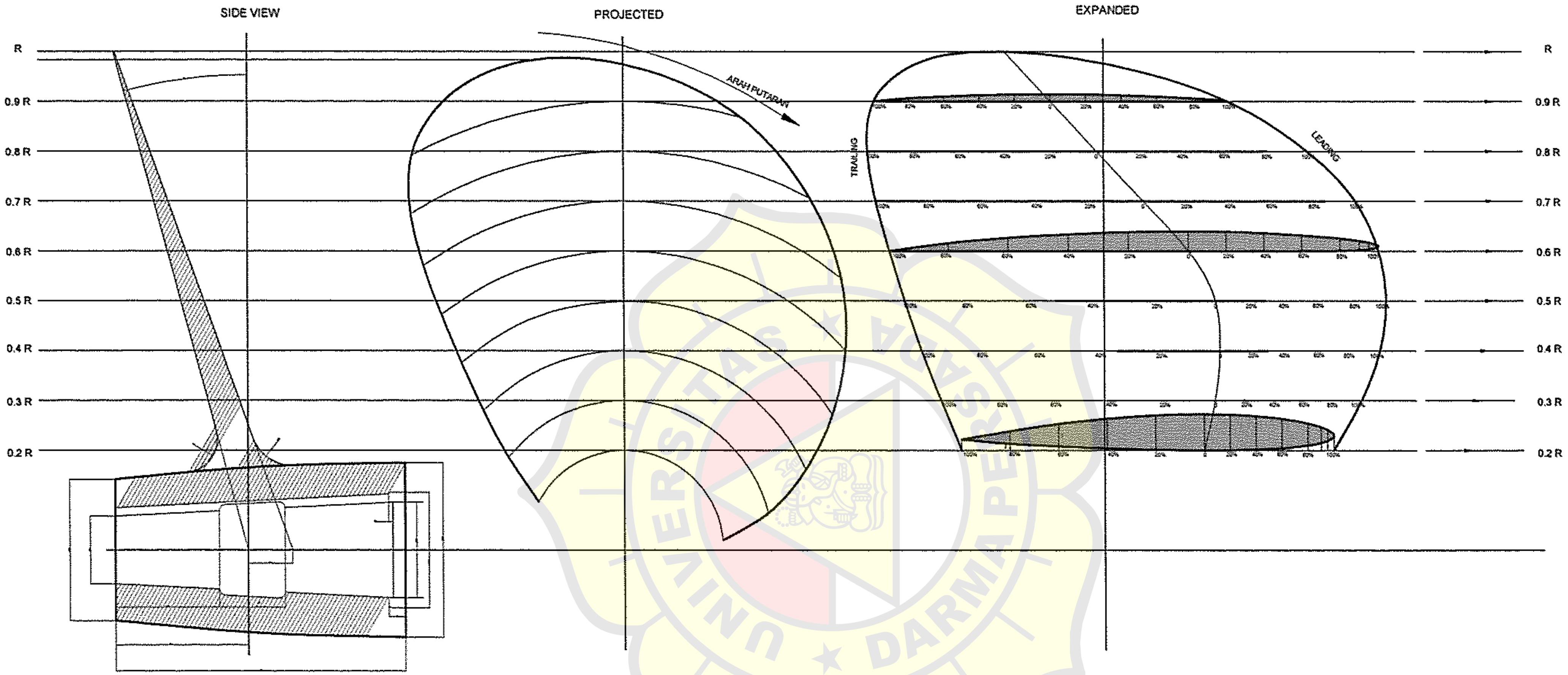
LAMPIRAN



UKURAN UTAMA :

PANJANG SELURUHNYA (Loa) = 105.00 m
PANJANG A.G.T. (Lpp) = 99.30 m
LEBAR (B) = 18.80 m
TINGGI (H) = 9.80 m
SARAT (T) = 6.00 m

UKURAN BALING - BALING :

DIAMETER = 4.2 m
PITCH = 1124mm pada 0.67 R
DAUN = 4 BUAH
Ae/Ao = 0.90
RAKE = 15°

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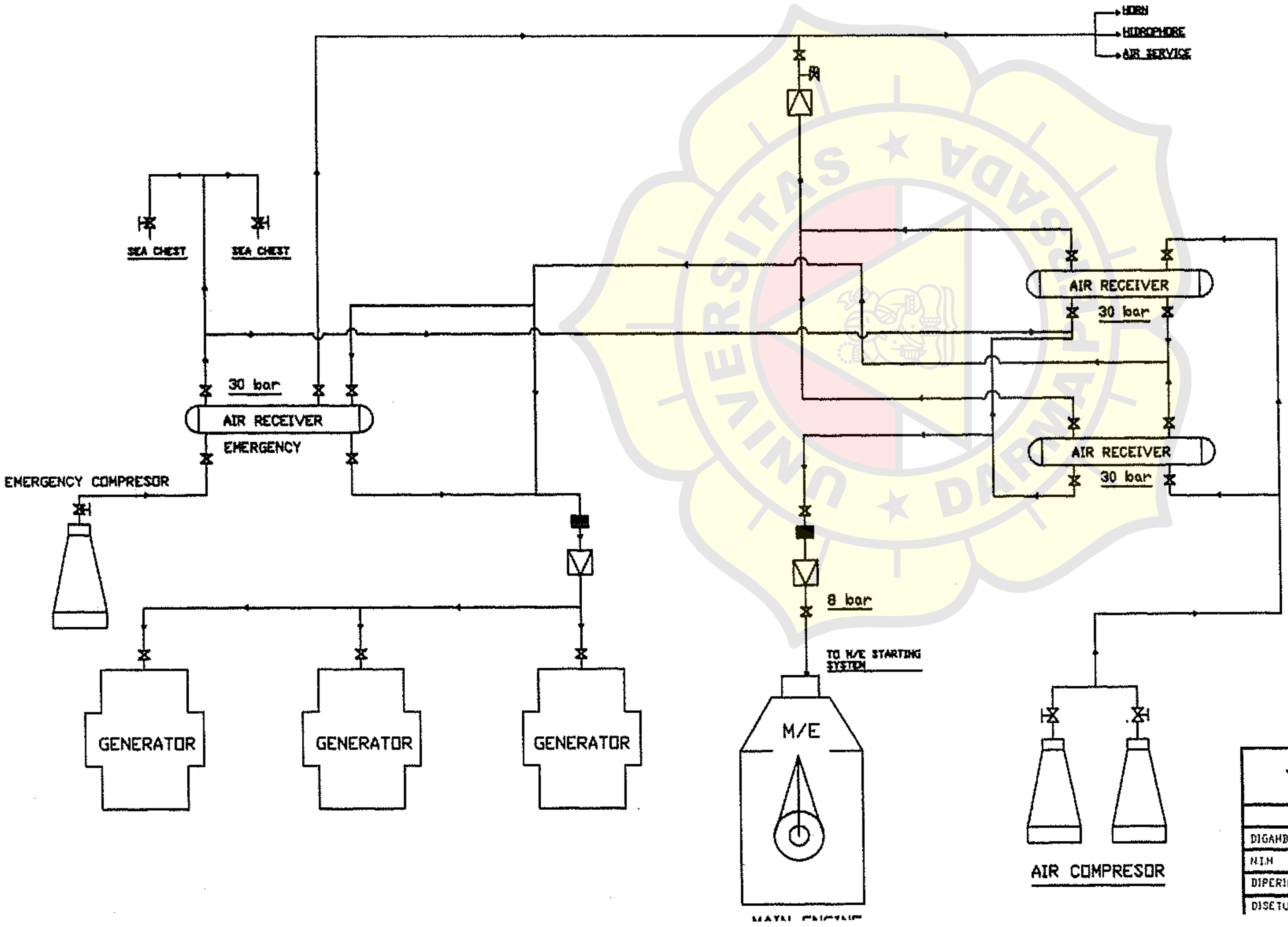
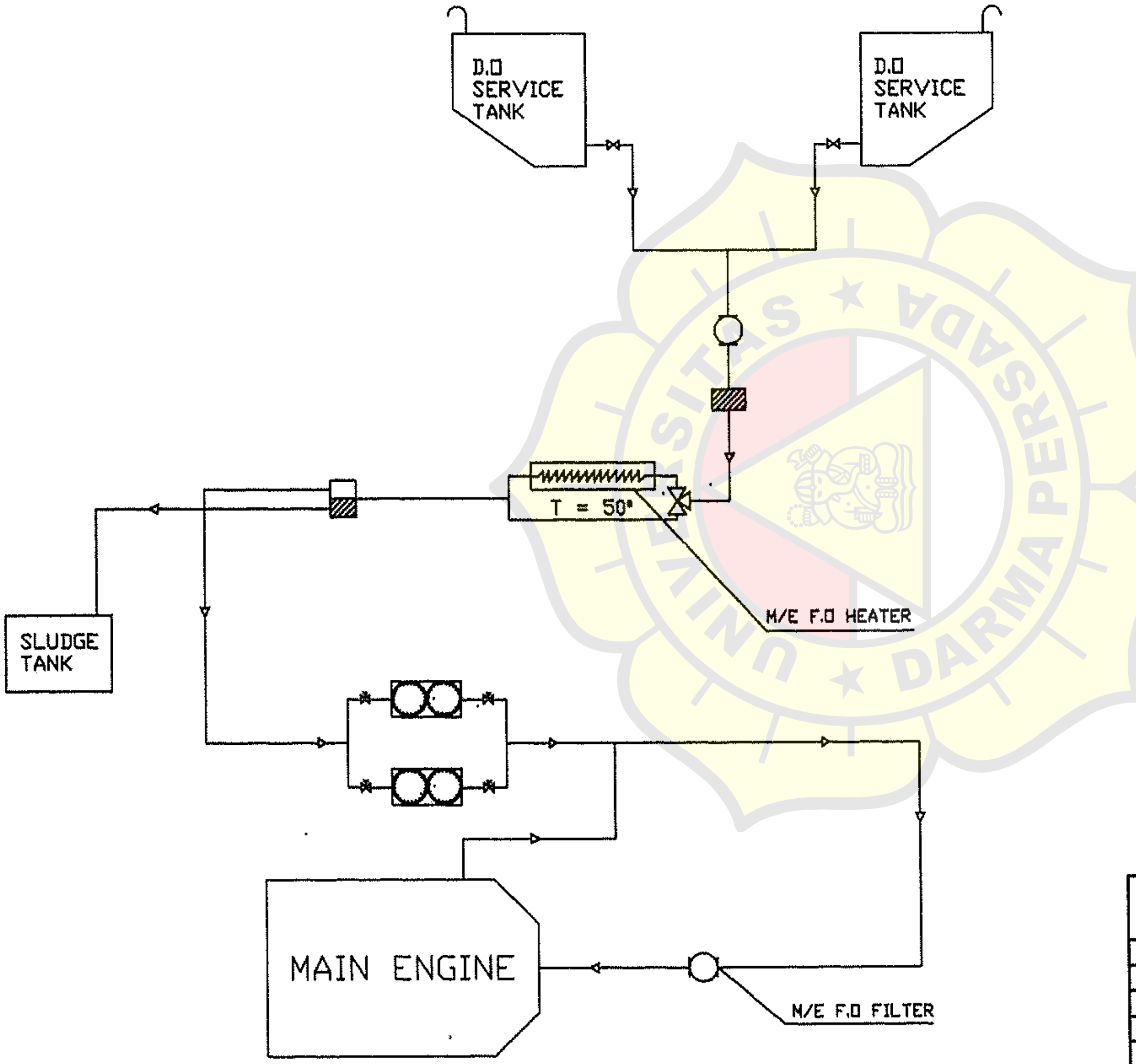
BALING - BALING
TANKER 6500 DWT



LEGENDA	
SYMBOL	NAME
⋈	STOP VALVE
⋈	STOP GLOBE VALVE
⊠	REDUCING
■	STRAINER

JURUSAN TEKNIK SISTEM PERKAPALAN
FAKULTAS TEKNOLOGI KELAUTAN
UNIVERSITAS DARMA PERSADA

		TGL	PARAF	KET.
DIGAMBAR	ILHAN ANDRI YANUAR			
NIM	03320001			
DIPERIKSA	Ir. ENDRO PRABOWO, MSc	30-07-09		
DISETUJUI	Ir. ENDRO PRABOWO, MSc	30-07-09		



LEGENDA	
SYMBOL	NAME
⌶	FILTER
▨	STRAINER
⋈	THREE WAY VALVE
⋈	STOP VALVE
⋈	STOP GLOBE VALVE
∞	PUMP (2 KW)

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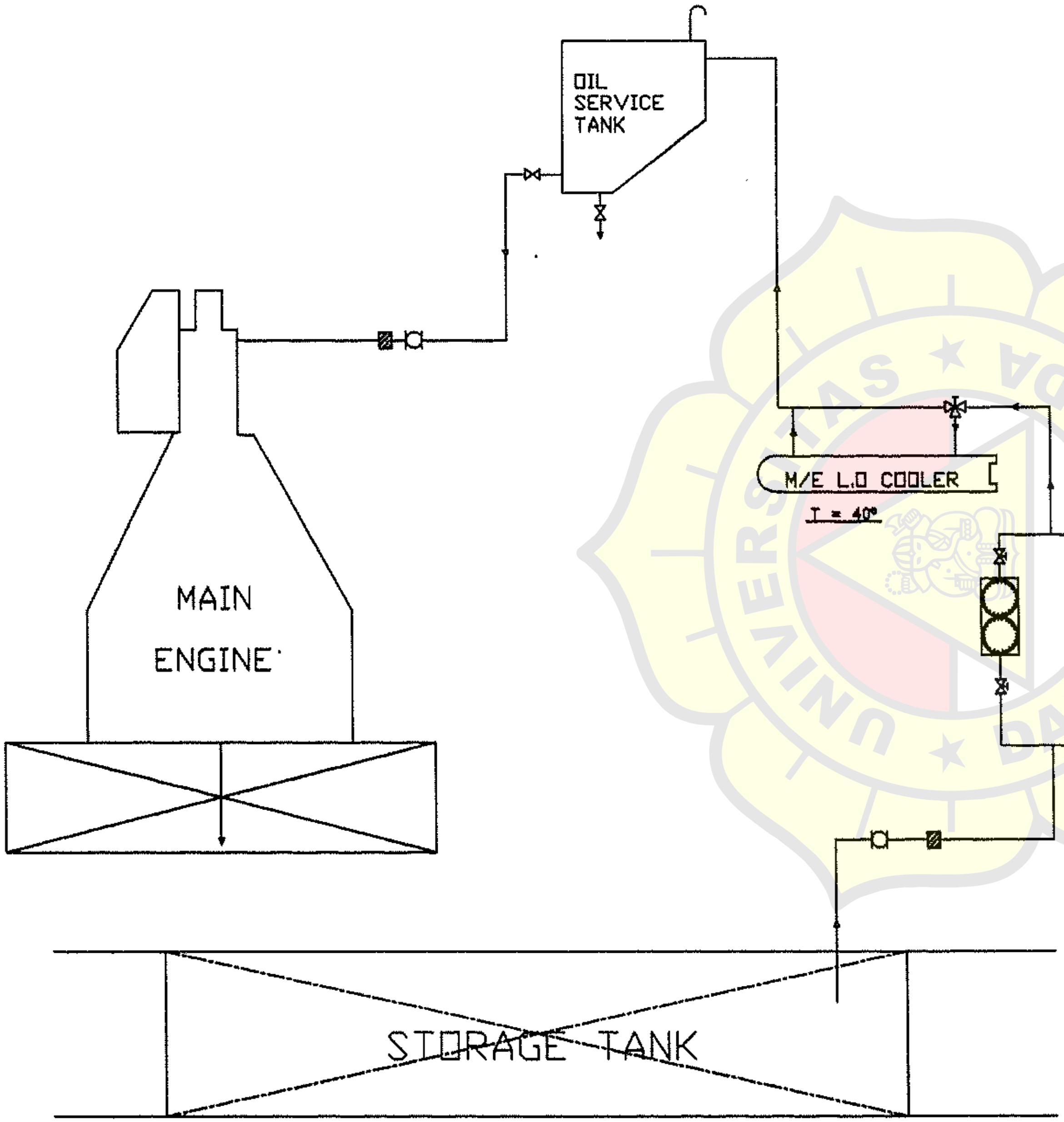
		TGL	PARAF
DIGAMBAR	ILHAM ANDRI YANUAR		
N.I.M	03320001		
DIPERIKSA	Ir. ENDRO PRABOWO, M.Sc	03-06-09	
DISETUJUI	Ir. ENDRO PRABOWO, M.Sc	05-06-0	

FUEL OIL SYSTEM



LEGENDA	
SYMBOL	NAME
✱	THREE WAY VALVE
◘	FILTER
◯◯	PUMP (6 KW)
▨	STRAINER
⋈	STOP VALVE
╭	AIR PIPE VENT
⧓	GLOBE VALVE

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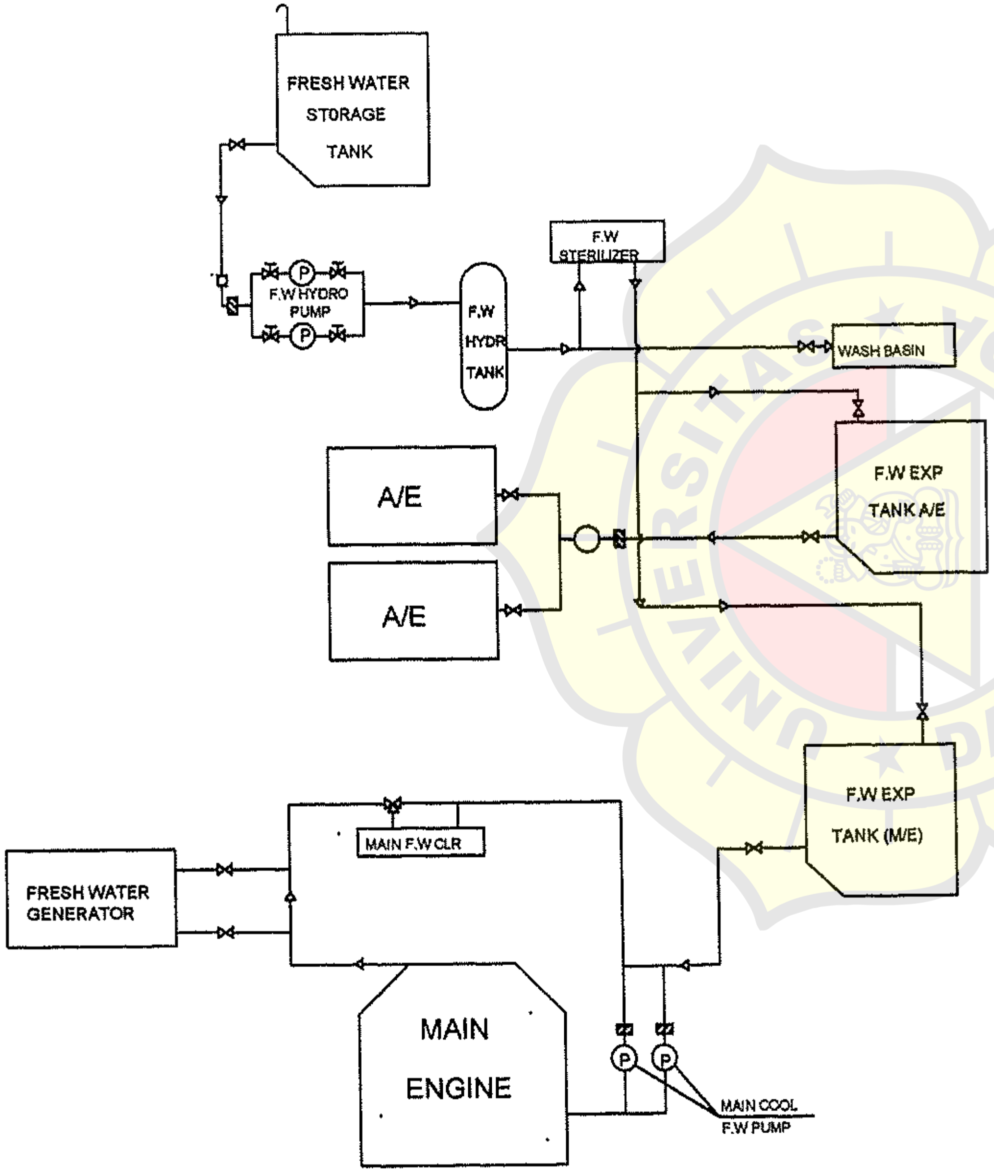
FAKULTAS TEKNOLOGI KELAUTAN
UNIVERSITAS DARMA PERSADA

		TGL	PARAF
DIGAMBAR	ILHAM ANDRI YANUAR		
N.I.M	03320001		
DIPERIKSA	Ir. ENDRO PRABOWO, M.Sc	03-06-09	
DISETUJUI	Ir. ENDRO PRABOWO, M.Sc	03-06-09	



LEGENDA	
SYMBOL	NAME
▨	STRAINER
╮	AIR VENT PIPE
⋈	STOP VALVE
Ω	FILTER
Ⓟ	PUMP (12 KW)
⋈	STOP GLOBE VALVE

JURUSAN TEKNIK SISTEM PERKAPALAN
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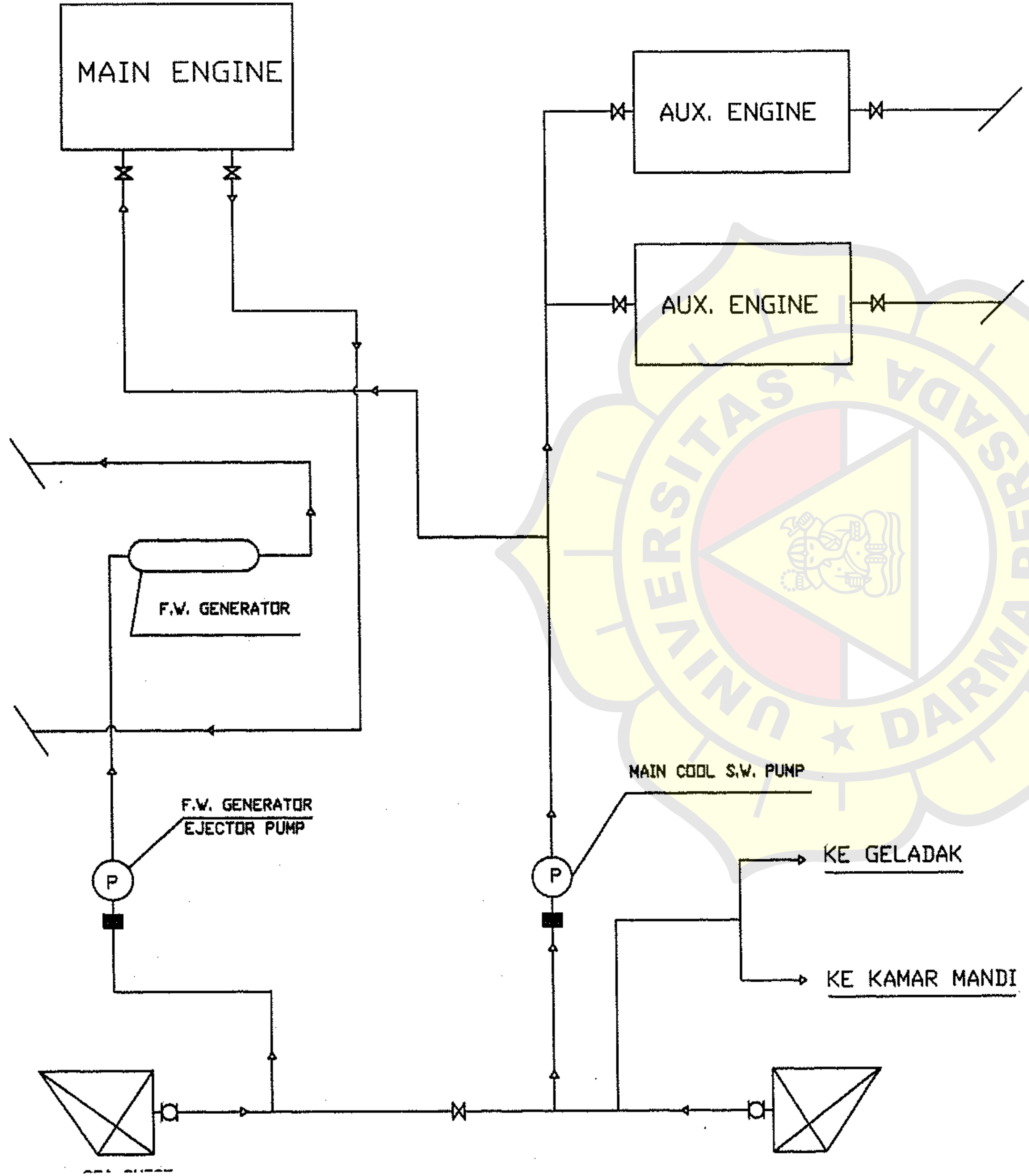
UNIVERSITAS DARMA PERSADA

		TGL	PARAF
DIGAMBAR	ILHAM ANDRI YANUAR		
N.I.M	03320001		
DIPERIKSA	Ir. ENDRO PRABOWO, M.Sc	03-06-09	
DISETUJUI	Ir. ENDRO PRABOWO, M.Sc	03-06-09	

FRESH WATER SYSTEM

TANKER 6500 DWT



LEGENDA

SYMBOL	NAME
⋈	STOP VALVE
■	STRAINER
Ⓟ	PUMP
◘	FILTER

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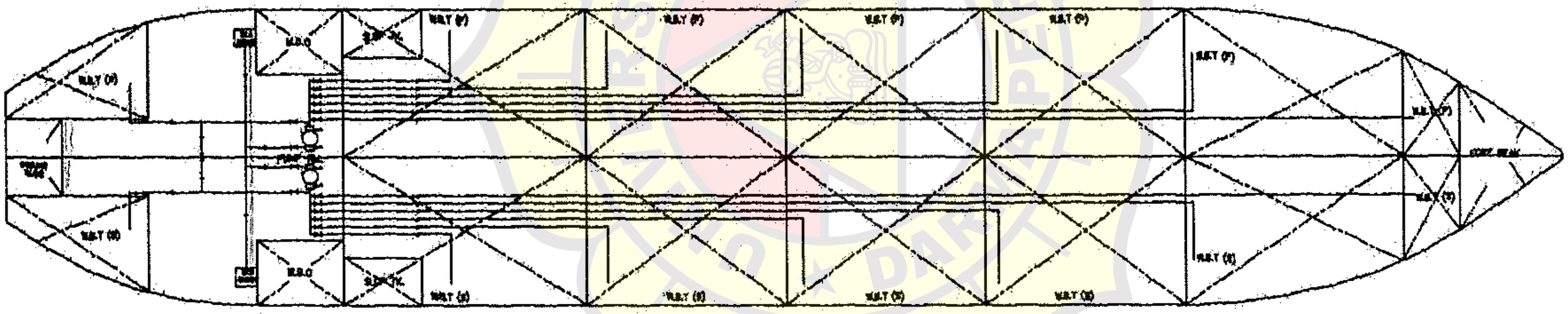
UNIVERSITAS DARMA PERSADA

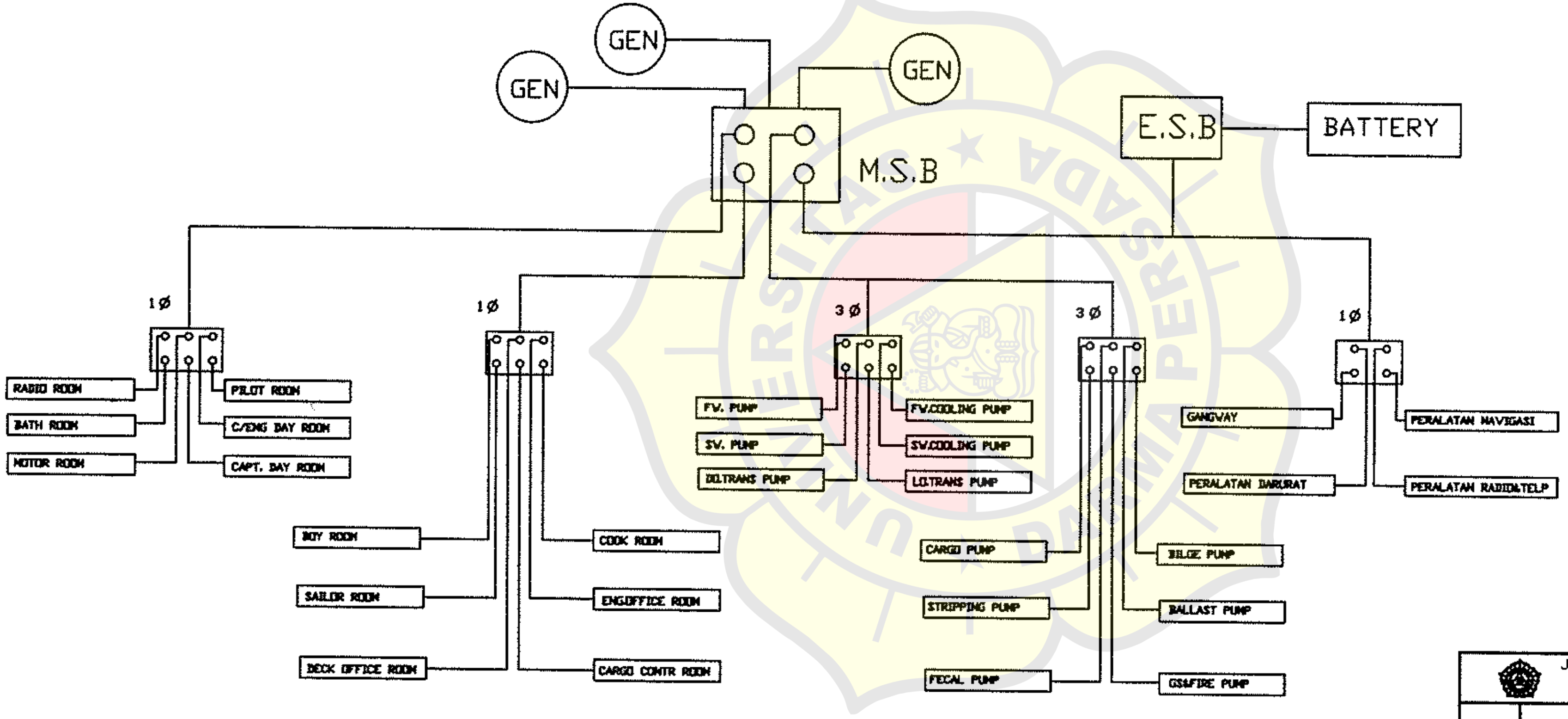
		TGL	PARAF	KET.
DIGAMBAR	ILHAM ANDRI YANUAR			
N.I.M	03320001			



JURUSAN TEKNIK SISTEM PERKAPALAN
FAKULTAS TEKNOLOGI KELAUTAN
UNIVERSITAS DARMA PERSADA

		TGL	PARAF
DIGAMBAR	ILHAM ANDRI YANUAR		
N.I.M	03320001		
DIPERIKSA	Ir. ENDRO PRABOWO, M.Sc	13-06-09	
DISETUJUI	Ir. ENDRO PRABOWO, M.Sc	03-06-09	

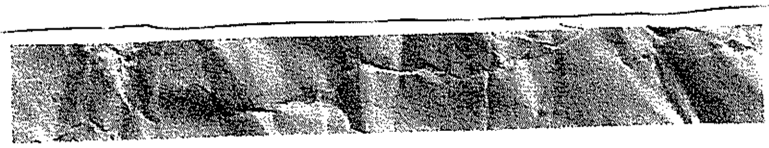
BALLAST SYSTEM



JURUSAN TEKNIK SISTEM PERKAPALAN
FAKULTAS TEKNOLOGI KELAUTAN
UNIVERSITAS DARMA PERSADA

		TGL.	PARAF	KET.
DIGAMBAR	ILHAM ANDRI YANUAR			
NIM	03320001			
DIPERIKSA	Ir. ENDRO PRABOVO, MSc	9-9-09		
DISETUJUI	Ir. ENDRO PRABOVO, MSc	9-9-09		

ELECTRICAL BLOK DIAGRAM



WÄRTSILÄ 26

Main data

Cylinder bore ....260 mm
Piston stroke...320 mm
Cylinder output..................325, 340 kW/cyl
Speed...900, 1000 rpm
Mean effective pressure........24.0, 25.5 bar
Piston speed...........................9.6, 10.7 m/s

Fuel specification:
Fuel oil ....730 cSt/50 °C
7200 sR1/100 °F
ISO 8217, category ISO-F-RMK 700
SFOC 182–184 g/kWh
at ISO condition

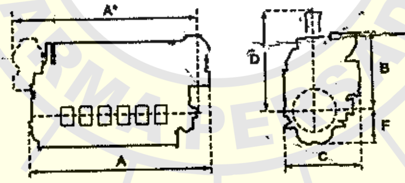
Rated power

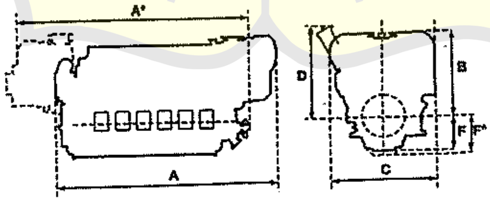
Engine type	900 rpm 325 kW/cyl kW	bhp	1000 rpm 340 kW/cyl kW	bhp
6L26	1 950 ✓	2 650 ✓	2 040	2 775
8L26	2 600	3 535	2 720	3 700
9L26	2 925	3 975	3 060	4 160
12V26	3 900	5 300	4 080	5 545
16V26	5 200	7 070	5 440	7 395

Dimensions (mm) and weights (tonnes)

Engine type	A*	A	B*	B	C*	C	D	F dry sump	F wet sump	Weight dry sump	Weight wet sump
6L26	4 258	4 110	1 881	1 802	1 912	1 883	2 430	818	950	18.4	16.9
8L26	5 117	4 890	2 019	1 825	1 912	1 979	2 430	818	950	22.9	21.0
9L26	5 507	5 280	2 019	1 825	1 912	1 979	2 430	818	950	24.8	22.7
12V26	5 218	4 968	2 074	2 074	2 453	2 453	2 060	800	1 110	29.2	31.9
16V26	6 223	5 973	2 151	2 151	2 469	2 489	2 060	800	1 110	33.0	36.5

*Turbocharger at flywheel end.
For definitions see page 61.

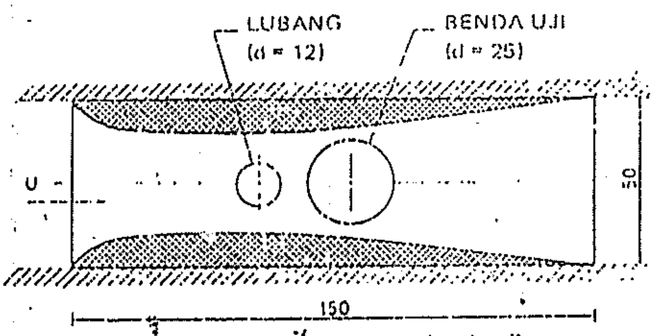




LAMPIRAN 1

Banyak percobaan yang telah dilakukan untuk membandingkan tahanan relatif dari berbagai bahan dengan kerusakan akibat erosi. Diperkenalkan konsep kekuatan erosi (erosion strength). Konsep ini telah berhasil dipakai sekalipun cara penyaluran energi ke bahan sangat beraneka ragam. Cukup banyak pula upaya yang telah dilakukan untuk mencari hubungan antara beberapa sifat mekanis bahan baling-baling yang dapat langsung diukur dengan kemampuan bahan tersebut dalam menahan kerusakan akibat erosi, dengan percobaan kavitasi, tubrukan (impingement), atau lainnya. Dalam pelaksanaan pengujian, erosi pada benda uji di dalam fluida dapat ditimbulkan dengan jalan menggetarkan benda tersebut, misalnya, seperti yang diajukan dalam "Standard Method of Vibratory Cavitation Erosion Test". (Metode Standar untuk Pengujian Kavitasi dengan Gerakan) (ASTM, 1972).

Pengujian demikian itu dapat dilakukan di tempat yang mempunyai fasilitas untuk foil yang berputar, di tempat yang mempunyai aparatus untuk diskus yang berputar (Dashnaw dan kawan-kawan, 1980), atau di terusan aliran air dengan sirkulasi tertutup (Hansson dan Mørch, 1977). Bagian pengujian dari fasilitas tersebut mempunyai alat pemegang benda uji (specimen holder). Di alat ini benda akan diuji disisipkan demikian rupa sehingga merupakan bagian dari dinding induk (central wall) yang mulus. Gambar 6.6.6 menunjukkan sebuah alat pemegang benda uji. Aliran melewati ke dua sisi dinding tersebut secara simetris. Sebuah lubang di dalam dinding tersebut akan menimbulkan rongga kavitasi di dekat benda di dalam aliran yang menuju ke benda (upstream). Dengan mengatur tekanan dalam rentang tekanan kempis dan kecepatan aliran maka rongga tersebut akan mengempis di dekat permukaan benda uji. Salah satu cara untuk mengalibrasi berbagai keadaan kerusakan akibat kavitasi adalah dengan memakai aloi nikel yang kekuatan dan kekerasannya ditentukan lebih dulu sebagai bahan standar. Secara umum dapat diperhatikan bahwa semakin keras, kuat, dan kaku (modulusnya besar) material itu semakin tahan terhadap kerusakan akibat erosi.



Gambar 6.6.6: Pemegang benda uji.

Untuk dapat memperkirakan erosi baling-baling dengan cara yang dapat diandalkan maka telah dikembangkan suatu cara yang disebut teknik "permukaan lunak" (soft surface). Karena erosi kavitasi menjadi cepat ketika mencapai intensitas kritis maka pemakaian lapisan permukaan (coating) yang lunak yang intensitasnya pada model yang dipakai disesuaikan dengan skala model itu akan dapat memberikan kriteria yang memuaskan. Permukaan yang dipakai untuk model baling-baling dapat bervariasi dari aloi aluminium anoda dan timah lunak murni hingga tinta yang dipakai dalam rekayasa untuk membuat cetakan biru, tinta stensil, dan tinta bolpoin. Proses erosi pada permukaan yang dibuat dari bahan metal dapat memakan waktu beberapa hari, sedangkan pengujian dengan memakai lapisan dari tinta stensil akan dapat diselesaikan dalam waktu 5 menit saja. Metode permukaan lunak dengan waktu uji yang tepat terbukti memberikan petunjuk mengenai erosi pada skala penuh (benda yang sebenarnya) yang dapat dipercaya, dan memberikan perkiraan letak erosi yang lebih tepat daripada yang diperkirakan berdasarkan metode visual.

Badan kapal mendapatkan eksitasi dari baling-baling terutama dalam dua cara : (1) Beban daun baling-baling yang tidak tunak dapat disalurkan ke badan kapal melalui poros (gaya bantalan = bearing forces) dan (2) medan tekanan yang mengikuti kisaran daun baling-baling disalurkan melalui air ke badan kapal, menyebabkan timbulnya tekanan getar pada pelat badan kapal (gaya permukaan = surface forces). Hasil percobaan menunjukkan bahwa dalam kondisi tidak ada kavitasi kedua jenis gaya tersebut mempunyai besaran yang hampir sama. Karena adanya kavitasi tak tunak yang ekstensif pada baling-baling sebagian besar kapal niaga maka gaya permukaan umumnya beberapa kali lebih besar daripada gaya bantalan. Dengan demikian maka besarnya gaya permukaan sebagian besar ditentukan oleh perilaku kavitasi yang ada pada baling-baling yang bersangkutan. Jika akan menentukan gaya ini dengan percobaan model maka percobaan tersebut harus dilakukan di tempat yang mempunyai fasilitas demikian rupa sehingga model baling-baling tersebut akan bekerja dan mengalami kavitasi di dalam medan arus ikut dengan kondisi yang sedapat mungkin sama dengan kondisi yang sebenarnya. Jenis fasilitas berikut ini dapat dipakai untuk pengujian demikian itu :

1. Terowongan kavitasi konvensional (lihat Gb. 3.3.1*B*); medan arus ikut ditimbulkan dengan memakai beberapa model badan belakang (model tiruan = dummy models) yang dikombinasikan dengan jala.

2. Terowongan kavitasi yang tempat (ruang) ujinya mempunyai panjang dan luas yang dapat menampung model yang lengkap yang diperlukan untuk menimbulkan medan arus ikut (lihat Gb. 3.3.1*C*).
3. Fasilitas yang dapat dipakai untuk melakukan pengujian di permukaan air bebas (lihat Gb. 3.3.1*D* dan Gb. 3.3.1*G*).

Fluktuasi tekanan dapat diukur dengan transduser tekanan yang dipasang rata dengan permukaan badan kapal. Transduser tersebut dibuat dalam bentuk silinder dengan garis tengah sekitar 20 mm dan tinggi sekitar 15 mm. Perpindahan relatif antara inti ferit (ferrite core) yang dipasang pada membran dengan kumparan yang dipasang di dalam tempat transduser diukur dengan memakai jembatan elektris.

Jika bukan getaran tetapi bunyi akibat kavitasi yang merupakan obyek yang dikehendaki maka transduser tekanan tersebut diganti dengan hidropon (hydrophone). Dalam hal ini skala merupakan masalah yang sangat rumit, dan harus dipakai beberapa anggapan. Sebagai anggapan dasar adalah pola kavitasi pada model dan pola kavitasi dalam skala penuh keduanya memenuhi kesamaan geometris. Anggapan ini mempunyai pengertian bahwa jari-jari masing-masing gelembung berbanding lurus dengan faktor skala. Selain itu, lingkup daerah meluasnya gelembung kavitasi dan distribusi ukuran relatifnya yang timbul pada model dianggap sama dengan yang timbul pada skala penuh. Dari anggapan itu maka banyaknya gelembung yang timbul pada daun model baling-baling pada suatu posisi sudut dianggap sama dengan banyaknya gelembung yang timbul pada daun baling-baling yang sebenarnya pada posisi itu. Berikut ini akan dibahas lebih lanjut mengenai masalah itu.

6.6.5. Prosedur Uji Model di dalam Terowongan Kavitasi.

Beberapa fasilitas yang dapat dipakai untuk melakukan uji kavitasi dengan memakai model dibahas di Bab 3, 3.2. Pengujian kavitasi harus dilakukan demikian rupa sehingga semua gaya spesifik (seperti misalnya gaya dorong dan gaya torsi) yang bekerja pada model mirip dengan yang bekerja pada obyek dalam skala penuh. Karena itu syarat berikut ini harus dipenuhi :

1. Kesamaan geometris.
2. Kesamaan kinematis.
3. Kesamaan dinamis.

Menurut butir 1 maka model tersebut harus merupakan obyek yang sebenarnya yang diperkecil dalam suatu skala. Secara umum model baling-baling hampir merupakan jiplakan dari baling-baling yang sebenarnya. Begitu pula halnya dengan badan kapal, tetapi karena terbatasnya ukuran terowongan kavitasi atau fasilitas maka kondisi lingkungan di sekeliling model skala tidak dapat sama seperti kondisi lingkungan sebenarnya yang diperkecil dalam skala itu. Pasti akan ada masalah mengenai permukaan bebas dan akan ada pengaruh dinding terowongan. Contohnya, gelombang tekanan yang ditimbulkan oleh masing-masing rongga kavitasi akan dipantulkan dari dinding terowongan. Dengan demikian maka sinyal yang dicatat oleh transduser pada badan model adalah jumlah dari sinyal dari gelombang tekanan yang ditimbulkan langsung oleh rongga kavitasi dengan sinyal dari gelombang tekanan yang dipantulkan dari dinding terowongan. Agar sinyal dari gelombang tekanan yang dipantulkan dari dinding demikian itu dapat dikontrol maka kondisi pemantulan dari dinding terowongan harus diperhitungkan dalam prosedur kalibrasi.

Kesamaan kinematis (butir 2) akan terpenuhi jika kecepatan pada sisi model dan kecepatan pada sisi obyek yang sebenarnya semuanya mempunyai arah yang sama. Maka

$$\frac{V_{Am}}{n_m D_m} = \frac{V_{As}}{n_s D_s} \qquad (6.6.11)$$

$$J_m = J_s \qquad (6.6.12)$$

$$V_{Am} = \frac{n_n}{n_s} \frac{V_{As}}{\lambda} \qquad (6.6.13)$$

V_A adalah kecepatan maju baling-baling, n laju kisaran, D garis tengah baling-baling, J angka maju, dan rasio skala. Huruf m dan s yang ditulis di bawah masing-masing menunjukkan bahwa kuantitas tersebut berlaku untuk model dan untuk kapal. Ini juga berarti bahwa distribusi arus ikut pada model skala harus seperti distribusi arus ikut di belakang buritan baling-baling pada kapal yang sebenarnya. Medan arus ikut dapat ditimbulkan dengan memakai model kapal yang lengkap yang diletakkan di dalam tempat uji di terowongan kavitasi atau dengan memakai sejumlah model badan belakang yang dikombinasikan dengan memakai jala.

Untuk kesamaan dinamis (butir 3) hukum Froude dan hukum Reynolds harus dipenuhi :

$$V_{Am} = \frac{V_{As}}{\sqrt{\lambda}} \text{ (hukum Froude)} \qquad (6.6.14)$$

$$V_{Am} = V_{As}\lambda \text{ (hukum Reynolds)} \qquad (6.6.15)$$

a dalam percobaan model terjadi kavitasi maka amaan dinamis tersebut juga mensyaratkan agar (a) utan kesamaan angka kavitasi, (b) hukum Weber, ı (c) pengaruh kandungan udara di dalam air pada omena kavitasi, harus pula diperhitungkan.

Untuk butir (a) diperlukan, antara model dan al, fenomena kavitasi yang sama dan resiko kavitasi ıg sama. Fenomena kavitasi yang sama berarti

$$\left(\frac{p - p_0}{\frac{1}{2}\rho U^2}\right)_m = \left(\frac{p - p_0}{\frac{1}{2}\rho U^2}\right)_s \qquad (6.6.16)$$

u

$$\frac{\Delta p_m}{q_m} = \frac{\Delta p_s}{q_s} \qquad (6.6.17)$$

n resiko kavitasi yang sama berarti

$$\left(\frac{p_0 - p_v}{q}\right)_m = \left(\frac{p_0 - p_v}{q}\right)_s \qquad (6.6.18)$$

u

$$\sigma_{vm} = \sigma_{vs} \qquad (6.6.19)$$

n ini menunjukkan bahwa angka kavitasi untuk odel harus sama dengan angka kavitasi untuk skala nuh. Simbol yang dipakai dalam Pers. (6.6.16) – 6.19) telah dijelaskan sebelumnya; juga lihat njelasan mengenai Pers. (6.6.1) – (6.6.9). Selanjutnya perlukan kesamaan dalam tegangan permukaan lembung kavitasi. Ini memerlukan kesamaan dalam gka Weber W untuk rongga yang serupa :

$$W = \frac{\rho U^2 l}{T} \qquad (6.6.20)$$

adalah tegangan permukaan, ρ massa jenis fluida, U cepatan, l panjang karakteristik, dapat berupa garis ngah gelembung. Dengan memakai yang disebut apilaritas kinematis (kinematic capilarity)

$$\kappa = \frac{T}{\rho} \qquad (6.6.21)$$

maka berdasarkan hukum Weber

$$U_m = U_s \sqrt{\frac{\kappa_m}{\kappa_s}} \sqrt{\lambda} \qquad (6.6.22)$$

U_m adalah kecepatan air di dalam tempat uji di terowongan kavitasi.

Jelas bahwa kelima syarat yang disebutkan tadi :

$$\begin{aligned}
&(6.6.13): \quad U_m = c_1 U_s \lambda^{1} && (J_m = J_s) \qquad (6.6.23)\\
&(6.6.14): \quad U_m = c_2 U_2 \lambda^{1/2} && \text{(Froude)}\\
&(6.6.15): \quad U_m = c_3 U_2 \lambda && \text{(Reynolds)}\\
&(6.6.19): \quad U_m = c_4 U_s && (\sigma_{vm} = \sigma_{vs})\\
&(6.6.22): \quad U_m = c_5 U_s \lambda^{1/2} && \text{(Weber)}
\end{aligned}$$

dalam pelaksanaan pengujian di terowongan kavitasi, tidak dapat dipenuhi secara serentak. U adalah kecepatan aliran pada profil baling-baling, λ rasio skala, dan $c_1 - c_5$ merupakan koefisien yang berbeda. Persamaan (6.6.13), kesamaan angka maju, harus selalu dipenuhi. Persamaan (6.6.19), kesamaan angka kavitasi, harus juga dipenuhi untuk menjamin adanya kesamaan dalam fenomena kavitasi. Umumnya hukum Froude diabaikan seperti halnya dalam uji baling-baling terbuka yang biasa.

Harga angka Reynolds tidak boleh terlalu rendah. Jika harga angka Reynolds rendah maka akan ada resiko bahwa sebagian besar dari baling-baling model yang bersangkutan akan mempunyai aliran laminar, sedangkan yang skala penuh akan mempunyai aliran turbulen. Harga angka Reynolds terendah yang dapat dipakai tidak dapat digunakan untuk mendapatkan suatu kriteria. Harga angka Reynolds yang diperlukan sangat tergantung pada jenis dan ukuran profil baling-baling dan juga pada medan arus ikut. Secara kasar dapat dikatakan bahwa baling-baling yang mempunyai garis tengah 200 – 250 mm sebaiknya dioperasikan pada laju kisaran yang tidak kurang dari 25 – 30 kisaran per detik, dan ini berarti angka Reynolds sebesar sekitar 10^6. Dalam hal ini angka Reynolds didefinisikan sebagai

$$R_n = \frac{C_{0,75R}\sqrt{V_A^2 + (0,75\ \pi n D)^2}}{\nu} \qquad (6.6.24)$$

$c_{0,75R}$ adalah lebar daun baling-baling pada $0,75R$, R jari-jari baling-baling, D garis tengah, n laju kisaran, V_A kecepatan maju baling-baling, dan ν koefisien viskositas kinematis.

Angka Reynolds juga dapat didefinisikan sebagai

$$R_n = 5,3 \frac{A_E/A_0}{Z} \frac{nD^2}{\nu} \qquad (6.6.25)$$

ersamaan ini memberikan harga angka Reynolds yang ampir sama dengan yang diberikan oleh Pers. (6.6.24). $_E$ adalah luas bentang daun baling-baling, A_0 luas skus, Z banyaknya daun baling-baling, dan n, D, serta seperti dalam Pers. (6.6.24).

Mengenai hukum Weber, sekalipun harga kritis ngka Reynolds dilampaui kecepatan dalam pelaksanaan rcobaan umumnya tidak akan cukup untuk dapat emenuhi hukum Weber tersebut. Selain itu, ındungan gas di dalam air yang berada di terowongan ıvitasi juga merupakan hal yang penting. Untuk endapatkan hasil pengamatan yang tepat mengenai nomena kavitasi air tersebut harus mempunyai ındungan gas yang sesuai.

Pada bagian atas terowongan terdapat kubah (dome) ng berisi air yang mempunyai permukaan bebas (lihat b. 3.3.2) dan udara di atas permukaan air di bawah rsebut dapat dipompa keluar dengan memakai pompa kum hingga dicapai tekanan statis di tengah model suai dengan yang dikehendaki. Setelah beberapa saat mudian kandungan gas di dalam air tersebut juga aktis akan tetap. Sebagai ukuran kandungan gas pakai rasio kandungan gas, yaitu rasio antara gas ırut dan tak larut) di dalam cairan yang diuji dengan ındungan gas di dalam cairan jenuh (saturated) pada hu dan tekanan standar

$$a_s = \frac{\alpha}{\alpha_s} \qquad (6.6.26)$$

ındungan gas di dalam cairan dapat dalam keadaan rut atau tak larut. Sebagaimana disebutkan di 6.6.1, val terjadinya kavitasi diduga ada kaitannya dengan s dalam keadaan tak larut yang dikandung di dalam (i. Agar di dalam air terdapat inti dalam jumlah yang kup untuk dapat mengawali terjadinya kavitasi dan enyebabkan kavitasi dapat tumbuh, kandungan gas dalam air tersebut harus melebihi harga batas tertentu nisalnya $a_s = 0,3$). Jika kandungan gas menjadi lebih ndah daripada harga batas tersebut maka pertumbuh- i dan tebal rongga kavitasi yang terjadi akan rkurang dan fluktuasi tekanan pada badan model ırangkali akan terlalu rendah.

Jika percobaan dilakukan di terowongan kavitasi ng tempat ujinya mempunyai panjang dan luas yang pat menampung model yang lengkap maka dapat harapkan bahwa harga fluktuasi tekanan yang dicatat ri hasil percobaan tersebut akan lebih tepat daripada hasil yang dicatat dari terowongan yang lebih kecil. Selain itu, jika medan arus ikut seluruhnya hanya ditimbulkan oleh badan model saja tanpa kontribusi dari jala maka dapat diharapkan bahwa interferensi antara baling-baling dan badan kapal yang penting yang dihasilkan dengan cara itu adalah benar.

Fasilitas yang mempunyai permukaan bebas seperti terowongan jenis D dan G (Gb. 3.3.1) dapat diharapkan memberikan keuntungan tambahan sebagai berikut :

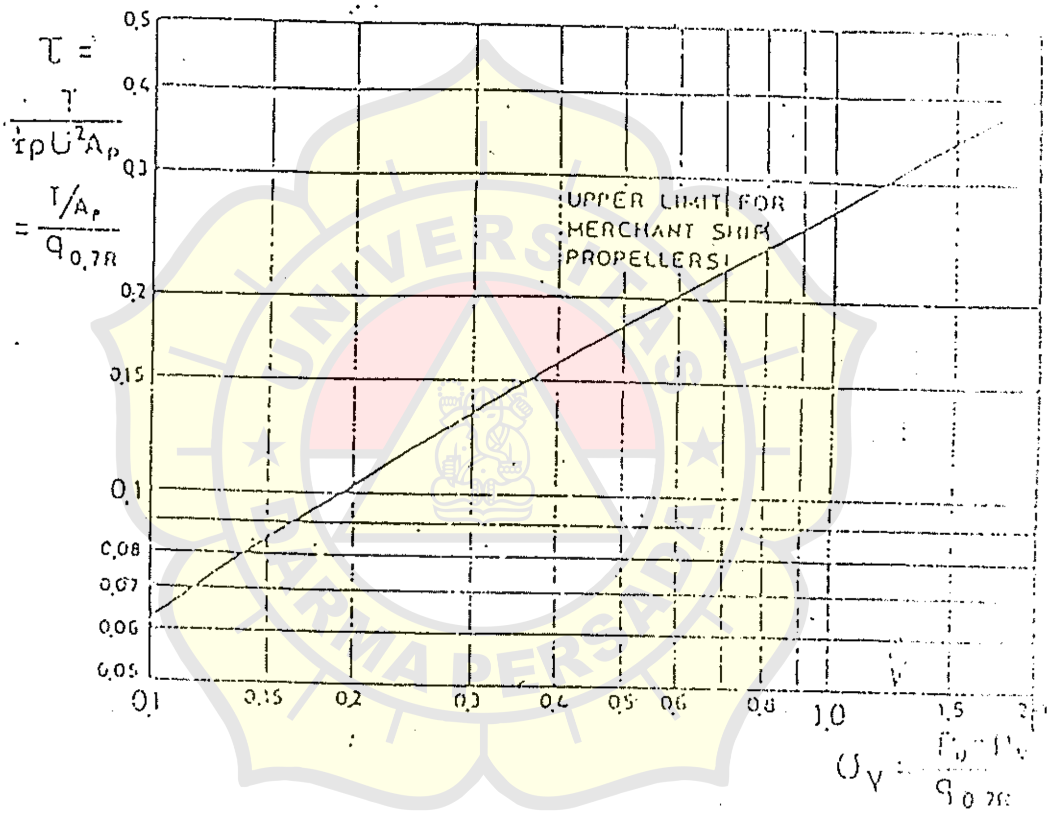
1. Distribusi arus ikut yang dihasilkan agak lebih baik daripada yang dihasilkan di fasilitas tanpa permukaan bebas.
2. Percobaan dengan kondisi balas, yaitu baling-baling berada didekat permukaan air, dapat dilakukan.

Di lain pihak pemakaian fasilitas dengan permukaan bebas tersebut juga memberikan kerugian :

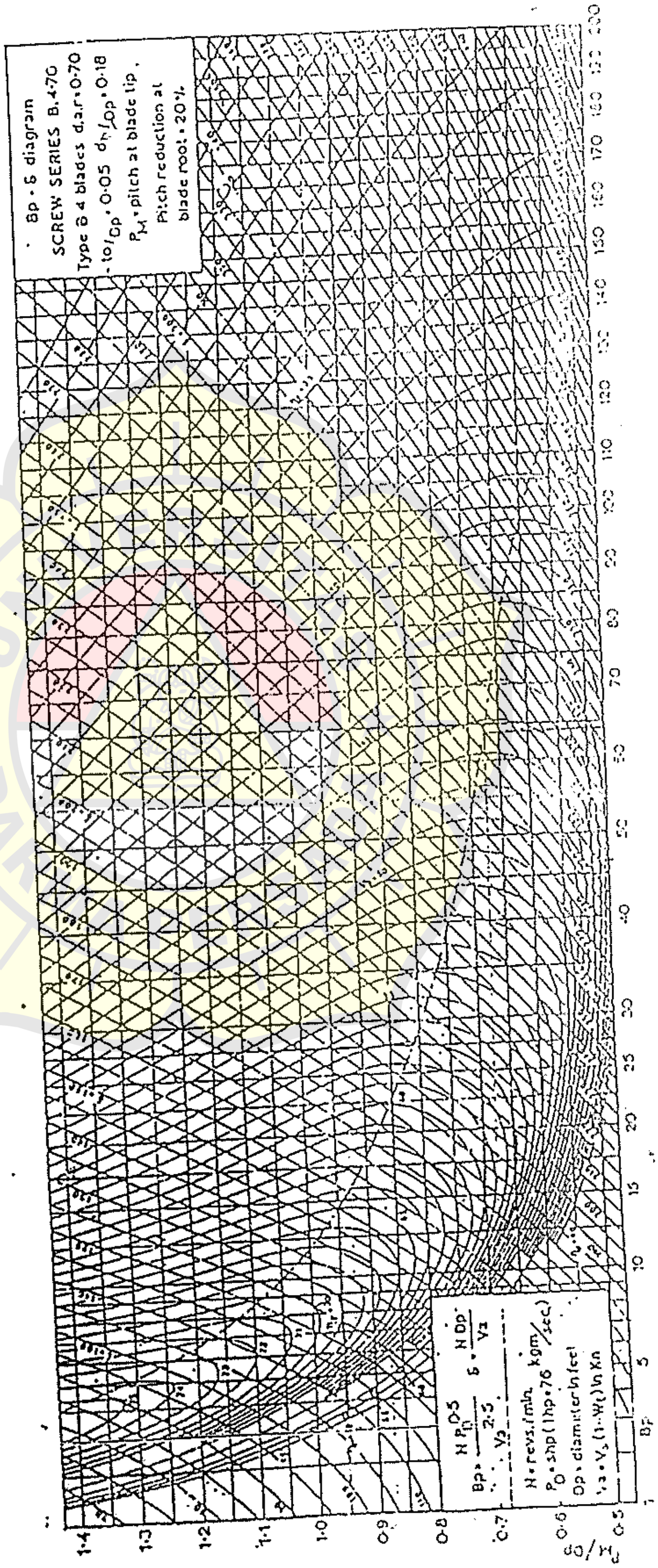
1. Karena adanya permukaan bebas maka kecepatan model harus sesuai dengan hukum Froude. Ini berarti bahwa kecepatan aliran akan agak rendah (1 – 3 m/detik). Agar dapat membuat angka kavitasi yang benar diperlukan tekanan statis yang sangat rendah di dalam terowongan kavitasi. Tekanan rendah ini dapat menyulitkan pengadaan inti dalam jumlah yang cukup atau spektrum inti yang sesuai untuk dapat menghasilkan bentuk kavitasi yang "benar." Untuk mengatasi kesulitan ini maka inti harus diadakan secara rekaan, misalnya dengan memasukkan udara ke dalam air atau dengan cara eletroklisa.
2. Keterbatasan kecepatan berarti rendahnya angka Reynolds. Ini akan menyebabkan tidak sesuainya pola kavitasi yang dihasilkan di terowongan dengan pola kavitasi dalam skala penuh. Masalah ini dapat diatasi sebagian dengan memakai model kapal yang lebih besar daripada yang umumnya dipakai ditangki percobaan (12 m dibandingkan dengan 6 – 8 m).

Dalam hal tertentu terowongan kavitasi harus dikalibrasi. Melalui the International Towing Tank Conference (ITTC) telah dilakukan pembandingan hasil percobaan dari berbagai terowongan. Dengan begitu maka masing-masing laboratorium dapat memeriksa ketepatan fasilitasnya. Beberapa laboratorium membandingkan foto yang diambil dari uji kavitasi dengan foto erosi baling-baling kapal yang diamati dalam pengedokan. Ini merupakan cara yang baik sekali untuk mengalibrasi terowongan kavitasi. Pemotretan kavitasi pada skala penuh dan pada model yang diambil dengan kecepatan tinggi juga dapat menghasilkan informasi yang berguna.

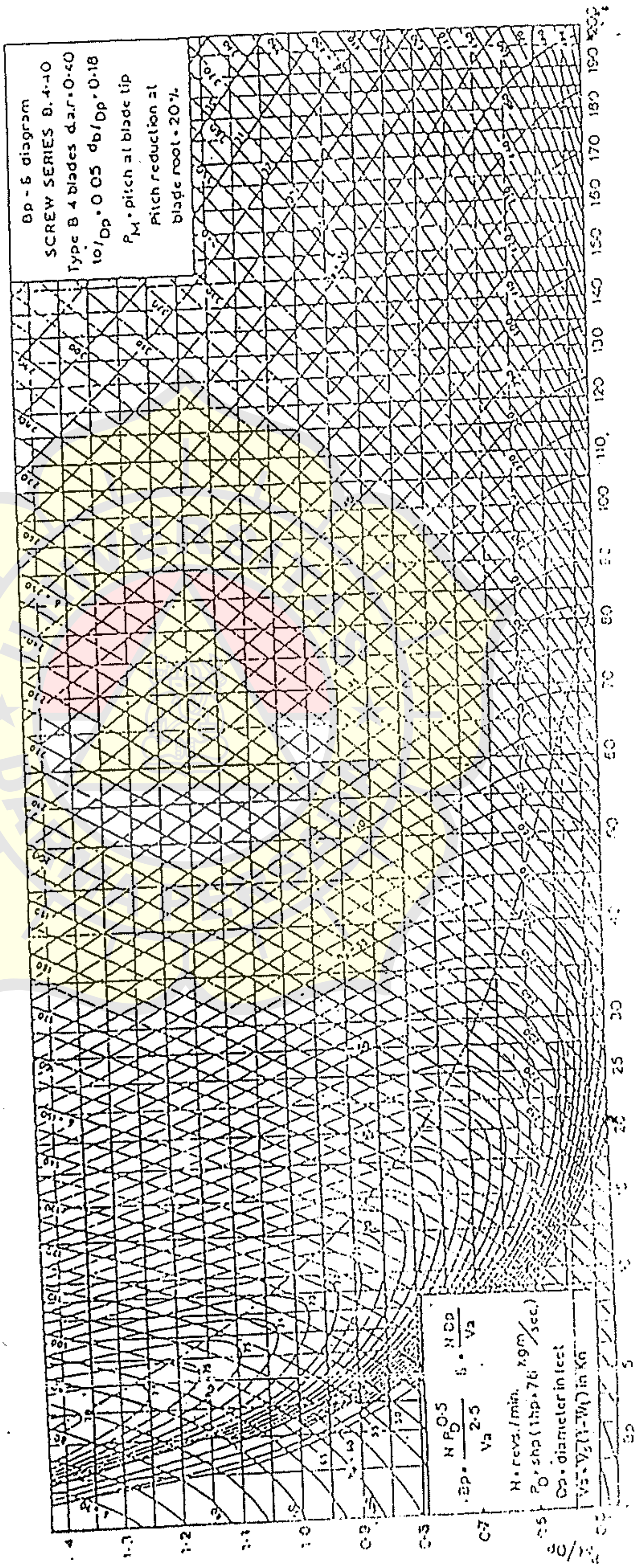
GRAFIK BURRIL



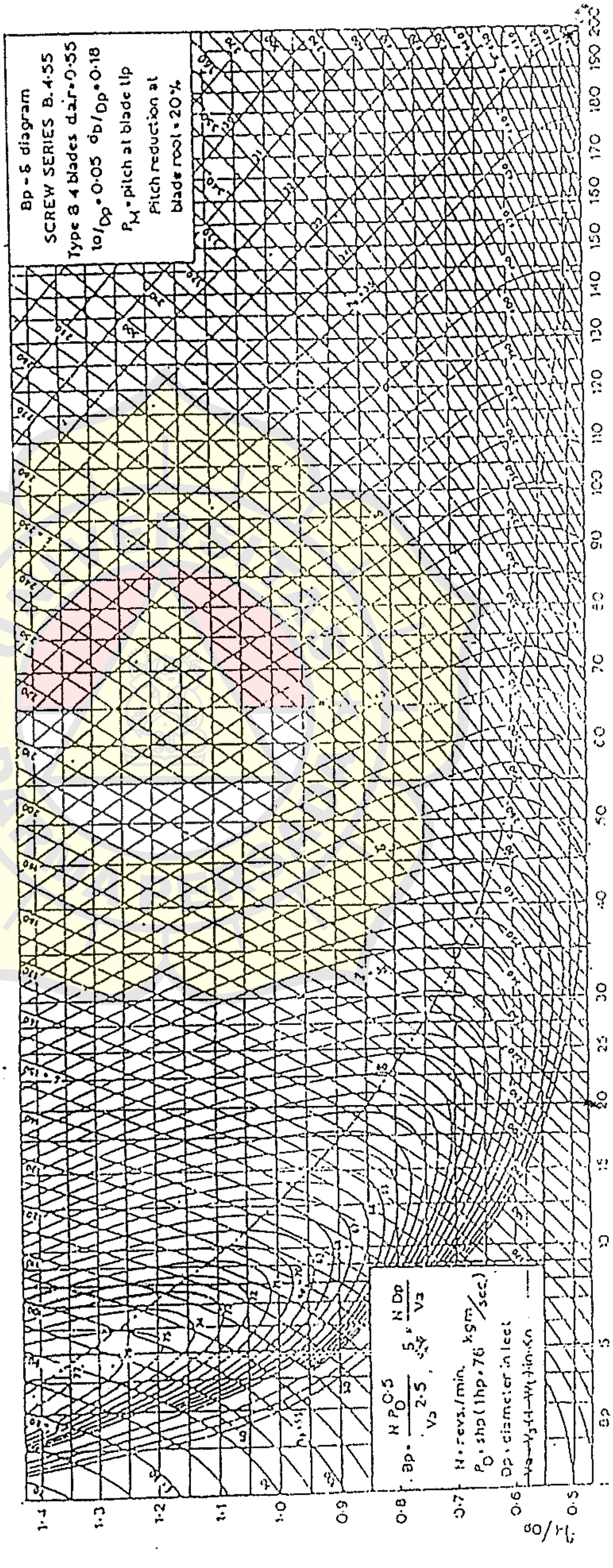
Lampiran 18. Diagram Bp – δ – Series B4-70



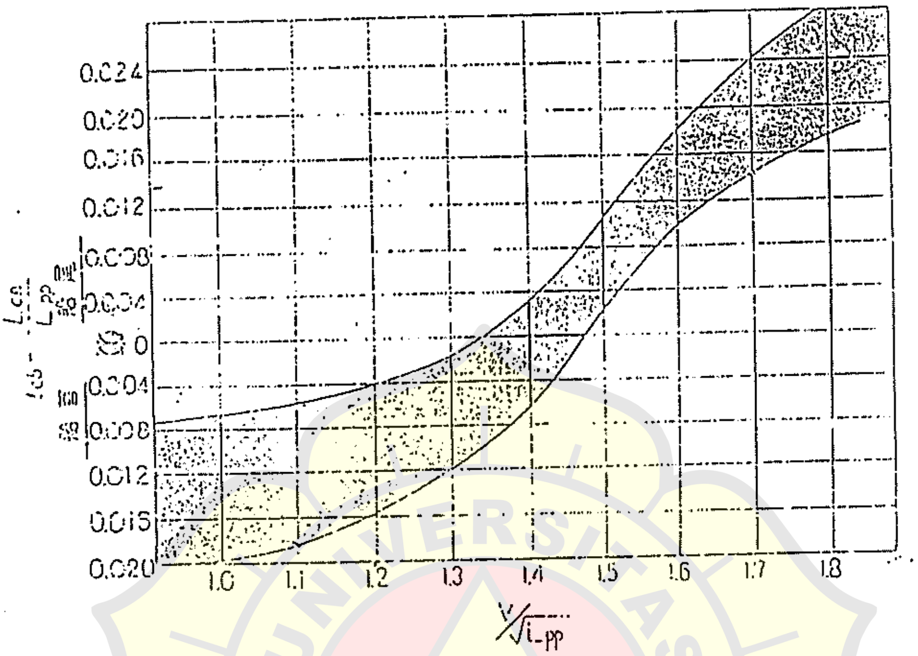
Lampiran 16. Diagram Bp -- δ -- Series B4-40



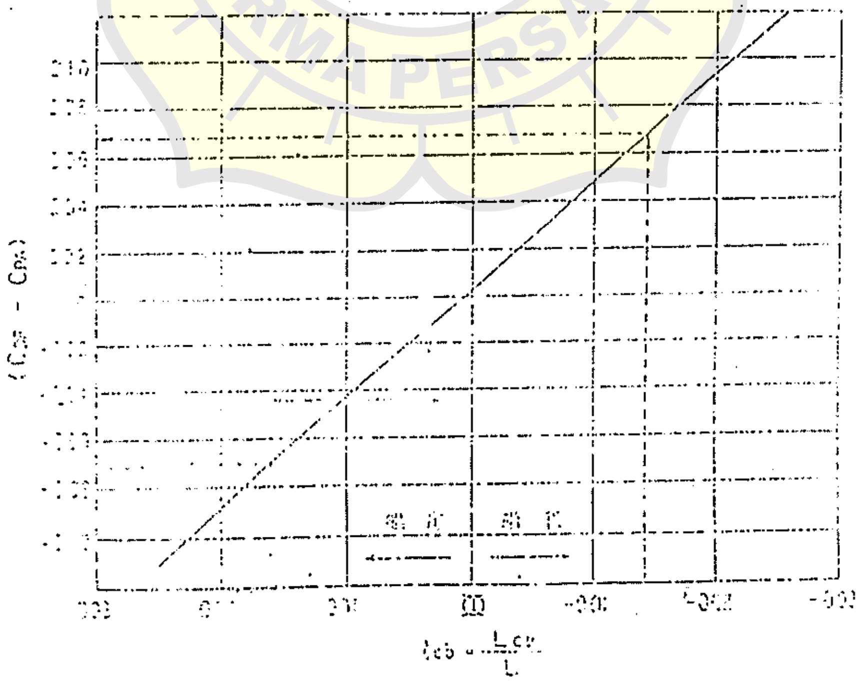
Lampiran 17. Diagram Bp – δ Series B4-55



Lampiran 3. Diagram untuk menentukan letak LCB



Lampiran 4. Diagram untuk menetukan koefisien depan dan belakang (Cpf - Cpa)



LAMPIRAN 4

LAAL

Engine output
243~669 kW (330~910 PS)

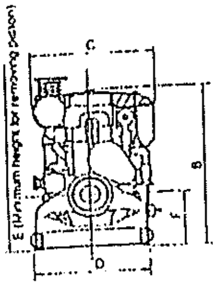
Specifications

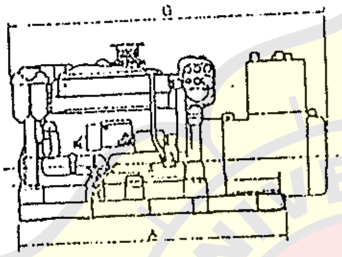
Engine model		6LAAL-DTN	6LAAL-UTN			12LAAL-DTN		12LAAL-UTN	
No. of cylinders		6				V12			
Cylinder bore × stroke	mm	148×165				148×165			
Continuous rated output	kW (PS)	243 (330)	265 (360)	309 (420)	353 (480)	530 (720)	618 (840)	574 (780)	669 (910)
Engine speed	rpm	1200	1200	1500	1800	1500	1800	1500	1800
Generator capacity	kW	220	240	280	320	480	560	520	600
Starting system		Electric starting (Air-motor starting is available.)				Electric starting (Air-motor starting is available.)			
Dry weight	kg	1990	2050			3660		3680	

The engine dry weight may differ depending upon the specifications and attached accessories

Dimensions (Units: mm)

Depending on the specifications or options that have been chosen, your model may differ slightly from the one in the photograph





Engine model	6LAAL-DTN	6LAAL-UTN		12LAAL-DTN	12LAAL-UTN
Engine speed (rpm)	1200	1200	1500 1800	1500 1800	1500 1800
A	2340	2530	2340	2900	2900
B	1469	1469		1610	1510
C	1061	1061		1452	1452
D	1000	1000		1080	1080
E	1414	1414		1315	1315
F	483	483		640	640
G	2725	2785	2625	3544	3544
[illegible]	3312	3710	[illegible]	6400	6450

* Please confirm all specifications, etc. on the separate delivery specifications sheet

4HAL2/6HAL2

Engine output
72~305 kW (98~414 PS)

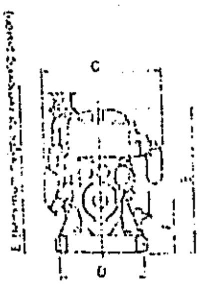
Specifications

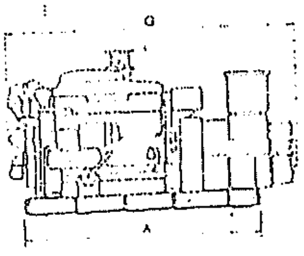
Engine model		4HAL2-TN1			4HAL2-TN			6HAL2-N			6HAL2-TN			6HAL2-HTN			6HAL2-DTN		
No. of cylinders		4						6											
Cylinder bore × stroke	mm	130×165						130×165											
Continuous rated output	kW (PS)	72 (98)	89 (121)	116 (157)	90 (122)	115 (156)	135 (183)	90 (122)	115 (156)	135 (181)	120 (163)	150 (204)	180 (244)	160 (217)	220	265 (360)	200 (271)	255 (346)	30 (41
Engine speed	rpm	1200	1500	1800	1200	1500	1800	1200	1500	1800	1200	1500	1800	1200	1500	1500	1200	1500	160
Generator capacity	kW	64	80	104	80	100	120	80	100	120	104	136	160	144	200	240	180	232	28
Starting system		Electric starting (Air-motor starting is available.)																	
Dry weight	kg	1030			1030			1380			1395			1410			1420		

The engine dry weight may differ depending upon the specifications and attached accessories

Dimensions (Units: mm)

Depending on the specifications or options that have been chosen, your model may differ slightly from the one in the photograph





Engine model	4HAL2-TN1		4HAL2-TN		6HAL2-N		6HAL2-TN		6HAL2-HTN		6HAL2-DTN	
Engine speed (rpm)	1200	1500 1800	1200	1500 1800	1200	1500 1800	1200	1500 1800	1200	1500 1800	1200	1500 1800
A	1600		1600		1970		1970	2050	2150		2180	
B	1206		1206		1285		1351		1351		1351	
C	1013		1013		1115		1115		1115		1115	
D	800		800		800		800		800		800	
E	1213		1213		1268		1268		1268		1267	
F	450		450		435		485		485		485	
G	2071	2047	2071	2047	2331	2115	2481	2524	2625	2619	2622	2632
[illegible]	1750	1820	1310	1470	2130	2190	2290	2340	2630	2680	2750	279

* Please confirm all specifications, etc. on the separate delivery specifications sheet

Yanmar Diesel Engine Co., Ltd.

Specifications (Mains)

* Asterisk shows DIN6

Model	No. of cylinders	Bore x stroke: mm	Cont. rating output: hp/rpm	Dry weight: kg	Dimensions L x W x H: mm
D18	2	70 x 70	18/4500	74, 79	722 x 460 x 1286
D27	3	70 x 70	27/4500	82, 87	722 x 460 x 1368
D36	3	70 x 70	36/4500	114, 118	730 x 460 x 1433
1GM10	1	75 x 72	*9/3600	76	547 x 410 x 485
2GM20	2	75 x 72	*18/3600	106	638 x 455 x 495
2GM20F	2	75 x 72	*18/3600	114	643 x 482 x 545
3GM30	3	75 x 72	*27/3600	130	735 x 455 x 495
3GM30F	3	75 x 72	*27/3600	138	740 x 455 x 545
3HM35	3	80 x 85	*34/3400	158	786 x 485 x 617
3HM35F	3	80 x 85	*34/3400	167	791 x 475 x 638
2TD	2	100 x 115	26/2100	330	874 x 526 x 805
3TD	3	100 x 115	39/2100	400	1009.5 x 526 x 825
4TD	4	100 x 115	52/2100	510	1235.5 x 526 x 854.5
4JH2E	4	82 x 86	*50/3600	228	888.4 x 565 x 634.5
4JH2-TE	4	82 x 86	*62/3600	234	888.4 x 565 x 634.5
4JH2-HTE	4	82 x 86	*75/3600	244	888.4 x 565 x 643.5
4JH2-DTE	4	82 x 86	*88/3600	244	888.4 x 565 x 643.5
3ESDE	3	120 x 135	56/1800	680	1255 x 689 x 967
4ESDL	4	120 x 135	74/1800	800	1473 x 694 x 1015
4LH-TE	4	100 x 110	*110/3300	340	1058.2 x 649 x 726
4LH-HTE	4	100 x 110	*140/3300	350	1058.2 x 649 x 726
4CHE	4	105 x 125	70/2300	655	1372 x 688 x 1025
6CHE	6	105 x 125	105/2300	785	1661 x 690 x 1018
6CH-HTE	6	105 x 125	155/2300	830	1658 x 690 x 1056
6CH-DTE	6	105 x 125	190/2300	880	1658 x 690 x 1091
6CH-UTE	6	105 x 125	255/2550	915	1551.5 x 730 x 1111
4KDE	4	145 x 170	110/1450	1430	1701 x 731 x 1164
6KDE	6	145 x 170	165/1450	2263	2495 x 741 x 1202
6HA(M)E	6	130 x 150	165/2000	1145	1529 x 885 x 1037
6HA(M)-HTE	6	130 x 150	240/2000	1230	1529 x 939 x 1233
6HA(M)-DTE	6	130 x 150	300/2000	1250	1529 x 939 x 1233
6GH-UTE	6	117.9 x 140	350/2300	1335	1762 x 898.5 x 1247
6LAAE	6	148 x 165	240/1900	2120	1703 x 921 x 1275.5
6LA-DTE	6	148 x 165	400/1800	1890	1719 x 1012.5 x 135
6LAA-UTE	6	148 x 165	530/1850	1890	1719 x 1012.5 x 135
8LAA-DTE	Vee 8	148 x 165	530/1800	2420	1983 x 1430 x 1420
8LAA-UTE	Vee 8	142 x 165	650/1850	2420	1983 x 1430 x 1420
12LAA-DTE	Vee 12	148 x 165	800/1800	3300	2553 x 1430 x 1470
12LAA-UTE	Vee 12	148 x 165	1000/1850	3300	2553 x 1430 x 1470
S165	6	165 x 210	200/1200	3100	2574.5 x 1043 x 15
S165-T	6	165 x 210	300/1300	3150	2574.5 x 1070 x 15
S165-UT	6	165 x 210	450/1300	3600	2697 x 1070 x 158
S165-ST	6	165 x 210	550/1300	3780	2697 x 1070 x 158
S165-ET	6	165 x 210	600/1350	3780	2847 x 1070 x 158

(Continued on nex

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LAMPIRAN

SKOCI

STANDART UKURAN SEKOCI BERMOTOR :

L	E	H	Kapasitas	Jumlah orang	Berat sekoci dari kayu	Berat sekoci dari plat	Berat motor	Berat perlengkapan	Berat total
8,00	2,60	1,16	14,5	34	1700	1900	820	450	2550
8,50	2,60	1,16	15,4	33	1800	2100	820	430	2925
9,00	2,70	1,22	17,8	46	1900	2300	870	510	3450
9,50	2,80	1,22	19,4	50	2100	2500	1120	530	3750

STANDART UKURAN SEKOCI KERJA

L1	L	B	H	Kapasitas	Jumlah orang	Berat penumpang	Berat perlengkapan	Berat sekoci	Berat total
3,60	3,76	1,55	0,6	2,0	4	300	60	300	650
3,80	3,95	1,65	0,65	2,5	5	375	60	360	795
4,00	4,16	1,75	0,70	3,0	6	450	60	420	930
4,50	4,66	1,00	0,78	3,5	7	525	70	450	1045
5,00	5,18	1,85	0,72	4,0	8	600	70	500	1170
5,50	5,68	1,90	0,75	4,7	9	675	80	600	1355
6,00	6,18	2,00	0,80	5,8	11	825	80	700	1605

LAMPIRAN

SKOCI

STANDART UKURAN SEKOCI OLEH BOT (BOARD OF TRADE) ENGLAND

Tabei II

L. B. H (m)	L. B. H (ft3)	Kapasitas (ft3)	Jumlah orang	berat sekoci (kg)	Berat Orang (kg)	berat perlengkapan (kg)	Total berat (kg)
9,4 x 2,74 x 1 x 1,114	30 x 9 x 3,75	607	60	2205	4500	356	7061
8,84 x 2,74 x 1,10	29 x 8,75 x 3,60	545	54	1976	4050	356	6382
8,53 x 2,59 x 1,07	28 x 8,50 x 3,50	500	50	1824	3750	330	5894
8,23 x 2,51 x 1,04	27 x 8,25 x 3,40	454	45	1645	3376	330	5351
7,92 x 2,44 x 0,99	26 x 8,00 x 3,25	405	40	473	3000	305	4778
7,62 x 2,36 x 0,96	25 x 7,75 x 3,15	366	36	1326	2700	305	4331
7,31 x 22,9 x 0,91	24 x 7,50 x 3,00	324	32	1109	2400	254	3943
7,01 x 2,29 x 0,89	23 x 7,50 x 2,90	309	30	1087	2250	254	3591
6,71 x 2,21 x 0,84	22 x 7,25 x 2,75	236	26	955	1950	229	3134
6,40 x 2,13 x 0,82	21 x 7,00 x 2,70	238	23	864	1725	229	2818
5,10 x 2,06 x 0,79	20 x 6,75 x 2,60	210	21	762	1575	203	2540
5,79 x 1,98 x 0,76	19 x 6,50 x 2,50	182	18	650	1350	178	2178
5,49 x 1,90 x 0,73	18 x 6,25 x 2,40	162	16	590	1200	152	1942
5,18 x 1,83 x 0,715	17 x 6,00 x 2,30	143	14	508	1050	152	1710
4,90 x 1,75 x 0,70	16 x 5,75 x 2,30	127	12	475	900	127	1494

Ballast capacity used for

- trim (immersion of propeller; resistance)
- providing of sufficient stability (at the end of the voyage)
- heeling (heavy lift vessels; RoRo-vessels; container ships, because of container guides).
- longitudinal strength (bulker, tanker)
- immersion of ship (tanker, to avoid heavy motions in sea-way; therefore light or heavy ballast).

Ballast capacity to be provided depending on ship type and on desires of the owner: between 10% and 50% of deadweight.

Additions to required ballast tank volumina are larger at the ends of the ship.

- +5% lower fore peak tank
- +3% upper fore peak tank
- +2% double bottom tank.

The new IMCO-rules recommend segregated ballast tanks to avoid pollution. Cargo oil tanks are separated from the ballast tank system. The economy decreases and more tank capacity is needed.

Sounding/ullage tables delivered by yard.

Provisions/persons/luggage

Weight of provisions	3 ... 5 kg/pers · day
weight of persons	75 kg (crew and passengers)
weight of luggage	20 kg/pers (short distance) 60 kg/pers (long distance passenger and crew).

e and Location of Main Engine

another part of the contract influencing ship design.

ip weight, volume, fuel consumption).

nomy is determined by the choice of the main engine type, also

[redacted]

of gravity are not yet exactly known in the early project stage. If the model does not accomplish the required speed the designer has to alter the hull. This alteration, however, is possible in the early project stage only. If the trial speed in ballast condition corresponds to the model trial speed in ballast, it can be assumed that service speed in loaded condition is attained, too.

Service speed of a ship is smaller than trial speed because of:

- increase of resistance by wind more than Beaufort 2
- increase of resistance by seaway
- increase of resistance by fouling on shell plating.

In general

$V_{trial} \approx 1.06 \cdot V_{service}$ (this corresponds to a power margin of about 20 - 25%).

The propeller is designed for 85% ... 90% of the driving power, at 100% of revolutions.

5. Consumables and tanks

There are some more special requirements in ship design:

Capacities of

- consumables
- provisions
- ballast.

a) consumables are (depending on type of engine plant, time fo one round trip, number of crew members):

- fuel oil

$$W_{fuel\ oil}\ [t] = P_{Bme} \cdot b_{me} + P_{ae} \cdot b_{ae} \cdot \frac{S}{V_{serv}} \cdot 10^{-6} \cdot K$$

$$[1.3\ \ldots\ 1.5]$$

last brackets for reserve:

- fuel rests in tanks
- seaway
- wind
- waiting time
- (- according to owner's desire).

P_{Bme} = break horsepower of the main engine [KW]

b_{me} = specific fuel oil consumption main engine [g/KW·h]

P_{ae} = total power of auxillary engines [KW]

b_{ae} = specific fuel oil consumption auxillary engines [g/KW·h]

s = operating range [sm]

V_{serv} = speed [kn]

1 KW = 0.736 PS (BHP).

[illegible]
1 HP (HORSEPOWER)
= 550 foot pounds per second
= 0,746 kilowatt
= 1,014 PS (or Cheval Vapeur)
1 PS (Pferdestärke) or CV (Cheval Vapeur)
= 542 foot pounds per second
= 0,986 hp
= 0,736 kw

[illegible] = 0,5071

1 kw (kilowatt)
= 1000 watts
= 1,340 hp
= 1,359 PS or CV
= 737 foot pounds

Motors:

Specific fuel oil consumption:

for two-stroke engines b = 205 ... 211 [g/KW·h]

for four-stroke engines with cylinder power more than 300 KW

b = 196 ... 209 [g/KW·h]

for full power: addition 5%

for diesel fuel: reduction 5% (dependent on heating value of diesel fuel)

For steam turbines:

Standard circulation without furnace gas reheat

livesteam: 64 ... 82 bar at 513 ... 538°C

b = 278 ... 286 [g/KW·h].

with furnace gas reheat

livesteam: 80 ... 110 bar at 513 ... 538°C

b = 252 ... 265 [g/KW·h]

For gas turbines:

Gasoline and light crude oils

b = 299 ... 312 [g/KW·h]

Specific weight of heavy fuel oil: γ = 0.95 t/m³

Required volume of storage tanks

$$V_{oil} = \frac{W}{\gamma} \quad [m^3]$$

1kw = 0,736 PS

Additions to the volume

- 2% for double bottom tanks
- 1 ... 2% for top tanks and deep tanks
- 2% for thermal expansion, i.e. 98% filled only.

Diesel oil

used for auxiliary engines and for the main engine durinc estuary trading.

$W_{diesel} = (0.1 \; ... \; 0.2) \cdot W_{heavy\ fuel\ oil}$

specific weight $\gamma_{diesel} = 0.85 \; t/m^3$

Volume: $V_{diesel} = \frac{W_{diesel}}{\gamma_{diesel}} \quad [m^3]$

additions see fuel oil

Lubrication oil

In general ships have about 30 ... 50 t lubrication oil, because otherwise the tanks will get too small. (Accordir to owner's desire).

$W_{lubr.} = P_{Bme} \cdot b_{me} \cdot \frac{S}{V_{serv}} + addition$

$b = 0.8 \; ... \; 1.2 \; [g/KW \cdot h]$ diesel engine two stroke

$b = 1.2 \; ... \; 1.6 \; [g/KW \cdot h]$ diesel engine four stroke

$b = 0.14 \; [g/KW \cdot h]$ turbines and gearboxes

specific weight $\gamma_{lubr} = 0.90 \; t/m^3$; $V = \frac{W}{\gamma} \; (m^3)$

Fresh water

- drinking water 10 ... 20 kg/pers · day
- washing water 60 kg/pers · day without bathing room
  up to 200 kg/pers · day with bathing room
- boiler feed water 0.14 kg/KW·h plus first filling

additions to the tank volume: 3 ... 4% for special coatin
in case of fresh w

Fresh water tanks have to be separated from all other tan by cofferdams.

LAMPIRAN 6

(1) fans of service and living compartments, designed to provide induced ventilation in these spaces;

(2) cargo hold fans, designed for ventilating the holds of dry-store bulk carriers, tankers and refrigerated cargo vessels, as well as refrigerated provision chambers;

(3) boiler plant fans, designed to produce artificial draught for the steam boilers;

(4) coal bunker fans.

Depending upon [illegible] they [illegible] fans are classified as:

(1) supply fans [illegible] connected with the spaces being served;

(2) exhaust fans [illegible] the fan inlet is connected to the spaces being served;

(3) ceiling fans, designed to produce air movement in the spaces without providing exchange.

As regards the pressure they develop, fans are divided into:

(1) low-pressure fans developing a head up to 100 mmH_2O;

(2) medium-pressure fans developing a head up to 300 mmH_2O;

(3) high-pressure fans developing a head up to 1,500 mmH_2O.

According to the mechanical composition of the gas they handle, there are:

(1) fans for delivering pure gases;

(2) dust fans designed for delivering gases polluted by mechanical impurities.

The specific velocity, n_s, of a fan is a value relating the air discharge, Q cu m per [illegible], full head H mmH_2O, at normal atmospheric conditions and the fan wheel speed, n rpm, at the highest efficiency:

$$n_s = \frac{n\sqrt{Q}}{\sqrt[4]{H^3}}$$

Gas passing through the fan is compressed to only the slightest degree and is therefore assumed to be an incompressible fluid. In this case all the main principles in the theory and operation of centrifugal pumps are valid for fans as well.

The capacity of a fan for ventilating definite service quarters must be sufficient to maintain the chemical composition, humidity and temperature of the air within the requirements of sanitary regulations.

The unwholesomeness, or contamination, of the air in a room or compartment due to the presence of people is usually estimated by the carbon dioxide content, which increases with an increase of harmful impurities in the air. The carbon dioxide content of the air must not exceed 0.1 to 0.15 per cent by volume.

The fan capacity required to maintain a stipulated chemical composition of the air in a compartment is

$$Q_{ch} = V_r \frac{V_{rc}}{V_{mr} - V_{ca}} \text{ cu m per hour} \qquad (273)$$

where V_{rc} = volume of carbon dioxide produced per cu m of the given room, litres per cu m

V_r = volume of the room, cu m

$V_{mr} \approx 1$ = the maximum carbon dioxide content per cu m of the given room, litres per cu m

$V_{ca} \approx 0.3$ = carbon dioxide content per cu m of sea air entering the room, litres per cu m.

The volume of air required to maintain the prescribed temperature in a room is

$$Q_t = \frac{Q_r}{c_a(t_r - t_{fa})\gamma_{fa}} = \frac{Q_r}{c_a(t_r - t_{fa})\frac{\gamma_0}{1+\alpha t_r}} = \frac{Q_r(1+\alpha t_r)}{c_a(t_r - t_{fa})}\gamma_0 \qquad (274)$$

where $c_a \approx 0.24$ = mean heat capacity of air, kcal per kg °C

t_r = given temperature of the room, °C

t_{fa} = temperature of the fresh air entering the room, °C

Q_r = amount of heat entering the room, kcal per hour

γ_{fa} = density of the fresh air entering the room, kg per cu m

$\gamma_0 \approx 1.29$ = density of dry air at 0°C and a pressure of 760 mmHg, kg per cu m

$\alpha = \frac{1}{273}$ = coefficient of volumetric expansion of air.

The amount of external air required to maintain the relative humidity in a room is

$$Q_{hu} = \frac{100 D_{hu}}{\varphi_r d_r - \varphi_{fa} d_{fa}} \text{ cu m per hour} \qquad (275)$$

where D_{hu} = amount of moisture entering the room, g per hour

d_r and d_{fa} = absolute humidity of saturated air at the room temperature, t_r, and at the temperature, t_{fa}, of the entering air, g per cu m (see Table 38)

φ_r and φ_{fa} = relative humidity of the air in the room and of the entering air, per cent.

Data on the relative humidity and temperature of the outside air depending upon the locality in which the ship is operating, and the permissible values for various accommodations are listed in Table 39.

The amount of carbon dioxide, heat and vapour produced by persons in a room can be calculated from the data of Table 40.

Daya untuk setiap kilowatt refrigerasi merupakan kebalikan dari koefisien prestasi, dan suatu sistem refrigerasi yang efisien akan memiliki nilai daya per-kilowatt refrigerasi yang rendah, tetapi mempunyai koefisien prestasi yang tinggi.

Contoh berikut ini menegambarkan perhitungan untuk menentukan prestasi daur kompresi uap standar.

Contoh 10-1 Suatu daur kompresi-uap standar menghasilkan 50 kW refrigerasi dengan menggunakan refrigeran 22, bekerja pada suhu pengembunan 35°C dan suhu penguapan −10°C. Hitunglah (*a*) dampak refrigerasi dalam kilojoule per-kilogram, (*b*) laju pendauran refrigeran dalam kilogram per-detik, (*c*) daya yang dibutuhkan oleh kompresor dalam kilowatt, (*d*) koefisien prestasi, (*e*) laju alir volume yang diukur pada pipa husap kompresor, (*f*) daya per kilowatt refrigerasi dan (*g*) suhu buang pada kompresor.

Penyelesaian Langkah pertama penyelesaian adalah menggambar diagram tekanan-entalpi (Gambar 10-12) dan menentukan dari Tabel A-6, Tabel A-7, dan Gambar A-4, entalpi-entalpi pada titik-titik penting. Nilai h_1 adalah entalpi uap jenuh pada −10°C, yaitu 401,6 kJ/kg.

Untuk menemukan h_2 melalui garis entropi tetap geser titik 1 hingga mencapai tekanan jenuh yang sesuai dengan suhu 35°C. Tekanan pengembunan ini adalah 1354 kPa, dan nilai $h_2 = 435,2$ kJ/kg.

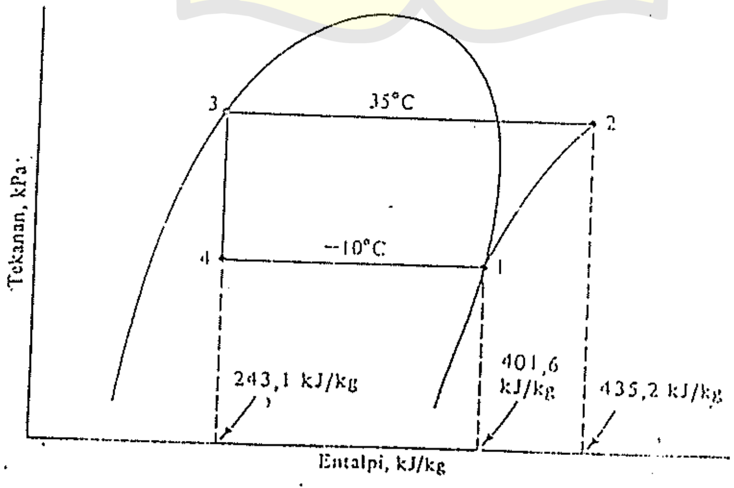
Nilai h_3 dan h_4 identik, dan sama dengan entalpi cairan jenuh pada 35°C, yaitu 243,1 kJ/kg. Sehingga

$$h_1 = 401,6 \text{ kJ/kg} \qquad h_2 = 435,2 \text{ kJ/kg}$$

$$h_3 = h_4 = 243,1 \text{ kJ/kg}$$

(*a*) Dampak refrigerasi:

$$h_1 - h_4 = 401,6 - 243,1 = 158,5 \text{ kJ/kg}$$



Gambar 10-12 Diagram tekanan-entalpi untuk sistem dalam Contoh 10-1.

Sifat-sifat zat yang melebur dan membeku

1. Waktu melebur atau membeku suhu zat tetap tidak berubah
2. Umumnya zat sebelum mencair/membeku didahului oleh kelunakan atau meleleh
3. Umumnya zat yang mencair, volumenya [illegible] (kecuali es, besi, perak dan bismut)
4. Pada umumnya titik lebur/titik beku itu naik/turun apabila tekanannya bertambah tinggi/rendah
5. Titik lebur logam paduan, biasanya lebih rendah daripada titik lebur logam-logam asalnya. Misalnya timah solder (200°C) terdiri dari 50 % timbal (328°C) dan 50 % timah (232°C).
6. Tidak semua zat dapat mencair/membeku, ada yang tinggal tetap tidak berubah, ada pula yang dipisahkan secara kimia.
7. Dalam keadaan tertentu(tenang), beberapa macam zat cair dapat didinginkan sampai ke suhu di bawah titik bekunya. Apabila zat cair tersebut digerakkan, maka akan segera membeku.

KALOR LEBUR & KALOR UAP

Pada tekanan satu atmosfir

NAMA ZAT	MELEBUR/MEMBEKU			MENGUAP/MENGEMBUN		
	Titik lebur °C	Kalor lebur		Titik didih °C	Kalor uap	
		[illegible]	[illegible]		[illegible]	Btu/lb
Air (H_2O)	–	–	[illegible]	100	539	970,4
Es	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(Air) Raksa(Hg)	–39	[illegible]	[illegible]	[illegible]	[illegible]	127,2
Amonia (NH_3)	–75	[illegible]	[illegible]	[illegible]	327	585
R – 12(CCl_2F_2)	–158			[illegible]	38,57	71,0
R – 22($CHClF_2$)	–160			[illegible]	55,[illegible]	100,5
R – 502				[illegible]	[illegible]	76,0
Timbal(Pb)	327	[illegible]	[illegible]	[illegible]	175	313,4
Timah(Sn)	232	[illegible]	[illegible]	[illegible]		
Aluminium(Al)	660	[illegible]	[illegible]	[illegible]		
Tembaga(Cu)	1083	49	87,7	2300	1750	3134
Seng(Zn)	420	28,1	50,3	907		
Emas(Au)	1063	12,6	22,6	2960		
Perak(Ag)	960	21	37,6	2210		
Besi(Fe)	1530	28	50,1	2735		

Tabel A-7 Refrigeran 22: sifat-sifat uap gas panas lanjut[3]

t, °C	v, L/kg	h, kJ/kg	s, kJ/kg · K	v, L/kg	h, kJ/kg	s, kJ/kg · K	v, L/kg	h, kJ/kg	s, kJ/kg · K
	Suhu jenuh, −20°C			h_1 Suhu jenuh, −10°C			Suhu jenuh, 0°C		
-20	92,8432	397,467	1,7841						
-15	95,1474	400,737	1,7969						
-10	97,4256	404,017	1,8095	65,2399	401,555	1,7671			
-5	99,6806	407,307	1,8219	57,0051	404,983	1,7800			
0	101,915	410,610	1,8341	68,6524	408,412	1,7927	[illegible]	405,361	1,7518
5	104,130	413,926	1,8461	70,2751	411,845	1,8052	[illegible]	[illegible]	1,7649
10	106,328	417,258	1,8580	71,8785	415,283	1,8174	[illegible]	412,507	1,7777
15	108,510	420,606	1,8697	73,4644	418,730	1,8295	[illegible]	[illegible]	1,7903
20	110,678	423,970	1,8813	75,0346	422,186	1,8414	[illegible]	[illegible]	1,8026
25	112,832	426,353	1,8928	76,5904	425,651	1,8531	[illegible]	[illegible]	1,8145
	Suhu jenuh, 5°C			h_2 Suhu jenuh, 10°C			Suhu jenuh, 15°C		
5	40,3556	407,143	1,7446						
10	41,4580	410,851	1,7578	34,7136	408,835	1,7377			
15	42,5379	414,542	1,7708	35,6907	412,651	1,7511	[illegible]	[illegible]	[illegible]
20	43,5979	418,222	1,7834	36,6454	416,442	1,7642	[illegible]	[illegible]	[illegible]
25	44,6401	421,891	1,7958	37,5804	420,215	[illegible]	[illegible]	[illegible]	[illegible]
30	45,6665	425,567	1,8080	38,4981	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	46,6786	429,229	1,8200	39,4002	[illegible]	[illegible]	[illegible]	[illegible]	1,7833
40	47,6779	432,897	1,8319	40,2834	431,469	1,8137	[illegible]	[illegible]	1,7954
45	48,6656	436,569	1,8435	41,1642	435,211	1,8256	[illegible]	[illegible]	1,8075
50	49,6427	440,247	1,8550	42,0286	438,954	1,8373	[illegible]	[illegible]	1,8197

Tabel A-7 (lanjutan)

	Suhu jenuh, 20°C			Suhu jenuh, 25°C			Suhu jenuh, 30°C		
20	26,0032	411,918	1,7246						
25	26,7900	415,977	1,7383	22,6242	413,289	1,7153			
30	.27,5542	419,991	1,7517	23,3389	417,457	[illegible]	[illegible]	[illegible]	1,7120
35	28,2989	423,970	1,7646	24,0306	421,627	[illegible]	[illegible]	[illegible]	1,7262
40	29,0264	427,922	1,7774	24,7027	425,721	[illegible]	[illegible]	[illegible]	[illegible]
45	29,7389	431,852	1,7895	25,3575	429,779	[illegible]	[illegible]	[illegible]	1,7534
50	30,4379	435,766	1,8021	25,9974	433,807	[illegible]	[illegible]	[illegible]	1,7664
55	31,1250	439,668	1,8141	26,6239	437,813	[illegible]	[illegible]	[illegible]	[illegible]
60	31,8012	443,561	1,8258	27,2386	441,801	[illegible]	[illegible]	[illegible]	[illegible]
65	32,4678	447,450	1,8374	27,8427	445,777	[illegible]	[illegible]	[illegible]	[illegible]
	Suhu jenuh, 32°C			Suhu jenuh, 34°C			Suhu jenuh, 36°C		
35	19,0907	417,648	1,7182	17,8590	416,325	1,7099			
40	19,7093	422,014	1,7322	18,4675	420,792	1,7243	[illegible]	[illegible]	1,7162
45	20,3062	426,310	1,7458	.9,0526	425,174	1,7382	[illegible]	[illegible]	1,7304
50	20,8847	430,549	1,7591	19,6178	429,487	1,7517	[illegible]	[illegible]	1,7442
55	21,4471	434,743	1,7719	20,1660	433,747	1,7647	[illegible]	[illegible]	1,7575
60	21,9956	438,900	1,7845	20,6994	437,963	1,7775	[illegible]	436,970	1,7704
65	22,5318	443,028	1,7968	21,2199	442,143	1,7899	[illegible]	441,207	1,7830
70	23,0571	447,133	1,8089	21,7289	446,294	1,8021	20,4807	445,410	1,7954
75	23,5726	451,219	1,8207	22,2278	450,424	1,8141	[illegible]	449,586	1,8074
80	24,0794	455,292	1,8323	22,7176	454,535	1,8258	[illegible]	453,739	1,8193

Perubahan zat dari wujud padat menjadi wujud cair pada titik leburnya disebut *mencair* atau *melebur*. Pada waktu melebur harus ditambahkan kalor laten lebur, sedangkan suhunya tetap tidak berubah. Suhu itu disebut *titik cair* atau *titik lebur*.

Membeku (Solidification)

Perubahan zat dari wujud cair menjadi wujud padat pada titik bekunya disebut *membeku*. Pada waktu membeku dilepaskan kalor laten beku, sedangkan suhunya tetap tidak berubah. Suhu tersebut dinamakan *titik beku* zat itu.

KALOR JENIS & KALOR BEKU DARI MAKANAN

Nama Makanan	KALOR JENIS		KALOR BEKU		TITIK BEKU	
	Sebelum beku Btu/lb°F	Setelah beku Btu/lb°F	kkal/kg	Btu/lb	°C	°F
Daging sapi	0,75	0,40	54,7	90,0	−0,5	31,3
Daging kambing	0,67	0,30	46,6	83,5	−1,7	29
Daging babi	0,68	0,33	48,3	86,5	−2,2	28
Ham asap	0,60	0,32	48,3	86,5	−0,5	31,3
Ikan segar	0,76	0,41	56,4	101,0	−2,2	28
Ayam	0,79	0 37	59,2	106,0	−2,8	27
Mentega	0,64	0,34	8,4	15,0	−1,1	30
Keju	0,64	0,36	44,1	79,0	−8,3	17
Telur	0,85	0,45	55,8	100,0	−0,5	31,6
Susu	0,90	0,49	69,2	124,0	−0,6	31
Anggur	0,90	0,61	62,5	112,0	−2,2	28
Apel	0,89	0,43	68,1	122,0	−1,7	28,9
Advokat	0,91	0,49	75,9	136,0	−2,8	27,2
Jeruk	0,91	0,44	69,8	125,0	−2,2	28
Nanas	0,90	0,50	71,5	128,0	−1,7	29,2
Tomat	0,92	0,46	73,7	132,0	−0,9	30,6
Kentang	0,86	0,47	63,1	113,0	−1,7	29
Ketimun	0,93	0,48	76,5	137,0	0,8	30,5
Seledri	0,91	0,46	75,9	136,0	1,3	29,7
Kubis	0,93	0,47	73,7	132,0	−0,5	31,2
Bunga kool	0,90	0,46	74,3	133,0	−1,1	30,1
Wortel	0,86	0,45	70,4	126,0	−0,6	31
Air	1,00	0,504	80,4	144,0	0,0	32

KONSTANTA FISIS

Konstanta Avogadro	N_A	$6{,}022169 \times 10^{23}$	molekul/gram-mol
Konstanta Faraday	$\mathcal{F}$	$9{,}648670 \times 10^{4}$	coulomb/gram-mol elektron
Konstanta Planck	h	$6{,}626196 \times 10^{-34}$	Joule-detik
Konstanta gas	$\overline{R}$	$8{,}31434 \times 10^{0}$	Joule/gram-mol-K
Konstanta Boltzmann	k	$1{,}380622 \times 10^{-23}$	Joule/molekul-K
Konstanta Stefan-Boltzmann	σ	$5{,}66961 \times 10^{-8}$	Watt/meter^2-K^4
Elektron-volt	eV	$1{,}6021917 \times 10^{-19}$	Joule/eV

FAKTOR KONVERSI

Hubungan-hubungan yang tepat (menurut definisi the National Bureau of Standards) diikuti oleh tanda asterisk (*). Yang lainnya adalah hasil pengukuran fisis, atau hanya pendekatan. Kedua angka yang pertama masing-masing faktor konversi berarti pangkat untuk bilangan 10. Misalnya, untuk mengkonversi 5 inci menjadi ukuran ekivalensinya dalam Satuan Sistem International (MKSA), kalikan dengan 0,0254 untuk mendapatkan 0,1270 m.

Untuk mengkonversi:	Menjadi:	Kalikan dengan:
	(Panjang)	
angstrom	meter	−10 1,00*
foot	meter	−01 3,048*
inci	meter	−02 2,54*
mikron	meter	−06 1,00*
mile (A.S)	meter	+03 1,609344*
	(Luas)	
foot^2	meter^2	−02 9,290304*
inch^2	meter^2	−04 6,4516*
mile^2 (U.S. statute)	meter^2	+06 2,589988110336*
	(Volume)	
foot^3	meter^3	−02 2,8316846592*
gallon (Inggeris)	meter^3	−03 4,546087
gallon (A,S)	meter^3	−03 3,785411784*
liter	meter^3	−03 1,00*
	(Massa)	
gram	kilogram	−03 1,00*
lbm (pound massa, avoirdupois)	kilogram	−01 4,5359237*
slug	kilogram	+01 1,45939029
ton (metrik)	kilogram	+03 1,00*
ton (short, 2000 pound)	kilogram	+02 9,0718474*

FAKTOR KONVERSI (*lanjutan*)

Untuk mengkonversi:	Menjadi:	Kalikan dengan:
	(Gaya)	
dine	newton	−05 1,00*
kilogram gaya, kg.	newton	+00 9,80665*
pound gaya lbg (avoirdupois)	newton	+00 4,4482216152605*
	(Tekanan)	
atmosfer	newton/meter^2	+05 1,01325*
bar	newton/meter^2	+05 1,00*
foot air (4 C0	newton/meter^2	+03 2,98898
inci air raksa (0 C)	newton/meter^2	+03 3,386389
meter air raksa (0 C0	newton/meter^2	+05 1,333224
lbg/foot^2	newton/meter^2	+01 4,7880258
lbg/inci^2 (psi)	newton/meter^2	+03 6,8947572
mikron air raksa (0 C)	newton/meter^2	−01 1,333224
	(Kerapatan)	
gram/sentimeter^3	kilogram/meter^3	+03 1,00*
lbm/foot^3	kilogram/meter^3	+01 1,6018463
	(Energi)	
British thermal unit (International Steam Table)	joule	+03 1,055056
British thermal unit (termokimia)	joule	+03 1,054350264488
kalori (International Steam Table)	joule	+00 4,1868
kalori (thermochemical)	joule	+00 4,184*
elektron volt	joule	−19 1,60210
erg	joule	−07 1,00*
foot lbg	joule	+00 1,3558179
joule (internasional, 1948)	joule	+00 1,000165
kilowaat jam	joule	+06 3,60*
kilowatt jam (internasional, 1948)	joule	+06 3,60059
watt jam	joule	+03 3,60*
	(Daya)	
Btu (IST)/detik	watt	+03 1,055056
Btu (termokimia)/detik	watt	+03 1,054350264488
kalori (termokimia)/detik	watt	+00 4,184*
dayakuda (550 foot-lbf/detik)	watt	+02 7,4569987
dayakuda (listrik)	watt	+02 7,46*

(*dilanjutkan*)

FAKTOR KONVERSI (*lanjutan*)

Untuk mengkonversi:	Menjadi:	Kalikan dengan:
	(Listrik)	
ampere (internasional, 1948)	ampere	−01 9,99835
ampere jam	coulomb	+03 3,60*
coulomb (internasional, 1948)	coulomb	−01 9,99835
faraday (didasarkan pada karbon 12)	coulomb	+04 9,64870
faraday (kimia)	coulomb	+04 9,64957
faraday (fisika)	coulomb	+04 9,65219
ohm (internasional, 1948)	ohm	+00 1,000495
gauss	tesla	−04 1,00*
volt (internasional, 1948)	volt	+00 1,000330
maxwell	weber	−08 1,00*
	(Temperatur)	
Celsius (temperatur)	Kelvin	K = C + 273,15*
Rankine (temperatur)	Kelvin	K = (5/9)R*
Fahrenheit (temperatur)	Celsius	C = (5/9)(F − 32)*
	(Konduktifitas termal)	
Btu inci/foot^2 - detik-F	Joule/meter-det-K	+02 5,1887315
	(Viskositas)	
stoke	meter^2/detik	−04 1,00*
foot^2/detik	meter^2/detik	−02 9,290304*
lbf-detik/foot^2	newton-detik/meter^2	+01 4,7880258
poise	newton-detik/meter^2	−01 1,00*
slug/foot-detik	newton-detik/meter^2	+01 4,7880258
	(Lain-lain)	
derajat (sudut)	radian	−02 1,7453292519943
Btu (IST)/lbm	joule/kilogram	+03 2,326*
Btu (IST)/foot^2 jam	watt/meter^2	+00 3,1545
Btu (IST)/foot jam F	watt/meter-C	+00 1,7307
Btu (IST)/foot^2 jam F	watt/meter^2-C	+00 5,6783
Btu (IST)/lbm-F	joule/kilogram-C	+03 4,1868*
Btu (IST)/lbm-F	kalori (IST)/gram-C	+00 1,00*
kalori (IST)/kilogram	joule/kilogram-C	+00 4,1868
langley	joule/meter^2	+04 4,184*

SIMBOL

Lampiran B

Harga-harga Kontanta Gas Universal

$R = 8{,}314\ \mathrm{J \cdot mol^{-1} \cdot K^{-1}} = 8{,}314\ \mathrm{kJ \cdot kmol^{-1} \cdot K^{-1}} = 8{,}314\ \mathrm{m^3 \cdot Pa \cdot mol^{-1} \cdot K^{-1}}$

$= 0{,}008314\ \mathrm{kJ \cdot mol^{-1} \cdot K^{-1}} = 0{,}08314\ \mathrm{L \cdot bar \cdot mol^{-1} \cdot K^{-1}}$

$= 83{,}14\ \mathrm{cm^3 \cdot bar \cdot mol^{-1} \cdot K^{-1}} = 8314\ \mathrm{cm^3 \cdot kPa \cdot mol^{-1} \cdot K^{-1}}$

$= 82{,}06\ \mathrm{cm^3 \cdot atm \cdot mol^{-1} \cdot K^{-1}} = 0{,}08206\ \mathrm{L \cdot atm \cdot mol^{-1} \cdot K^{-1}}$

$= 62356\ \mathrm{cm3 \cdot torr \cdot mol{-}1 \cdot K{-}1} = 62{,}356\ \mathrm{L \cdot torr \cdot mol^{-1} \cdot K^{-1}}$

$= 11{,}987\ \mathrm{kal \cdot mol^{-1} \cdot K^{-1}} = 1{,}986\ \mathrm{Btu \cdot lb\ mol^{-1} \cdot R^{-1}}$

$= 0{,}7302\ \mathrm{ft^3 \cdot atm \cdot lb\ mol^{-1} \cdot R^{-1}} = 10{,}73\ \mathrm{ft^3 \cdot psia \cdot lb\ mol^{-1} \cdot R^{-1}}$

$= 1545\ \mathrm{ft \cdot lb_f \cdot lb\ mol^{-1} \cdot R^{-1}}$

Lampiran C

Konstanta Kritis dan Faktor Asentrik

Senyawa	T_c/K	P_c/bar	[illegible]	[illegible]	[illegible]
Argon	150,8	48,7	74,9	0,291	0,0
Xenon	289,7	58,4	118,0	0,286	0,0
Metana	190,6	46,0	99,0	0,285	0,008
Oksigen	154,6	50,5	73,4	0,288	0,021
Nitrogen	126,2	33,9	89,5	0,290	0,040
Karbon monoksida	132,9	35,0	93,1	0,295	0,049
Etilena	282,4	50,4	129,0	0,276	0,085
Hidrogen sulfida	373,2	89,4	98,5	0,284	0,100
Propana	396,8	42,5	203,0	0,281	0,152
Asetilena	308,3	61,4	113,0	0,271	0,184
Sikhloheksana	553,4	40,7	308,0	0,273	0,213
Benzena	562,1	48,9	259,0	0,271	0,212
Karbon dioksida	304,2	73,8	94,0	0,274	0,225
Ammonia	405,6	112,8	72,5	0,242	0,250
n-Pentana	469,6	33,7	304,0	0,262	0,251
n-Heksana	507,4	29,7	370,0	0,260	0,296
Asenton	508,1	47,0	209,0	0,232	0,309
Air	647,3	221,2	57,1	0,229	0,344
n-Heptana	540,2	27,4	432,0	0,263	0,351
n-Oktana	568,8	24,8	492,0	0,259	0,394
Metanol	512,6	81,0	118,0	0,224	0,559
Etanol	516,2	63,8	167,0	0,248	0,635

Uap Air Jenuh (Satuan SI)

V = VOLUME JENIS $(\mathrm{cm^3 \cdot g^{-1}}$ atau $\mathrm{L \cdot kg^{-1}})$

H = ENTALPI JENIS $(\mathrm{kJ \cdot kg^{-1}})$

U = ENERGI DALAM JENIS $(\mathrm{kJ \cdot kg^{-1}})$

S = ENTROPI JENIS $(\mathrm{kJ \cdot kg^{-1} \cdot K^{-1}})$

TEMPERATURE		ABS. PRESS.	SPECIFIC VOLUME V			INTERNAL ENERGY U			ENTHALPY H			ENTROPY S		
t °C	K	kPa	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
0	273.15	0.611	1.000	206300	206300	−0.04	2375.7	2375.6	−0.04	2501.7	2501.6	0.0000	9.1578	9.1578
0.01	273.16	0.611	1.000	206200	206200	0.0	2375.6	2375.6	0.00	2501.6	2501.6	0.0	9.1575	9.1575
1	274.15	0.657	1.000	192600	192600	4.17	2372.7	2376.9	4.17	2499.2	2503.4	0.0153	9.1158	9.1311
2	275.15	0.706	1.000	179900	179900	8.39	2369.9	2378.3	8.39	2496.8	2505.2	0.0306	9.0741	9.1047
3	276.15	0.757	1.000	168200	168200	12.60	2367.1	2379.7	12.60	2494.5	2507.1	0.0459	9.0326	9.0785
4	277.15	0.813	1.000	157300	157300	16.80	2364.3	2381.1	16.80	2492.1	2508.9	0.0611	8.9915	9.0526
5	278.15	0.872	1.000	147200	147200	21.01	2361.4	2382.4	21.01	2489.7	2510.7	0.0762	8.9507	9.0269
6	279.15	0.935	1.000	137800	137800	25.21	2358.6	2383.8	25.21	2487.4	2512.6	0.0913	8.9102	9.0014
7	280.15	1.001	1.000	129100	129100	29.41	2355.8	2385.2	29.41	2485.0	2514.4	0.1063	8.8699	8.9762
8	281.15	1.072	1.000	121000	121000	33.60	2353.0	2386.6	33.60	2482.6	2516.2	0.1213	8.8300	8.9513
9	282.15	1.147	1.000	113400	113400	37.80	2350.1	2387.9	37.80	2480.3	2518.1	0.1362	8.7903	8.9265
10	283.15	1.227	1.000	106400	106400	41.99	2347.3	2389.3	41.99	2477.9	2519.9	0.1510	8.7510	8.9020
11	284.15	1.312	1.000	99910	99910	46.18	2344.5	2390.7	46.18	2475.5	2521.7	0.1658	8.7119	8.8776
12	285.15	1.401	1.000	93830	93840	50.38	2341.7	2392.1	50.38	2473.2	2523.6	0.1805	8.6731	8.8536
13	286.15	1.497	1.001	88180	88180	54.56	2338.9	2393.4	54.57	2470.8	2525.4	0.1952	8.6345	8.8297
14	287.15	1.597	1.001	82900	82900	58.75	2336.1	2394.8	58.75	2468.5	2527.2	0.2098	8.5963	8.8060
15	288.15	1.704	1.001	77980	77980	62.94	2333.2	2396.2	62.94	2466.1	2529.1	0.2243	8.5582	8.7826
16	289.15	1.817	1.001	73380	73380	67.12	2330.4	2397.6	67.13	2463.8	2530.9	0.2388	8.5205	8.7593
17	290.15	1.936	1.001	69090	69090	71.31	2327.6	2398.9	71.31	2461.4	2532.7	0.2533	8.4830	8.7363
18	291.15	2.062	1.001	65090	65090	75.49	2324.8	2400.3	75.50	2459.0	2534.5	0.2677	8.4458	8.7135
19	292.15	2.196	1.002	61340	61340	79.68	2322.0	2401.7	79.68	2456.7	2536.4	0.2820	8.4088	8.6908
20	293.15	2.337	1.002	57840	57840	83.86	2319.2	2403.0	83.86	2454.3	2538.2	0.2963	8.3721	8.6684
21	294.15	2.485	1.002	54560	54560	88.04	2316.4	2404.4	88.04	2452.0	2540.0	0.3105	8.3356	8.6462
22	295.15	2.642	1.002	51490	51490	92.22	2313.6	2405.8	92.23	2449.6	2541.8	0.3247	8.2994	8.6241
23	296.15	2.808	1.002	48620	48620	96.40	2310.7	2407.1	96.41	2447.2	2543.6	0.3389	8.2634	8.6023
24	297.15	2.982	1.003	45920	45930	100.6	2307.9	2408.5	100.6	2444.9	2545.5	0.3530	8.2277	8.5806
25	298.15	3.166	1.003	43400	43400	104.8	2305.1	2409.9	104.8	2442.5	2547.3	0.3670	8.1922	8.5592
26	299.15	3.360	1.003	41030	41030	108.9	2302.3	2411.2	108.9	2440.2	2549.1	0.3810	8.1569	8.5379
27	300.15	3.564	1.003	38810	38810	113.1	2299.5	2412.6	113.1	2437.8	2550.9	0.3949	8.1218	8.5168
28	301.15	3.778	1.004	36730	36730	117.3	2296.7	2414.0	117.3	2435.4	2552.7	0.4088	8.0870	8.4958
29	302.15	4.004	1.004	34770	34770	121.5	2293.8	2415.3	121.5	2433.1	2554.5	0.4227	8.0524	8.4751
30	303.15	4.241	1.004	32930	32930	125.7	2291.0	2416.7	125.7	2430.7	2556.4	0.4365	8.0180	8.4546
31	304.15	4.491	1.005	31200	31200	129.8	2288.2	2418.0	129.8	2428.3	2558.2	0.4503	7.9839	8.4342
32	305.15	4.753	1.005	29570	29570	134.0	2285.4	2419.4	134.0	2425.9	2560.0	0.4640	7.9500	8.4140
33	306.15	5.029	1.005	28040	28040	138.2	2282.6	2420.8	138.2	2423.6	2561.8	0.4777	7.9163	8.3939
34	307.15	5.318	1.006	26600	26600	142.4	2279.7	2422.1	142.4	2421.2	2563.6	0.4913	7.8828	8.3740
35	308.15	5.622	1.006	25240	25240	146.6	2276.9	2423.5	146.6	2418.8	2565.4	0.5049	7.8495	8.3543
36	309.15	5.940	1.006	23970	23970	150.7	2274.1	2424.8	150.7	2416.4	2567.2	0.5184	7.8164	8.3348
37	310.15	6.274	1.007	22760	22760	154.9	2271.3	2426.2	154.9	2414.1	2569.0	0.5319	7.7835	8.3154
38	311.15	6.624	1.007	21630	21630	159.1	2268.4	2427.5	159.1	2411.7	2570.8	0.5453	7.7509	8.2962
39	312.15	6.991	1.007	20560	20560	163.3	2265.6	2428.9	163.3	2409.3	2572.6	0.5588	7.7184	8.2772
40	313.15	7.375	1.008	19550	19550	167.4	2262.8	2430.2	167.5	2406.9	2574.4	0.5721	7.6861	8.2583
41	314.15	7.777	1.008	18590	18590	171.6	2259.9	2431.6	171.6	2404.5	2576.2	0.5854	7.6541	8.2395
42	315.15	8.198	1.009	17690	17690	175.8	2257.1	2432.9	175.8	2402.1	2577.9	0.5987	7.6222	8.2209
43	316.15	8.639	1.009	16840	16840	180.0	2254.3	2434.2	180.0	2399.7	2579.7	0.6120	7.5905	8.2025
44	317.15	9.100	1.009	16040	16040	184.2	2251.4	2435.6	184.2	2397.3	2581.5	0.6252	7.5590	8.1842
45	318.15	9.582	1.010	15280	15280	188.3	2248.6	2436.9	188.4	2394.9	2583.3	0.6383	7.5277	8.1661
46	319.15	10.09	1.010	14560	14560	192.5	2245.7	2438.3	192.5	2392.5	2585.1	0.6514	7.4966	8.1481
47	320.15	10.61	1.011	13880	13880	196.7	2242.9	2439.6	196.7	2390.1	2586.9	0.6645	7.4657	8.1302
48	321.15	11.16	1.011	13230	13230	200.9	2240.0	2440.9	200.9	2387.7	2588.6	0.6776	7.4350	8.1125
49	322.15	11.74	1.012	12620	12620	205.1	2237.2	2442.3	205.1	2385.3	2590.4	0.6906	7.4044	8.0950
50	323.15	12.34	1.012	12040	12050	209.2	2234.3	2443.6	209.3	2382.9	2592.2	0.7035	7.3741	8.0776
51	324.15	12.96	1.013	11500	11500	213.4	2231.5	2444.9	213.4	2380.5	2593.9	0.7164	7.3439	8.0603
52	325.15	13.61	1.013	10980	10980	217.6	2228.6	2446.2	217.6	2378.1	2595.7	0.7293	7.3138	8.0432
53	326.15	14.29	1.014	10490	10490	221.8	2225.8	2447.6	221.8	2375.7	2597.5	0.7422	7.2840	8.0262
54	327.15	15.00	1.014	10020	10020	226.0	2222.9	2448.9	226.0	2373.2	2599.2	0.7550	7.2543	8.0093
55	328.15	15.74	1.015	9577.9	9578.9	230.2	2220.0	2450.2	230.2	2370.8	2601.0	0.7677	7.2248	7.9925
56	329.15	16.51	1.015	9157.7	9158.7	234.3	2217.2	2451.5	234.4	2368.4	2602.7	0.7804	7.1955	7.9759
57	330.15	17.31	1.016	8758.7	8759.8	238.5	2214.3	2452.8	238.5	2365.9	2604.5	0.7931	7.1663	7.9595
58	331.15	18.15	1.016	8379.8	8380.8	242.7	2211.4	2454.1	242.7	2363.5	2606.2	0.8058	7.1373	7.9431
59	332.15	19.02	1.017	8019.7	8020.8	246.9	2208.6	2455.4	246.9	2361.1	2608.0	0.8184	7.1085	7.9269
60	333.15	19.92	1.017	7677.5	7678.5	251.1	2205.7	2456.8	251.1	2358.6	2609.7	0.8310	7.0798	7.9108
61	334.15	20.86	1.018	7352.1	7353.2	255.3	2202.8	2458.1	255.3	2356.2	2611.4	0.8435	7.0513	7.8948
62	335.15	21.84	1.018	7042.7	7043.7	259.4	2199.9	2459.4	259.5	2353.7	2613.2	0.8560	7.0230	7.8790
63	336.15	22.86	1.019	6748.2	6749.3	263.6	2197.0	2460.7	263.6	2351.3	2614.9	0.8685	6.9948	7.8633
64	337.15	23.91	1.019	6468.0	6469.0	267.8	2194.1	2462.0	267.8	2348.8	2616.6	0.8809	6.9667	7.8477
65	338.15	25.01	1.020	6201.3	6202.3	272.0	2191.2	2463.2	272.0	2346.3	2618.4	0.8933	6.9388	7.8322
66	339.15	26.15	1.020	5947.2	5948.2	276.2	2188.3	2464.5	276.2	2343.9	2620.1	0.9057	6.9111	7.8168
67	340.15	27.33	1.021	5705.2	5706.2	280.4	2185.4	2465.8	280.4	2341.4	2621.8	0.9180	6.8835	7.8015
68	341.15	28.56	1.022	5474.6	5475.6	284.6	2182.5	2467.1	284.6	2338.9	2623.5	0.9302	6.8561	7.7864
69	342.15	29.84	1.022	5254.8	5255.8	288.8	2179.6	2468.4	288.8	2336.4	2625.2	0.9425	6.8288	7.7714
70	343.15	31.16	1.023	5045.2	5046.3	292.9	2176.7	2469.7	293.0	2334.0	2626.9	0.9548	6.8017	7.7565
71	344.15	32.53	1.023	4845.4	4846.4	297.1	2173.8	2470.9	297.2	2331.5	2628.6	0.9670	6.7747	7.7417
72	345.15	33.96	1.024	4654.7	4655.7	301.3	2170.9	2472.2	301.4	2329.0	2630.3	0.9792	6.7478	7.7270
73	346.15	35.43	1.025	4472.7	4473.7	305.5	2168.0	2473.5	305.5	2326.5	2632.0	0.9913	6.7211	7.7124
74	347.15	36.96	1.025	4299.0	4300.0	309.7	2165.1	2474.8	309.7	2324.0	2633.7	1.0034	6.6945	7.6979

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Table 42

Compartment	Number of air renewals per hour for Supply ventilation	Exhaust ventilation
[illegible]		
Public rooms (staterooms, dining saloons, etc.)	15 to 20	10 to 15
Smoking rooms	—	15 to 20
Gymnasiums	15	20
Swimming pools	15	20
Russian baths	—	10 to 20
Galleys	5 to 10	40 to 60
Provision rooms without cooling facilities	5 to 10	10 to 15
Bathrooms, toilets and laundries	5	15 to 20
Sick bays	5 to 10	10 to 20
Baggage rooms	—	20
Deck refreshment bars	10 to 15	25 to 30
Upper deck passageways	—	6
Middle deck passageways	—	7
Lower deck passageways	—	8
Engine and boiler rooms	30	35

p_{st}=760 mmHg, relative humidity of φ_{st}=50 per cent and density γ_{st}=1.2 kg per cu m. The capacity of the fan determined for air in a given state, having a pressure p_a, volume Q_a and temperature t_a, can be converted to the standard air capacity by using formula (276) which is derived from the equation

[illegible]

whence

$$Q_{st} = [illegible] \frac{p_a}{760} [illegible] \qquad (276)$$

[illegible] hour

The theoretical head developed by the fan is expressed in mm of water column:

$$H_{t\infty} = \frac{1}{g}(c_{2u}u_2 - c_{1u}u_1) = \frac{1,000}{g}\frac{\gamma_{air}}{\gamma_{wat}}(c_{2u}u_2 - c_{1u}u_1) =$$

$$= \rho(c_{2u}u_2 - c_{1u}u_1)\ \mathrm{mmH_2O} \qquad (27[illegible])$$

where [illegible] kg per cu m

[illegible]

Upon radial entry of the air into the fan impeller vanes:

$$H_{t\infty} = \rho c_{2u}u_2\ \mathrm{mmH_2O}$$

Taking into account the effect of having a finite number of impeller vanes on the developed head by the factor σ and for the losses of head in the fan by the hydraulic efficiency η_h we obtain the actual head

$$H = H_{t\infty}\sigma\eta_h = \sigma\rho c_{2u}u_2\eta_h = \sigma\rho\frac{c_{2u}}{u_2}u_2u_2\eta_h =$$

$$= \sigma\rho\varphi_h u_2^2\eta_h = \rho\psi_h u_2^2\ \mathrm{mmH_2O} \qquad (272)$$

where $\varphi_h = \frac{c_{2u}}{u_2}$ = eddy current factor

$\psi_h = \sigma\varphi_h\eta_h$ = head factor taken equal to: 0.8 to 1.1 for forward-curved vanes; 0.6 to 0.8 for radial, or straight, vanes; 0.5 to 0.7 for backward-curved vanes.

The fan head required to accommodate a given ventilating system depends upon the resistance and characteristic curves of the latter.

The permissible maximum peripheral speeds (tip speeds) of an impeller, based upon fan design and strength considerations, are listed in Table 43. The table also lists the most widely used inlet and outlet angles of the vanes.

Table 43

Type of fan	Peripheral speed, m per sec	Inlet angle	Outlet angle
Low-pressure	30 to 40	95 to 105	15 to 25
Medium-pressure	40 to 50	125 to 130	30 to 35
High-pressure	50 to 90	140 to 145	40 to 45

Backward curved vanes are rarely employed and then only for low-pressure fans. The number of vanes is usually assigned so as to facilitate laying out and may be equal to 4, 6, 8, 12, 16, 24, [illegible]

(1) fans of service and living compartments, designed to provide induced ventilation in these spaces;

(2) cargo hold fans, designed for ventilating the holds of dry-store bulk carriers, tankers and refrigerated cargo vessels, as well as refrigerated provision chambers;

(3) boiler plant fans, designed to produce artificial draught for the steam boilers;

(4) coal bunker fans.

Depending upon the way they are installed fans are classified as:

(1) supply fans in which the fan discharge is connected with the spaces being served;

(2) exhaust fans in which the fan inlet is connected to the spaces being served;

(3) ceiling fans, designed to produce air movement in the spaces without providing exchange.

As regards the pressure they develop, fans are divided into:

(1) low-pressure fans developing a head up to 100 mmH_2O;

(2) medium-pressure fans developing a head up to 300 mmH_2O;

(3) high-pressure fans developing a head up to 1,500 mmH_2O.

According to the mechanical composition of the gas they handle, there are:

(1) fans for delivering pure gases;

(2) dust fans designed for delivering gases polluted by mechanical impurities.

The specific velocity, n_s, of a fan is a value relating the air discharge, Q cu m per hour, full head, H mmH_2O, at normal atmospheric conditions and the fan wheel speed, n rpm, at the highest efficiency:

$$n_s = \frac{n\sqrt{Q}}{\sqrt[4]{H^3}}$$

Gas passing through the fan is compressed to only the slightest degree and is therefore assumed to be an incompressible fluid. In this case all the main principles in the theory and operation of centrifugal pumps are valid for fans as well.

The capacity of a fan for ventilating definite service quarters must be sufficient to maintain the chemical composition, humidity and temperature of the air within the requirements of sanitary regulations.

The unwholesomeness, or contamination, of the air in a room or compartment due to the presence of people is usually estimated by the carbon dioxide content, which increases with an increase of harmful impurities in the air. The carbon dioxide content of the air must not exceed 0.1 to 0.15 per cent by volume.

The fan capacity required to maintain a stipulated chemical composition of the air in a compartment is

$$Q_{ch} = V_r \frac{V_{rc}}{V_{mr} - V_{cc}} \text{ cu m per hour} \qquad (273)$$

where V_{rc} = volume of carbon dioxide produced per cu m of the given room, litres per cu m

V_r = volume of the room, cu m

$V_{mr} \approx 1$ = the maximum carbon dioxide content per cu m of the given room, litres per cu m

$V_{cc} \approx 0.3$ = carbon dioxide content per cu m of sea air entering the room, litres per cu m.

The volume of air required to maintain the prescribed temperature in a room is

$$Q_t = \frac{Q_r}{c_a (t_r - t_{fa}) \gamma_{fa}} = \frac{Q_r}{c_a (t_r - t_{fa}) \frac{\gamma_0}{1 + \alpha t_r}} = \frac{Q_r (1 + \alpha t_r)}{c_a (t_r - t_{fa})} \gamma_0 \qquad (274)$$

where $c_a \approx 0.24$ = mean heat capacity of air, kcal per kg °C

t_r = given temperature of the room, °C

t_{fa} = temperature of the fresh air entering the room, °C

Q_r = amount of heat entering the room, kcal per hour

γ_{fa} = density of the fresh air entering the room, kg per cu m

$\gamma_0 \approx 1.29$ = density of dry air at 0°C and a pressure of 760 mmHg, kg per cu m

$\alpha = \frac{1}{273}$ = coefficient of volumetric expansion of air.

The amount of external air required to maintain the relative humidity in a room is

$$Q_{hu} = \frac{100 D_{hu}}{\varphi_r d_r - \varphi_{fa} d_{fa}} \text{ cu m per hour} \qquad (275)$$

where D_{hu} = amount of moisture entering the room, g per hour

d_r and d_{fa} = absolute humidity of saturated air at the room temperature, t_r, and at the temperature, t_{fa}, of the entering air, g per cu m (see Table 38)

φ_r and φ_{fa} = relative humidity of the air in the room and of the entering air, per cent.

Data on the relative humidity and temperature of the outside air depending upon the locality in which the ship is operating, and the permissible values for various accommodations are listed in Table 39.

The amount of carbon dioxide, heat and vapour produced by persons in a room can be calculated from the data of Table 40.

Each adult produces per hour	Carbon dioxide, litres/h	Heat, kcal/h	Vapour, g/h
At hard physical work	45	150	130
At quiet work	23	100	75
At rest	23	75	70
At sleep	23	75	40
Each child up to 12 years of age produces	12	50	23

It should be noted that the amount of vapour produced in a room by the operation of steam engines and steam lines is approximately equal to 1 or 2 per cent of the steam consumption of the engines or lines.

The heat generated by various sources and introduced into the premises they occupy can be determined from the formulas listed in Table 41.

In calculating the fan capacity required for engine and boiler rooms it is necessary to take into consideration the amount of air required for the operation of internal combustion engines and boilers.

The approximate volumes of air required for the operation of internal combustion engines, V_{eic}, and boilers, V_b, are found from the following formulas:

$$V_{eic} = 60\,\alpha_{ex} V_{cyl} n \text{ cu m per hour}$$

where V_{cyl} = total displacement of the cylinders, cu m

n = engine shaft speed, rpm

α_{ex} = 1.3 to 1.5 = excess air coefficient.

$$V_b = 1.15\,\alpha_b (1 + \alpha t_{fa})\, B \frac{Q_l}{1{,}000} \text{ cu m per hour}$$

where $\alpha_b \approx 1.2$ to 1.5 = excess air coefficient

α = coefficient of volumetric expansion of air

B = fuel consumption, kg per hour

Q_l = lower calorific value of the fuel, kcal per kg.

The required fan capacities calculated from formulas (273), (274) and (275) will not be the same and therefore the highest value should be taken for any given compartment.

Tentative values of the required capacity can be estimated on the basis of the number of air renewals per hour n_{rc} as established by experience for various accommodations (Table 42).

Table 41

Source of heat	Heat emitted into surroundings, Q_l, kcal/h	Notation
Steam boilers	(0.03 to 0.05) $G_f Q_l$	Q_f = total fuel consum tion in boiler, k per hour Q_l = lower calorific valu of the fuel, kc per kg G_s = steam consumptio kg per hour Δi = useful heat dro kcal per kg N_e = effective power N = power, kW i_e = mean current de sity per sq mm c conductor cross sec tion, A per sq m η = efficiency of ele trical machine g_e = fuel consumptio kg per hp-h k = coefficient of hea transmission c room walls, kcal pe hour per sq m pe deg C F = area of the roo walls, sq m Δt = difference in tem peratures of roo wall surfaces an external surfaces o ship's hull, deg
Steam turbines	0.005 $G_s \Delta i$	
Steam engines	(0.005 to 0.01) $G_s \Delta i$	
Auxiliary machinery	(0.02 to 0.03) $G_s \Delta i$	
Steam lines	0.01 $G_s \Delta i$	
Internal combustion engines	0.02 $N_e g_e Q_l$	
Electrical machinery:		
(a) with recirculating cooling system	$64\, N \frac{1-\eta}{\eta}$	
(b) without cooling	$864\, N \frac{1-\eta}{\eta}$	
Lighting fixtures	864 N	
Wires, bus bars, cables and fittings	2,160 i_e^2	
Heat introduced from outside by transmission through ship's hull	$\Sigma kF \Delta t$	

In this case, if V_{com} is the volume of the compartment in cu m the required hourly capacity of the fan will be

$$Q_a = n_{rc} V_{com} \text{ cu m per hour}$$

The fan capacity needed is selected on the basis of what is called standard air. This means air at a temperature $t_{st} = 20°C$, pressur

The power required to drive a fan is found from the formula

$$N_a = \frac{Q_a H}{75\eta_t 3,600} \text{ hp}$$

The overall efficiency of a fan is made up of the following efficiencies:

1. Hydraulic efficiency, which takes into consideration the loss of head in the fan

$$\eta_h = \frac{H}{H + \Delta H} = \frac{H}{H_t} = 0.7 \text{ to } 0.85$$

where ΔH = loss of head in the fan.

2. Hydraulic friction efficiency which takes into account the losses due to the friction of the impeller shrouds against the fluid being transferred

$$\eta_{fr} = \frac{N_{fr}}{N_a} = \frac{\beta 10^{-6} \rho D_2^2 u_2^3}{N_a}$$

where N_{fr} = power lost in overcoming fluid friction

$\beta = (5 \text{ to } 15)\,(1 + 5\frac{b_2}{D_2})$ = coefficient obtained from data compiled by the Central Institute of Aero- and Hydrodynamics

b_2 = width of the impeller at air outlet

D_2 = impeller diameter at air outlet

For backward-curved vanes—$\eta_{fr} \simeq 0.6$ to 0.75

For forward-curved vanes—$\eta_r \simeq 0.75$ to 0.9.

3. Mechanical efficiency which takes into account the losses due to mechanical friction

$$\eta_m = \frac{N_a - \Delta N_{mf}}{N_a} \approx 0.95 \text{ to } 0.99$$

where ΔN_{mf} = power lost in overcoming mechanical friction. The overall efficiency of a fan is thus

$$\eta_t = \eta_h \eta_{fr} \eta_m = 0.4 \text{ to } 0.75 \qquad (279)$$

The overall efficiency of an axial fan may reach $\eta_t \approx 0.84$.

2-2. Design and Selection of Fans

Strictly aerodynamical calculations in fan design do not, as a rule, ensure results in subsequent tests that comply with the initial design data.

More accurate results may be achieved by designing a fan similar to one which has already been built, tested and modified to obtain the most favourable aerodynamic and design features.

This type of fan design is carried out by the similarity method using aerodynamic diagrams and dimensionless characteristics which we will consider in the following.

The initial data for fan design comprise: the total head, H, consisting of the static, H_{st}, and dynamic, H_{dyn}, heads, capacity, Q_s, and the rotational speed, n, at maximum efficiency. Thus

$$H = H_{st} + H_{dyn} = H_{st} + \frac{v^2}{2g} \times 10^{-3} \text{ mmH}_2\text{O} \qquad (280)$$

where v = mean velocity in the discharge connection of the fan. On the basis of the discharge per second, Q_s head, H, and speed, n, we next determine the specific velocity of the fan.

The specific velocity of a fan is a value that relates the air discharge, Q_{st} cu m per sec, the total head, H mmH$_2$O, and the impeller speed, n, at maximum efficiency:

$$n_s = \frac{n\sqrt{Q_{st}}}{\sqrt[4]{H^3}} \qquad (281)$$

It is evident that the ratio of the capacities of a series of geometrically similar fans of identical design can be expressed by the dimensionless discharge coefficient $\overline{Q}_k$. Therefore

$$\overline{Q}_k = \frac{Q_s}{F u_2}$$

and

$$Q_s = \overline{Q}_k F u_2 = \overline{Q}_k \frac{\pi D_2^2}{4} u_2 \text{ cu m per sec}$$

where F = area of the impeller, sq m

D_2 = outside diameter of the impeller, m.

The peripheral speed at the outlet circumference of the impeller is found from the formula

$$u_2 = \frac{\pi D_2 n}{60} \text{ m per sec}$$

The pressure developed by a series of geometrically similar fans can be characterized by the pressure coefficient, $\overline{H}_k$:

$$\overline{H}_k = \frac{H}{u_2^2 \rho} \text{ -- for the total head, and}$$

$$\overline{H}_{kst} = \frac{H_{st}}{u_2^2 \rho} \text{ -- for the static head.}$$

Whence, if we know $\overline{H}_k$ from the characteristics of pilot models, we can determine

$$H = \overline{H}_k u_2^2 \rho \text{ mmH}_2\text{O}$$

$$H_{st} = \overline{H}_{kst} u_2^2 \rho \text{ mmH}_2\text{O} \qquad (282)$$

difference in pressures in the chambers will cause the vanes to turn clockwise.

As soon as the helmsman stops turning the wheel the pressure in the system drops, valve *41* is returned to its central position by spring *44* and the rudder comes to rest.

In cases when the rudder is operated by emergency steering facilities (quadrants, rudder tackle, etc.), compression of the liquid in the chambers is prevented by opening the relief-bypass valve *33* by its spindle *45*.

The interaction of the parts of this steering gear for counterclockwise rotation of the rudder can be followed out in Fig. 156.

4-4. Determining the Principal Data Required in the Design of Steam and Electric Steering Gears

The main initial data required to determine the principal dimensions of steering gears are the rudder characteristic, χ_r, the torque, M_{rs}, in kg-m developed on the rudder head and the time, τ, required to put over the rudder.

The time required to put the rudder from hard-over to hard-over, depending upon the purpose of the ship and used in steering gear design, is listed in Table 47. It should not exceed the standards established by the U. S. S. R. Shipping Register.

The time that elapses before the steering engine reaches its rated speed, which we shall call the starting time, must be taken into consideration by reducing the time τ for putting the rudder from hard-over to hard-over by 1.5 to 2 seconds.

Table 47

[illegible]	Time required to put rudder from hard-over to hard-over, sec	Speed of rudder movement, deg/sec, for rudder angle of	
		$2\alpha^\circ = 70^\circ$	$2\alpha^\circ = 64^\circ$
Ice breakers	15	4.66	4.25
Sea-going craft and transport ships . . .	25 to 30	2.8 to 2.34	2.56 to 2.13
Towboats	20 to 25	3.5 to 2.8	3.2 to 2.56
River craft	40 to 45	1.75 to 1.55	1.6 to 1.44

If we denote the gearing ratio between the rudder stock and steering engine shaft as i_{sg}, the overall efficiency of the steering gear as η_{sg} and the speed at which the rudder stock turns, expressed in rpm, as n_{rs}, then the torque developed on the steering engine shaft and its speed, n_m rpm, will be

$$M_m = \frac{M_{rs}}{i_{sg}\eta_{sg}} \text{ kg-m} \tag{312}$$

$$n_m = i_{sg} n_{rs} \text{ rpm} \tag{313}$$

where n_m = 100 to 350 rpm for steam engines
n_m = 300 to 1,800 rpm for electric motors.

The angular velocity of rotation ω_{rs} of the rudder stock can be calculated from the following formulas:

$$\omega_{rs} = \frac{\pi n_{rs}}{30} \text{ 1/sec} \tag{314}$$

$$\omega_{rs} = \frac{2\alpha^\circ}{\tau}\,\frac{\pi}{180^\circ} \text{ 1/sec} \tag{315}$$

where α° = maximum rudder angle from the middle-line plane.

It follows from formula (314) that

$$n_{rs} = \frac{30\omega_{rs}}{\pi} \text{ rpm} \tag{316}$$

Combining equations (315) and (316) we obtain

$$n_{rs} = \frac{30}{\pi}\,\frac{2\alpha^\circ}{\tau}\,\frac{\pi}{180} = \frac{1}{3}\,\frac{\alpha^\circ}{\tau} \text{ rpm} \tag{317}$$

Combining equations (313) and (317) we can write

$$i_{sg} = \frac{n_m}{n_{rs}} = \frac{n_m}{\frac{1}{3}\frac{\alpha^\circ}{\tau}} = 3n_m\frac{\tau}{\alpha^\circ} \tag{318}$$

Taking equations (314) and (315) into consideration, the power developed on the rudder stock is

$$N_{rs} = \frac{M_{rs}\omega_{rs}}{75} = \frac{M_{rs}}{75}\,\frac{2\alpha^\circ}{\tau}\,\frac{\pi}{180^\circ} = 4.65\,\frac{M_{rs}}{10^4}\,\frac{\alpha^\circ}{\tau} \text{ metric hp} \tag{319}$$

$$N_{rs} = \frac{M_{rs}\omega_{rs}}{75} = \frac{M_{rs}}{75}\,\frac{\pi n_{rs}}{30} = 1.395\,\frac{M_{rs}n_{rs}}{10^3} \approx 1.4\,\frac{M_{rs}n_{rs}}{10^3} \text{ metric hp} \tag{320}$$

The shaft horse power of the steering engine motive unit will be

$$N_m = \frac{N_{rs}}{\eta_{sg}} = 4.65\,\frac{M_{rs}}{10^4\eta_{sg}}\,\frac{\alpha^\circ}{\tau} \text{ metric hp} \tag{321}$$

$$N_m = \frac{N_{rs}}{\eta_{sg}} = 1.4\,\frac{M_{rs}}{10^3\eta_{sg}}\,n_{rs} \text{ metric hp} \tag{322}$$

The shaft horse power can also be determined from the shaft torque

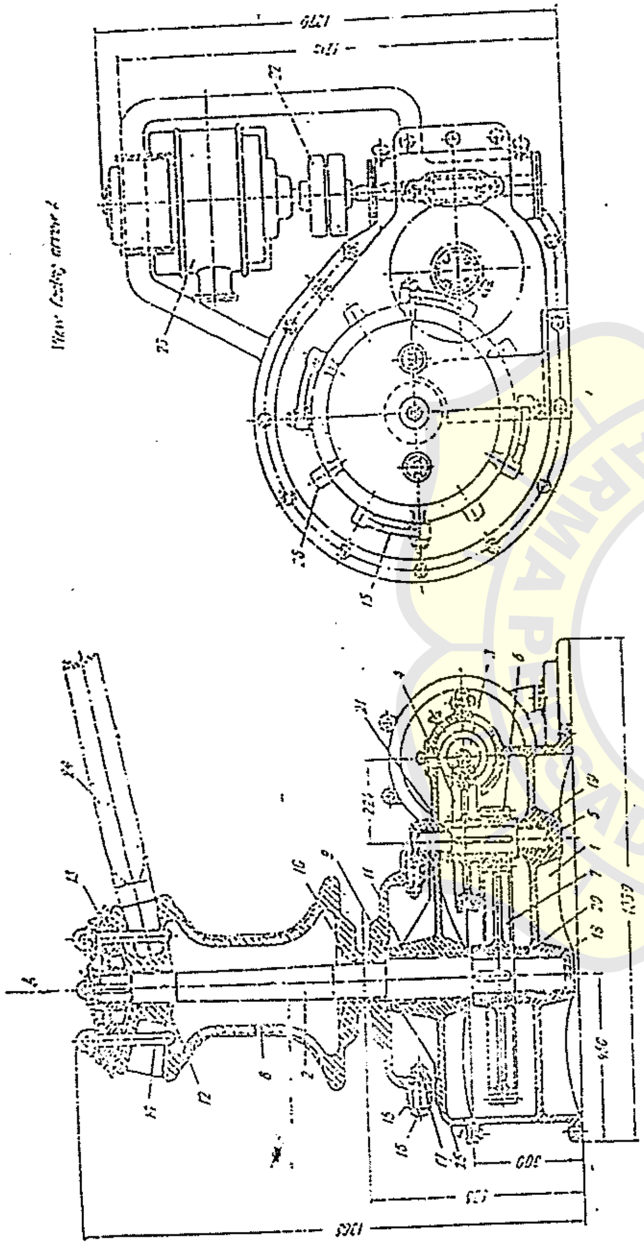


Fig. 169.

5-3. Determining the Principal Dimensions of Anchoring and Warping Machinery

The initial data used to determine the principal dimensions of anchoring machinery are the required pull of the cable lifter and the speed at which the anchor is weighed from the anchorage depth, which is equal to the distance from the hawse hole to the bottom.

It is advisable to determine the pull on the cable lifter so as to ensure that one anchor will be brought in at a speed of at least 12 m per min from the anchorage depth which is taken equal to:

80 m if each anchor weighs 1,000 kg or less
90 m if the anchor weighs from 1,500 to 3,000 kg
100 m if the anchor weighs from 3,000 to 6,000 kg.

The following notation will be used to derive the formulas for determining the pull on the cable lifter:

G_a = weight of the anchor, kg
p_a = weight per running metre of the chain cable, kg
L_a = length of the suspended cable, m
γ_a = 7,750 = density of the material of the anchor, kg per cu m
γ_w = 1,025 = density of sea water, kg per cu m
f_h = 1.28 to 1.35 = a factor taking into account the friction losses in the hawse hole and stopper.

The required pull of the cable lifter to hoist two anchors is

$$T_{cl} = 2f_h(G_a + p_a L_a)\left(1 - \frac{\gamma_w}{\gamma_a}\right) = 2 \times 1.35(G_a + p_a L_a)\left(1 - \frac{1,025}{7,750}\right) = = 2.35(G_a + p_a L_a) \text{ kg} \qquad (383)$$

in hoisting one anchor

$$T_{cl} = 1.175(G_a + p_a L_a) \text{ kg}$$

The following empirical formulas can be derived from a comparison of the weights of anchors and the size of their chains as stipulated by the U.S.S.R. Shipping Register, as well as the U.S.S.R. Standard on anchor chain:

The chain bar size $d_c \approx \sqrt{G_a}$ mm. The weight per running metre of anchor chain is

$$\left.\begin{aligned} &(a)\ p_{co} = 0.020 d_c^2 \text{ kg for open-link chain} \\ &(b)\ p_{cs} = 0.0218 d_c^2 \text{ kg for stud-link chain} \end{aligned}\right\} \qquad (384)$$

According to the U.S.S.R. Shipping Register the aft anchoring arrangement, usually consisting of a capstan, must break away the anchor and heave it in at a speed of at least 9 m per min.*

---

* In breaking away one anchor from the bottom

$$T_{cl} = 2G_a + 1.175(G_a + p_a L_a) \text{ kg}$$

If a windlass serves both for handling the anchor and for warping, the pull of the warp ends must not exceed

$$T_w = \frac{R_{br}}{6} \qquad (385)$$

where R_{br} = breaking strength of the warping hawser.

The speed at which a capstan barrel heaves in a warping hawser can be taken from Table 58 which has been compiled from the manufacturing specifications for capstans worked out by the Central Marine Research Institute of the U.S.S.R.

Table 58

Pull of the capstan barrel, kg	Hawser heaving-in speed, m per sec	Useful power, kg-m/sec
1,200	0.3	360
3,000	0.25	750
4,500	0.2	900
7,000	0.167	1,165
12,000	0.150	1,800

The speed at which a warping hawser is heaved in by a windlass is not limited by the values in Table 58, and usually is equal to about 0.4 m per sec.

It has been stated previously that the same machinery is employed both for anchoring and warping purposes. It follows that windlasses and capstans must be designed so as to ensure normal operation of both the anchoring and warping arrangements.

As a rule, anchoring and warping capstans and windlasses are designed to ensure the proper operation of the anchoring arrangement, and then a check is made to see whether they provide for the required pull and heaving-in speed of the warping hawsers.

The number of anchors, their weight, the size of the anchor chain cables, the circumference of warping hawsers and towing ropes, and their length are determined from the tables of the pertinent regulations of the Shipping Register. To find these values it is necessary to calculate the rigging characteristic of the anchoring and warping arrangement:

$$X = L(B + H) + \Sigma\chi_i \qquad (386)$$

where L = length of the ship at the summer load line, m

B = maximum breadth between the outer edges of the ship's hull, m

H = height of the side amidships, measured from the upper edge of the keel to the lower edge of the strength deck stringer, m

$\Sigma\chi_i$ = correction factor taking into account the sail effect of the superstructures.

Correction factors for the sail effect of the superstructures having a height h_i and length l_i consist of:

(a) correction factors for the superstructures of the forecastle, poop and midships, each having a length l_{sp} and height h_{sp}:

$$\chi_{sp} = k_{1sp}\Sigma l_{sp} h_{sp}$$

where k_{1sp} = 0.75 if the total length of the superstructures is equal to or less than 0.5 L

$k_{1sp} = 1.5\frac{l_{sp}}{L}$ if the total length of the superstructures exceeds 0.5 L

(b) correction factors for the deck houses, each having a height h_{dh} and length l_{dh}:

$$\chi_{dh} = k_{dh}\Sigma l_{dh} h_{dh}$$

where k_{dh} = 0.5 if the deck house has a length l_{dh} equal to or less than 0.5 L

$k_{dh} = \frac{l_{dh}}{L}$ if the length, l_{dh}, of the deck house exceeds 0.5 L.

If the breadth, b_{dh}, of the deck house exceeds its length, l_{dh}, then the product $b_{dh}h_{dh}$ is substituted into the equation in place of $l_{dh}h_{dh}$. Thus

$$\chi_{dh} = k_{dh}\Sigma b_{dh} h_{dh}$$

(c) correction factor for the quarter deck having a length l_q and height h_q:

$$\chi_q = l_q h_q$$

Data on the anchoring and warping arrangements are listed in Tables 59 and 60. The weight of each anchor is found by dividing their total weight by the number of anchors. The separate anchors may be lighter than the specified values by 7.5 per cent. The lengths of the anchor chain cables are given in the table on the assumption that the average length of each shot is 25 m. The cable length does not include the lengths of the chain slip, joining shackles, connecting links and short pieces of shots with swivels. If the tabular cable length comprises an odd number of shots, then the length of the starboard anchor chain cable is taken one shot longer than the port cable.

A section, taken through the central plane of the usual five-snug cable lifter (Fig. 170) perpendicular to the shaft will be a regular

Table 59

Self-Propelled Transport Ships with an Unlimited Region of Navigation

No.	Characteristic X	Anchors			Chain cable for bower anchors		Chain or steel rope for the stream anchor		
		Bower		Stream anchor, kg	Total length of two cables, m	Anchor chain size, mm	Length, m	Anchor chain size, mm	Diameter of steel rope, mm
		Quantity	Total weight, kg						
1	50	2	150	25	100	12	50	—	6.5
2	75	2	200	25	125	13	50	—	8.8
3	100	2	250	50	125	15	50	—	11
4	150	2	300	50	150	16	50	—	11
5	200	2	350	50	175	17	75	—	11
6	250	2	450	75	200	18	75	11	13
7	300	2	500	75	225	19	75	13	13
8	350	2	600	100	250	20	75	14	15.5
9	400	2	700	100	275	21	75	14	15.5
10	450	2	750	125	300	22	100	15	17.5
11	500	2	800	150	300	24	100	16	17.5
12	550	2	900	175	325	25	100	16	17.5
13	600	3	1500	200	350	27	100	17	17.5
14	650	3	1700	225	350	28	100	18	19.5
15	700	3	1800	250	375	29	100	18	20.5
16	750	3	2100	250	375	30	100	19	20.5
17	800	3	2250	250	375	31	125	19	20.5
18	850	3	2400	275	375	32	125	20	22
19	900	3	2700	300	375	33	125	21	24
20	950	3	3000	300	400	34	125	21	24
21	1000	3	3200	350	400	36	125	22	24
22	1100	3	3500	400	400	37	125	23	26
23	1200	3	3750	400	420	38	150	25	26
24	1300	3	4100	450	450	40	150	25	28
25	1400	3	4250	450	450	41	150	25	28
26	1500	3	4500	500	450	42	150	26	28
27	1600	3	4750	500	450	43	150	26	28
28	1700	3	5250	600	450	45	150	28	30
29	1850	3	5500	600	450	46	150	28	30
30	2000	3	5750	700	450	46	150	29	31.5
31	2150	3	6000	700	475	48	175	29	31.5
32	2300	3	6500	800	500	49	175	29	32.5
33	2500	3	6750	800	500	50	175	29	32.5
34	2700	3	7500	900	500	52	175	30	33.5
35	3000	3	8250	1000	500	53	200	31	33.5
36	3300	3	9000	1000	500	55	200	31	33.5
37	3600	3	9750	1250	525	57	200	33	34.5
38	3900	3	10500	1250	550	59	225	33	34.5
39	4200	3	11000	1400	550	61	225	34	37
40	4500	3	11500	1500	550	62	225	35	37
41	4800	3	12900	1650	550	65	225	36	—
42	5100	3	13500	1750	550	67	250	37	—
43	5400	3	14500	1750	575	68	250	37	—
44	5800	3	15000	2000	600	70	250	40	—
45	6200	3	15800	2000	600	72	250	40	—
46	6600	3	15300	2250	600	74	275	43	—
47	7000	3	17600	2250	600	76	275	43	—
48	7400	3	18000	2250	600	77	275	44	—
49	7800	3	19500	2500	600	80	275	46	—
50	8200	3	20300	2700	600	82	275	48	—
51	8600	3	21000	2800	600	83	275	49	—
52	9000	3	22000	3000	600	85	275	50	—
53	9500	3	23000	3000	600	87	275	50	—

Note: Two bower anchors with a total weight of at least 2/3 of the tabular value are sufficient for ships navigating in the Caspian Sea and having a characteristic of 600 or larger.

pentagon. If the bar size of the anchor chain cable is denoted as d_c mm, then the chain pitch equal to $8d_c$ is to be accommodated along one side AC of the pentagon. Thus, since $AB = BC = 4d_c$, it is evident from triangle OBC that the effective diameter of the cable lifter is

$$D_{cl} = 2R_{cl} = 2\frac{4d_c}{\sin\alpha} = \frac{8d_c}{\sin\frac{360^\circ}{10}} = 13.6d_c \text{ mm} = 0.013d_c \text{ m} \quad (387)$$

The length of anchor chain cable heaved in in one revolution of the cable lifter is

$$l_c = 5l_c = 5\times 8d_c = 40d_c \text{ mm} = 0.04d_c \text{ m} \quad (388)$$

where d_c=chain bar size, mm.

Table 60

Mooring and Warping Ropes

Characteristic	Towing rope			Warping hawsers							
								Cable warps			
	Length, m	Circumference of hemp rope, mm	Diameter of steel rope, mm	Total length, m	Number of ropes	Circumference of hemp rope, mm	Diameter of steel rope, mm	Total length, m	Number of ropes	Circumference of hemp rope, mm	Diameter of steel rope, mm
50	50	75	—	50	1	65	—	—	—	—	—
75	50	90	11	50	1	65	—	—	—	—	—
100	75	90	11	75	1	65	8.5	—	—	—	—
150	75	100	12	75	1	75	9.5	—	—	—	—
200	100	100	12	100	2	75	9.5	—	—	—	—
250	100	125	15	140	2	100	12	—	—	—	—
300	110	125	15	160	2	100	12	—	—	—	—
350	110	150	17.5	160	2	100	12	—	—	—	—
400	135	150	17.5	180	2	125	15	80	1	100	12
450	135	150	17.5	180	2	125	15	80	1	100	12
500	135	150	17.5	200	2	125	15	85	1	100	12
550	135	175	19.5	200	2	125	15	85	1	100	12
600	135	175	19.5	220	2	150	17.5	90	1	100	12
650	135	175	19.5	240	2	150	17.5	90	1	100	12
700	150	200	21.5	240	2	150	17.5	90	1	100	12
750	150	200	21.5	360	4	150	17.5	90	1	125	15
800	150	200	21.5	360	4	150	17.5	90	1	125	15
850	175	200	21.5	360	4	150	17.5	90	1	125	15
900	175	225	24	360	4	175	19.5	120	2	125	15
950	175	225	24	360	4	175	19.5	120	2	125	15
1000	175	225	24	360	4	175	19.5	120	2	150	17.5
1100	175	225	24	360	4	175	19.5	140	2	150	17.5
1200	190	250	26	360	4	175	19.5	140	2	150	17.5
1300	190	250	26	400	4	200	21.5	150	2	150	17.5
1400	190	275	28	400	4	200	21.5	150	2	150	17.5
1500	190	275	28	450	4	200	21.5	150	2	150	17.5
1600	200	300	30	480	4	200	21.5	180	2	150	17.5
1700	200	300	30	480	4	200	21.5	180	2	150	17.5
1850	200	325	32.5	540	4	200	21.5	180	2	175	19.5
2000	200	350	34.5	540	4	200	21.5	180	2	175	19.5
2150	200	350	34.5	540	4	200	21.5	180	2	175	19.5
2300	220	350	34.5	540	4	225	24	180	2	175	19.5
2500	220	350	34.5	640	4	225	24	200	2	175	19.5

Continued

Characteristic	Towing rope			Warping hawsers							
								Cable warps			
	Length, m	Circumference of hemp rope, mm	Diameter of steel rope, mm	Total length, m	Number of ropes	Circumference of hemp rope, mm	Diameter of steel rope, mm	Total length, m	Number of ropes	Circumference of hemp rope, mm	Diameter of steel rope, mm
2700	220	350	34.5	640	4	225	24	200	2	200	21.5
3000	220	250	34.5	640	4	225	24	200	2	200	21.5
3300	240	375	39	640	4	250	26	200	2	200	21.5
3600	240	375	39	640	4	250	26	200	2	200	21.5
3900	240	400	43.5	640	4	250	26	200	2	200	21.5
4200	240	400	43.5	640	4	250	26	200	2	225	24
4500	240	425	48.5	720	4	250	26	200	2	225	24
4800	240	425	48.5	720	4	250	26	200	2	225	24
5100	240	—	53	720	4	275	28	240	2	225	24
5400	240	—	53	800	4	275	28	240	2	250	26
5600	240	—	53	880	4	275	28	240	2	250	26
6200	240	—	57	960	6	300	30	240	2	250	26
6600	240	—	57	960	6	300	30	240	2	250	26
7000	240	—	57	960	6	300	30	240	2	250	26
7400	240	—	57	960	6	300	30	400	4	250	26
7800	240	—	57	960	6	300	30	480	4	250	26
8200	240	—	61.5	960	6	300	30	430	4	250	26
8600	240	—	61.5	960	6	325	32	480	4	250	26
9000	240	—	61.5	960	6	325	32	480	4	250	26
9600	240	—	61.5	960	6	325	32	480	4	250	26

Notes: 1. If the actual characteristic is between two tabular values, data should be taken for the next larger tabular characteristic.

2. The diameter and circumference of ropes selected from the table for ships with square rigging are to be increased by one size.

3. The towing rope for nonpropelling vessels is taken one size larger than the tabular value (in diameter and circumference). In addition to the towing rope indicated in the table, towing vessels (tugs) must have a towing rope for towing other vessels. This latter is to be selected in accordance with the pulling capacity of the hook which is taken with a fivefold margin of safety.

4. If Manilla or sisal hemp ropes are to be used instead of ordinary hemp, they can be taken one size less than the tabular value.

Denoting the heaving-in speed of the anchor cable as v_a m per sec, we can find the speed, n_{cl}, in rpm, of the cable lifter from the equation

$$i_s n_{cl} = 60\, v_a$$

(a) for windlasses and capstans of bower anchors:

$$n_{cl} = \frac{60\,v_a}{0.04\,d_c} = \frac{60 \times 0.2}{0.04\,d_c} = \frac{300}{d_c} \quad \text{rpm}$$

(b) for the stern anchoring capstan:

$$n_{cl} = \frac{9}{0.04\,d_c} = \frac{225}{d_c} \quad \text{rpm}$$

The efficiency of the anchoring arrangement is $\eta_a = 0.7$ to 0.85 for mechanisms with spur gearing and $\eta_a = 0.65$ to 0.75 for mechanisms with worm gearing. It is the product of the efficiencies of the transmissions and shaft bearings in the gear train (Fig. 171):

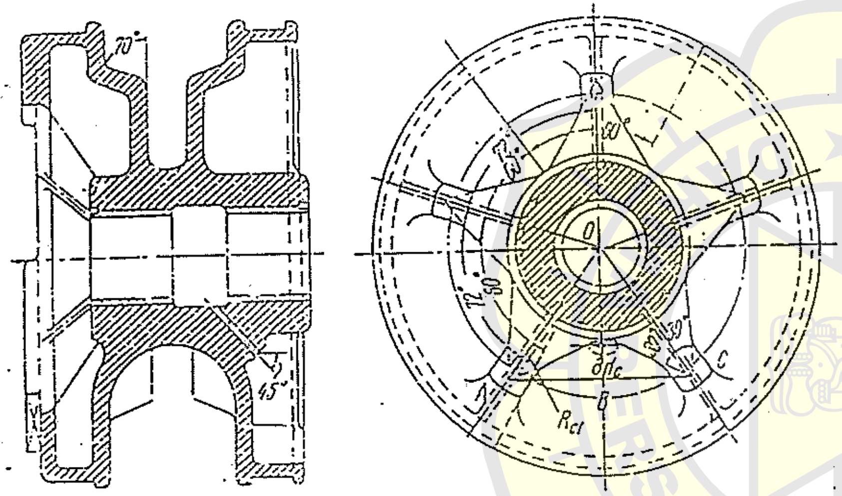


Fig. 170.

$$\eta_a = \eta_{cl}\eta_{sh}^{a}\eta_{pg}^{c}\eta_{wg}$$

where η_{cl}, η_{sh}, η_{pg}, η_{wg} = efficiencies of the cable lifter, shaft bearings, pairs of spur gears and worm gearing

a and c = number of shaft bearings and pairs of spur gears.

The torque on the cable lifter is

$$M_{cl} = \frac{T_{cl}D_{cl}}{2\eta_{cl}} \quad \text{kg-m}$$

where $\eta_{cl} = 0.9$ to 0.92 = efficiency of the cable lifter.

Denoting the engine shaft speed as n_m, the gearing ratio of the mechanism (Table 61) is

$$i_a = \frac{n_m}{n_{cl}}$$

Table 61

Anchor-handling gear	Motive unit shaft speed n_m, rpm	Gearing ratio of mechanism, i_a
Hand-operated capstans		4 to 40
Steam capstans	160 to 320	18 to 60
Electric capstans	800 to 1450	110 to 200
Hand-powered windlasses		9 to 18
Steam windlasses	90 to 270	6 to 30
Electric windlasses	720 to 1550	105 to 250

The torque developed on the shaft of the motive unit is

$$M_m = \frac{M_{cl}}{i_c\eta_a} \quad \text{kg-m}$$

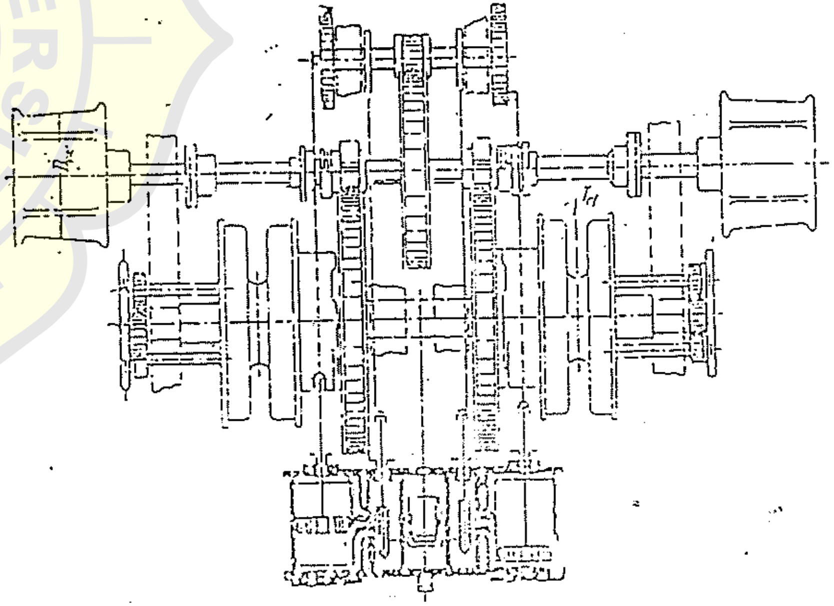


Fig. 171.

where Q_b = 570 to 2,175 = weight of the fully rigged boat, kg

Q_p = total weight of all persons allowed to embark (the weight of one person is approximately 75 kg; the number of persons in a boat may reach 78), kg

$Q_f = 0.05(Q_b + Q_p)$ = weight of the boat's falls, kg

k_n = 0.9 to 1.1 = coefficient of nonequal distribution of the movable load due to the weight of the persons in the boat.

The maximum tension of the fall at the winch head, after running over the maximum number of guide devices, is

$$T_{max}=\frac{[illegible](Q_b+1.1Q_p)+Q_f}{m\eta_f\eta_r\eta_s^a}$$

where m = total number of blocks in the boat's falls;

$$\eta_f=\frac{1}{m\varepsilon^m}\frac{\varepsilon^m-1}{\varepsilon-1}=\text{efficiency of the boat's falls}$$

ε = coefficient depending upon the ratio of the block diameter to the tackle fall diameter ($\varepsilon=1.1$ for a hemp fall and $\varepsilon=1.04$ to 1.06 for a steel wire rope)

η_r = 0.9 to 0.97 = efficiency of the davit guide roller

η_s = 0.9 to 0.97 = efficiency of the snatch-block

a = maximum number of blocks between the davit guide roller and the winch head.

The tension at the end of a rope that has run over the minimum number of blocks is

$$T_{min}=\frac{[illegible](Q_b+0.9Q_p)+Q_f}{m\eta_f\eta_r\eta_s^c}$$

where c = minimum number of blocks.

The diameter d_f of a hemp fall is selected according to the breaking strength $(T_{max}+T_{min})6\leq R_b$, as a function of the boat length from Table 6[illegible] [illegible] Shipping Register.

Table [illegible]

Boat length, m	Circumference of tackle fall, mm	Breaking strength, kg
8.25 to 9.[illegible]	95	[illegible],100
7.62 to 8.25	90	5,400
7.35 to 7.62	83	4,000
6.72 to 7.35	73	3,900

The winch head diameter is

$$D_h=(5\text{ to }8)\,d_f$$

The speed, v_b, with which the boats are hoisted and lowered is assigned so that if the ship is rolling one of these operations can be carried out during the rolling period. This can be accomplished if the heaving-in speed is greater than the vertical component of the crest speed of waves running along the length of the ship. It has been established that the boat hoisting speed must be at least v_b = 0.15 m per sec under these conditions. The heaving-in speed of the tackle fall when single-sheave blocks are used must in this case be v_f = 0.3 m per sec.

The required winch head speed is found from the equation

$$\pi(D_h+d_f)\,n_h=60v_f$$

$$n_h=\frac{60v_f}{\pi(D_h+d_f)}=19.1\,\frac{v_f}{D_h+d_f}\quad\text{rpm}$$

Assigning a motive unit speed (n_m = 500 to 1,600 rpm for electric motors and n_m = 300 to 380 rpm for steam engines), we can find the gearing ratio of the boat winch. Thus

$$i_{bw}=\frac{n_m}{n_h}$$

In designing nonreversible worm gearing the number of teeth on the worm wheel is taken in the range from 24 to 44. The pulling force on the winch head is equal to the sum of the pulling forces on the tackle falls:

$$T=T_{max}+T_{min}$$

Disregarding friction losses, the torque developed on the winch head shaft will be

$$M_h=\frac{T(D_h+d_f)}{2}$$

If the winch has an efficiency of η_{bw}, the torque and power on the motive unit shaft will be

$$M_{mt}=\frac{M_h}{\eta_{bw}i_{bw}}=\frac{T(D_h+d_f)}{2\eta_{bw}i_{bw}}$$

and

$$N_e=\frac{M_{mt}n_m}{716.20}\quad\text{metric hp}$$

The cylinder diameter and indicated power of steam boat winches are determined from the same Posdyunin formulas used in

The mean shaft power of the motive unit should be

$$N_c = \frac{M_m n_m}{716.20} \quad \text{metric hp}$$

The mean indicated power is

$$N_{im} = \frac{N_c}{\eta_m}$$

The cylinder diameter of the steam engine, according to Posdyunin's formula which is based on the conditions for starting from a dead stop, is

$$D_{ca} = 1.37 \sqrt[3]{\frac{M_m}{\psi_a \eta_m (\alpha_i k_i p_{ts} - p_{ss})}} \quad \text{cm} \tag{389}$$

where M_m = torque developed on the shaft of the engine, kg-cm
ψ_a = 0.85 to 1.7 = cylinder ratio, i.e., $S : D_{ca}$.

The value of $(\alpha_i k_i p_{ts} - p_{ss})$ is approximately from 10 to 15 per cent lower than that taken for a steering engine, due to longer distance from the anchoring mechanism to the steam supply, resulting in higher condensation losses in the pipelines. The other values in the formula are to be within the same limits as for steam steering engines.

The indicated power N_{ia} required to start the engine from rest and the coefficient of reserve power are

$$N_{ia} = \frac{\psi_a D_{ca}^3 (\alpha_i k_i p_{ts} - p_{ss}) n_m}{143,300} \quad \text{metric hp} \tag{390}$$

$$\varphi_{res} = \frac{N_{ia}}{N_{im}}$$

The steam consumption of the engine driving the anchoring arrangement is

$$G_{ia} = g_{ia} N_{ia} \quad \text{kg per hour}$$

where g_{ia} = specific steam consumption, kg per ihp-hr (the same values are taken as for a steam steering engine).

If need arises to determine the pull on the cable lifter from data measured on the anchoring mechanism, formula (390) can be used.

Solving Posdyunin's formula (389) for the torque developed on the shaft of the steam engine we can write

$$M_m = \left(\frac{D_{ca}}{1.37}\right)^3 \eta_m \psi_a (\alpha_i k_i p_{ts} - p_{ss}) \quad \text{kg-cm}$$

On the other hand, if i_a is the total gearing ratio of the transmission in the anchoring mechanism, then

$$M_m = \frac{M_{cl}}{\eta_a i_a} = \frac{T_{cl} D_{cl}}{2 \eta_a i_a} \quad \text{kg-cm}$$

Combining the last two equations we obtain

$$T_{cl} = \frac{2 M_m \eta_a i_a}{D_{cl}} = 2 \left(\frac{D_{ca}}{1.37}\right)^3 \frac{\eta_m \psi_a (\alpha_i k_i p_{ts} - p_{ss}) \eta_a i_a}{D_{cl}} =$$

$$= 0.78 \frac{D_{ca}^3}{D_{cl}} \eta_m \psi_a (\alpha_i k_i p_{ts} - p_{ss}) \eta_a i_a \quad \text{kg}$$

The diameter of the warp ends is taken equal to

(a) $D_{we} = (5 \text{ to } 8) d_w$ for hemp ropes (391)

(b) $D_{we} = (15 \text{ to } 20) d_w$ for steel ropes (392)

where d_w = diameter of the warping hawser.

Warp end diameters determined from the diameter of hemp ropes will be suitable for steel ropes as well.

Denoting the hawser heaving-in speed as v_w m per sec we can find the speed of the warping shaft from the length of hawser heaved in per minute. Thus

$$n_w = \frac{60 v_w}{\pi (D_{we} + d_w)} = 19.1 \frac{v_w}{D_{we} + d_w} \quad \text{rpm} \tag{393}$$

where v_w = hawser heaving-in speed, m per sec, is to be assigned according to the pull of the warp end (Table 58).

The gearing ratio between the warping shaft and the shaft of the motive unit is

$$i_w = \frac{n_m}{n_w}$$

The pulling force developed on the warp end is

$$T_{we} = \frac{M_{we}}{\frac{1}{2}(D_{we} + d_w)} = \frac{2 M_m \eta_w i_w}{D_{we} + d_w} \leqslant \frac{R_{br}}{6} \tag{394}$$

where M_{we} = torque developed on the warp end
η_w = efficiency of the transmission between the warping and motive unit shafts.

If n_m rpm is the speed of the motive unit shaft, the speed at which the hawser is heaved in will be

$$v_w = \frac{\pi (D_{we} + d_w) n_m}{60 i_w} \quad \text{m per sec} \tag{395}$$

maximum pressure, p_f kg per sq m, then the amount of liquid pumped is

$$V_p = V_e - V_f = D_1 \quad \text{cu m}$$

This equation can be solved for V_e and V_f:

$$V_e = V_f + D_1 = V_f + \frac{D}{6}$$

and

$$V_f = V_e - D_1 = V_e - \frac{D}{6}$$

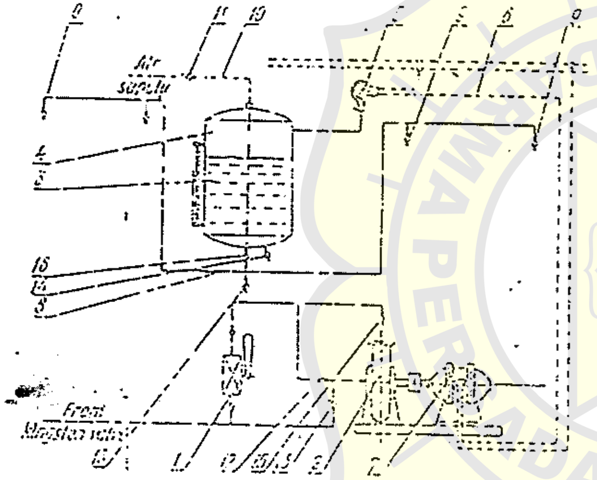


Fig. 189.

The equation of state for the air in the air cushion can be written as

$$V_e p_e = V_f p_f = \left(V_f + \frac{D}{6}\right) p_e = \left(V_e - \frac{D}{6}\right) p_f$$

Therefore the minimum and maximum volumes of [illegible]

$$V_f = \frac{Dp_e}{6(p_f - p_e)} \quad \text{and} \quad V_e = \frac{Dp_f}{6(p_f - p_e)}$$

Denoting by V_0 the volume of liquid remaining in the tank at the lowest level, we find that the volume of the pneumatic tank is

$$V_t = V_0 + V_e = V_0 + \frac{Dp_f}{6(p_f - p_e)}$$

Such tanks may also be used in the drinking and washing water sys-

(D) SANITARY AND SCUPPER SYSTEMS

The sanitary and scupper systems serve to remove water from the deck and also to dispose of used water from baths, laundries, refreshment bars, galleys, storerooms, etc. Water is drained from the decks through scuppers and their pipes which range from 50 to 100 mm in diameter.

The diagram in Fig. 190 shows how water is removed through scupper pipes *1* from the upper decks and compartment decks. From each deck water runs down to the next lower deck through scupper pipes until it reaches the last open deck above the load waterline from where it is discharged overboard through deck scuppers 2. Large amounts of water drain from open decks through freeing ports *10* installed in the bulwarks.

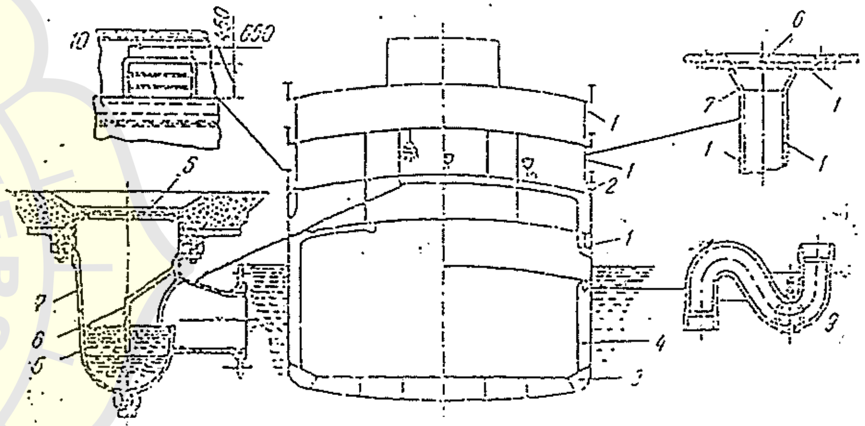


Fig. 190.

Water is drained from decks located lower than the load waterline through scupper pipes *1* into bilge courses 3 or into dirty water tanks arranged in the double-bottom or side spaces from where it is discharged overboard by pumps.

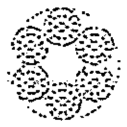
Scuppers 7 with grates 6, cowls 8 and sumps 5 avoid clogging of the scupper pipes. S-traps 9 are provided in scupper pipes which drain water from closed compartments to prevent the odour of the sewage spaces from getting into the compartments.

Shipside outlets of scupper pipes serving closed compartments are fitted with swing-check valves to exclude sea water in rough weather.

Sanitary pipelines made of galvanized pipe must be laid with

Table 37

WIRE ROPES

Nominal strength	[illegible] N/mm²	1570 N/mm²	1570 N/mm²
Nominal dia of rope	accord. to DIN 3055  Round rope 6 × 7 Constr. 6(6 + 1) + FE	accord. to DIN 3060  Round rope Standard 6 × 19 Constr. 6(12 + 6 + 1) + FE	accord. to DIN 3068  Round rope Standard 6 × 24 Constr. 6(15 + 9 + FE) + FE
	Nominal breaking load¹)		
mm	kN	kN	kN
8	33,4	30,9	28,2
10	52,2	43,2	44,0
12	75,1	69,5	63,3
14	102	94,6	86,2
16	134	124	113
18	169	156	142
20	209	193	175
22	252	234	213
24	300	278	253
26	353	328	297
28	409	378	345
32	534	494	450
36	676	625	570
40	835	772	704
44	–	934	851
48	–	1110	1100
52	–	1300	1190
56	–	1510	1330
[illegible]	[illegible] Guy pendants	Shrouds, Stays, Guy pendants, Preventers, fastened by means of ropes-sockets to the hull, Ropes for single-reeved span, not to be topped under load	Cargo runners (hoisting ropes) Span wire ropes (luffing ropes) Guy pendant, Guy tackle, Preventer

¹) [illegible] for ropes with core of fibre material. The nominal breaking loads are [illegible] of same construction are used with core of steel wire rope.

Nominal strength	1570 N/mm²	1770 N/mm²	1570 N/mm²	1770 N/mm²
Nominal dia of rope	DIN 3066  Round rope Standard 6 × 37 Construction 6(18 + 12 + 6 + 1) + FE		DIN 3059  Round rope Warrington-Seale 6 × 36 Construction 6(14 + 7/7 + 7 + 1) + FE	
	Nominal breaking load¹)			
mm	kN	kN	kN	kN
8	29,5	33,4	–	–
10	45,3	52,2	51,3	58,4
12	56,6	75,1	74,5	84,1
14	90,7	102	102	114
16	113	134	132	149
18	150	169	163	189
20	135	209	207	234
22	224	253	251	283
24	267	301	296	336
26	313	353	350	395
28	363	409	406	458
32	474	534	530	598
36	600	676	671	757
40	741	835	829	934
44	596	1010	1006	1130
48	1070	1200	1190	1350
52	1250	1410	1406	1530
56	1150	1640	1629	1830
60	1670	1880	1360	2190
64	1900	2140	–	–

Approved for gears with a SWL up to 10 t:	Nominal strength 1570 N/mm²: cargo runners (hoisting ropes), span ropes (luffing ropes), guy tackles, preventer, etc., which are carried not permanently set
Approved for gears with a SWL up to 10 t:	Nominal strength 1770 N/mm²: cargo runners (hoisting ropes), span ropes (luffing ropes) [illegible]

Denomination of a rope made of round strands

according to nominal diameter of rope, DIN-standard, type of core, surface of wires, nominal strength of wires, kind and direction of impact

e. g.: rope 20 DIN 3066 – FE zn S 1570 sZ

According to DIN 3051, Sheet 4, Table 1

meaning of the following abbreviations:

FE = fibre core

[illegible] = [illegible]

Notes to Table 44.

Shackles

1. Shackles may be subjected only to tensile loads.

2. Wherever possible, shackles should be so connected that the bolt side is attached to a round eye and the strap side to an elongated eye or chain link.

3. Type C shackles are to be used for fastening cargo and span blocks, for attaching guy blocks, span runners and guy pendants to the head fitting and for beckets to the eyes of blocks.

4. Shackles for cargo hooks to Table 45, cargo chains and cargo hook swivels must have slotted bolts (type B).

5. Type A shackles may only be used for connecting the lower guy blocks and snatch blocks to the deck.

Table 44

SHACKLES

according to DIN 82101, Feb. 76

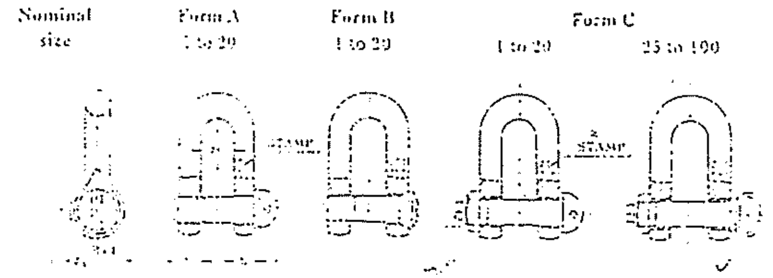
Member	Material
Bow	RSt 37-2, St 44-2 DIN 17100, C 22 DIN 17200 or C 15 DIN 17210
Pin	St 52 K DIN 1652, St 44-2 DIN 17100 or C 22 DIN 17200

Nominal size	Working load limit "WLL"	s_1	d_1	d_2	Pin	
					d	Thread
	t	mm	mm	mm	mm	
1	1	21	13	32	16	M 16
1,6	1,6	27	17	40	20	M 20
2	2	30	19	44	22	M 22
2,5	2,5	33	21	48	24	M 24
3	3,2	38	24	54	27	M 27
4	4	42	27	60	30	M 30
5	5	47	30	72	36	M 36
6	6,3	53	31	78	39	M 39
8	8	60	33	90	45	M 45
10	10	66	42	96	48	M 48
12	12,5	73	47	104	52	M 52
16	16	81	51	120	60	M 60
20	20	90	53	136	68	M 68
25	25	109	63	144	72	M 72 × 6
32	32	110	70	160	80	M 80 × 6
40	40	125	79	180	90	M 90 × 6
50	50	140	88	200	100	M 100 × 6
63	63	155	95	220	110	M 110 × 6
80	80	175	119	250	125	M 125 × 6
100	100	200	125	280	140	M 140 × 6

Symbol

according to Form nominal size and No. of Table.

e. g.: Shackle A 16 - [11]



Tempera-ture, °C	Density, kg/m³	Absolute humidity, g/m³	Vapour pressure, mm Hg
−25	1,424	0.64	0,540
−24	1,418	0.71	0,600
−22	1,406	0.86	0,745
−21	1,401	0.95	0,825
−20	1,395	1.05	0,910
−19	1,390	1.15	1,000
−18	1,384	1.25	1,095
−17	1,379	1.35	1,190
−16	1,374	1.46	1,290
−15	1,368	1.58	1,400
−14	1,363	1.70	1,520
−13	1,358	1.83	1,635
−12	1,353	1.98	1,780
−11	1,347	2.14	1,930
−10	1,342	2.31	2,093
−9	1,337	2.49	2,267
−8	1,332	2.69	2,455
−7	1,327	2.90	2,658
−6	1,322	3.13	2,876
−5	1,317	3.37	3,113
−4	1,312	3.64	3,368
−3	1,306	3.92	3,644
−2	1,303	4.22	3,941
−1	1,298	4.55	4,263
0	1,293	4.89	4,600
+1	1,288	5.23	4,940
+2	1,284	5.60	5,302
+3	1,279	5.98	5,667
+4	1,275	6.39	6,097
+5	1,270	6.82	6,534
+6	1,265	7.28	6,998
+7	1,261	7.76	7,492
+8	1,255	8.26	8,017
+9	1,252	8.82	8,574
+10	1,247	9.39	9,165
+11	1,243	10.01	9,792
+12	1,239	10.64	10,457
+13	1,235	11.32	11.162
+14	1,230	12.03	11.908
+16	1,222	13.59	13.536
+17	1,217	14.43	14.421
+18	1,213	15.31	15.357
+19	1,209	16.25	16.346
+20	1,205	17.22	17.391
+21	1,201	18.25	18.495
+22	1,197	19.33	19.659
+23	1,193	20.48	20.888
+24	1,189	21.68	22.184
+25	1,185	22.93	23.550
+26	1,181	24.24	24.988
+27	1,177	25.64	26.505
+28	1,173	27.09	28.101
+29	1,169	28.62	29.782
+30	1,165	30.21	31.548
+31	1,161	31.89	33.406
+32	1,157	33.64	35.350
+33	1,154	35.48	37.411
+34	1,149	37.40	39.565
+35	1,146	39.41	41.827
+36	1,142	41.51	44.201
+37	1,139	43.71	46.691
+38	1,135	46.00	49.302
+39	1,131	48.40	52.039
+40	1,128	50.91	54.906
+41	1,124	53.52	57.910
+42	1,121	56.25	61.055
+43	1,117	59.09	64.346
+44	1,114	62.05	67.790
+45	1,110	65.14	71.391
+46	1,107	68.36	75.158
+47	1,103	71.73	79.093
+48	1,100	75.22	83.204
+49	1,096	78.86	88.499
+50	1,093	82.63	91.982

Table 39

Data on fresh air and sea water						
	Warmest period of navigation			Coldest period of navigation		
Locality	Temperature of outside air t_{fa}, °C	Water temperature t_w, °C	Relative humidity of outside air φ_{fa}, %	Temperature of outside air t_{fa}, °C	Water temperature t_w, °C	Relative humidity of outside air φ_{fa}, %
Rivers that freeze	20 to 30	16 to 25	55 to 65	−5	4	75 to 85
Seas in high or temperate latitudes	10 to 25	5 to 15	65 to 75	−25 to −35	0 to −2	80 to 85
Warm seas	25 to 30	20 to 25	55 to 65	−15 to −20	4	75 to 85
Tropical seas	30	27	70	20	27	70
Navigation in any localities	30	27	70	−25	0	80

Air requirements for shipboard accommodations:			
	Air temperature		
Accommodations	Coldest period of navigation, t_r, °C	Warmest period of navigation, t_r, °C	Relative humidity φ_r, %
Living and passenger accommodations, state-rooms and ward-rooms	18	$t_{fa}+5°C$	40 to 6
Passageways of living and service accommodations	15	$t_{fa}+5°C$	75 to 8
Bath- and shower-rooms	25	$t_{fa}+10°C$	70
Cloak-rooms	20	$t_{fa}+5°C$	70 to 8
Wash-rooms and laundries	15	$t_{fa}+5°C$	50
Toilets	12	$t_{fa}+5°C$	80
Galleys	8 to 22	$t_{fa}+10°C$	80
Pantries	8	$t_{fa}+5°C$	80
Wet provisions and vegetable storage rooms	2	$t_{fa}+5°C$	80

LAMPIRAN 8

II. $y = 1 - \sqrt{\frac{F_1(1-Y_1)^2 + F_2(1-Y_2)^2}{F}}$

dimana : $y_1 = (0{,}68 - 0{,}43 - \Delta y + 0{,}18 \; \frac{2h_1 + l_1}{H})w$

$y_2 = (0{,}68 - 0{,}43 - \Delta y + 0{,}18 \; \frac{2h_1 + l_2}{H})w$

$F = F_1 + F_2$

Rumus :

III. Untuk kemudi yang setengah menggantung.

Pengaruh permukaan air dan Gelombang pada kerja Kemudi.

Terbentuk putaran air pada sayap kemudi menyebabkan pengurangan tekanan pada kemudi juga menurunkan gaya angkat, kalau letak kemudi lebih dalam dari batas permukaan air.

Jika permukaan air laut tenang, kecepatan kapal dan sudut letak kemudi kecil maka bagian kemudi yang ada di atas permukaan air akan bekerja lebih baik dari pada letak kemudi yang lebih dalam dari permukaan air.

Untuk kapal-kapal yang mempunyai kecepatan besar dan dengan adanya gelombang yang tak teratur, efek baiknya (yaitu dengan sebagian kemudi di atas permukaan air) tidak akan terjadi.

Jadi untuk kapal barang atau kapal penumpang yang berlayar dilautan terbuka, dianjurkan letak kemudi jika mungkin dibawah waterline konstruksi.

Dalam percobaan model kapal yang sebenarnya menerangkan bahwa arus gelombang dapat menambah besar moment pada kemudi dalam pelayaran lurus ataupun dalam sirkulasi.

Menurut percobaan "*Henson*" dan "*Hantleker*" (dari Swedia). Gelombang dengan ketinggian 4 meter dapat menambah besarnya moment yang maximum dalam sirkulasi dan besarnya 35% jika dibandingkan dengan moment maximum dalam sirkulasi dilautan yang tenang.

Percobaan lain yang dilakukan di Jepang, untuk laut yang bergelombang maka moment yang timbul 2,5 kali moment maximum diair tenang.

Percobaan di Holland menunjukkan moment yang timbul di air bergelombang, 3 kali moment maximun di air pada sudut kemudi 30.

Bentuk geometris Kemudi.

A). Dipandang dari letak sayap kemudi terhadap porosnya maka kemudi dapat dibagi :

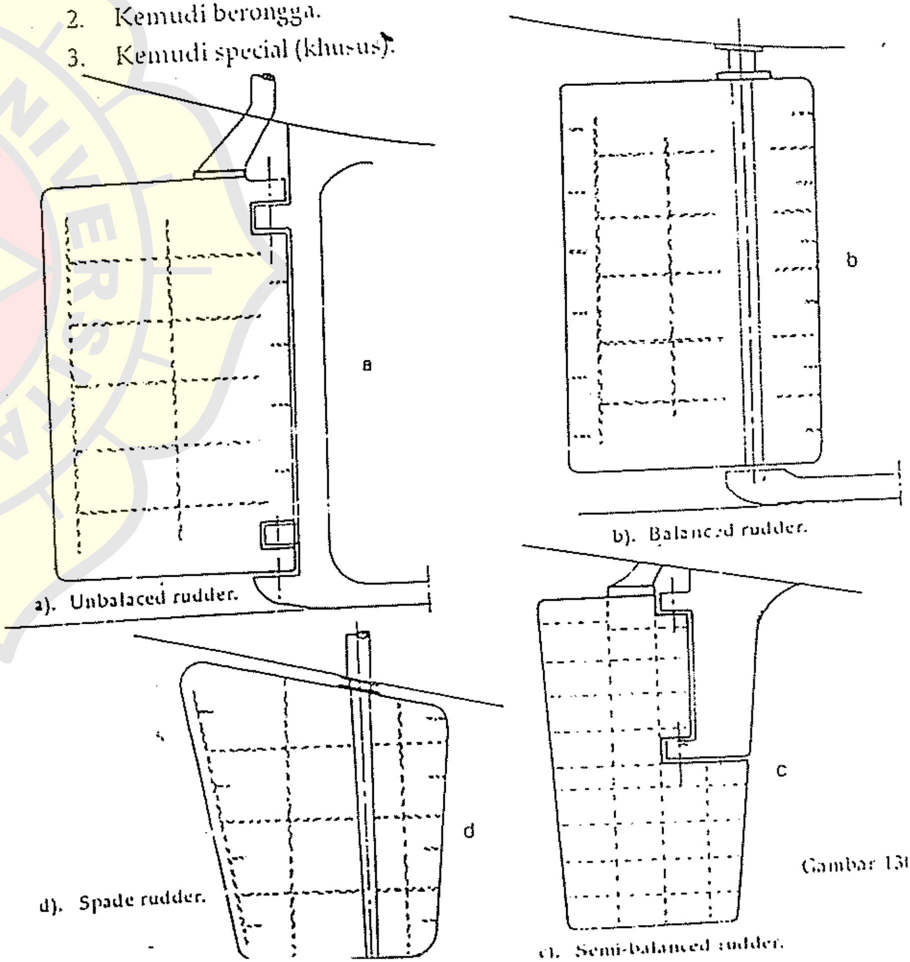
1. Kemudi biasa, dimana semua luas sayap kemudi terletak dibelakang sumbu putar kemudi (gambar a).
2. Kemudi balansir, dimana luas sayap kemudi terbagi dua, bagian dimuka dan dibelakang sumbu putar kemudi (gambar b).
3. Kemudi setengah balansir, dimana bagian atas sayap kemudi termasuk kemudi biasa, sedang bagian bawah merupakan kemudi balansir sedangkan bagian atas dan bawah tetap merupakan satu bagian (gambar c).

B). Dipandang dari sulfies (sepatu linggi) dibagi :

1. Kemudi meletak (gambar a dan b)
2. Kemudi menggantung (gambar d)
3. Kemudi setengah menggantung (gambar c)

C). Dipandang dari konstruksinya dibagi :

1. Kemudi plat (satu lapis plat).
2. Kemudi berongga.
3. Kemudi special (khusus).



a). Unbalaced rudder.

b). Balanced rudder.

c). Semi-balanced rudder.

d). Spade rudder.

Gambar 130.

θ_g = sudut antara letak bidang sayap kemudi dengan bidang yang sejajar dengan bidang simetri (bidang bujur kapal).

Pada saat kemudi berada ditengah-tengah

Untuk kemudi tunggal yang dipasang pada bidang bujur kapal keadaan sudut vertikal dan horisontal sama dengan nol.

Luas daun kemudi.

Menurut ketentuan *"Det Norske Veritas"* 1974 luas kemudi dirumuskan sebagai berikut :

$$F = \frac{TL}{100} \{ 1 + 25 (\frac{B}{L} \quad m^2$$

Dimana : T = sarat air (m)

L = panjang kapal antara garis tegak atau 0,96 LWL jika angka ini lebih besar (m).

B = lebar kapal (m).

dengan catatan :

Kemudi yang tak bekerja langsung dibelakang baling-baling luasnya ditambah dengan 30% dari ketentuan di atas. Untuk kapal-kapal dengan kemudi kembar dianjurkan, jumlah luas kemudi 3% LT.

Untuk pengontrolan dapat dipakai pedoman batas-batas : menurut G.W. Sabolev

$$\frac{0,025}{\sqrt[3]{\frac{L_1}{\delta B} - 6,2}} < \frac{F}{L_1 T} < \frac{0,03}{\sqrt[3]{\frac{L_1}{\delta B} - 72}}$$

dimana : B = lebar kapal

δ = koefisien blok

L_1 = panjang kapal

= 0,96 LWL.

$\times 90 \{ 1 + 25 (\frac{B}{96}$

Luas daun kemudi dapat pula dinyatakan dalam % LT sebagai berikut :

Type Kapal	% LT
1. Kapal barang, single screw dengan kecepatan sedang	1,5 - 2,5
2. Kapal barang, single screw dengan kecepatan tinggi.	1,6 - 2,0
3. Kapal barang kecil, single screw.	2,0 - 2,5
4. Kapal barang, twin screw, single rudder.	1,5 - 2,1
5. Kapal barang, twin screw, twin rudder.	2,1 - 3,0
6. Kapal tangker ukuran sedang.	1,3 - 1,9
7. Kapal tangker	1,7 - 2,1
8. Kapal penumpang kecepatan tinggi (L 60 m).	1,2 - 1,7
9. Kapal penumpang & barang besar kecepatan sedang.	1,6 - 2,0
10. Kapal penumpang ukuran sedang, kecepatan tinggi.	1,7 - 2,0
11. Kapal penumpang ukuran kecil kecepatan lambat.	1,7 - 2,3
12. Kapal pelayaran pantai (*coaster*).	2,0 - 3,3
13. Kapal ikan.	2,5 - 5,5
14. Kapal tunda.	3,0 - 6,0
15. Kapal layar besar.	2,0 - 2,5
16. Kapal layar sedang.	2,0 - 3,0
17. Kapal pandu.	2,3 - 4,0
18. Kapal kecil.	4,0 - 4,5
19. Kapal tak bermotor.	4,0 - 5,0

Bentuk sayap kemudi diperhitungkan menurut bentuk bagian belakang kapal (cruiser stern, biasa dan lain-lain dan ukuran bentuk sepatu linggi).

Umumnya pada teknologi pembuatan kapal dipilih bentuk sayap yang sederhana, empat persegi, tetapi untuk mendapat gaya tekan air yang maximum pada sayap kemudi, kadang-kadang dibagian atas dibuat miring membesar.

Untuk kapal-kapal yang mempunyai satu baling-baling dimana bentuk bagian belakang yang agak runcing, biasanya memakai kemudi yang setengah menggantung dengan bentuk trapesium termasuk rongga porosnya, dengan lebar bagian bawahnya kecil dengan demikian juga tebal profilnya makin ke bawah makin berkurang.

Pada kemudi balansir, untuk mengurangi kemungkinan getaran, bagian
asan balansir dianjurkan ≤ 23 dari seluruh luas kemudi dan lebar bagian
lansir pada potongan-potongan horisontal < 0,35 lebar sayap kemudi.

Pada kapal-kapal yang mempunyai batas sarat air yang cukup
nggi mempunyai ukuran yang tinggi (λ = hp/bp cukup tinggi).

Tetapi tinggi kemudi harus diperlihatkan pula menurut bentuk
urian kapal.

Beberapa batasan untuk harga λ :

Kapal barang dan kapal penumpang : λ = 1,8

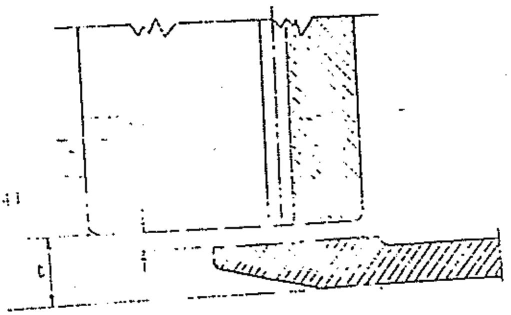
Kapal coaster : λ = 1,05 - 1,15

Kapal tunda, pandu : λ = 1,8

Kapal ikan ukuran sedang : λ = 1,55 - 2,0

Dianjurkan tinggi tiap-tiap kemudi harus menutupi diameter baling-baling. Bagian bawah kemudi untuk menjaga kerusakan-kerusakan dangeseran dengan dasar laut harus lebih tinggi dari garis dasar kapal.

Batas-batasnya sebagai berikut :



mbar 141

- Untuk kemudi menggantung atau setengah mengantung
  t = (4 - 10%) h
- Untuk kemudi bertupu ;
  t = (6 - 12)% h

Dimana :

h = tinggi kemudi.

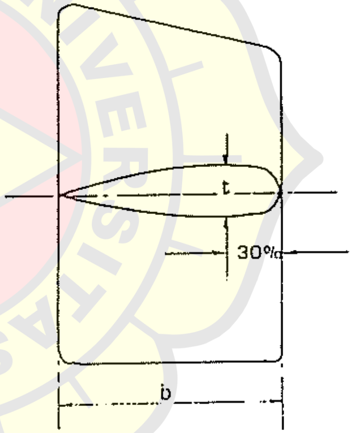
Catatan : Umumnya untuk semua bentuk diambil ketentuan :

t :50 m/m.

h Van Lammeren ditetapkan batasan-batasan λ = h/b sebagai berikut :

Type kapal dan kemudi	h/d
1. kapal barang 1 baling-baling dan kapal penumpang semuanya dengan kemudi balansir.	1,8
2. Kapal pantai 1 baling-baling dengan kemudi balansir.	1,15
1 baling-baling dan kapal pandu.	1,75
4. Untuk semua kapal dengan 2 baling-baling dengan-kemudi biasa.	1,5
5. Untuk kapal-kapal 2 baling-baling dengan kemudi-setengah balansir.	1,1
6. Untuk kapal-kapal dengan 2 baling-baling dengan-dua kemudi.	2,2

Bentuk kemudi harus dibuat sedemikian supaya dengan perubahan letak kemudi dalam sudut attack yang tidak begitu besar. kapal dapat membuat belokan besar, dengan catatan pada saat yang sama dengan perubahan letak kemudi tersebut diperhitungkan supaya tidak mempengaruhi kecepatan kapal.



Gambar 142.

Berdasarkan praktek yang dilakukan, koefisien tebal plat profil kemudi :

Ct = t/b terletak dalam batas-batas : 0,18 - 0,22.

Tetapi untuk kemudi setengah menggantung pada kapal besar hanya Ct mencapai 0,5.

Untuk kemudi biasa (tak balansir) untuk twin screw diambil batas-batas.

Ct = 0,15 - 0,18

Untuk setengah balansir :

Ct = 0,18 - 0,22

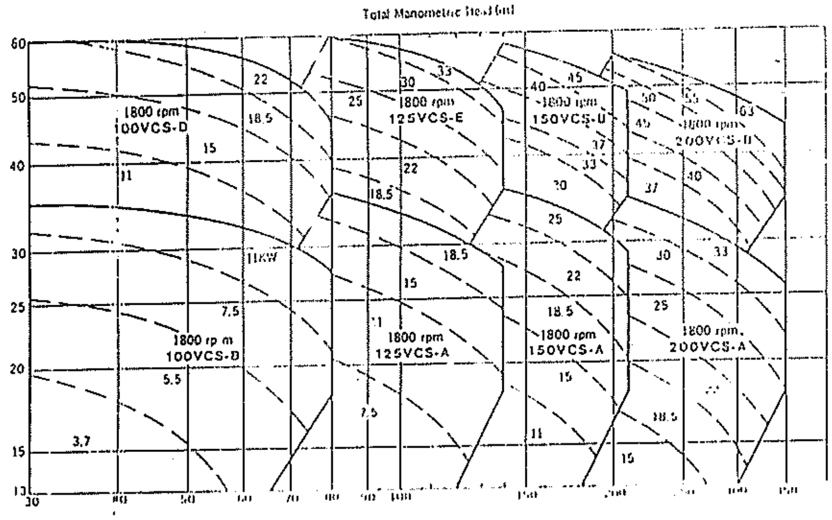
Kemudi kembar menggantung biasanya lebih tebal dari kemudi yang bertumpu, tetapi untuk menjaga kekuatan, kemudi tersebut mempunyai harga : Ct = 0,2

Untuk menghindari getaran dianjurkan supaya jarak maximum penampang kemudi yaitu 30% lebar profil, dihitung dari permukaan depan.

Koefisien kompensasi dihitung dengan rumus pendekatan yang menghasilkan perhitungan moment putar yang sangat kecil di poros, sehingga memperkecil kekuatan motor penggerak kemudi serta pengeluaran energi untuk merubah letak kemudi.

LAMPIRAN 9

PERFORMA[illegible]



EXPLANATION ON PERFORMANCE CHAR

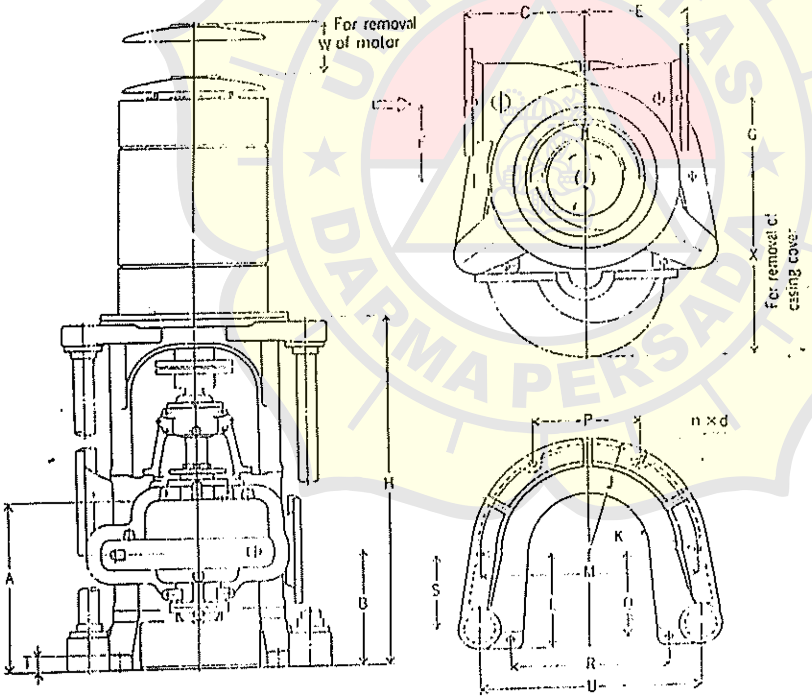
In selecting the size of a pum pattern, if the required specific point of Q-H falls just on th boundary line in the performanc chart, please select the smaller siz of the nominal bore of the patter from the adjoining ones.

The numerals entered between d agonal dotted lines, show the requ red capacity of the driver in Kw.

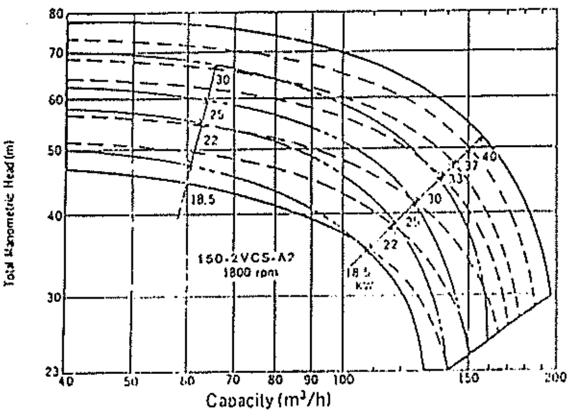
The driver with this capacity wi never be overloaded at any point o the Q-H curve developed by tl pump at the rated speed

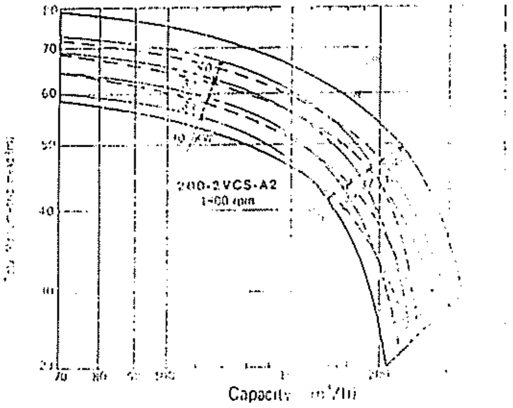
Ex. In case, the specified capacity, total head and speed are 125m³/h, 30m and 1,750 rpm respectively.
Select 125 VCS-A from the adjoining patterns of 125 VCS A, 125 VCS E and 150 VCS A.
Capacity of the driver, 18.5 KW.

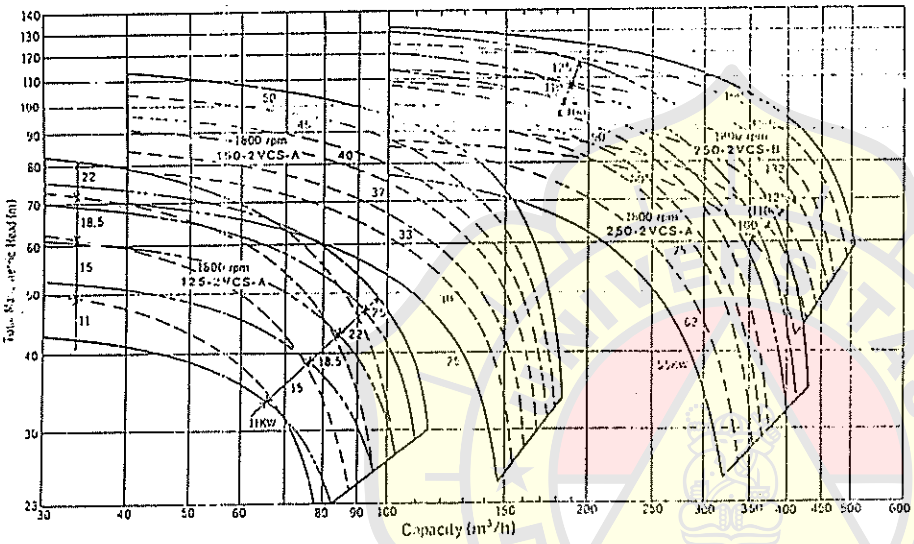
DIMEN[illegible]

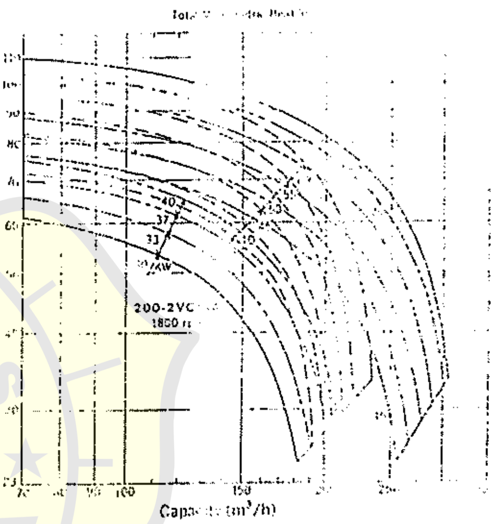


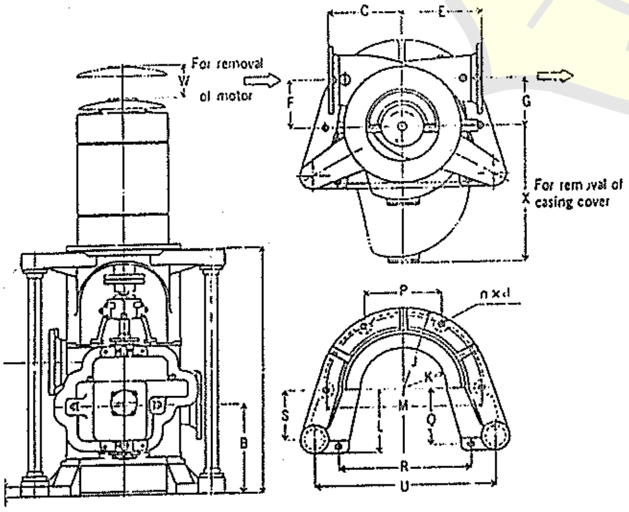
TYPE	MOTOR		NOMINAL BORE		DIMENSIONS (mm)																				WEIGHT (kg) PUMP	
	KW	rpm	SUC	DEL	A	B	C	E	F	G	H	J	K	L	M	P	Q	R	S	T	U	nxd	W	X	FC CASING	BC CASIN
100 VCS-B	3.7~11	1800	100	100	357	270	250	220	180	180	790	280	150	260	510	255	235	420	·	30		[illegible]x23	110	330	218	218
100 VCS-D	11~22				377	290	280	250	210	210	850	"	"	"	"	"	"	"	·	"	·	"	"	400	228	248
125 VCS-A	7.5~18.5		125.	125	374	270	250	220	200	200	797	"	"	"	"	"	"	"	·	"	·	"	"	340	248	[illegible]
125 VCS-E	18.5~33				394	290	290	260	230	230	880	"	"	"	"	"	"	"	·	"	·	"	140	420	262	275
150 VCS-A	11~26		150	350	456	326	310	270	210	210	901	340	190	280	630	315	255	470	·	"		"	110	360	[illegible]	371
150 VCS-B	30~45				493	373	340	300	220	220	1061	"	"	"	"	"	"	"		"		"	150	500	417	[illegible]
200 VCS-A	15~33		200	200	486	326	320	280	230	230	953	"	"	"	"	"	"	"	220	"	"	"	"	490	422	427
200 VCS-B	37~63				485	325	350	300	"	"	1022	"	"	"	"	"	"	"	"	"	"	"	"	520	462	472











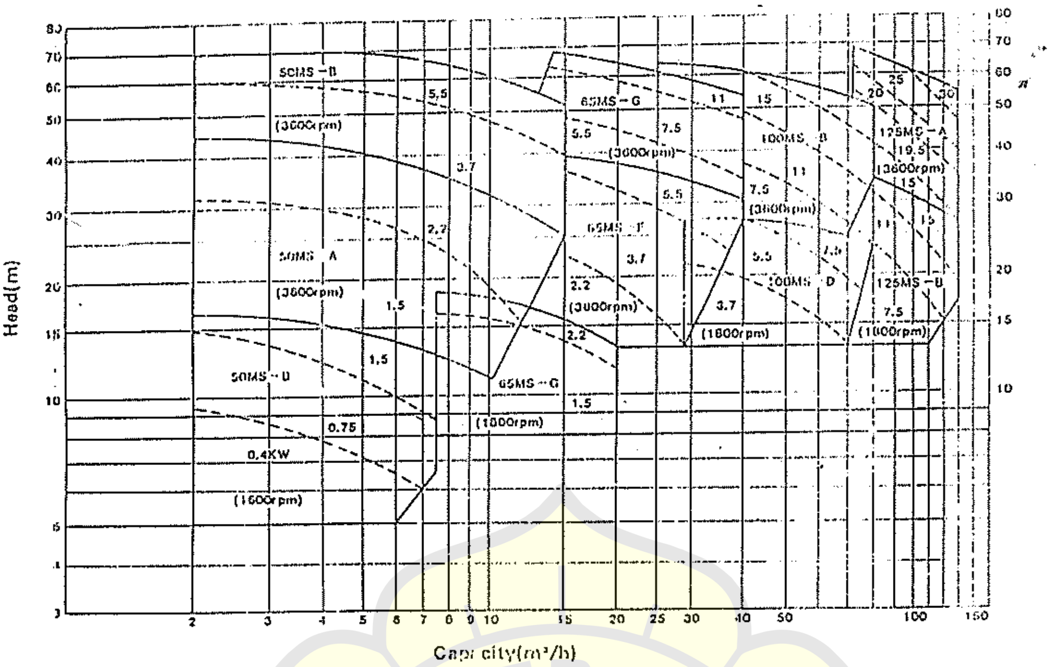
In selecting the size of pump pattern, if the required specified point of Q-H falls just on the boundary lines in the performance chart, please select the smaller size of the nominal bore of the pattern from the adjoining ones.

Dotted and chain lines show the limit of the required motor output, and additionally the tendency of the characteristic Q-H curves of the pump. If the specified point of Q-H falls on one of these lines, the numeral entered (in kw) just below that line shall be taken as the rated motor output.

Further, the applicable impellers will be different depending upon the variation in combination of required Q and H, such as 2 or 3 points are specified for instance. Accordingly, the characteristic curves will become different as shown in dotted or chain lines in the figures.

TYPE	MOTOR		NOMINAL BORE		DIMENSIONS (mm)																				WEIGHT (kg) PUMP	
	KW	rpm	SUC.	DEL.	A	B	C	E	F	G	H	J	K	L	M	P	Q	R	S	T	U	n x d	W	X	FC CASING	SC CASING
125-2VCS-A	11 ~ 25	1800	125	125	538	370	320	320	180	180	1117	340	190	280	630	315	255	470	220	30	650	6x23	140	570	602	612
150-2VCS-A	18.5~50		150	150	556	366	350	300	220	230	1109	"	"	"	"	"	"	"	"	"	"	"	"	"	705	720
200-2VCS-A	30 ~ 80		200	200	638	417	"	370	"	220	1191	400	205	340	740	370	310	560	270	34	780	6x27	"	620	762	772
250-2VCS-A	55~125		250	250	730	465	400	430	245	245	1298	"	"	"	"	"	"	"	"	"	"	"	"	720	902	907
250-2VCS-B	90~160				750	485	"	"	"	"	1354	450	250	440	840	420	410	630	355	"	930	8x27	176	850	[illegible]	975

PERFORMANCE CHART



EXPLANATION ON PERFORMANCE CHART

In selecting the size of a pump pattern, if the required specified point of O-H falls just on the boundary line in the performance chart, please select the small size of nominal bore of the pattern from the adjoining ones.

The numerals entered between diagonal dotted lines in the performance chart show the required capacity of the driver in KW. The driver with this capacity will never be overloaded at any point on the O-H curve developed by the pump at the rated speed.

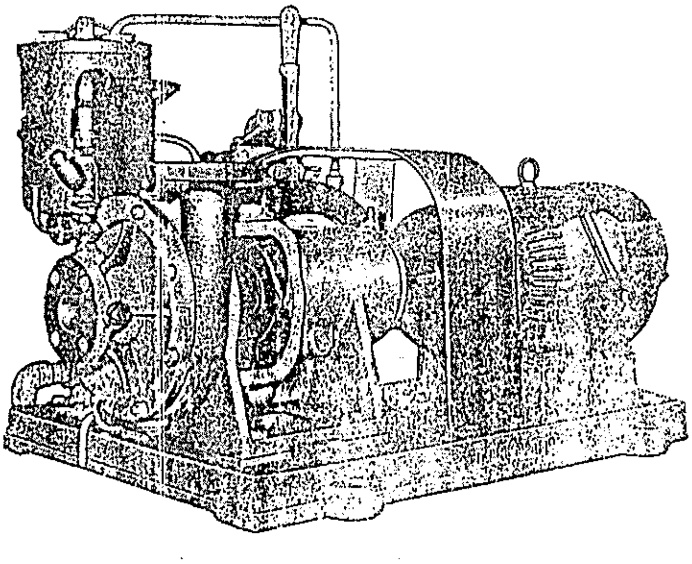
Ex. In case, the specified capacity, total head and speed are 30 m³/h, 15 m and 3,450 rpm, respectively
Select 50 MS-B from between the adjoining patterns of 50 MS-B and 65MS-F, capacity of driver, 3.7 KW.

SELF-PRIMING [illegible]

The pump can be supplied, if required, with automatic priming equipment including its necessary accessories such as sealing water tank, non-return valve, float valve and piping.

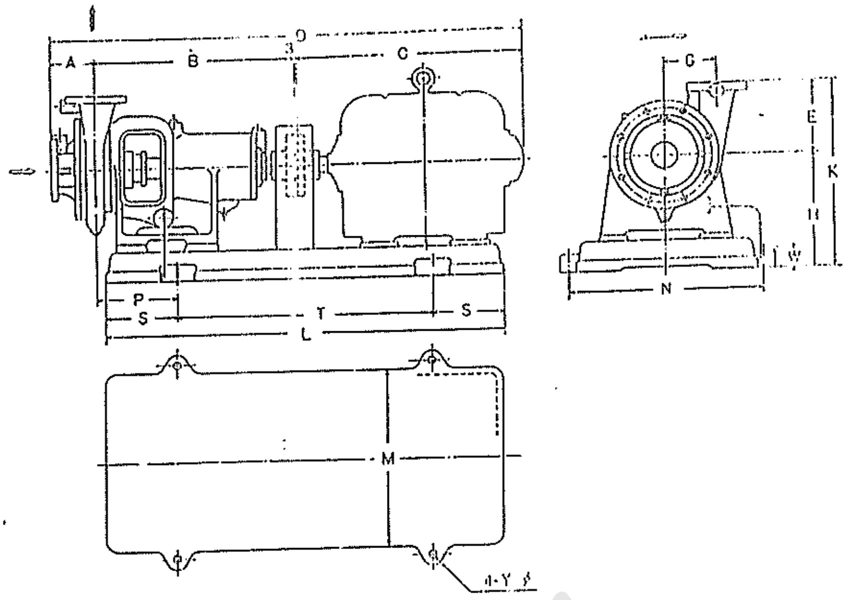
The feature of this automatic priming system is as follws:-

The primer is driven from the main pump shaft through combination coupling and friction pulley. The engagement and disengagement of the pulley are controlled automatically by means of a mechanism which is subjected to the discharge pressure developed by the main pump.



The primer ceases operation automatically on the accomplishment of the priming of the main pump and remains idle during the main pump is in service.

If the air breaks into the main pump for some reason, resulting in going down of the discharge pressure developed by the main pump, the primer begins to work automatically and the cycle recommences.



TYPE	MOTOR		NOMINAL BORE		DIMENSIONS (mm)																WEIGHT (kg) PUMP WITH BED	
	KW	rpm	SUC.	DEL.	A	B	C*	D*	E	G	H	K	L	M	N	P	S	T	W	Y	FC CASING	SC CASING
50MS-A	1.5	3600	50	50	95	400	297	795	150	105	230	380	760	290	320	150	125	510	25	15	102	105
	2.2	"	"	"	"	"	325	823	"	"	"	"	"	"	"	"	"	"	"	"	"	"
50MS-B	0.4	1800	"	"	"	"	207	705	160	120	230	390	760	290	320	150	125	510	25	15	107	110
	0.75	"	"	"	"	"	248	746	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	1.5	"	"	"	"	"	297	795	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	3.7	3600	"	"	"	"	355	853	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	5.5	"	"	"	"	"	414	912	"	"	"	"	"	"	"	"	"	"	"	"	"	"
65MS-F	2.2	3600	65	65	105	400	325	833	160	105	230	390	760	290	320	150	125	510	25	15	132	136
	3.7	"	"	"	"	"	355	863	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	5.5	"	"	"	"	"	414	922	"	"	"	"	"	"	"	"	"	"	"	"	"	"
65MS-G	1.5	1800	65	65	105	490	297	895	170	120	310	480	930	360	390	182	140	650	40	15	174	180
	2.2	"	"	"	"	"	325	923	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	5.5	3600	"	"	"	"	414	1012	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	7.5	"	"	"	"	"	452	1050	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	11	"	"	"	"	"	556	1154	"	"	"	"	"	"	"	"	"	"	"	"	"	"
100MS-B	7.5	3600	100	100	136	490	452	1081	180	125	320	500	1060	360	390	167	160	740	40	19	210	216
	11	"	"	"	"	"	556	1185	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	15–18.5	"	"	"	"	"	600	1229	"	"	"	"	"	"	"	"	"	"	"	"	"	"
100MS-D	3.7	1800	100	100	130	488	355	976	220	160	310	530	850	330	360	175	140	570	40	15	199	205
	5.5	"	"	"	"	"	414	1035	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	7.5	"	"	"	"	"	452	1073	"	"	"	"	"	"	"	"	"	"	"	"	"	"
125MS-A	15–18.5	3600	125	125	150	493	600	1246	220	150	320	540	1080	400	430	170	160	760	40	19	240	247
	22	"	"	"	"	"	625	1271	"	"	"	"	"	"	"		"	"	"		"	"
	25–30	"	"	"	"	"	663	1309	"	"	"	"	"	"	"	"	"	"	"		"	"
125MS-B	7.5	1800	125	125	150	493	452	1098	250	195	320	570	1060	360	390	170	160	740	40	19	245	246
	11	"	"	"	"	"	556	1202	"	"	"	"	"	"	"	"	"	"	"	"	"	"
	15	"	"	"	"	"	600	1246	"	"	"	"	"	"	"	"	"	"	"	"	"	"

Note: Asterisked dimensions vary somewhat with driver.

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