BAB VII

PERHITUNGAN BEBAN LISTRIK

7.1 Kebutuhan listrik kapal

Motor bantu atau generator berfungsi sebagai sumber energi untuk berbagai kebutuhan listrik di kapal, dimana kapasitas dan jumlah yang diperlukan disesuaikan dengan kebutuhan listrik tersebut antara lain: pompa-pompa, penerangan, serta keperluan-keperluan lain sehingga kapal dapat beroperasi dengan baik.

Sumber tenaga listrik diatas kapal dapat dibagi menjadi :

- Generator utama
- *Generator emergency*

Pemakaian beban listrik dibedakan menjadi beberapa kondisi pelayaran:

- Kondisi saat olah gerak
- Kondisi saat berlayar
- Kondisi saat sandar

A. Beban listrik sistem penerangan (*ship lightings load*)

Untuk menentukan jumlah unit lampu yang digunakan maka menggunakan rumus sebagai berikut :

$$N = \frac{E \times A}{\text{lumen} \times UF \times LLF}$$

Dimana :

N = Jumlah pencahayaan (lampu) yang diperlukan untuk setiap ruangan

E = Standar iluminasi berdasarkan tipe ruangan [lux]

A = Luas area [m^2]

Lumen = lumen keluaran cahaya sesuai dengan spesifikasi lampu [lm]

UF = Faktor utilisasi

LLF = Faktor rugi cahaya

Besaran parameter-parameter diatas disesuaikan menurut kondisi dan jenis tiap-tiap ruangan di kapal. Penentuan besaran parameter tersebut adalah sebagai berikut :

1. Luas area [A]

Berikut adalah luas area dari masing-masing geladak :

Geladak Navigasi	Jumlah	panjang p [m]	lebar l [m]	Luas area A [m²]
Ruang Kemudi	1	7,6	3,3	25,08
Ruang Nahkoda	1	3,3	3	9,9
Ruang KKM	1	3,3	3	9,9
Dapur	1	3,3	3,5	11,55
Mess	1	3,3	3,5	11,55
Kamar mandi / WC	1	3,3	2,3	7,6
Gang way	1	8,8	1	8,8
Ruang Tangga	1	3,3	2,3	7,6
Sisi luar terbuka ruang kemudi (P/S)	2	5,5	2,3	12,65
Geladak Penumpang				
Ruang PenumpangVIP	1	9,4	7	65,8
R. Penumpang Ekonomi & Tatami	1	23,5	12	282
Urinoir	1	1,8	2,5	4,5
Musholla	1	4,5	2,5	11,25
Tempat Wudhu	1	1,3	1,5	1,95
Kamar Mandi/WC (P/S)	10	1,3	1,5	1,95
Ruang hias (P/S)	2	1,3	1,2	1,56
Cafetaria	1	7	2,35	16,45
Sisi luar ruang penumpang haluan (P/S)	2	4,5	1,4	6,3
Sisi luar ruang penumpang buritan (P/S)	2	5,5	1,5	8,25
Geladak Kendaraan				
Ruang muat kendaraan	1	35	8,2	287
R.muat kendaraan geladak terbuka haluan	1	11,5	6	69
R.muat kendaraan geladak terbuka buritan	1	11,5	6	69
Ruang pompa darurat	1	4,7	2,5	11,75
Ruang generator darurat	1	4,7	2,5	11,75
Ruang CO_2	1	3,5	1,4	4,9
Gudang	1	3,5	1,4	4,9
Kamar mandi/WC (P/S)	4	1,5	1,2	1,8
Kamar ABK	6	3,5	1,9	6,65
Ruang tangga kamar mesin(P/S)	2	1,3	1,4	1,82
R. tangga ruang kosong (P/S)	4	1,9	1,6	3,04
Geladak Alas				
Kamar mesin	1	8,5	12	102
Ruang kontrol mesin	1	4	1,5	6
Ruang kosong	4	12	3	36

2. Standar iluminasi ruangan di kapal [E]

Berdasarkan *Japan Marine Standards 1995 hal 309-312,* total iluminasi yang dibutuhkan dalam setiap ruangan kapal adalah sebagai berikut :

Geladak Navigasi	**Iluminasi E (lx)**
Ruang Kemudi	200
Ruang Nahkoda	100
Ruang KKM	100
Dapur	100
Mess	200
Kamar mandi / WC	50
Gang way	50
Ruang Tangga	50
Sisi luar terbuka ruang kemudi (P/S)	20
Geladak Penumpang	
Ruang PenumpangVIP	100
R. Penumpang Ekonomi & Tatami	100
Urinoir	50
Musholla	50
Tempat Wudhu	50
Kamar Mandi/WC (P/S)	50
Ruang hias (P/S)	50
Cafetaria	100
Sisi luar R. penumpang haluan (P/S)	20
Sisi luar R. penumpang buritan (P/S)	20
Geladak Kendaraan	
Ruang muat kendaraan	50
R.muat kendaraan geladak terbuka haluan	20
R.muat kendaraan geladak terbuka buritan	20
Ruang pompa darurat	50
Ruang generator darurat	50
Ruang CO_2	50
Gudang	50
Kamar mandi/WC (P/S)	50
Kamar ABK	100
Ruang tangga kamar mesin(P/S)	100
R. tangga ruang kosong (P/S)	50
Geladak Alas	
Kamar mesin	150
Ruang kontrol mesin	200
Ruang kosong	50

3. *Light Flux* (*Lumen*)

Setiap lampu memiliki karakteristik pencahayaan yang berbeda-beda. Lumen adalah karateristik lampu yang menandakan besaran iluminasi yang dihasilkan dari tiap-tiap lampu. Direncanakan pada kapal menggunakan marine lamps dan marine *fluorescent lamps*. Berikut adalah beberapa spesifikasi lampu marine (*marine lamps*) dan lampu marine fluorescent berdasarkan *Japan Marine Standards JIS F 8407* dan *JIS C 7601*.

Marine Lamps

Marine Lamps	
Tipe	*Light flux* [lm]
KG 110V 10 W	60
KG 110V 20 W	142
KG 110V 40 W	540
KG 110V 60 W	590
KG 110V 100 W	1150
KG 110V 200 W	2740
KG 110V 300 W	4500

Marine Fluorescent Lamps

Marine Fluorescent Lamps	
Tipe	*Light flux [lm]*
FL-4W	90, 95, 100
FL-6W	155, 170, 180
FL-8W	260, 280, 290
FL-10W	410, 440, 460, 490, 530
FL-15W	710, 780, 820, 860, 920
FL-20W	1010, 1100, 1160, 1320, 1400
FL-30W	1480, 1620, 1700, 1790, 1900
FL-40W	2610, 2850, 3000, 3180, 3380

4. Faktor Utilisasi [UF]

Fluks cahaya yang dapat mencapai bidang datar selalu kurang dari lumen keluaran lampu karena sejumlah tertentu cahaya akan diserap oleh berbagai macam tekstur permukaan. Diasumsikan faktor utilisasi = 0,7.

5. Faktor Rugi cahaya [LLF]

Cahaya keluaran dari sebuah luminari akan berkurang seiring dengan bertambahnya usia pemakaian karena terjadinya akumulasi debu dan kotoran pada lampu. Faktor ini berkisar 0,8-0,9. Diasumsikan faktor rugi cahaya 0,8.

Berdasarkan data diatas, maka dapat ditentukan jumlah lampu tiap ruangan serta daya yang dibutuhkan untuk penerangan dalam kapal.

Geladak Navigasi	**Luas [m²]**	**E [lx]**	**Tipe Lampu**	**lumen [lm]**	**UF**	**LLF**	**N [unit]**	**Jumlah ruang**	**Daya [Watt]**
Ruang Kemudi	25,08	200	FL-20W	1400	0,7	0,8	6	1	120
Ruang Nahkoda	9,9	100	FL-20W	1010	0,7	0,8	2	1	40
Ruang KKM	9,9	100	FL-20W	1010	0,7	0,8	2	1	40
Dapur	11,55	100	FL-20W	1010	0,7	0,8	2	1	40
Mess	11,55	200	FL-20W	1400	0,7	0,8	2	1	40
Kamar mandi / WC	7,6	50	FL-8W	280	0,7	0,8	2	1	16
Gang way	8,8	50	FL-10W	410	0,7	0,8	2	1	20
Ruang Tangga	7,6	50	FL-15W	710	0,7	0,8	1	1	15
Sisi luar terbuka ruang kemudi (P/S)	12,65	20	KG20W	142	0,7	0,8	3	2	120
Geladak Penumpang									
Ruang PenumpangVIP	65,8	100	FL-20W	1010	0,7	0,8	12	1	240
R. Penumpang Ekonomi & Tatami	282	100	FL-20W	1400	0,7	0,8	36	1	720
Urinoir	4,5	50	FL-8W	260	0,7	0,8	2	1	16
Musholla	11,25	50	FL-10W	410	0,7	0,8	2	1	20
Tempat Wudhu	1,95	50	FL-10W	410	0,7	0,8	1	1	10
Kamar Mandi/WC (P/S)	1,95	50	FL-10W	410	0,7	0,8	1	10	100
Ruang hias (P/S)	1,56	50	FL-10W	410	0,7	0,8	1	2	20
Cafetaria	16,45	100	FL-15W	920	0,7	0,8	3	1	45
Sisi luar R. penumpang haluan (P/S)	6,3	20	KG20W	142	0,7	0,8	2	2	80
Sisi luar R. penumpang buritan (P/S)	8,25	20	KG20W	142	0,7	0,8	2	2	80
Geladak Kendaraan									
Ruang muat kendaraan	287	50	FL-20W	1400	0,7	0,8	18	1	360
R. kendaraan geladak terbuka haluan	69	20	KG200W	2740	0,7	0,8	1	1	200
R. kendaraan geladak terbuka buritan	69	20	KG200W	2740	0,7	0,8	1	1	200
Ruang pompa darurat	11,75	50	FL-15W	780	0,7	0,8	1	1	15
Ruang generator darurat	11,75	50	FL-15W	780	0,7	0,8	1	1	15
Ruang CO_2	4,9	50	FL-15W	780	0,7	0,8	1	1	15
Gudang	4,9	50	FL-15W	780	0,7	0,8	1	1	15
Kamar mandi/WC (P/S)	1,8	50	FL-10W	410	0,7	0,8	1	4	40
Kamar ABK	6,65	100	FL-20W	1010	0,7	0,8	1	6	120
Ruang tangga kamar mesin(P/S)	1,82	100	FL-15W	710	0,7	0,8	1	2	30
R. tangga ruang kosong (P/S)	3,04	50	FL-10W	410	0,7	0,8	1	4	40
Geladak Alas									
Kamar mesin	102	150	FL-30W	1700	0,7	0,8	1	1	30
Ruang kontrol mesin	6	200	FL-20W	1400	0,7	0,8	1	1	20
Ruang kosong	36	50	FL-15W	920	0,7	0,8	3	4	180
Total Daya									**3062**

Dari kebutuhan daya tiap ruangan maka dapat dijumlah keseluruhan daya yang terpakai untuk penerangan adalah sebesar 3062 Watt atau 3,062 kW.

***Note*

Berdasarkan *BKI Rules Vol IV section 11 tabel 11.1*, jarak minimum antara luminari diatur berdasarkan besarnya daya lampu tersebut.

Rated power (Watt)	*Minimun distances* (m)
diatas 100	0.5
100-300	0.8
300-500	1

B. Beban listrik sistem nautikal, komunikasi, dan peralatan keselamatan

Peralatan	[Daya Watt]
Radio equipment (1.8 kW; 220V; 1Φ; 50Hz)	1800
Giro kompas dan pilot (0.35 kW; 220V; 1Φ; 50Hz)	350
Echo Sounder (0.5 kW; 220V; 1Φ; 50Hz)	500
General Alarm (0.2 kW; 220V; 1Φ; 50Hz)	200
Interior Communication (0.75 kW; 220V; 1Φ; 50Hz)	750
Radar (1.60 kW; 220V; 1Φ; 50Hz)	1600
Motor sirine and motor horn (0.2 kW; 220V; 1Φ; 50Hz)	200
Total Daya	5400 Watt

C. Beban listrik sistem monitoring dan lampu navigasi

Peralatan	Daya (Watt)
Mast Head Light	60
Anchor Light	60
Port Side Side Light (red)	60
Stern Light	60
StarBoard Side Light (green)	60
Fire and Smoke Det.	200
Morse Light	80
Search Light	1000
Total Daya	1580 Watt

D. **Beban listrik sistem pelayanan mesin induk**

Peralatan	Unit	Daya (Watt)
FO Transfer Pump	1	3700
Lubricating Oil Pump	1	5500
FW Cooling Pump	1	3700
SW Cooling Pump	1	5500
Air Compressors	1	4000
Total Daya		**22400 Watt**

E. **Beban listrik sistem pelayanan umum**

Peralatan	Unit	Daya (Watt)
Bilge Pump	1	7500
Ballast Pump	1	11000
FW Sanitary Pump	1	1500
SW Sanitary Pump	1	1500
Fire Pump	1	22000
Oil Water Separator (OWS)	1	2700
Total Daya		**46200 Watt**

F. **Beban listrik sistem permesinan geladak**

Peralatan	Daya (Watt)
Mesin Kemudi	1011
Mesin Jangkar	36690
Mesin Tali Temali	6659
Boat Winch	2460
Ramp door winch	85000
Total Daya	**131820 Watt**

G. Beban listrik sistem pendinginan

Peralatan	Daya (Watt)
E/R Supply Fan	4000
E/R Exhaust Fan	2200
R. Penumpang Ekonomi Supply Fan	1500
R. Penumpang Ekonomi Exhaust Fan	3000
R. Nahkoda AC unit	680
R. KKM	680
R. Kemudi AC unit	2100
R. Penumpang VIP AC unit	5100
R. penyimpanan makanan	3320
Ruang kontrol mesin	680
Mess	1270
Total Daya	**24530 Watt**

Berdasarkan macam-macam kondisi pelayaran, maka diperkirakan total daya keseluruhan yang dibutuhkan setiap kondisi pelayaran diuraikan sebagai berikut :

Geladak / Peralatan	Daya (Watt)	Beban berlayar		Beban olah gerak		Beban Sandar	
		L.F	Daya	L.F	Daya	L.F	Daya
Lighting & Stop Kontak							
Geladak Penumpang	1331	1	1331	1	1331	1	1331
Geladak Kendaraan	1050	1	1050	1	1050	1	1050
Geladak Alas	230	1	230	1	230	1	230
Geladak Navigasi	451	1	451	1	451	1	451
Sistem Nautikal							
Radio equipment	1800	1	1800	1	1800	-	
Giro kompas dan pilot	350	1	350	1	350	-	
Echo Sounder	500	1	500	-		-	
General Alarm	200	0,5	200	-		0,5	200
Interior Communication	750	1	750	1	750	1	750
Radar	1600	1	1600	-		1	1600
Motor sirine and motor horn	200	0,5	200	0,5	200	0,5	200
Lampu Navigasi							
Mast Head Light	60	-	60	-		1	60
Anchor Light	60	-		-		1	60
Port Side Side Light (red)	60	0,5	60	1	60	-	
Stern Light	60	-	60	-		1	
StarBoard Side Light (green)	60	1	60	1	60	-	
Fire and Smoke Det.	200	1	200	1	200	1	200
Morse Light	80	0,5	80	0,5	80	-	

Search Light	1000	0,5	1000				
Sistem pelayanan motor induk							
FO Transfer Pump	3700	1	3700	1	3700		
Lubricating Oil Pump	5500	1	5500	1	5500	0,5	5500
FW Cooling Pump	3700	1	3700	1	3700	0,5	3700
SW Cooling Pump	5500	1	5500	1	5500	0,5	5500
Air Compressors	4000	0,5	4000	0,5	4000	1	4000
Sistem pelayanan umum							
Bilge Pump	7500	1	7500	1	7500	0,5	7500
Ballast Pump	11000	1	11000	1	11000	0,5	11000
FW Sanitary Pump	1500	1	1500	1	1500	0,5	1500
SW Sanitary Pump	1500	1	1500	1	1500	0,5	1500
Oil Water Separator (OWS)	2700	1	2700			0,5	2700
Fire Pump	22000	-		-		-	
Permesinan geladak							
Mesin Kemudi	1011	1	1011	1	1011	1	1011
Mesin Jangkar	36690	-		1	36690	1	36690
Mesin Tali Temali	6659	-		1	6659	1	6659
Boat Winch	2460	-		0,5	2460	0,5	2460
Ramp door winch	85000	-		-		1	85000
Sistem pengkondisian udara							
E/R Supply Fan	4000	1	4000	1	4000	1	4000
E/R Exhaust Fan	2200	1	2200	1	2200	1	2200
R.Penumpang Ekonomi Fan(in)	1500	1	1500	1	1500	1	1500
R.Penumpang Ekonomi Fan(ex)	3000	1	3000	1	3000	1	3000
R.Nahkoda AC unit	680	0,5	680	0,5	680	0,5	680
R. KKM	680	0,5	680	0,5	680	0,5	680
R.Kemudi AC unit	2100	1	2100	1	2100	1	2100
R. Penumpang VIP AC unit	5100	1	5100	1	5100	1	5100
R. penyimpanan makanan	3320	0,5	3320	0,5	3320	0,5	3320
Ruang kontrol mesin	680	1	680	1	680	1	680
Mess	1270	0,5	1270	0,5	1270	0,5	1270
Total daya			**82123**		**121812**		**205382**

Jadi jumlah daya berdasarkan kondisi pelayaran adalah sebagai berikut:

a. Kondisi berlayar : 82,123 kW

b. Kondisi olah gerak : 121,812 kW

c. Kondisi sandar : 205,382 kW

7.2 Perencanaan perhitungan Generator

Berdasarkan *BKI 2009 Rules Vol IV section 3B-1.1-2*, setiap kapal harus memiliki minimum 2 (dua) buah independen generating set. Perhitungan kapasitas dari generating sets dihitung dimana apabila salah satu generating sets rusak, generating set lainnya mampu mensuplai kebutuhan seperti :

- Kondisi normal pelayaran dan keselamatan kapal
- Kondisi minimum kenyamanan dalam kapal meliputi :
    1. Penerangan yang cukup
    2. Refrigasi
- Ventilasi memadai dan sanitari serta penyediaan air minum

Penggunaan generator sebagai sumber tenaga listrik di kapal, yang mampu memenuhi listrik terbesar yaitu pada waktu kapal dalam kondisi bersandar serta pertimbangan ditambah 20% pada besarnya pemakaian beban dari generator :

$$\text{Daya (kW)} = P_{max} + (0,2 \times P_{max})$$

Dimana:

P_{max}	= 205,382 kW	(diambil daya pada saat kondisi bersandar)
Daya	= 205,382 + (0,2 × 205,382)	
	= 246,458 kW	

Maka dengan demikian direncanakan pemakaian generator sebanyak 2 buah. Masing-masing generator mempunyai kapasitas daya yang sama yaitu 246,458 kW.

Spesifikasi Generating set

Merk	= YANMAR
Tipe	= 6HAL2-DTN
Daya motor	= 255 kW
RPM	= 1500 rpm
Jumlah silinder	= 6
Cylinder (bore x stroke)	= 130 × 165 mm
Dimension	= 1563 × 1163 × 1410 mm
Jumlah	= 2 set

7.3 Perencanaan Generator Darurat dan Batery

A. Generator darurat

Generator darurat hanya digunakan saat kapal tidak beroperasi atau pada saat terjadi kondisi darurat,seperti saat bersandar di pelabuhan atau saat berlabuh dalam jangka waktu yang cukup lama.

Keperluan tersebut adalah :

Peralatan	Daya (Watt)
Fire Pump	22000
Ballast Pump	11000
Air Compressors	4000
Radio equipment	1800
Giro kompas dan pilot	350
Echo Sounder	500
General Alarm	200
Interior Communication	750
Radar	1600
Motor sirine and motor horn	200
Lampu Geladak Penumpang	1331
Lampu Geladak Kendaraan	1050
Lampu Geladak Alas	230
Lampu Geladak Navigasi	451
R. penyimpanan makanan	3320
Mast Head Light	60
Anchor Light	60
Port Side Side Light (red)	60
Stern Light	60
StarBoard Side Light (green)	60
Fire and Smoke Det.	200
Morse Light	300
Search Light	1000
Mesin Jangkar	36690
Mesin Tali Temali	6659
Boat Winch	2460
Total Daya	**96391 Watt**

Dengan demikian dapat dipilih 1 buah generator darurat dengan spesifikasi sebagai berikut :

Spesifikasi Generating set

Merk	= YANMAR
Tipe	= 4HAL2-TN
Daya motor	= 115 kW
RPM	= 1500 rpm
Jumlah silinder	= 4
Cylinder (bore x stroke)	= 130 – 165 mm
Dimension	= 1219 × 1117 × 1264 mm
Jumlah	= 1 set

B. Baterai

Di rencanakan di rumah kemudi dipasang baterai darurat hanya digunakan untuk peralatan penerangan dan peralatan navigasi. Keperluan tersebut adalah :

Peralatan navigasi		= 5,4
Penerangan darurat		= 0,12+
	Jumlah	= 5,52 kW

Baterai yang direncanakan untuk rumah kemudi 2 × 275 Ah 12 V dan untuk mesin bantu sebanyak 2 set dengan masing-masing kapasitas 100 Ah 12 V

REFERENSI

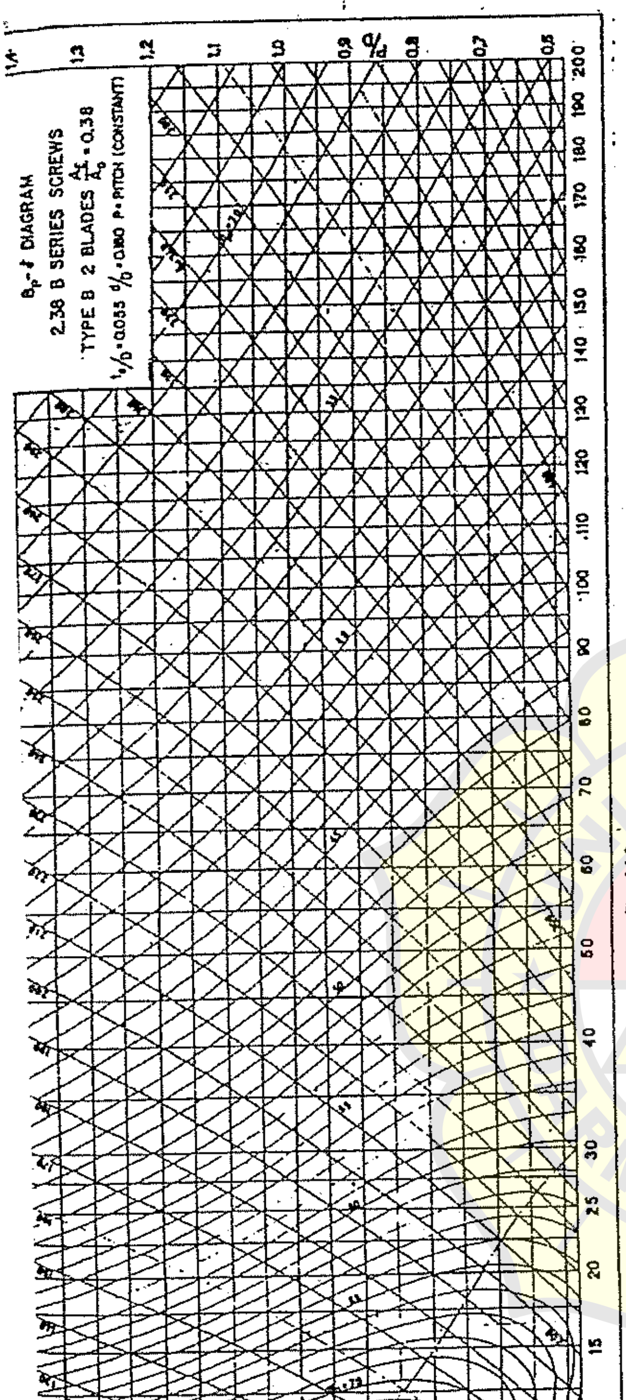


Fig. 113

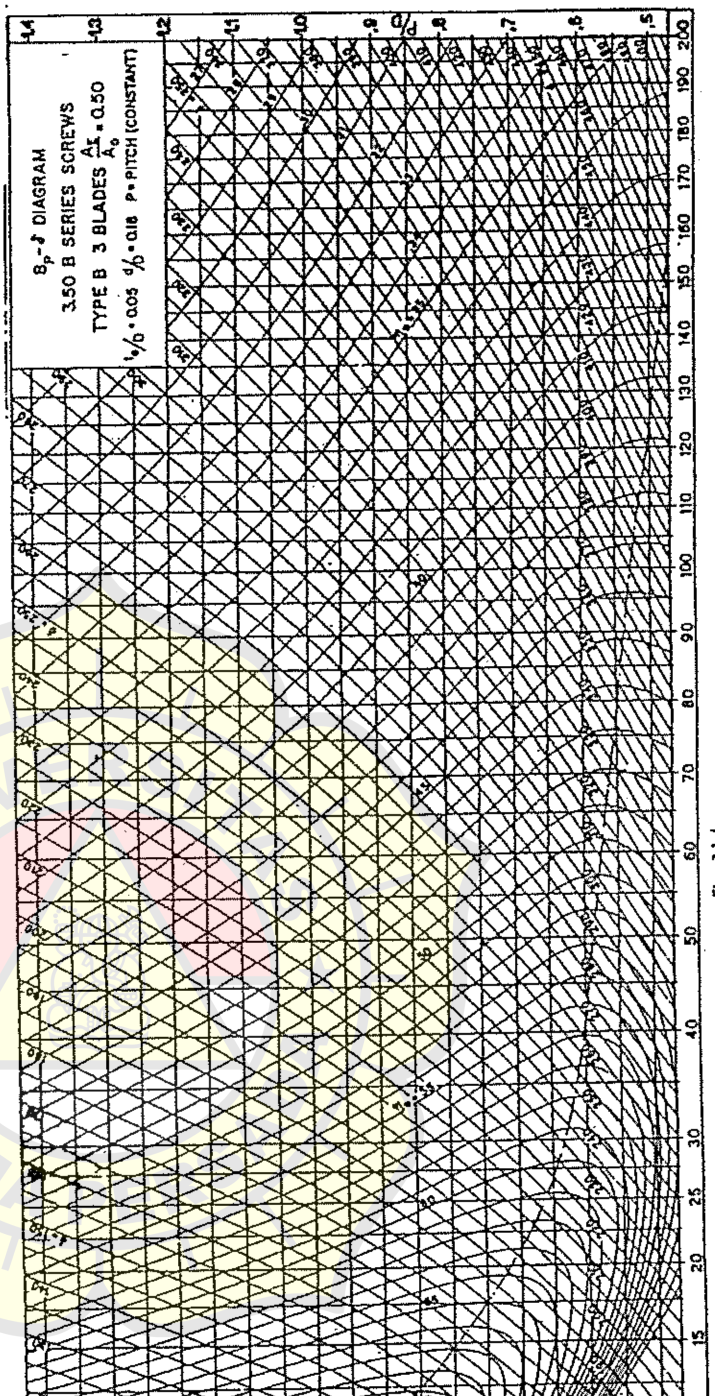


Fig. 114

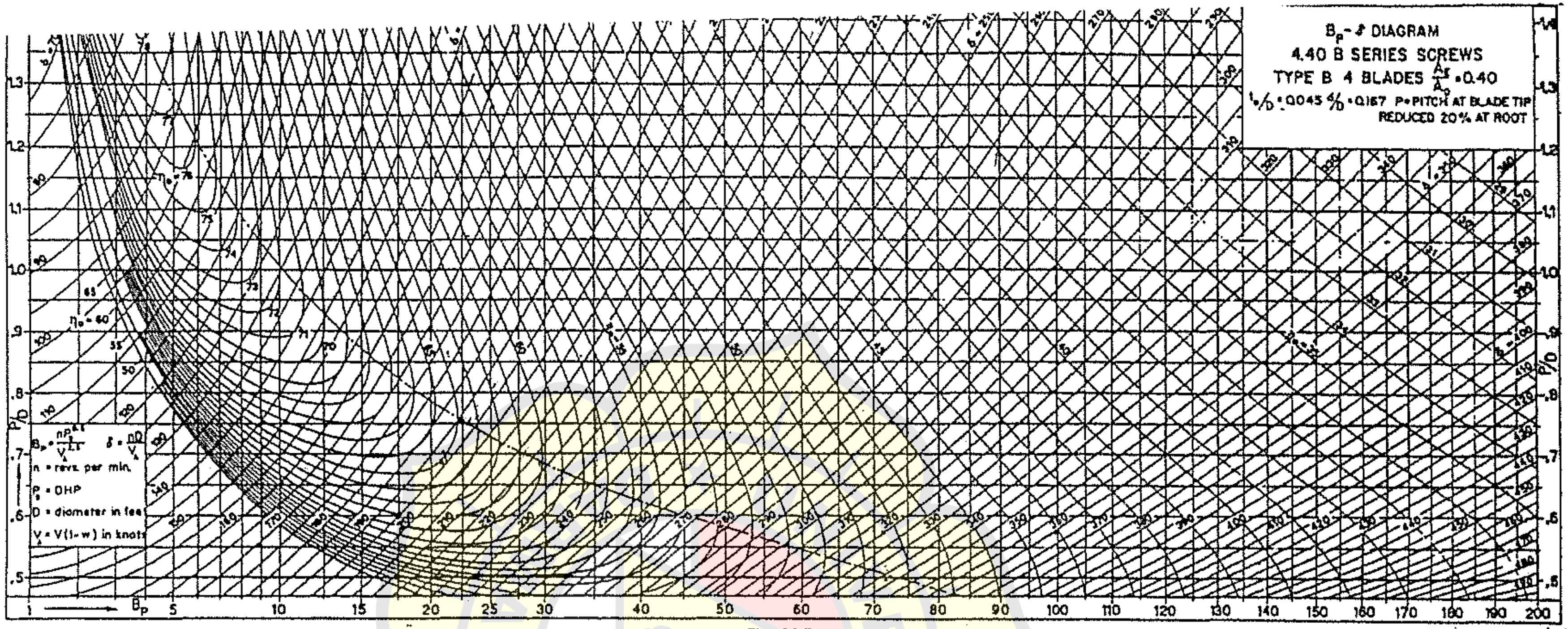
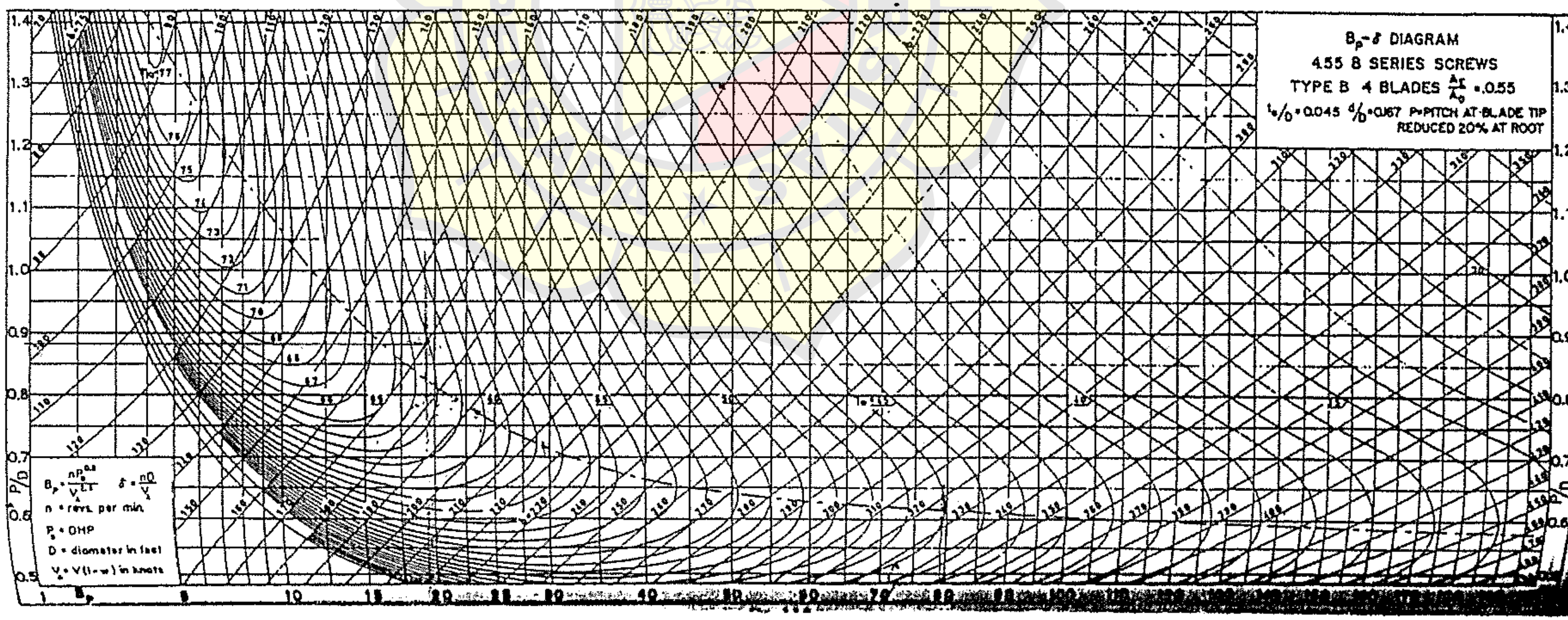

Bp - δ DIAGRAM
4.40 B SERIES SCREWS
TYPE B 4 BLADES $\frac{A_E}{A_0}$ = 0.40
t_0/D = 0.045 d/D = 0.167 P = PITCH AT BLADE TIP REDUCED 20% AT ROOT
$B_p = \frac{nP^{0.5}}{V_A^{2.5}}$ $\delta = \frac{nD}{V_A}$
n = revs. per min.
P_s = DHP
D = diameter in feet
$V_A = V(1-w)$ in knots
P/D
Bp

Fig. 115


Bp - δ DIAGRAM
4.55 B SERIES SCREWS
TYPE B 4 BLADES $\frac{A_E}{A_0}$ = 0.55
t_0/D = 0.045 d/D = 0.167 P = PITCH AT BLADE TIP REDUCED 20% AT ROOT
$B_p = \frac{nP_s^{0.5}}{V_A^{2.5}}$ $\delta = \frac{nD}{V_A}$
n = revs. per min.
P_s = DHP
D = diameter in feet
$V_A = V(1-w)$ in knots
P/D
Bp

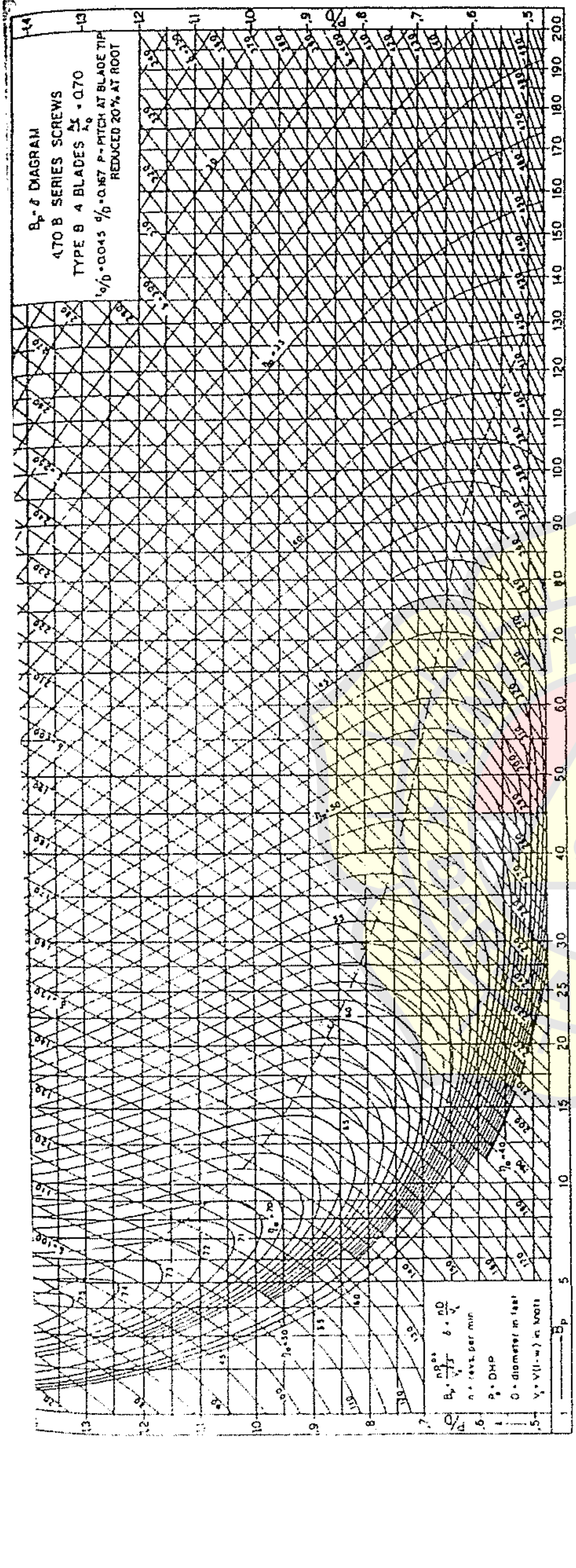


Fig. 117

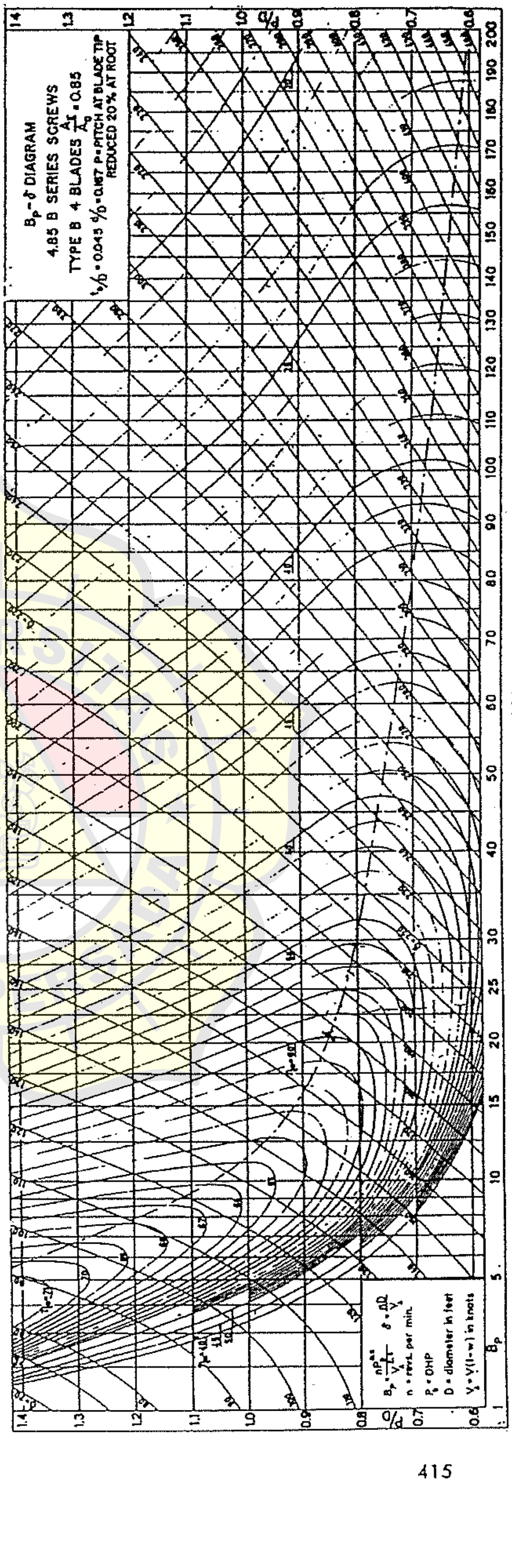
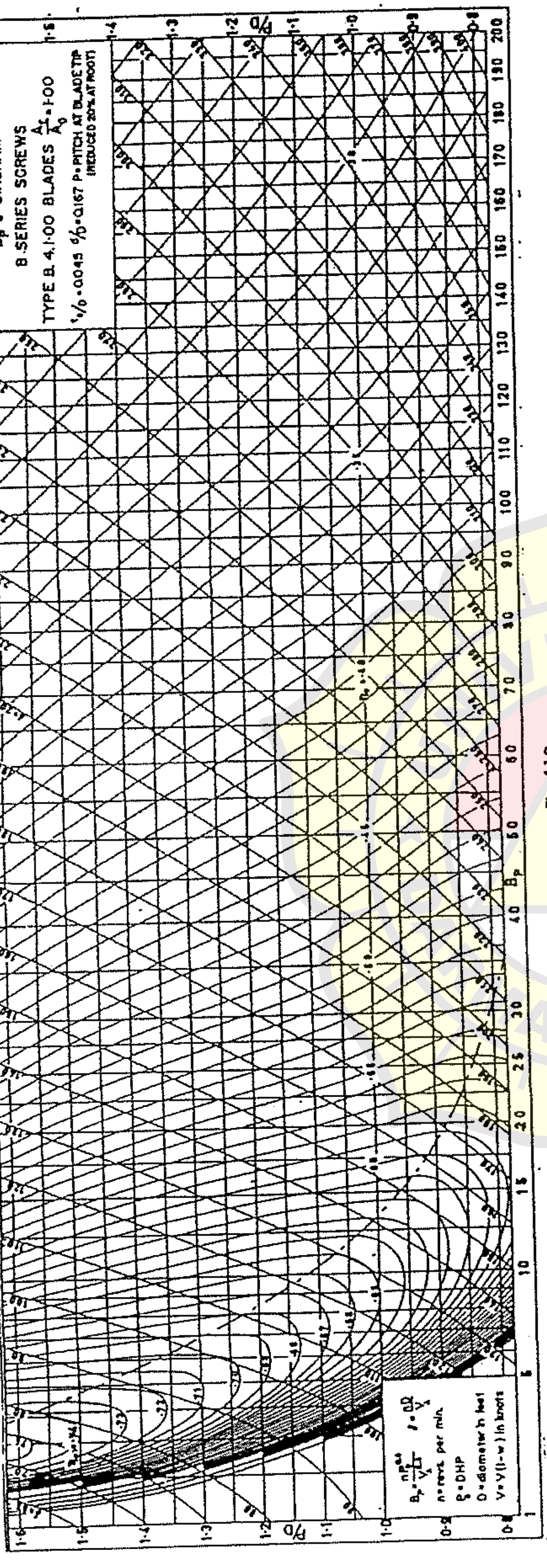
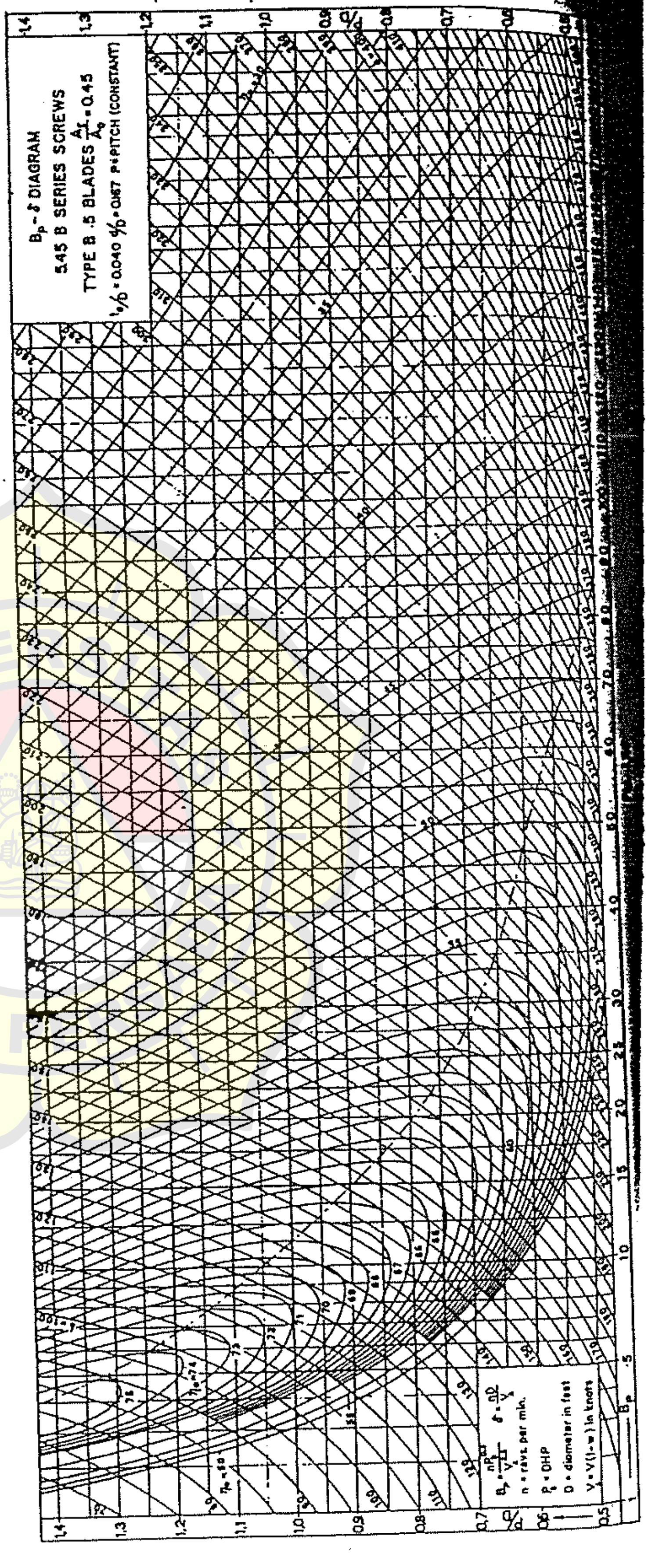


Fig. 118



$B_p - \delta$ DIAGRAM
B. SERIES SCREWS
TYPE B. 4. 1·00 BLADES $\frac{A_E}{A_0}$ = 1·00
$t/_D$ = 0·045 $s/_D$ = 0·167 P = PITCH AT BLADE TIP (REDUCED 20% AT ROOT)
P/D
B_p
$B_p = \frac{nP^{0.5}}{V_A^{2.5}}$ $\delta = \frac{nD}{V_A}$
n = revs. per min.
P = DHP
D = diameter in feet
V_A = V(1 - w) in knots



$B_p - \delta$ DIAGRAM
5.45 B SERIES SCREWS
TYPE B. 5 BLADES $\frac{A_E}{A_0}$ = 0.45
$t/_D$ = 0.040 $s/_D$ = 0.167 P = PITCH (CONSTANT)
P/D
B_p
$B_p = \frac{nP^{0.5}}{V_A^{2.5}}$ $\delta = \frac{nD}{V_A}$
n = revs. per min.
P = DHP
D = diameter in feet
V_A = V(1 - w) in knots

Fig. 119

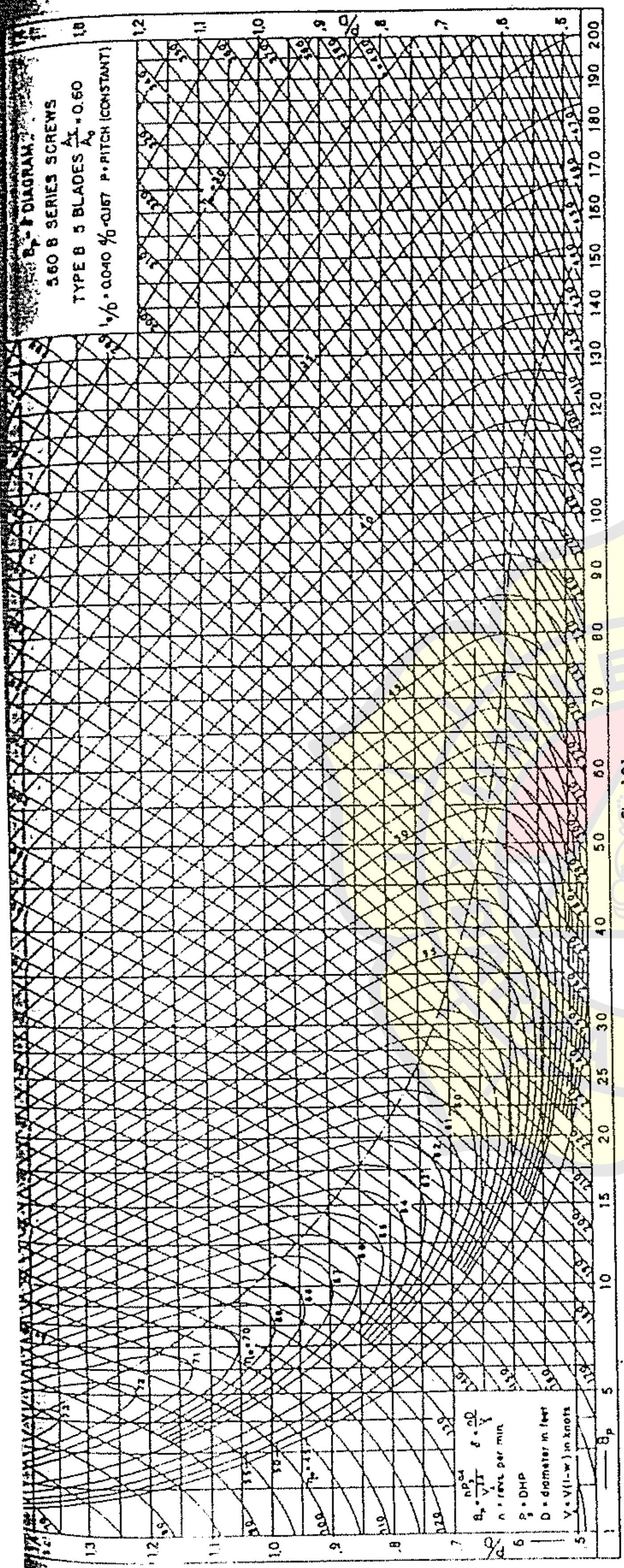


Fig. 121

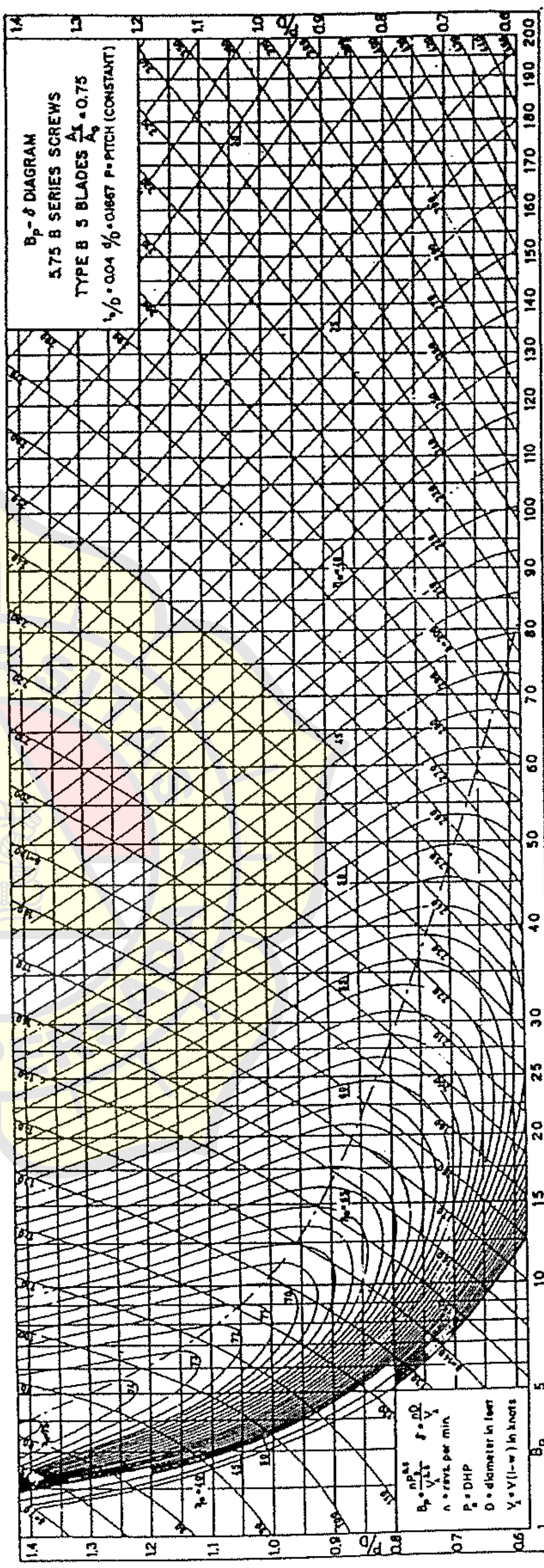


Fig. 122

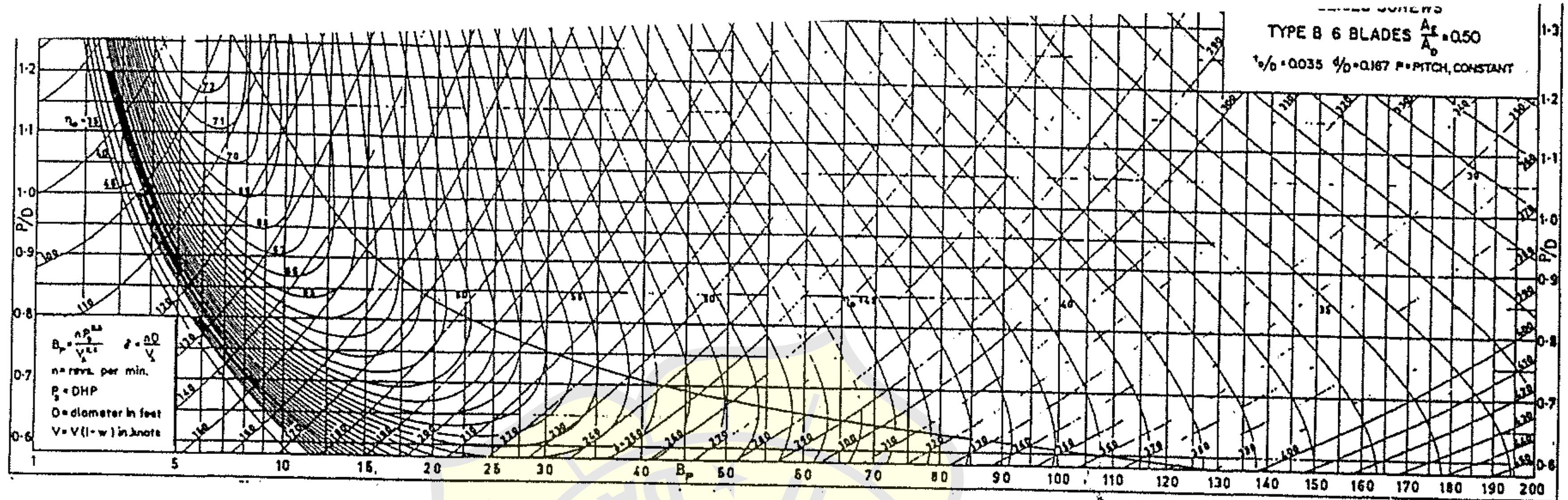


Fig. 123

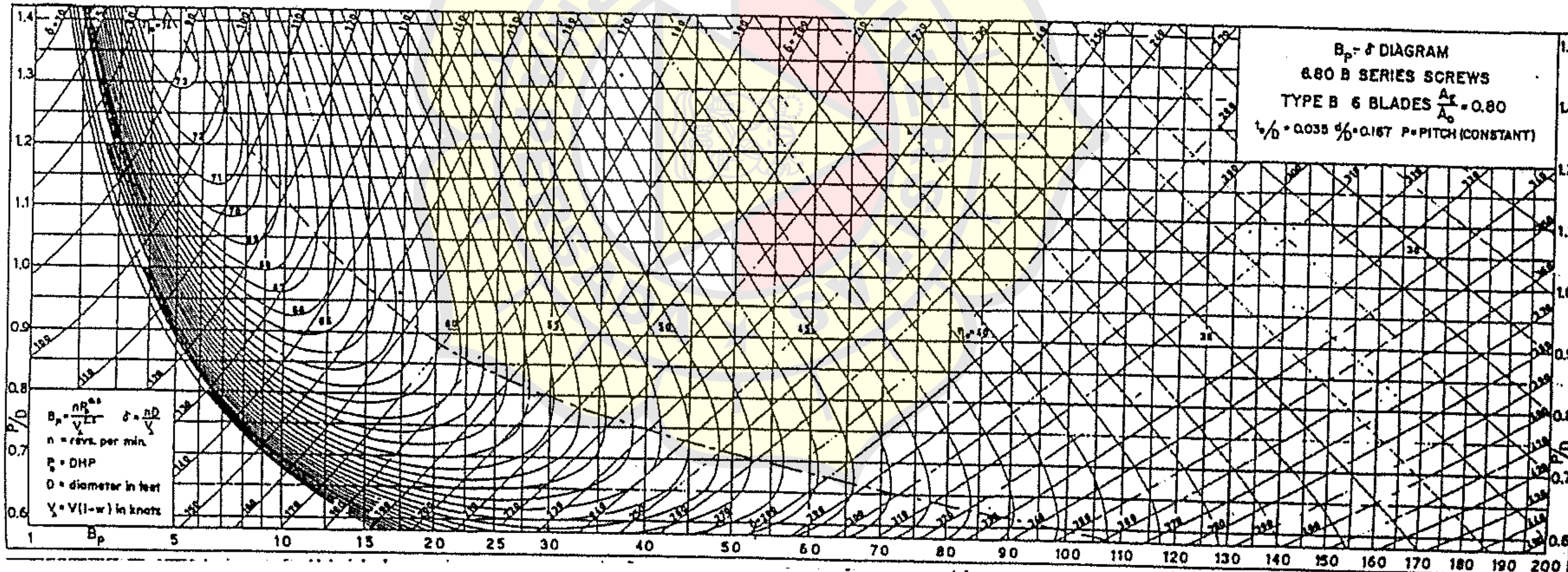


Fig. 124

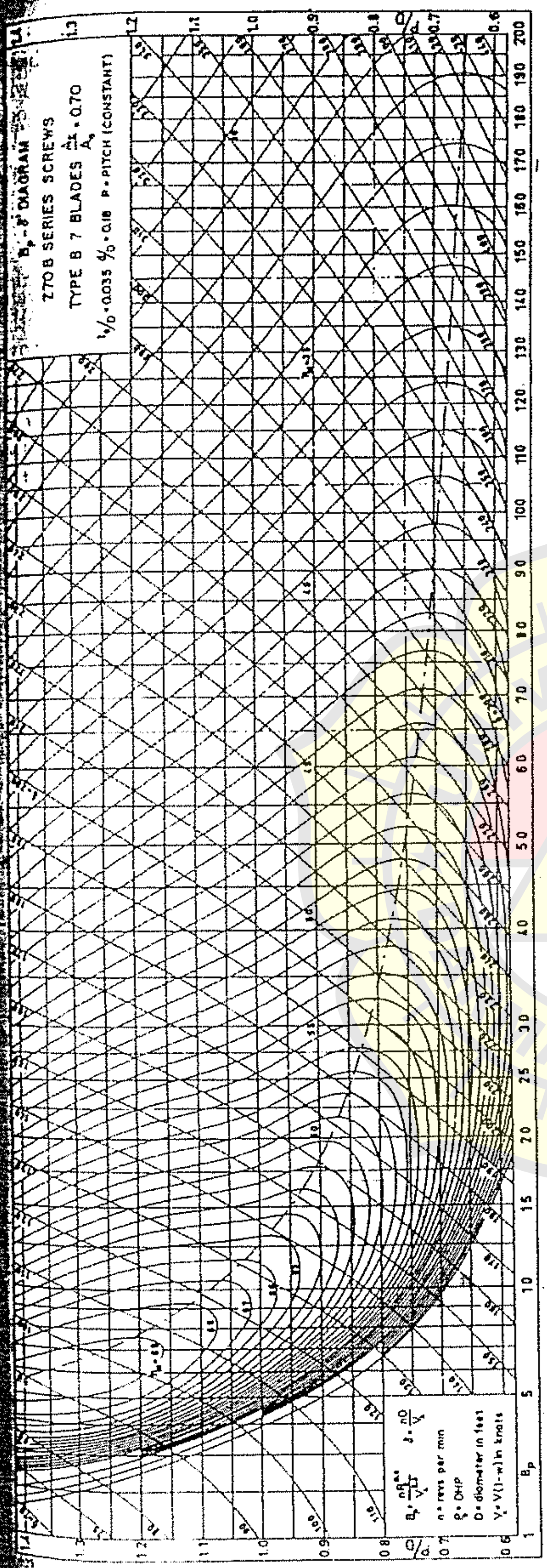


Fig. 125

where

n = revolutions per minute
P_D = delivered horsepower at propeller
V_A = speed of advance, knots
D = propeller diameter, ft

The charts consist of contours of constant propeller efficiency η_0 and of constant advance coefficient δ plotted on a grid of B_P and pitch ratio, P/D, as in Fig. 113.

The model results used to construct the charts are based upon experiments in fresh water and allowance for this must be made in the design calculations.

The information required for making a propeller design from these charts may be summarized as follows:

1 Principal dimensions, proportions and form coefficients for ship, to estimate wake and thrust-deduction factors and other propulsion information.

2 ehp from model tests or estimated from other available data, using information under 1.

3 Engine power and rated rpm.

4 Speed of ship.

5 Any restrictions, such as a limit on the maximum diameter of the propeller.

The dhp at the propeller can be estimated from equation (73)

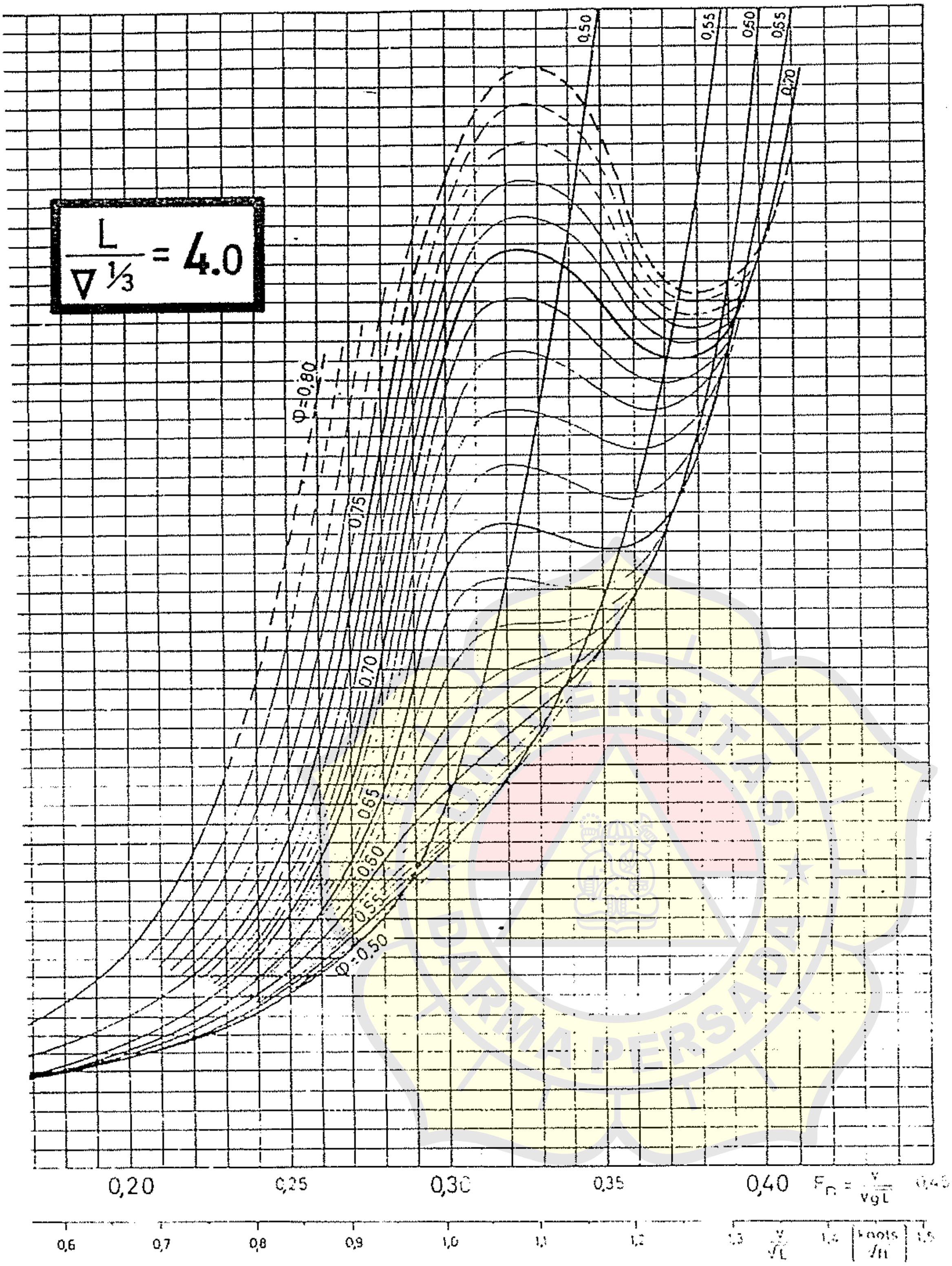
$$P_D = \frac{P_E(1 + x)}{\eta_D}$$

where the quasi-propulsive coefficient η_D can be taken from such published data as Series 60, from the trial results of a similar ship or, in many cases, from experiments run with a model of the ship in question with a stock propeller of approximately the correct diameter and pitch. The estimated value will later be checked in the course of the design.

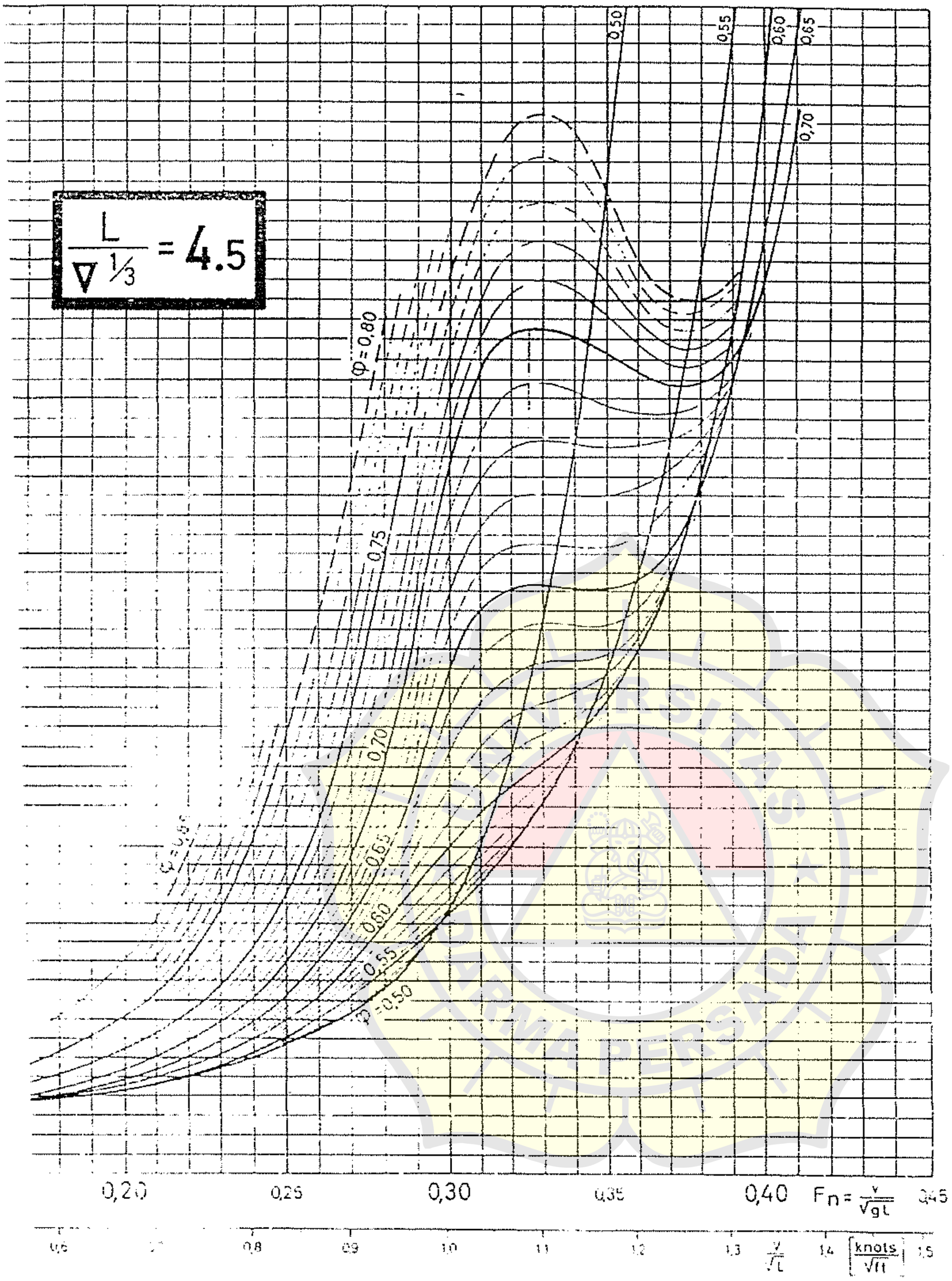
For a new ship in trial condition, ehp may be estimated either from specific model tests or by series data, in either case with the addition of a suitable model-ship correlation allowance C_A. This latter will depend on a number of factors such as the method of shell construction, quality of paint surface, time out of dock and size of ship (Section 20). For normal standard estimates, using the ATTC coefficients, it is still the agreed procedure for all published work to assume that $C_A = +0.0004$. In commercial work, clients may require estimates involving other values of C_A which they have derived from an analysis of the performance of their own ships. Otherwise the value of $+0.0004$ is used.

The ehp must also be increased to include the resistance of any appendages not fitted during model tests, such as bilge keels or bossings.

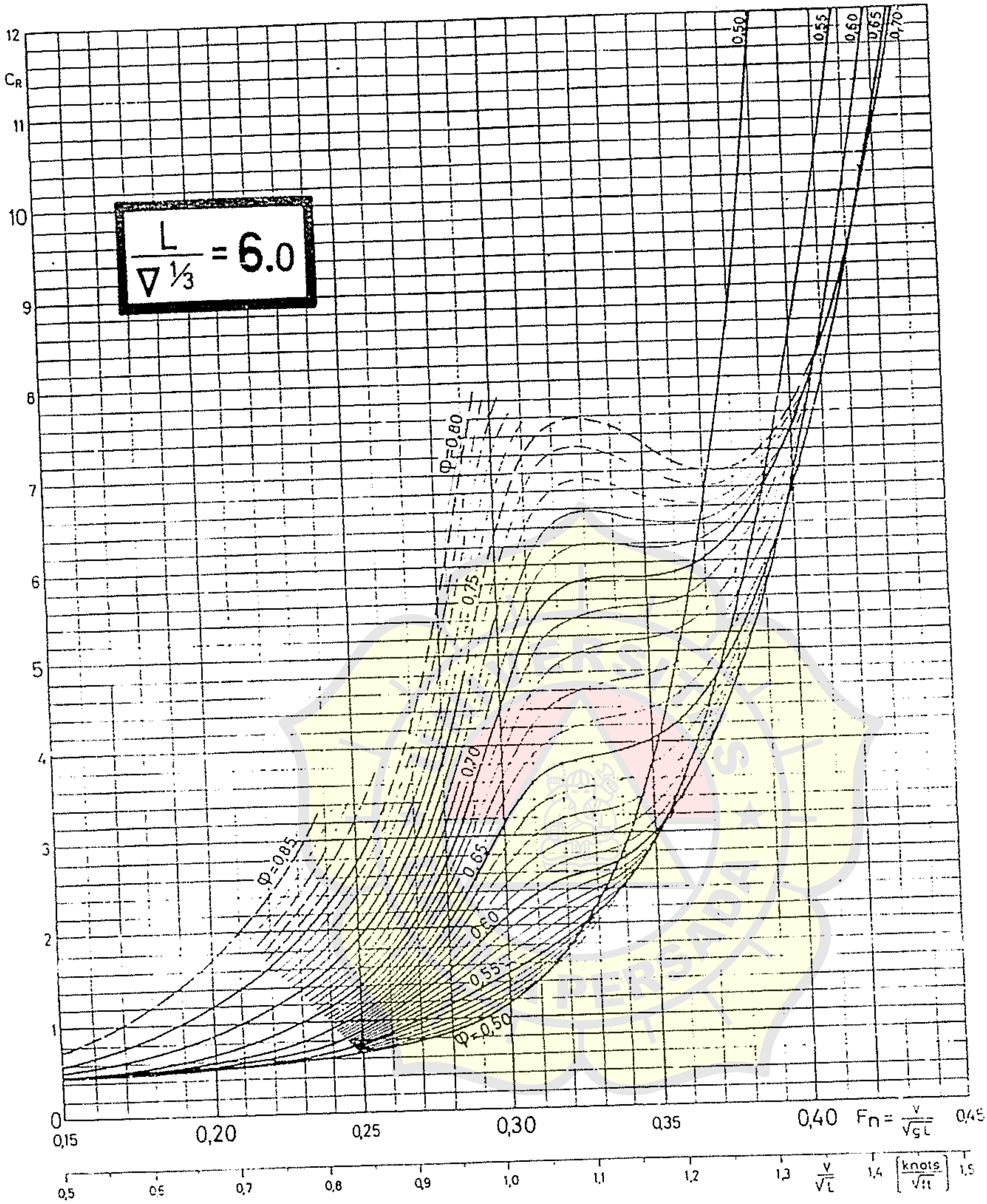
It is desirable in general to design the propeller to suit the expected average service conditions rather than those on trial, which are unlikely to be repeated. The service allowance should be chosen upon the basis of the average weather conditions on the ocean routes on which the ship is expected to trade. The North Atlantic, for example, makes more exacting demands in this respect than most oceans. In the absence of any such special



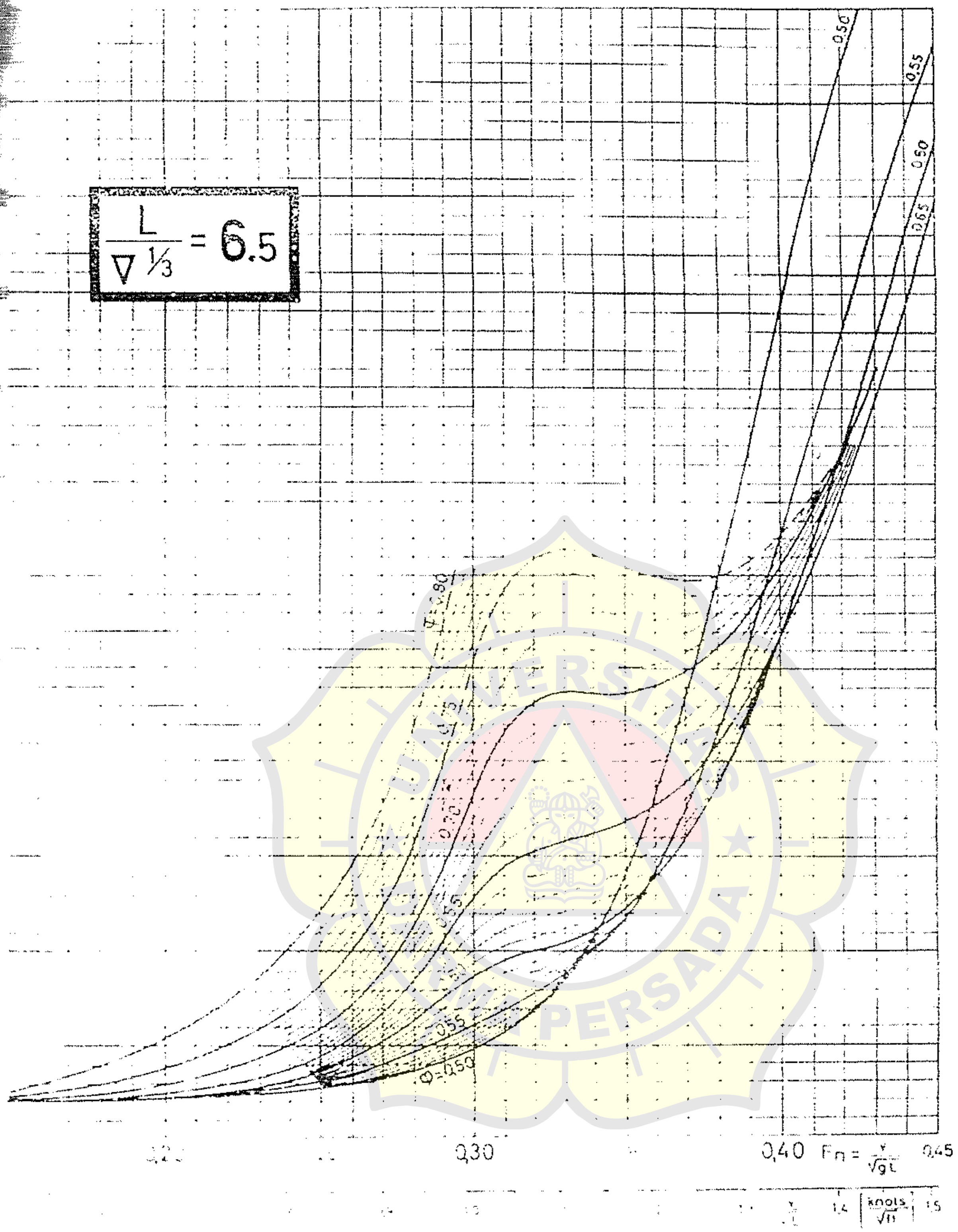
Residuary resistance coefficient versus speed–length ratio for different values of longitudinal prismatic coefficient



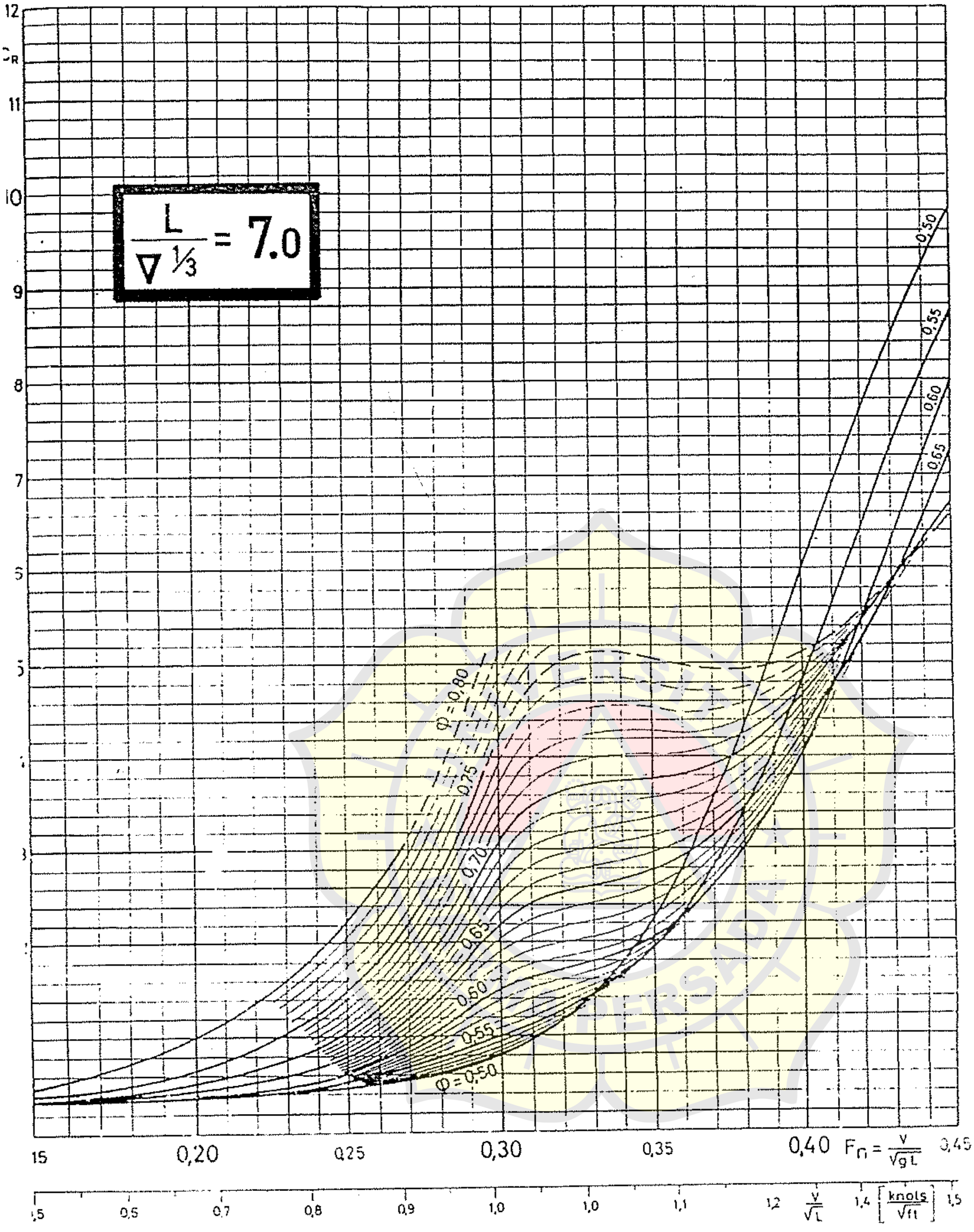
...esistance ... coefficient versus speed-length ratio for different values of longitudinal prismatic coefficient.



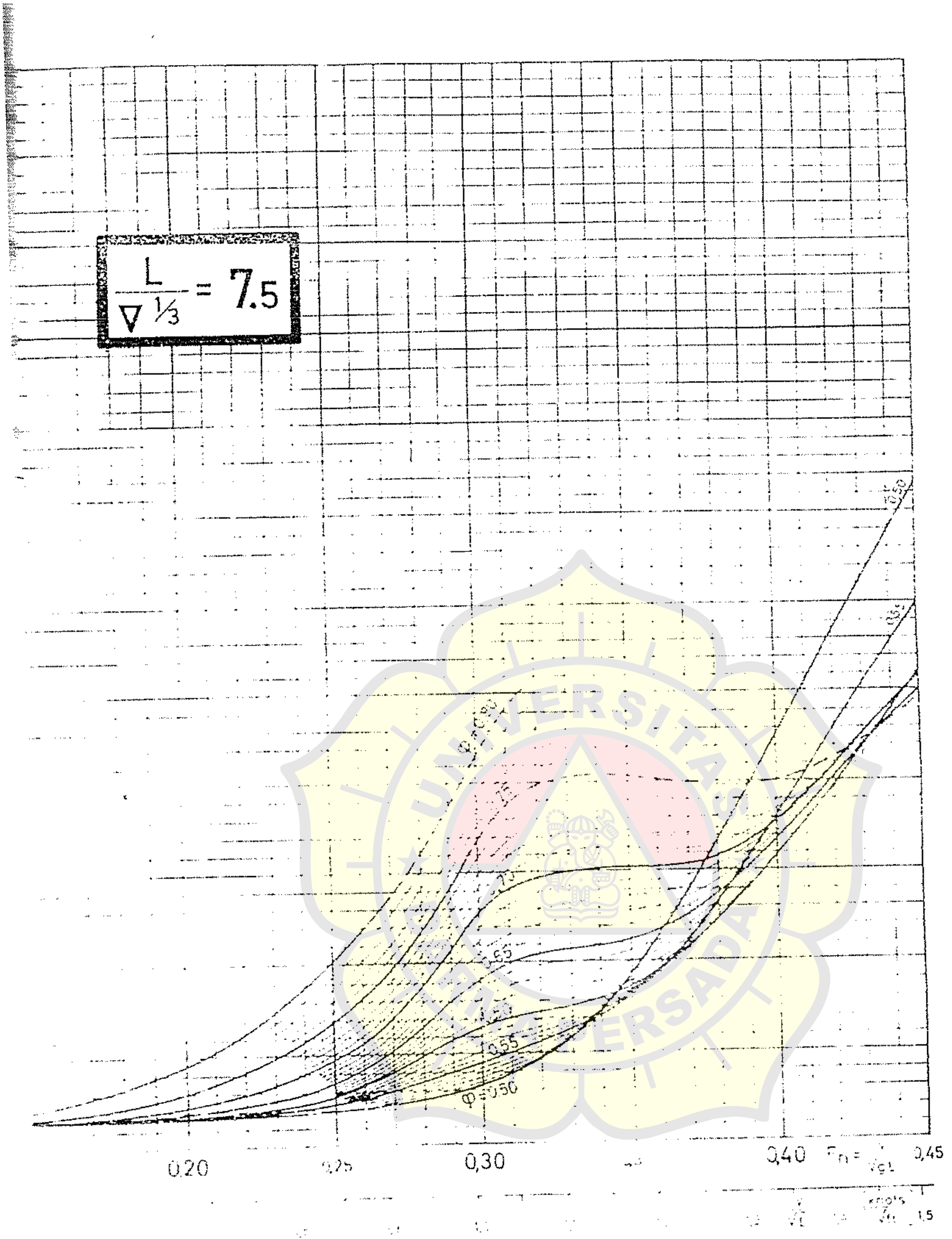
ure 5.5.9. Residuary resistance coefficient versus speed–length ratio for different values of longitudinal prismatic coefficient ·· = 6.0.

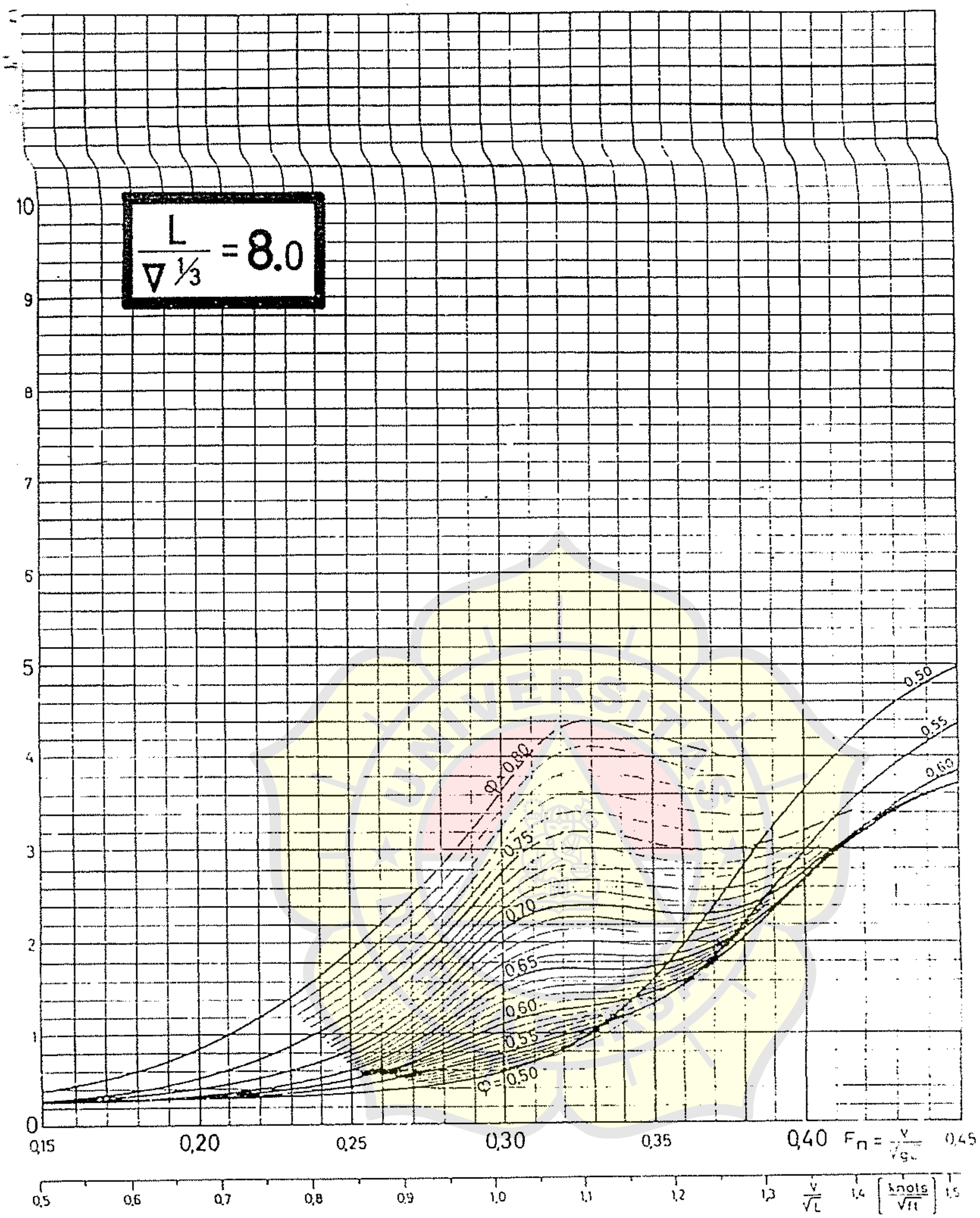


prismatic coefficient



.5.11. Residuary resistance coefficient versus speed–length ratio for different values of longitudinal prismatic coefficient. 7.0.


$\frac{L}{\nabla^{1/3}} = 7.5$
0,20
0,25
0,30
0,40
0,45
Φ=0,50
0,55
0,65
knots



...re 5.5.13 Residuary resistance coefficient versus speed–length ratio for different values of longitudinal prismatic coefficient ... = 8.0.

$_D$ adalah luas kembang daun baling-baling; dalam erhitungan kasar luas ini dapat diganti dengan luas entang daun baling-baling A_E.

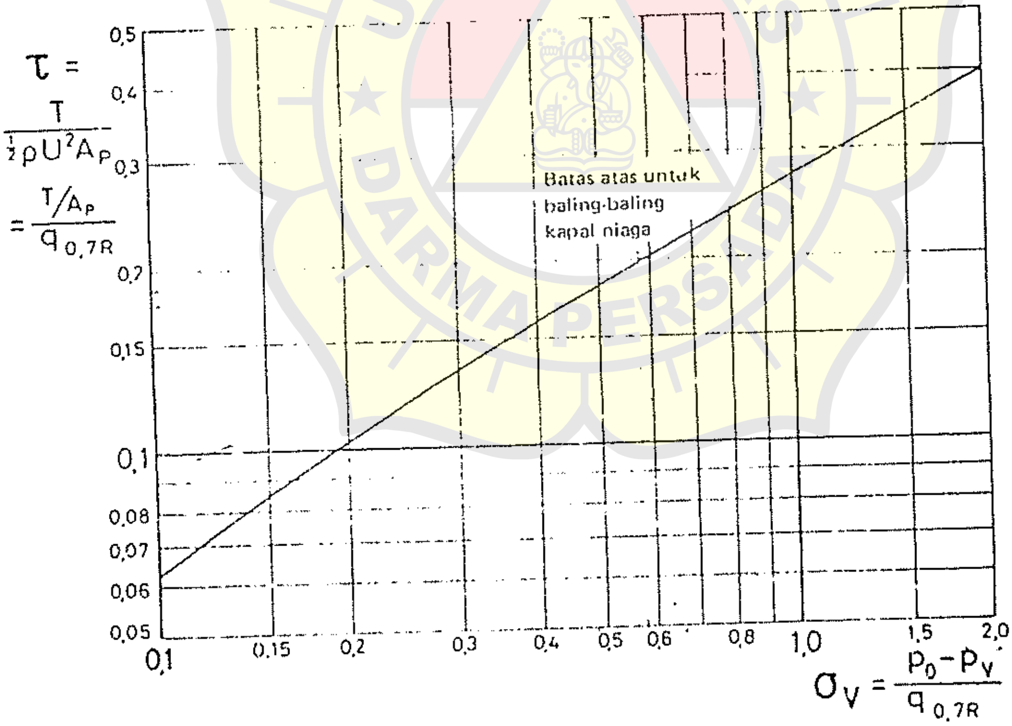
Gambar 6.6.8. menunjukkan salah satu kurva yang iajukan oleh **Burrill** (1943). Kurva tersebut merupaan kurva "batas atas yang disarankan untuk balingaling kapal niaga", yaitu berarti bahwa untuk ıenghindari kavitasi yang berlebihan dan erosi dalam ondisi pelayaran rata-rata di laut maka baling-baling apal yang bersangkutan harus bekerja di bawah kurva ersebut.

Kriteria tersebut dapat pula dinyatakan dalam syarat ahwa luas bentang yang diperlukan harus tidak kurang ari

$$\left(\frac{A_E}{A_0}\right)_{\text{min}} = \frac{T}{A_0(1{,}067 - 0{,}229P/D)(0{,}3\sigma_{0,7R}^{0,5} - 0{,}03)q_{0,7R}} \qquad (6.6.32)$$

$_0$ adalah luas diskus baling-baling $(= \pi D^2/4)$. riteria ini sangat kasar. **Van Manen** memakai teori ısaran untuk menghitung seri baling-baling berdaun dua, tiga, empat, dan lima dengan berbagai rasio luas daun dan dengan berbagai rasio langkah ulir. Hasilnya digambar dalam diagram (**Manen**, 1957b, Gb. 66 dan 67), yaitu seperti Gb. 6.6.8. Hasil tersebut menunjukkan ketergantungan kriteria kravitasi tersebut pada parameter tadi, terutama pada rasio langkah ulir.

Hasil yang diberikan di Gb. 6.6.9 adalah hasil dari baling-baling berdaun empat dengan rasio luas bentang 0,60 dari seri baling-baling kapal niaga yang diuji di suatu terowongan kavitasi (**Burrill** dan **Emerson**, 1962–1963) terhadap koefisien maju dan angka kavitasi dalam rentang yang luas. Dalam gambar tersebut diberikan garis untuk 2,5%, 5%, 10%, 20%, dan 30% kavitasi punggung yang timbul. Dari gambar tersebut terlihat bahwa garis batas atas untuk baling-baling kapal niaga yang ditunjukkan di Gb. 6.6.8. terletak sangat dekat dengan garis untuk 5% kavitasi punggung. Hasil pengamatan baling-baling menunjukkan bahwa jika baling-baling tersebut bekerja pada kondisi perancangan atau pada kondisi kerja yang sesuai dengan garis 5% maka baling-baling itu akan didapatkan dalam keadaan yang cukup bersih dan bebas erosi, barangkali bukan karena mengkilapkan permukaan logam tersebut setelah beberapa tahun bekerja. Karena satu dan lain hal mengusahakan agar mendapatkan luas daun yang sekecil mungkin lebih disukai daripada mendapatkan kelebihan luas daun yang besar.



Gambar 6.6.8. Diagram kavitasi (Burrill).

Table 38

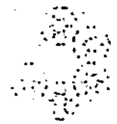
Temperature, °C	Density, kg/m³	Absolute humidity, g/m³	Vapour pressure, mmHg	Temperature, °C	Density, kg/m³	Absolute humidity, g/m³	Vapour pressure, mmHg
—25	1,424	0.64	0,540	+13	1,235	11.32	11.162
—24	1,418	0.71	0,600	+14	1,230	12.03	11.908
—22	1,406	0.86	0,745	+16	1,222	13.59	13.536
—21	1,401	0.95	0,825	+17	1,217	14.43	14.421
—20	1,395	1.05	0,910	+18	1,213	15.31	15.357
—19	1,390	1.15	1,000	+19	1,209	16.25	16.346
—18	1,384	1.25	1,095	+20	1,205	17.22	17.391
—17	1,379	1.35	1,190	+21	1,201	18.25	18.495
—16	1,374	1.46	1,290	+22	1,197	19.33	19.659
—15	1,368	1.58	1,400	+23	1,193	20.48	20.888
—14	1,363	1.70	1,520	+24	1,189	21.68	22.184
—13	1,358	1.83	1,635	+25	1,185	22.93	23.550
—12	1,353	1.98	1,780	+26	1,181	24.24	24.988
—11	1,347	2.14	1,930	+27	1,177	25.64	26.505
—10	1,342	2.31	2,093	+28	1,173	27.09	28.101
—9	1,337	2.49	2,267	+29	1,169	28.62	29.782
—8	1,332	2.69	2,455	+30	1,165	30.21	31.548
—7	1,327	2.90	2,658	+31	1,161	31.89	33.406
—6	1,322	3.13	2,876	+32	1,157	33.64	35.350
—5	1,317	3.37	3,113	+33	1,154	35.48	37.411
—4	1,312	3.64	3,368	+34	1,149	37.40	39.565
—3	1,308	3.92	3,644	+35	1,146	39.41	41.827
—2	1,303	4.22	3,941	+36	1,142	41.51	44.201
—1	1,298	4.55	4,263	+37	1,139	43.71	46.691
0	1,293	4.89	4,600	+38	1,135	46.00	49.302
+1	1,288	5.23	4,940	+39	1,131	48.40	52.039
+2	1,284	5.60	5,302	+40	1,128	50.91	54.906
+3	1,279	5.98	5,687	+41	1,124	53.52	57.910
+4	1,275	6.39	6,097	+42	1,121	56.25	61.055
+5	1,270	6.82	6,534	+43	1,117	59.09	64.346
+6	1,265	7.28	6,998	+44	1,114	62.05	67.790
+7	1,261	7.76	7,492	+45	1,110	65.14	71.391
+8	1,256	8.28	8,017	+46	1,107	68.36	75.158
+9	1,252	8.82	8,574	+47	1,103	71.73	79.093
+10	1,247	9.39	9,165	+48	1,100	75.22	83.204
+11	1,243	10.01	9,792	+49	1,096	78.86	88.499
+12	1,239	10.64	10,457	+50	1,093	82.63	91.982

Table 39

Locality	Data on fresh air and sea water						Air requirements for shipboard accommodations			
	Warmest period of navigation			Coldest period of navigation			Accommodations	Air temperature		Relative humidity φ_r, %
	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}, %		Coldest period of navigation, t_r, °C	Warmest period of navigation, t_r, °C	
Rivers that freeze	20 to 30	16 to 25	55 to 65	—5	4	75 to 85	Living and passenger accommodations, state-rooms and ward-rooms	18	t_{fa}+5°C	40 to 60
Seas in high or temperate latitudes	10 to 25	5 to 15	65 to 75	—25 to —35	0 to —2	80 to 85	Passageways of living and service accommodations	15	t_{fa}+5°C	75 to 85
Warm seas	25 to 30	20 to 25	55 to 65	—15 to —20	4	75 to 85	Bath- and shower-rooms	25	t_{fa}+10°C	70
Tropical seas	30	27	70	30	27	70	Cloak-rooms	20	t_{fa}+5°C	70 to 80
Navigation in any localities	30	27	70	—25	0	80	Wash-rooms and laundries	15	t_{fa}+5°C	60
							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

Table 37

WIRE ROPES

Nominal dia of rope	1570 N/mm²	1570 N/mm²	1570 N/mm²
	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 3064  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	48,2	44,0
12	75,1	69,5	63,3
14	102	94,6	86,2
16	134	124	113
18	169	156	143
20	209	193	176
22	252	234	213
24	300	278	253
26	353	326	297
28	409	378	345
32	534	494	450
36	675	625	570
40	835	772	703
44	–	934	851
48	–	1110	1100
52	–	1300	1190
56	–	1510	1330
Approved for gears with a SWL [illegible]	Shrouds, Stays, Guy pendants	Set mast, Stays, Guy pendants, Preventers, fastened by shackles or ropes secured to the hull, Ropes for an unreeved span not to be tapped under load	Cargo runners (hoisting ropes), Span wire ropes, (luffing ropes), Guy pendant, Guy tackle, Preventer

¹) [illegible] are valid for ropes with core of fibre material. The nominal breaking loads are [illegible] if ropes 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 3064  Round rope Warrington-Seal 6 × 36 Construction 6(14 + 7/7 + 7 + 1) + FE	
	Nominal breaking load¹)			
mm	kN	kN	kN	kN
8	29,5	33,4	–	–
10	46,3	52,2	51,3	58,4
12	66,6	75,1	74,5	84,1
14	90,7	102	102	114
16	113	134	133	149
18	150	169	168	189
20	185	209	207	234
22	224	253	251	283
24	267	301	298	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	896	1010	1006	1130
48	1070	1200	1190	1350
52	1250	1410	1400	1580
56	1450	1640	1620	1830
60	1670	1880	1860	2100
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, preventers, [illegible] 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), slings

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

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 auxiliary engines [KW]

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

s = operating range [sm]

V_{serv} = speed [kn]

1 KW = 0.736 PS (BHP).

Power unit heat units
1 HP (horsepower)
= 550 foot pounds per second
= 0.746 kilowatt
= 1,014 PS (or cheval vapeur)
1 PS (pferdestaerke) or CV (cheval vapeur)
= 542 foot pounds per second
= 0.986 hp
= 0.736 kw

1 long ton = 1,01605 ...
1 short ton = 0,907185 ...

1 kw (kilowatt)
= 1000 watts
= 1.340 hp
= 1.359 PS or CV
= 737 foot pounds per sec

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: $\gamma = 0.95$ t/m³

Required volume of storage tanks

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

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.

16. 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 for one round trip, number of crew members):

- fuel oil

$$W_{fuel\ oil}\ [t] = (P_{Bme} \cdot b_{me} + P_{ae} \cdot b_{ae}) \cdot \frac{S}{V_{serv}} \cdot 10^{-6} \cdot K \cdot [1.3 \ldots 1.5]$$

last brackets for reserve:

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

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 during estuary trading.

$w_{diesel} = (0.1 \ldots 0.2) \cdot w_{heavy\ fuel\ oil}$

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. (According to owner's desire).

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

b = 0.8 ... 1.2 [g/KW·h] diesel engine two stroke
b = 1.2 ... 1.6 [g/KW·h] diesel engine four stroke
b = 0.14 [g/KW·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 coatings in case of fresh water

Fresh water tanks have to be separated from all other tanks.

b) 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).

... and Location of Main Engine

...nother part of the contract influencing ship design.
...p weight, volume, fuel consumption).
...omy is determined by the choice of the main engine type, also

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 seaway; 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).

...omy is determined by the choice of the main engine type, also 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

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

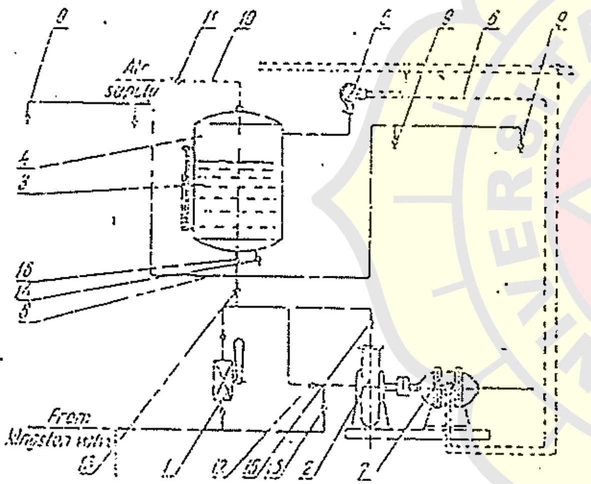


Fig. 189.

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 the air are

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

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

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

(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

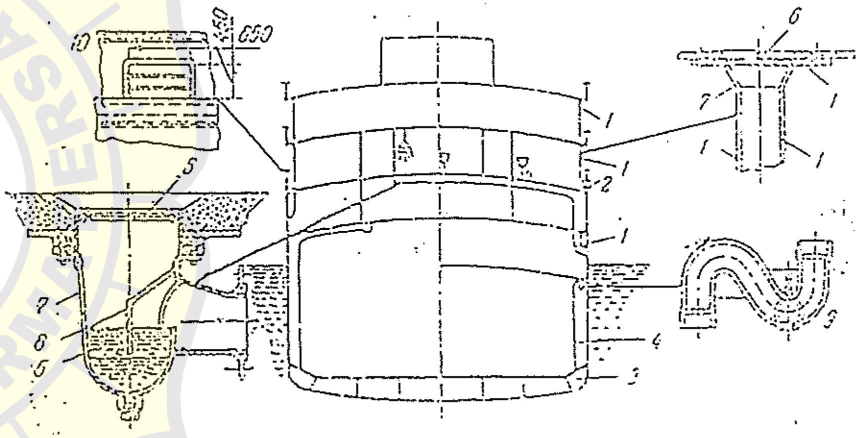


Fig. 190.

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.

Water is drained from decks located lower than the load waterline through scupper pipes *4* 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.

(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

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

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

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

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

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

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.

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_{re} 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 consumption in boiler, kg per hour
Steam turbines	0.005 $G_s \Delta i$	
Steam engines	(0.005 to 0.01) $G_s \Delta i$	Q_l = lower calorific value of the fuel, kcal per kg
Auxiliary machinery	(0.02 to 0.03) $G_s \Delta i$	
Steam lines	0.01 $G_s \Delta i$	G_s = steam consumption, kg per hour
Internal combustion engines	0.02 $N_e g_c Q_l$	Δi = useful heat drop, kcal per kg; N_e = effective power
Electrical machinery:		N = power, kW
(a) with recirculating cooling system	$64\,N \frac{1-\eta}{\eta}$	i_e = mean current density per sq mm of conductor cross section, A per sq mm
(b) without cooling	$864\,N \frac{1-\eta}{\eta}$	
Lighting fixtures	864 N	η = efficiency of electrical machine
Wires, bus bars, cables and fittings	2,160 i_e^2	
Heat introduced from outside by transmission through ship's hull	$\Sigma kF \Delta t$	g_c = fuel consumption, kg per hp-h; k = coefficient of heat transmission of room walls, kcal per hour per sq m per deg C; F = area of the room walls, sq m; Δt = difference in temperatures of room wall surfaces and external surfaces of ship's hull, deg C

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

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

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, pressure

Table 42

Compartment	Number of air renewals per hour for	
	Plenum ventilation	Exhaust ventilation
Passengers', officers' and crew accommodations	10 to 15	—
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

$$\frac{p_{st}Q_{st}}{1+\alpha t_{st}}=\frac{p_aQ_a}{1+\alpha t_a}$$

whence

$$Q_{st}=\frac{(1+\alpha t_{st})\,p_aQ_a}{p_{st}\,(1+\alpha t_a)}=Q_a\frac{\left(1+\frac{1}{273}20\right)}{\left(1+\frac{1}{273}t_a\right)}\frac{p_a}{760}=$$

$$=Q_a\frac{293}{\ldots}\frac{p_a}{\ldots}\text{ cu m per h}\ldots$$

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

$$H_{t\,\infty}=\frac{1}{g}(c_{2u}u_2-c_{1u}u_1)=\frac{1{,}000}{g}\frac{\gamma_{air}}{\gamma_{wat}}(c_{2u}u_2-c_{1u}u_1)=$$
$$=\rho(c_{2u}u_2-c_{1u}u_1)\ \text{mmH}_2\text{O} \qquad (277)$$

where γ_{air} = density of air, kg per cu m

γ_{wat} = 1,000 = density of water, kg per cu m

ρ = mass density of air, kg-sec² per m⁴.

Upon radial entry of the air onto the fan impeller vanes

$$H_{t\,\infty}=\rho c_{2u}u_2\ \text{mmH}_2\text{O}$$

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

$$H=H_{t\,\infty}\,\sigma\eta_h=\sigma\rho c_{2u}u_2\eta_h=\sigma\rho\frac{c_{2u}}{u_2}u_2u_2\eta_h=$$
$$=\sigma\rho\varphi_h u_2^2\eta_h=\rho\psi_h u_2^2\ \text{mmH}_2\text{O} \qquad (278)$$

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 ...

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

$$N_m = \frac{Q_a H}{75\eta_f 3{,}600} \text{ hp}$$

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

$\beta = (5 \text{ to } 15)\left(1+5\frac{b_2}{D_2}\right)$ = 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—$\eta_{fr} \cong 0.6$ to 0.75

For forward-curved vanes—$\eta_r \cong 0.75$ 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

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

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

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_g, 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:

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

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

$$\overline{Q}_k = \frac{Q_s}{Fu_2}$$

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

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

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 counter-clockwise rotation of the rudder can be followed out in Fig. 158.

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.

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,

Table 47

Type of ship	Time required to put rudder from hard-over to hard-over, sec	Speed of rudder movement, deg/sec, for rudder angle of	
		$2\alpha° = 70°$	$2\alpha° = 64°$
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

expressed in rpm, as n_{rs}, then the torque developed on the steering engine shaft and its speed, n_m rpm, will be

$$M_m = \frac{M_{rs}}{i_{sg}\eta_{sg}} \text{ kq-m} \quad (312)$$

$$n_m = i_{sg} n_{rs} \text{ rpm} \quad (313)$$

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:

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

$$\omega_{rs} = \frac{2\alpha°}{\tau}\frac{\pi}{180°} \text{ 1/sec} \quad (315)$$

where $\alpha°$ = maximum rudder angle from the middle-line plane.

It follows from formula (314) that

$$n_{rs} = \frac{30\omega_{rs}}{\pi} \text{ rpm} \quad (316)$$

Combining equations (315) and (316) we obtain

$$n_{rs} = \frac{30}{\pi}\frac{2\alpha°}{\tau}\frac{\pi}{180} = \frac{1}{3}\frac{\alpha°}{\tau} \text{ rpm} \quad (317)$$

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

$$i_{sg} = \frac{n_m}{n_{rs}} = \frac{n_m}{\frac{1}{3}\frac{\alpha°}{\tau}} = 3n_m\frac{\tau}{\alpha°} \quad (318)$$

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

$$N_{rs} = \frac{M_{rs}\omega_{rs}}{75} = \frac{M_{rs}}{75}\frac{2\alpha°}{\tau}\frac{\pi}{180°} = 4.65\frac{M_{rs}}{10^4}\frac{\alpha°}{\tau} \text{ metric hp} \quad (319)$$

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

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

$$N_m = \frac{N_{rs}}{\eta_{sg}} = 4.65\frac{M_{rs}}{10^4\eta_{sg}}\frac{\alpha°}{\tau} \text{ metric hp} \quad (321)$$

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

The shaft horse pow...

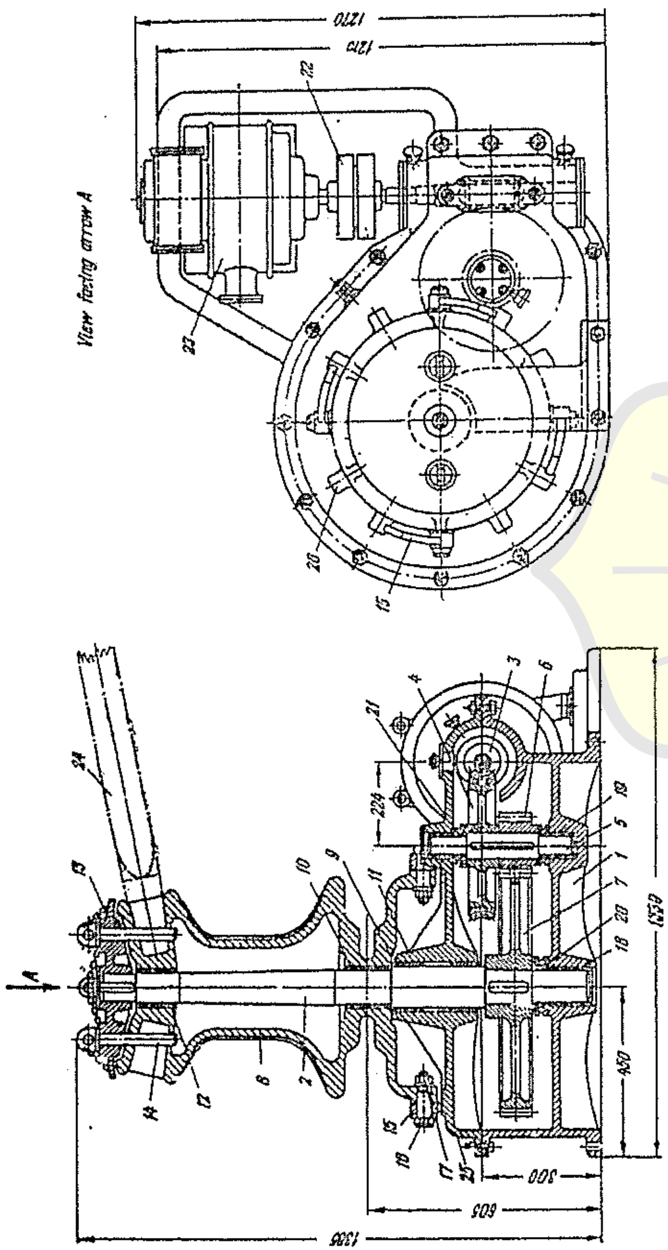


Fig. 169.

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

$$T_{cl}=2f_h(G_a+p_aL_a)\left(1-\frac{\gamma_w}{\gamma_a}\right)=2\times1.35\,(G_a+p_aL_c)\left(1-\frac{1,025}{7,750}\right)= =2.35\,(G_a+p_aL_a)\quad\text{kg} \qquad (383)$$

In hoisting one anchor

$$T_{cl}=1.175\,(G_a+p_aL_a)\quad\text{kg}$$

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

$$\left.\begin{aligned}&(a)\ p_{ao}=0.023\,d_c^2\ \text{kg for open-link chain}\\&(b)\ p_{as}=0.0218\,d_c^2\ \text{kg for stud-link chain}\end{aligned}\right\}\qquad(384)$$

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

$$T_{cl}=2G_a+1.175\,(G_a+p_aL_a)\quad\text{kg}$$

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

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

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:

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

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: Bower: Quantity	Anchors: Bower: Total weight, kg	Anchors: Stream anchor, kg	Chain cable for bower anchors: Total length of two cables, m	Chain cable for bower anchors: Anchor chain size, mm	Chain or steel rope for the stream anchor: Length, m	Chain or steel rope for the stream anchor: Anchor chain size, mm	Chain or steel rope for the stream anchor: Diameter of steel rope, mm
1	50	2	150	25	100	12	50	—	8.8
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

Continued

No.	Characteristic X	Anchors: Bower: Quantity	Anchors: Bower: Total weight, kg	Anchors: Stream anchor, kg	Chain cable for bower anchors: Total length of two cables, m	Chain cable for bower anchors: Anchor chain size, mm	Chain or steel rope for the stream anchor: Length, m	Chain or steel rope for the stream anchor: Anchor chain size, mm	Chain or steel rope for the stream anchor: Diameter of steel rope, mm
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	16300	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

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

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

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

where d_c=chain bar size, mm.

Table 60

Mooring and Warping Ropes

Characteristic	Towing rope: Length, m	Towing rope: Circumference of hemp rope, mm	Towing rope: Diameter of steel rope, mm	Warping hawsers: Total length, m	Warping hawsers: Number of ropes	Warping hawsers: Circumference of hemp rope, mm	Warping hawsers: Diameter of steel rope, mm	Cable warps: Total length, m	Cable warps: Number of ropes	Cable warps: Circumference of hemp rope, mm	Cable warps: 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	480	4	200	21.5	150	2	150	17.5
1600	200	300	30	480	4	200	21.5	150	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	150	17.5
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: Length, m	Towing rope: Circumference of hemp rope, mm	Towing rope: Diameter of steel rope, mm	Warping hawsers: Total length, m	Warping hawsers: Number of ropes	Warping hawsers: Circumference of hemp rope, mm	Warping hawsers: Diameter of steel rope, mm	Cable warps: Total length, m	Cable warps: Number of ropes	Cable warps: Circumference of hemp rope, mm	Cable warps: Diameter of steel rope, mm
2700	220	350	34.5	640	4	225	24	200	2	200	21.5
3000	220	350	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
5800	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	480	4	250	26
7800	240	—	57	960	6	300	30	480	4	250	26
8200	240	—	61.5	960	6	300	30	480	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

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

(a) for windlasses and capstans of bower anchors:

$$n_{cl}=\frac{60\,v_a}{0.04\,d_c}=\frac{60\times0.2}{0.04\,d_c}=\frac{300}{d_c}\quad \text{rpm}$$

(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

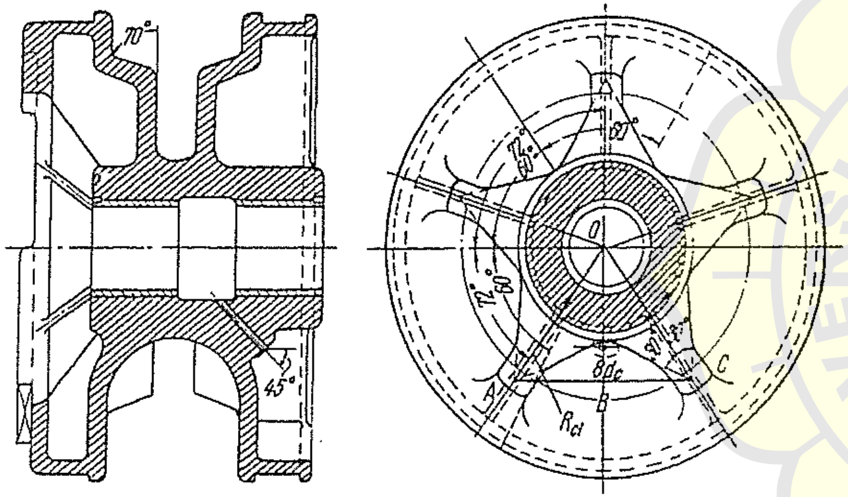


Fig. 170.

with worm gearing. It is the product of the efficiencies of the transmissions and shaft bearings in the gear train (Fig. 171):

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

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	150 to 320	18 to 60
Electric capstans	500 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

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

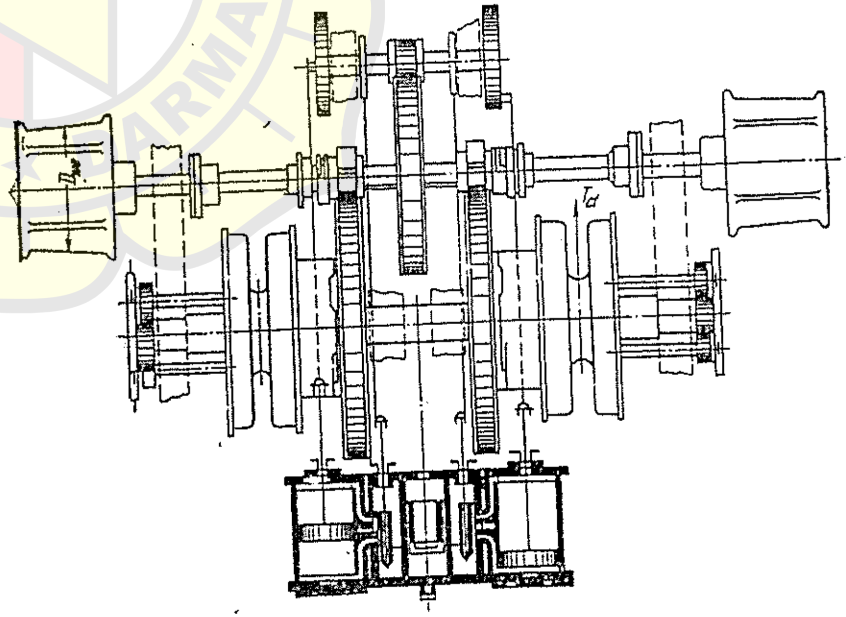


Fig. 171.

The mean shaft power of the motive unit should be

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

The mean indicated power is

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

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

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

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 $(\alpha_i k_i p_{ls} - p_{ss})$ 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

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

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

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

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

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

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

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

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

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

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

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

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

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

The pulling force and heaving-in speed obtained from the above formulas must conform to the requirements for warping appliances. If the heaving-in speed is unsuitable, it is necessary to change the gearing ratio of the transmission between the motive unit shaft and the warping shaft correspondingly. If the mechanism does not develop the required pulling force on the warp ends, then its power requirements must be determined from the conditions stipulated for warping appliances.

The gearing ratio required to develop a pulling force T_{we} for a given torque on the motive unit shaft can be found from the following formula:

$$i_w = \frac{T_{we}(D_{we} + d_w)}{2M_m \eta_w} \qquad (395)$$

The power ratings of the electric motors for driving anchoring arrangements and their shaft speeds are selected from nominal values in the same way as for a steering gear.

The gearing ratio of the mechanism is found from the formula:

$$i_a = \frac{n_r \pi D_{cl}}{60 v_a} \qquad (397)$$

The rated torque of the motor is

$$M_r = \frac{T_{cl} D_{cl}}{2 i_a \eta_a} \quad \text{kg-cm} \qquad (398)$$

where T_{cl} = required pull on the cable lifter
η_a = overall efficiency of the mechanism.

The mean effective power of the motor is

$$N_e = \frac{M_r n_r}{97{,}500} \quad \text{kW} \qquad (399)$$

The regulations of the U.S.S.R. Shipping Register stipulate that each anchoring and warping arrangement must have an emergency hand drive. A rocker bar usually serves as the emergency hand drive for windlasses. The power requirements of this mechanism are calculated on the basis of the force required to break away and hoist one anchor.

The pull required to hoist the anchor, for the hand drive shown schematically in Fig. 172, is determined from the condition of equality of the moments of acting forces in reference to the main shaft.

The moment, developed by the reaction of the anchor and counteracting the effort to break it away, is

$$M_{ar} = \frac{T_{cl} D_{cl}}{2\eta_{cl}} \quad \text{kg-m} \qquad (400)$$

where η_{cl} = 0.94 = efficiency of the cable lifter.

The moment developed by the forces applied to the ends of the rocker arm is

$$M_{ar} = P_{tr}(R_{rw} + a)\eta_{rw} \quad \text{kg-m} \qquad (401)$$

where R_{rw} = 0.3 to 0.8 = radius of the ratchet wheel, m
η_{rw} = 0.92 = efficiency value accounting for the friction in the teeth of the ratchet wheel and in the joints of the tie rod and shoe
a = 0.13 to 0.21 = distance from the circumference of the ratchet wheel to the tie rod axis, m
P_{tr} = force acting on the tie rod, in kg.

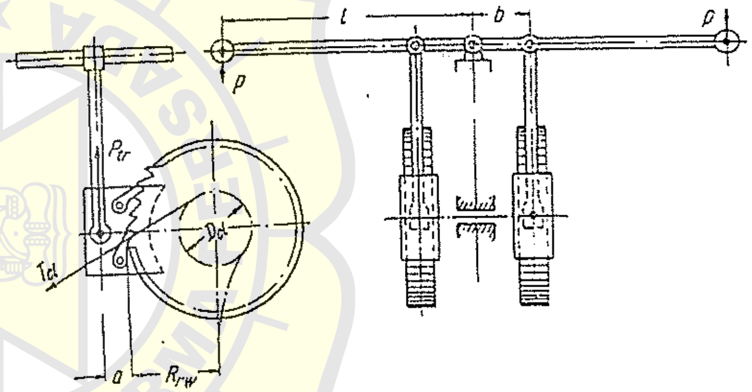


Fig. 172.

Combining equations (400) and (401) we obtain

$$P_{tr} = \frac{T_{cl} D_{cl}}{2(R_{rw} + a)\eta_{rw}\eta_{cl}} \quad \text{kg} \qquad (402)$$

The force applied to the tie rod when the rocker arm is operated is found from the equation for the moments of all forces applied to the rocker arm in reference to its pivot:

$$p_{dh} k_{dh} l \eta_{hj} = P_{tr} b$$

whence

$$p_{dh} = \frac{P_{tr} b}{k_{dh} l \eta_{hj}} \qquad (403)$$

where p_{dh} = force exerted by one deck hand operating the rocker arm, kg
k_{dh}=4 to 16 = number of deck hands operating the rocker arm
η_{hj}=0.98 = efficiency of the hinged joints (including the pivot) of the rocker arm

The pulling force, T_b, on the winch barrel (Figs. 174 and 175) is

$$T_b = \frac{P+Q}{\eta_p^k} = P_g \quad (412)$$

where P = weight of the useful load being hoisted, kg
Q = (0.0028 to 0.0022) P = weight of the cargo hook with the shackle, kg
η_p = 0.9 to 0.96 = efficiency of one pulley
k = number of intermediate pulleys between the boom iron and the winch barrel.

A two-speed winch is designed for a given pulling force, P_g, in double-gear operation. The gearing ratio for single-gear operation usually ranges from 4 to 6 and for double-gear operation, from 6 to 12.

The diameter of the winch barrel is taken to be

$$D_b = (16.5 \text{ to } 18)d_r \quad (413)$$

where the rope diameter, d_r, is selected according to its breaking strength, $R_{br} = 6P_g$.

The length of the winch barrel is

$$L_b = (1.1 \text{ to } 1.6)D_b \quad \text{cm}$$

The number of layers, z, of rope wound on the barrel depends upon the size of the latter and the length of the rope to be wound. This length, L_r, ranges from 40 to 75 m and the number of layers does not exceed five.

The diameter, d_r, and kind of rope is selected so that the actual tensile strength

$$R_{br} \geqslant k_m P_g \text{ kg} \quad (414)$$

where $k_m \geqslant 6$ = margin of safety.

The number of turns that can be accommodated along the length of the barrel is

$$m = \frac{L_b}{d_r} \quad (415)$$

The length of rope accommodated is:
in the first layer

$$l_{m1} = \pi(D_b + d_r)m$$

in the second layer

$$l_{m2} = \pi[D_b + (4d_r - d_r)]m = \pi(D_b + 3d_r)m$$

in the third layer

$$l_{m3} = \pi[D_b + (6d_r - d_r)]m = \pi(D_b + 5d_r)m$$

in the z-th layer

$$l_{mz} = \pi[D_b + (2zd_r - d_r)]m = \pi[D_b + d_r(2z-1)]m \quad (416)$$

Thus, the rope capacity of the barrel, if the rope is wound, is:
in one layer

$$L_{m1} = l_{m1} = \pi(D_b + d_r)m$$

in two layers

$$L_{m2} = l_{m1} + l_{m2} = \pi(D_b + d_r)m + \pi(D_b + 3d_r)m = \pi(2D_b + 4d_r)m$$

in three layers

$$L_{m3} = L_{m2} + l_{m3} = \pi(2D_b + 4d_r)m + \pi(D_b + 5d_r)m = \pi(3D_b + 9d_r)m$$

in z layers

$$L_{mz} = \pi(zD_b + z^2 d_r)m \quad (417)$$

The barrels of cargo winches are made with a smooth surface to increase their rope capacity, reduce their cost and to simplify their manufacture. They are not equipped with rope guiding devices. This leads to a certain lack of uniformity in the arrangement of the rope on the barrel which is taken into account by the factor $\beta_b \approx 0.9$ in calculating the rope capacity.

Thus equation (417) can be rewritten as

$$L_{mz} = \beta_b \pi m(zD_b + z^2 d_r)m \quad (418)$$

If the required rope capacity of the winch barrel is known beforehand, equation (418) can be solved for z to find the number of layers in which the rope will be accommodated. Thus

$$\beta_b \pi m d_r z^2 + \beta_b \pi m D_b z - L_{mz} = 0$$

$$z^2 + \frac{D_b}{d_r}z - \frac{L_{mz}}{\beta_b \pi m d_r} = 0$$

then

$$z = -\frac{D_b}{2d_r} + \sqrt{\left(\frac{D_b}{2d_r}\right)^2 + \frac{L_{mz}}{\beta_b \pi m d_r}} = -\frac{D_b}{2d_r} + \sqrt{\frac{D_b^2}{4d_r^2}\left(1 + \frac{4L_{mz}d_r^2}{\pi D_b^2 \beta_b m d_r}\right)}$$

$$z = \frac{D_b}{2d_r}\left(\sqrt{1 + \frac{4d_r L_{mz}}{\beta_b D_b^2 \pi m}} - 1\right) \quad (419)$$

The maximum torque on the winch barrel is usually developed at the beginning in hoisting the load or at the end in lowering it since it is necessary to overcome the inertia of the load. Moreover, the torque increases at the end of hoisting because the rope is wound in z layers.

In the latter case, calculations are usually conducted using the design diameter of the barrel which is

$$D_{bd}=D_b+d_r(2z-1) \quad \text{m} \tag{420}$$

The torque developed on the barrel shaft is

$$M_{bd}=\frac{1}{2}[D_b+d_r(2z-1)]\frac{T_b}{\eta_b} \quad \text{kg-m} \tag{421}$$

where η_b = efficiency of the winch barrel.

The rotational speed, n_{bd}, of the barrel is found from the following equation for a load hoisting speed v_{ld} with the double gearing of the winch engaged:

$$n_{bd}=\frac{60v_{ld}}{\pi D_{bd}}=19.1\frac{v_{ld}}{D_{bd}} \quad \text{rpm} \tag{422}$$

The overall gearing ratio of the winch with the double gearing engaged is

$$i_{wd}=\frac{n_m}{n_{bd}}=\frac{n_m}{\frac{60v_{ld}}{\pi D_{bd}}}=\frac{n_m\pi D_{bd}}{60v_{ld}} \tag{423}$$

where n_m=80 to 250 = speed of the winch steam engine shaft, rpm
n_m = 500 to 3,000 = shaft speed of the electric motor, rpm.

The overall efficiency, η_{wd}, of the winch when the double gearing is engaged is the product of the efficiencies of the shafts (η_{sh}), pairs of spur gears (η_{pg}), barrel (η_b) and worm gearing (η_{wg}). Thus

$$\eta_{wd}=\eta_{sh}^a\eta_{pg}^c\eta_b\eta_{wg} \tag{424}$$

where a and c = number of shafts and pairs of gears, respectively
η_{wd} = 0.7 to 0.85 for winches with spur gearing
η_{wd} = 0.65 to 0.75 for winches with worm gearing.

The required shaft torque of the motive unit is

$$M_{md}=\frac{M_{bd}}{i_{wd}\eta_{wd}} \quad \text{kg-m} \tag{425}$$

The diameter of the steam engine cylinder and the required power to start from rest are determined from Posdyunin's formula:*

$$D_{cw}=1.37\sqrt[3]{\frac{M_{md}}{\Psi_r\eta_m(\alpha_ik_ip_{ls}-p_{ss})}} \quad \text{cm} \tag{426}$$

* The symbols denote the same values as in the case of steering engines.

where $k_i=\frac{1+\ln\Delta}{\Delta}$ = coefficient of mean theoretical indicated pressure for a ratio of steam expansion Δ
M_{md} = torque developed on the engine shaft, kg-cm.

The indicated power of the engine required to start from rest under load is

$$N_i=\frac{D_{cw}^3(\alpha_ik_ip_{ls}-p_{ss})\,n_m\Psi_r}{143{,}300} \quad \text{hp} \tag{427}$$

Values of k_i as a function of the admission ratio (reciprocal of the expansion ratio) $\delta=\frac{l}{\Delta}$ are listed in Table 62.

Table 62

δ	0.5	0.6	0.7	0.8	0.9	1
k_i	0.848	0.907	0.95	0.979	0.995	1

If T_{bs} is the given rated pulling force for the single gearing engagement of the winch, calculated from equation (412) for the given load hoisting capacity, then, according to equation (421), the torque developed on the winch barrel is

$$M_{bs}=\frac{1}{2}[D_b+d_r(2z-1)]\,T_{bs} \quad \text{kg-m} \tag{428}$$

Assuming that the motive unit shaft rotates at a constant speed n_m we can write

$$\frac{M_{bd}}{i_{wd}\eta_{wd}}=\frac{M_{bs}}{i_{ws}\eta_{ws}} \tag{429}$$

where η_{ws} = overall efficiency of the winch when the single gearing is engaged
i_{ws} = gearing ratio of the winch with the single gearing engaged.

It follows that the required gearing ratio is

$$i_{ws}=\frac{M_{bs}}{M_{bd}}\frac{\eta_{wd}}{\eta_{ws}}i_{wd} \tag{430}$$

The speed of the winch barrel for single gearing is

$$n_{bs}=\frac{n_m}{i_{ws}} \quad \text{rpm} \tag{431}$$

During towing operations clutch member *10* is engaged with gear *15*. In warping, when the winch barrel *1* should be stationary, clutch member *10* is disengaged from gear *15* and shaft *9* is driven from the engine through gears *13* and *14*.

A steady force is established on the tow rope during towing operations in calm weather and the barrel is locked by a band brake applied through crank handle *8*. In this case the steam supply is cut off from the engine.

The brake band fits in a groove of rim *11* on the barrel. The brake has buffer springs *28* and its design differs in no way from that of ordinary band brakes employed on windlasses and winches.

In rough weather towing, the brake is released and the live steam line is opened.

Thus, in this case, the resistance of the vessels being towed is transmitted through the rope to the winch barrel and further, through the gearing and crank gear of the steam engine to the piston. This force, acting on the piston in one direction, is counter-balanced by the pressure of the steam acting in the opposite direction, thereby holding the barrel stationary.

In rough weather, the resistance to movement of the towed vessel will vary due to the dynamic loads resulting from wind and wave action. These dynamic loads on the rope are absorbed by the action of the automatic device *5*.

Live steam is supplied to the engine through pipeline *17* and is admitted to the starting valve when the automatic device is turned off. This valve is controlled with lever *7* and permits the winch to be reversed.

When the automatic device is turned on, steam is admitted through the valve with handwheel *6* into chest *5* of the device and then passes to the starting valve.

The automatic device operates as follows. Under the action of the increased dynamic load the rope turns the winch barrel and, with it, shaft *29* and bevel gear *30* which meshes with gear *33*. Bevel gear *33* is freely mounted on shaft *31* and can be engaged with it by shifting clutch member *32* along a key on the same shaft using lever *25*.

Gear *33* and clutch member *32*, enclosed in housing *26*, are to be engaged when the automatic device is turned on. In this case, the rotation of gear *30* is transmitted to shaft *31* and handwheel *18* which is keyed on this shaft.

As shaft *31* rotates, cylinder *27* will move axially along the threaded part of the shaft shifting stem *34* of piston valve *35* and the valve itself in the same direction.

According to the position shown in the illustration the valve will move to the left increasing the amount of live steam admitted

through flanges *36* and *37* to the starting valve and, consequently, through the valve to the distribution valves of the steam engine.

As soon as the dynamic load on the rope is relieved and drops to the normal value, the engine starts operation and rotates the winch barrel in the corresponding direction. Shaft *29* will turn in the same direction actuating the automatic device in winch valve *35* is returned to its initial position when the tow rope is heaved in to its normal length.

The pressure of the steam admitted into the engine cylinders counter-balances the resistance to movement of the towed vessel until the next dynamic load appears, after which the automatic device begins operating again.

After disengaging clutch member *32* from gear *33*, the engine can be started by turning handwheel *18* in either direction depending upon the position of the starting valve.

Movable idlers are provided to uniformly wind the rope on barrel *1* and to prevent adjacent turns of the same layer from being wound on each other.

During winch operation, the idler carriage *3* travels back and forth along rods *19* which are parallel to the winch barrel axis. Tow rope *20* runs between the rollers *21* and *22* and is wound on the proper place on the barrel as guided by these rollers.

The idler carriage is traversed by the action of screw *23* on the carriage drive dog *38* which operates as a nut mating with the screw. Screw *23* is driven from the barrel through a transmission (not shown in the illustration). The thread of screw *23* consists of an endless right- and left-hand groove into which the drive dog *38* fits. The screw rotates constantly in one direction. The carriage is automatically reversed at the ends of its travel when the dog reaches the guide member *24* at each end of the screw which swivels the dog and guides it from the part of the groove with one hand to the part with the opposite hand. Swivel of the dog and transition from the right- to the left-hand parts of the groove and vice versa enable the dog to be used as a nut with right-hand thread when the carriage travels in one direction and as one with left-hand thread after the carriage is reversed.

Power calculations of a towing winch begin by selecting the length and size of the tow rope from Table 60 in accordance with the characteristic of the vessel to be towed, as computed from formula (386). The pulling force developed by the winch barrel should not exceed

$$T_b = \frac{R_{br}}{8}$$

The length of the tow rope ranges from 135 to 300 m. The rope capacity of the winch barrel is calculated to accommodate 80 per cent of the total length of the rope.

It should be noted that an increase in the design diameter of the barrel due to the layers of rope wound on it increases the torque on the barrel shaft and the heaving-in speed, while a reduction in the design diameter reduces these values. The number of turns accommodated in one layer on a barrel with a length L_b is

$$m=\frac{L_b}{a_b+d_r}$$

where $a_b \approx 1$ mm = clearance between the turns of rope.

The remaining calculations are done according to equations (415) through (427). If the main characteristics of the steam engine are given, the pulling force developed by the towing winch is determined from formula (432).

The power of the motive unit required to drive a towing winch can also be calculated from the formula

$$N_i=\frac{T_b v_h}{60\times 75\eta_w\eta_n} \quad \text{metric hp}$$

where $v_h \approx 0.33$ to 0.5 = heaving-in speed of the rope, m per sec.

Knowing the torque developed on the motive unit shaft and assuming that it runs at constant speed we can plot a curve showing the variation of the pulling force with the design diameter D_{bd} of the barrel using the formula*

$$N_e=\frac{M_m n_m}{716.20}=\frac{M_b n_b i_w}{716.20 i_w \eta_w}=\frac{M_b n_b}{716.20\eta_w}=\frac{T_b D_{bd} n_b}{2\times 716.20\eta_w} \quad \text{metric hp}$$

6-3. Ash Hoisting Winches

Various ash-disposal devices are employed to extract ashes and cinders from the boiler room and discharge them overboard.

Cinders are usually hoisted to the deck with hand, steam or electric ash hoisting winches and are discharged overboard by hand.** A vent duct commonly serves as the hoisting shaft. Steam winches are driven by single-expansion duplex steam engines with a piston stroke and cylinder diameter ranging from 100 to 120 mm and running at 80 to 300 rpm. The engine shaft is usually linked through worm gearing with the winch barrel whose diameter may range from 180 to 300 mm. The ratio of the worm gearing may vary from 10 to 20 for a rope heaving-in speed of 0.4 to 0.8 m per sec. The engine is reversed by the starting valve. Load lifting capacities of ash hoisting winches range from 100 to 400 kg.

The construction of a steam-and-hand ash hoisting winch is shown in Fig. 183.

Worm *8* is mounted on the shaft *6* of a single-expansion two-cylinder vertical steam engine. This worm meshes with worm wheel *9* mounted on shaft *10* of the winch barrel *7*. The barrel is freely mounted on the shaft together with ring *11* which has a lug *12*. Bolt *13*, located between projections *14* of the barrel, passes through a slot in lug *12*. Ring *11* and ratchet wheel *15* are secured on the shaft by a single key *16*. Pawl *17* of ratchet wheel *15* is pivoted on a pin between lugs *29* of the barrel. This pawl is disengaged from the wheel and held in the disengaged position by hook *18* when the winch is to be driven by the steam engine. Flat spring *30* presses the pawl into engagement with the teeth of the ratchet wheel for the hand drive. Worm *19*, also keyed on shaft *10*, meshes with worm wheel *20* on vertical shaft *21* whose lower end is threaded and carries the nut *22*. Lever *24*, which actuates the differential valve *25*, is mounted on trunnions *28*. The engine is started by shifting the differential valve *25* from its central position, turning lever *24* about trunnions *28*.

The movement of the pistons is transmitted through piston rods *5* and connecting rods *4* to crank disk *26* and further through worm *8*, worm wheel *9*, shaft *10* and ring *11* to the barrel *7*. At the same time, worm *19* rotates vertical shaft *21* through worm wheel *20*.

Axial movement of shaft *21* is restricted so that upon its rotation, nut *22* will travel vertically. Its action, through trunnions *28*, on lever *24* returns the differential valve *25* to the central position. Here we have the same servomotor principle that is employed in steering gear.

If ashes are to be hoisted by hand, bolt *13* with its nut is shifted along the slot of lug *12* towards the centre to bring it out of engagement with the projections *14* of barrel *7*. The pawl *17* is placed into the position shown in the illustration and crank handle *27* is secured to the winch barrel. The winch is driven with this handle.

The same formulas are used in ash hoisting winch design as for other types of winches.

6-4. Boat Winches

Boat-handling gear is used for:

(1) communications between the ship and shore when the ship is riding at anchor in a roadstead;

(2) saving the passengers and crew in case of a shipwreck.

The boat-handling gear must include:

* This formula is applicable to any type of winch.

** Ash-disposal devices of the ejector type are classified as jet pumps.

consideration all parasitic resistances in the boat's falls and in the various guide blocks through which the tackle fall runs to the winch heads.

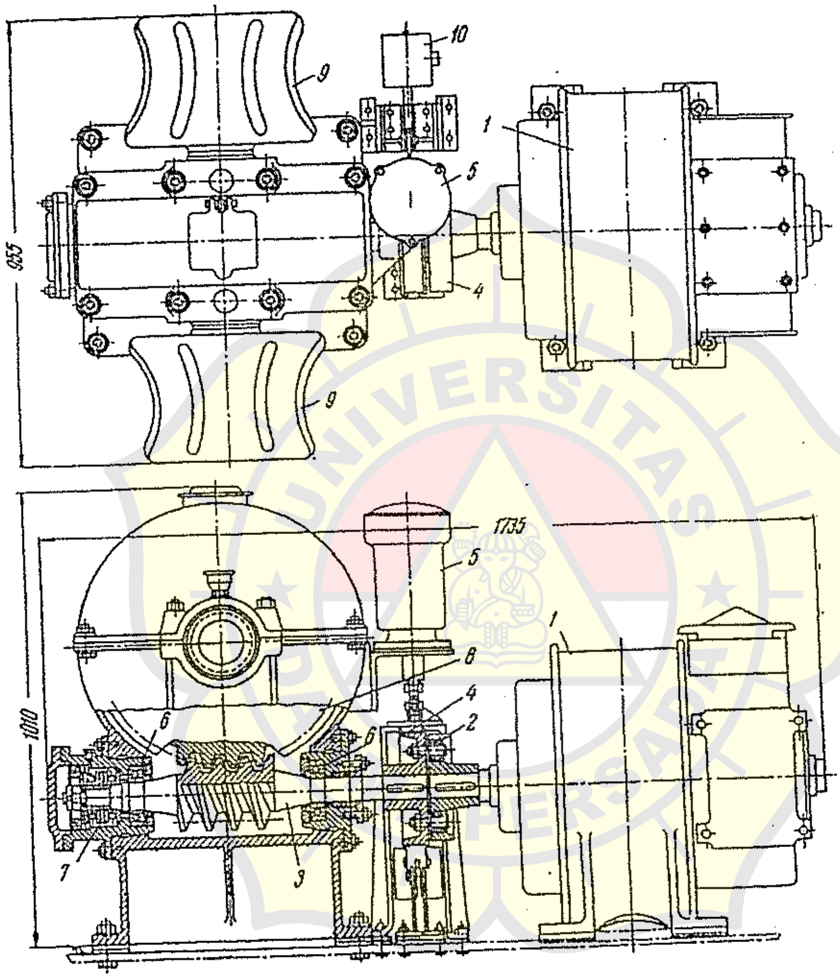


Fig. 184.

The design load Q acting on the falls of one davit is determined from the formula

$$Q = 0.5\,(Q_b + Q_p k_n) + Q_f$$

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

$$T_{max}=\frac{0.5\,(Q_b+1.1Q_p)+Q_f}{m\eta_f\eta_r\eta_s^a}$$

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

$$T_{min}=\frac{0.5\,(Q_b+0.9Q_p)+Q_f}{m\eta_f\eta_r\eta_s^c}$$

where c = minimum number of blocks.

The diameter, d_f, of a hemp fall is selected according to the breaking strength $(T_{max}+T_{min})\,6\leqslant R_{br}$ as a function of the boat length from Table 63 (U.S.S.R. Shipping Register).

Table 63

Boat length, m	Circumference of tackle fall, mm	Breaking strength, kg
8.25 to 9.14	95	6,100
7.62 to 8.25	89	5,400
7.35 to 7.62	83	4,600
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 = 200 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

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

and

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

The cylinder diameter and indicated power of steam boat winches are determined from the same Posdyunin formulas used in determining these values for other steam-powered auxiliary machinery.

The required motor power rating for an electric winch can be calculated from the formula

$$N_e=\frac{(T_{max}+T_{min})\,v_b}{75\times 60\eta_{bw}} \quad \text{metric hp}$$

6-5. Winch Operation

Before starting a winch it is necessary to make sure by inspection that it is in order and that no foreign objects hinder the moving parts of the winch. Then, warm up the steam supply line and the winch engine, apply lubricant to all friction surfaces, check the starting gear by turning it to the "hoist" and "lower" positions, check whether the speed-changing clutches engage and disengage properly and whether the braking gear is in order. After this, test the forward and reverse operation of the winch; if no knocking is heard and reversal is rapid and smooth, the winch is ready for regular operation. The winch is started and stopped and the shaft speed is changed in operation by opening and closing a stop valve or the starting valve. The winch is reversed either by shifting the links of the reversing gear or by operating the starting valve.

During winch operation it is necessary to see that lubricant is being properly fed, to check the temperature of the parts subjected to friction and to listen for knocking. As soon as abnormal noise is heard, stop the winch, find and eliminate the cause of the noise.

The load lowering speed should be regulated by applying the brake. Backsteam should be resorted to only when the load drops too fast even after applying the brake.

If hoisting operations are interrupted for short periods in winter, the winch should be run idle at low speed with open blow-off valves.

If the winch is not to be operated for a prolonged period in winter, it is necessary to drain the condensate from the cylinders and the live and exhaust steam lines.

Winch operation is prohibited if cracks are found in critical parts, if the motive mechanism, steam distribution or breaking gear is out of order or if the gears are excessively worn or some of the teeth are missing.

Part Three

SHIPBOARD SYSTEMS

Chapter 7

GENERAL SYSTEMS

7-1. Classification and Functions of Shipboard Systems

Any shipboard system comprises a network of special pipelines with their component machinery, apparatuses and instruments, and is designed to perform definite functions on the ship. Shipboard systems may be classified as general, special and marine power plant systems.

The classification and functions of general shipboard systems and the special systems of tankers and ice-breakers are indicated in Table 64.

Pipeline elements ensure airtight joints between the separate components and parts of a pipeline system and otherwise enable the system to serve the purpose it is designed for.

Elements of pipelines include:

(a) piping, which is the main element of a line and connects the point where a fluid is received to the point of discharge;

(b) connecting, or line, fittings which connect the separate pipes and components of a pipeline together and to the ship's hull (flanges, tees, elbows, bulkhead castings, deck plates, and couplings);

(c) disconnecting and regulating fittings (valves) which serve to connect, disconnect or switch over either separate sections of a pipeline or the whole pipeline, and also for regulating the pressure and controlling the flow in a pipeline;

(d) valve gear which provides for control of valves and other fittings either from their place of installation (local control) or from a distance (remote control);

Lampiran – 1

Tabel-L1.1 Viskositas kinematis air tawar ν dalam satuan centiStokes [cST = 10^{-6} m²/dt.] pada suhu dalam satuan °C

°C	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
0	1,7867	1,7806	1,7745	1,7685	1,7625	1,7565	1,7505	1,7446	1,7387	1,7329
1	1,7270	1,7212	1,7155	1,7097	1,7040	1,6984	1,6927	1,6871	1,6815	1,6759
2	1,6704	1,6649	1,6594	1,6540	1,6486	1,6432	1,6378	1,6325	1,6272	1,6219
3	1,6167	1,6114	1,6062	1,6011	1,5959	1,5908	1,5857	1,5806	1,5756	1,5706
4	1,5656	1,5606	1,5557	1,5507	1,5459	1,5410	1,5361	1,5313	1,5265	1,5217
5	1,5170	1,5123	1,5075	1,5029	1,4982	1,4936	1,4890	1,4844	1,4798	1,4752
6	1,4707	1,4662	1,4617	1,4573	1,4529	1,4484	1,4441	1,4397	1,4353	1,4310
7	1,4267	1,4224	1,4181	1,4139	1,4096	1,4054	1,4013	1,3971	1,3929	1,3888
8	1,3847	1,3806	1,3766	1,3725	1,3685	1,3645	1,3605	1,3565	1,3525	1,3486
9	1,3446	1,3407	1,3368	1,3330	1,3291	1,3253	1,3215	1,3177	1,3139	1,3102
10	1,3064	1,3027	1,2990	1,2953	1,2916	1,2879	1,2843	1,2807	1,2771	1,2735
11	1,2699	1,2663	1,2528	1,2592	1,2557	1,2522	1,2487	1,2453	1,2418	1,2384
12	1,2350	1,2315	1,2282	1,2248	1,2214	1,2181	1,2148	1,2115	1,2082	1,2049
13	1,2016	1,1983	1,1951	1,1918	1,1886	1,1854	1,1823	1,1791	1,1759	1,1728
14	1,1696	1,1665	1,1634	1,1603	1,1572	1,1541	1,1511	1,1481	1,1450	1,1420
15	1,1390	1,1360	1,1330	1,1301	1,1271	1,1242	1,1212	1,1183	1,1154	1,1125
16	1,1097	1,1068	1,1040	1,1011	1,0983	1,0955	1,0927	1,0899	1,0871	1,0843
17	1,0816	1,0788	1,0751	1,0733	1,0706	1,0679	1,0652	1,0625	1,0599	1,0572
18	1,0546	1,0519	1,0493	1,0467	1,0441	1,0415	1,0389	1,0363	1,0338	1,0312
19	1,0287	1,0261	1,0236	1,0211	1,0186	1,0161	1,0136	1,0111	1,0866	1,0062
20	1,0037	1,0013	0,9989	0,9965	0,9941	0,9917	0,9893	0,9869	0,9845	0,9822
21	0,9798	0,9775	0,9752	0,9729	0,9705	0,9682	0,9659	0,9636	0,9614	0,9591
22	0,9568	0,9546	0,9523	0,9501	0,9479	0,9457	0,9435	0,9413	0,9391	0,9369
23	0,9347	0,9326	0,9304	0,9283	0,9261	0,9240	0,9218	0,9197	0,9176	0,9155
24	0,9134	0,9113	0,9092	0,9072	0,9051	0,9031	0,9010	0,8990	0,8960	0,8949
25	0,8929	0,8909	0,8889	0,8869	0,8849	0,8829	0,8809	0,8790	0,8770	0,8751
26	0,8731	0,8712	0,8693	0,8673	0,8654	0,8635	0,8616	0,8597	0,8578	0,8560
27	0,8541	0,8522	0,8504	0,8485	0,8467	0,8448	0,8430	0,8412	0,8393	0,8375
28	0,8357	0,8339	0,8321	0,8303	0,8286	0,8268	0,8250	0,8232	0,8215	0,8197
29	0,8180	0,8163	0,8145	0,8128	0,8111	0,8094	0,8077	0,8060	0,8043	0,8026
30	0,8009	0,7992	0,7976	0,7959	0,7942	0,7926	0,7909	0,7892	0,7876	0,7859

Contoh .

Air di tangki percobaan Laboratorium Hidrodinamika ITS pada saat *resistance test* tgl.1 Juni 1994 dilaksanakan : suhu 27,0° C, sehingga :

$$\nu_{\text{air tawar}} = 0{,}8541 \text{ cST } (= 0{,}8451.10^{-6} \text{ m}^2/\text{dt.})$$

Tabel-L1.2 Viskositas kinematis air laut (air dengan kadar garam 3,5%) [cST][10^{-6} m²/dt.] pada suhu dalam satuan °C

°C	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
0	1,3284	1,8224	1,8163	1,8103	1,8044	1,7984	1,7925	1,7866	1,7808	1,7749
1	1,7692	1,7634	1,7577	1,7520	1,7463	1,7407	1,7351	1,7296	1,7240	1,7185
2	1,7131	1,7076	1,7022	1,6968	1,6915	1,6861	1,6808	1,6755	1,6703	1,6651
3	1,6599	1,6547	1,6496	1,6445	1,6394	1,6343	1,6293	1,6243	1,6193	1,6143
4	1,6094	1,6045	1,5996	1,5948	1,5899	1,5851	1,5803	1,5756	1,5708	1,5661
5	1,5614	1,5568	1,5521	1,5475	1,5429	1,5384	1,5338	1,5293	1,5248	1,5203
6	1,5158	1,5114	1,5070	1,5026	1,4982	1,4939	1,4896	1,4853	1,4810	1,4767
7	1,4724	1,4681	1,4640	1,4598	1,4556	1,4515	1,44474	1,4433	1,4392	1,4351
8	1,4310	1,4270	1,4230	1,4190	1,4150	1,4110	1,4071	1,4032	1,3993	1,3954
9	1,3915	1,3877	1,3839	1,3800	1,3762	1,3725	1,3687	1,33650	1,3612	1,3575
10	1,3538	1,3501	1,3465	1,3428	1,3392	1,3356	1,3320	1,3284	1,3248	1,3213
11	1,3177	1,3142	1,3107	1,3072	1,3038	1,3003	1,2969	1,2934	1,2900	1,2866
12	1,2832	1,2799	1,2765	1,2732	1,2699	1,2666	1,2633	1,2600	1,2568	1,2535
13	1,2503	1,2471	1,2438	1,2406	1,2375	1,2343	1,2311	1,22280	1,2248	1,2217
14	1,2186	1,2155	1,2124	1,2094	1,2063	1,2033	1,2003	1,1973	1,1943	1,1913
15	1,1883	1,1853	1,1824	1,1794	1,1765	1,1736	1,1707	1,1678	1,1649	1,1620
16	1,1592	1,1563	1,1535	1,1507	1,1479	1,1451	1,1423	1,1395	1,1367	1,1340
17	1,1313	1,1285	1,1258	1,1231	1,1204	1,1177	1,1150	1,1123	1,1097	1,1070
18	1,1044	1,1018	1,0991	1,0965	1,0939	1,0914	1,0888	1,0862	1,0836	1,0811
19	1,0785	1,0760	1,0735	1,0710	1,0685	1,0660	1,0635	1,0611	1,0586	1,0562
20	1,0537	1,0513	1,0489	1,0465	1,0441	1,0417	1,0393	1,0369	1,0345	1,0322
21	1,0298	1,0275	1,0251	1,0228	1,0205	1,0182	1,0159	1,0136	1,0113	1,0090
22	1,0068	1,0045	1,0023	1,00003	0,9978	0,9956	0,9934	0,9912	0,9890	0,9868
23	0,9846	0,9824	0,9802	0,9781	0,9759	0,9738	0,9716	0,9695	0,9674	0,9653
24	0,9632	0,9611	0,9590	0,9569	0,9550	0,9527	0,9507	0,9486	0,9466	0,9446
25	0,9425	0,9405	0,9385	0,9365	0,9345	0,9325	0,9305	0,9285	0,9265	0,9245
26	0,9226	0,9206	0,9187	0,9167	0,9148	0,9129	0,9109	0,9090	0,9071	0,9052
27	0,9333	0,9014	0,8995	0,8977	0,8958	0,8939	0,8921	0,8902	0,8884	0,8865
28	0,8847	0,8829	0,8811	0,8792	0,8774	0,8756	0,8738	0,8721	0,8703	0,8685
29	0,8667	0,8649	0,8632	0,8614	0,8597	0,8579	0,8562	0,8545	0,8527	0,8510
30	0,84931	0,8476	0,8459	0,8442	0,8425	0,8408	0,8391	0,8374	0,8357	0,8340

Contoh :

Tangki percobaan Laboratorium Hidrodinamika ITS saat melaksanakan *model test / resistance test* untuk kapal *tanker* 1500DWT dalam bulan Juni 1994 mengambil. asumsi suhu air laut dimana kapal akan dioperasikan = 28,0° C, sehingga ·

$$\nu_{\text{air laut}} = 0{,}8847 \text{ cST } (= 0{,}8847.10^{-6} \text{ m}^2/\text{dt.})$$

Tabel-L1.3 Massa jenis udara (kering)

Suhu [°C]	γ_{udara} [kg/m3]
0	1,293
5	1,270
10	1,247
15	1,226
20	1,184
25	1,184
30	1,165

be longer than required for retracting of the burner for the purpose of routine maintenance. Only hose assemblies from approved hose assembly manufacturers are to be used.

10. Service tanks

10.1 On cargo ships of 500 GT or above and all passenger ships two fuel oil service tanks for each type of fuel used on board necessary for propulsion and essential systems are to be provided. Equivalent arrangements may be permitted.

10.2 Each service tank is to have a capacity of at least 8 h at maximum continuous rating of the propulsion plant and normal operation load of the generator plant.

11. Operation using heavy fuel oils

11.1 Heating of heavy fuel oil

11.1.1 Heavy fuel oil tanks are to be fitted with a heating system.

The capacity of the tank heating system is to be in accordance with the operating requirements and the quality of fuel oil intended to be used.

With BKI's consent, storage tanks need not be fitted with a heating system provided it can be guaranteed that the proposed quality of fuel oil can be pumped under all ambient and environmental conditions.

For the tank heating system, see Section 10, B.5.

11.1.2 Heat tracing is to be arranged for pumps, filters and oil fuel lines as required.

11.1.3 Where it is necessary to preheat injection valves of engines running with heavy fuel oil, the injection valve cooling system is to be provided with additional means of heating.

11.2 Treatment of heavy fuel oil

11.2.1 Settling tanks

Heavy fuel settling tanks or equivalent arrangements with sufficiently dimensioned heating systems are to be provided.

Settling tanks are to be provided with drains, emptying arrangements and with temperature measuring instruments.

11.2.2 Heavy fuel oil cleaning for diesel engines

For cleaning of heavy fuels, purifiers or purifiers combined with automatic filters are to be provided.

11.2.3 Fuel oil blending and emulsifying equipment

Heavy fuel oil/diesel oil blending and emulsifying equipment requires approval by BKI.

11.3 Service tanks

11.3.1 For the arrangement and equipment of service tanks, see Section 10, B.

11.3.2 The capacity of the service tanks is to be such that, should the treatment plant fail, the supply to all the connected consumers can be maintained for at least 8 hours.

11.3.3 Where the overflow pipe of the service tank is terminated in the settling tanks, suitable means are to be provided to ensure that no untreated heavy fuel oil can penetrate into the daily service tank in case of overfilling of a settling tank.

11.3.4 Daily service tanks are to be provided with drains and with discharge arrangements.

11.4 Change-over arrangement diesel oil/ heavy oil

11.4.1 The change-over arrangement of the fuel supply and return lines is to be so arranged that faulty switching is excluded and to ensure reliable separation of the fuels.

Change-over valves which allow intermediate positions are not permitted.

11.4.2 The change-over devices are to be accessible and permanently marked. Their respective working position is to be clearly indicated.

11.4.3 Remote controlled change-over devices are to be provided with limit position indicators at the control platforms.

11.5 Fuel supply through stand pipes

11.5.1 Where the capacity of stand pipes exceeds 500 ℓ, the outlet pipe is to be fitted with a remote controlled quick-closing valve operated from outside the engine room. Stand pipes are to be equipped with air/gas vents and with self-closing connections for emptying and draining. Stand pipes are to be fitted with a local temperature indicator.

11.5.2 Atmospheric stand pipes (pressureless)

Having regard to the arrangement and the maximum fuel level in the service tanks, the stand pipes are to be so located and arranged that sufficient free space for degasification is available inside the stand pipes.

Section 29

Passenger Ships

I. Passenger Ships

A. General

1. The requirements given in Sections 1 - 22 apply to passenger ships unless otherwise mentioned in this Section. The various special regulations for passenger ships contained in the Rules for Machinery Installations, Volume III and Rules for Electrical Installations, Volume IV, are to be observed.

2. A passenger ship as defined in this Section is a ship carrying more than 12 passengers on board.

3. The Notation PASSENGER SHIP will be affixed to the Character of Classification of ships complying with the Construction Rules for the carriage and/or accommodation of passengers and with the applicable requirements of the Chapters II-1 and II-2 of **SOLAS** as amended.

4. Exemptions from the requirements may be granted only within the frame work of options given therein and are subject to approval by the competent Administration.

5. Passenger ship will be assigned the symbol ☐ for characterizing proof of damage stability according to the relevant requirements. The following data will be entered into an appendix to the Certificate :

– Code for the specification of the proof of damage stability according to Rules for Classification and Surveys, Volume I, Section.2. C.3.1.2.

6. Passenger vessels, which due to their overall design are only suitable for trade in defined waterways (e.g. "Shallow Water Service") may in no case be assigned an extended Navigation Notation to the Character of Classification, even if the strength of the hull is sufficient for a wider range of service (e.g. "Coasting Service"). In that event, this may be expressed in the Certificate by adding the following note: "The strength of the hull structural elements complies with the service range ...".

7. The terms used in this Section are the same as those of **SOLAS** as amended.

B. Documents for Approval

In addition to those specified in Section 1, G. the documents according to Section 36, A. are to be submitted.

C. Watertight Subdivision

1. For location of collision bulkhead and stern tube see Section 11, A.2.

2. Openings in watertight bulkheads below the bulkhead deck, see Chapter II-1 Reg. 13 of **SOLAS** as amended.

D. Double Bottom

A double bottom shall be fitted extending from the collision bulkhead to the after peak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship. The arrangement shall comply with Chapter II-1 of **SOLAS** as amended and Section 36.

E. Openings in the Shell Plating

1. The number of openings in the shell plating is to be reduced to the minimum compatible with the design and proper working of the ship.

2. The arrangement and efficiency of the means for closing any opening in the shell plating shall be consistent with its intended purpose and the position in which it is fitted and generally to the satisfaction of the Administration.

3. Arrangement, position and type of side scuttles and associated deadlights are to be in accordance with the requirements of Chapter II-1 Reg. 15 of **SOLAS** as amended and with Regulation 23, **ICLL**.

4. Doors in the shell plating below the bulkhead deck are to be provided with watertight closures. Their lowest point is not to be located below the deepest subdivision load line. The corresponding requirements of the **ICLL** (Reg. 21) have also to be observed. Regarding pilot doors additional requirements are given in Chapter V Reg. 23 of **SOLAS** as amended.

5. The inboard openings of ash- and rubbish shoots, etc., are to be fitted with efficient covers. If the inboard openings are situated below the margin line, the covers are to be watertight and, in addition, automatic non-return valves are to be fitted in the shoots above the deepest subdivision load line. Equivalent arrangements may be approved.

Section 11

Watertight Bulkheads

A. General

1. Watertight subdivision

1.1 All ships are to have a collision bulkhead, a stern tube bulkhead and one watertight bulkhead at each end of the engine room. In ships with machinery aft, the stern tube bulkhead may substitute the aft engine room bulkhead.

1.2 For ships without longitudinal bulkheads in the cargo hold area the number of watertight transverse bulkheads should, in general, not be less than given in Table 11.1.

Table 11.1 Number of watertight transverse bulkheads

L [m]	Arrangement of machinery space	
	aft	elsewhere
L ≤ 65	3	4
65 < L ≤ 85	4	4
85 < L ≤ 105	4	5
105 < L ≤ 125	5	6
125 < L ≤ 145	6	7
145 < L ≤ 165	7	8
165 < L ≤ 185	8	9
L > 185	to be special considered	

1.3 One or more of the watertight bulkheads required by 1.2. may be dispensed with where the transverse strength of the ship is adequate. The number of watertight bulkheads will be entered into the Register.

1.4 Number and location of transverse bulkheads fitted in addition to those specified in 1.1 are to be so selected as to ensure sufficient transverse strength of the hull.

1.5 For ships which require proof of survival capability in damaged conditions, the watertight sub-division will be determined by damage stability calculations. For oil tankers see Section 24, A.2., for passenger vessels see Section 29-I, C., for special purpose ships see Section 29-II, C., for cargo ships of more than 100 m in ength see Section 36 and for supply vessels see Section 34, A.2. For liquefied gas tankers see Rules for Ships Carrying Liquefied Gases in Bulk, Volume IX, Section 2. For chemical tankers see Rules for Ships Carrying Dangerous Chemicals in Bulk, Volume X, Section 2.

.. Arrangement of watertight bulkheads-

.1 Collision bulkhead

.1.1 A collision bulkhead shall be located at a distance from the forward perpendicular of not less than 0,05 L_c or 10 m, whichever is the less, and, except as may be permitted by the Administration, not more than 0,08 L_c or 0,05 L_c + 3 m, whichever is the greater

2.1.2 Where any part of the ship below the waterline extends forward of the forward perpendicular, e.g., a bulbous bow, the distance x shall be measured from a point either:

– at the mid-length of such extension, i.e. x = 0,5 ⋅a

at a distance 0.015 Lc forward of the forward perpendicular, i.e. x = 0.015 ⋅Lc, or

– at a distance 3 m forward of the forward perpendicular, i.e. x = 3,0 m

whichever gives the smallest measurement.

The length L_c and the distance a are to be specified in the approval documents.

2.1.3 If 2.1.2 is applicable, the required distances specified in 2.1.1 are to be measured from a reference point located at a distance x forward of the F.P.

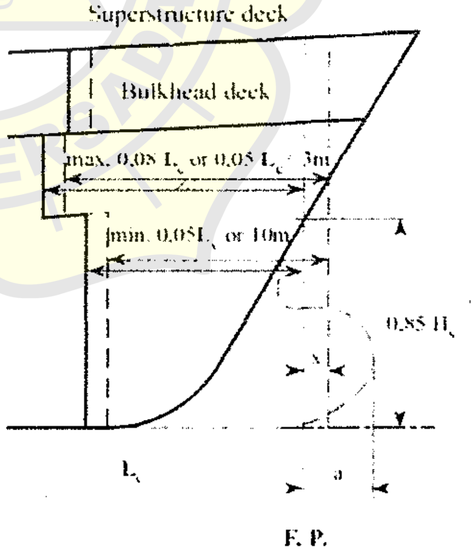


Fig.11.1 Location of collision bulkhead

2.1.4 The collision bulkhead shall extend watertight up to the bulkhead deck. The bulkhead may have steps or recesses provided they are within the limits prescribed in 2.1.1.

2.1.5 No doors, manholes, access openings, or ventilation ducts are permitted in the collision bulkhead below the bulkhead deck.

Section 9

Framing System

A. Transverse Framing

1. General

1.1 Frame spacing

Forward of the collision bulkhead and aft of the after peak bulkhead, the frame spacing shall in general not exceed 600 mm.

1.2 Definitions

k = material factor according to Section 2, B.2.

ℓ = unsupported span [m] according to Section 3, C., see also Fig. 9.1

ℓ_{min} = 2,0 m

ℓ_{Ku}, ℓ_{Ko} = length of lower/upper bracket connection of main frames within the length ℓ [m], see Fig. 9.1

m_a = $0{,}204 \; \frac{a}{\ell} \left[4 - \left(\frac{a}{\ell}\right)^2\right]$, where $\frac{a}{\ell} \le 1$

e = spacing of web frames [m]

p = p_s or p_e as the case may be

p_s = load on ship's sides [kN/m²] according to Section 4, B.2.1

p_e = load on bow structures [kN/m²] according to Section 4, B.2.2 or stern structures according to Section 4, B.2.3 as the case may be

p_l = 'tween deck load [kN/m²] according to Section.4, C.1.

p_1, p_2 = pressure [kN/m²] according to Section 4, D.1.

H_u = depth up to the lowest deck [m]

c_r = factor for curved frames

= $1{,}0 - 2\,\frac{s}{\ell}$

c_{rmin} = 0,75

s = max. height of curve.

2. Main frames

2.1 Scantlings

2.1.1 The section modulus W_R and shear area A_R of the main frames including end attachments are not to be less than:

$$W_R = n \cdot c \cdot a \cdot \ell^2 \cdot p \cdot c_r \cdot k \quad [cm^3]$$

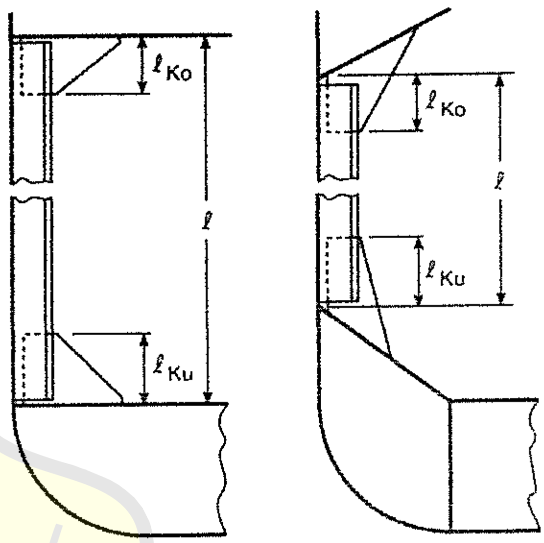


Fig. 9.1 Unsupported span of transverse frames

upper end shear area :

$$A_{RO} = \left(1 - 0{,}817 \cdot m_a\right) 0{,}04 \cdot a \cdot \ell \cdot p \cdot k \quad [cm^2]$$

lower end shear area :

$$A_{RU} = \left(1 - 0{,}817 \cdot m_a\right) 0{,}07 \cdot a \cdot \ell \cdot p \cdot k \quad [cm^2]$$

n = $0{,}9 - 0{,}0035 \cdot L$ for $L < 100$ m

= 0,55 for $L \ge 100$ m

c = $1{,}0 - \left(\frac{\ell_{Ku}}{\ell} + 0{,}4 \cdot \frac{\ell_{Ko}}{\ell}\right)$

c_{min} = 0,6

Within the lower bracket connection the section modulus is not to be less than the value obtained for $c = 1{,}0$.

2.1.2 In ships with more than 3 decks the main frames are to extend at least to the deck above the lowest deck.

2.1.3 The scantlings of the main frames are not to be less than those of the 'tween deck frames above.

2.1.4 Where the scantlings of the main frames are determined by strength calculations, the following permissible stresses are to be observed:

bending stress: $\sigma_b = \frac{150}{k}$ [N/mm²]

shear stress: $\tau = \frac{100}{k}$ [N/mm²]

1.6 Pipe layout

1.6.1 To prevent the ingress of ballast and seawater into the ship through the bilge system two means of reverse-flow protection are to be fitted in the bilge connections.

One of such means of protection is to be fitted in each suction line.

1.6.2 The direct bilge suction and the emergency suction need only one means of reverse-flow protection as specified in 1.5.1.

1.6.3 Where a direct seawater connection is arranged for attached bilge pumps to protect them against running dry, the bilge suctions are also to be fitted with two reverse flow protecting devices.

1.6.4 The discharge lines of oily water separators are to be fitted with a reverse flow protecting valve at the ship's side.

2 Calculation of pipe diameters

2.1 The calculated values according to formulae (4) to (6) are to be rounded up to the next higher nominal diameter.

2.2 Dry cargo and passenger ships

a) Main bilge pipes

$$d_H = 1{,}68 \cdot \sqrt{(B+H)\cdot L} + 2 \quad [mm] \qquad (4)$$

b) Branch bilge pipes

$$d_z = 2{,}15 \cdot \sqrt{(B+H)\cdot \ell} + 2 \quad [mm] \qquad (5)$$

d_H = calculated inside diameter of main bilge pipe [mm]

d_z = calculated inside diameter of branch bilge pipe [mm]

L = length of ship between perpendiculars [m]

B = moulded breadth of ship [m]

H = depth of ship to the bulkhead deck [m]

ℓ = length of the watertight compartment [m]

2.3 Tankers

The diameter of the main bilge pipe in the engine rooms of tankers and bulk cargo/oil carriers is calculated using the formula:

$$d_H = 3{,}0 \cdot \sqrt{(B+H)\cdot \ell_1} + 35 \quad [mm] \qquad (6)$$

ℓ_1 = total length of spaces between cofferdam or pump-room bulkhead and stern tube bulkhead [m]

Other terms as in formulae (4) and (5).

Branch bilge pipes are to be dimensioned in accordance with 2.2 b). For bilge installations for spaces in the cargo area of tankers and bulk cargo/oil carriers see Section 15.

2.4 Minimum diameter

The inside diameter of main and branch bilge pipes is not to be less than 50 mm. For ships under 25 m length, the diameter may be reduced to 40 mm.

3. Bilge pumps

3.1 Capacity of bilge pumps

Each bilge pump must be capable of delivering :

$$Q = 5{,}75 \cdot 10^{-3} \cdot d_H^2 \quad [m^3/h] \qquad (7)$$

Q = minimum capacity [m^3/h]

d_H = calculated inside diameter of main bilge pipe[mm]

3.2 Where centrifugal pumps are used for bilge pumping, they are to be self-priming or connected to an air extracting device.

3.3 One bilge pump with a smaller capacity than that required according to formula (7) is acceptable provided that the other pump is designed for a correspondingly larger capacity. However, the capacity of the smaller bilge pump is not to be less than 85 % of the calculated capacity.

3.4 Use of other pumps for bilge pumping

3.4.1 Ballast pumps, stand-by seawater cooling pumps and general service pumps may also be used as independent bilge pumps provided they are self-priming and of the required capacity according to formula (7).

3.4.2 In the event of failure of one of the required bilge pumps, one pump each is to be available for fire fighting and bilge pumping.

3.4.3 Fuel and oil pumps are not to be connected to the bilge system.

3.4.4 Bilge ejectors are acceptable as bilge pumping arrangements provided that there is an independent supply of driving water.

3.5 Number of bilge pumps for cargo ships

Cargo ships are to be provided with two independent mechanically driven bilge pumps. On ships up to 2000 GT, one of these pumps may be attached to the main engine.

On ships of less than 100 GT, one mechanically driven bilge pump is sufficient. The second independent bilge pump may be a permanently installed manual bilge pump. The engine-driven bilge pump may be coupled to the main propulsion plant.

3.6 Number of bilge pumps for passenger ships

At least three bilge pumps are to be provided. One pump may be coupled to the main propulsion plant. Where the criterion of service numeral according to **SOLAS 74** is 30[7)] or more, an additional bilge pump is to be provided.

4. Bilge pumping for various spaces

4.1 Machinery spaces

4.1.1 On ships of more than 100 GT, the bilges of every main machinery space are to be capable of being pumped simultaneously as follows:

a) through the bilge suctions connected to the main bilge system

b) through one direct suction connected to the largest independent bilge pump

c) through an emergency bilge suction connected to the sea cooling water pump of the main propulsion plant or through another suitable emergency bilge system

4.1.2 If the ship's propulsion plant is located in several spaces, a direct suction in accordance with 4.1.1 b) is to be provided in each watertight compartment in addition to branch bilge suctions in accordance with 4.1.1 a).

When the direct suctions are in use, it is to be possible to pump simultaneously from the main bilge line by means of all the other bilge pumps.

The diameter of the direct suction may not be less than that of the main bilge pipe.

4.1.3 On steam ships the diameter of the emergency bilge suction is to be at least 2/3 of the diameter and on motor ships equal to the diameter of the suction line of the pump chosen according to 4.1.1c). Deviations from this requirement need the approval of BKI. The emergency bilge suction is to be connected to the cooling water pump suction line by a reverse-flow protection according to 1.5.1.

This valve is to be provided with a plate with the notice:

Emergency bilge valve!
To be opened in an emergency only!

Emergency bilge valves and cooling water inlet valves are to be capable of being operated from above the floor plates.

4.1.4 Rooms and decks in engine rooms are to be provided with drains to the engine room bilge. A drain pipe which passes through a watertight bulkhead is to be fitted with a self-closing valve.

4.2 Shaft tunnel

A bilge suction is to be arranged at the aft end of the shaft tunnel. Where the shape of the bottom or the length of the tunnel requires, an additional bilge suction is to be provided at the forward end. Bilge valves for the shaft tunnel are to be arranged outside the tunnel in the engine room.

4.3 Cargo holds

4.3.1 Cargo holds are to be normally fitted with bilge suctions fore and aft.

For water ingress protection systems, see Rule for Electrical Installations, Volume IV, Section 18, B.4.1.9.

4.3.2 Cargo holds having a length under 30 m may be provided with only one bilge suction on each side.

4.3.3 On ships with only one cargo hold, bilge wells are to be provided fore and aft.

4.3.4 For cargo holds for the transport of dangerous goods, see Section 12, P.7.

4.3.5 In all Ro/Ro cargo spaces below the bulkhead deck where a pressure water spraying system according to Section 12, L.2.3 is provided, the following is to be complied with:

- the drainage system is to have a capacity of not less than 1,25 times of the capacity of both the water spraying system pumps and required number of fire hose nozzles
- the valves of the drainage arrangement are to be operable from outside the protected space at a position in the vicinity of the drencher system controls
- bilge wells are to be of sufficient holding

7) See SOLAS 1974, Chapter II-1, Part B, Regulation 6.

2. Tank filling and suction lines

2.1 Filling and suction lines from storage, settling and service tanks situated above the double bottom and from which in case of their damage fuel oil may leak, are to be fitted directly on the tanks with shut-off devices capable of being closed from a safe position outside the space concerned.

In the case of deep tanks situated in shaft or pipe tunnel or similar spaces, shut-off devices are to be fitted on the tanks. The control in the event of fire may be effected by means of an additional shut-off device in the pipe outside the tunnel or similar space. If such additional shut-off device is fitted in the machinery space it is to be operated from a position outside this space.

2.2 Shut-off devices on fuel oil tanks having a capacity of less than 500 ℓ need not be provided with remote control.

2.3 Filling lines are to extend to the bottom of the tank. Short filling lines directed to the side of the tank may be admissible.

Storage tank suction lines may also be used as filling lines.

2.4 Where filling lines are led through the tank top and end below the maximum oil level in the tank, a non-return valve at the tank top is to be arranged.

2.5 The inlet connections of suction lines are to be arranged far enough from the drains in the tank so that water and impurities which have settled out will not enter the suctions.

2.6 For the release of remotely operated shut-off devices, see Section 12, B.10.

3. Pipe layout

3.1 Fuel lines may not pass through tanks containing feed water, drinking water, lubricating oil or thermal oil.

3.2 Fuel lines which pass through ballast tanks are to have an increased wall thickness according to Table 11.5.

3.3 Fuel lines are not to be laid directly above or in the vicinity of boilers, turbines or equipment with high surface temperatures (over 220 °C) or in way of other sources of ignition.

3.4 Flanged and screwed socket connections in fuel oil lines are to be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakages onto hot surfaces, into machinery air intakes, or other sources of ignition.

The number of detachable pipe connections is to be limited. In general, flanged connections according to recognized standards are to be used.

3.4.1 Flanged and screwed socket connections in fuel oil lines which lay directly above hot surfaces or other sources of ignition are to be screened and provided with drainage arrangements.

3.4.2 Flanged and screwed socket connections in fuel oil lines with a maximum allowable working pressure of more than 0,18 N/mm^2 and within about 3 m from hot surfaces or other sources of ignition and direct sight of line are to be screened. Drainage arrangements need not to be provided.

3.4.3 Flanged and screwed socket connections in fuel oil lines with a maximum allowable working pressure of less than 0,18 N/mm^2 and within about 3 m from hot surfaces or other sources of ignition are to be assessed individually taking into account working pressure, type of coupling and possibility of failure.

3.4.4 Flanged and screwed socket connections in fuel oil lines with a maximum allowable working pressure of more than 1,6 N/mm^2 need normally to be screened.

3.4.5 Pipes running below engine room floor need abnormally not to be screened.

3.5 Shut-off valves in fuel lines in the machinery spaces are to be operable from above the floor plates.

3.6 Glass and plastic components are not permitted in fuel systems. Sight glasses made of glass located in vertical overflow pipes may be permitted.

3.7 Fuel pumps are to be capable of being isolated from the piping system by shut-off valves.

4. Fuel transfer, feed and booster pumps

4.1 Fuel transfer, feed and booster pumps are to be designed for the intended operating temperature.

4.2 A fuel transfer pump is to be provided. Other service pumps may be used as a stand-by pump provided they are suitable for this purpose.

4.3 At least two means of oil fuel transfer are to be provided for filling the service tanks.

4.4 Where a feed or booster pump is required to supply fuel to main or auxiliary engines, stand-by pumps are to be provided. Where pumps are attached to the engines, stand-by pumps may be dispensed with for auxiliary engines.

4.5 For emergency shut-down devices, see Section 12, B.9.

5. Plants with more than one main engine

For plants with more than one main engine, complete spare feed or booster pumps stored on board may be accepted instead of stand-by pumps provided that the feed or booster pumps are so arranged that they can be replaced with the means available on board.

For plants with more than one main engine, see also Section 2, G.

6. Shut-off devices

6.1 On cargo ships of 500 GT or above and on all passenger ships for plants with more than one engine, shut-off devices for isolating the fuel supply and over-production/recirculation lines to any engine from a common supply system are to be provided. These valves are to be operable from a position not rendered inaccessible by a fire on any of the engines.

6.2 Instead of shut-off devices in the over-production/recirculation lines check valves may be fitted. Where shut-off devices are fitted, they are to be locked in the operating position.

7. Filters

7.1 Fuel oil filters are to be fitted in the delivery line of the fuel pumps.

7.2 For ships with Class Notation **OT** the filter equipment is to satisfy the requirements of Rules for Automation, Volume VII, Section 2.

7.3 Mesh size and filter capacity are to be in accordance with the requirements of the manufacturer of the engine.

7.4 Uninterrupted supply of filtered fuel has to be ensured during cleaning of the filtering equipment. In case of automatic back-flushing filters it is to be ensured that a failure of the automatic back-flushing will not lead to a total loss of filtration.

7.5 Back-flushing intervals of automatic back-flushing filters provided for intermittent back-flushing are to be monitored.

7.6 Fuel oil filters are to be fitted with differential pressure monitoring. On engines provided for operation with gas oil only, differential pressure monitoring may be dispensed with.

7.7 Engines for the exclusive operation of emergency generators and emergency fire pumps may be fitted with simplex filters.

7.8 Fuel transfer units are to be fitted with a simplex filter on the suction side.

7.9 For filter arrangement, see Section 2, G.3.

8. Purifiers

8.1 Manufacturers of purifiers for cleaning fuel and lubricating oil are to be approved by BKI.

8.2 Where a fuel purifier may exceptionally be used to purify lubricating oil the purifier supply and discharge lines are to be fitted with a change-over arrangement which prevents the possibility of fuel and lubricating oils being mixed.

Suitable equipment is also to be provided to prevent such mixing occurring over control and compression lines.

8.3 The sludge tanks of purifiers are to be fitted with a level alarm which ensures that the level in the sludge tank cannot interfere with the operation of the purifier.

9. Oil firing equipment

Oil firing equipment is to be installed in accordance with Section 9. Pumps, pipelines and fittings are subject to the following requirements.

9.1 Oil fired main boilers are to be equipped with at least two service pumps and two preheaters. For filters see 7. Pumps and heaters are to be rated and arranged that the oil firing equipment remains operational even if one unit should fail. This also applies to oil fired auxiliary boilers and thermal oil heaters unless other means are provided for maintaining continuous operation at sea even if a single unit fails.

9.2 Hose assemblies for the connection of the burner may be used. Hose assemblies are not to fresh cooling water systems approval may be given for the carriage on board of reserve pumps ready for mounting provided that the arrangement of the main fresh cooling water pumps enables the change to be made with the means available on board. Shut-off valves shall be provided enabling the main pumps to be isolated from the fresh cooling water system.

5.2 If cooling air is drawn from the engine room, the design of the cooling system is to be based on a room temperature of at least 45 °C.

The exhaust air of air-cooled engines may not cause any unacceptable heating of the spaces in which the plant is installed. The exhaust air is normally to be led to the open air through special ducts.

5.3 Where engines are installed in spaces in which oil-firing equipment is operated, Section 9, A.5 is also to be complied with.

6. Charge air system

6.1 Exhaust gas turbocharger

6.1.1 The construction and testing of exhaust gas turbocharger are subject to Section 3 II (Turbo-machinery/Gas Turbines and Exhaust Gas Turbo-chargers).

6.1.2 Exhaust gas turbochargers may exhibit no critical speed ranges over the entire operating range of the engine.

6.1.3 The lubricating oil supply shall also be ensured during start-up and run-down of the exhaust gas turbochargers.

6.1.4 Even at low engine speeds, main engines shall be supplied with charge air in a manner to ensure reliable operation.

Where necessary, two-stroke engines are to be equipped with directly or independently driven scavenging air blowers.

6.1.5 If, in the lower speed range or when used for manoeuvring, an engine can be operated only with a charge air blower driven independently of the engine, a stand-by charge air blower is to be installed or an equivalent device of approved design.

6.1.6 With main engines emergency operation shall be possible in the event of a turbocharger failure.

6.2 Charge air cooling

6.2.1 The construction and testing of charge air coolers are subject to Section 8.

6.2.2 Means are to be provided for regulating the temperature of the charge air within the temperature range specified by the engine manufacturer.

6.2.3 The charge air lines of engines with charge air coolers are to be provided with sufficient means of drainage.

6.3 Fire extinguishing equipment

The charge air receivers of crosshead engines which have open connection to the cylinders are to be connected to an approved fire extinguishing system (see Table 12.1) which is independent of the engine room fire extinguishing system.

7. Exhaust gas lines

7.1 Exhaust gas lines are to be insulated and/or cooled in such a way that the surface temperature cannot exceed 220 °C at any point.

Insulating materials shall be non-combustible.

7.2 General rules relating to exhaust gas lines are contained in Section 11, M.

H. Starting equipment

1. General

Engine starting equipment shall enable engines to be started up from "dead ship" condition according to Section 1, D.6.1 using only the means available on board.

2. Starting with compressed air

2.1 Starting air systems for main engines are to be equipped with at least two starting air compressors. At least one of the air compressors shall be driven independently of the main engine and shall supply at least 50 % of the total capacity required.

2.2 The total capacity of the starting air compressors is to be such that the starting air receivers designed in accordance with 2.4 or 2.5, as applicable, can be charged from atmospheric pressure to their final pressure within one hour.

Normally, compressors of equal capacity are to be installed.

This does not apply to an emergency air compressor which may be provided to meet the requirement stated in 1.

2.3 If the main engine is started with compressed air, the available starting air is to be divided between at least two starting air receivers of approximately equal size which can be used independently of each other.

2.4 The total capacity of air receivers is to be sufficient to provide, without their being replenished, not less than 12 consecutive starts alternating between Ahead and Astern of each main engine of the reversible type, and not less than six starts of each main non-reversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

2.5 With multi-engine installations the number of start-up operations per engine may, with BKI's agreement, be reduced according to the concept of the propulsion plant.

The Guidance for Sea Trials of Motor Vessels, may be observed.

2.6 If starting air systems for auxiliaries or for supplying pneumatically operated regulating and manoeuvering equipment or tyfon units are to be fed from the main starting air receivers, due attention is to be paid to the air comsumption of this equipment when calculating the capacity of the main starting air receivers.

2.7 Other consumers with a high air consumption apart from those mentioned in 2.6 may not be connected to the main starting air system. Separate air supplies are to be provided for these units. Deviations to this require the agreement of BKI.

2.8 If auxiliary engines are started by compressed air sufficient air capacity for three consecutive starts of each auxiliary engine is to be provided.

2.9 If starting air systems of different engines are fed by one receiver it is to be ensured that the receiver air pressure cannot fall below the highest of the different systems minimum starting air pressures.

2.10 Approximate calculation of the starting air supply

For the approximate calculation of the starting air supply the following formulae may be used.

2.10.1 Starting air for installations with reversible engines

Assuming an initial pressure of 30 bar and a final pressure of 9 bar in the starting air receivers, the preliminary calculation of the starting air supply for a reversible main engine may be performed as follows:

$$J = a.\sqrt[3]{\left(\frac{H}{D}\right)}.(z + b.p_{e,e}.n_A + 0{,}9).V_h.c$$

J = total capacity of the starting air receivers [dm^3]

D = cylinder bore [mm]

H = stroke [mm]

V_h = swept volume of one cylinder (in the case of double-acting engines, the swept volume of the upper portion of the cylinder)

$P_{e,perm}$= maximum permissible working pressure of the starting air receiver [bar]

z = number of cylinders [–]

$P_{e,e}$ = mean effective working pressure in cylinder at rated power [bar]

The following values of "a" are to be used:

- for two-stroke engines: a = 0,4714
- for four-stroke engines: a = 0,4190

The following values of "b" are to be used:

- for two-stroke engines: b = 0,059
- for four-stroke engines: a = 0,056

The following values of "c" are to be used:

c = 1, where $p_{e,perm}$ = 30 bar

$$c = \frac{0{,}0584}{1 - e^{(0{,}11 - 0{,}05 . \ln P_{e,perm})}}$$

Where $P_{e,perm}$ > 30 bar, if no pressure-reducing valve is fitted.

e = Euler's number (2,718...) [-]

Where $P_{e,perm}$ > 30 bar, if a pressure-reducing valve is fitted, which reduces the pressure $p_{e,perm}$ to the starting pressure P_A, the value of "c" shown in Fig. 2.7 is to be used.

The following values of n_A are to be applied :

$n_A = 0{,}06 . n_o + 14$ where $n_o \leq 1000$

$n_A = 0{,}25 . n_o - 176$ where $n_o < 1000$

n_o = rated speed [min^{-1}]

2.10.2 Starting air for installations with non-reversible engines

For each non-reversible main engine driving a controllable pitch propeller or where starting without torque resistance is possible the calculated starting air supply may be reduced to 0,5 · J though not less than that needed for six start-up operations.

3. Electrical starting equipment

3.1 Where main engines are started electrically, two mutually independent starter batteries are to be installed. The batteries are to be so arranged that they cannot be connected in parallel with each other. Each battery shall enable the main engine to be started from cold.

The total capacity of the starter batteries must be sufficient for the execution within 30 minutes, without recharging the batteries, of the same number of start-up operations as is prescribed in 2.4. or 2.5 for starting with compressed air.

3.2 If two or more auxiliary engines are started electrically, at least two mutually independent batteries directly on the tanks with shut-off devices according to G.2.1

The remote operation of shut-off valves according to G.2.1 may be dispensed with:

- for valves which are kept closed during normal operation.
- where an unintended operation of a quick closing valve would endanger the safe operation of the main propulsion plant or essential auxiliary machinery.

2.2.2 Where lubricating oil lines are to be led in the vicinity of hot machinery, e.g. superheated steam turbines, steel pipes which should be in one length and which are protected where necessary are to be used.

2.2.3 For screening arrangements of lubricating oil pipes G.3.4 applies as appropriate.

2.3 Filters

2.3.1 Lubricating oil filters are to be fitted in the delivery line of the lubricating oil pumps.

2.3.2 Mesh size and filter capacity are to be in accordance with the requirements of the manufacturer of the engine.

2.3.3 Uninterrupted supply of filtered lubricating oil has to be ensured under cleaning conditions of the filter equipment.

In case of automatic back-flushing filters it is to be ensured that a failure of the automatic back-flushing will not lead to a total loss of filtration.

2.3.4 Back-flushing intervals of automatic back-flushing filters provided for intermittent back-flushing are to be monitored.

2.3.5 Main lubricating oil filters are to be fitted with differential pressure monitoring. On engines provided for operation with gas oil only, differential pressure monitoring may be dispensed with.

2.3.6 Engines for the exclusive operation of emergency generators and emergency fire pumps may be fitted with simplex filters.

2.3.7 For protection of the lubricating oil pumps simplex filters may be installed on the suction side of the pumps if they have a minimum mesh size of 100 μ.

2.3.8 For the arrangement of filters, see Section 2, G.3.

2.4 Lubricating oil coolers

It is recommended that turbine and large engine plants be provided with more than one oil cooler.

2.5 Oil level indicators

Machines with their own oil charge are to be provided with a means of determining the oil level from outside during operation. This requirement also applies to reduction gears, thrust bearings and shaft bearings.

2.6 Purifiers

The requirements in G.8. apply as appropriate.

3. Lubricating oil pumps

3.1 Main engines

3.1.1 Main and independent stand-by pumps are to be arranged.

Main pumps driven by the main engines are to be so designed that the lubricating oil supply is ensured over the whole range of operation.

3.1.2 For plants with more than one main engine see Section 2, G.4.2.3.

3.2 Main turbine plant

3.2.1 Main and independent stand-by lubricating oil pumps are to be provided.

3.2.2 Emergency lubrication

The lubricating oil supply to the main turbine plant for cooling the bearings during the run-down period is to be assured in the event of failure of the power supply. By means of suitable arrangements such as gravity tanks the supply of oil is also to be assured during starting of the emergency lubrication system.

3.3 Main reduction gearing (motor vessels)

3.3.1 Lubricating oil is to be supplied by a main pump and an independent stand-by pump.

3.3.2 Where a reduction gear has been approved by BKI to have adequate self-lubrication at 75 % of the torque of the propelling engine, a stand-by lubricating oil pump for the reduction gear may be dispensed with up to a power-speed ratio of

$$P/n_1 \ [\mathrm{kW/min^{-1}}] \leq 3{,}0$$

n_1 = gear input revolution $[\mathrm{min}^{-1}]$

K. Fresh Water Cooling Systems

1. General

1.1 Fresh water cooling systems are to be so arranged that the engines can be sufficiently cooled under all operating conditions.

1.2 Depending on the requirements of the engine plant, the following fresh water cooling systems are allowed:

- a single cooling circuit for the entire plant
- separate cooling circuits for the main and auxiliary plant
- several independent cooling circuits for the main engine components which need cooling (e.g. cylinders, pistons and fuel valves) and for the auxiliary engines
- separate cooling circuits for various temperature ranges

1.3 The cooling circuits are to be so divided that should one part of the system fail, operation of the auxiliary systems can be maintained.

Change-over arrangements are to be provided for this purpose if necessary.

1.4 As far as possible, the temperature controls of main and auxiliary engines as well as of different circuits are to be independent of each other.

1.5 Where, in automated engine plants, heat exchangers for fuel or lubricating oil are incorporated in the cylinder cooling water circuit of main engines, the entire cooling water system is to be monitored for fuel and oil leakage.

1.6 Common engine cooling water systems for main and auxiliary plants are to be fitted with shut-off valves to enable repairs to be performed without taking the entire plant out of service.

2. Heat exchangers, coolers

2.1 The construction and equipment of heat exchangers and coolers are subject to the requirements of Section 8.

2.2 The coolers of cooling water systems, engines and equipment are to be so designed to ensure that the specified cooling water temperatures can be maintained under all operating conditions. Cooling water temperatures are to be adjusted to meet the requirements of engines and equipment.

2.3 Heat exchangers for auxiliary equipment in the main cooling water circuit are to be provided with by-passes if in the event of a failure of the heat exchanger it is possible by these means to keep the system in operation.

2.4 It is to be ensured that auxiliary machinery can be maintained in operation while repairing the main coolers. If necessary, means are to be provided for changing over to other heat exchangers, machinery or equipment through which a temporary heat transfer can be achieved.

2.5 Shut-off valves are to be provided at the inlet and outlet of all heat exchangers.

2.6 Every heat exchanger and cooler is to be provided with a vent and a drain.

2.7 Keel coolers, box coolers

2.7.1 Arrangement and construction drawings of keel and box coolers are to be submitted for approval.

2.7.2 Permanent vents for fresh water are to be provided at the top of keel coolers and chest coolers.

2.7.3 Keel coolers are to be fitted with pressure gauge connections at the fresh water inlet and outlet.

3. Expansion tanks

3.1 Expansion tanks are to be arranged at sufficient height for every cooling water circuit.

Different cooling circuits may only be connected to a common expansion tank if they do not interfere with each other. Care is to be taken here to ensure that damage to or faults in one system cannot affect the other system.

3.2 Expansion tanks are to be fitted with filling connections, aeration/de-aeration devices, water level indicators and drains.

4. Fresh water cooling pumps

4.1 Main and stand-by cooling water pumps are to be provided for each fresh water cooling system.

4.2 Main cooling water pumps may be driven directly by the main or auxiliary engines which they

Table 12.2 Number and minimum capacity of fire pumps

Passenger ships				Cargo ships	
≥ 4.000 GT		< 4.000 GT		≥ 500 GT	< 500 GT
Number of power-driven fire pumps					
3		2		2	1
Minimum capacity V (m^3/h) of one fire pump [1])					
[2])$5{,}1 \cdot 10^{-3} \cdot d^2_H$	$3{,}8 \cdot 10^{-3} \cdot d^2_H$	[2])$7{,}65 \cdot 10^{-3} \cdot d^2_H$	$5{,}75 \cdot 10^{-3} \cdot d^2_H$	$3{,}8 \cdot 10^{-3} \cdot d^2_H$	

[1]) d_H (mm) = theoretical diameter of the bilge main (see Section 11,N. formula 4.)

[2]) Applicable to passenger ships with a criterion numeral of 30 or over in accordance with SOLAS 1974 as amended, Chapter II-1, Part B, Regulation 6.

1.3.10 On passenger ships of 1.000 GT and over, the water fire extinguishing equipment in interior locations is to be installed in such a way that at least one jet of water with the prescribed nozzle discharge pressure is immediately available. The uninterrupted supply of water is to be ensured by the automatic starting of one of the specified fire pumps.

1.3.11 On passenger ships of less than 1.000 GT, the immediate availability of water for fire fighting is to be safeguarded according to either 1.3.10 or 1.3.12.

1.3.12 On ships with the Class Notation **"OT"**, at least one fire pump is to be provided with remote starting arrangements from the bridge and from the central fire control station, if there is one.

The associated shut-off valves from the sea water inlet to the fire main are to be capable of being controlled from the above named positions. Alternatively locally-operated valves may be used; these are to be permanently kept open and provided with appropriate sign, e.g. :

"Valve always to be kept open !"

1.3.13 Where on cargo ships of 500 GT and over and on passenger ships the fire pumps are located in different compartments, at least one fire pump has to fulfil all requirements of an emergency fire pump specified in 1.4 (i.e. independent power and water supply, etc.), with the exception of 1.4.1 first sentence being not applicable.

.4 Emergency fire pumps

.4.1 The emergency fire pumps is to be capable of delivering at least 40 % of the total capacity specified for the main fire pumps, but in any case not less than 25 m^3/h for passenger ships of less than .000 GT and for cargo ships of 2.000 GT and over, and in any case not less than 15 m^3/h for cargo ships of less than 2000 GT.

The emergency fire pump is to be of self-priming type.

1.4.2 The emergency fire pump must be capable of supplying water to all parts of the ship from two hydrants simultaneously at the pressure stated in Table 12.3; see also 2.2.1.

1.4.3 All the power and water supply equipment required for the operation of the emergency fire pump must be independent of the space where the main fire pumps are installed.

The electrical cables to the emergency fire pump may not pass through the machinery spaces containing the main fire pumps and their source(s) of power and prime mover(s).

If the electrical cables to the emergency fire pump pass through other high fire risk areas, they are to be of a fire resistant type.

1.4.4 The supply of fuel intended for the operation of the emergency fire pump has to be sufficient for at least 18 hours at nominal load.

The fuel tank intended for the emergency fire pump power supply must contain sufficient fuel to ensure the operation of the pump for at least the first 6 hours without refilling. This period may be reduced to 3 hours for cargo ships off less than 5.000 GT.

1.4.5 The space where the emergency fire pump and its power source are installed is not to be directly adjacent to machinery spaces of category A[9]) or to the space where the main fire pumps are installed. Where this is not feasible, the division between the rooms is to be formed by not more than one bulkhead. Recesses have to be restricted to a

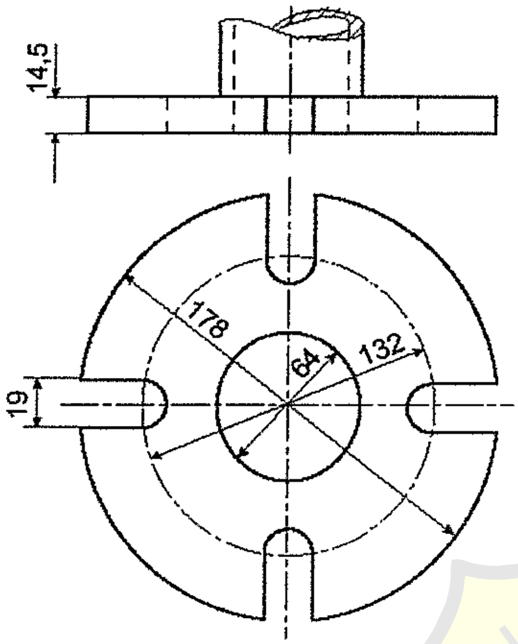


Fig.12.1 International shore connection

Alternatively to the steel casing the piping may be thick-walled according to Section 11., Table 11.20b, Column B, but not less than 11 mm, all welded and be insulated equivalent to A-60 standard.

2.2.2 On passenger ships of 4.000 GT and over, the fire main must be constructed as a ring system equipped with appropriately sited isolating valves.

2.2.3 Fire mains are to be provided with drain valves or cocks.

2.2.4 Branch pipes from the fire mains for hawse flushing are to be capable of being shut off in the vicinity of the main fire pump(s) or from the open deck. Other branch pipes not serving fire fighting purposes and which are used only occasionally may be accepted if capable of being shut from the open deck. The shut-off devices, are to be fitted with warning signs instructing personnel to close them ıfter use.

:.2.5 On tankers, the fire main is to be fitted with solating valves in a protected position at the poop ront and on the tank deck at intervals of not more han 40 m.

:.2.6 In piping sections where the possibility of reezing exists during operation of the ship in cold limates, suitable provisions are to be made for ontinuously pressurized pipelines.

.3 Fire main design

.3.1 The following formula should be used as uidance for the sizing of the fire main :

: = $0{,}8 \cdot d_H$

: = internal diameter of fire main

ı = theoretical diameter of main. bilge pipe

in accordance with Section 11, N.2.

d_{Fmin} = 50 mm

For pipe thicknesses see Section 11, Table 11.5 (Seawater lines).

2.3.2 On passenger ships the diameter d_F need not to exceed d_{Fmax} = 175 mm, on cargo ships d_{Fmax} = 130 mm respectively.

2.3.3 The entire fire main is to be designed for the maximum permissible working pressure of the fire pumps subject to a minimum working pressure of 10 bar.

2.3.4 At no point in the ship the discharge pressure at the nozzles is to be less than the values shown in Table 12.3 when water is drawn simultaneously from any two adjacent hydrants. On liquefied gas tankers this requirement is to be met at a minimum pressure at the nozzles of 0,50 N/mm^2 (refer to Rules for Ships Carrying Liquefied Gases in Bulk, Volume IX, Section 11, 11.2.1.

Table 12.3 Pressure at nozzles

Type of vessel	GT	Pressure at nozzle [N/mm^2]
Cargo ships	< 6.000 ≥ 6.000	0,25 0,27
Passenger ships	< 4.000 ≥ 4.000	0,30 0,40

2.4 Hydrants

2.4.1 Hydrants are to be so positioned that water from two nozzles simultaneously, one of which is to be from a single length of hose, may reach

- any part of the ship to which passengers and crew normally have access during the voyage,
- any part of an empty cargo space,

In ro-ro spaces or vehicle spaces it has to be possible to reach any part with water from two nozzles simultaneously, each from single length of hose.

In passenger ships any part of accommodation, service and machinery spaces are to be capable of being reached with water from at least two nozzles, one of which is to be from a single length of hose, when all watertight doors and all doors in main vertical zone bulkheads are closed.

2.4.2 Deck hydrants are to be arranged such that they remain accessible when carrying deck cargo. Hydrants are to be located near the accesses to spaces. In the case of cargo spaces for the transport of dangerous goods, the additional requirements of P are to be observed.

E. General Water Fire Extinguishing Equipment (Fire and Deckwash System)

1. Fire pumps

1.1 Number of pumps

1.1.1 Passenger ships of 4.000 GT and over are to be equipped with at least three, and passenger ships of less than 4.000 GT with at least two fire pump.

In passenger ships of 1.000 GT and over, fire pumps, their sea connections and power sources are to be distributed throughout the ship in such a way that an outbreak of fire in one compartment cannot put them out of action simultaneously. Where, on passenger ships of less than 1.000 GT, the main fire pumps are located in one compartment, an additional emergency fire pump is to be provided outside this compartment.

1.1.2 Cargo ships of 500 GT and over are to be equipped with at least two, and cargo ships of less than 500 GT with at least one fire pump.

1.1.3 On cargo ships of 500 GT and over a fixed emergency fire pump is to be provided if an outbreak of fire in one compartment can put all the fire pumps out of action.

An emergency fire pump is also to be provided if the main fire pumps are installed in adjacent compartments, and the division between the compartments is formed by more than one bulkhead or deck.

1.1.4 On cargo ships, in every machinery space containing ballast, bilge or other water pumps, provision shall be made for connecting at least one of these pumps to the fire extinguishing system. Such connection may be dispensed with where none of the pumps is capable of the required capacity or pressure.

1.2 Minimum capacity and pressure head

1.2.1 The minimum capacity and the number of fire pumps shall be as specified in Table 12.2.

1.2.2 Where fire pumps with different capacities are installed, no pumps is to supply less than 80% of the total required capacity divided by the specified number of fire pumps.

1.2.3 Each fire pumps is to be capable of supplying sufficient water for at least two of the nozzles used on board the ship.

On ships for the carriage of dangerous goods the requirements of P. are also be complied with.

The capacity of a fire pump is not to be less than 25 m^3/h.

On cargo ships of less than 100 GT the fire pump is to be capable of supplying water for at least one effective jet of water via a 9 mm nozzle.

1.2.4 The total required capacity of the fire pumps - excluding emergency fire pumps - need not exceed 180 m^3/h on cargo ships.

1.2.5 For emergency fire pumps, see 1.4.

1.2.6 The pressure head of every fire pump is to be so chosen that the requirement of 2.3.4 is met. On cargo ships of less than 300 GT, instead of the pressure given in Table 12.3 every nozzle is under the conditions of 2.3.4 be capable of delivering a water jet of at least 12 m length horizontally.

1.3 Drive and arrangement of pumps

1.3.1 Each fire pump is to have a power source independent of the ship's propulsion machinery.

1.3.2 On cargo ships of less than 1.000 GT, one of the fire pumps may be coupled to an engine which is not exclusively intended to drive this pump.

1.3.3 On cargo ships of less than 300 GT, the fire pump may be coupled to the main engine provided that the line shafting can be detached from the main engine (e.g. by means of a clutch coupling or reversing gear).

1.3.4 Fire pumps and their power source may not be located forward of the collision bulkhead. In cargo ships, BKI may, on request, permit exceptions to this requirement.

1.3.5 Fire pumps and their sea connections are to be located as deep as possible below the ship's light waterline.

Where such an arrangement is impracticable, the pumps less than are to be of self-priming type or are to be connected to a priming system.

1.3.6 Provision is to be made for supplying at least one of the fire pumps in the machinery space with water from two sea chests.

On ships with ice class, a suction from the de-iced seawater cooling system is to be provided for at least one of the fire pumps.

1.3.7 For emergency fire pumps, see 1.4.

1.3.8 Ballast, bilge and other pumps provided for pumping seawater and having a sufficient capacity may be used as fire pumps provided that at least one pump is immediately available for fire fighting purposes.

1.3.9 Centrifugal pumps are to be connected to the fire mains by means of screw-down non-return valves or a combination of a shut-off and a non-return device.

are to be fitted with a shut-off valve at the shell.

4. Strainers

The suction lines of the seawater pumps are to be fitted with strainers.

The strainers are to be so arranged that they can be cleaned during service.

Where cooling water is supplied by means of a scoop, strainers in the main seawater cooling line can be dispensed with.

5. Seawater cooling pumps

5.1 Diesel engine plants

5.1.1 Main propulsion plants are to be provided with main and stand-by cooling water pumps.

5.1.2 The main cooling water pump may be attached to the propulsion plant. It is to be ensured that the attached pump is of sufficient capacity for the cooling water required by main engines and auxiliary equipment over the whole speed range of the propulsion plant.

The drive of the stand-by cooling water pump is to be independent of the main engine.

5.1.3 Main and stand-by cooling water pumps are each to be of sufficient capacity to meet the maximum cooling water requirements of the plant.

Alternatively, three cooling water pumps of the same capacity and delivery head may be arranged, provided that two of the pumps are sufficient to supply the required cooling water for full load operation of the plant.

With this arrangement it is permissible for the second pump to be automatically put into operation only in the higher temperature range by means of a thermostat.

5.1.4 Ballast pumps or other suitable seawater pumps may be used as stand-by cooling water pumps.

5.1.5 Where cooling water is supplied by means of a scoop, the main and stand-by cooling water pumps are to be of a capacity which will ensure reliable operation of the plant under partial load conditions and astern operation as required in Section 2, E.5.1.1e). The main cooling water pump is to be automatically started as soon as the speed falls below that required for the operation of the scoop.

5.2 Steam turbine plants

5.2.1 Steam turbine plants are to be provided with a main and a stand-by cooling water pump.

The main cooling water pump is to be of sufficient capacity to supply the maximum cooling water requirements of the turbine plant. The capacity of the stand-by cooling water pump is to be such as to ensure reliable operation of the plant also during astern operation.

5.2.2 Where cooling water is supplied by means of a scoop, the main cooling water pump is to be of sufficient capacity for the cooling water requirements of the turbine plant under conditions of maximum astern output.

The main cooling water pump is to start automatically as soon as the speed falls below that required for the operation of the scoop.

5.3 Plants with more than one main engine

For plants with more than one engine and with separate cooling water systems, complete spare pumps stored on board may be accepted instead of stand-by pumps provided that the main seawater cooling pumps are so arranged that they can be replaced with the means available on board.

5.4 Cooling water supply for auxiliary engines

Where a common cooling water pump is provided to serve more than one auxiliary engine, an independent stand-by cooling water pump with the same capacity is to be fitted. Independently operated cooling water pumps of the main engine plant may be used to supply cooling water to auxiliary engines while at sea, provided that the capacity of such pumps is sufficient to meet the additional cooling water requirement.

If each auxiliary engine is fitted with an attached cooling water pump, stand-by cooling water pumps need not to be provided.

6. Cooling water supply in dry dock

It is recommended that a supply of cooling water, e.g. from a water ballast tank, is to be available so that at least one diesel generator and, if necessary, the domestic refrigerating plant may run when the ship is in dry dock. Cargo and container cooling systems are to conform to the requirements stated in Rules for Refrigerating Installations, Volume VIII, Section I,1.4.

manually operated fire alarm call points and all internal signals required in an emergency, such as General Emergency Alarm, CO_2 - alarm

if these facilities cannot be supplied in dependently from an emergency storage battery for the duration of 36 hours.

1.2.4 For 36 hours

a) the stipulated emergency fire pumps

b) the automatic sprinkler pump

c) the emergency bilge pump and all the devices necessary for the operation of electrically-powered remotely controlled drainage valves

d) the auxiliary equipment for the emergency diesel generator

1.2.5 During the period stipulated by Section 7, A.4., the steering gear if an emergency supply is obligatory, and the rudder angle indicator.

1.2.6 For 3 hours on Ro/Ro passenger ships the supplementary emergency illumination with own storage battery luminaries, see Section 16.

1.2.7 For one hour the electric operated Low Location Lighting (LLL system).

1.2.8 For half an hour

a) all watertight doors which in accordance with Rules for Machinery Installations, Volume III, shall be power-operated, their controls and the stipulated indicating and warning devices in accordance with Section 7.D. (see also 1.4.2 b))

b) the emergency equipment which brings the passenger lift cars to the next exit point for reasons of escape. If there are several passenger lift cars, they may in an emergency be brought to the exit point successive

1.3 For a ship which regularly makes voyages of limited duration, the national authorities may approve a shorter period than the 36 hours stipulated in 1.2.1 to 1.2.4, but not less than 12 hours, if in their opinion this ensures an adequate level of safety.

1.4 The emergency source of electrical power for passenger ships may be either a generator set with a transitional source of emergency electrical power or a storage battery.

1.4.1 If the emergency source of electrical power is a generator set it shall be powered by a suitable prime mover with its own independent fuel supply in accordance with Rules for Machinery Installations, Volume III, Section 10.B, and an independent cooling system. The set shall start automatically if the main power supply fails. Supply to the consumers listed under 1.2 shall be taken over automatically by the emergency set. The emergency electrical supply provisions shall be such that its rated load capacity is assured as quickly as possible but not later than 45 seconds after failure of the main power supply.

1.4.2 The transitional emergency source of electrical power shall be a storage battery which in the case of failure of the main and emergency power supplies immediately supplies the consumers listed below, until the emergency generator set described under 1.4.1 is operative and connected.

Its capacity shall be so rated that it is capable, without recharging to supply the consumers for the period as specified below. During this period its terminal voltage shall remain within ± 12 % of the rated value.

The following consumers are to be taken into account, insofar as they depend on an electrical power source for their operation:

a) for half an hour the lighting stipulated under 1.2.1 and 1.2.2 a), lanterns and lights and all equipment stipulated under 1.2.3 a), 1.2.3 c) and 1.2.3 d) insofar as these are not supplied independently by their own emergency storage battery during the stipulated period

b) power for closing the watertight doors without a requirement for simultaneous closure of all doors and for their indicating devices and warning signals, as stipulated under 1.2.8 a).

1.4.3 If the emergency source of electrical power is a storage battery it shall be capable in the event of failure of the main electrical power supply to take over automatically and immediately the supply to the consumers listed under 1.2 and of supplying them without a recharging for the stipulated period. During this period its terminal voltage shall remain within ± 12 % of the rated value.

1.4.4 An indication of inadmissible battery discharge (emergency source of electrical power and transitional emergency electrical power source) shall be provided at the main switchboard or in the engine control room.

2. Power systems

ponen-komponen elektronik di suatu industri akan memerlukan tingkat iluminasi yang lebih tinggi dari, perakitan komponen-komponen mesin yang dilakukan di dalam sebuah garasi karena komponen-komponen elektronika berukuran lebih kecil dan dibutuhkan detail-detail halus dalam perakitannya.

Perhitungan iluminasi dengan hukum kebalikan kuadrat yang dijabarkan sebelumnya pada awal-awal bahasan hanya cocok untuk membuat skema rancangan sistem penerangan di mana tidak terdapat permukaan pantulan yang dapat menghasilkan iluminasi tambahan lain. Metode ini dapat digunakan untuk merancang skema penerangan luar untuk sebuah gereja, jembatan, maupun gedung-gedung publik.

Penerangan dalam menghasilkan cahaya yang ditujukan langsung pada permukaan di mana pekerjaan dilakukan. Akan tetapi terdapat pula sumber iluminasi sekunder yang dihasilkan oleh cahaya-cahaya yang dipantulkan dari dinding ataupun langit-langit gedung. Pada saat merancang skema penerangan dalam, metode perancangan yang digunakan akan bergantung pada besarnya fluks total yang dibutuhkan untuk menghasilkan iluminasi tertentu pada suatu tempat di mana pekerjaan dilaksanakan. Metode ini secara umum dikenal dengan nama *metode lumen*.

Berdasarkan metode lumen ini, formula yang digunakan untuk menentukan jumlah luminari total yang dibutuhkan untuk menghasilkan iluminasi tertentu pada suatu tempat di mana pekerjaan dilaksanakan ialah sebagai berikut:

$$\text{Luminari total} = \frac{\text{tingkat iluminasi (lx)} \times \text{luas area (m}^2\text{)}}{\text{lumen keluaran dari masing-masing luminari (lm)} \times UF \times LLF}$$

di mana,

- tingkat iluminasi dipilih setelah mempertimbangkan tingkat iluminasi yang direkomendasikan melalui kode-kode IES,
- luas area adalah luas area yang diiluminasi di mana pada area inilah pekerjaan-pekerjaan akan dilakukan,
- lumen keluaran dari masing-masing luminari adalah sesuai dengan spesifikasi pabrik yang diberikan atau dapat diperoleh dari tabel-tabel referensi, misalnya tabel 10.2
- UF adalah faktor utilisasi, dan
- LLF adalah faktor rugi-rugi cahaya.

Faktor Utilisasi (UF)

Fluks cahaya yang dapat mencapai bidang datar di mana pekerjaan dilakukan selalu kurang dari lumen keluaran lampu karena sejumlah tertentu cahaya akan diserap oleh berbagai macam tekstur permukaan. Metode untuk menghitung besarnya faktor utilisasi dijelaskan pada Memorandum Teknis No.5 Piagam Institusi Teknik Jasa Layanan Gedung (*Chartered Institution of Building Services Engineers, CIBSE*). Selain itu, pada umumnya pabrik-pabrik yang memproduksi alat-alat penerangan akan

Tabel 10.2 Karakteristik lampu tabung 1500 mm 65 W dengan pin ganda

Warna Tabung	Lumen lampu mula-mula*	Lumen lampu†	Kualitas pengembalian warna	Penampakan warna
Sinar mentari buatan	2600	2100	Sempurna	Sejuk
De luxe natural	2900	2500	Sangat baik	Sedang
De luxe putih hangat	3500	3200	Baik	Hangat
Natural	3700	3400	Baik	Hangat
Sinar mentari	4800	4450	Cukup	Sejuk
Putih hangat	4950	4600	Cukup	Hangat
Putih	5100	4750	Cukup	Hangat
Merah	250‡	250	Jelek	Merah

* Lumen lampu mula-mula ialah lumen lampu yang diukur setelah 100 jam pemakaian
† Lumen lampu ialah lumen lampu yang diukur setelah 2000 jam pemakaian tabung berwarna dimaksudkan
‡ ...nya untuk penggunaan dekoratif

Posisi pelayanan	Lampu dapat dioperasikan dalam setiap posisi
Usia pemakaian	[illegible]
Efikasi	[illegible] dengan 70 lm/W bergantung pada warna tabung

Section 4

Installation Protection and Power Distribution

A. Three-Phase Main Generators

1. General

The main generators supply the relevant main switchboard, either individually or in parallel.

1.1 Single operation

Single operation means that each generator supplies a busbar system assigned to it. Where this method is used, it shall be possible to connect the consumers or consumer groups to at least two different busbar systems or generators by means of selector switches.

1.2 Parallel operation

In parallel operation, the generators supply a common busbar system of the main switchboard, to which the consumer feeders are connected.

2. Protection equipment

2.1 General

2.1.1 Generators shall be at least protected against damage due to short circuits and overloads.

2.1.2 Protection equipment for generators is to be arranged within the switchgear field of the generator to be protected and supplied from the generator side.

2.1.3 Short-circuit protection and overload protection equipment is to be provided in every non- earthed conductor.

2.2 Short-circuit protection

2.2.1 The short-circuit protection is to be set at an overcurrent of more than 50 %, but at a value less than the steady short-circuit current. It shall have a short- time delay compatible with the selectivity of the system (up to about 500 milliseconds).

2.2.2 The short-circuit protection shall not be disabled by undervoltage.

2.2.3 Generators with a rated output of 1500 kVA or more are to be equipped with a suitable protective device which in the event of a short-circuit inside the generator or in the cable between generator and circuit-breaker opens the breaker and de-energises the generator.

Examples of suitable protective equipment are differential protection or generator-neutral-point monitoring.

2.3 Overload protection

2.3.1 The overload protection, which is to be set to a value between 10 % and 50 % overcurrent, shall trip the generator circuit-breaker with a time delay of not more than 2 minutes. A setting above 50 % overcurrent may be allowed, where this is required by the working conditions and is compatible with the generator characteristics. The overload protection shall not impair immediate reconnection of the generator.

2.3.2 A device is installed which, when the generator's rated current is exceed, cause a warning signal after about 5 seconds and automatically disconnects the non essential and if necessary the secondary essential equipment.

On passenger ships and ships with unattended machinery spaces the automatic disconnection of non essential consumers is mandatory.

2.4 Reverse-power protection

2.4.1 Generators from 50 kVA output upwards provided for parallel operation are to be protected by a delayed reverse-power release.

2.4.2 The protection shall be selected and set in accordance with the characteristics of the prime mover. Setting guidance values are: for turbo generators 2 % to 6 %, for diesel generators 8 % to 15 % of the rated output delayed from 2 to 5 seconds. The setting should, if possible be at 50 % of the tractive power of the prime mover. Should the operating voltages decrease to 50 % of the rated value, the reverse-power protection shall remain effective within the limits stated.

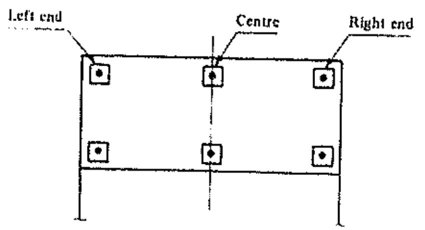
2.5 Undervoltage protection

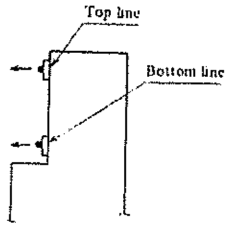
Generator circuit-breakers are to be provided with undervoltage protection. In the event of a decrease of the voltage to 70 % - 35 % of the rated voltage, the generator circuit-breaker shall open automatically. Undervoltage releases shall have a short-time delay adapted to the short-circuit protection.

Appendix table 1 Dimension, cap and characteristics (Continued)

Types	Classification of size	Rated lamp wattage	Rated input voltage	Start test voltage	Initial characteristics										Lumen maintenance factor	(Reference) Rated life
					Lamp wattage	Lamp current	(Reference) Lamp voltage	Total luminous flux lm								
								D	N	W, WW, L	EX-D	EX-N	EX-W, WW-L			
		W	V	V	W	A	V								%	h
FL4	4	4	100	94	4.6	0.162±0.020	30	(90)	(95)	(100)	-	-	-	-	2400 or more
FL6	6	6			5.9	0.147±0.020	44	(155)	(170)	(180)	-	-	-	-	
FL8	8	8			7.9	0.170±0.020	56	(260)	(280)	(290)	-	-	-	-	
FL10	10	10			9.5	0.230±0.030	46	410	440	460	490	530	540	75 or more	4000 or more
FL15	15	15			14.7	0.300±0.030	55	710	780	820	860	920	940		
FL20SS/18	20	18			18.0	0.340±0.040	59	1010	1100	1160	1320	1400	1430	85 or more	6000 or more
FL20S		20			19.0	0.360±0.040	58								
FL30S	30	30			30.0	0.610±0.050	55	1480	1620	1700	1790	1900	1940	75 or more	
FL40SS/37	40	37	200	180	37.0	0.410±0.040	108	2610	2850	3000	3180	3380	3450	85 or more	8000 or more
(FL40SS/38)		38			38.0	0.410±0.040	109								
FL40S		40			39.5	0.420±0.040	106								

Remarks
1. The value attaching ( ) to the value of total luminous flux shall be the reference value.
2. Total luminous flux of -DL, -SDL and -EDL in color rendering property classification shall be 75% or more, 65% or more and 60% or more of this table's value respectively.
3. Total luminous flux of shatterproof types shall be 97% or more of this table's value.
4. Lumen maintenance factor of -DL, -SDL and -EDL in color rendering property classification shall be more than the value deducting 5 from this table's value.





Remarks:
1. Symbol ▭ signifies the instrument, and "•→" the measuring point and direction of illumination meter.
2. Measuring shall be carried out with an illumination meter placed parallel to the face of instrument at the left end, centre and right end on top and bottom lines.
3. The value of illumination shall be an arithmetic mean of measurements.

Fig. 12 Method of Measurement on Gauge

Reference Standard

JIS C 1609 – Illuminance Meters

Table Required Illumination and Method of Measurement

(1) Living area

Space	Illumination lx	Method of measurement	Remark
Captain class day room	150	Fig. 1	
Captain class bed room	100	Fig. 1	
Cabin	100	Fig. 1	
State room, passenger room	100	Fig. 1	
On desk	250	Fig. 11	Local lighting in captain class room, captain class bed room, cabin, and state room
Berth at pillow	200	Fig. 9	Local lighting in captain class room, captain class bed room, cabin, and state room
Mirror front	200	Fig. 10	Local lighting in captain class room, captain class bed room, cabin, and state room
Bath room	50	Fig. 1	
Lavatory, toilet	50	Fig. 1	
Mirror front	200	Fig. 10	
Barber shop and beauty parlor	200	Fig. 1	
Dining saloon, mess room	200	Fig. 1	
on dining table	250	Fig. 11	
on table (writing, game)	250	Fig. 11	
Smoking room	200	Fig. 1	
Recreation room	200	Fig. 1	For a Japanese-style room, illumination at a height of 400 mm above floor
on dining table	250	Fig. 11	
on table (writing, game)	250	Fig. 11	
Sports room, gymnasium	200	Fig. 1	
Library	200	Fig. 1	
on table	250	Fig. 11	
Lounge	200	Fig. 1	
Cocktail lounge	-	-	Mood lighting; suitable illumination
Hospital	100	Fig. 1	
Dispensary	200	Fig. 1	
on dispensary table	500	-	Table face right under lamp or bulb
Shopping area	200	Fig. 1	For ferry boat, passenger ship, etc
Passage, alley way, corridor passage	50	Fig. 2	
Staircase	50	Fig. 3	Including companion way

Table (cont'd)

Space	Illumination lx	Method of measurement	Remark
Entrance for passenger	100	-	Mean value of several suitable points near entrance
Outer passage	10	Fig. 4	
Swimming pool	50	-	Measuring point shall be on water surface at pool centre

(2) Navigation area

Space	Illumination lx	Method of measurement	Remark
Wheelhouse	50	Fig. 1	
Chart room	50	Fig. 1	
on chart table	250	-	Table face right under lamp or bulb
Radio office	200	Fig. 1	
Operating table	250	Fig. 11	
Electric room, such as gyro room, radar room, etc.	100	Fig. 1	
Pilot house	100	Fig. 1	Crane barge, rig
Navigation room	200	Fig. 1	Crane barge, rig
Operating room	200	Fig. 1	Crane barge, rig
Rig management room	200	Fig. 1	Crane barge, rig

(3) Service area

Space	Illumination lx	Method of measurement	Remark
Office	100	Fig. 1	
on desk	250	Fig. 11	
Galley	100	Fig. 1	
on cooking table	250	-	Centre of cooking table surface
Pantry, butcher shop, bakery etc.	100	Fig. 1	
Provision store (dry)	50	Fig. 1	
Refrigerated provision chamber	30	Fig. 1	
Laundry	100	Fig. 1	
Drying room	50	Fig. 1	
Locker and store	50	Fig. 1	

Table (cont'd)

(4) Operating area

Space	Illumination lx	Method of measurement	Remark
Main passage, stair and entrance in eng. room, boiler room and aux. machine room	100	Fig. 3, Fig. 5, Fig. 6	
Operation area in engine room, boiler room and aux. machine room	150	-	At a height of 850 mm above floor of operation area and monitoring station
Access to the rear of tanks in eng. room, boiler room and aux. machine room	20	Fig. 6	
Engine control room	200	Fig. 1	
on gauge	300	Fig. 12	Not applicable to photoelectric digital instrument board, display surface of CRT etc.
on operating table	300	Fig. 12	Not applicable to photoelectric digital instrument board, display surface of CRT etc.
Work shop	100	Fig. 1	
on work bench	300	-	Centre of work bench surface
at work face of machine and tool	500	-	
Engine room store	50	Fig. 1	
Shaft tunnel	20	Fig. 6	
Cargo control room	200	Fig. 1	
on gauge	300	Fig. 12	Not applicable to photoelectric digital instrument board, display surface of CRT, etc.
on operating table	300	Fig. 12	Not applicable to photoelectric digital instrument board, display surface of CRT, etc.
Emergency generator room	100	Fig. 1	
on gauge	200	Fig. 12	
Battery room	50	Fig. 1	
Boatswain's store	50	Fig. 1	
Paint store	50	Fig. 1	
Cargo oil pump room	50	Fig. 5, Fig. 6	Near passageway, stairway, and pump
Steering gear room, aircond. room etc.	50	Fig. 1	
Refrigerated cargo hold	30	Fig. 7	
General cargo hold (fixed light)	20	Fig. 8	
Under deck passage	20	Fig. 2	Container ship, dredger
Cargo handling space	20	-	Horizontal plane near operating handle
Mooring area	20	-	Mean value of measurements at several suitable points in a horizontal plane at a height of 850 mm above deck

Section 14

Additional Rules for Passenger Ships

A. General

1. Scope

These regulations apply additionally to electrical plants on passenger ships.

2. Reference to other BKI Rules

2.1 Rules for Hull, Volume II

2.2 Rules for Machinery Installations, Volume III

2.3 Section 16

B. Installation of Electrical Equipment

1. Attention is drawn to special provisions for structural fire protection for control stations. Control stations are e.g:

- location of the emergency source of electrical power
- bridge and chart room.
- radio room
- main fire alarm and fire fighting station
- engine control room if is located outside the engine room
- rooms in which central stations for general emergency alarm and loudspeaker systems (PA-systems) for emergency announcements are located

2. Switch- and distribution boards in the passenger area shall not be accessible to passengers

C. Electrical Power Supply Systems

1. Emergency electrical power supply

1.1 An independent emergency source of electrical power shall be provided

1.2 The emergency source of electrical power shall be capable of simultaneously supplying at least the following equipment (if its operation depends on a source of electrical power) for the duration mentioned below, taking starting currents into account:

1.2.1 Emergency illumination for 36 hours

a) at all launching stations for survival appliances on deck and along the outside of the hull

b) in all passageways of the service- and accommodation area, on stairs and at exits and in passenger-lift cars

c) in the machinery rooms and main-generator stations, including their control positions.

d) at all control stations, engine control room, on the bridge, and each main- and emergency switchboard

e) at all storage places for fireman's outfit.

f) in the steering gear compartment and the CO_2 room

g) at the fire pumps listed in 1.2.4, the sprinkler pump and the emergency bilge pump, and at the starting-positions for their motors.

1.2.2 For 36 hours

a) the navigation lights and any other signalling lights required in accordance with the "International Regulations for Preventing Collisions at Sea"

b) the **SOLAS** Chapter IV required "VHF radio installation" and, if necessary the "MF radio installation" and the "ship earth station" and the "MF/HF radio installation".

1.2.3 For 36 hours

a) all internal alarm systems and information equipment required in an emergency

b) all ship navigation devices, which are required in **SOLAS** V/12

c) the fire detection and fire alarm system and the system for operating and monitoring the fire doors

d) devices for the intermittent operation of the daylight-signalling-lamp, the ship's siren, the

2.4 All lighting fixtures are to be so mounted that combustible parts are not ignited by the generated heat, and they themselves are not exposed to damage. The minimum distances indicated on the lighting fixtures are to be respected.

Where no minimum distances are specified, the minimum distances in the direction of radiation indicated in Table 11.1 shall be applied for lighting fixtures in accordance with IEC 60598-1 Luminaries, Part 1: General Requirements and Tests.

Table 11.1 Minimum distances for the mounting of lighting fixtures

Rated power [W]	Minimum distances [m]
up to and incl. 100	0,5
over 100 up to and incl. 300	0,8
over 300 up to and incl. 500	1,0

C. Socket-Outlets

1. General

1.1 The supply for socket-outlets in the accommodation, day rooms and service rooms (250 V) are to be run from lighting distribution panels. The maximum fuse rating for a circuit is 16 A.

1.2 For the sockets of distribution systems with different voltages and/or frequencies, non interchangeable plugs and socket outlets shall be used.

1.3 Plug-in connections shall not be installed below the floor in engine rooms or boiler rooms.

1.4 Socket outlets for power circuits over 16 A AC or 10 A DC shall be interlocked in such a way that the plug can be neither inserted nor withdrawn when the socket contacts are live.

2. Shower rooms and bathing rooms

2.1 In shower rooms and bathing rooms the following electrical equipment shall be installed in accordance with IEC publication 60364-7-701

2.2 The minimum degree of protection against foreign bodies and water shall be according to Table 11.2.

Table 11.2 Minimum degree of protection against foreign bodies and water in zone 0, 1 and 2

Zone	Degree of protection of the needed electrical equipment in shower rooms and bathing rooms
0	IP X7
1	IP 55
2	IP 34

3. Cargo holds

Sockets in cargo holds may be installed only in positions with sufficient protection against mechanical damage.

4. Container connections

4.1 Socket connections for refrigerated containers shall be supplied from own sub-distribution panels. At the sub-distribution panels shall be indicated whether these distribution panels are live and which supply circuit is switched on.

4.2 Several socket-outlets may be grouped together for common supply via one power cable, provided that the individual connections are protected at site against overcurrent and short circuit, and the supply cable is rated for the total power demand. For details, see Section 12, C.

Table (cont'd)

Space	Illumination lx	Method of measurement	Remark
Passage way on upper deck (weather)	8	-	Any measuring point on deck surface (in accordance with ILO)
Each oil transfer connection point	54	-	Horizontal plane at connection point (in accordance with USCG)
Each oil transfer operation work area	11	-	At height of 900 mm above deck near valve and hose davit (in accordance with USCG)
Car deck (car ferry)	50	Fig. 7	Car ferry (with no car on board)
Car deck (car carrier)	50	Fig. 7	Car ferry (with no car on board)
Stowage position of lifeboat and liferaft	20	-	Mean value of measurement at several points in a horizontal plane at a height of 850 mm above deck near stowage position
Lifeboat launching position	2		Any measuring points on launching position

Ships — Cable penetration of "A" class fire protection divisions — Design

1. Scope

This Japanese Industrial Standard specifies the general requirements for the design of cable penetration of "A" Class division conforming to the requirements of SOLAS(1).

Note(1): The International Convention for the Safety of Life at Sea, 1974 including the 1983 Amendments

Remark: The construction and materials of the "A" Class division through which cables penetrate shall be such that they are approved by the Administration

2. Definitions

For the purpose of this Standard, the following definitions apply.

(1) **"A" Class fire protection divisions** "A" Class divisions are divisions formed by bulkheads and decks which comply with each performance of 3.

(2) **Standard fire test** General term covering the test specimens, test ovens, testing procedures and acceptance criteria in accordance with the IMO(2) recommendation

(3) **Thermal insulative material** Non-combustible materials forming the "A" Class divisions.

(4) **Seal compounds** Materials forming the "A" Class divisions used for filling spaces around electric cables.

(5) **Non-combustible materials** Materials which neither burn nor give off flammable vapours in sufficient quantity of self-ignition when heated to approximately 750 °C

Note (2) An acronym for International Maritime Organization

3. Performance

The performance of the "A" Class divisions shall be as specified below.

(1) They shall be insulated with non-combustible materials of the approved type such that the average temperature of the unexposed side will not exceed 139 °C above the initial temperature within the period corresponding to respective class given in **Table 1**, nor will the temperature, at any point including any point, exceed 180 °C above the initial temperature.

Table 1 Measuring period

Class	Time (min.)
A-60	60
A-30	30
A-15	15
A-0	0

(2) They shall be so constructed that the passage of smoke and flame can be restricted before the 60-minute long standard fire test is completed.

(3) They shall be constructed of steel or other equivalent materials.

4. Construction of Cable Penetrations

The construction and materials of cable penetrations through the "A" Class divisions shall be classified into the following types, and the basic construction shall be as shown in **Figs. 1 to 4**.

(1) Coaming and putty seal compound materials (**Fig. 1**)

(2) Coaming and liquid seal compound materials (**Fig. 2**)

(3) Multi-cable transit (**Fig. 3**)

Table 1 Lamps for General Illumination

Type		Rated wattage W	Rated voltage V	Classification	Glass bulb Type	Glass bulb Dia. mm	Length mm	Base	Standard direction of lamp	Initial characteristics Consumption W	Initial characteristics Light flux lm	Initial characteristics Efficiency lm/W	Endurance time for vibration under over voltage h	Static life h	Shape
KG 24 V	10 W	10	24	Gas-filled	A55	55 ± 1	98 ± 3	E26/25 or B22D/26 × 26	Down	10.0 ± 0.7	85 ± 13	8.5 ± 1.0	25	1000	
KG 100 V 110 V 115 V	10 W	10	100 110 115	Vacuum	A55	55 ± 1	98 ± 3	E26/25 or B22D/26 × 26	Down	10.0 ± 0.7	60 ± 7	6.0 ± 0.6	15	2000	
KG 24 V	20 W	20	24	Gas-filled	A55	55 ± 1	98 ± 3	E26/25 or B22D/26 × 26	Down	20.0 ± 1.4	220 ± 33	11.0 ± 1.3	45	1000	
KG 100 V 110 V 115 V	20 W	20	100 110 115	Vacuum	A55	55 ± 1	98 ± 3	E26/25 or B22D/26 × 26	Down	20.0 ± 1.4	142 ± 17	7.1 ± 0.7	40	2000	
KG 220 V 230 V	20 W	20	220 230	Vacuum	A55	55 ± 1	98 ± 3	E26/25 or B22D/26 × 26	Down	20.0 ± 1.4	112 ± 17	5.6 ± 0.7	15	2000	
KG 24 V	40 W	40	24	Gas-filled	A55	55 ± 1	105 ± 3	E26/25 or B22D/26 × 26	Down	40.0 ± 2.8	540 ± 81	13.5 ± 1.6	50	1000	
KG 100 V 110 V 115 V	40 W	40	100 110 115	Gas-filled	A55	55 ± 1	105 ± 3	E26/25 or B22D/26 × 26	Down	40.0 ± 2.8	335 ± 41	8.4 ± 0.9	40	1500	
KG 220 V 230 V	40 W	40	220 230	Vacuum	A60	60 ± 1	110 ± 4	E26/25 or B22D/26 × 26	Down	40.0 ± 2.8	260 ± 39	6.5 ± 0.8	30	2000	
KG 24 V	60 W	60	24	Gas-filled	A60	60 ± 1	110 ± 4	E26/25 or B22D/26 × 26	Down	60.0 ± 4.2	870 ± 130	14.5 ± 1.7	50	1000	
KG 100 V 110 V 115 V	60 W	60	100 110 115	Gas-filled	A60	60 ± 1	110 ± 4	E26/25 or B22D/26 × 26	Down	60.0 ± 4.2	590 ± 71	9.8 ± 1.0	50	1500	Fig. (1)
KG 220 V 230 V	60 W	60	220 230	Gas-filled	A60	60 ± 1	110 ± 4	E26/25 or B22D/26 × 26	Down	60.0 ± 4.2	440 ± 66	7.4 ± 0.9	40	1500	
KG 24 V	100 W	100	24	Gas-filled	A70	70 ± 1	136 ± 4	E26/25 or B22D/26 × 26	Down	100 ± 7	1550 ± 230	15.5 ± 1.9	50	1000	
KG 100 V 110 V 115 V	100 W	100	100 110 115	Gas-filled	A70	70 ± 1	136 ± 4	E26/25 or B22D/26 × 26	Down	100 ± 7	1150 ± 140	11.5 ± 1.2	50	1500	
KG 220 V 230 V	100 W	100	220 230	Gas-filled	A70	70 ± 1	136 ± 4	E26/25 or B22D/26 × 26	Down	100 ± 7	920 ± 140	9.2 ± 1.1	40	1500	
KG 100 V 110 V 115 V	200 W	200	100 110 115	Gas-filled	PS 80	80 ± 1	175 ± 5	E26/30 × 28 or B22D/26 × 26	Down	200 ± 14	2740 ± 320	13.7 ± 1.4	50	1500	
KG 220 V 230 V	200 W	200	220 230	Gas-filled	PS 80	80 ± 1	175 ± 5	E26/30 × 28 or B22D/26 × 26	Down	200 ± 14	2280 ± 350	11.4 ± 1.1	50	1500	
KG 100 V 110 V 115 V	300 W	300	100 110 115	Gas-filled	PS 95	95 ± 1	213 ± 7	E39/41	Down	300 ± 21	4500 ± 540	15.0 ± 1.5	50	1500	
KG 220 V 230 V	300 W	300	220 230	Gas-filled	PS 95	95 ± 1	213 ± 7	E39/41	Down	300 ± 21	3810 ± 570	12.7 ± 1.5	50	1500	
KG 100 V 110 V 115 V	500 W	500	100 110 115	Gas-filled	PS110	110 ± 1	232 ± 8	E39/41	Down	500 ± 35	8200 ± 980	16.5 ± 1.6	50	1500	
KG 220 V 230 V	500 W	500	220 230	Gas-filled	PS110	110 ± 1	232 ± 8	E39/41	Down	500 ± 35	7100 ± 1100	14.2 ± 1.7	50	1500	

Remarks: 1. The letters and figures for types shall mean as follows

K: Marine lamps

G: Lamps for general use

Figures following G: Rated voltage

Figures following V: Rated wattage

2. The glass bulbs shall be of transparent of frosted [illegible]

Table 2 Lamps for Indicating Light

Type	Rated wattage W	Rated voltage V	Classification	Glass bulb Type	Glass bulb Dia. mm	Length mm	Base	Standard direction of lamp	Initial characteristics Consumption W	Initial characteristics Light flux lm (Reference value)	Endurance time for vibration under cover-voltage h	Static life h	Shape
V 2 W	2	18	Vacuum	T13	13 ± 1	33 ± 2	E12/15	Horizontal	2.0 ± 0.3	–	20	1500	
V 2 W	2	24	Vacuum	T10	10 ± 1	28 ± 2	BA9S/13	Horizontal	2.0 ± 0.3		20	1500	
V 3 WC	3	24	Vacuum	T19	19 ± 1	45 ± 3	E12/15 or BA15D/19	Horizontal	3.0 ± 0.5	(15)	20	1500	Fig. (2)
V 3 WE						50 ± 3	E14/22						
V 5 WB	5	24	Vacuum	T19	19 ± 1	65 ± 3	E12/15 or BA15D/19	Horizontal	5.0 ± 0.8	(32)	20	1500	
V 5 WC	5	24	Vacuum	T19	19 ± 1	45 ± 3	E12/15 or BA15D/19	Horizontal	5.0 ± 0.8	(32)	20	1500	
V 5 WE						50 ± 3	E14/22						
V 5 WD	5	24	Vacuum	G19	19 ± 1	35 ± 2	E12/15 or BA15D/19	Horizontal	5.0 ± 0.8	(30)	20	1500	Fig. (3)
V 5 WC	5	115	Vacuum	T19	19 ± 1	45 ± 3	E12/15 or BA15D/19	Horizontal	8 max	(20)	15	1500	
V 5 WE						50 ± 3	E14/22						
V 10 WA	10	115	Vacuum	T26	26 ± 1	75 ± 3	E26/25 or B22D/26 × 26	Horizontal	10.0 ± 1.5	(50)	15	1500	Fig. (2)
V 10 WC	10	115	Vacuum	T19	19 ± 1	45 ± 3	E12/15 or BA15D/19	Horizontal	10.0 ± 1.5	(50)	15	1500	
V 10 WE						50 ± 3	E14/22						
V 10 W	10	220	Vacuum	T19	19 ± 1	50 ± 3	E14/22	Horizontal	15 max	(35)	15	1500	

: 1. The letters for types shall mean as follows:

P: Lamps for indicating light

A,B,C,D: Length

2. The glass bulbs shall be of transparent.

Table 6.5 Mechanical and technological properties of carbon and carbon manganese steel forgings in normalized or quenched and tempered condition for room temperature

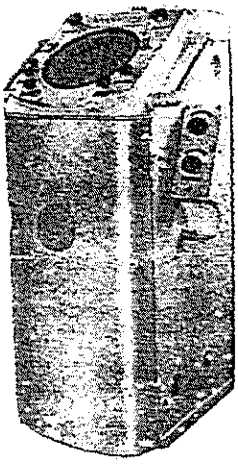
Minimum tensile strength 1), 2) R_m [N/mm²]	Relevant heat treatment diameter [mm]	Yield strength R_{eH} [N/mm²] min.	Elongation (for $L_o = 5,65 \cdot \sqrt{S_o}$) A [%] min.			Reduction in area Z [%] min.			Impact energy KV 3) [J] min.			Impact energy KU [J] min.			Brinell hardness HB (Guide values)
			long.	tang.	trans.	long.	tang.	trans.	long.	tang.	trans.	long.	tang.	trans.	
360	≤ 250	180	28	24	20	50	42	35	40	32	25	38	30	25	95 - 125
	> 250 ≤ 500								32	25	18	30	25	20	
	> 500 ≤ 1000								32	25	18	29	23	18	
400	≤ 250	200	26	23	19	50	42	35	40	32	25	38	30	25	110 – 150
	> 250 ≤ 500								32	25	18	30	25	20	
	> 500 ≤ 1000								32	25	18	27	22	17	
440	≤ 250	220	24	21	18	50	42	35	38	30	22	35	27	22	125 - 160
	> 250 ≤ 500								32	25	18	30	25	20	
	> 500 ≤ 1000								30	24	18	25	20	15	
480	≤ 250	240	22	19	16	45	38	30	35	27	22	32	25	22	135 – 175
	> 250 ≤ 500								32	25	18	30	25	20	
	> 500 ≤ 1000								26	24	14	22	17	12	
520	≤ 250	260	21	18	15	45	38	30	32	25	20	30	25	20	150 - 185
	> 250 ≤ 500								25	20	15	25	20	17	
	> 500 ≤ 1000								24	18	13	20	15	11	
560	≤ 250	280	20	17	14	40	34	27	25	20	15	25	20	17	160 - 200
	> 250 ≤ 500								25	20	15	25	20	17	
	> 500 ≤ 1000								23	14	12	19	12	10	
600	≤ 250	300	18	16	13	40	34	27	18	15	12	20	17	15	175 - 215
	> 250 ≤ 500								18	15	12	20	17	15	
	> 500 ≤ 1000								18	14	12	17	12	10	
640	≤ 250	320	17	15	12	40	32	27	18	15	12	20	17	15	185 - 230
	> 250 ≤ 500								18	15	12	20	17	15	
680	≤ 250	340	16	14	12	40	32	27	18	15	12	20	17	15	200 - 240
	> 250 ≤ 500								18	15	12	20	17	15	
720	≤ 250	360	15	13	11	40	32	27	18	15	12	20	17	15	210 - 250
	> 250 ≤ 500								18	15	12	20	17	15	
760	≤ 250	380	14	12	10	35	30	24	18	15	12	20	17	15	225 - 265
	> 250 ≤ 500								18	15	12	20	17	15	

1) Where the minimum tensile strength of a steel grade falls between two of the graduated values, the requirements are to be determined by interpolation, see 4.2.2.

2) The tensile strength determined by testing may not exceed the specified minimum tensile strength, if less than 600 N/mm², by more than 120 N/mm². Where the minimum tensile strength is ≥ 600 N/mm² not more than 150 N/mm² may be exceeded.

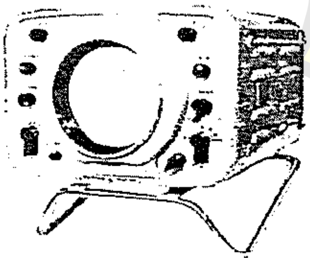
3) The propeller shafts, rudderstocks and heel pintles of ships with ice class symbols are subject to the impact energy values stipulated in 4.3.

TOKYO KEIKI SEIZOSHO CO., LTD.



Radar (MK II-DO)

Radar (MR-30A)



Radar (BR-15)

RADARS

Developed on the basis of technical assistance of Sperry Gyroscope Co., U.S.A.

MK II-DT

1) True Tracking Indication: Moving objects move on the scope with their respective speed and bearings giving to the deck officer exact idea of the relative location of his ship.

2) Off Center Indication: Gives an extended indication of intended direction.

3) Dual Pulsing System: Gives finer range resolution at short ranges and clearer pattern at long ranges.

4) Variable Markers: Enables navigator to d... the target position accurately.

MK II-DO

All functions are the same to MK II—DT, except this model can not give True Tracking Indication.

MR-30 A

10″ scope radar with comparable performan... to large-sized radars. Equipped with the Dual Pulsing System and Variable Markers.

BR-20

A compact 10″ scope radar can be installed at any cramped space. Most fitted for small passenger boat, fishing boat, etc. Also equipped with the Dual Pulsing System.

BR-15

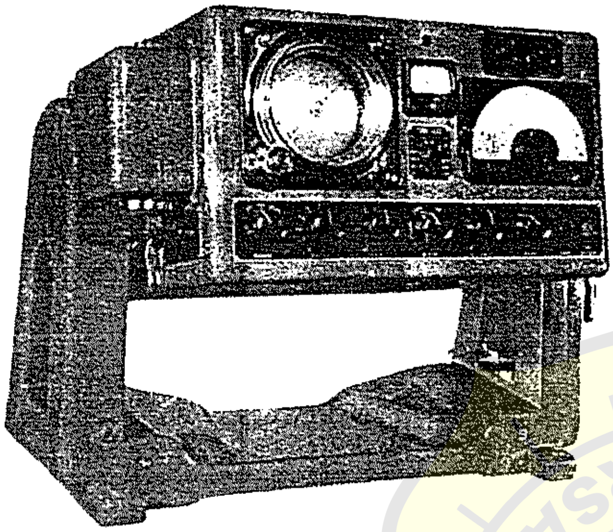
All features are the same to BR-20 except scope dia. is 7″. First of all radars of this size equipped with Dual Pulsing System.

PARTICULARS OF TKS RADARS

Type		MK II-DT & DO	MR-30A	BR-20 & BR-15
Scope Dia.		12″	10″	10″ 7″
Peak Power		40 KW	—ditto—	15 KW
Frequency		9375 MC 45 MC	—ditto—	—ditto—
Pulse Width		0.1 μS (1, 2, 6 mile range) 0.4 μS (15, 40 mile range)	—ditto—	0.1 μS (0.6, 2, 6 mile range) 0.4 μS (10, 20 mile range)
Scanner		4′ 8′ 12′	4′	4′
Beam Width	Horizontal Vertical	2 1 0.65 15 15 15	1.9 16	— ditto —
Resolution	Bearing Range	2 1 0.65 20 m 20 m 20 m	1.9 20 m	—ditto—
Range		1, 2, 6, 15 and 40 mile	—ditto—	0.6, 2, 6, 15, 30 mile
Marker	Fixed Variable	0.5, 2, 5 mile 0.3, 20 mile	0.5, 2, 5, 10 mile 0.3, 20 mile	0.2, 1, 2, 5 mile none

KODEN ELECTRONICS CO., LTD.

MARINE RADIO DIRECTION FINDER



Marine Radio Direction Finder.

Koden Electronics Co., Ltd. supplies a new radio direction finder. efficient and helpful equipment to marine transportation and fishing industry. It may be said to be an outstanding development in the field of electronics.

FEATURES

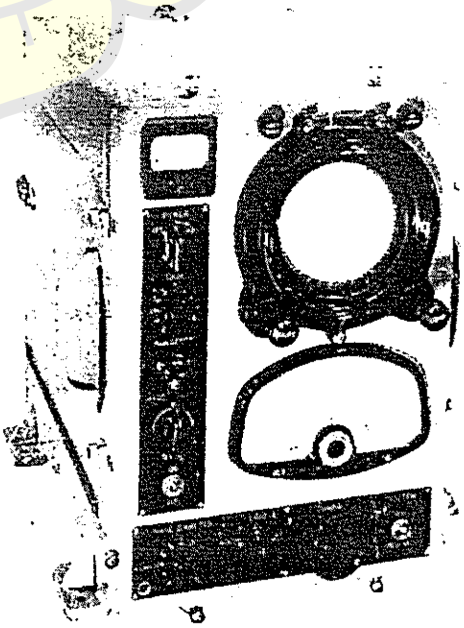
1. FULL AUTOMATIC OPERATION
   No more action is needed except tuning.
2. INSTANT MEASUREMENT
   Measurement is repeated 15 times per second automatically.
3. DIRECT READING
   Wave's Angle is indicated on CRT screen with full azimuth scale.
1. DISTANCE CAN BE ESTIMATED
   As the image of cathode ray tube indicates not only the direction of the coming wave but also intensity of the wave, approximate distance from a sending ship can be easily obtained.
5. HIGH ACCURACY
   Indicate accuracy is well limited within one degree.

DESCRIPTION

Frequency range	200 kc - 1700 kc, 4 band.
Receiver system	9 tube super-heterodyne
Tubes	6SD7×1 6SA7×2 6SI7×1 6SK7×2 6SJ7×1 6V6×2
Power rectifier	Serenium rectifier
Cathode ray tube	120 F BL
Repeating freq. of measurement	15 r. p. s.
Maximum distortionless output	0.5 W over at 1000 C S
Overall selectivity	Less than 6 db at ±1.5 kc width and 60 db at ±6.5 kc
Overall amplitude	more than 130 db
Signal to image ratio	more than 40 db at 410 kc
Minimum sensitivity	Less than 10μV/m at 410 kc
Power consumption	100V-220V AC, 50 c. 100W 100 V DC 3 A. or 24 V DC 9 A invertor used
Possible range of quadrontal error correction	±20°

PRINCIPAL COMPONENTS

Item	Number	Dimension (mm)	Weight (kg)
Receiver	1	505×657×620	53
Goniometer	1	220×508×280	16
Loop Ant.	1	diameter 1200	28
Power Unit	1	220×317×237	17
Spare Parts	1	180×440×270	10



KS-262 U RDF for Fishing Vessels.

MITSUI SHIPBUILDING & ENGINEERING CO., LTD.

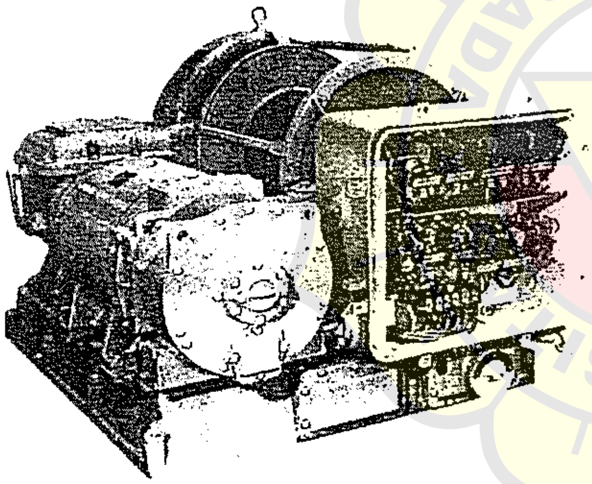
MITSUI TWO-SPEED ELECTRIC WINCH

This equipment has mechanism and characteristics as given below.

(1) Having a dual reduction gear, it is capable of making two speeds by means of a change-over device.

(2) All necessary parts like drum ends, joints, and couplings are completely enclosed, so as to obviate all the possibilities of the cable's being caught or falling-in.

(3) The motor is of compound type with field coils consisting of a set of shunt coils and two sets of series-wound ones. It is provided with bearings on its both ends and is connected to the reduction gear by means of a universal joint. It can therefore be very easily dismounted or mounted.



(4) The magnetic brake is of disc-type, adopting a compound system of the company's unique design, installed on the shaft-end on the opposite side of the motor coupling. It features an exceedingly prompt action at the time of starting, and works accurately and with sure safety even against an abrupt notch-back or in the operation of dynamo brake lowering.

(5) Though the braking gear is entirely built-in inside the body of the winch, it is so designed that any part of the gear may easily be dismounted or replaced for the convenience of maintenance. The master controller works in smooth and easy action and, moreover, is separable from the main body to be set in any desired place. It is made from the company's special design that, though perfectly water-tight, it may easily be exposed to inspection.

(6) When hoisting, the motor is capable of making double speed at ½ load or below, with the series-wound coils displaying their conspicuous characteristic of compound winding; and in the operation of lowering, the motor runs into the state of compound generating as speed increases to reach a certain point, due also to the characteristic of compound winding, and on this account, power consumption is far lower in comparison with any type of winch heretofore in use. Furthermore, the master controller is so light in weight with simple construction, and is so efficient in acceleration, which makes an outstanding feature of this type of winch. In spite of dynamo brake lowering system being adopted, an electric circuit of very simple construction is used and this diminishes the possibility of breakdown while it affords considerable convenience for maintenance.

(7) Using only six contactors and four relays, plus a small number of auxiliary contactors, the controller of automatic interlocking type is so designed that it is constructed with the simplest possible mechanism and yet it will work with the highest possible performance.

(8) As a whole, welding method is used as far as possible in its construction so that the equipment will be reduced in its weight.

(9) For perfect maintenance and prompt repair work, it has a complete maintenance outfit of the company's special design consisting of voltmeter, ammeter, ohmmeter, controller for circuit test, etc. In the setup of the mechanism, circumspective attention has been given to facilitate quick replacement of expendable parts, and due considerations have been paid so that one will know the control circuit at a glance, by giving all the wiring colored distinction with symbols of terminals clearly mentioned.

Principal Data

		2.5/5 T Winch		3/5 T Winch	
Load	Main drum	2.5/5T	2.5/5T	3/5T	3/5T
	Aux. drum	2/4T	2/4T	2.4/4T	2.4/4T
Hoisting Speed	Main drum	50/25M	60/30M	33/20M	40/25M
	Aux. drum	43/21.5M	51.5/26M	28.5/17M	34.5/21.5M
Drum Dia. × Width	Main drum	465×680	465×680	465×680	465×680
	Aux. drum	400×400	400×400	400×400	400×400
Motor	HP.	35	41	28	35
	Voltage	220	220	220	220
	R. P. M.	525	635	410	525
	Rated	30 min.	30 min.	30 min.	30 min.
Reduction Gear	Dual reduction (2 speed inter-changeable)	〃	〃	〃	〃
Rule	NK. Lloyd. AB.	〃	〃	〃	〃
Overall Weight	4 tons	〃	〃	〃	〃

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.

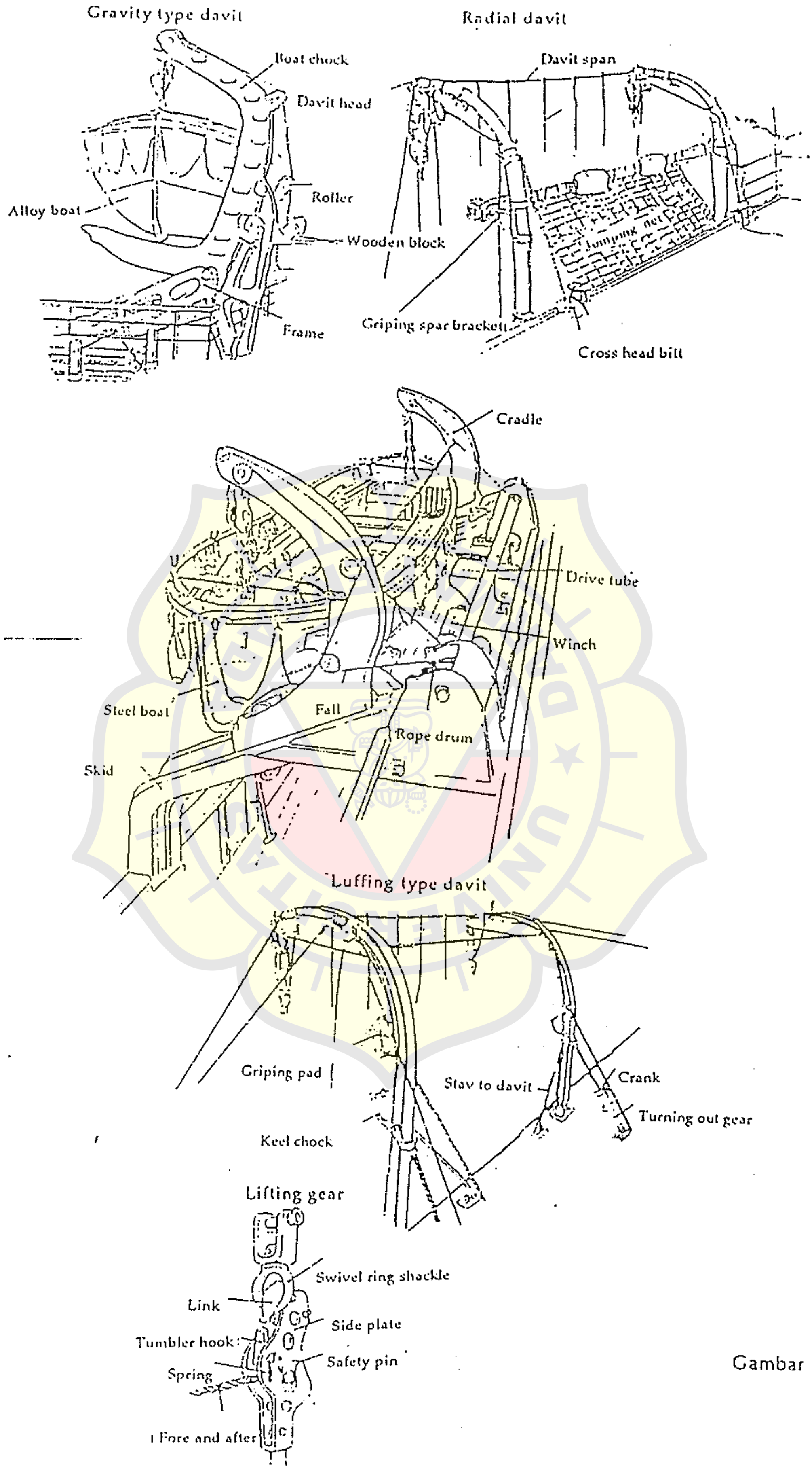
KALOR JENIS & KALOR BEKU DARI MAKANAN

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,?	90,0	−0,5	31,3
Daging kambing	0,67	[illegible]	[illegible]	83,5	1,7	[illegible]
Daging babi	0,68	[illegible]	[illegible]	86,5	[illegible]	[illegible]
Ikan asap	0,60	[illegible]	48,3	85,5	−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	[illegible]	[illegible]	15,0	1,1	30
[illegible]	0,64	[illegible]	44,1	79,0	[illegible]	17
Telur	0,85	0,45	[illegible]	100,0	0,5	31,6
Susu	0,90	0,49	69,2	124,0	−0,6	31
Anggur	0,90	0,51	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	63,8	125,0	−2,2	28
Nanas	0,90	0,50	[illegible]	[illegible]	−1,7	29,2
Tomat	0,92	0,46	73,7	132,0	−0,9	30,6
[illegible]	0,36	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

STANDART UKURAN SEKOCI OLEH BOT (BOARD OF TRADE) ENGLAND

Tabel 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	1646	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	1180	2400	254	3843
7,01 x 2,29 x 0,88	23 x 7,50 x 2,90	300	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
6,10 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
4,88 x 1,75 x 0,70	16 x 5,75 x 2,30	127	12	475	900	127	1484


Gravity type davit
Boat chock
Davit head
Roller
Alloy boat
Wooden block
Frame
Radial davit
Davit span
Jumping net
Griping spar bracket
Cross head bitt
Cradle
Drive tube
Winch
Steel boat
Fall
Rope drum
Skid
Luffing type davit
Griping pad
Stay to davit
Crank
Turning out gear
Keel chock
Lifting gear
Swivel ring shackle
Link
Side plate
Tumbler hook
Safety pin
Spring
Fore and after

Gambar

Tabel. 13.4. Persyaratan Minimal Jumlah Jabatan di Kapal, Sertifikat Kepelautan dan Jumlah Awak Kapal *Bagian Mesin*

No	Jabatan	KW. 7.500 atau >			KW. 3.000 s/d < 7.500		
		Jml	COC	COP	Jml	COC	COP
1	2	3	4	5	6	7	8
1	KKM	1	ATT I	10 a 2) -5)	1	ATT I	10 b 2) -5)
2	Masinis II	1	ATT II	10 a 2) -5)	1	ATT II	10 b 2) -5)
3	Masinis	2	ATT III	10 c 2) -5)	1	ATT III	10 c 2) -5)
4	Mandor Mesin	1	ATT Dasar	10 d 2) -6)	1	ATT Dasar	10 d 2) -6)
5	Juru Minyak	3	ATT Dasar	10 d 2) -6)	3	ATT Dasar	10 d 2) -6)
6	Pembantu di Kamar Mesin	1	-	10e	1	-	10a

No	Jabatan	KW. 750 s/d 3.000			KW. 750		
		Jml	COC	COP	Jml	COC	COF
1	2	3	4	5	6	7	8
1	KKM	1	ATT II , III	10 b 2) -5)	1	ATT IV	10 c 2) -5)
2	Masinis II	1	ATT III	10 b 2) -5)	1	ATT IV	10 c 2) -5)
3	Masinis	1	ATT III	10 c 2) -5)	1	ATT V	10 c 2) -5)
4	Mandor Mesin	1	ATT Dasar	10 d 2) -6)	1	ATT Dasar	10 d 2) -6)
5	Juru Minyak	3	ATT Dasar	10 d 2) -6)	3	ATT Dasar	10 d 2) -6)
6	Pembantu di Kamar Mesin	-	-	-	-	-	-

Catatan :

1. COC (Certificate Of Competency) = Sertifikat Keahlian Pelaut, yaitu Sertifikat Ahli Nautika Tingkat (ANT), Sertifikat Ahli Teknika Tingkat (ATT) dan Sertifikat Ahli Radio Elektronika (REK)
2. COP (Certificate Of Proficiency) = Sertifikat Keterampilan Pelaut tercantum pada Pasal 9 untuk bagian Deck dan Pasal 10 untuk Bagian Mesin
3. Masing-masing Sertifikat Keahlian selain ANT Dasar dan ATT Dasar harus dikukuhkan sesuai jabatan
4. Operator Radio dapat dirangkap oleh Nakhoda dengan Mualim atau dua orang Mualim yang memiliki minimal Sertifikat ORU
5. Operator Radio berijazah ORU jika kapal dilengkapi dengan Radio Telephony, berijazah REK II jika kapal dilengkapi dengan Radio Telegraphy

DAERAH PELAYARAN KAWASAN INDONESIA

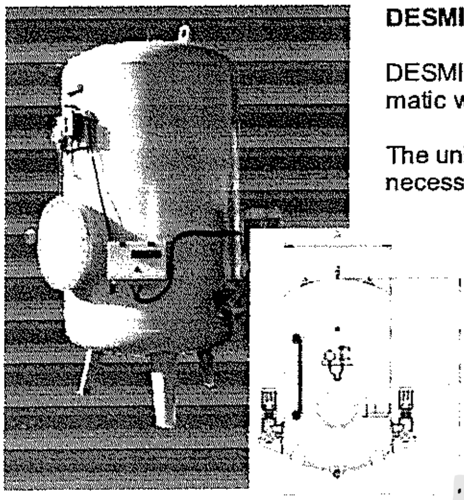
Tabel. 13.3. Persyaratan Minimal Jumlah Jabatan di Kapal, Sertifikat Kepelautan dan Jumlah Awak Kapal *Bagian Deck*

No	Jabatan	GT.10.000 atau >			GT. 3.000 s/d < 10.000		
		Jml	COC	COP	Jml	COC	COP
1	2	3	4	5	6	7	8
1	Nakhoda	1	ANT I	9 a 3)-8)	1	ANT I	9 a 3)-8)
2	Mualim I	1	ANT I	9 a 3)-8)	1	ANT I	9 a 3)-8)
3	Mualim	2	ANT III	9 d 3)-7)	2	ANT III	9 d 3)-7)
4	Operator Radio	1	ORU/REK	-	1	ORU/REK II	-
5	Serang	1	II	9 f 2) -7)	1	ANT Dasar	9 f 2) -7)
6	Juru Mudi	3	ANT Dasar	9 f 2) -7)	3	ANT Dasar	9 f 2) -7)
7	Kelasi	1	ANT Dasar	9g	1	-	9g
8	Koki	1	-	9g	1	-	9g
9	Pelayar	1	-	9g	1	-	-

No	Jabatan	GT.1500 s/d < 3.000			GT 500 s/d < 1500		
		Jml	COC	COP	Jml	COC	COP
1	2	9	10	11	12	13	14
1	Nakhoda	1	ANT II	9 b 3)-8)	1	ANT II	9 b 3)-8)
2	Mualim I	1	ANT II	9 b 3)-8)	1	ANT II	9 b 3)-8)
3	Mualim	1	ANT III	9 d 3)-7)	-	ANT III	9 d 3)-7)
4	Operator Radio	1	ORU/REK	-	1	ORU/REK II	-
5	Serang	1	II	9 f 2) -7)	-	-	9 f
6	Juru Mudi	3	ANT Dasar	9 f 2) -7)	1	-	9 f
7	Kelasi	1	ANT Dasar	-	-	-	-
8	Koki	1	-	9g	1	-	9g
9	Pelayan	1	-	-	-	-	-

No	Jabatan	GT. < 500		
		Jml	COC	COP
1	2	9	10	11
1	Nakhoda	1	ANT IV	9c1)c)-h)
2	Mualim I	1	ANT IV	9e3)-7)
3	Mualim	-	-	-
4	Operator Radio	1	ORU/REK II	-
5	Serang	-	-	-
6	Juru Mudi	1	-	9 f
7	Kelasi	-	-	-
8	Koki	1	-	9g
9	Pelayan	-	-	-

Other DESMI products



DESMI hydrophore unit

DESMI hydrophore sets are complete, pre-mounted units, designed to ensure automatic water supply on board vessels.

The units include pressure tank, pumps, pressure switch, motor starter, and all necessary connections.

By using the air charging valve the pressure in the tank is preset. The pressure switch will start and stop the pumps automatically.

The DESMI hydrophore units are available in different sizes from 35 to 5000 litres and from 4 to 15 bar working pressure.

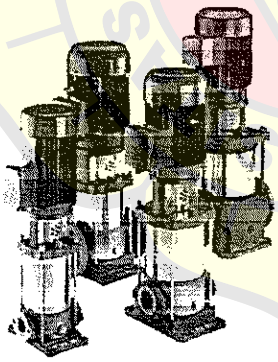
The hydrophore can be delivered with one or two pumps in vertical or horizontal design; with capacities to customers' requirements.

The pumps and pressure tanks are available in different materials to avoid corrosion.

DESMI vertical multistage in-line centrifugal pumps

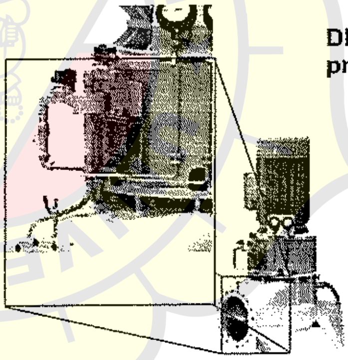
DESMI vertical multistage centrifugal pumps type DPV are developed for the specific demands of our customers. The hydraulic parts of the DPV pumps are manufactured from high-grade polished stainless steel 304, assuring optimum performance, high corrosion resistance, low power consumption and long life.

- High-grade vertical in-line multistage centrifugal pump
- All wetted parts in stainless steel 304 or 316
- High efficiency and long working life
- Low maintenance
- Low noise level
- Small floor space required



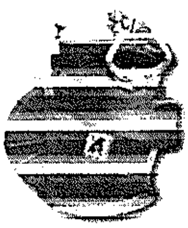
DESMI ejector priming unit or separate priming pumps

The DESMI air priming ejector is designed for mounting on non-selfpriming centrifugal pumps thus making the pump unit self-priming.



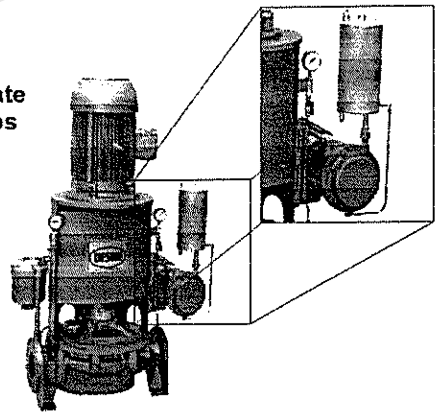
DESMI air ejector priming unit

Vertical Archimedes' screw pumps DOP-250



Capacity range: Up to 125 m³/h
Pressure range: Up to 10 bar
Used for high viscosity liquids such as oil, molasses, oil mixed liquids etc. As a skimmer pump, for off-loading, and within industry.

DESMI separate priming pumps

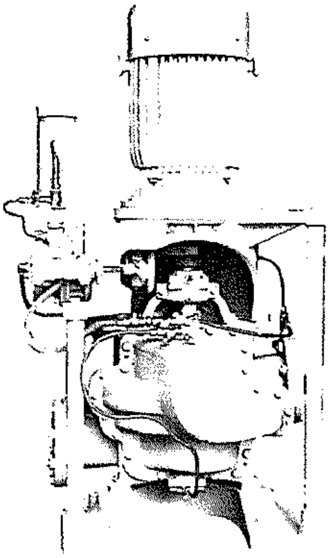


In addition to use as marine pumps, DESMI supplies gear pumps for many different applications to onshore industries and centrifugal pumps for public utilities such as district heating, water supply, and sewage systems.

TAIKO

CENTRIFUGAL PUMP

VS

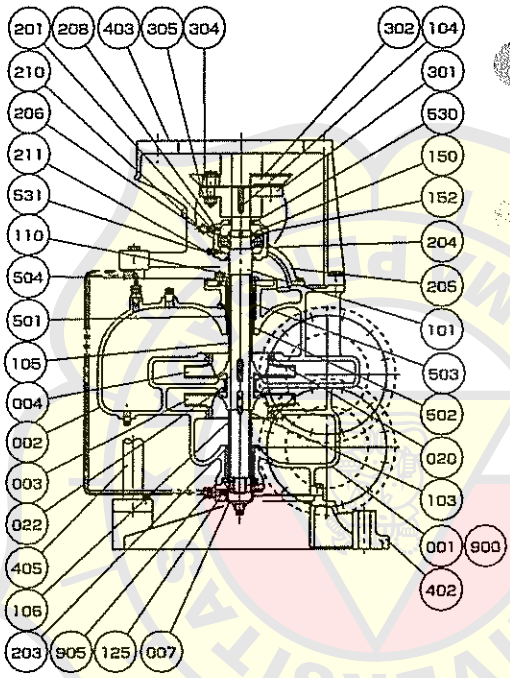


Application

Fire & G.S. Pump
Bilge & Ballast Pump

Feature

Vertical Two-stage Single-suction
Split-casing Type



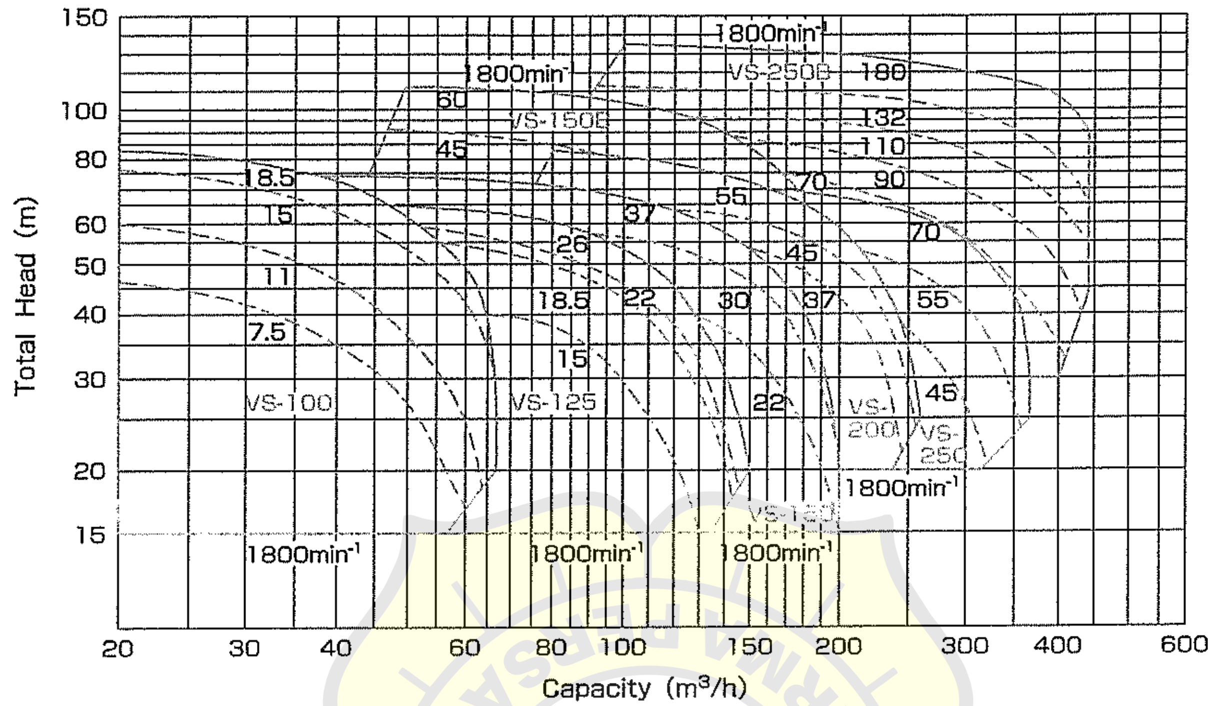
Part No.	Name	Req. No.	Sea Water Material	Sea Water JIS	Fresh Water Material	Fresh Water JIS
001	CASING	1	BRONZE	CAC402	CAST IRON	FC200
002	CASING COVER	1	BRONZE	CAC402	CAST IRON	FC200
003	IMPELLER	1	PHOSPHOR BRONZE	CAC502A	PHOSPHOR BRONZE	CAC502A
004	IMPELLER	1	PHOSPHOR BRONZE	CAC502A	PHOSPHOR BRONZE	CAC502A
007	BOTTOM COVER	1	BRONZE	CAC402	CAST IRON	FC200
020	CASING RING	2	BRONZE	CAC402	BRONZE	CAC402
022	STAGE BUSH	1	BRONZE	CAC402	BRONZE	CAC402
101	SHAFT	1	STAINLESS STEEL	SUS304	STAINLESS STEEL	SUS304
103	KEY	2	STAINLESS STEEL	SUS304	STAINLESS STEEL	SUS304
104	KEY	1	CARBON STEEL	S45C	CARBON STEEL	S45C
105	SLEEVE	1	STAINLESS STEEL	SUS304	STAINLESS STEEL	SUS304
106	SLEEVE	1	STAINLESS STEEL	SUS304	STAINLESS STEEL	SUS304
110	O-RING	1	RUBBER	NBR	RUBBER	NBR
125	SLEEVE NUT	2	STAINLESS STEEL	SUS304	STAINLESS STEEL	SUS304
150	BEARING NUT	1	MILD STEEL	SS400	MILD STEEL	SS400
52	BEARING WASHER	1	MILD STEEL	SS400	MILD STEEL	SS400
201	BALL BEARING	1	BEARING STEEL	SUJ2	BEARING STEEL	SUJ2
03	BOTTOM METAL	1	LEAD BRONZE	–	LEAD BRONZE	–
04	BEARING SPACER	1	MILD STEEL	SS400	MILD STEEL	SS400
05	BEARING HOUSING	1	CAST IRON	FC200	CAST IRON	FC200

Part No.	Name	Req. No.	Sea Water Material	Sea Water JIS	Fresh Water Material	Fresh Water JIS
206	HOUSING COVER	1	CAST IRON	FC200	CAST IRON	FC200
208	BEARING COVER	1	CAST IRON	FC200	CAST IRON	FC200
210	GREASE NIPPLE	1	BRASS	C3602	BRASS	C3602
211	GREASE FITTING	1	BRASS	C3602	BRASS	C3602
301	COUPLING	1	CAST IRON	FC200	CAST IRON	FC200
302	COUPLING	1	CAST IRON	FC200	CAST IRON	FC200
304	COUPLING RING	8	RUBBER	NBR	RUBBER	NBR
305	COUPLING BOLT & NUT	8	MILD STEEL	SS400	MILD STEEL	SS400
402	PUMP BED	1	CAST IRON	FC200	CAST IRON	FC200
403	MOTOR FRAME	1	CAST IRON	FC200	CAST IRON	FC200
405	SUPPORT	2	STEEL GAS PIPE	SGP	STEEL GAS PIPE	SGP
501	GLAND PACKING	5	CARBONIZED FIBER	–	CARBONIZED FIBER	–
502	NECK BUSH	1	BRONZE	CAC402	BRONZE	CAC402
503	LANTERN RING	1	BRONZE	CAC402	BRONZE	CAC402
504	GLAND	1	BRONZE	CAC402	BRONZE	CAC402
530	OIL SEAL	1	RUBBER	NBR	RUBBER	NBR
531	OIL SEAL	1	RUBBER	NBR	RUBBER	NBR
900	GASKET	1	PAPER	–	PAPER	–
905	GASKET	1	RUBBER	NBR	RUBBER	NBR

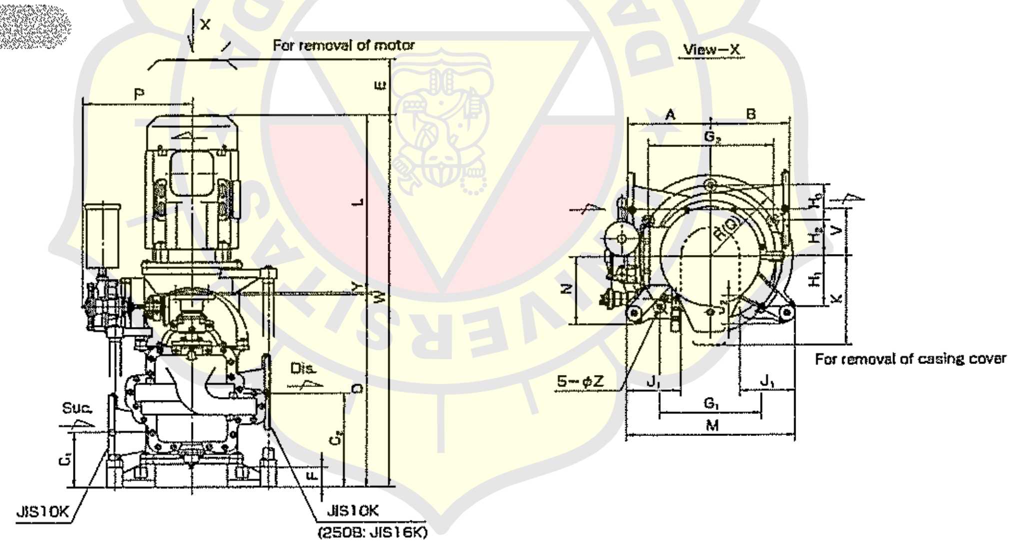
CENTRIFUGAL PUMP

VS

Performance



Dimension



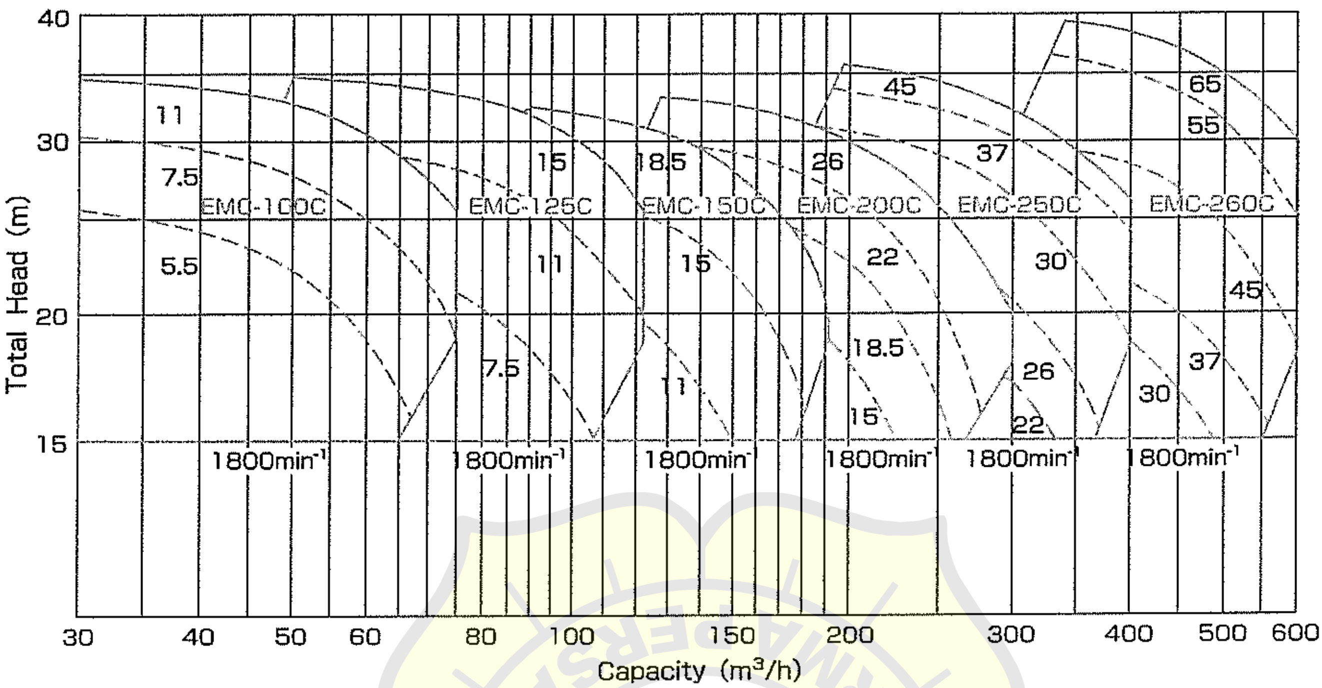
Model No.	Motor kW	Motor min⁻¹	Bore Suc.	Bore Dis.	A	B	C1	C2	D	E	F	G1	G2	H1	H2	H3	J1	J2	K	L	M	N	P	Q	V	W	Y	Z
VS-100	7.5									150										460						829		
	11	1800	100	100	300	270	220	380	846	200	80	368	450	184	130	130	175	80	450	695	590	240	485	310	170	944	3	24
	15																			635						984		
	18.5																			665						1034		
VS-125	15																			635						1598		
	18.6	1800	125	125	290	320	262	442	960	200	90	353	433	177	125	125	180	105	540	685	630	255	485	300	175	1648	3	26
	22																											
	26																			725						1689	4	
VS-150	22									200										685						1564	3	
	30	1800	150	150	370	350	245	428	876		90	424	520	212	150	150	215	120	630	725	750	303	485	360	210	1605	4	28
	37									250										800						1680		
VS-150B	45	1800	150	150	350	330	262	442	972	250	90	424	520	212	150	150	215	120	630	800	750	303	485	360	200	1776	4	28
	60																			1050						2026		
VS-200	37																			800						1680		
	45	1800	200	200	370	350	245	428	876	250	90	424	520	212	150	150	215	120	630		750	303	485	360	210		4	28
	55																			950						1830		
VS-250	45																			800						1759		
	55	1800	200	200	400	430	290	552	955	250	90	424	520	212	150	150	215	120	670	950	750	303	485	360	210	1909	4	28
	70																			1050						2009		
VS-250B	70																			1050						2149		
	90																											
	110	1800	250	250	430	430	290	490	1095	250	80	452	554	226	160	160	245	105	800	1210	750	303	540	365	330	2309	4	28
	132																			1290						2389		
	180																			1566						2665		

Dimension (mm)

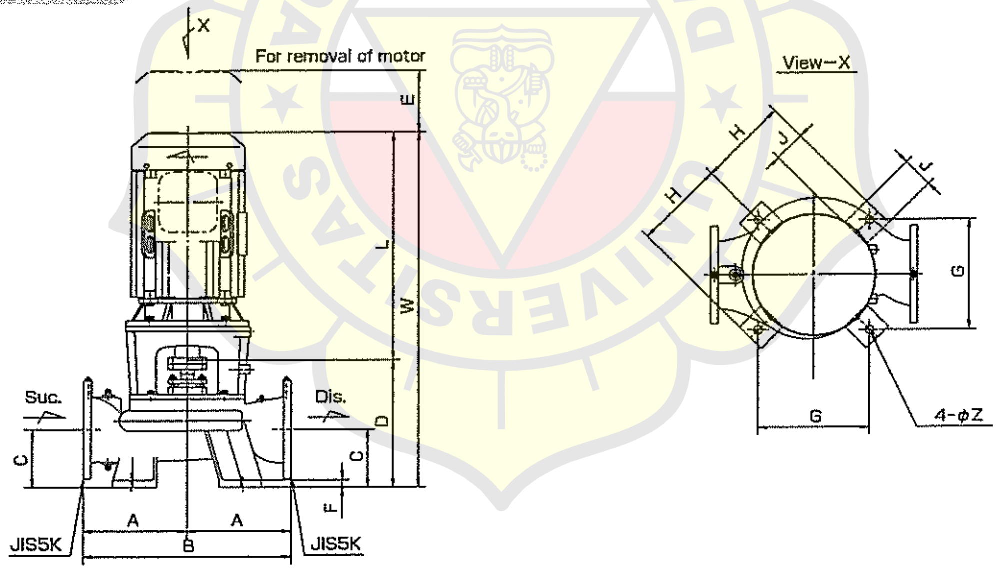
CENTRIFUGAL PUMP

EMC

Performance



Dimension

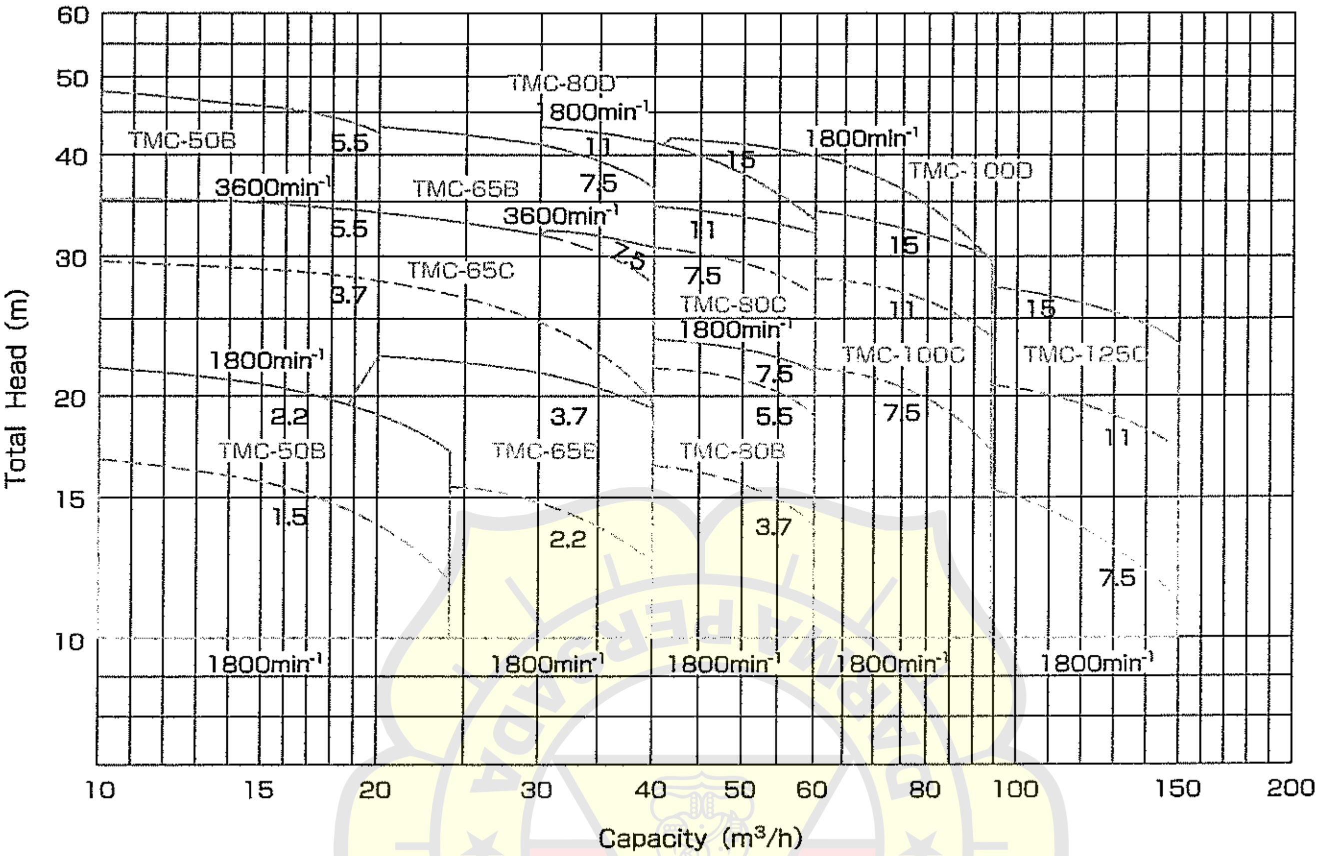


Model No.	Motor kW	Motor min⁻¹	Bore Suc.	Bore Dis.	A	B	C	D	E	F	G	H	J	L	W	Z
EMC-100C	5.5	1800	100	100	280	560	150	360	150	25	290	240	100	480	840	28
	7.5															
	11								200					595	855	
EMC-125C	7.5	1800	125	125	300	600	160	370	150	25	290	240	100	480	850	28
	11								200					595	965	
	15													635	1005	
EMC-150C	11	1800	150	150	315	630	160	393	200	25	360	290	100	595	888	28
	15													635	1028	
	18.5													685	1078	
EMC-200C	15	1800	200	200	335	670	190	418	200	25	360	290	100	635	1053	28
	18.5													685	1103	
	22															
	26													725	1143	
EMC-250C	22	1800	250	250	400	800	220	490	200	25	410	325	100	685	1175	28
	26													725	1215	
	30															
	37															
	45								250					800	1280	
EMC-260C	30	1800	250	250	400	800	220	520	200	25	410	325	100	725	1245	28
	37								250					800	1320	
	45															
	55													950	1470	
	65													1050	1570	

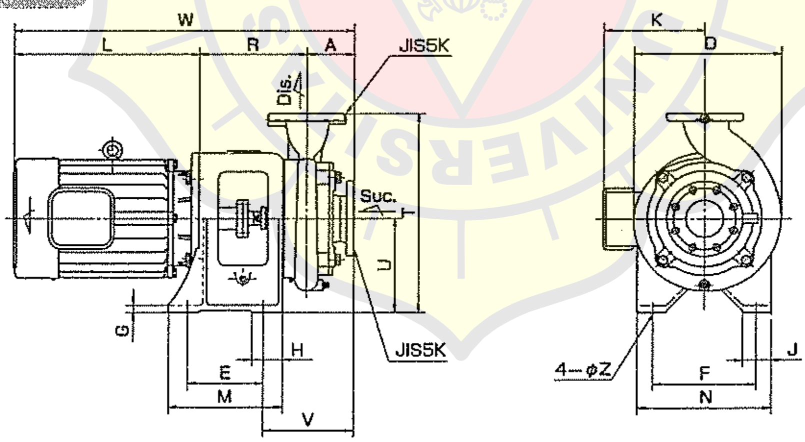
Dimension (mm)

CENTRIFUGAL PUMP

Performance

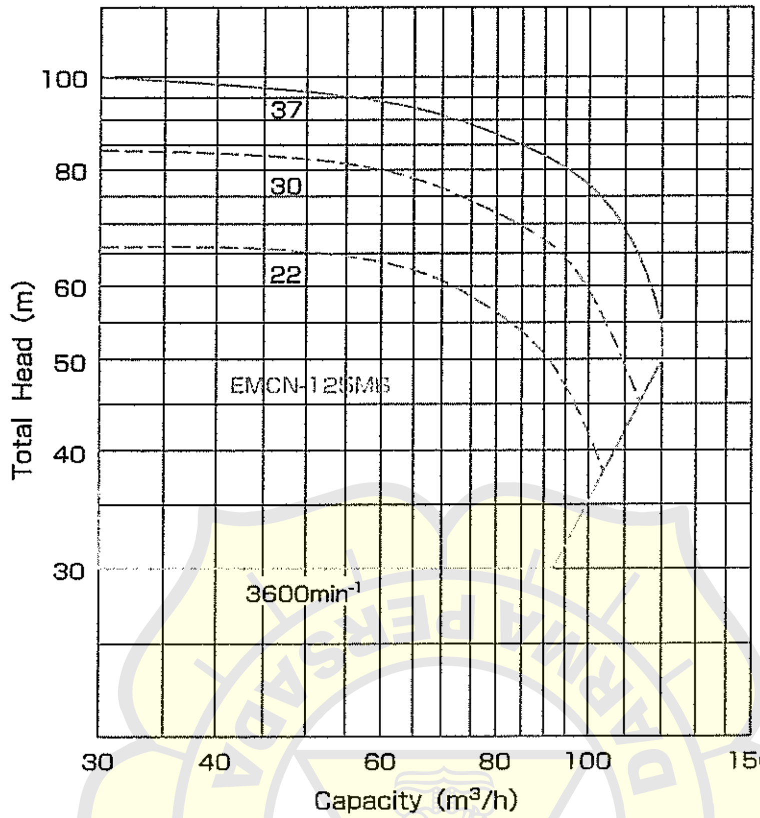


Dimension

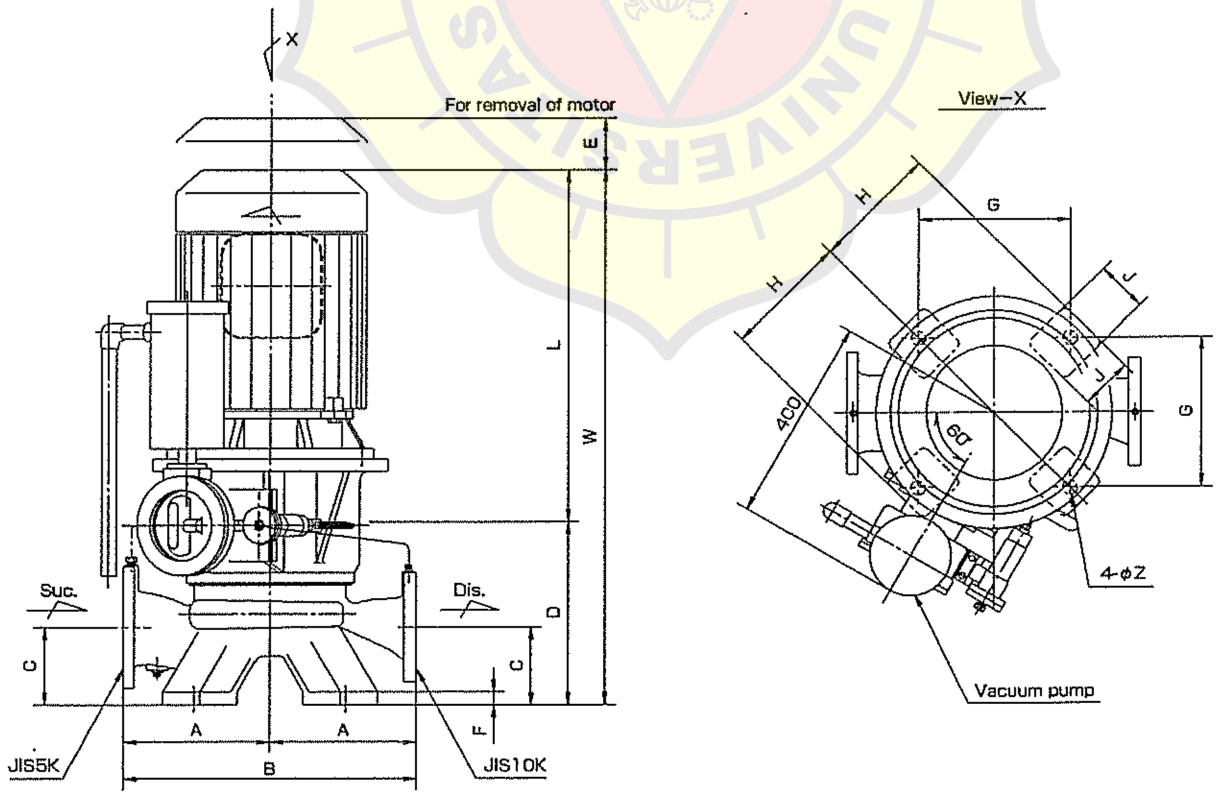


Model No.	Motor kW	Motor min⁻¹	Bore Suc.	Bore Dis.	A	D	E	F	G	H	J	K	L	M	N	R	T	U	V	W	Z
TMC-50B	1.5	1800	50	50	100	265	150	220	15	80	65	195	300	250	280	215	370	190	205	615	15
	2.2						180		18			205	330	280		225				655	
	5.5	3600					200	270				265	400	300	330	245	390	210		745	
TMC-65B	2.2	1800	65	65	100	285	180	220	18	80	65	205	330	280	280	227	390	190	207	657	15
	3.7											215	355							682	
	7.5	3600					200	270				265	400	300	330	247	410	210		747	
TMC-65C	3.7	1800	65	65	100	335	180	220	18	80	65	215	355	280	280	227	415	190	207	682	15
	5.5						200	270				265	400	300	330	247	435	210		747	
	7.5																				
TMC-80B	3.7	1800	80	80	100	325	180	220	18	80	65	215	355	280	280	232	415	190	212	687	15
	5.5						200	270				265	400	300	330	252	435	210		752	
	7.5																				
TMC-80C	7.5	1800	80	80	100	365	200	270	18	80	75	265	400	300	350	252	500	250	212	752	19
	11								20			285	485			282				867	
TMC-80D	11	1800	80	80	125	405	200	270	20	80	75	285	485	300	350	290	530	250	245	900	19
TMC-100C	7.5	1800	100	100	125	385	200	270	18	80	75	265	400	300	350	253	530	250	238	778	19
	11								20			285	485			283				893	
	15												525							933	
TMC-100D	15	1800	100	100	125	405	200	270	20	80	75	285	525	300	350	290	565	250	245	940	19
TMC-125C	7.5	1800	125	125	140	420	200	270	18	80	75	265	400	300	350	265	530	250	265	805	19
	11								20			285	485			295				920	
	15												525							960	

Performance



Dimension



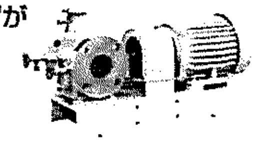
Model No.	Motor		Bore		Dimension (mm)											
	kW	min⁻¹	Suc.	Dis.	A	B	C	D	E	F	G	H	J	L	W	Z
	22													685	1050	
EMCN-125MB	30	3600	125	100	280	560	150	365	250	25	290	240	100	725	1090	28
	37													770	1135	

特長 Feature

NHGシリーズは、一般電動横形低圧・内装軸受式歯車ポンプです。

NHG series is motor driven horizontal low pressure internal bearing type gear pumps.

温　　度：世界にさきがけて考案された、一点連続接触歯車"欠円ギヤー"が標準です。



Tooth Profile: To be the first in the world to design a one-point-contact-gear called "Segmental Gear" as our standard model.

仕様 Specification

歯　　形：取扱い油温は、最高80℃です。

Temperature: Maximum handling oil temperature is 80℃.

軸　　受：内装軸受式で揚液による自己潤滑方式のため、潤滑性を有する液に適します。

Bearing: Internal bearing is self-lubricated by pumping liquid which is suitable to serve lubricant fluids.

軸　　封：グランドパッキン式が標準です。ご要望に応じて、メカニカルシール式又はオイルシール式を製作します。

Shaft Seal: The conventional gland packing is our standard; however, the mechanical seal type is also available.

フランジ：吸込み、吐出し共JIS10Kです。

Flange: Both suction and discharge are JIS10K.

軸　　心：ポンプと電動機との軸継手の芯の振れの許容範囲は、回転速度2000～500min⁻¹において、軸継手側面で0.1mm以下、軸継手端面で0.1mm以下です。

Centering: If connecting the pump with the motor, the standard allowable alignment value at the rate of 2000 to 500min⁻¹at the shaft coupling side surface should be under 0.1mm and at the shaft coupling end surface should be under 0.1mm.

水圧試験：計画仕様圧力の2倍が標準です。最高1.20MPaです。

Hydraulic Test: Twice the value of the designed specification pressure with a maximum value of 1.20MPa.

吐出し量：吐出し量は、吐出圧力0.60MPa、粘度25.8mm²/sにおける量です。許容吸込圧力範囲は、ポンプ入口において、－0.05～0.20MPaです。

Capacity: The following capacity shows at viscosity of 25.8mm²/s with discharge pressure of 0.60MPa. The allowable suction pressure range is –0.05 to 0.20MPa at the pump suction.

形番 Model No.	口径 Bore (mm) 吸込み×吐出し Suc.×Dis.	吐出し量 Capacity (m^3/h) 60Hz 1200min⁻¹	60Hz 1800min⁻¹	50Hz 1000min⁻¹	50Hz 1500min⁻¹
NHG-0.3	32×25	0.3	0.45	0.25	0.37
NHG-0.5		0.5	0.75	0.41	0.62
NHG-1		1	1.5	0.8	1.2
NHG-1.5	40×32	1.5	2.2	1.2	1.8
NHG-2		2	3	1.6	2.5
NHG-2.5	50×40	2.5	3.7	2	3
NHG-3		3	4.5	2.5	3.7
NHG-4	65×50	4	6	3.3	5
NHG-5		5	7.5	4	6
NHG-6		6	9	5	7.5
NHG-7.5	80×65	7.5	11	6	9
NHG-10		10	15	8	12
NHG-12		12	18	10	15
NHG-15		15	22	12	18
NHG-20	100×80	20	30	16	25
NHG-25		25	—	20	30
NHG-30	125×100	30	—	25	—

Model	Cycle	Cylinders	Bore (mm)	Stroke (mm)	Mean Piston Speed (m/s)	Speed (rev/min)	Output (kW/cl)	Output range (kW)	Bmep (bar)	Sfoc (g/kW h)
Yanmar Diesel Engine Co Ltd 2-1-1 Yaesu 2-chome, Chuo-ku, Tokyo 105 JAPAN										
6HYM-ETE (H)	4	6L	132.9	165	10.7	1950	61.33	368	16.4	201
6HYM-ETE (M)	4	6L	132.9	165	11.5	2100	73.50	441	18.3	206
6HYM-ETE (L)	4	6L	132.9	165	11.8	2150	79.67	478	19.4	209
6HYM-ETE (S)	4	6L	132.9	165	12.1	2200	85.83	515	20.4	211
6AYM-STE	4	6L	155	180	11.4	1900	80.83	485	15.0	202
6AYM-ETE	4	6L	155	180	11.4	1900	101.67	610	18.9	202
6AYM-GTE	4	6L	155	180	11.65	1938	111.67	670	20.4	205
12LAK-STE2	4	12V	150	165	10.18	1850	67.42	809	14.9	202
6NY16 series	4	6L	160	220	9.0-10.67	1350-1600	55.17-93.17	331-559	12.2-17.4	211-218
6RY17P-EV	4	6L	165	219	10.95	1500	104.17	625	17.8	
6RY17P-GV	4	6L	165	219	10.95	1500	122.67	736	20.9	202
6N18A-V series	4	6L	180	280	8.40-8.87	900-950	73.50-122.67	441-736	13,8-21,8	194-197
6N21A-V series	4	6L	210	290	7.73-8.22	800-850	110.33-159.33	662-956	16.5-22.4	187
8N21A series	4	8L	210	290	7.73-8.70	800-900	128.75-165.50	1030-1324	19.23-22.0	193-194
6EY26 series	4	6L	260	385	9.63	750	245.17-320.00	1471-1920	19.19-25.05	188
8N280M-V series	4	8L	280	380	9.12	720	239.00-294.25	1912-2354	17.02-20.96	192
6N330 series	4	6L	330	440	9.09	620	367.83-429.00	2207-2574	18.92-22.06	198
8N330 series	4	8L	330	440	9.09	620	367.75-413.75	2942-3310	18.92-22.06	198

A2-S | Single Lens -IP56

Application
Vessels of 20M and above in length
In compliance with IMO 1972

Protection degree IP56
Visibility : Min. 3n.mile, mast head 6n.mile (Nautical mile)

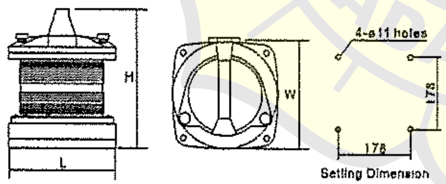
Materials
Cover & lower body : Polycarbonate
Lens : Polycarbonate

Finish
Cover & lower body : Mat black
Lens : Colored lens

Equipment
Incandescent lamp : 40/60/100W
Lamp holder : FE26/B22
One cable gland 20a~c
(Diameter : Max.16mm cable)
Dangerous cargo & huge vessel light - Separate P.C.B box

Electrical
AC 100~240V, 50/60Hz are available on request

Technical Drawing



Specification

Model No.	Capacity	L(mm)	W(mm)	H(mm)	Weight(Kg)	Remarks
A2-SM(Masthead)	40~60W	226	226	293	2.4	Clear(225°)
A2-SP(Port)	40~60W	226	226	293	2.4	Red(112.5°)
A2-ST(Starboard)	40~60W	226	226	293	2.4	Green(112.5°)
A2-SS(Stern)	40~60W	226	226	293	2.8	Clear(135°)
A2-SW(Anchor)	40~60W	226	226	293	2.8	Clear(360°)
A2-SR(N.U.C)	40~60W	226	226	293	2.8	Red(360°)
HY-100G20BH(Huge vessel light)	100W	226	226	293	2.8	Green180~200F/min
DC-100R20AH(Dangerous cargo light)	100W	226	226	293	2.8	Red120~140F/min
MV-SW0020H(Maneuvering light)	100W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

A2-D | Double Lens -IP56

Application
Vessels of 20M and above in length
In compliance with IMO 1972

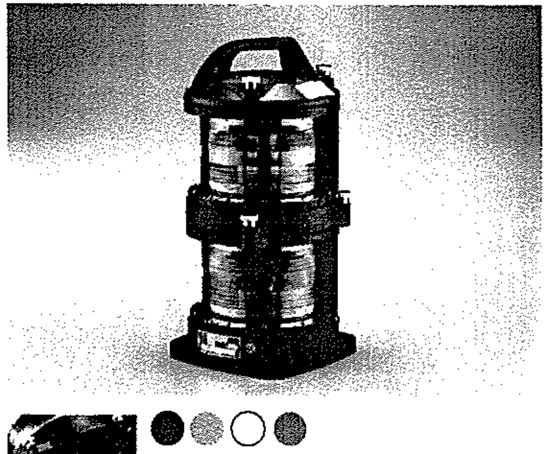
Protection degree IP56
Visibility : Min. 3n.mile, mast head 6n.mile
(Nautical mile)

Materials
Cover & lower body : Polycarbonate
Lens : Polycarbonate

Finish
Cover & lower body : Mat black
Lens : Colored lens

Equipment
Incandescent lamp : 40/60W
Lamp holder : FE26/B22
Two cable glands 20a~c
(Diameter : Max.16mm cable)

Electrical
AC 100~240V, 50/60Hz are available on request



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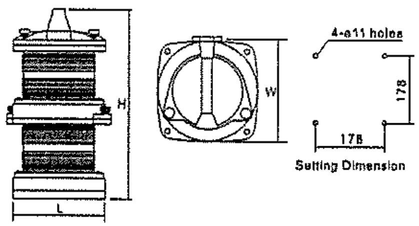


Specification

Model No.	Capacity	L(mm)	W(mm)	H(mm)	Weight(Kg)	Remarks
A2-DM(Masthead)	40~60W X 2	226	226	475	4.6	Clear(225°)
A2-DP(Port)	40~60W X 2	226	226	475	4.6	Red(112.5°)
A2-DT(Starboard)	40~60W X 2	226	226	475	4.6	Green(112.5°)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PS-K-R | Room control type | Search Light

-IP56

Application
Bridge wing
Chemical processing and industrial areas

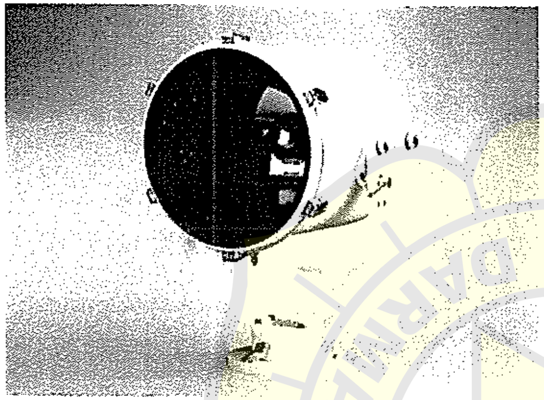
Features IP56

Materials
Body : Stainless steel
Arm : Stainless steel
Front glass : Heat and impact resistant glass
Latch : Stainless steel

Finish
Body : White epoxy powder coat and stove enamelled(Munsell No. N-9.3)

Equipment
Incandescent lamp : 1/2/3KW
Halogen lamp : 1/2/3KW
Lamp holder : TE39
One cable gland M24 (Diameter : Max. 17mm cable)
Incandescent lamp
Horizontal rotation : 360°

Electrical
AC 100~240V, 50/60Hz are available on request



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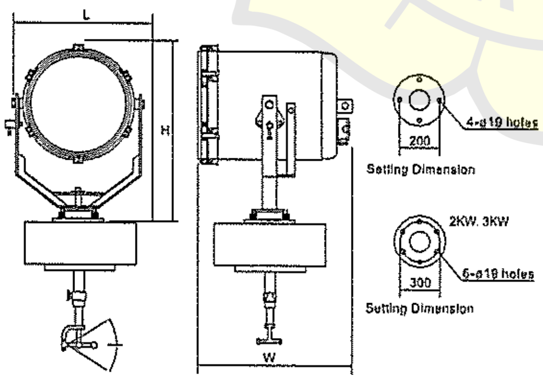


Specification

Model No.	Capacity	L(mm)	W(mm)	H(mm)	Weight(Kg)	Remarks
PS1KI-20UWCR-N	1KW	480	510	695	32	Room control
PS2KI-20UWCR	2KW	[illegible]	[illegible]			

PS-K-E | Electric Remote Control Type | Search Light

-IP56

Application
Bridge wing
Chemical processing and industrial areas

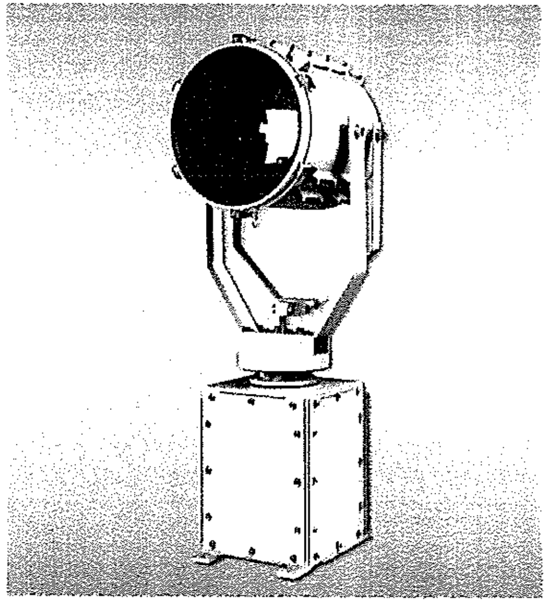
Protection degree IP56

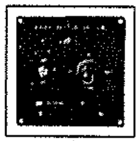
Materials
Body : Stainless steel
Arm : Steel zinc coated
Front glass : Heat and impact resistant glass

Finish
Body : White epoxy powder coat and stove enamelled(Munsell No. N-9.3)

Equipment
Lamp holder : TE39/40
Cable gland M24 (Diameter : Max. 17mm cable)
Low base unit with cabin control
- Horizontal rotation : ±165°
- Vertical movement : up(20°), down(35°)
Incandescent lamp
- Separate control panel with ON/OFF switch and joystick switch
Incandescent lamp : 1/2/3KW
Halogen lamp : 1/2/3KW

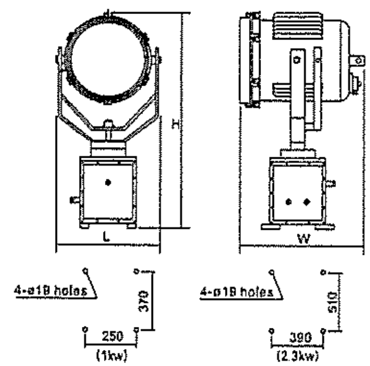
Electrical
AC 100~240V, 50/60Hz are available on request





PS-K-E Control panel

Technical Drawing



Specification

Model No.	Capacity	L(mm)	W(mm)	H(mm)	Weight(Kg)	Remarks

are made of chrome. The fan body can turn between 0 – 90 for the convenience during the air duct installation.

3. TECHNICAL SPECIFICATIONS TABLE

SPECIFICATIONS		Model / Unit	MAS 008	MAS 010	MAS 012	MAS 015	MAS 018	MAS 020	MAS 022	MAS 024
Cooling Capacity		Btu/h	7.500	9.500	12.200	15.000	18.200	20.000	22.100	24.600
Heating Capacity		Btu/h	7.600	9.700	12.600	15.800	18.700	20.300	22.600	25.000
Power Consumption		W	680	900	1.270	1.600	2.000	2.200	2.400	2.630
Current	Indoor Unit	A	0,3	0,4	0,5	0,6	0,6	0,7	0,7	0,7
	Outdoor Unit	A	3,0	3,7	5,3	6,6	8,7	10,1	10,5	11,3
Indoor Unit	Length	mm	290	290	320	450	450	450	450	450
	Width	mm	270	270	270	320	320	320	320	320
	Height	mm	320	320	320	350	350	350	350	350
	Net Weight	kg	12	12	14	18	19	19	20	22
	Air Flow	m^3/h	275	320	520	650	780	950	1.100	1.250
	Fan Motor Power	W	60	70	100	110	110	115	120	120
Outdoor Unit	Length	mm	330	330	330	330	330	330	330	330
	Width	mm	270	270	270	320	320	320	320	320
	Height	mm	320	320	340	370	370	370	400	400
	Net Weight	kg	17	18	19	25	27	27	29	32
Suction Pipe		Inch	3/8"	3/8"	3/8"	1/2"	1/2"	1/2"	1/2"	1/2"
Discharge Pipe		Inch	1/4"	1/4"	1/4"	3/8"	3/8"	3/8"	3/8"	3/8"
Condenser Pipe		Inch	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"
Drain Pipe		Inch	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"
Duct Diameter		mm	100	100	125	125	2x125	150	150	150
Proposed Fuse for the System		A	C 16	C 16	C 16	C 20	C 20	C 25	C 25	C 25
Max Pump Current That can be Connected to the Unit Electrical Box		A	4	4	4	4	4	4	4	4
Condenser water flow		l/m	9	11	13	13	16	19	19	20
Voltage		V	230							
Frequency		Hz	50							
IP Class			IP 22							
Feeding Cable Cross Section /Type			3 x 2,5 / Tin Coated							

Technical Specifications for Multi-Ton Condensing Units

Model[7]	CS*24R			
Capacity in BTU/hr	24,000			
Voltage (VAC)[1]	208-230	208-230	220-240	380-415
Cycle (Hz)/Phase (Ph)[2]	60/1	60/3	50/1	50/3
R-22 Refrigerant (oz/kg)	48/1.3	48/1.3	48/1.3	48/1.3
417A Refrigerant (oz/kg)	48/1.3	N/A	48/1.3	N/A
Full Load Amps (FLA) Cool	7.3	5.4	7.8	3.1
Full Load Amps (FLA) Heat	9.0	6.4	8.9	3.7
Locked Rotor Amps (Comp)[4]	57.0	41.0	65.0	30.0
Kilo-Volt-Amps (KVA) Heat	2.1	2.5	2.4	2.7
Max. Circuit Breaker (Amps)	35	25	35	10
Min. Circuit Ampacity (Amps)	22	15	22	8
Base Valves (Disch. X Suct.)	3/8" X 5/8"			
Height (in/mm)[5]	21.8/546			
Width (in/mm)	16.00/406			
Depth (in/mm)	16.00/406			
Net Weight (lb/kg)[6]	115/52.2			
Gross Weight (lb/kg)[6]	120/54.4			

Model[7]	CS*30R			
Capacity in BTU/hr	30,000			
Voltage (VAC)[1]	208-230	208-230	220-240	220-240
Cycle (Hz)/Phase (Ph)[2]	60/1	60/3	50/1	50/1
R-22 Refrigerant (oz/kg)	50/1.4	50/1.4	50/1.4	N/A
417A Refrigerant (oz/kg)	50/1.4	N/A	N/A	50/1.4
Full Load Amps (FLA) Cool	8.4	6.2	9.8	9.8
Full Load Amps (FLA) Heat	10.9	7.4	12.1	11.8
Locked Rotor Amps (Comp)[4]	61.0	48.0	65.1	65.0
Kilo-Volt-Amps (KVA) Heat	2.5	2.6	2.8	2.8
Max. Circuit Breaker (Amps)	45	30	50	40
Min. Circuit Ampacity (Amps)	28	17	28	25
Base Valves (Disch. X Suct.)	3/8" X 3/4"			
Height (in/mm)[5]	21.50/546			
Width (in/mm)	16.00/406			
Depth (in/mm)	16.00/406			
Net Weight (lb/kg)[6]	127/57.6			
Gross Weight (lb/kg)[6]	132/59.9			

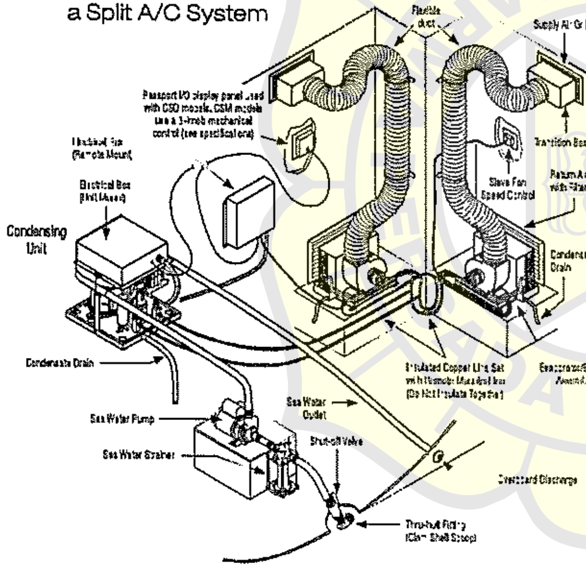
Model[7]	CS*36R			
Capacity in BTU/hr	36,000			
Voltage (VAC)[1]	208-230	208-230	220-240	380-415
Cycle (Hz)/Phase (Ph)[2]	60/1	60/3	50/1	50/3
R-22 Refrigerant (oz/kg)	56/1.6	56/1.6	56/1.6	56/1.6
417A Refrigerant (oz/kg)	N/A	N/A	56/1.6	N/A
Full Load Amps (FLA) Cool	10.5	6.8	12.8	4.3
Full Load Amps (FLA) Heat	12.9	8.3	14.6	5.8
Locked Rotor Amps (Comp)[4]	73.0	60.0	87.0	35.0
Kilo-Volt-Amps (KVA) Heat	3.0	3.3	3.5	3.6
Max. Circuit Breaker (Amps)	50	30	60	15
Min. Circuit Ampacity (Amps)	29	18	35	11
Base Valves (Disch. X Suct.)	3/8" X 3/4"			
Height (in/mm)[5]	25.50/648			
Width (in/mm)	16.00/406			
Depth (in/mm)	16.00/406			
Net Weight (lb/kg)[6]	135/61.2			
Gross Weight (lb/kg)[6]	140/63.5			

Model[7]	CS*48R			
Capacity in BTU/hr	48,000			
Voltage (VAC)[1]	208-230	208-230	220-240	380-415
Cycle (Hz)/Phase (Ph)[2]	60/1	60/3	50/1	50/3
R-22 Refrigerant (oz/kg)	78/2.2	78/2.2	78/2.2	78/2.2
417A Refrigerant (oz/kg)	78/2.2	N/A	78/2.2	N/A
Full Load Amps (FLA) Cool	13.1	8.2	22.3	5.4
Full Load Amps (FLA) Heat	15.9	9.6	24.8	6.3
Locked Rotor Amps (Comp)[4]	87.0	70.0	132.2	45.0
Kilo-Volt-Amps (KVA) Heat	3.7	3.7	6.0	4.5
Max. Circuit Breaker (Amps)	60	40	60	30
Min. Circuit Ampacity (Amps)	35	23	46	17
Base Valves (Disch. X Suct.)	3/8" X 3/4"			
Height (in/mm)[5]	25.50/648			
Width (in/mm)	16.00/406			
Depth (in/mm)	16.00/406			
Net Weight (lb/kg)[6]	145/65.8			
Gross Weight (lb/kg)[6]	150/68.0			

Model[7]	CS*60R		
Capacity in BTU/hr	60,000		
Voltage (VAC)[1]	208-230	220-240	440-480
Cycle (Hz)/Phase (Ph)[2]	60/1	50/3	60/3
R-22 Refrigerant (oz/kg)	N/A	80/2.3	80/2.3
417A Refrigerant (oz/kg)	80/2.3	N/A	N/A
Full Load Amps (FLA) Cool	17.2	22.0	6.1
Full Load Amps (FLA) Heat	22.0	24.8	7.4
Locked Rotor Amps (Comp)[4]	132.2	136.0	60.0
Kilo-Volt-Amps (KVA) Heat	5.1	6.0	5.0
Max. Circuit Breaker (Amps)	60	80	25
Min. Circuit Ampacity (Amps)	46	50	15
Base Valves (Disch. X Suct.)	5/8" X 3/4"		
Height (in/mm)[5]	28.8/732		
Width (in/mm)	24.00/610		
Depth (in/mm)	24.00/610		
Net Weight (lb/kg)[6]	173/78.5		
Gross Weight (lb/kg)[6]	181/81.6		

Notes:
[1] BTU and electrical data are based on a 45°F/7.2°C evaporator and 100°F/37.8°C condenser in cool mode, and a 45°F/7.2°C evaporator and 130°F/54.4°C condenser in heat mode.
[2] Add a "Z" or "ZSO" after the "K" in the 24K-48K model numbers to denote 220-240V/60Hz or 240-220V/60Hz respectively.
[3] Electrical specifications are for reverse cycle units; straight cool units might use smaller circuit breakers.
[4] Some standard 60Hz units may be operated at 50Hz at reduced voltages, however there will be a loss in capacity, and the amp draw may be higher or lower than listed. Dedicated 50Hz units are available that provide full capacity but these cannot be operated at 60Hz. For more information regarding compressor voltages, refer to Dometic Environmental Systems' Customer News & Information website.
[5] Compressor locked rotor amps (LRA) will vary with voltage and load, and may be higher or lower than listed.
[6] Electrical box height is 3.5"/89mm; subtract that from unit height if box will be remotely mounted.
[7] Weights are based on 60Hz/1Ph equipment.
*D = Elite or Passport I/O Control (CSD); M = Mechanical Control (CSM)

Typical Installation of a Split A/C System



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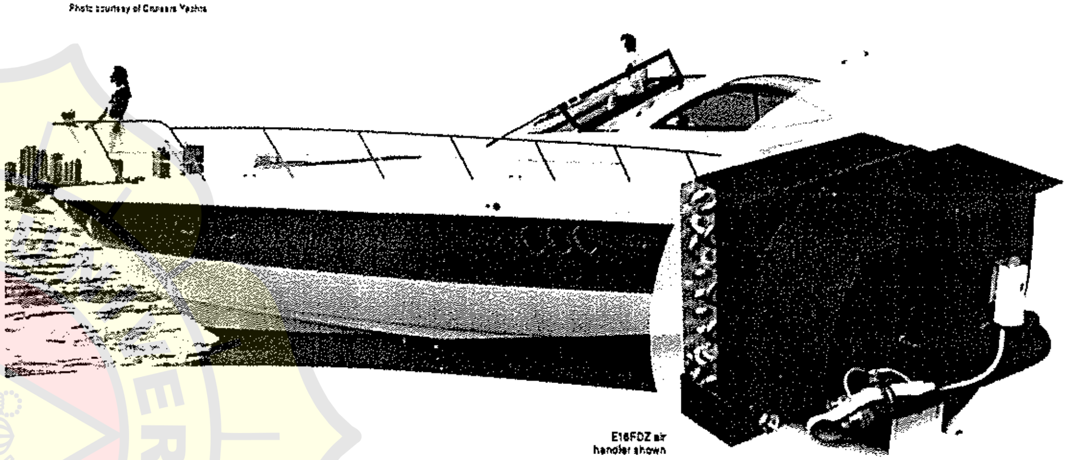
E Series DX Air Handlers

With Quiet & Efficient Blowers

Photo courtesy of Cruisers Yachts



E16FDZ air handler shown

The Marine Air Direct Expansion Air Handler has a compact modular design. For maximum efficiency, the plenum chambers are increased and the coils have enhanced fins and rifled tubing. The unit also offers easy disassembly for access to components.

The air handler's centrifugal blowers are quiet and efficient with fully insulated housings. For installation flexibility, the blower rotates to horizontal or vertical positions. Thermoplastic mounting rings enable easy installation of ducting or transition boxes.

The condensate drain pan includes two ½" FPT drain hook-ups, and it is insulated to prevent sweating.

As with all Marine Air products, quality is assured. Each unit is pre-charged, test-run in all operating modes, and leak-checked at the factory prior to shipping. All surface components are constructed of or coated with materials resistant to fire and corrosion. Charge Guard® protection provides sealed access ports that ensure environmental protection and system integrity. All Direct Expansion Air Handlers meet or exceed applicable ABYC and US Coast Guard regulations, CE directives, and general Air Conditioning and Refrigeration Industry (ARI) standards.

Key Benefits

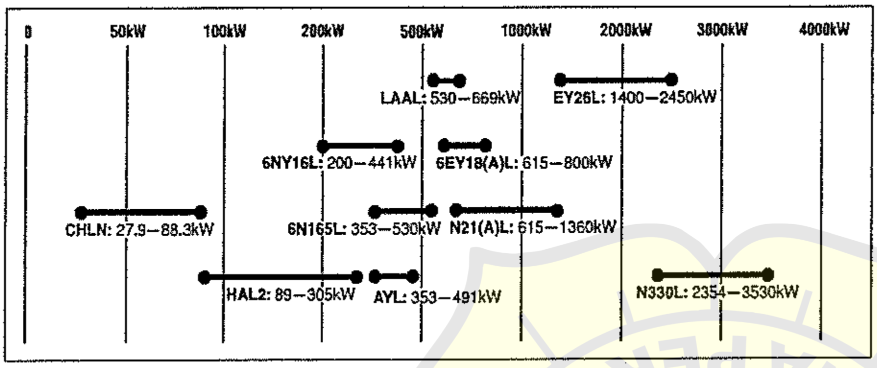
- Models available in 4K, 6K, 9K, 12K, and 16K BTU/hr (115V and 230V), as well as 18K, and 24K BTU/hr (230V only).
- Compact modular design with increased efficiency.
- Easy disassembly for component access.
- Quiet, efficient blowers rotate to vertical or horizontal positions.
- Insulated drain pan prevents sweating and includes two ½" FPT drain hook-ups.
- Factory pre-charged, tested, and leak-checked prior to shipping.
- Meets or exceeds all applicable standards and regulations.

ISO 9001:2008

MARINE AIR SYSTEMS®

MARINE AUXILIARY ENGINES

Marine Auxiliaries. High Performance and Reliable Marine Power.



Reliable power equipment is indispensable for modern vessel operation—for safe navigation, labor saving and the improvement of the inboard environment. Yanmar Marine Diesel Generator Equipment is produced in the most advanced production facilities available and under strict quality control that has been certified by many of the world's most authoritative major shipping classification organizations. These include LRS, ABS, DNV, BV, RINA and NK.

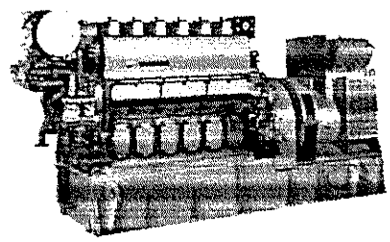
Small diesel engines

While it is common to have these engines installed out-of-sight and out-of-mind, coupled permanently to a generator, winch, pump etc, all these engines still carry the Yanmar breeding and pedigree.
Yanmar auxiliary engines are:
— environmentally friendly
— marine use units which can be indirect fresh-water cooled.
— low noise and have low vibration characteristics
— compact, powerful and economical on fuel.

6CHL-N

Medium - large diesel engines

A close look at world listings of newly launched ships in many cases show one or more Yanmar auxiliary engine mentioned amongst the specifications.
They are chosen because they offer the best available mix of reliability, fuel economy, long life, service back-up, in a design that lightweight, low noise and low vibration.



6EY18(A)L

Small diesel engines

Model	No. of cylinders	Bore × stroke: mm	Cont. rating output: kW (hp)/min⁻¹ (rpm)	Dry weight: kg	Dimensions L×W×H: mm
4CHL-N	4	105×125	27.9(38.0)/1500, 36.8(50.0)/1800	500	1089×922×1051
4CHL-TN	4	105×125	36.8(50.0)/1500, 45.6(62.0)/1800	520	1082×922×1173
6CHL-N	6	105×125	45.6(62.0)/1500, 54.4(74.0)/1800	625	1378×942×1082
6CHL-TN	6	105×125	54.4(74.0)/1500, 73.6(100.0)/1800	645	1378×942×1224
6CHL-HTN	6	105×125	73.6(100.0)/1500, 88.3(120.0)/1800	675	1378×942×1224

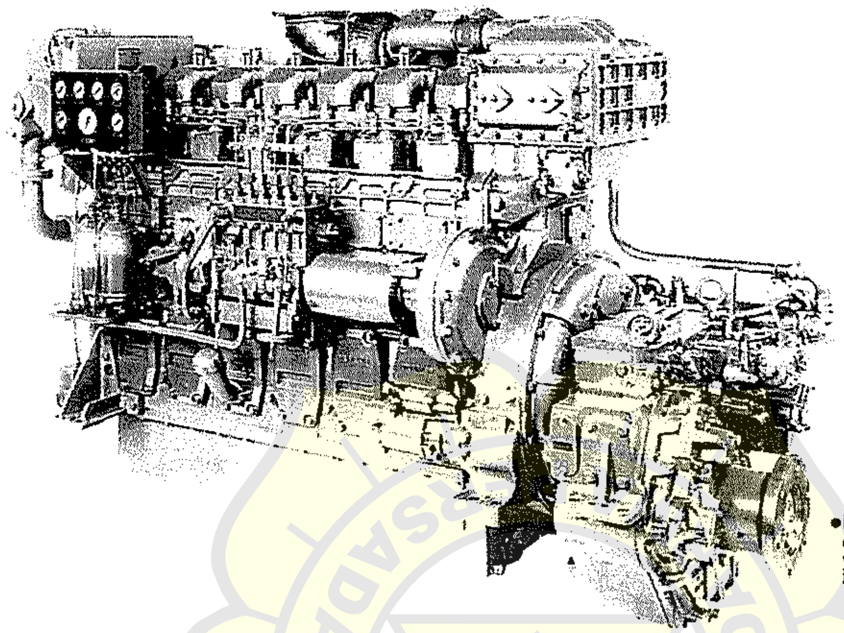
Medium-large diesel engines

★: Max. output

Model	No. of cylinders	Bore × stroke: mm	Cont. rating output: kW (hp)/min⁻¹ (rpm)	Dry weight: kg	Dimensions L×W×H: mm
4HAL2-TN1	4	130×165	89(121)/1500, 116(157)/1800	1030	1219×1117×1264
4HAL2-TN	4	130×165	115(156)/1500, 135(183)/1800	1030	1219×1117×1264
6HAL2-N	6	130×165	90(122)/1200, 115(156)/1500	1380	1563×1163×1344
6HAL2-TN	6	130×165	150(204)/1500, 180(244)/1800	1395	1563×1163×1410
6HAL2-HTN	6	130×165	220(299)/1500, 265(360)/1800	1410	1563×1163×1410
6HAL2-DTN	6	130×165	255(346)/1500, 305(414)/1800	1420	1563×1163×1410
6AYL-ST	6	155×180	353(480)/1800	2435	1859×1443×1498
6AYL-ET	6	155×180	438(596)/1500, 491(668)/1800	2435	1859×1443×1498
12LAAL-DTN	V12	148×165	530(720)/1500, 618(840)/1800	3860	2251×1452×1669
12LAAL-UTN	V12	148×165	574(780)/1500, 669(910)/1800	3880	2251×1452×1669

6NY16

331～559kW



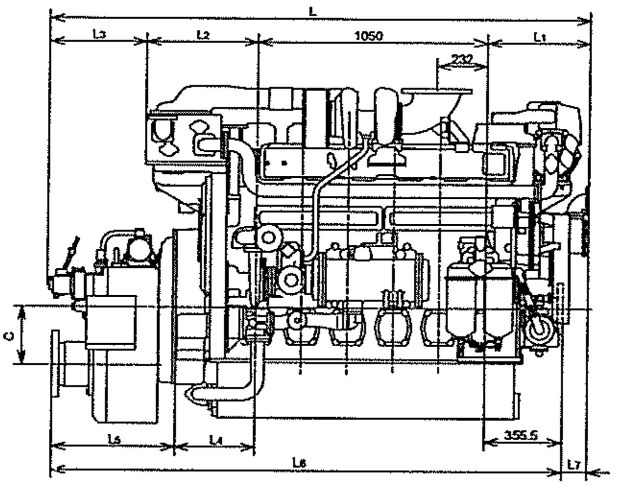
● Depending on the specifications or options that have been chosen, your model may differ slightly from the one in the photograph.

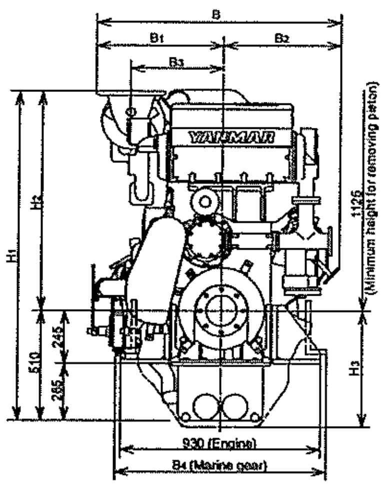
(Spe)cations

(Mo)del	6NY16-UT	6NY16-ST	6NY16A-UT	6NY16A-ST
(No. o)f cylinders	6	6	6	6
(B)ore X stroke mm	160 × 200	160 × 200	160 × 200	160 × 200
(Continuou)s rated output kW (PS)	331 (450)	405 (550)	478 (650)	559 (760)
(Eng)ine speed min^{-1} (rpm)	1350	1350	1600	1600
(Dry) mass kg	2880		2880	
(Re)duction gear	YX-240-1		YX-351	
	Offset		Offset	
(Reduction) gear ratio (ahead)	2.08, 2.55, 3.03, 3.50		2.25, 2.67, 3.11, 3.51	
(Re)duction gear mass kg	670		1050	
	In case the classification rule required, only YX-351 is available.			

The engine dry weight may differ depending upon the specifications and attached accessories. The elastic coupling weight is included in the dry weight.

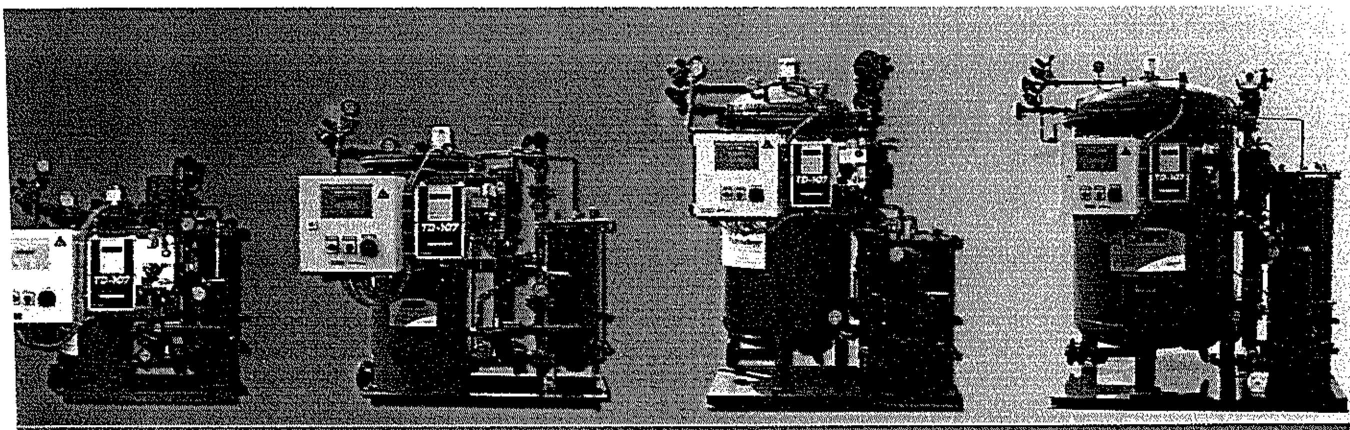
(Dimensi)ons(Unit:mm)





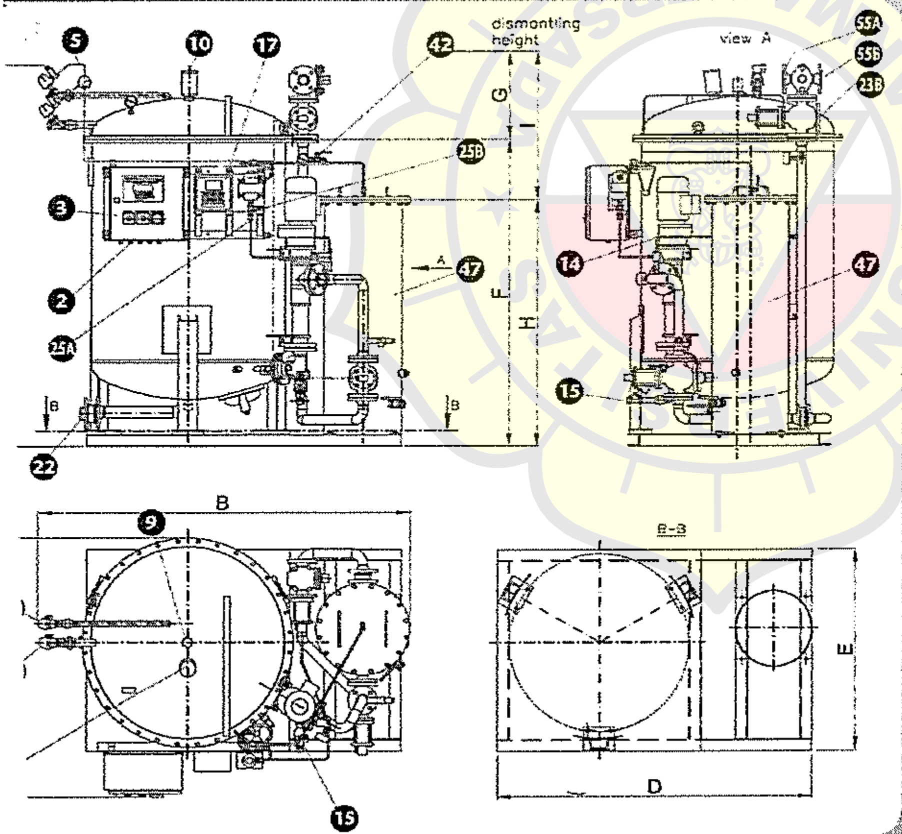
Engine	Marine gear	L	L_1	L_2	L_3	L_4	L_5	L_6	L_7	B	B_1	B_2	B_3	H_1	H_2	H_3	C	W
6NY16-UT/ST	YX-240-1	2478	473	514	441	369	562	2337	117	1136	589	547	429	1523	1013	539	269	980
	YX-351	2690	473	514	653	369	798	2573	117	1136	589	547	429	1523	1013	473	138	960
6NY16A-UT/ST	YX-240-1	2509	504	543	412	369	562	2337	148	1223	629	594	469	1600	1090	539	269	980
	YX-351	2721	503	543	625	369	562	2573	147	1223	629	594	469	1600	1090	473	138	960

Please confirm all specifications, etc. on the separate delivery specifications sheet. When installing the product, please request a separate outline drawing of the engine with detailed information regarding installation.

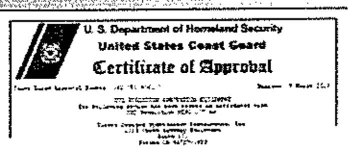


USA Technical Dimensions for OWS

Size (GPM)	Size (m^3/hr)	A (ft)	B (ft)	C (ft)	D (ft)	E (ft)	F+G (ft)	H+I (ft)	Power (kW)	Dry Wgt (lbs)
0.4	0.1	3.61	2.35	2.13	n/a	n/a	2.85	1.64	0.50	190
1.1	0.3	3.67	3.53	2.53	2.70	1.25	3.44	2.59	2.00	408
2.2	0.5	3.84	3.90	2.36	2.85	1.15	3.97	4.23	2.70	507
4.4	1.0	4.20	4.35	2.69	3.41	1.48	4.74	4.23	2.70	573
6.6	1.5	5.07	4.77	2.85	3.89	1.64	5.56	5.07	2.70	750
11.0	2.5	5.84	4.97	3.59	4.02	2.46	6.63	4.23	3.00	1124
22.0	5.0	6.56	6.35	4.43	5.33	3.44	7.25	5.92	4.00	1874
44.0	10.0	7.92	7.91	5.12	6.17	4.27	8.19	5.99	4.50	2646



- **2** Power supply
- **3** Control box
- **4** Oil discharge
- **5** Backwashing outlet
- **6** Air inlet (6-8 bar)
- **9** Senosrelectrode
- **10** Electrical heating
- **14** Mono pump
- **15** Backwashing inlet
- **17** 15ppm oil alarm monitor
- **22** Bilge water inlet
- **23B** Recirculation to bilge tank
- **25A** Sample water inlet
- **25B** Flushing water inlet
- **42** IMO-sample cock
- **47** Polisher
- **55A** Discharge to overboard
- **55B** Recirculation to bilge tank



IMO MEPC 107(49) USCG CERTIFIED

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