8.2.

THE SHIP HULL DEFINITION AND HYDROSTATIC DATA

The ship hull definition was done by hand. I gathered information about several diving support vessels to see the caracteristica which mark these special ships.

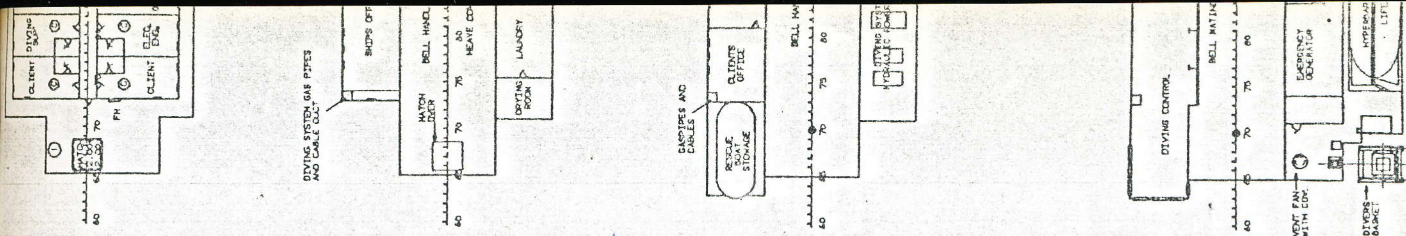
On the following pages you will see some examples of these ships' hull form.

In general they are quite wide in order to be more stable. They are not built to sail very fast, and they always have a large workdeck aft. A few years ago nearly all diving vessels were big tugger ship which had been rebuilt to fit the diving need, but during the last decade many ships built specially for support of the diving function has been created. They still, however, reminds of big tugger ships.

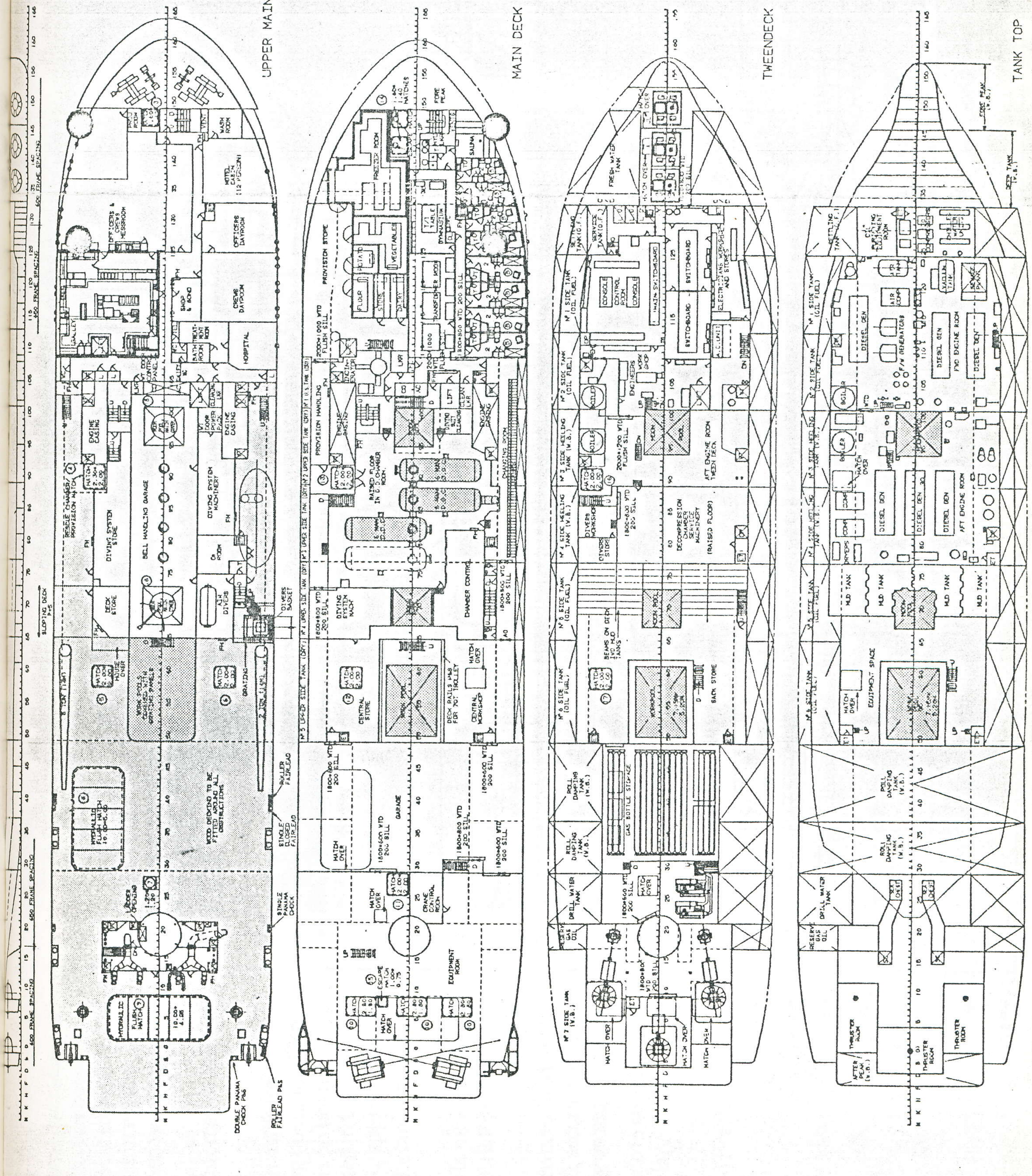
The B/L is in general between 0.2 and 0.3. The block coefficient is in general between 0.7 and 0.8.

In designing the Stena Seawell a lot of efforts were carried out in order to make a stabil ship with a low resistance hull. Also the ease of production was taken into account.

At the phase of the hull definition of Silver Searambler the diving section rooms had been designed, so this more or less dictated the size of the hull. The Stena Seawell had been designed with a "bulp" shape of the bow. Model testing had shown that the resistance of the ship was improved and that the front projected area of the tunnel thrusters were minor. I incorporated, therefore, this idea into my design:



The Stena Seawell



nication and loud hailer

tures. A removable helicopter
per Puma etc. has been
wheelhouse. Strength is
ky 61. The main mast is
d down when working

as been reinforced to facilitate
ame.

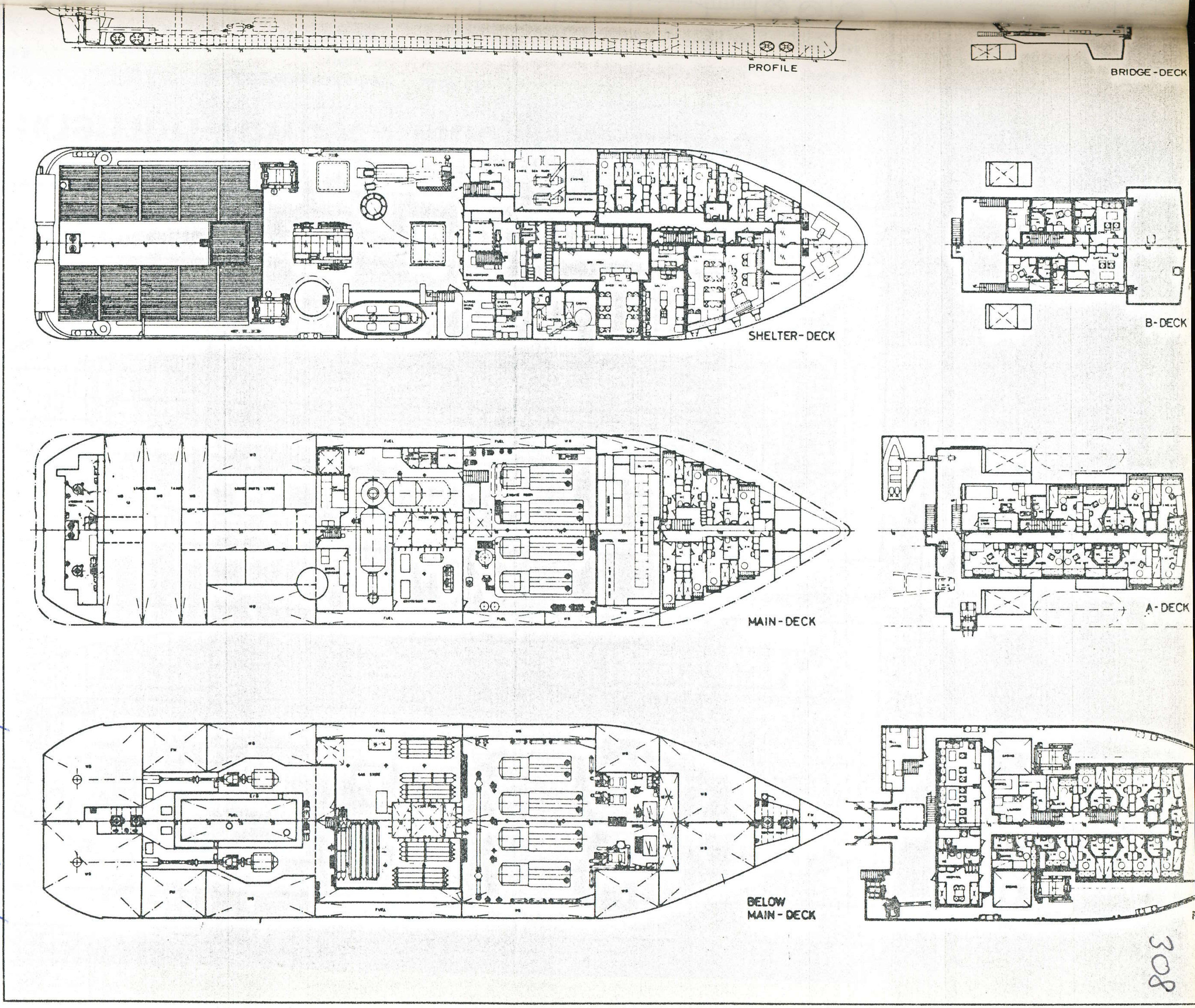
s have been made for the
il skimming operations, as
quipment is on board.
en designated to take
al capacity of approx. 800m³
s separate the tanks from the

been left to fit pipe handling
hich may work together
ne.

asily be converted and
safety vessel, accommodating
ns depending on requirements.

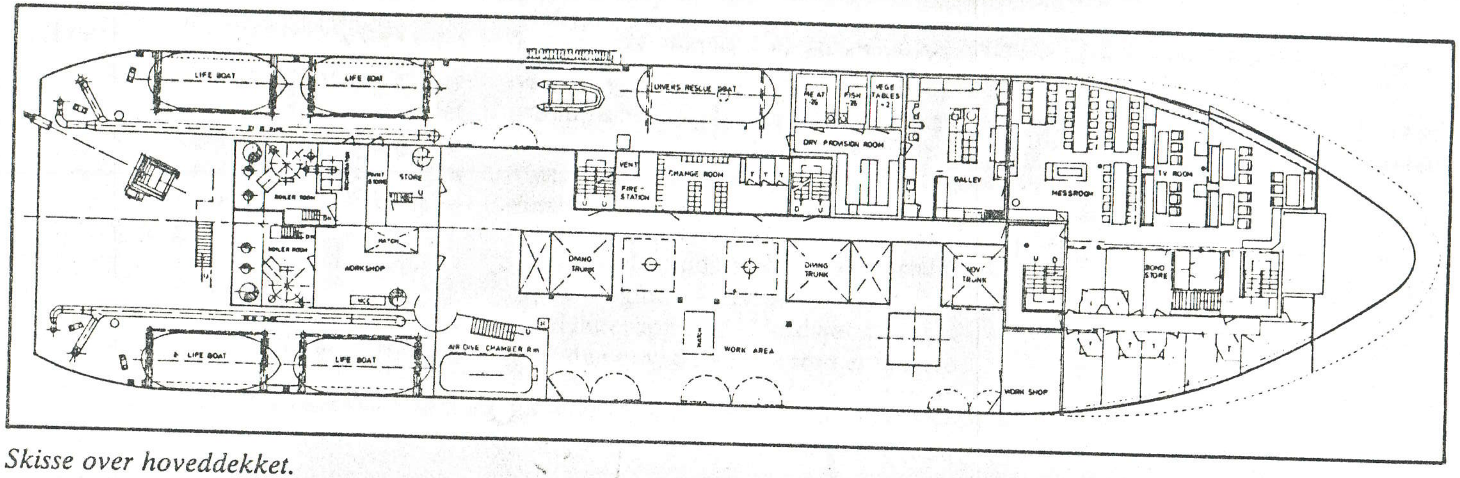
ve been made to supply
rs from the large power

inerator and Fresh Water
is installed.

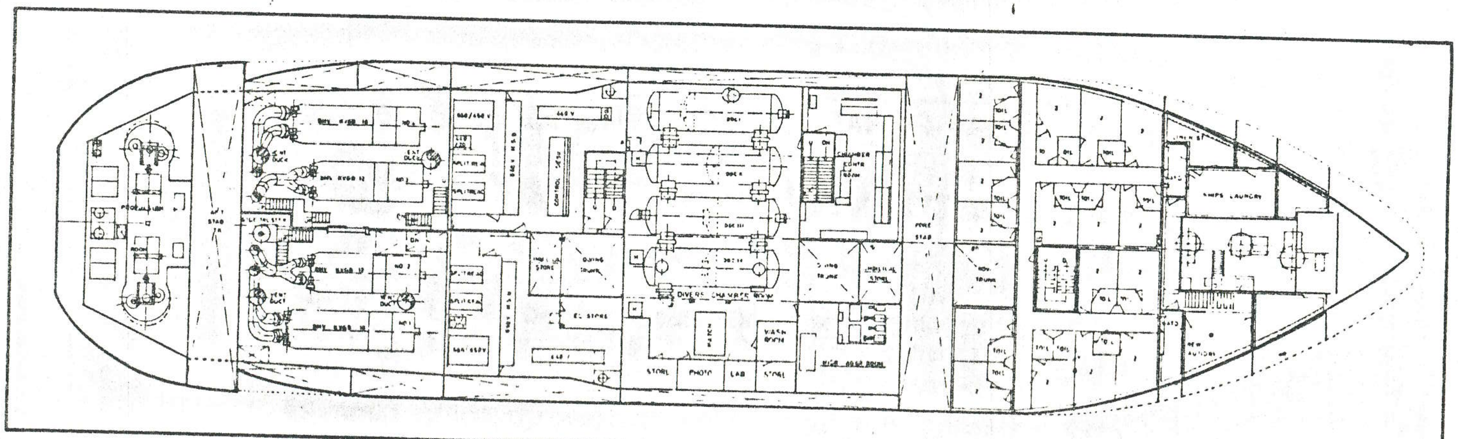


standard shape

standard shape



Skisse over hoveddekket.



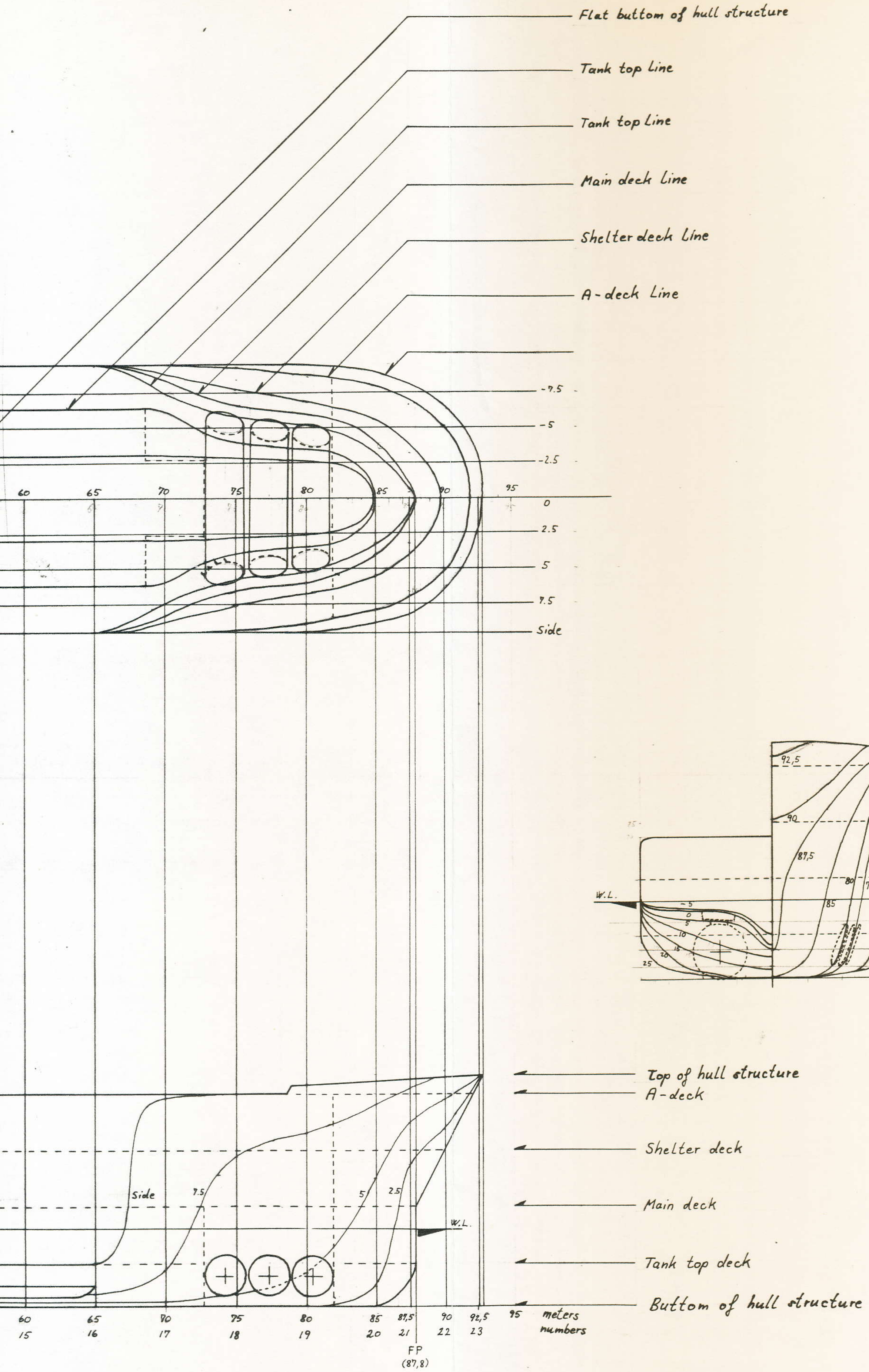
Skisse over nedre tweendekk.

ca 1/450

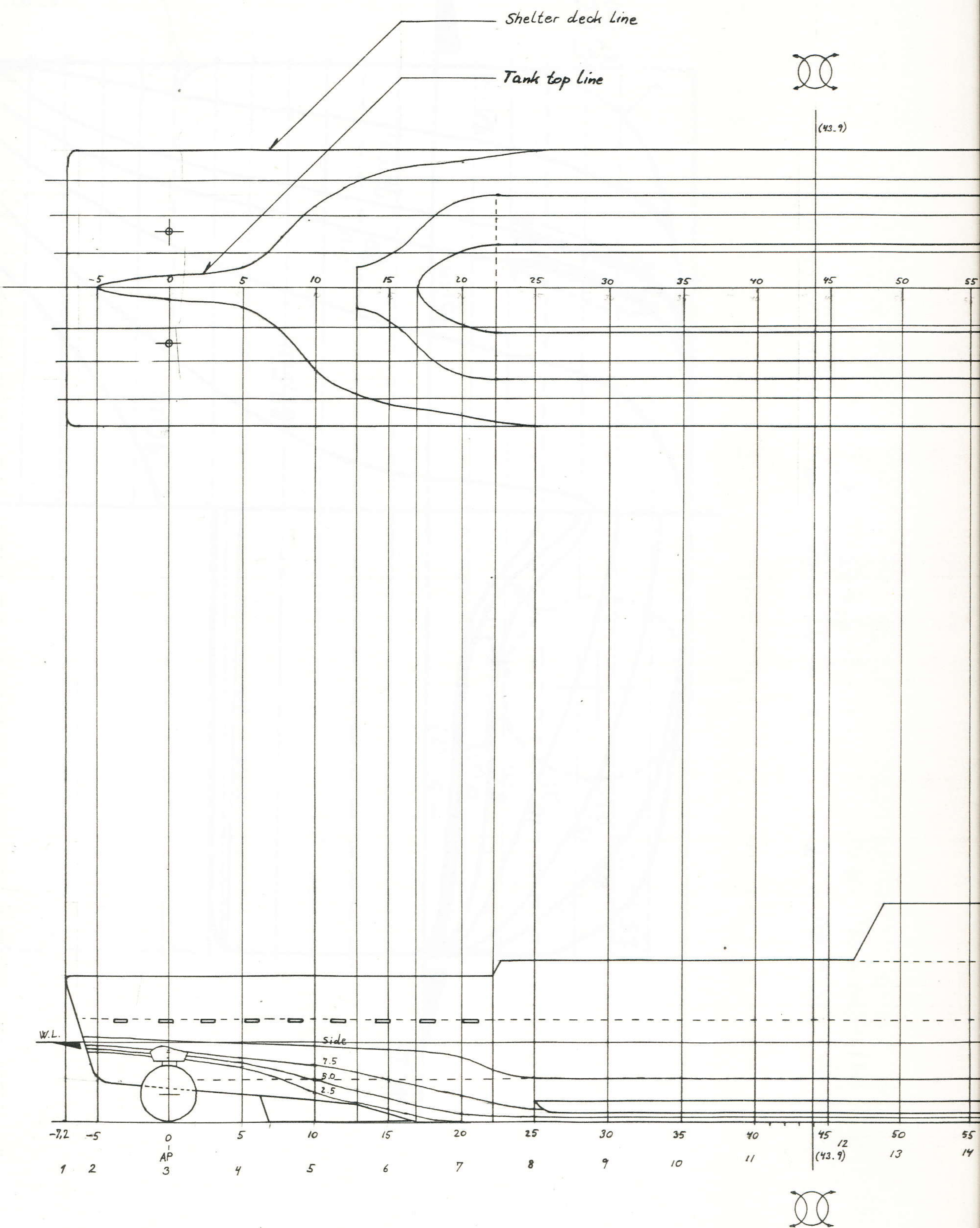
Hoveddimensjoner «Seaway Harrier»:

Lengde over alt	83.40 m	Dødvekt sommerfribord	2000tonn
Lengde mellom perpendikulærene	73.00 m	Tonnasje	4 800 brt.
Bredde	19.50 m	Kapasitet brennolje	1 500 m
Dybde til hoveddekk	8.60 m	Vannballast	1000 m
Dybde til øvre dekk	14.60 m	Drikkevann	[illegible]
Dypgang sommerfribord	[illegible]		

310

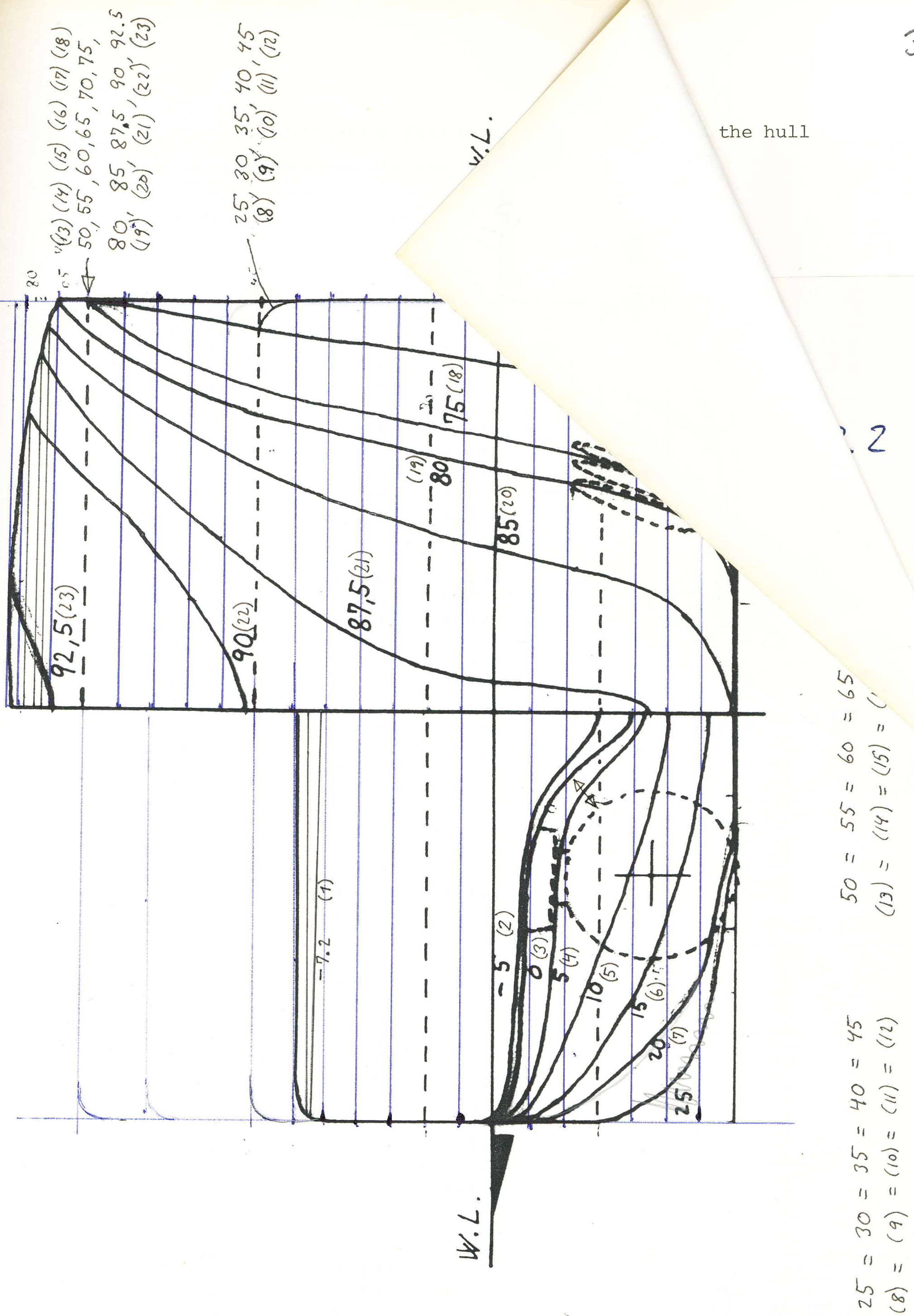


HULL DEFINITION	1:400	0-15
SILVER SEARAMBLER	7/6-86	John Gault



Shelter deck line
Tank top line
(43.9)
-5
0
5
10
15
20
25
30
35
40
45
50
55
W.L.
Side
7.5
5.0
2.5
-7,2
AP
1 2 3 4 5 6 7 8 9 10 11 12 13 14

the hull



SILVER SEARAMBLER

The initial hull definition data were given as input to the hull drawing program. The results are shown in the following:

The input data of 23 stations:

1) x = -7.2

POINT	TYPE	y	z
1.00	K	0.000	9.534
2.00		2.903	9.613
3.00		5.785	9.685
4.00		8.868	9.753
5.00	P	9.266	9.897
6.00		8.845	9.870
7.00		6.827	9.843
8.00		4.800	9.846
9.00		2.060	9.829
10.00	T	0.000	9.844

2) x = -5

POINT	TYPE	y	z
1.00	K	0.000	3.144
2.00		.701	3.534
3.00		1.766	4.381
4.00		2.990	4.810
5.00		4.781	4.963
6.00		7.053	5.100
7.00		8.589	5.242
8.00		9.200	5.422
9.00		9.470	5.770
10.00		9.490	6.321
11.00		9.499	7.263
12.00		9.489	8.380
13.00		9.471	9.254
14.00		9.373	9.810
15.00		9.097	10.037
16.00		8.872	10.101
17.00	P	8.501	10.172
18.00		7.036	10.211
19.00		4.871	10.212
20.00		2.053	10.185
21.00	T	0.000	10.203

3) x = 0

POINT	TYPE	y	z
1.00	K	0.000	2.402
2.00		.278	2.505
3.00		.799	3.065
4.00		1.750	4.033
5.00		2.660	4.505
6.00		4.313	4.770
7.00		6.290	4.837
8.00		7.985	4.951
9.00		9.163	5.208
10.00		9.382	5.384
11.00		9.494	5.584
12.00		9.509	6.297
13.00		9.498	7.906
14.00		9.466	9.484
15.00		9.389	9.750
16.00		9.142	9.968
17.00		8.846	10.064
18.00	P	8.458	10.109
19.00		6.708	10.215
20.00		4.913	10.218
21.00		2.604	10.150
22.00	T	0.000	10.123

POINT	TYPE	y	z
1.00	K	0.000	2.049
2.00		.317	2.152
3.00		.948	2.670
4.00		1.807	3.475
5.00		2.728	3.915
6.00		4.342	4.122
7.00		6.209	4.241
8.00		7.847	4.449
9.00		8.991	4.826
10.00		9.439	5.230
11.00		9.531	5.655
12.00		9.561	7.264
13.00		9.552	8.733
14.00		9.512	9.556
15.00		9.346	9.935
16.00		9.051	10.079
17.00		8.714	10.147
18.00	P	8.405	10.165
19.00		6.675	10.297
20.00		4.287	10.219
21.00		1.724	10.189
22.00	T	0.000	10.186

4) x = 5

POINT	TYPE	y	z
1.00	K	0.000	1.570
2.00		.964	1.652
3.00		3.101	2.235
4.00		5.385	3.031
5.00		8.508	4.310
6.00		9.198	4.709
7.00		9.446	5.142
8.00		9.513	5.594
9.00		9.517	6.977
10.00		9.509	8.603
11.00		9.462	9.553
12.00		9.302	9.937
13.00		8.998	10.112
14.00	A	8.440	10.177
15.00		6.415	10.274
16.00		3.316	10.211
17.00		.852	10.210
18.00	T	0.000	10.188

ERROR: NUMBER OF TYPE P IS ILLEGAL

5) x = 10

POINT	TYPE	y	z
1.00	K	0.000	.609
2.00		1.366	.755
3.00		3.463	1.142
4.00		5.613	1.799
5.00		7.544	2.834
6.00		8.851	3.798
7.00		9.370	4.550
8.00		9.487	5.223
9.00		9.490	7.326
10.00		9.461	8.702
11.00		9.417	9.468
12.00		9.307	9.800
13.00		8.943	10.003
14.00	P	8.385	10.079
15.00		5.879	10.134
16.00		2.843	10.092
17.00	T	0.000	10.072

6) x = 15

POINT	TYPE	y	z
1.00	K	0.000	.015
2.00		2.465	.028
3.00		4.123	.306
4.00		5.477	.563
5.00		6.246	.829
6.00		7.414	1.656
7.00		8.258	2.471
8.00		8.953	3.324
9.00		9.438	4.315
10.00		9.483	5.336
11.00		9.493	7.129
12.00		9.460	9.496
13.00		9.388	9.766
14.00		9.175	9.991
15.00		8.925	10.073
16.00	P	8.386	10.152
17.00		6.145	10.213
18.00		3.808	10.205
19.00		1.291	10.182
20.00	T	0.000	10.190

7) x = 20

POINT	TYPE	y	z
1.00	K	0.000	.000
2.00		2.738	.132
3.00		4.284	.075
4.00		5.971	.228
5.00		6.959	.483
6.00		8.231	1.141
7.00		8.841	1.956
8.00		9.416	2.770
9.00		9.500	3.888
10.00		9.500	5.572
11.00		9.500	7.725
12.00		9.500	9.203
13.00		9.337	9.535
14.00		9.204	9.794
15.00		9.018	9.959
16.00	P	8.786	10.070
17.00		7.892	10.101
18.00		4.975	10.242
19.00		2.793	10.346
20.00	T	0.000	10.486

8 = 9 = 10 = 11 = 12

x = 25, 30, 35, 40, 45

POINT	TYPE	y	z
1.00	K	0.000	.025
2.00		1.860	.002
3.00		3.094	.003
4.00		4.712	.213
5.00		6.114	.444
6.00		7.246	.770
7.00		8.489	1.465
8.00		9.259	2.667
9.00		9.511	3.198
10.00		9.500	3.847
11.00		9.500	4.536
12.00		9.500	4.836
13.00	9	9.500	6.391
15.00		9.514	8.957
16.00	C	9.507	9.981
17.00		9.493	11.409
18.00		9.503	12.840
19.00		9.521	13.895
20.00	P	9.515	14.928
21.00		9.068	14.920
22.00		7.156	14.935
23.00		4.211	14.958
24.00		1.888	14.982
25.00	T	0.000	15.017

ERROR: ILLEGAL TYPE= 9 FOR POINT NO. 13

13 ok

13 = 14 = 15 = 16

x= 50, 55, 60, 65 m.

POINT	TYPE	y	z
1.00	K	0.000	.003
2.00		2.055	.000
3.00		3.077	.025
4.00		4.218	.129
5.00		5.117	.254
6.00		5.858	.391
7.00		6.267	.636
8.00		6.832	1.295
9.00		7.190	1.993
10.00		7.847	3.592
11.00		8.578	5.923
12.00		8.456	7.358
13.00		8.701	9.742
14.00		9.200	12.571
15.00		9.442	13.918
16.00	P	9.603	14.956
17.00		9.352	14.975
18.00		7.557	14.959
19.00		4.864	14.992
20.00		2.651	15.028
21.00	T	0.000	15.074

17) x = 70 m

POINT	TYPE	y	z
1.00	K	0.000	.043
2.00		1.777	.001
3.00		3.113	.040
4.00		3.777	.178
5.00		4.260	.315
6.00		4.529	.457
7.00		5.021	.853
8.00		5.398	1.571
9.00		5.839	3.063
10.00		6.683	6.385
11.00		7.092	9.314
12.00		7.453	10.850
13.00		8.107	12.716
14.00		8.755	13.952
15.00		9.380	14.766
16.00	P	9.546	14.953
17.00		9.083	14.942
18.00		7.349	14.938
19.00		4.194	14.967
20.00		1.928	14.993
21.00	T	0.000	15.029

18) $x = 75$ m

POINT	TYPE	y	z
1.00	K	0.000	.022
2.00		1.784	.021
3.00		3.042	.040
4.00		3.731	.397
5.00		4.425	.930
6.00		4.874	1.876
7.00		5.485	3.717
8.00		5.909	6.190
9.00		6.387	8.743
10.00		6.897	10.911
11.00		7.321	12.144
12.00		7.917	13.450
13.00		8.506	14.530
14.00	P	8.859	15.006
15.00		7.508	14.983
16.00		4.820	15.025
17.00		2.578	15.044
18.00	T	0.000	15.102

19) $x = 80$ m

POINT	TYPE	y	z
1.00	K	0.000	.019
2.00		.456	.104
3.00		1.707	.675
4.00		2.524	1.382
5.00		2.817	1.930
6.00		3.111	2.741
7.00		3.688	4.685
8.00		4.108	6.677
9.00		4.526	8.102
10.00		5.281	10.258
11.00		6.113	11.998
12.00		7.134	13.774
13.00		7.714	14.620
14.00	P	8.008	14.970
15.00		7.206	14.977
16.00		4.961	14.984
17.00		2.684	15.011
18.00	T	0.000	15.058

20) $x = 85$ m

21) x = 87.5 m

POINT	TYPE	y	z
1.00	K	0.000	1.976
2.00		.210	2.082
3.00		.353	2.422
4.00		.566	3.910
5.00		.910	6.638
6.00		1.502	8.230
7.00		2.831	10.425
8.00		4.979	13.037
9.00		6.595	14.718
10.00	P	6.958	15.086
11.00		4.947	15.013
12.00		2.732	15.029
13.00	T	0.000	15.075

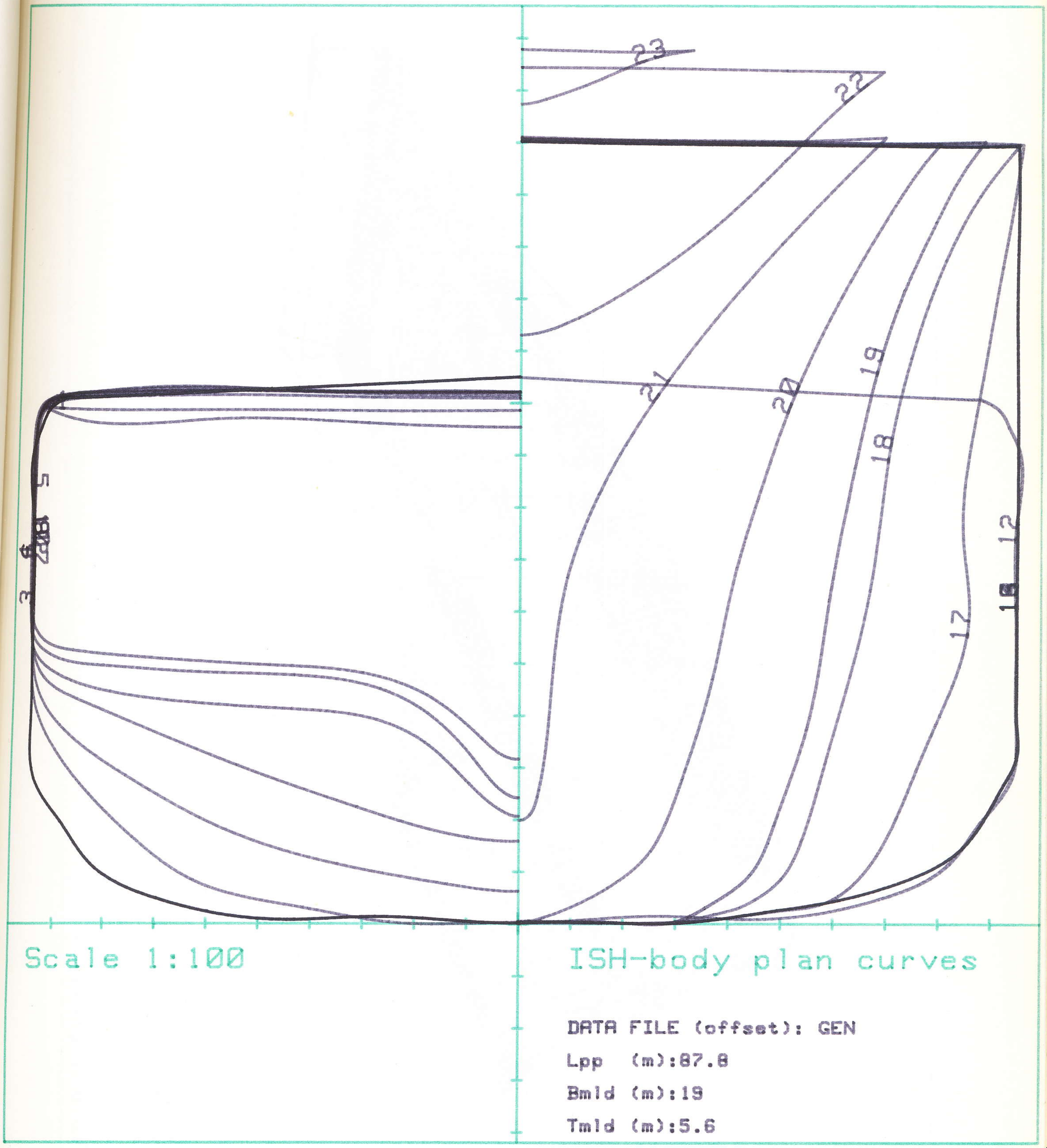
22) x = 90 m

POINT	TYPE	y	z
1.00	K	0.000	11.295
2.00		.839	11.503
3.00		2.409	12.380
4.00		3.555	13.237
5.00		5.044	14.638
6.00		6.536	16.055
7.00	P	6.917	16.345
8.00		5.075	16.378
9.00		2.717	16.419
10.00	T	0.000	16.436

23) x = 92.5 m

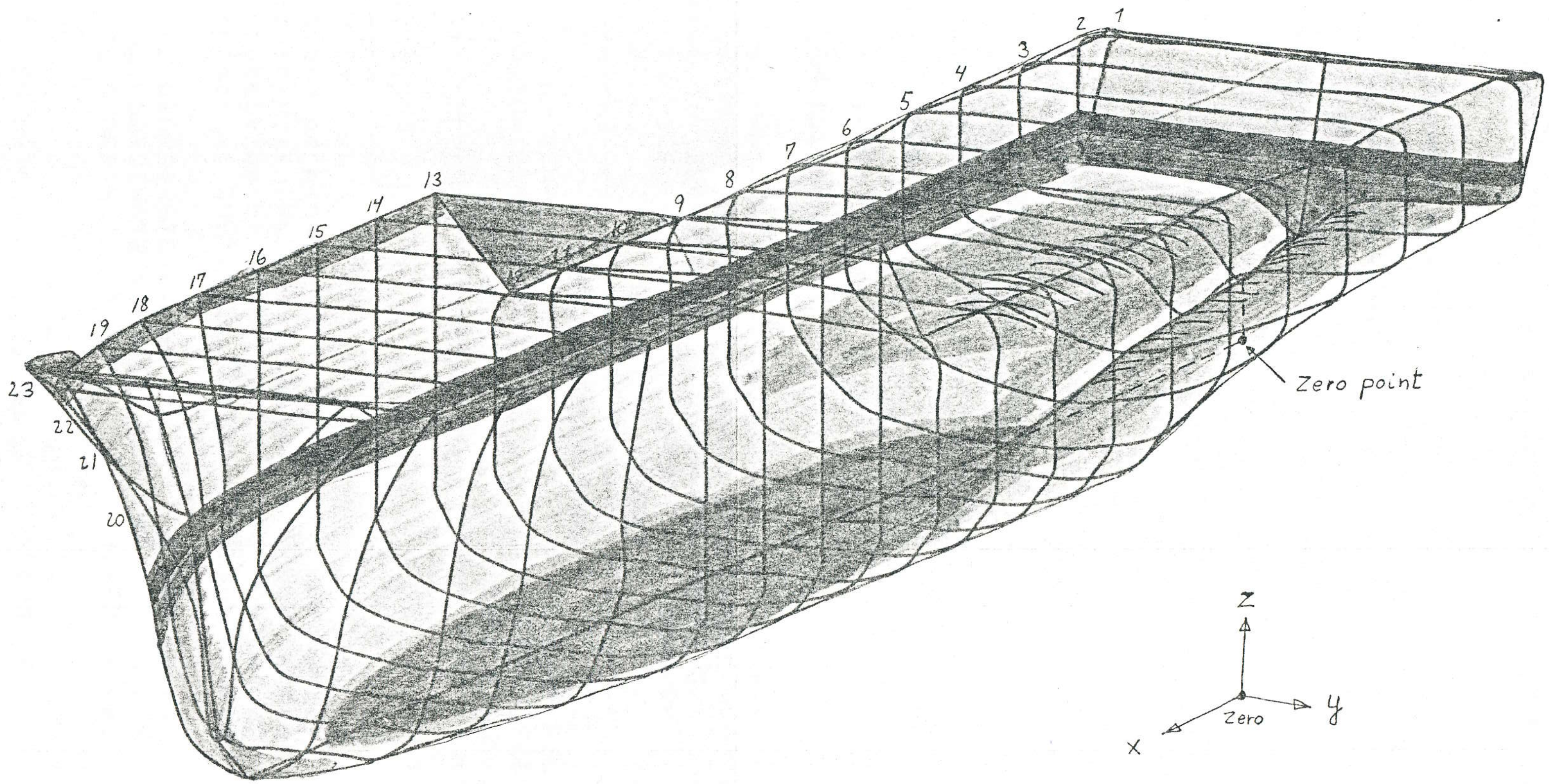
POINT	TYPE	y	z
1.00	K	0.000	15.727
2.00		.467	15.819
3.00		1.230	16.083
4.00		1.941	16.383
5.00		2.540	16.608
6.00	P	3.286	16.753
7.00		2.336	16.727
8.00		1.347	16.747
9.00	T	0.000	16.778

The output from the program is shown in the following and was used in order to evaluate or verify the correctness of the input data:



ISH-ship definition

DATA FILE (offset): GEN
Lpp (m):87.8
Bmld (m):19
Tmld (m):5.6



Now that it has been evaluated that the input data of the ship hull definition is within the acceptable limits the data could be used by the Hydrostatic Calculation Program.

The program was run several times and the hydrostatic data for the conditions:

Draught in meters:
2.800
3.500
4.000
4.200
4.800
4.900
5.600
6.300
6.400
7.000
7.200

Are shown in the following:

```
*  **   *    *   ----------------------------------   *  **   *    *
* *     *    *      ISH STYRKE - BASIC PROGRAMMEL      * *     *    *
*  **   *****     DEPARTMENT OF OCEAN ENGINEERING     *  **   *****
*     * *    *   THE TECHNICAL UNIVERSITY OF DENMARK  *     * *    *
*  **   *    *            DK 2800  LYNGBY             *  **   *    *
--------------------------------------------------------------------
*                        HYDROSTATIC DATA                          *
* BUILDERS:JOHN GENART                        PROGRAM FILE : HYDRO *
* IDENTIFICATION:SEARAMBLER                   VERSION FEBRUARY 1986 *
* DATE:                INITIALS:              DATA FILE: GEN       *
--------------------------------------------------------------------

MAIN PARTICULARS :
------------------

LENGTH between perpendiculars (Lpp)   87.800 metres
BREADTH moulded at DWL ......(Bmld)   19.000 metres
DEPTH to highest point of shear ...   15.000 metres
DRAUGHT moulded at DWL ......(Tmld)    5.600 metres

LONGITUDINAL COORDINATE AT A.P. ...    0.000 metres
LONGITUDINAL COORDINATE AT AMIDSHIP   43.900 metres
LONGITUDINAL COORDINATE AT F.P. ...   87.800 metres


DENSITY OF SEA WATER ..............    1.025  t/m^3

HULL ALLOWANCE SPECIFIED ..........    1.004

TRIM (draught(AP) - draught(FP)) ..    0.000 metres

NUMBER OF DRAUGHTS USED ...........   7
LOWEST DRAUGHT ....................    2.800 metres
HIGHEST DRAUGHT ...................    7.000 metres
```

DRAUGHT T metres	VOLUME moulded metres^3	DISPLACEMENT sea water t	LCB metres	TCB metres	KB metres	WETTED SURFACE projec. metres^2	WETTED SURFACE true metres^2
2.800	2828.66	2910.97	-3.203	0.000	1.566	1451.47	0.00
3.500	3754.80	3864.06	-2.505	0.000	1.957	1610.96	0.00
4.200	4726.97	4864.52	-1.814	0.000	2.346	1798.53	0.00
4.900	5774.42	5942.46	-.899	0.000	2.746	2028.22	0.00
5.600	6908.78	7109.83	.242	0.000	3.156	2214.67	0.00
6.300	8064.55	8299.23	1.146	0.000	3.556	2353.35	0.00
7.000	9227.96	9496.49	1.845	0.000	3.944	2492.74	0.00

LCB (longitudinal centre of buoyancy) : positiv abaft midship
TCB (transverse centre of buoyancy) : positiv to port side (Y>0)
KB (VCB, vertical centre of buoyancy) : positiv upwards from base line

DRAUGHT T metres	WATERPLANE AREA metres^2	LCF metres	TCF metres	KML metres	KMT metres	DISPLA./ DRAUGHT t/m	MOMENT TO CHANGE TRIM t*m/m
2.800	1282.34	-.928	0.000	198.16	12.628	1319.66	6517.9
3.500	1354.34	.159	0.000	170.71	11.100	1393.75	7427.0
4.200	1438.49	2.008	0.000	160.69	10.131	1480.35	8773.1
4.900	1564.99	4.861	0.000	164.46	9.956	1610.53	10945.2
5.600	1636.63	6.376	0.000	155.05	9.775	1684.26	12300.2
6.300	1645.57	6.417	0.000	135.90	9.261	1693.46	12510.1
7.000	1652.41	6.429	0.000	121.28	8.940	1700.50	12691.0

LCF (longitudinal centre of flotation) : positiv abaft midship
TCF (transverse centre of flotation) : positiv to port side (Y>0)
KML (longitudinal metacentre) : positiv upwards from base line
KMT (transverse metacentre) : positiv upwards from base line

DRAUGHT T metres	KN metres	Cb Block	Cw Waterplane	Cm Amidship	Cp Prismatic	LENGTH AT WATERPLANE metres
		(coefficients are based on Lpp,Bmdl and T)				
2.800	0.000	.606	.769	.836	.724	90.87
3.500	0.000	.643	.812	.869	.740	93.36
4.200	0.000	.675	.862	.891	.757	93.81
4.900	0.000	.706	.938	.906	.779	94.21
5.600	0.000	.740	.981	.918	.806	94.57
6.300	0.000	.767	.986	.927	.828	94.91
7.000	0.000	.790	.991	.934	.846	95.23

KN (cross curve of stability : GZ= KN-KG*SIN(angle of heel))

HYDROSTATIC DATA ARE STORED ON FILE :GENA

```
*  **  *   *    ------------------------------------    *  **  *   *
* *    *   *         ISH STYRKE - BASIC PROGRAMMEL      * *    *   *
*  **  *****     DEPARTMENT OF OCEAN ENGINEERING        *  **  *****
*    * *   *   THE TECHNICAL UNIVERSITY OF DENMARK      *    * *   *
*  **  *   *           DK 2800  LYNGBY                  *  **  *   *
----------------------------------------------------------------------
*                     HYDROSTATIC DATA
* BUILDERS:JOHN GENART                                               *
* IDENTIFICATION:SILVER SEARAMBLER        PROGRAM FILE : HYDRO       *
* DATE: 4 JULY 86   INITIALS: JOHN GE     VERSION FEBRUARY 1986      *
                                          DATA FILE: GEN             *
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MAIN PARTICULARS :

LENGTH between perpendiculars (Lpp)	87.800	metres
BREADTH moulded at DWL ......(Bmld)	19.000	metres
DEPTH to highest point of shear ...	15.000	metres
DRAUGHT moulded at DWL ......(Tmld)	5.600	metres
LONGITUDINAL COORDINATE AT A.P. ...	0.000	metres
LONGITUDINAL COORDINATE AT AMIDSHIP	43.900	metres
LONGITUDINAL COORDINATE AT F.P. ...	87.800	metres
DENSITY OF SEA WATER	1.025	t/m^3
HULL ALLOWANCE SPECIFIED	1.004	
TRIM (draught(AP) - draught(FP)) ..	0.000	metres
NUMBER OF DRAUGHTS USED	5	
LOWEST DRAUGHT	4.000	metres
HIGHEST DRAUGHT	7.200	metres

THE SECTIONAL DATA ARE STORED ON FILE GENHY2

DRAUGHT T metres	VOLUME moulded metres^3	DISPLACEMENT sea water t	LCB metres	TCB metres	KB metres	WETTED SURFACE projec. metres^2	true
✓ 4.000	4443.32	4572.62	-2.025	0.000	2.235	1730.96	0.00
✓ 4.800	5618.95	5782.46	-1.049	0.000	2.688	1984.31	0.00
✓ 5.600	6908.78	7109.83	.242	0.000	3.156	2214.67	0.00
✓ 6.400	8230.33	8469.83	1.257	0.000	3.612	2373.21	0.00
7.200	9561.98	9840.23	2.017	0.000	4.054	2532.77	0.00

LCB (longitudinal centre of buoyancy) : positiv abaft midship
TCB (transverse centre of buoyancy) : positiv to port side (Y>0)
KB (VCB, vertical centre of buoyancy) : positiv upwards from base line

DRAUGHT T metres	WATERPLANE AREA metres^2	LCF metres	TCF metres	KML metres	KMT metres	DISPLA./ DRAUGHT t/m	MOMENT TO CHANGE TRIM t*m/m
4.000	1399.51	1.109	0.000	158.74	10.264	1440.24	8150.9
4.800	1535.00	4.141	0.000	160.49	9.889	1579.67	10392.9
5.600	1636.63	6.376	0.000	155.05	9.775	1684.26	12300.2
6.400	1646.40	6.418	0.000	133.54	9.203	1694.31	12534.3
7.200	1655.08	6.431	0.000	117.82	8.884	1703.24	12750.9

LCF (longitudinal centre of flotation) : positiv abaft midship
TCF (transverse centre of flotation) : positiv to port side (Y>0)
KML (longitudinal metacentre) : positiv upwards from base line
KMT (transverse metacentre) : positiv upwards from base line

DRAUGHT T metres	KN metres	Cb Block	Cw Waterplane	Cm Amidship	Cp Prismatic	LENGTH AT WATERPLANE metres
		(coefficients are based on Lpp,Bmdl and T)				
4.000	0.000	.666	.839	.885	.752	93.69
4.800	0.000	.702	.920	.904	.776	94.15
5.600	0.000	.740	.981	.918	.806	94.57
6.400	0.000	.771	.987	.928	.831	94.95
7.200	0.000	.796	.992	.936	.851	95.33

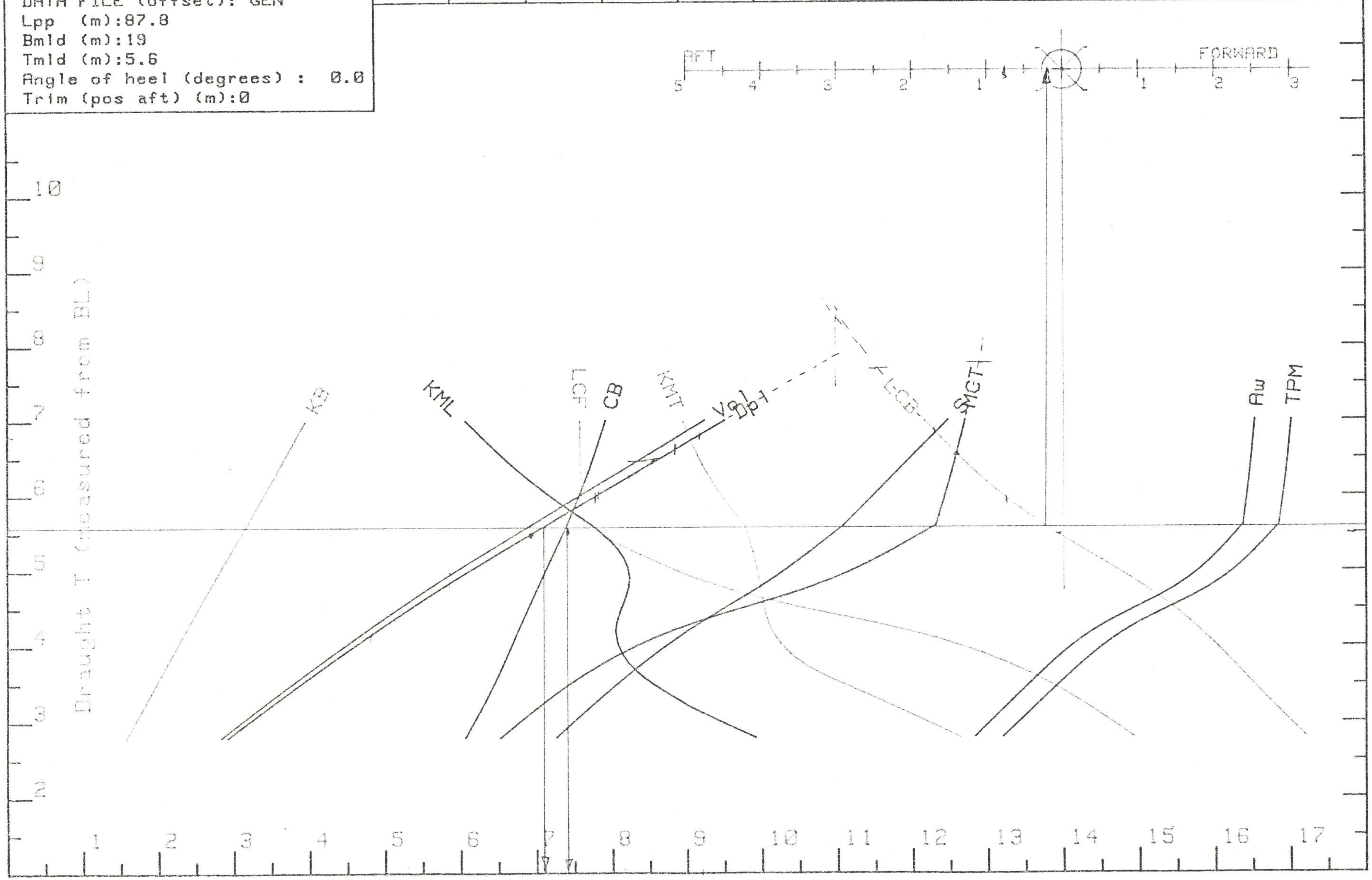
KN (cross curve of stability : GZ= KN-KG*SIN(angle of heel))

HYDROSTATIC DATA ARE STORED ON FILE :GENHY3

ISH-hydrostatic curves	T	Vol	Dpl	LCB	KB	S	Aw	LCF	KML	KMT	TPM	MCT	CB
	1	1000	1000	1	1	200	100	1	20	1	100	1000	.1
	m	m^3	t	m	m	m^2	m^2	m	m	m	t/m	tm/m	

tons per meter

DATE:
DATA FILE (offset): GEN
Lpp (m):87.8
Bmld (m):19
Tmld (m):5.6
Angle of heel (degrees) : 0.0
Trim (pos aft) (m):0



8.3.

THE FREEBOARD CALCULATION

This calculation has been performed in regard of the International Convension of Load lines, 1966. I was helped by Professor Harvald.

The aft deck hatch on the shelterdeck is closed during sailing and the SDC I bell room on main deck is also closed by a waterproof hatch over the moon pool during sailing. Therefore, the ship is defined as a closed shelter-decker allowing a higher load line.

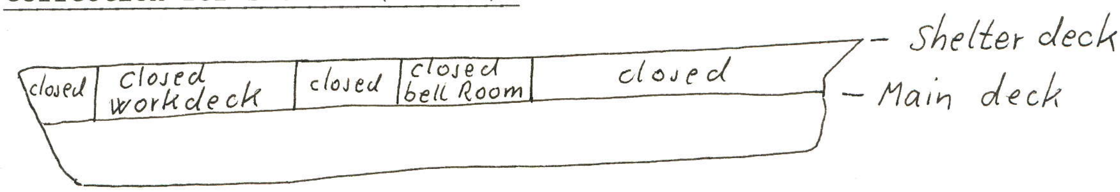
$L = 87.8$ m. $B = 19.0$ m. $D_t = 7.0$ m.

$d_t = 0.85 \times 7.0 = 5.95$ m.

Displacement at d_t is 7650 tons

curved deck = 19.0/50 = 0.38 m.

Correction for shelter (closed):



Normal hight of shelter = 2.29 m.

This hight of shelter = 4.00 m.

dh = 1.71 m.

Correction for draught D_t = 7.0 m.

$L/15 = 87.8/15 = 5.85$ m.

$D_t - L/15 = 1.15$ m.

$L/3.96 = 87.8/3.96 = 22.17$ m. $> R = 20$ m.

$8.33 \times 1.15 \times 20$ m = 0.192 m.

Sheer spring calculation:

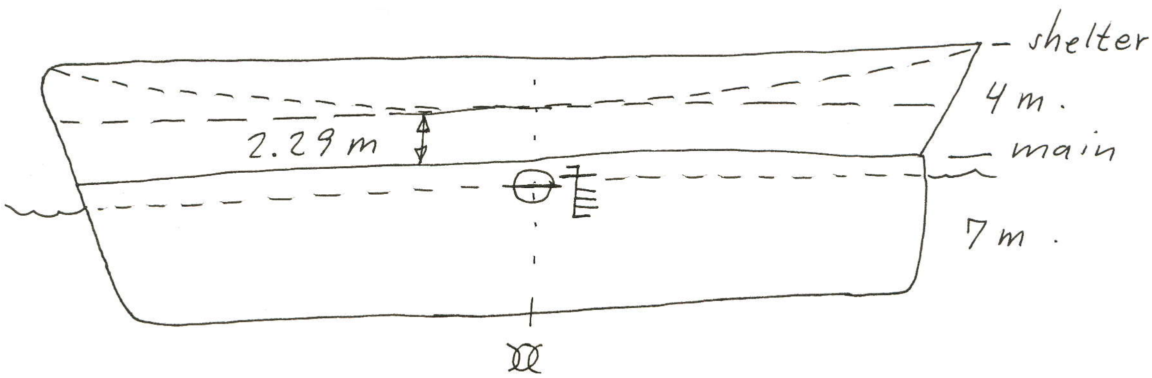
S_a = aft sheer $S_f = 2 \times S_a$ = fore sheer

$S_a = 8.33 \times L + 254 = 8.33 \times 87.8 + 254 =$ 0.985 m.

$1/18 \times P_1 = S_a/2 = 0.985/2 = 0.493$ (area relationship)

$1/18 \times P_2 = 1/3 \times (dh + B/50) = 1/3 \times (1.71 + 19/50) = 0.697$

$K = 1/18 \times P_2 - 1/18 \times P_1 = 0.697 - 0.493 = 0.204$ m.



Correction for superstructures (shelter) of motorships:

Fixed value.................................. - 1.067 m.

Correction for sheer:

S = length of shelterdeck = 97.0 m.

$S/(2 \times L) = 97.0/(2 \times 87.8) = 0.55$ max 0.5.

Correction = $K \times (0.75 - S/(2 \times L)) = 0.204 \times (0.75 -$ ~~0.55~~ 0.5$)$ = ~~0.041~~ m.
= 0.0408 m.
negative

Freeboard from table for L = 87.8 m.:.........1.030 m.

Final calculation of freeboard:

Table:..1.030 m.
Correction for D_t:................................0.192 m.
Correction for shelter:........................-1.067 m.
Correction for sheer:.............................÷0.041 m.

Summer freeboard:.................................~~0.196~~ m.
0.114 m. > 0.05 ok!

Moulded draught:	7.000 M.	7.000
Summer freeboard:	0.196 m.	0.114
Max allowed draught:	6.800 m.	6.886 m. → 9400 t.

At this draught the displacement is 9200 t according to the hydrostatic curve diagram.

8.4.

CALCULATING THE LIGHT SHIP WEIGHT

I will define the light ship weight as consisting of the following components:

1) The steel weight
2) The outfit weight
3) The machine weight
4) The weight of the diving system

The lost bouyancy due to the moon pools filled with sea water will be included in the outfit calculation. The lost bouyancy due to the fore tunnel thrusters which are filled with sea water is included in the machine calculation. This is done because the moon pools will be filled with water all the time according to the draught and the tunnels will be filled all the time. Therefore, the dead weight is not affected by these properties - they are relative constant and should therefore not be included in the dead weight which can be changed.

In order to get proper information about the methods and the weights of a similar diving ship I visited the ships warft "Dannebrog" in Aarhus, Denmark, and talked with the engineer Niels Levinsen. I received vital information about the subject and Niels showed me the warft and the building berth (145 x 21.6 meters) where the one of the two diving vessels for a Dutch customer (owner DIFKO) were being built. I can use the weight information of these ships for my weight calculation, but with the following exceptions:

1) The diving system (the "dannebrog" ship is equipped with a system from Offshore Marine Engineering and my ship is with a Dräger system).
2) A heavy duty lift has been introduced.
3) An electric-hydralic dynamic mooring system has been introduced.
4) A CO2 station has been introduced.
5) Hydraulic fire/noise/water doors has been introduced.
6) A huge heli fuel tank has been introduced.

THE STEEL WEIGHT:

Bridge/wheel house:	tons	x	z
(9 m/9 m) x (34 m/18 m) x 40 tons =	75	54	28
Fire Bridge, aft 7 t x 4/3 pce. =	10	41	31
Fire Bridge, fore 7 x 1/3 pce. =	2	71	31
Funnels, 24 t x 15/11 m. =	33	68	25
House, ACC III deck: 30 t x 27/19 m x 9/9 m =	43	53	25
House, ACC II deck: 55 t x 27/35 m =	43	53	22
House, ACC I deck: 55 t x 33/35 m =	52	51	19
Heliplatform (excl. pillars)	25	83	18
Support of heliplatform	3	83	17
Heli fuel tank (3 x 6 m3 = 18 m3) 2 x 4 x 2.25, surface 43 m2 0.01 m thickness x 43 m2 x 8 t/m3 holders 0.56 t	4	85	16
Superstructure deck: shell, $35 \times \frac{(2 \times 50 + 2 \times 7 + 5 + 2 \times 10)\ m2}{(2 \times 36 + 18 + 2 \times 24)\ m2}$	35	58	16
inside, the same calculation	32	58	16

	tons	x	z
Shelter deck:			
shell, $36 \times \frac{4 \times (2 \times 75 + 19)\ m2}{6 \times (2 \times 50 + 18)\ m2}$	34	55	12
Inside, 60 x 62/37 m	100	55	12
Various pillars, channels, reinforcements: $15 \times \left(\frac{87.8}{75}\right)^2 \times \left(\frac{19}{18}\right) \times \left(\frac{6.00}{5.50}\right)^{0.33}$	22	48	14
Bulkwark, aft, 15 t x 1	15	0	11
Bulkwark, fore, 15 t x 2 x 35/(2x14 + 18)m	23	83	15
Hull Beam, $1040\ t \times \left(\frac{87.8}{75}\right)^2 \times \left(\frac{19}{18}\right) \times \left(\frac{6.00}{5.50}\right)^{0.33}$	1560	49	6
F.C.L. decks, 70 t x 72 x 19/48 x 18 m2	110	55	14
The steel weight	2221	51	9.6

8.5.

THE WEIGHT OF THE OUTFIT:

	tons	x	z
The accomodation area on the superstructure deck of the no. 188 "Dannebrog" is similar to both the ACC I, ACC II and ACC III on my ship in regard of furniture, etc.			
Accom, furniture etc. bridge	12	53	28
-------------------- ACC III	19	53	25
-------------------- ACC II	19	53	22
-------------------- ACC I	19	53	19
-------------------- Super	10	72	16
-------------------- Shelter	13	70	16
-------------------- Main	5	50	8
-------------------- tank top	1	50	4
Galley, pantry, dishwash, etc.	4	76	10
Wood deck, aft, 21 t x (80 + 324) m2/504 m2	17	10	8
Hatch cover, workdeck, 5 t x 80/12.25 m2	33	5	10
Hatch cover, aft moon pool, top	5	33	7
Hatch cover, bottom moon pool, fore	9	51	0
Hatch cover, bottom moon pool, aft	8	33	0
Ladders, extern 70 m/20 m x 3 t	10	40	17
Gangways, 2 t x 181 m /130 m	3	58	24
Various wooden equipment	4	45	12

	tons	x	z
High holding power anchors, aft	8	-8	8
High holding power anchors, fore	8	88	12
Anchor stowage, extern, aft, 2 x 0.5	1	-8	8
Anchor stowage, ectern, fore, 2 x 0.5	1	88	12
Windlass, 2 x 15	30	86	15
Wire, fore, 2 x 1500 m x 49ø, 25 x 1886/1520 mm2	31	85	13
Wire, aft (the same)	31	6	9
Mooring wires, reels, tows, etc	6	44	12
Mooring pollards, rollers, chocks, etc.	5	44	12
Masts	2	59	34
Capstans	5	0	11
Cranes, 5 t x 2 pce. (incl. steel)	16	31	17
Cranes, 2 x 60 t, (incl. steel)	120	15	14
MOB-boats incl. davits, 2 x 3 t	6	27	13
Life boats, closed, incl. davits 4 pce.	34	56	20
Life rafts, belts, bouys	2	34	12
Hydraulic pump units	2	44	10

	tons	x	z
Steel/tyre fenders	20	53	12
Side doors in each hull side, 2 x 4 t x 20.4 m2/13.5 m2	12	51	10
A-frame cranes, 2 x 3 t	6	51	9
Cargo lashing equipment	1	23	8
Travell crane, diving area (excl. steel)	1	56	15
Roll Damp tank, machine, pipes, valves	3	48	3
Railing, top eheel house/fire bridge, 2 t x 88/60 m (0.034 t/m)	3	53	30
Railing, bridge deck, 2 x 30 x 0.034	2	53	27
Railing, ACC III, (2 x 28 + 11) x 0.034	2	51	25
Railing, ACC II, (2 x 34 + 9) x 0.034	3	48	22
Railing, ACC I, (2 x 44 + 11) x 0.034	3	52	18
Railing, Superstructure, (2 x 25 + 11) x .034	2	27	16
Railing, Shelter Deck, (2 x 21) x 0.034	1	19	11
Manhole covers, w.t. slid doors, etc.	10	40	5
Navigation equipment/radio, etc.	5	43	28

	tons	x	z
Various equipment, tools, fittings,	5	51	13
Accom. float floor/vinyl, etc., Bridge deck, 4 t x 350/210 m2 (i.e. 0.02 t/m2)	7	53	27
Vinyl, ACC III, 0.02 x 200 m2	4	53	24
Vinyl, ACC II, 0.02 x 200 m2	4	53	21
Vinyl, ACC I, 0.02 x 225 m2	5	50	18
Vinyl, Super, 0.02 x 650 m2	13	60	15
Vinyl, Shelter, 0.02 x 750 m2	15	52	11
Vinyl, Main Deck, 0.02 x 800 m2	16	44	7
Vinyl, Tank Top, 0.02 x 50 m2	1	50	3
Tiles, galley, provisions, 5 t x 70/60 men	6	75	8
Laundries, etc, 3 x 70/60 men	4	75	8
Painting, 20 t x sideview area ratio, 2560/1350 m2	38	54	10
Air and sound pipes, 5 t x 1668/1350 m2	5	44	8
Pipes outside engine room,			
30 t x diving system weight ratio, 566 t / 300 t	57	42	10

	tons	x	z
Insulation, 22 t x (ship volumen pp) / (ship volumen pp)'			
= 18350 m3/(10800 m3) x 22 t	31	53	14
Ventilation, natural,	3	55	18
Vent, cowels, grids, ducts, fans,etc.	8	51	12
Vent, A/C transformer room,	8	64	10
Vent, diving area, 2 x 156 m2/126 m2,	3	42	10
Windows, bridge, 2 t x 49 pce/34 pce	3	48	29
Windows, ACC III, 1 t x 18/12	2	53	25
Windows, ACC II, --------	2	53	22
Windows, ACC I, 1 t x 20/12,	2	53	19
Sidelights, main deck	1	60	9
Sidelights, shelter deck,	1	65	13
El-installations, cables, lamps, trays, boards, etc. 2 t x 3360 KW/2150 KW	3	55	11
Taut wire winches, 2 x 2 t	4	21	11
Dynamic pos. system, computer, etc,	2	44	28
Laundry machines,	1	76	8
Drencher system, dive area, aft,	1	30	6
Drencher system, dive area, fore	1	54	10

	tons	x	z
Drencher system, dive area, ROV,	1	54	6
Drencher system, sheltered work deck,	1	6	6
Var. equipment, founds, etc.	3	56	14
CO2-station, bottles, etc. 30 pce. (45 kg CO2 each), 30 x 114 kg	4	37	16
two pce. mooring winches, aft	30	-4	9
Two pce. mooring winches, fore	30	94	13
Special el-hydraulic doors, noice, fire, waterproof, etc. ---------------, bridge none,			
---------------, ACC III, 1 pce.	1	67	25
---------------,ACC II, 1 pce.	1	67	21
---------------, ACC I, 3 pce.	3	60	19
---------------, Super, 2 pce.	2	69	16
---------------, Shelt, 5 pce.	5	54	12
----------------, main, 9 pce.	9	51	8
---------------, tank top, 9 pce.	9	43	4
Lift, 1 x 1.5 t + 1.5 t	3	69	11

	tons	x	z
Main staircase, 2.5 m stairs and 5 m gangways, per deck, 5 + 5 m = 10 m per deck, 0.2 t/m x 10 m x 7 decks	14	69	15
Moon Pool, lost bouyancy, aft, 0.95 x 3.5 x 3.5 x 6 x 1.025	71	34	3
Moon pool bouyancy loss, fore, 0.9 x 4.7 x 4.7 x 6 x 1.025	122	51	3
Total weight of outfit:	1138	42.6	11.5

8.6.

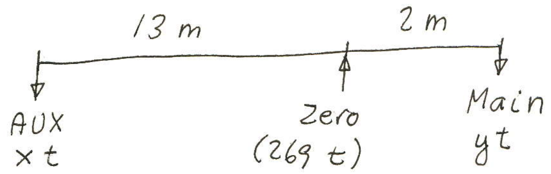
CALCULATING THE WEIGHT OF THE MACHINES

	tons	x	z
4 Diesel generators, 4 x 59.8	240	60	4
2 propulsion thrusters, 2 x 60.6	121	0	3
2 gears (1800/700 RPM) 2 x 3	6	5	5
2 el-engines for prop. 2 x 10	20	10	5
3 transv. thrusters, 3 x 7.45	23	77	2
3 el-engines (3 x 1000 KW), 3 x 3.3	10	77	5
3 transvers holes lost bouyancy:			
1.025 x (1 x pi x 11.5) - 2	35	74	2
1.025 x (1 x pi x 10.0) - 2	30	77	2
1.025 x (1 x pi x 9.0) - 2	27	80	2
1 Emergency diesel-generator (530 KW)	15	36	19
1 incinerator machine	4	69	8
2 boilers, exchaust-fired, 2 x 1.5	3	70	5
5 transformers,			
4600 v, 440v, 220 v, 1000 v, 660 v	18	64	8
2 FI/FI pumps, 2 x 3600 m3/h	15	42	16
4 monitors, aft bridge	5	41	31
1 monitor, fore bridge	1	70	31

	tons	x	z
Water pipes, monitors,			
12/26 = 0.5 t/m,			
0.5 x 31 m, aft FI/FI	16	41	15
0.5/4 x 29 m, fore FI/FI	4	55	30
Exchaust pipes, silensers, etc.			
15 t x 3360 KW/2150 KW	28	68	18

Auxhiliary machine calculation:

"Dannebrog" No. 188:



1) $13x = 2y$

2) $x + y = 269\ t$

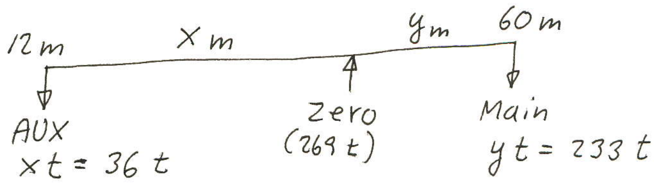
$x = 2/13\ y$

$2/13 y + y = 269$

$15/13\ y = 269$

$y = 233 t \qquad x = 269 - 233 = 36 t$

Searambler:



1) $36x = 233y$

2) $x + y = 48\ m$

$x = 233/36\ y$

$y + 233/36\ y = 48$

$y = 6.4\ m$

$x = 48 m - 6.4 = 41.6\ m \rightarrow 41.6 + 12 = \underline{\underline{54\ m}}$

Now, the placement of the auxhiliary machine weights have been estimated in regard of the placement of the main machines on both "Dannebrog" no. 188 and Silver Searambler.

	tons	x	z
Switchboards for 4600 v, 1000 v, 660 V, 440 v, 220 v, 13 t x 3960 KW/2150 KW	24		
Switchboards for the gas compressors, etc.	3		
Cables, starters, el-equipment, etc. 12 t x 3960/2150 KW	22		
Pumps, compressors, purifiers, etc. eng. ventilation, 12.5 + 12.5 x 3960/2150	36		
Coolers, filters, FW-generator, tanks, vent. ducts, etc. 12.5 + 12.5 x 3960/2150	36		
Pipes in eng. room, refrigerator machines, etc. 15 + 15 x 3960/2150	43		
Floor plates, cranes, lifting gear, workshop, etc.	36		
Spare parts, tools, console, insul., alarm system, ejectors, sound syst., extinguisher, bilge w. sep., water and oil on systems,	36		
Total of auxhiliary machines	269	54	6
Total Machine weight	890	50.2	5.7

8.7.

THE WEIGHT OF THE DIVING SYSTEM

At Drägerwerke in Travemünde I received the component list of the diving system on the huge semisub "Safe Regalia". This list provides very accurate information about the weights of the components. Later on I received further informations about new additional components from Dräger. Also the weights of diving components from other vendors such as Bruker, Mannesmann, Hägglund etc. has been gained, so that the diving system weight can be quite accurate calculated:

	tons	x	z
DDC I (with ante chamber I)	25	41	8
Clamp + trunk to SDC I	1	36	9
DDC II (With two transfer chambers)	33	42	8
Clamp + trunk to SDC II	1	46	11
DDC III (with ante chamber III)	25	44	8
IUC adapter, 2 pce.	1	42	8
SDC I (Dräger bell)	10	34	9
SDC II (Bruker bell)	13	46	14
HBL I + II, 2 x 17 tons	34	39	17
HBL-trunk, 2 x 3 tons	6	41	14
Surface diving containers with DDCs	13	60	8
Umbilicals for surf. dive. 6 x 200 m.	1	60	8
Diving baskets incl. bottles, 2x0.6 t	1	51	8
Air compressor incl. gas tank	2	23	4
DDC, HBL and SDC control panels,			
3 x 650 kg			
2 x 400			
1 x 950			
1 x 450			
1 x 220	4	23	8
SDC control panels,			
2 x 500			
2 x 20			
1 x 220			
1 x 500	2	63	12

		tons	x	z
LSS central unit compressor		5	23	16
LSS conditioning, 3 x 1800 kg		6	41	12
Gas Control Panel		2	27	4
O2-control panel	0.28 t			
Bunkerstation, gas,	0.13 t			
He/O2 gasmixer	0.64 t			
Charging panels, gas				
4 pce. x 0.015	0.06 t	1	29	7
He-compressor 1600 kg				
120				
40				
85	2 t			
He-compressor	2 t			
He-compressor 1000 kg				
100				
85	1 t	5	22	4
DDC sanitary system,				
4 pumps, cold/hot water,	0.5 t			
waste water tanks, 4 x 0.15	2.0 t			
SDC and divers hot water,				
el-water heater, 2 x 0.35				
Switchboard, 2 x 0.30				
Water tank, 1 x 0.58				
pumps 3 x 0.27				
divers outlet 1 x 0.12				
circ. pump, 2 x 0.02				
heat exch. 2 x 0.12		4	40	12
E-switchboard, main diving		2	42	11
E-switchboard, emergency, incl.				
Launch system, HBL, 2 x 3 t		6	39	16
Umbilical winch, aft dive		6	21	12
Umbilical cord, 500 m, aft dive		3	21	12
Umbilical cord, 500 m, aft dive		3	58	16
Umbilical winch, fore dive		6	58	16

	Tons	x	z
Main bell winches, fore, 2 x 10	20	58	16
Main bell winch, aft, 1 x 10	10	34	12
2 guide wire winches, fore, 2 x 5	10	58	16
2 guide wire winches, aft, 2 x 5	10	34	12
3 heave compensators, aft, 3 x 7.4	22	26	12
4 heave compensators, fore, 4 x 7.4	30	53	16
Clumpweight, fore	8	54	10
Clumpweight, aft	5	33	7
Curoer + trolley, fore	15	46	15
Cursor + trolley, aft	10	34	10
Oxygen stowage (18 x 16 x 0.157)	46	25	16
Long He-tubes, 26 x 2294 kg	60	42	4
"small" He-tubes, 24 x 1300	31	32	4
2 IUC, chamber incl. trolley	1	42	8
He-reclaim	2	31	4
Gas bag	1	42	4
Sea crab vehicle, 4350 + 2 x 2000 kg	9	3	8
Sea Crab trolley	5	3	8
Sea Crab, el-umbilical, 500 m.	1	19	12
Sea Crab, umbilical winch	4	19	12
Sea Crab, control panel	1	22	8
ROV, 2 pce. x 1.588 kg	3	51	9
ROV, el-umbilicals, 2 x 1 ton	2	51	8
ROV, stowage, 2 x 0.5 t	1	51	8
ROV, control panels, 2 x 0.5	1	64	8
Heavy surf. dive. gear, 6 x 150 kg	1	64	8
Saturation dive. gear,			
18 suits x 20 0.36 t			
helmets, 18 x 15 0.27 t			
Michela., 18 x 25 0.45 t	1	44	8
CCBS control panels, 2 x 0.450 t	1	63	12
CCBS, compressors, 2 x 0.5	1	23	4
CCBS, filter station, 2 x 0.35			
CCBS, tank 2 x 0.80	2	40	12

	Tons	x	z
SUB sea tools (el-hydraulic)	4	30	10
6 surface dive. hot water supp.			
suits, 6 x 100 kg = 0.6 t			
Scuba diving equipment,			
10 x 40 kg = 0.4 t	1	46	12
1 container, surf. dive. with			
2 el-heated hot water units	6	59	8
2 containers, 36 x 50 ltr. gas tubes			
and compressor, 200 bars	13	59	8
Total weight of diving system	560	39.6	10.7

8.8.

INITIAL DEAD WEIGHT CALCULATION

The dead weight is the weight on board which can be easily manipulated, i.e. it is the weights which are not constant in all conditions or which can be changed if necessary.

From the tank calculation we know that there are appr. 3519 tons in the tanks when the fore and aft water ballast are not included.

In the following is a list of the remaining components of the dead weight except the tank-01 and tank-11. Note that the water which the moon pools and the thruster tunnels are carrying is not included in the dead weight becauce I find this to be appr. non manipulatable - it will always be there.

	Tons	x	z
He-gas, 18000 m3 (he/o2) x 0.169 kg/m3	4	39	4
O2-gas, 5760 m3 x 1.354 kg/m3	8	25	15
Crew, 70 x 150 kg (a part of provisions)	10	50	13
Heli-fuel, 3 x 6 m3 x 0.79 t/m3	14	86	16
Non tank Dead Weight	36	57.2	13.6
Tank Dead Weight	3519	43.5	6.7

8.9.

GETTING THE WEIGHTS TOGETHER AND TRIMMING THE SHIP

Now we know the light ship weight and the initial dead weight of the ship. From this we can calculate how much we need to trim the ship by using the fore and aft ballast tanks and perhaps also cement or cement-steel ballast. The aft and fore water ballast will then be added to the dead weight and the cement-steel ballast will be included in the light ship weight.

	tons	x	z
Machines	890	50.2	5.7
Outfit	1138	42.6	11.5
Diving equipment	560	39.6	10.7
Steel	2221	51.0	9.6
Initial weight of light ship:	4809	47.5	9.5
Dead weight from non tanks	36	57.2	13.6
Dead weight from tanks (excl. trim WB)	3519	43.5	2.8
Initial displacement	8364	45.9	6.7

Now, at displacement 8400 t we can see - from the hydrostatic diagram - that the draught is 6.4 meters. We can also see that the LCB (longship center of bouyancy) is 43.9 - 1.3 = 42.6 m.

The gravety center lies 45.9 - 42.6 = 3.3 meters in front of the center of bouyancy. This is not very good because the ship has a big negative trim (the nose sticks down). We need to add weight in the aft end of the ship and for this purpose we have the aft water ballast tank-01 which can contain 326 m3.

On the next page the trim balance equation is presented.

X = the needed aft ballast in tons in tank-01

$$(42.6 + 3) \times X = (45.9 - 42.6) \times 8364$$
$$45.6X = 27601 \text{ tm}$$
$$X = 605 \text{ t}$$

Now, we must calculate with this new increased displacement:

Displacement = 8364 + 605 = 8969 tons. The draught is here = 6.6 m. The bouyancy center is here: 43.9 - 1.4 = 42.5 m.

$$(42.5 + 3) \times X = (45.9 - 42.5) \times 8364$$
$$X = 625 \text{ tons}$$

This calculation showed only an increase of 4% of the ballast weight, it is below the calculation error limit. The aft ballast weight need will be set to be 600 tons. (it is also known that there will be more weight on the aft sheltered workdeck which I will return to later on).

We already know that the tank-01 can only contain 326 m3, so it is no use to fill it with seawater only - it could newer make up to 600 tons. The fore center bottom water ballast tanks could be used here in order to compensate, but I prefer to spare these tanks at this point of time. In stead I would like to use a cement-steel ballast in tank-01. I would like, however to use as little cement-steel as possible and seawater for the rest of the volume:

The density of stone (cement) is 2.3 t/m^3.
The density of steel is 7.8 t/m^3.

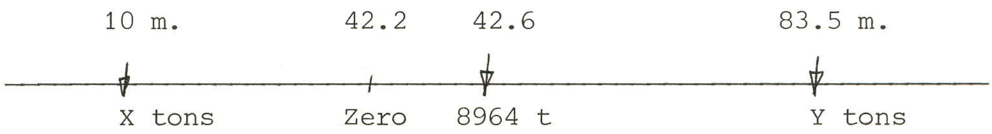
The steel will be low quality iron grains mixed in the cement which forms a concrete mass protected from too fast corrosion. There will be 75w/o steel and 25w/o cement, so the density of the cement-steel will be 6.43 t/m^3.

The volume of sea water in the aft ballast tank is X m^3.
The volume of cement-steel in the same tank is Y m^3.

$$X \times 1.025 + Y \times 6.43 = 600 \text{ t}$$
$$X + Y = 326 \text{ m}^3$$
$$Y = 326 - X$$
$$1.025X + (326 - X)6.43 = 600$$
$$1.025X + 2096 - 6.43X = 600$$
$$5.405X = 1496$$
$$X = 277 \text{ m}^3 \quad (284 \text{ t})$$
$$Y = 49 \text{ m}^3 \quad (315 \text{ t})$$

The ship is now trimmed at displacement = 8964 t, x =42.6 Z = 6.6
The draught is here 6.6 meter.

Now, the ship is loaded for the start of mission, but can take on even more weight before the maximum allowed draught of 6.8 meter is reached. As you already know the maximum displacement at this draught is 9200 tons. This gives us 9200 - 8964 = 236 tons. The center of bouyancy x is here 43.9 - 1.7 = 42.2 meters. The additional weight can, however, not be placed abowe this center. If the weight is placed on one of the workdecks it would mean that the fore water ballast tank would be used to trim the ship. This "trim-water" together with the workdeck load must not exceed the 236 tons:



1) $(42.2 - 10)X = (42.6 - 42.2)8964 + (83.5 - 42.2)Y$

2) $X + Y = 236, \quad X = 236 - Y$

Y = 54 tons in the fore water ballast tank-11
X = 182 tons, the maximum work-deck load in this condition.

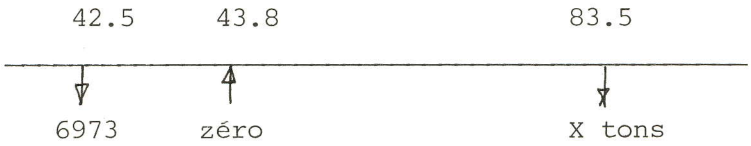
	Tons	x	z
Start of mission condition	8964	42.6	6.6
Deck load, extra	182	10.0	8.0
Water ballast in tank-11	54	83.5	7.0
full load condition	9200	42.2	6.6

During the mission the fuel oil, the breathing gas, and the heli-fuel will be used. The provisions has been included in the outfit calcualtion due to the belive that the tara weight will still be there, the garbadge, the sewage etc. and some new provisions will be sailed or flown by helicopter to the vessel on worksite. The reductions consists of:

He-gas	4	39	4
O2-gas	8	25	15
Heli-fuel	14	86	16
02	22.6	5	6
12	53.6	4	2.8
22	22.6	5	6
03	21.6	9	6
13	214.5	15	3
23	21.6	9	6
06	150.5	42	5
16	601.2	42	1.8
26	150.5	42	5
08	70.6	60	5
18	565.4	60	1.8
28	70.6	60	5
Deductions due to use	1991 t	43.1	3.01

	Tons	x	z
Start of mission condition	8964	42.6	6.6
Deductions due to use	1991	43.1	3.01
Initial end of mission cond.	6973	42.5	7.6

The displacement of 6973 tons gives a bouyancy center of 43.9 - 0.1 = 43.8 meter, that is in front of the gravety center so that the ship is too light in the fore end. The front water ballast tank-11 will be used to trim the ship:



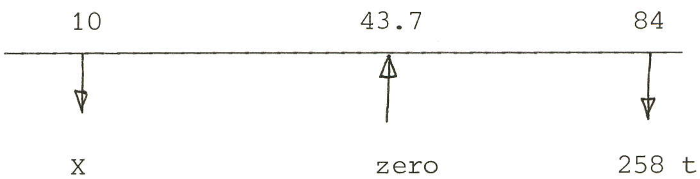
$$(43.8 - 42.5)6973 = (83.5 - 43.8)X$$

X = 228 tons in the fore water tank-11

The displacement is now 6973 + 228 = 7201 tons, which means that the bouyancy center has crawled further behind, so that a litte less weight in the fore tank-11 is actually needed, but the change is not that big.

End of mission condition	7201	43.7	7.6

The appr. remaining capacity of the fore water ballast tank-11 is 494 m3 x 1.025 x 0.96 - 228 = 258 tons. The possible load which we can have on the work deck in this condition using only the tank-11 to trim the ship can be calculated:



$$(43.7 - 10)X = (84 - 43.7)258$$
$$X = 309 \text{ tons load}$$

Now the displacement is 7201 + 258 + 309 = 7768 tons. the draught is here 6.0 meter, and the bouyancy center = 43.9 - 0.7 = 43.2 m, compared with the center of gravety at 43.7 meter . The ship is a little too heavy in the front, and a new iteration has to be performed in order to find the correct result. However, the improvement in the result will not change the possible weight that we found to be on the work deck very much.

The final results:

	Tons	x	z
Start of mission condition (draught = 6.6 meter)	8964	42.6	6.6
Start of mission with max load (draught = 6.8 meter)	9200	42.2	6.6
End of mission condition (draught = 5.65 meter)	7201	43.7	7.6
End of mission with max. load (draught = 6.1 meter)	7768	43.7	7.6

8.10.

CALCULATION OF THE TANK CAPACITIES

The tank design has initially been choosen by a rough calculation to meet the need for water ballast, fuel oil, rool damping, fresh water and heel stabilizing (crane stabilizing). The initial lay-out was performed to ensure that the distribution in rough numbers of the volume or rather the tonnage was somewhat equally distributed around the center of the ship.

The fresh water tank is belived to be full all the time due to an efficient fresh water generator. The density of fresh water is set to be 1.00 t/m3.

The fuel oil tank is belived to be full at mission start and al most empty at the end of the mission. They are equally distributed around the center of the ship. A rough initial calculation stated that the need of fuel oil per mission would be around 2000 m3, so the tank capacity has been set in total in regard to this. The density of marine fuel oil differs, however, from harbour to harbour, but is belived to be 0.98 t/m3. The service tank (settling tank), which is supposed to be at least in the hight level of the diesel engine room is placed in the side tank of the engine room. The American Bureau of Shipping is the classification society which has the most severe demands to the amount of m3 or tons of fuel oil. They states, that there is going to be enough fuel for a 24 hours engine run time at full work load (in case of a centrifugal separation breakdown). The day tank is much larger here (as long as there is enough space it is no problem to design the tank big - and the settling function will be even better.

The crane/heel stabilizing tanks capacity was initially calculated to meet the requirement of one crane working with maximum torque over board (60 tons). This is belived to be the maximum torque needed during operation. When both cranes are put into action it is possible to outbalance the two cranes. The ships stability torque (the GZ-arm) is bigger, but a need for no heeling is a desire.

The waterballast aft and fore has been chosen initially with about 45% in the aft section and 55% in the fore section (trim stab. tanks) due to a need for more work deck stabilizing ballast. The rool damping tanks which is placed in each side of the ship and connected through bottom tanks in separate pipes make way for the use of additional water ballast tanks in the centerline of the ship - almost equally distributed around the center of the ship.

The rool damping tanks themselves has been provided with the tank capacity left over. The efficiency of a rool damping tank do not only depend on the capacity envolved but also the efficiency of the rool damping pump system introduced. I will relate to this subject later.

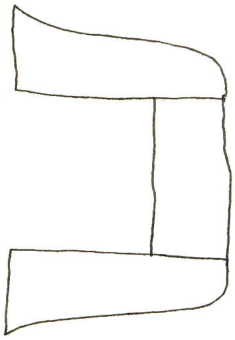
The stabilizing tanks, the water ballast tanks and the rool damping tanks all contain sea water with the density belived to be 1.025 t/m3.

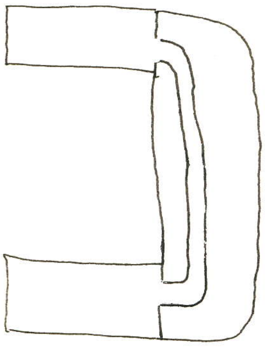
The Rool damping and Crane stabilizing tanks are all belived to contain half of the possible water volume on zero heel.

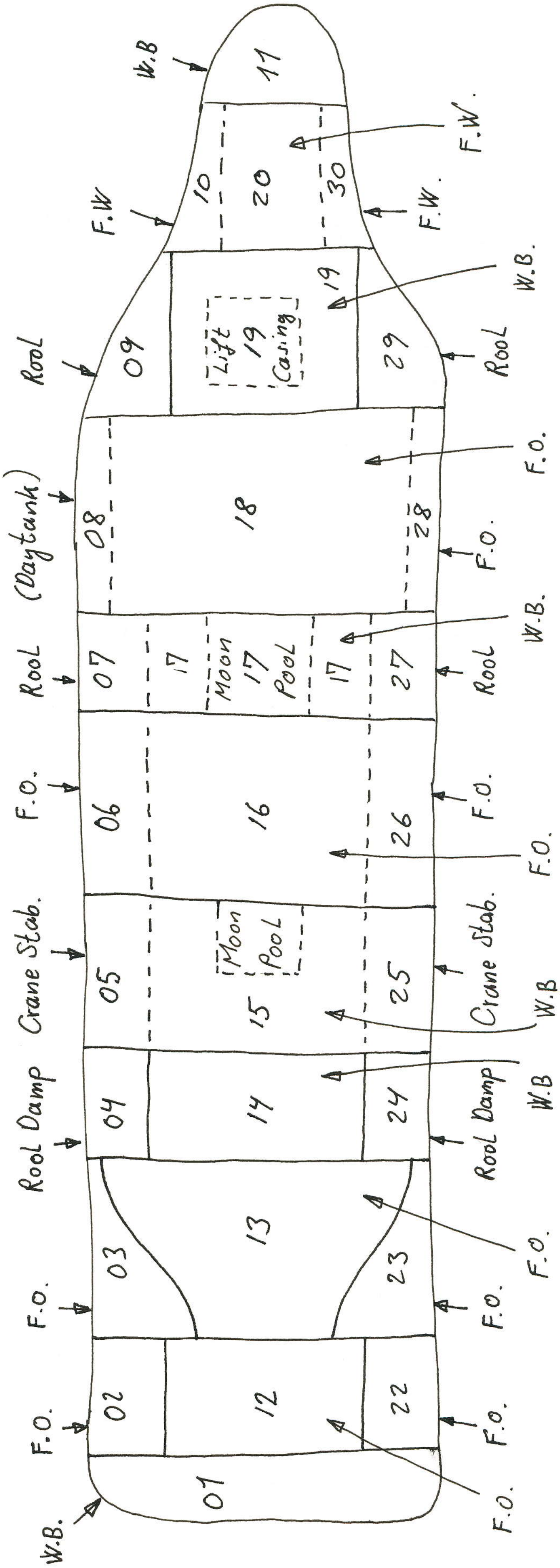
There are 29 tanks, numbered from 01 to 30. (the use of number 21 is omitted due to a more systematical numbering). The number 01-tank is the aft water ballast tank, the 11-tank is the fore waterballast tank, the 0X-tanks are all placed in the port side of the ship, the 1X-tanks are all placed as centertanks in the double bottom of the ship and the 2X-tanks are placed to the starboard side of the ship.

The tanks no. 14, 15, 16, 17, 18 and 20 are measured from side to side of ship, where the tanks no. 12, 13, 14 and 19 are limited by the side tanks.

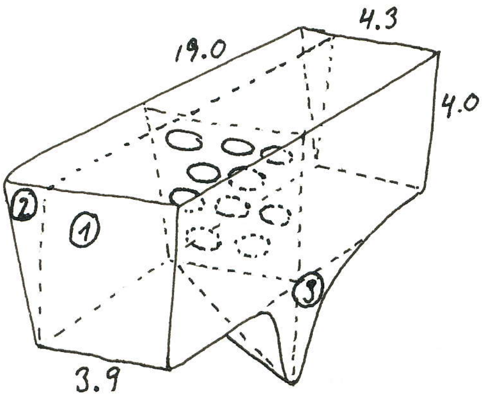
In measuring the tank dimensions the moulded lengths are used. Therefore, it is necessary to deduct the volume of bulkheads, pipes, valves, reinforcements, primer, anticorrosion paint etc. It has been evaluatet that the deduction is 4% of the tank volume. In tank no. 15 and 17 the moonpool volume has been deducted, in tank no. 19 the lift shaft room has been deducted and in tank no. 10, 20 and 30 the tunnels of the thrusters has been deductet.





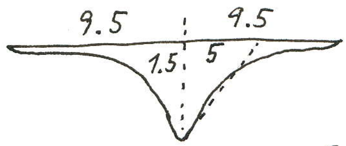

01
02
12
22
03
13
23
04
14
24
05
15
25
Moon Pool
06
16
26
07
17
Moon 17 Pool
27
08
18
28
09
Lift 19 Casing
19
29
10
20
30
11
W.B.
F.O.
F.O.
F.O.
Rool Damp
Crane Stab.
F.O.
Rool
(Daytank)
Rool
F.W
W.B
F.W.
F.W.
W.B.
Rool
F.O.
F.O.
W.B.
Rool
F.O.
F.O.
Crane Stab.
W.B
Rool Damp
W.B
F.O.
F.O.
F.o.
F.O.

TANK-01:



$$3.9 \times 4 \times 19 = 296 \text{ m}^3 \quad ①$$

$$\frac{(4{,}3 - 3.9) \times 4 \times 19}{2} = 15 \text{ m}^3 \quad ②$$

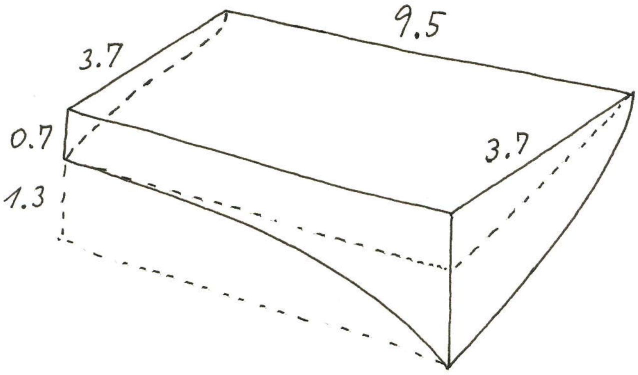


$$5 \times 1.5 = 7{,}5 \text{ m}^2$$

$$\frac{3{,}9}{2} \times 7.5 = 15 \text{ m}^3 \quad ③$$

$$① + ② + ③ = 296 + 15 + 15 = \underline{\underline{326 \text{ m}^3}}$$

TANK-02: and TANK-22:

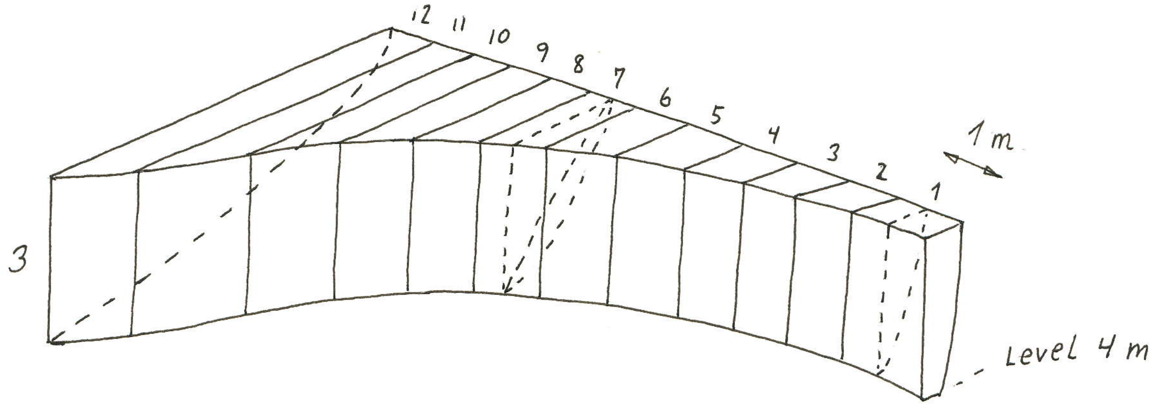


$$\frac{0.7 \times 3.7 \times 9.5}{2} = 12{,}3 \text{ m}^3$$

$$\frac{1.3 \times 3.7 \times 9{,}5}{2 \times 2} = 11.4 \text{ m}^3$$

$$11.4 + 12.3 = \underline{\underline{24 \text{ m}^3}}$$

TANK - 03 and TANK - 23



1) $\frac{1 \times 3 \times 0.2}{2} = 0.30\ m^3$ 2) $\frac{1 \times 3 \times 0.25}{2} = 0.38\ m^3$

3) $\frac{1 \times 3 \times 0.3}{2} = 0.45\ m^3$ 4) $\frac{1 \times 3 \times 0.4}{2} = 0.60\ m^3$

5) $\frac{1 \times 3 \times 0.5}{2} = 0.75\ m^3$ 6) $\frac{1 \times 3 \times 0.62}{2} = 0.93\ m^3$

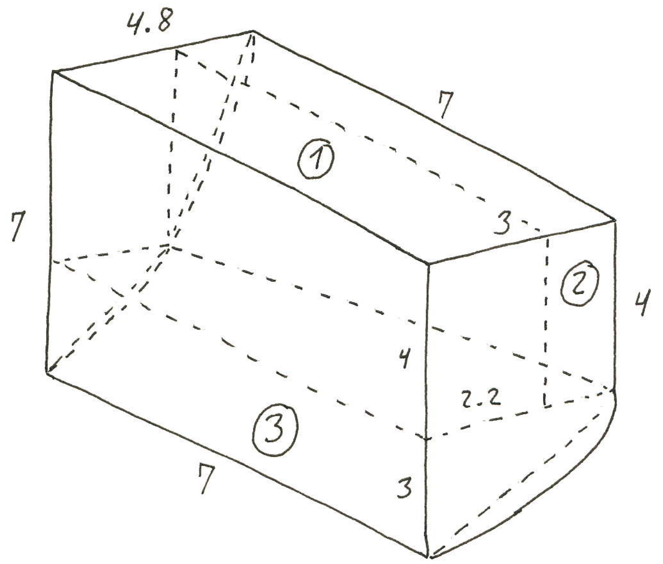
7) $\frac{1 \times 3 \times 0.8}{2} = 1.20\ m^3$ 8) $\frac{1 \times 3 \times 1.05}{2} = 1.58\ m^3$

9) $\frac{1 \times 3 \times 1.3}{2} = 1.95\ m^3$ 10) $\frac{1 \times 3 \times 1.85}{2} = 2.78\ m^3$

11) $\frac{1 \times 3 \times 2.6}{2} = 3.90\ m^3$ 12) $\frac{1 \times 3 \times 4.0}{2} = 6.00\ m^3$

$\sum_{1}^{12} = 21\ m^3$ $1.1 \times 21\ m^3 = \underline{\underline{23\ m^3}}$

TANK - 04 and TANK 24



$2.2 \times 4 \times 7 = 61.6\ m^3$ ①

$\frac{3.0 \times 2.2}{2} = 3.3\ m^2$ $\frac{3 \times 2.2}{2} = 3.3\ m^2$

$1.1 \times 3.3 = 3.6\ m^2$ $1.2 \times 3.3 = 4.0\ m^2$

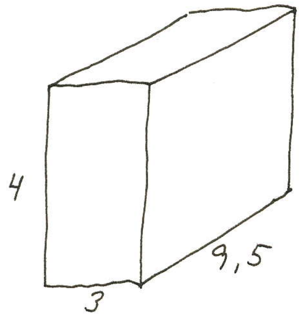
$\frac{3.6 \times 4}{2} = 3.8\ m^2$

$7 \times 3.8 = 26.6\ m^3$ ③

$\frac{0.8 \times 4 \times 7}{3\sqrt{2}} = 17.8\ m^3$ ②

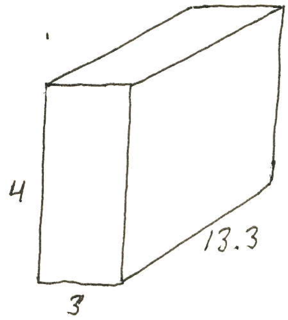
① + ② + ③ = $61.6 + 17.8 + 26.6 = \underline{\underline{106\ m^3}}$

TANK-05 and TANK 25:



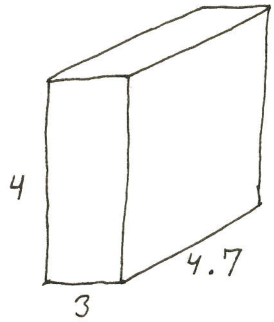
$4 \times 3 \times 9.5 = 114\ m^3$

TANK-06 and TANK-26:



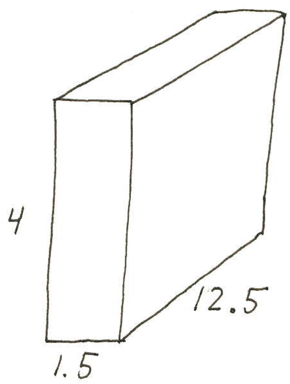
$4 \times 3 \times 13.3 = 160\ m^3$

TANK-07 and TANK-27:



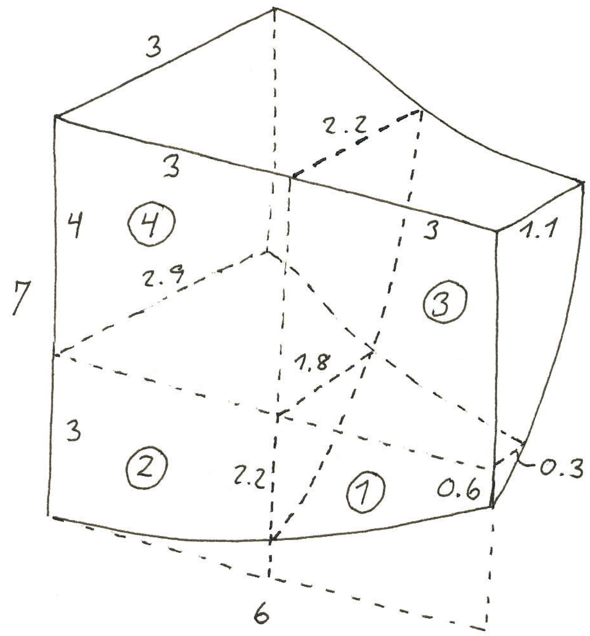
$4 \times 3 \times 4.7 = 56.4\ m^3$

TANK-08 and TANK-28:



$4 \times 1.5 \times 12.5 = 75\ m^3$

TANK 09 and TANK 29 :



$$\frac{0.6 \times 0.3}{2} = 0.09\ m^2 \qquad \frac{2.2 \times 1.8}{2} \times 1.1 = 2.18\ m^2$$

$$\frac{2.18 + 0.09}{2} \times 3 = 3.4\ m^3 \quad (1)$$

$$\frac{3 \times 2.9}{2} \times 1.4 = 6.09\ m^2$$

$$\frac{2.18 + 6.09}{2} \times 3 \times 1.1 = 13.65\ m^3 \quad (2)$$

$$1.1 \times 3 + \frac{3 \times 1.1}{2} = 4.95\ m^2$$

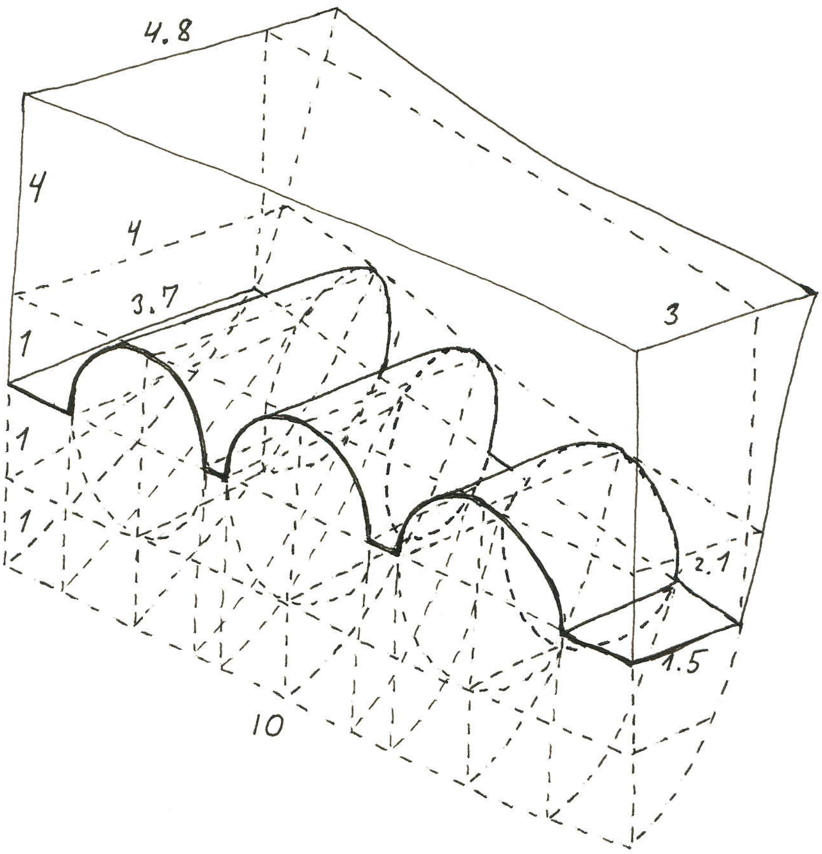
$$0.3 \times 3 + \frac{1.5 \times 3}{2} = 3.15\ m^2$$

$$\frac{4.95 + 3.15}{2} \times 4 = 16.2\ m^3 \quad (3)$$

$$4 \times \frac{2.9 + 1.8}{2} \times 1.1 \times 3 = 31.0\ m^3 \quad (4)$$

$$(1) + (2) + (3) + (4) = \underline{\underline{64\ m^3}}$$

TANK-10 and TANK-30:



½ Tunnel volume each:

1) $3.1 \times ½ \times 1^2 \times \pi = 4.87\ m^3$

2) $2.4 \times ½ \times 1^2 \times \pi = 3.77\ m^3$

3) $1.9 \times ½ \times 1^2 \times \pi = 2.98\ m^3$

Tunnel volume $= 11.6\ m^3$

$\frac{5 \times (4.8 - 3.7)}{2} = 2.75\ m^2$

$3.7 \times 5 = 18.5\ m^2$

$21.25\ m^2$

$1.5 \times 5 = 7.5\ m^2$

$\frac{5 \times (3 - 1.5)}{2} = 3.75\ m^2$

$11.25\ m^2$

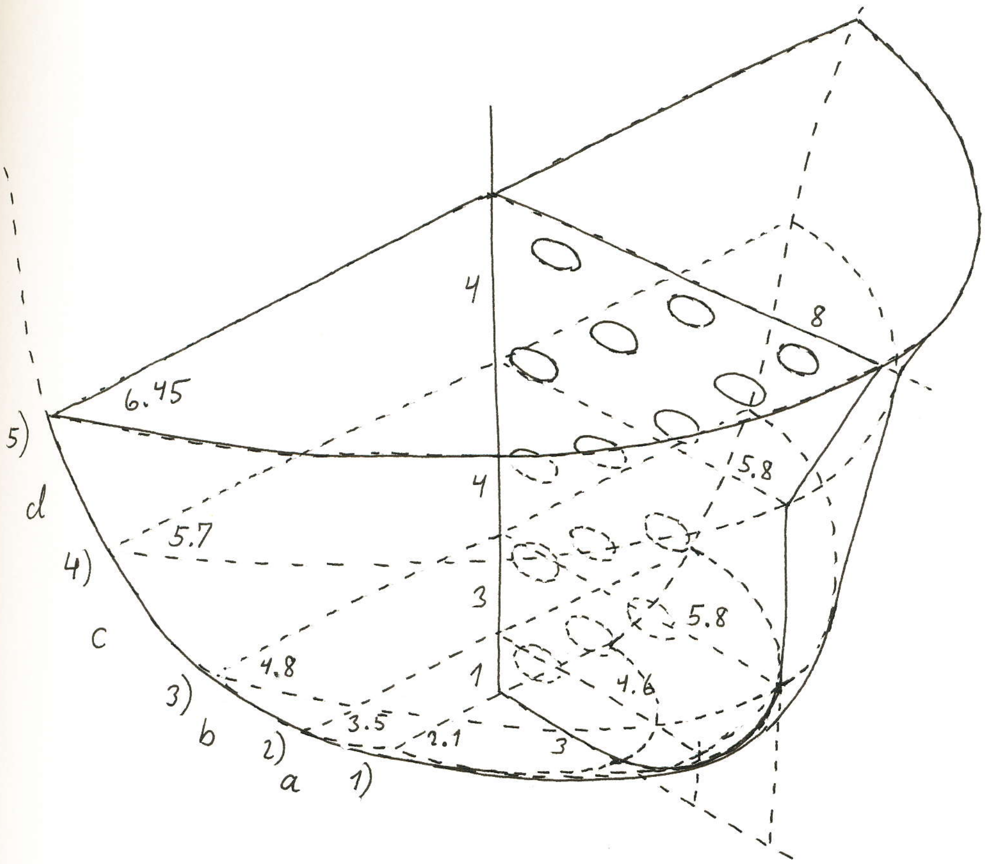
$\frac{(21.25 + 11.25)}{2} \times 0.95 = 15.4.4\ m^3$

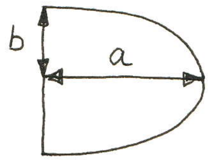
$10 \times 15.44 = 154.4\ m^3$

$\div$ Tunnels $= 11.6\ m^3$

$143 m^3$

TANK 11:





$\frac{1}{2}$ ELLIPSE = $\frac{1}{2}\pi \times a \times b$

Evaluated compensation for imperfect ellipse in each case.

1) $\frac{1}{2} \times \pi \times 3 \times 2.1 \times 0.95$ at 0.0 m. = $9.5\ m^2$ > 1 m

2) $\frac{1}{2} \times \pi \times 4.6 \times 3.5 \times 0.80$ at 1.0 m. = $20.24\ m^2$ > 2 m

3) $\frac{1}{2} \times \pi \times 5.8 \times 4.8 \times 0.90$ at 3.0 m. = $39.3\ m^2$ > 4 m

4) $\frac{1}{2} \times \pi \times 5.8 \times 5.7 \times 0.90$ at 7.0 m. = $46.7\ m^2$ > 4 m

5) $\frac{1}{2} \times \pi \times 8 \times 6.45 \times 0.95$ at 11.0 m = $77.0\ m^2$

a) $\frac{20.2 + 9.5}{2} \times 1 = 14.9\ m^3$

b) $\frac{39.3 + 20.2}{2} \times 2 = 59.5\ m^3$

c) $\frac{46.7 + 39.3}{2} \times 4 \times = 172.0\ m^3$

} $246\ m^3$

d) $\frac{77 + 46.7}{2} \times 4$ = $247\ m^3$

$494\ m^3$

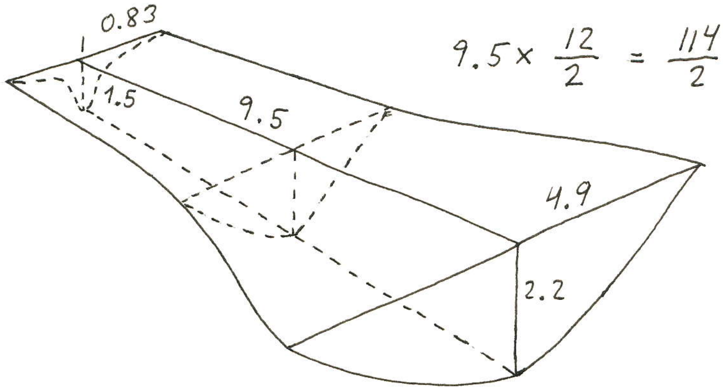
TANK 12:

$0.83 \times 1.5 = 1.245 \text{ m}^2$

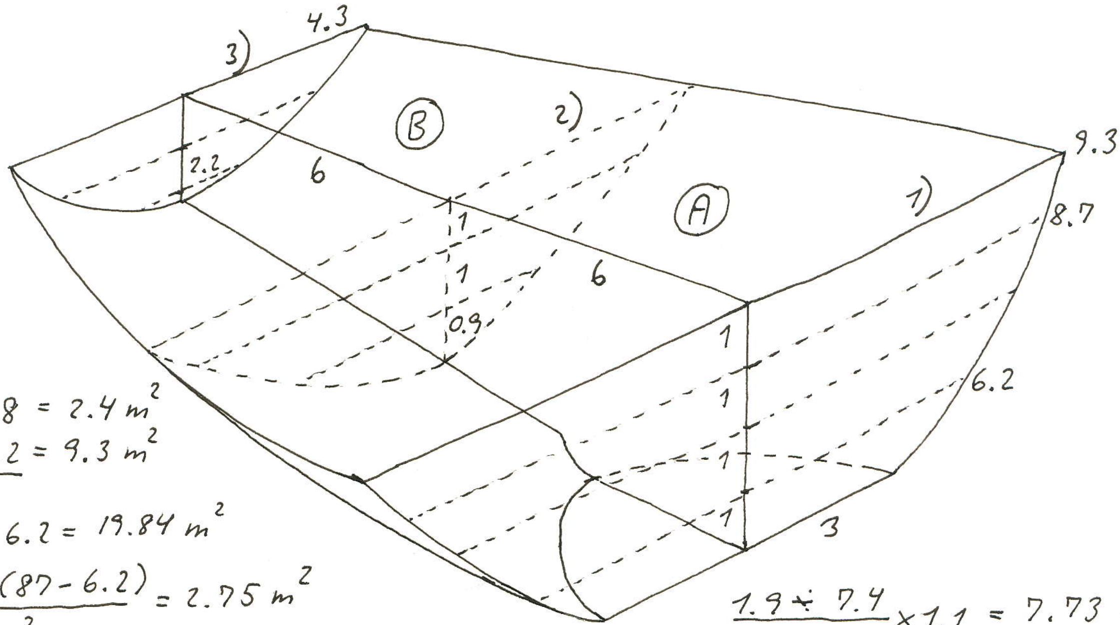
$4.9 \times 2.2 = 10.78 \text{ m}^2$

12 m^2

$9.5 \times \frac{12}{2} = \frac{114}{2} = \underline{\underline{57 \text{ m}^3}}$



TANK 13:



$3 \times 0.8 = 2.4 \text{ m}^2$

$\frac{3 \times 6.2}{2} = 9.3 \text{ m}^2$

$3.2 \times 6.2 = 19.84 \text{ m}^2$

$\frac{2.2 \times (87 - 6.2)}{2} = 2.75 \text{ m}^2$

$(8.7. - 6.2) \times 1 = 2.50 \text{ m}^2$

$\frac{(9.3 - 8.7) \times 1}{2} = 0.30 \text{ m}^2$

37.09 m^2

$+ 5\%$ 1.85

38.94 m^2

1)

$\frac{1.9 \div 7.4}{2} \times 1.1 = 7.73 \text{ m}^2$

$1 \times 7.4 = 7.4 \text{ m}^2$

$\frac{(8.7 - 7.4) \times 1}{2} \times 1.05 = 0.68 \text{ m}^2$

15.8 m^2

2)

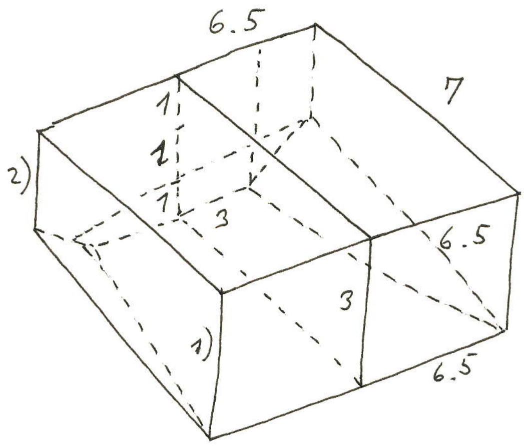
$\frac{2.2 \times 4.8}{2} = 5.28 \text{ m}^2$

A) $\frac{(38.94 + 15.8)}{2} \times 6 = 164 \text{ m}^3$

B) $\frac{(15.8 + 5.28)}{2} \times 6 = 64 \text{ m}^3$

$\underline{\underline{228 \text{ m}^3}}$

TANK 14:



1) $3 \times 6.5 = 19.5\ m^2$
$3 \times 3 = 9\ m^2$

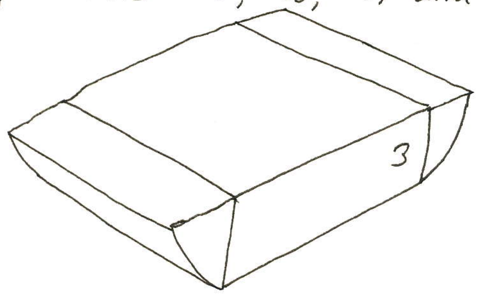
2) $\frac{1 \times 3.5}{2} = 1.75\ m^2$

$3.5 \times 2 = 7\ m^2$

1) + 2) $37.25\ m^2$

$7 \times 37.25 = \underline{\underline{261\ m^3}}$

Drawing of TANKS -15, -16, -17 and -18:



TANK-15:

$3 \times 9.5 \times 13 = 370\ m^3$
$3 \times 9.5 \times 3 = 86\ m^3$
$456\ m^3$
$3 \times 3.6 \times 3.6 = 39\ m^3$ (moon pool)
$\underline{\underline{417\ m^3}}$

TANK-16:

$3 \times 13.3 \times 13 = 519\ m^3$
$3 \times 13.3 \times 3 = 120\ m^3$
$\underline{\underline{639\ m^3}}$

TANK-17:

$3 \times 4.7 \times 13 = 183\ m^3$
$3 \times 4.7 \times 3 = 42\ m^3$
$225\ m^3$
$3 \times 4.8 \times 4.8 = 69\ m^3$ (moon pool)
$\underline{\underline{156\ m^3}}$

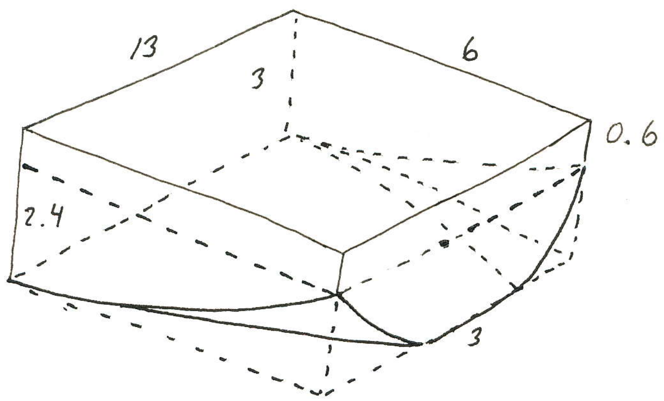
TANK-18:

$12.5 \times 13 \times 3 = 488\ m^3$

$12.5 \times 3 \times 3 = 113\ m^3$

$601\ m^3$

TANK-19:



$0.6 \times 6 \times 13 = 46.8\ m^3$

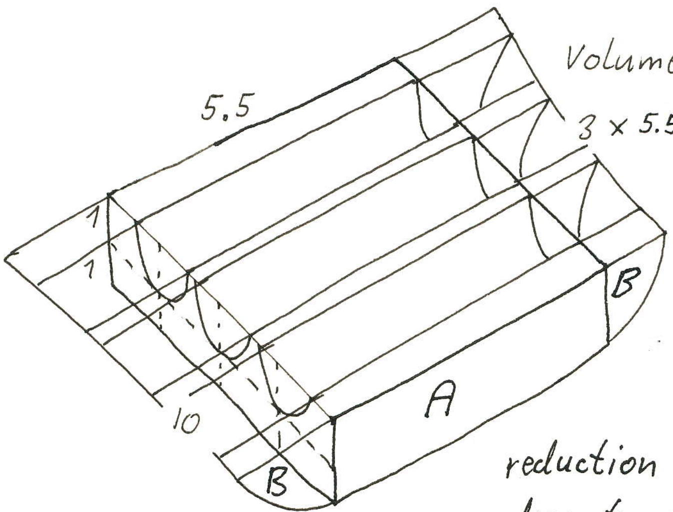
$\frac{6 \times 2.4 \times 13}{\sqrt{2}} = 132\ m^3$

$179\ m^3$

$5.5 \times 6 \times 3 = 99\ m^3$ (Lift Casing)

$80\ m^3$

TANK-20:



Volume of tunnels:

$3 \times 5.5 \times \frac{1}{2} \times 1^2 \times \pi = 26.0\ m^3$

$5.5 \times 2 \times 10 = 110\ m^3$

$\div$ tunnels $= 26\ m^3$

$84\ m^3$

reduction evaluated 25%
due to quite larger tunnels.

$0.75 \times 84 = 63\ m^3$ A

B) The wing-tanks of Tank-20: see next page.

Wing-tanks of TANK-20: The wolume will be reserved for cement ballast if needed later on.

$$\frac{2 \times 3.7 \times 1.2 + 2 \times 1.5 \times 1.2}{2} \times 10 = 62.4 \text{ m}^3$$

Tunnel volume:

1) $2.8 \times \frac{1}{2} \times \pi \cdot 1^2 = 4.4 \text{ m}^3$

2) $2.1 \times \frac{1}{2} \times \pi \cdot 1^2 = 3.3 \text{ m}^3$

3) $1.6 \times \frac{1}{2} \times \pi \cdot 1^2 = 2.5 \text{ m}^3$

10.2 m^3

$2 \times 10.2 = 20.4 \text{ m}^3$

82.8 m^3

CALCULATION OF THE TANK WEIGHT AND GRAVETY CENTER

The roll damping tanks are belived to be half full, the crane stabilizing tanks are belived to be half full and the fuel and fresh water tanks are belived to be full. The aft and the fore water ballast tanks are calculated later.

Tank	Cont.	m3	perm.	t/m3	t	x	z
02	FO	24	0.96	0.98	22.6	5	6
12	FO	57	----	----	53.6	4	2.8
22	FO	24	----	----	22.6	5	6
03	FO	23	----	----	21.6	9	6
13	FO	228	----	----	214.5	15	3
23	FO	23	----	----	21.6	9	6
04	RD	50	----	1.025	49.2	24	4
14	WB	260	----	-----	255.8	23	1.5
24	RD	50	----	-----	49.2	24	4
05	CS	57	----	-----	56	30.5	4
15	WB	417	----	-----	410.3	29.5	1.8
25	CS	57	----	-----	56	30.5	4
06	FO	160	----	0.98	150.5	42	5
16	FO	639	----	----	601.2	42	1.8
26	FO	160	----	----	150.5	42	5
07	RD	26	----	1.025	25.6	51	4
17	WB	156	----	-----	153.5	51	1.8
27	RD	26	----	-----	25.6	51	4
08	FO	75	----	0.98	70.6	60	5
18	FO	601	----	----	565.4	60	1.8
28	FO	75	----	----	70.6	60	5
09	RD	30	----	1.025	29.5	67	3.5
19	WB	80	----	-----	78.7	68	1.8
29	RD	30	----	-----	29.5	67	3.5
10	FW	143	----	1.0	137.3	75.5	5
20	FW	63	----	---	60.5	77	0.7
30	FW	143	----	---	137.3	75.5	5
					3519.3	43.5	2.8

THE ROLL DAMPING TANKS

The roll damping tanks can be used as heel stabilizing tanks, but the primer purpose is to lower the rolling of the ship in bad weather conditions.

The capacity is :

Tank	tons	y	torque (tons-meter)
04-24	98.4	7.5	735
07-27	51.2	8.0	410
09-29	59.0	7.0	413
	(209 t) Total Roll torque		1558 tons-meter

THE FRESH WATER TANKS

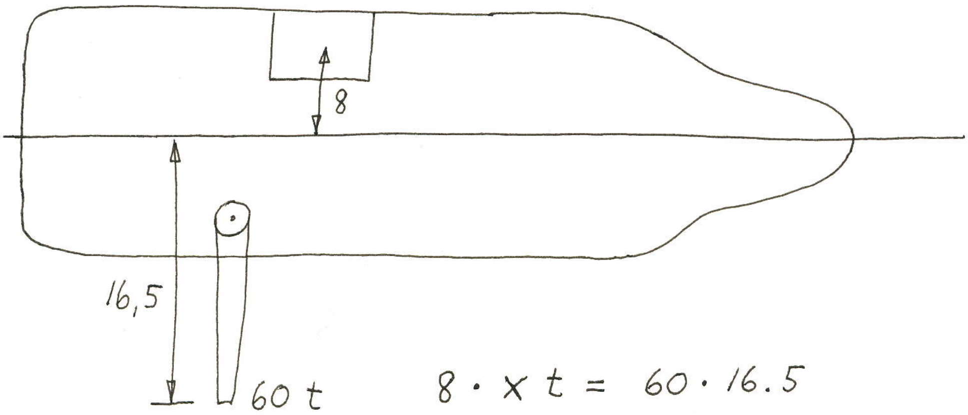
Tanks 10 + 20 + 30 = 137.3 + 60.5 + 137.3 = 335 tons

THE FUEL OIL TANKS

Tank	tons
02	22.6
12	53.6
22	22.6
03	21.6
13	214.5
23	21.6
06	150.5
16	601.2
26	150.5
08	70.6
18	565.4
28	70.6
Total	1965 tons

CRANE STABILIZING TORQUE

When using the one crane with maximum torque the crane stabilizing



$$8 \cdot x\,t = 60 \cdot 16.5$$

$$x = 124\ t$$

tanks are used. The 56 tons of seawater are pumped from the one side to the other providing a stabilizing torque of 2 x 56 tons at the evaluated gravety center of 8 meters:

$$2 \times 56 \times 8 = 896 \text{ tons-meter}$$

compared with the demand of:

$$60 \times 16.5 = 990 \text{ tons-meter}$$

The remaining 94 tons-meter can easily be obtained by using the stabilizing effect from one of the roll damping tanks because the are equiped with compressed air control. However, it may not be necessary because the stabilizing torque from the ship itself when a small heel angle is introduced may deliver a sufficient stabilizing torque.

When both crames are put in action in the workover mode the need for stabilizing the heeling will be much smaller. Two cranes lifting together 120 tons at x = 17 meter would demand a trim torque which will be provided by the big fore water ballast tank-11.

8.11. RESISTANCE, POWER AND PROPELLER ANALYSIS

This analysis has been performed by the help of the computerprograms available at the Department of Ocean Engineering. The input is the ship hull data and the hydrostatic data.

The propeller data, the engine power and the marine fuel consumption can be estimated by using this programmes.

In the following is shown the most importent results derrived from the interactive handling of the programs.

First of all there is the ships resistance data at different speeds and different draughts. I have shown the resistance curves for the draught = 4.8, 6.4 and 7.2 meter. At the max. displacement of 9200 tons the draught is 6.8 meter and this is drawn by hand at the curve diagram. From this we can calculate the effective power need at several speeds:

$$P_e = R \times V.$$

Now, we will add a value of 20% to the resistance in order to make sure that we compensate for the wave, wind, thruster tunnel resistance, moon pools bottom hatches imperfections, imperfections of ship hull, the fungus on the ship hull etc.

$$P_e = 1.2 \times R \times V \text{ (service condition)}$$

```
* ** *  *   ------------------------------------   * **  *  *
* *  *  *     ISH DESIGN - BASIC PROGRAMMEL        * *    *  *
* ** *****  DEPARTMENT OF OCEAN ENGINEERING        * ** *****
*   * *  *  THE TECHNICAL UNIVERSITY OF DENMARK    *   * *  *
* ** *  *          DK 2800  LYNGBY                 * **  *  *
-------------------------------------------------------------
*                RESISTANCE AND POWER                       *
* BUILDERS: JOHN GENART                 CASSETTE ISH-100    *
* IDENTIFICATION: SILVER SEARAMBLER     VERSION NOV 1979    *
* DATE: 4 JULY 86    INITIALS: JOHN GE  FILE: PROP          *
-------------------------------------------------------------
```

Ship resistance calculated by Guldhammer and Harvald's method.

Remarks:

Main dimensions:

```
   Length, calculation...:  83.676 m   (Laft. AP...:  6.000 m)
   Length between pp.....:  87.800 m   (Lfore. FP..:
-10.12398 DZ.DDD
m)
   Breadth...............:  19.000 m
   Draught, amidships....:   4.000 m
   Displacement..........:   4444 m^3
```

Coefficients:

```
   Block coeff., Lcal...: 0.699  Midship sect. coeff....: 0.885
   Block coeff., pp.....: 0.666  Prismatic coeff........: 0.790
   Length-displ. ratio..: 5.089
```

LCB abaft midship section: -2.03 m,   corr. for calc.:   -8.87 m

Maximum propeller diameter: 4.00 m (given as input).

Twin screw ship.

```
   Wetted surface (given as input):   1731 m^2
   (standard hull, standard appendages)

   Friction coefficient correction:  1.000

   Form specification:

                            Extreme:      +3
              U-form        Pronounced:   +2
                            Moderate:     +1
              N-form                       0
                            Moderate:     -1
              V-form        Pronounced:   -2
                            Extreme       -3

   Form fore:  1.0 ;     Form aft: -2.0


   Bulb area ratio: 0.000

   Cr-correction due to appendages, percent:  0

   Air and steering resistance correction: 0.110 (*10^-3)

Density of water: 1.025 t/m^3
Water temperature:  4.0 deg. c.
```

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T=4 m

RESISTANCE ANALYSIS

Remarks:

V m/s	Fn	base Cr	B/T	LCB	Sect.	Bulb	App.	Total Cr *1000
		Components of Cr*1000	corrections					
1.00	0.035	0.527	0.360	0.000	-.100	0.000	0.000	0.787
1.50	0.052	0.540	0.360	0.000	-.100	0.000	0.000	0.800
2.00	0.070	0.558	0.360	0.000	-.100	0.000	0.000	0.818
2.50	0.087	0.584	0.360	0.000	-.100	0.000	0.000	0.844
3.00	0.105	0.624	0.360	0.000	-.100	0.000	0.000	0.884
3.50	0.122	0.680	0.360	0.000	-.100	0.000	0.000	0.940
4.00	0.140	0.761	0.360	0.000	-.100	0.000	0.000	1.021
4.50	0.157	0.875	0.360	0.000	-.100	0.000	0.000	1.135
5.00	0.175	1.038	0.360	0.860	-.100	0.000	0.000	2.158
5.50	0.192	1.272	0.360	1.897	-.100	0.000	0.000	3.428
6.00	0.209	1.614	0.360	3.086	-.100	0.000	0.000	4.959
6.50	0.227	2.132	0.360	4.428	-.100	0.000	0.000	6.820
7.00	0.244	2.960	0.360	5.924	-.100	0.000	0.000	9.144
7.50	0.262	4.374	0.360	7.572	-.100	0.000	0.000	12.206
8.00	0.279	6.893	0.360	9.374	-.100	0.000	0.000	16.527

V m/s	Fn	Rn *10^-8	Cf' *1000	Ca *1000	Cas *1000	Ct *1000	R kN	Pe kW = R·V
1.00	0.035	0.518	2.297	0.493	0.110	3.687	3.3	3
1.50	0.052	0.778	2.161	0.493	0.110	3.564	7.1	11
2.00	0.070	1.037	2.072	0.493	0.110	3.493	12.4	25
2.50	0.087	1.296	2.007	0.493	0.110	3.455	19.2	48
3.00	0.105	1.555	1.956	0.493	0.110	3.443	27.5	82
3.50	0.122	1.814	1.915	0.493	0.110	3.458	37.6	132
4.00	0.140	2.074	1.880	0.493	0.110	3.504	49.7	199
4.50	0.157	2.333	1.850	0.493	0.110	3.588	64.5	290
5.00	0.175	2.592	1.823	0.493	0.110	4.585	101.7	508
5.50	0.192	2.851	1.800	0.493	0.110	5.831	156.5	861
6.00	0.209	3.110	1.779	0.493	0.110	7.342	234.5	1407
6.50	0.227	3.370	1.760	0.493	0.110	9.184	344.2	2237
7.00	0.244	3.629	1.743	0.493	0.110	11.490	499.5	3496
7.50	0.262	3.888	1.727	0.493	0.110	14.537	725.4	5441
8.00	0.279	4.147	1.713	0.493	0.110	18.843	1069.8	8559

Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

Resistance coefficient components calculated directly by the program. Ship input data, see the previous page.

gram. Ship input data, see the previous page.

Water temperature: 4.0 deg. c.

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*  **  *   *            DK 2800  LYNGBY                 *  **  *   *
----------------------------------------------------------------------
*                    RESISTANCE AND POWER                            *
* BUILDERS: JOHN GENART                          CASSETTE ISH-100    *
* IDENTIFICATION: SILVER SEARAMBLER              VERSION NOV 1979    *
* DATE: 4 JULY 86    INITIALS: JOHN GE           FILE: PROP          *
----------------------------------------------------------------------
```

Ship resistance calculated by Guldhammer and Harvald's method.

Remarks: T=4.8

Main dimensions:
- Length, calculation...: 93.800 m (Laft. AP...: 6.000 m)
- Length between pp.....: 87.800 m (Lfore. FP..: -.000 m)
- Breadth...............: 19.000 m
- Draught, amidships....: 4.800 m
- Displacement..........: 5621 m^3

Coefficients:
- Block coeff., Lcal...: 0.657 Midship sect. coeff....: 0.904
- Block coeff., pp.....: 0.702 Prismatic coeff........: 0.727
- Length-displ. ratio..: 5.275

LCB abaft midship section: -1.05 m, corr. for calc.: -2.68 m

Maximum propeller diameter: 4.00 m (given as input).

Twin screw ship.

Wetted surface (given as input): 1985 m^2
(standard hull, standard appendages)

Friction coefficient correction: 1.000

Form specification:

U-form	Extreme:	+3
	Pronounced:	+2
	Moderate:	+1
N-form		0
V-form	Moderate:	-1
	Pronounced:	-2
	Extreme	-3

Form fore: 1.0 ; Form aft: -2.0

Bulb area ratio: 0.000

Cr-correction due to appendages, percent: 0

Air and steering resistance correction: 0.110 (*10^-3)

Resistance coefficient components calculated directly by the program. Ship input data, see the previous page.

Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

RESISTANCE ANALYSIS

T = 4.800 m

Remarks:

V m/s	Fn	base Cr	B/T	LCB	Sect.	Bulb	App.	Total Cr *1000
		.... Components of Cr*1000	corrections					
1.00	0.033	0.492	0.233	0.000	-.100	0.000	0.000	0.625
1.50	0.049	0.499	0.233	0.000	-.100	0.000	0.000	0.632
2.00	0.066	0.509	0.233	0.000	-.100	0.000	0.000	0.642
2.50	0.082	0.522	0.233	0.000	-.100	0.000	0.000	0.656
3.00	0.099	0.540	0.233	0.000	-.100	0.000	0.000	0.674
3.50	0.115	0.564	0.233	0.000	-.100	0.000	0.000	0.698
4.00	0.132	0.597	0.233	0.000	-.100	0.000	0.000	0.731
4.50	0.148	0.642	0.233	0.000	-.100	0.000	0.000	0.776
5.00	0.165	0.705	0.233	0.000	-.100	0.000	0.000	0.839
5.50	0.181	0.795	0.233	0.000	-.100	0.000	0.000	0.928
6.00	0.198	0.925	0.233	0.150	-.100	0.000	0.000	1.208
6.50	0.214	1.119	0.233	0.433	-.100	0.000	0.000	1.686
7.00	0.231	1.422	0.233	0.834	-.100	0.000	0.000	2.389
7.50	0.247	1.913	0.233	1.352	-.100	0.000	0.000	3.398
8.00	0.264	2.755	0.233	1.987	-.100	0.000	0.000	4.876

V m/s	Fn	Rn *10^-8	Cf' *1000	Ca *1000	Cas *1000	Ct *1000	R kN	Pe kW
1.00	0.033	0.581	2.257	0.469	0.110	3.461	3.5	4
1.50	0.049	0.872	2.125	0.469	0.110	3.337	7.6	11
2.00	0.066	1.162	2.039	0.469	0.110	3.260	13.3	27
2.50	0.082	1.453	1.975	0.469	0.110	3.210	20.4	51
3.00	0.099	1.743	1.925	0.469	0.110	3.178	29.1	87
3.50	0.115	2.034	1.885	0.469	0.110	3.161	39.4	138
4.00	0.132	2.324	1.850	0.469	0.110	3.160	51.4	206
4.50	0.148	2.615	1.821	0.469	0.110	3.176	65.4	294
5.00	0.165	2.906	1.795	0.469	0.110	3.213	81.7	409
5.50	0.181	3.196	1.773	0.469	0.110	3.279	100.9	555
6.00	0.198	3.487	1.752	0.469	0.110	3.539	129.6	778
6.50	0.214	3.777	1.734	0.469	0.110	3.999	171.9	1117
7.00	0.231	4.068	1.717	0.469	0.110	4.685	233.5	1635
7.50	0.247	4.358	1.701	0.469	0.110	5.678	324.9	2437
8.00	0.264	4.649	1.687	0.469	0.110	7.142	465.0	3720

Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

Resistance coefficient components calculated directly by the program. Ship input data, see the previous page.

Water temperature: 4.0 deg. c.

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*  **  *   *   ---------------------------------   *  **  *   *
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*    * *   *  THE TECHNICAL UNIVERSITY OF DENMARK  *    * *   *
*  **  *   *            DK 2800  LYNGBY            *  **  *   *
-----------------------------------------------------------------
*                     RESISTANCE AND POWER                      *
* BUILDERS: JOHN GENART                      CASSETTE ISH-100   *
* IDENTIFICATION: SILVER SEARAMBLER          VERSION NOV 1979   *
* DATE: 4 JULY 86   INITIALS: JOHN GE        FILE: PROP         *
-----------------------------------------------------------------
```

Ship resistance calculated by Guldhammer and Harvald's method.

Remarks:

Main dimensions:

```
   Length, calculation...:  93.800 m   (Laft. AP...:  6.000 m)
   Length between pp.....:  87.800 m   (Lfore. FP..:  -.000 m)
   Breadth...............:  19.000 m
   Draught, amidships....:   5.600 m
   Displacement..........:    6913 m^3
```

Coefficients:

```
   Block coeff., Lcal...: 0.693   Midship sect. coeff....: 0.918
   Block coeff., pp.....: 0.740   Prismatic coeff........: 0.755
   Length-displ. ratio..: 4.924
```

LCB abaft midship section: 0.24 m,   corr. for calc.:   -1.39 m

Maximum propeller diameter: 3.64 m (default value 0.65 * draught).

Twin screw ship.

Wetted surface (given as input):   2215 m^2
(standard hull, standard appendages)

Friction coefficient correction: 1.000

Form specification:

	Extreme:	+3
U-form	Pronounced:	+2
	Moderate:	+1
N-form		0
	Moderate:	-1
V-form	Pronounced:	-2
	Extreme	-3

Form fore: 1.0 ;   Form aft: 2.0

Bulb area ratio: 0.000

Cr-correction due to appendages, percent: 0

Air and steering resistance correction: 0.110 (*10^-3)

Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

RESISTANCE ANALYSIS

Remarks: T = 5.6

V m/s	Fn	base Cr	B/T	LCB	Sect.	Bulb	App.	Total Cr *1000
		Components of Cr*1000	corrections					
2.00	0.066	0.563	0.143	0.000	0.033	0.000	0.000	0.739
3.00	0.099	0.605	0.143	0.000	0.033	0.000	0.000	0.781
4.00	0.132	0.685	0.143	0.000	0.033	0.000	0.000	0.861
5.00	0.165	0.842	0.143	0.000	0.033	0.000	0.000	1.018
6.00	0.198	1.162	0.143	0.101	0.033	0.000	0.000	1.439
7.00	0.231	1.863	0.143	0.671	0.033	0.000	0.000	2.710
8.00	0.264	3.682	0.143	1.738	0.033	0.000	0.000	5.596
9.00	0.297	8.703	0.143	3.302	0.033	0.000	0.000	12.181
10.00	0.330	10.842	0.143	5.363	0.033	0.000	0.000	16.382

V m/s	Fn	Rn *10^-8	Cf' *1000	Ca *1000	Cas *1000	Ct *1000	R kN	Pe kW
2.00	0.066	1.162	2.039	0.446	0.110	3.334	15.1	30
3.00	0.099	1.743	1.925	0.446	0.110	3.262	33.3	100
4.00	0.132	2.324	1.850	0.446	0.110	3.267	59.3	237
5.00	0.165	2.906	1.795	0.446	0.110	3.369	95.6	478
6.00	0.198	3.487	1.752	0.446	0.110	3.747	153.1	919
7.00	0.231	4.068	1.717	0.446	0.110	4.982	277.1	1940
8.00	0.264	4.649	1.687	0.446	0.110	7.839	569.5	4556
9.00	0.297	5.230	1.662	0.446	0.110	14.398	1323.9	11915
10.00	0.330	5.811	1.639	0.446	0.110	18.576	2108.7	21087

Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

Resistance coefficient components calculated directly by the program. Ship input data, see the previous page.

ADDED RESISTANCE SPECIFICATION

Added resistance remarks:

Resistance added to trial or service condition resistance.

Added resistance given as input:

V [m/s] Delta-R [kN]

```
*  **   *   *   -----------------------------------   *  **   *   *
* *     *   *        ISH DESIGN - BASIC PROGRAMMEL    * *     *   *
*  **   *****      DEPARTMENT OF OCEAN ENGINEERING    *  **   *****
*    * *    *   THE TECHNICAL UNIVERSITY OF DENMARK   *    * *    *
*  **   *   *             DK 2800  LYNGBY             *  **   *   *
----------------------------------------------------------------------
*                      RESISTANCE AND POWER                          *
* BUILDERS: JOHN GENART                          CASSETTE ISH-100    *
* IDENTIFICATION: SILVER SEARAMBLER              VERSION NOV 1979    *
* DATE: 4 JULY 86    INITIALS: JOHN GE           FILE: PROP          *
----------------------------------------------------------------------
```

Ship resistance calculated by Guldhammer and Harvald's method.

Remarks:

Main dimensions:

```
   Length, calculation...:    93.800 m    (Laft. AP...:  6.000 m)
   Length between pp.....:    87.800 m    (Lfore. FP..:  -.000 m)
   Breadth...............:    19.000 m
   Draught, amidships....:     6.400 m
   Displacement..........:      8232 m^3
```

Coefficients:

```
   Block coeff., Lcal...: 0.722    Midship sect. coeff....: 0.928
   Block coeff., pp.....: 0.771    Prismatic coeff........: 0.778
   Length-displ. ratio..: 4.646
```

LCB abaft midship section: 1.26 m,   corr. for calc.:   -.38 m

Maximum propeller diameter: 4.00 m (given as input).

Twin screw ship.

Wetted surface (given as input): 2374 m^2
(standard hull, standard appendages)

Friction coefficient correction: 1.000

Form specification:

```
                       Extreme:        +3
          U-form       Pronounced:     +2
                       Moderate:       +1
          N-form                        0
                       Moderate:       -1
          V-form       Pronounced:     -2
                       Extreme         -3
```

Form fore: 1.0 ;   Form aft: -2.0

Bulb area ratio: 0.000

Cr-correction due to appendages, percent: 0

Resistance coefficient components calculated directly by the program. Ship input data, see the previous page.

Air and steering resistance correction: 0.110 (*10^-3)

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Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

T= 6.4 m.

RESISTANCE ANALYSIS

Remarks:

V m/s	Fn	base Cr	B/T	LCB	Sect.	Bulb	App.	Total Cr *1000
		.... Components of Cr*1000						
			---------- corrections ----------					
1.00	0.033	0.590	0.075	0.000	-.100	0.000	0.000	0.565
1.50	0.049	0.600	0.075	0.000	-.100	0.000	0.000	0.575
2.00	0.066	0.615	0.075	0.000	-.100	0.000	0.000	0.590
2.50	0.082	0.637	0.075	0.000	-.100	0.000	0.000	0.612
3.00	0.099	0.669	0.075	0.000	-.100	0.000	0.000	0.644
3.50	0.115	0.714	0.075	0.000	-.100	0.000	0.000	0.689
4.00	0.132	0.778	0.075	0.000	-.100	0.000	0.000	0.753
4.50	0.148	0.868	0.075	0.000	-.100	0.000	0.000	0.843
5.00	0.165	0.996	0.075	0.000	-.100	0.000	0.000	0.971
5.50	0.181	1.175	0.075	0.000	-.100	0.000	0.000	1.150
6.00	0.198	1.430	0.075	0.000	-.100	0.000	0.000	1.405
6.50	0.214	1.799	0.075	0.122	-.100	0.000	0.000	1.896
7.00	0.231	2.352	0.075	0.432	-.100	0.000	0.000	2.758
7.50	0.247	3.219	0.075	0.873	-.100	0.000	0.000	4.067
8.00	0.264	4.663	0.075	1.447	-.100	0.000	0.000	6.085

V m/s	Fn	Rn *10^-8	Cf' *1000	Ca *1000	Cas *1000	Ct *1000	R kN	Pe kW
1.00	0.033	0.581	2.257	0.425	0.110	3.357	4.1	4
1.50	0.049	0.872	2.125	0.425	0.110	3.235	8.9	13
2.00	0.066	1.162	2.039	0.425	0.110	3.164	15.4	31
2.50	0.082	1.453	1.975	0.425	0.110	3.122	23.7	59
3.00	0.099	1.743	1.925	0.425	0.110	3.104	34.0	102
3.50	0.115	2.034	1.885	0.425	0.110	3.108	46.3	162
4.00	0.132	2.324	1.850	0.425	0.110	3.138	61.1	244
4.50	0.148	2.615	1.821	0.425	0.110	3.199	78.8	355
5.00	0.165	2.906	1.795	0.425	0.110	3.301	100.4	502
5.50	0.181	3.196	1.773	0.425	0.110	3.457	127.2	700
6.00	0.198	3.487	1.752	0.425	0.110	3.692	161.7	970
6.50	0.214	3.777	1.734	0.425	0.110	4.164	214.1	1391
7.00	0.231	4.068	1.717	0.425	0.110	5.010	298.7	2091
7.50	0.247	4.358	1.701	0.425	0.110	6.303	431.4	3235
8.00	0.264	4.649	1.687	0.425	0.110	8.307	646.9	5175

Density of water: 1.025 t/m^3
Water temperature: 4.0 deg. c.

Resistance coefficient components calculated directly by the program. Ship input data, see the previous page.

ISH - RESISTANCE AND POWER

RESISTANCE

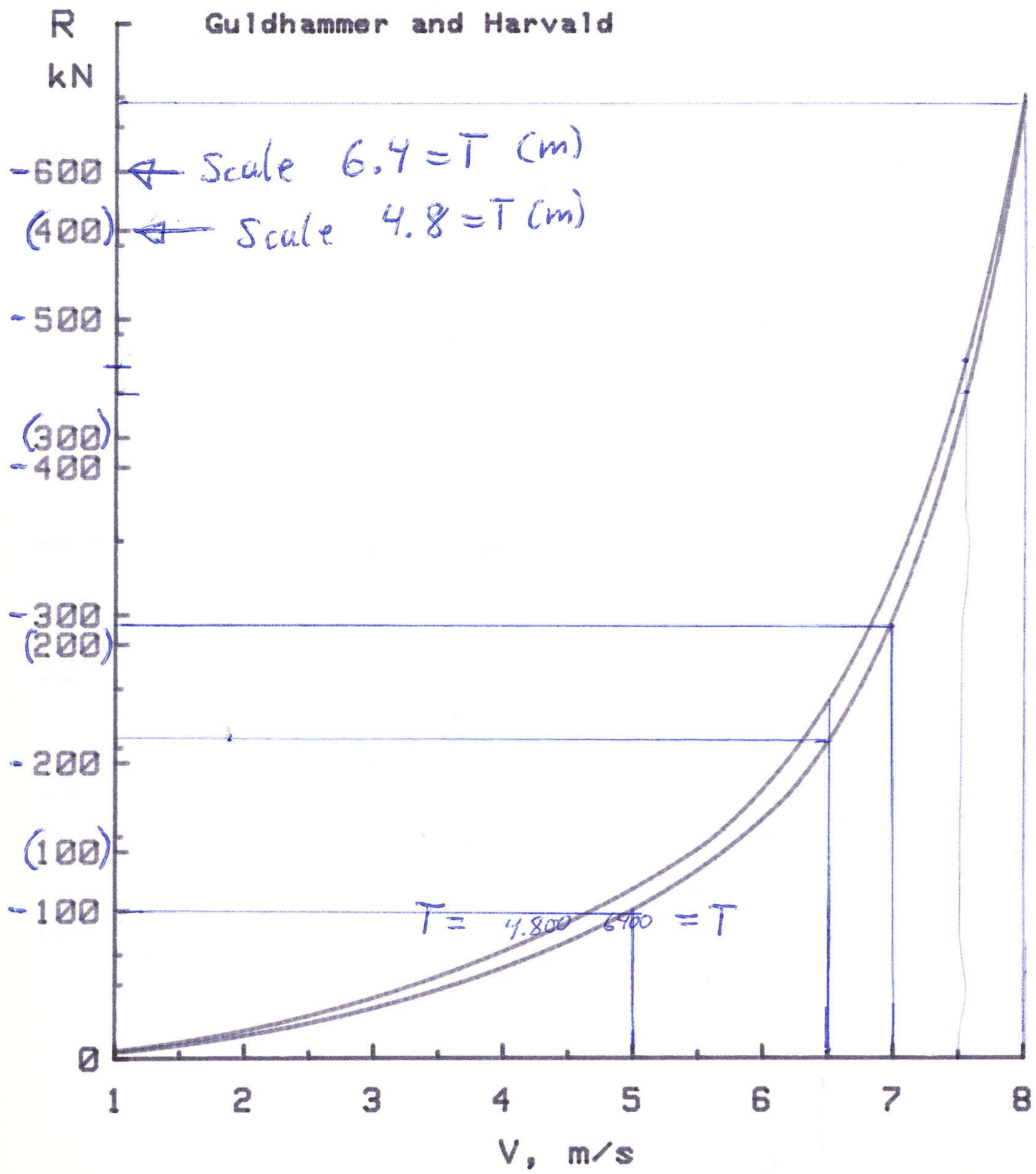
BUILDERS: JOHN GENART

IDENTIFICATION: SILVER SEARAMBLER

DATE: 4 JULY 86   INITIALS: JOHN GE

SHIP:

L, cal.:	93.800 m	Breadth:	19.000 m	Draught:	6.800 m
Block coef.:	0.882	Prism. coef.:	0.728	Lcal/Disp.:	5.876



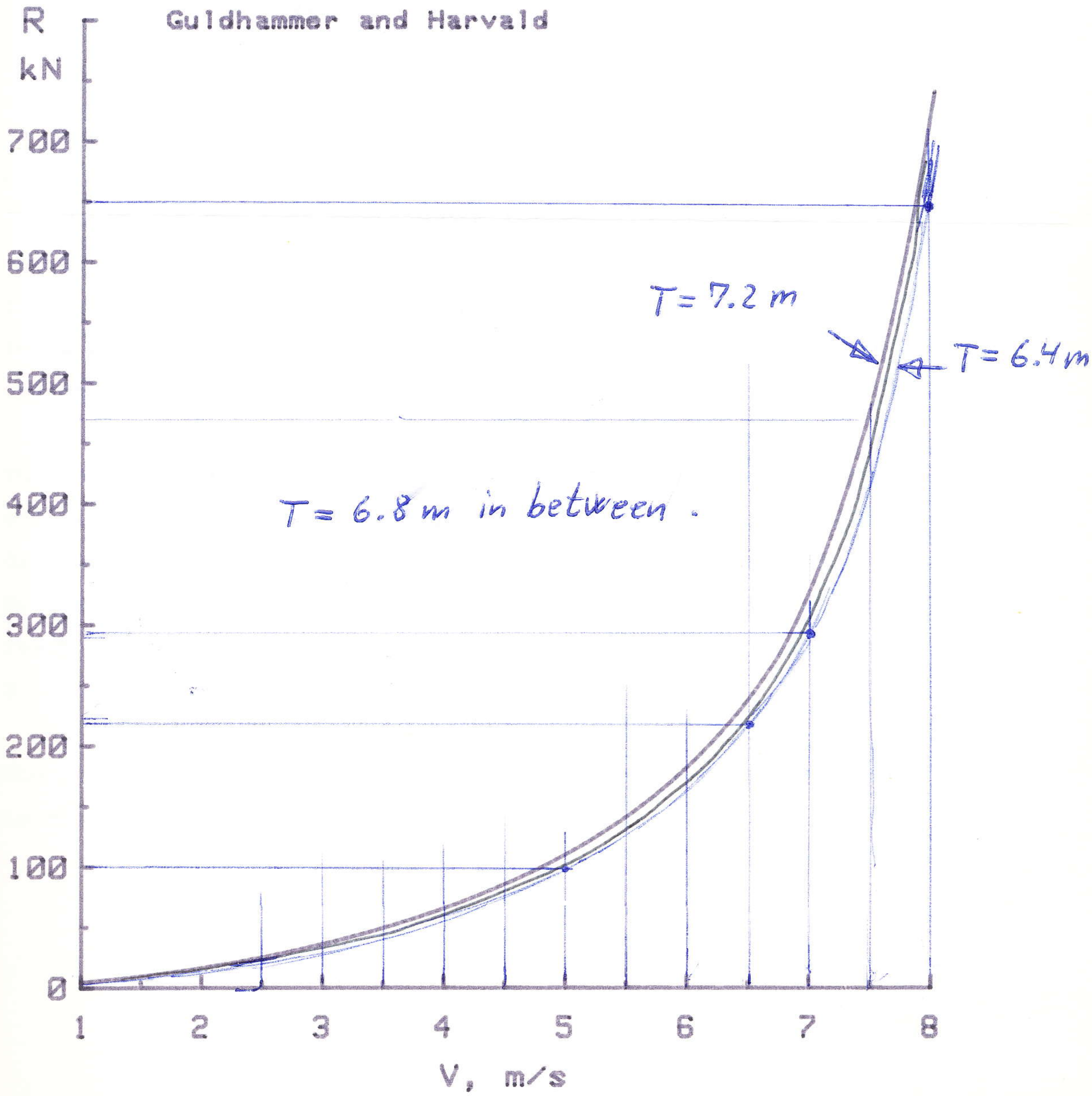
ISH - RESISTANCE AND POWER

RESISTANCE

BUILDERS: JOHN GENART
IDENTIFICATION: SILVER SEARAMBLER
DATE: 4 JULY 86   INITIALS: JOHN GE

SHIP:

L, cal.:	93.800 m	Breadth:	19.000 m	Draught:	7.200 m
Block coef.:	0.745	Prism. coef.:	0.796	Lcal/Disp.:	4.419



From the diagram we can calculate the following:

Speed (m/s)	Resistance (kN)	$P_e = R \times V$ (kW)	$P_e = 1.2 \times R \times V$ (kW)
3.0	35	105	126
3.5	48	168	202
4.0	65	260	312
4.5	80	360	432
5.0	110	550	660
5.5	140	770	924
6.0	180	1080	1296
6.5	240	1560	1872
7.0	320	2240	2688
7.5	440	3300	3960
8.0	700	5600	6720

Based on these results the propeller has been optimized using the program for a twin screw propeller ship. It has been carried out at several conditions and speeds. The initial hull shape and the initial placement of the propulsion thrusters gave allowance for a propeller diameter of maximum 4 meters, but I would like to try and optimize for a propeller with a diameter of appr. 3.5 meters.

The results showed that it was possible to reach a propeller efficiency of 0.54 at the speed 8.0 m/s at a condition with the draught = 7.2 meters. The propeller diameter is,however, 3.64 meter. By lowering the speed demand to appr. 7.50 m/s it was possible to reach a propeller efficiency of 0.56 and a propeller diameter of 3.5 meter. I will use this result in the following.

The propeller optimization results from the most importent cases is shown on the next few pages:

PROPELLER OPTIMIZATION.

Design condition:

Ship speed: 8.00 m/s.

Service condition. Service allowance: 20 percent.

Total resistance of ship at design speed: 683.4 kN.

Total thrust (impeller and nozzle)......: 438.8 kN.
Nozzle thrust...........................: -31.9 kN.

Neccessary power..: 5769 kW, per shaft,
at propeller revs.: 2.371 rps.

Choice of propeller (twin screw ship):

Wageningen nozzle propeller, Kd 5-100, nozzle no. 33
Number of blades, Z...................: 5
Expanded area ratio, specified, Ae/Ao.: 1.000
Expanded area ratio, neccessary.......: 1.209
from cavitation test.
Propeller diameter....................: 3.640 m
Pitch ratio at 0.7*R, P/D.............: 1.23

Cavitation test at design condition carried out according to Burrill's criterion for merchant ship propellers.

Shaft height assumed 0.6 * D above base line.

683.4 / (1 - 0,22)

Propulsion coefficients:

Wake coefficient, w ...., calc.: 0.25
Thrust deduction coefficient, t, calc.: 0.22

Hull efficiency, (1-t)/(1-w)..........: 1.03
Propeller efficiency..................: 0.54
Rotative efficiency..........., calc.: 0.97
Transmission efficiency...............: 0.87
Overall efficiency....................: 0.47

T = 7.2 m.

PROPELLER OPTIMIZATION.

Design condition:

Ship speed: 7.50 m/s.

Service condition. Service allowance: 20 percent.

Total resistance of ship at design speed: 468.5 kN.

Total thrust (impeller and nozzle)......: 301.0 kN.
Nozzle thrust...........................: -30.8 kN.

Neccessary power..: 3606 kW, per shaft,
at propeller revs.: 2.142 rps.

Choice of propeller (twin screw ship):

Wageningen nozzle propeller, Kd 5-100, nozzle no. 33
Number of blades, Z..................: 5
Expanded area ratio, specified, Ae/Ao.: 1.000
Expanded area ratio, neccessary.......: 1.009
from cavitation test.
Propeller diameter....................: 3.500 m
Pitch ratio at 0.7*R, P/D.............: 1.25

Cavitation test at design condition carried out according to Burrill's criterion for merchant ship propellers.

Shaft height assumed 0.6 * D above base line.

Propulsion coefficients:

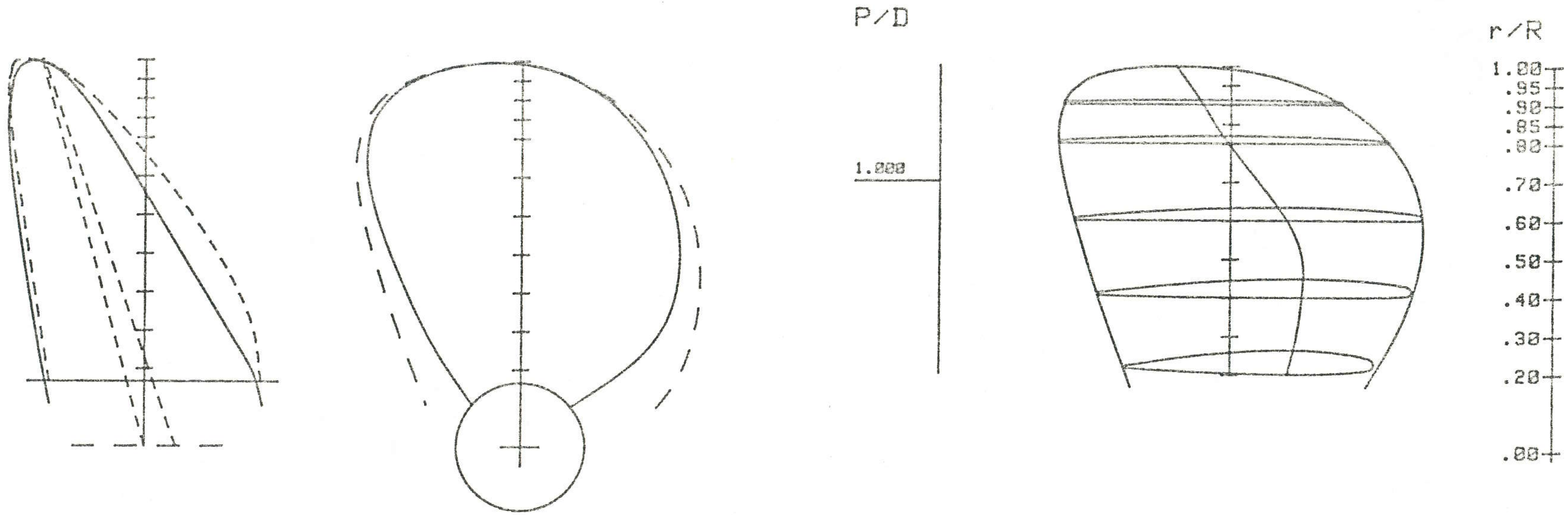
Wake coefficient, w ...., calc.: 0.25
Thrust deduction coefficient, t, calc.: 0.22

Hull efficiency, (1-t)/(1-w)..........: 1.03
Propeller efficiency..................: 0.56
Rotative efficiency..........., calc.: 0.97
Transmission efficiency...............: 0.87
Overall efficiency....................: 0.49

ISH - RESISTANCE AND POWER

Wageningen BB-series propeller

BUILDERS: JOHN GENART
IDENTIFICATION: SILVER SEARAMBLER
DATE: 4 JULY 86 INITIALS: JOHN GE



Rake (deg):	15.000
Radius of boss (m):	0.292
t/c at 0.75*R :	0.030
Vol. of blade (m3):	95.E-03
Pol.mom. int. (m5):	84.E-03

Diameter (m):	3.500
Number of blades :	5
Ae/Ao :	1.000
P/D at 0.7*R :	1.000
SCALE	1 : 21.43

ISH - RESISTANCE AND POWER

WAGENINGEN nozzle propeller

BUILDERS: JOHN GENART

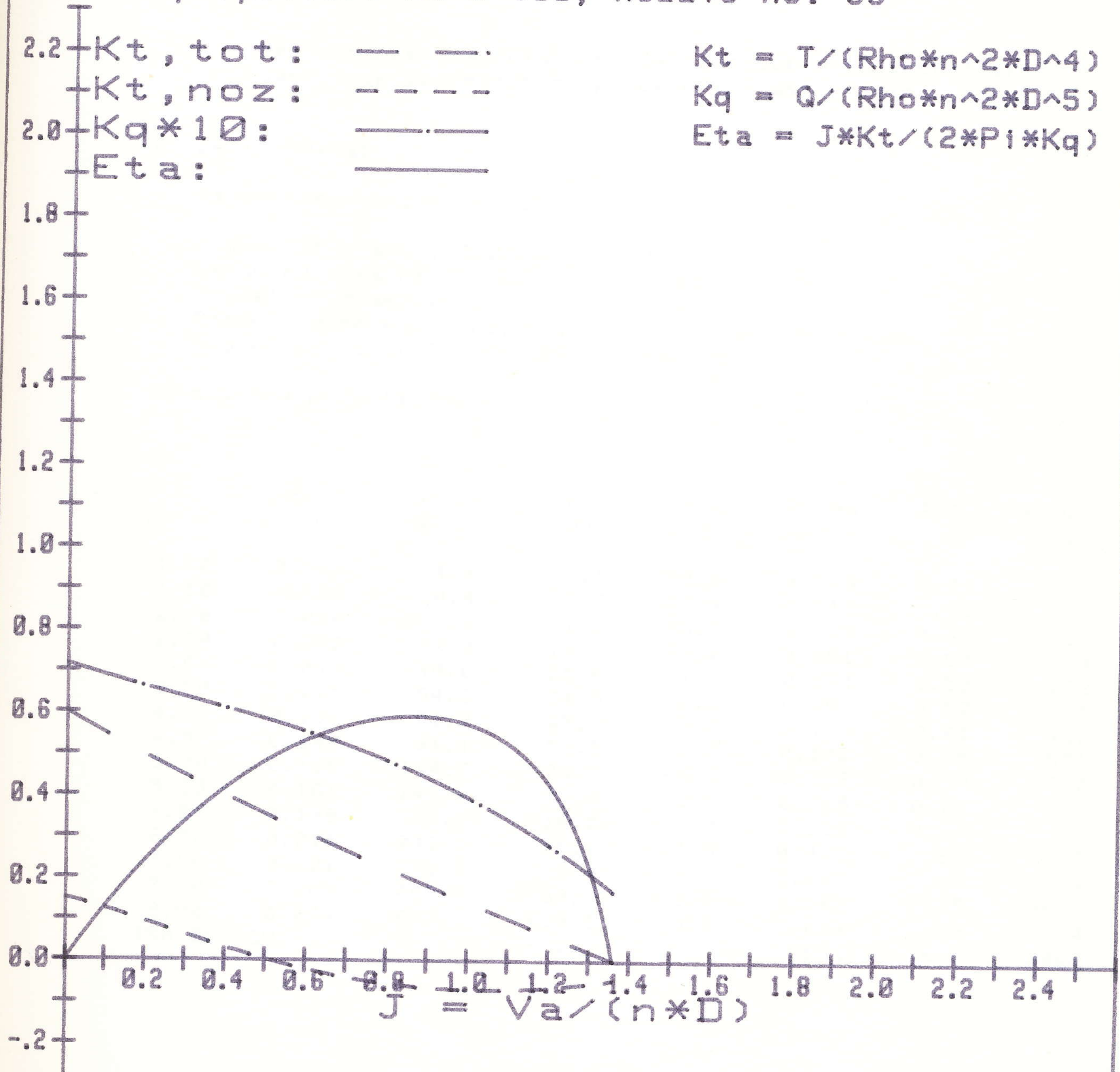
IDENTIFICATION: SILVER SEARAMBLER

DATE: 4 JULY 86 INITIALS: JOHN GE

No. of blades: 5 P/D at 0.7*R: 1.00

Ae/Ao: 1.000

Nozzle propeller: Kd 5-100, nozzle no. 33



385

T= 7.2 m

PERFORMANCE CALCULATION.

Condition:

Service condition. Service allowance: 20 percent.

Performance calculation carried out with propeller data from optimization procedure, last version used.

Propeller data:

Wageningen nozzle propeller, Kd 5-100, nozzle no. 33

Number of blades, Z........: 5
Expanded area ratio, Ae/Ao.: 1.000
Propeller diameter.........: 3.500 m
Propeller revolutions, n...: 2.142 rps., constant.
Propeller is of Controlable Pitch type.

Twin screw propulsion.

V [m/s]	Fn	R [kN]	T,tot. [kN]	T,noz. [kN]	Ae/Ao necc.	P/D	Power [kW]
1.00	0.033	4.8	3.1	24.4	0.009	0.41	131
1.50	0.049	10.4	6.7	21.4	0.019	0.43	155
2.00	0.066	18.2	11.7	18.3	0.033	0.46	189
2.50	0.082	28.0	18.0	15.0	0.051	0.50	234
3.00	0.099	40.0	25.6	11.4	0.074	0.53	292
3.50	0.115	54.3	34.9	7.5	0.101	0.57	365
4.00	0.132	71.2	45.7	3.2	0.133	0.61	457
4.50	0.148	91.1	58.5	-1.5	0.172	0.65	571
5.00	0.165	114.7	73.7	-6.5	0.218	0.70	717
5.50	0.181	143.4	92.0	-12.0	0.275	0.76	902
6.00	0.198	183.7	118.0	-18.0	0.357	0.83	1177
6.50	0.214	243.4	156.2	-24.3	0.483	0.92	1608
7.00	0.231	332.5	213.4	-29.7	0.680	1.05	2324
7.50	0.247	468.5	300.7	-30.8	1.009	1.25	3601
8.00	0.264	683.4	439.1	-19.9	1.624	1.59	6204

Increased propeller diameter.

ved 7.2 = T

PROPELLER OPTIMIZATION.

Design condition:

Ship speed: 7.50 m/s.

Service condition. Service allowance: 20 percent.

Total resistance of ship at design speed: 468.5 kN.

Total thrust (impeller and nozzle)......: 300.6 kN.
Nozzle thrust...........................: -45.6 kN.

Neccessary power..: 3460 kW, per shaft,
at propeller revs.: 1.682 rps.

Choice of propeller (twin screw ship):

Wageningen nozzle propeller, Kd 5-100, nozzle no. 33
Number of blades, Z...................: 5
Expanded area ratio, specified, Ae/Ao.: 1.000
Expanded area ratio, neccessary.......: 0.856
from cavitation test.
Propeller diameter....................: 4.000 m
Pitch ratio at 0.7*R, P/D.............: 1.28

Cavitation test at design condition carried out according to Burrill's criterion for merchant ship propellers.

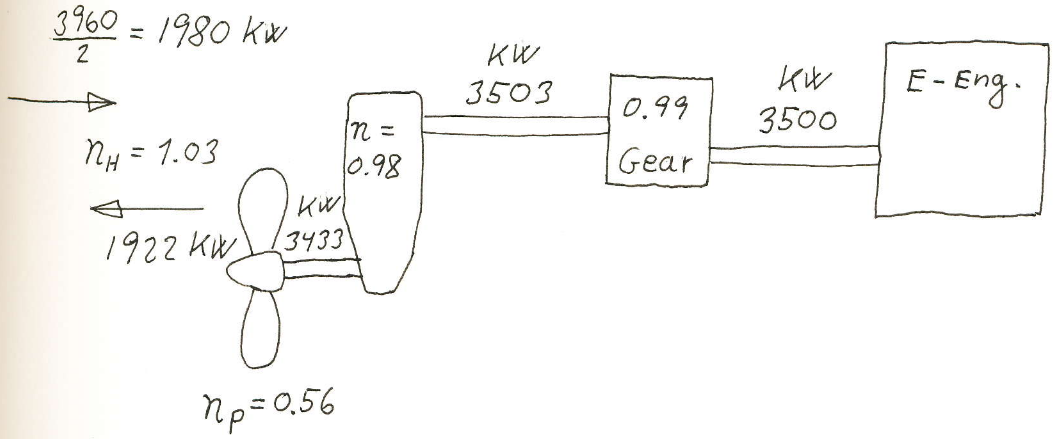
Shaft height assumed 0.6 * D above base line.

Propulsion coefficients:

Wake coefficient, w ...., calc.: 0.25
Thrust deduction coefficient, t, calc.: 0.22

Hull efficiency, (1-t)/(1-w)..........: 1.03
Propeller efficiency..................: 0.58 ← *not much increase, we need only D=3.5*
Rotative efficiency..........., calc.: 0.97
Transmission efficiency...............: 0.87
Overall efficiency....................: 0.51

We can now estimate the power need per shaft:



Each electrical main engine is going to deliver appr. 3500 kW.

On the next few pages you will see the range of the Kamewa rotatable thrusters. I have marked the one which I find to be most alike the one optimized propeller. The Kamewa propeller from the pamphlet is used to calculate or use the dimensions, weight, RPM etc.

POWER NEED AT SITE

At the operation on the work site the power use is very different from the power need when sailing at constant speed. The power need at site will change very much depending of what consumers that are put into action and with what work load.

The single switchboards for the different consumers, however, should be for max load.

To get a view of the power need at work site when the dynamic position system, the cranes, the deep sea diving system etc. are put in action we could write:

Dynamic position	2 x 3500	7000 kW
	3 x 1000	3000 kW
diving system, the switchboard on Safe Regalia for the diving system is of 788 kW		788 kW
CCBS, gas reclaim, Bruker bell, 2 x ROV, Sea Crab etc. have been added, evaluated:		100 kW
Diving winches, heave compensators, etc. each appr. 300 kW (16 pce. x 300 kW)		4800 kW
Crames, 2 x 380 kW:		760 kW
Other, evaluated:		1000 kW
At 100% power consumption:		17448 kW

However, all these consumers will not work at the same time and not with 100% power need.

I was told to calculate with a power load of 50% over a longer period:

.5 x 17448 kW = 8724 kW

A detailed power need analysis is needed to evaluate these numbers.

8.12.

THE ELECTRICAL MAIN ENGINES

The hight of the aft main engine room on the tank top deck was set to 3 meters in order to give adequate space for the electrical main engines. I called Sven Knudsen, an engineer at ASEA A/S and received the information that the engine models ranging from appr. 2000 kW to 3500 kW all have the same hight 2525 mm and that the need for additional top space is 475 mm giving a total needed hight of 3000 mm.

We need two engines both delivering up to 3500 kW. It turned out that the biggest available machine actually delivers 3500 kW. If a higher output is needed it will be necessary to couple two engines together.

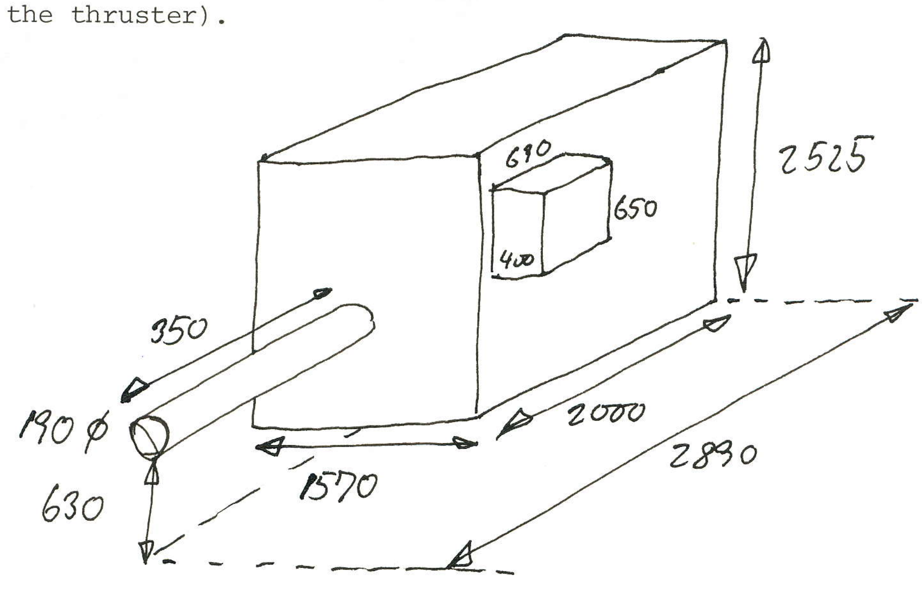
The 3500 kW engine is: Type MBR 630 L, NK 522 499 ASEA.

It is with four poles , 4600 V, 60 HZ, constant RPM of 1800. The total weight is appr. 10 tons.

If Two machines is going to be coupled together a heavy gear has to be set between the two engines. Two machines with a total output of 4000 kW has a much higher weight - up to 20 tons - even that the output from each engine is smaller than the single 3500 kW amchine.

The 3500 kW machine looks like this:

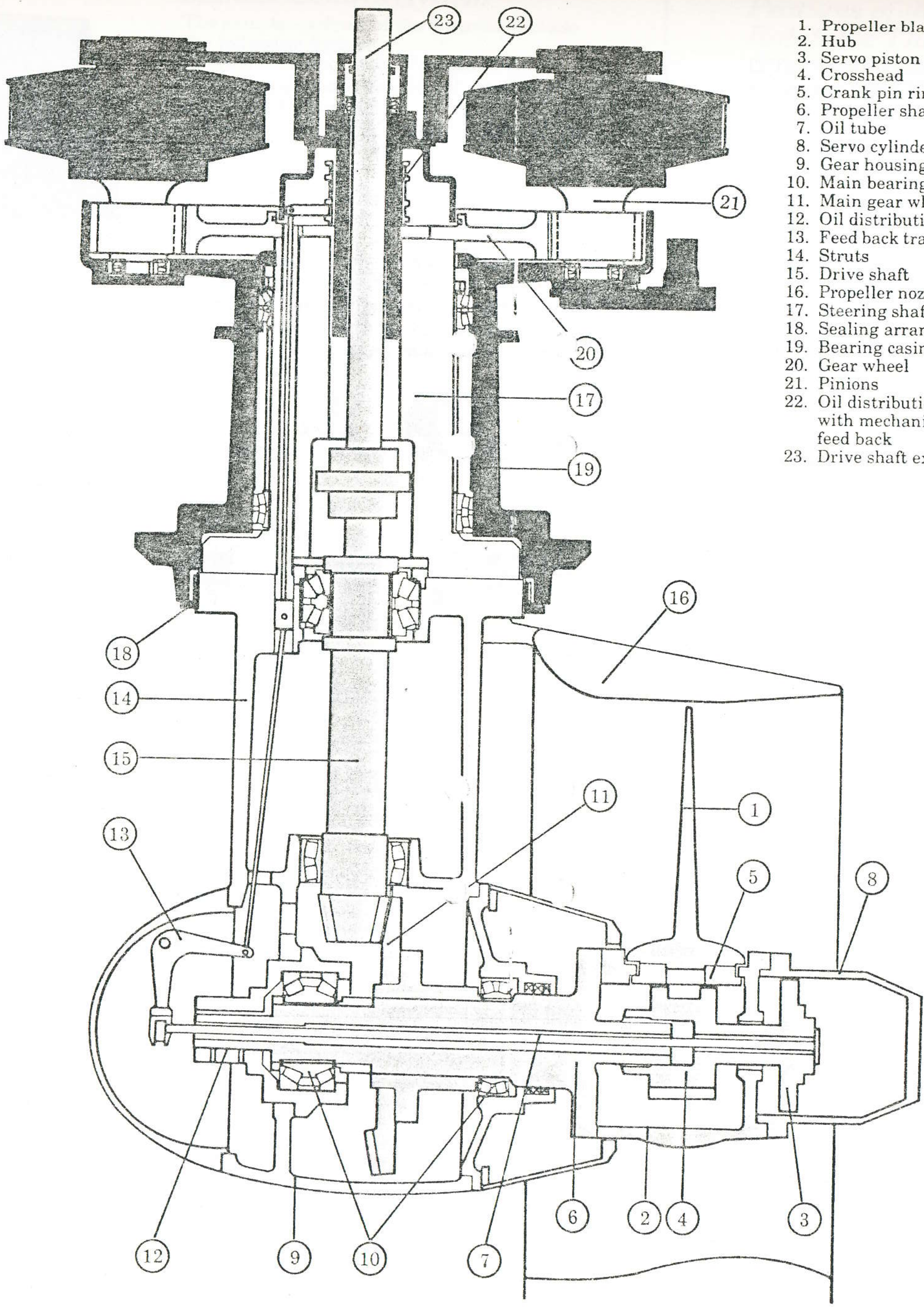
(it is an asynchronous squirrel cage motor with a simple direct-on-line starter with sufficient alternator capacity to meet the requirements of the thruster).



Basic Thruster Design

The Rotatable Thruster consists of the following main items:
☐ Propeller unit ☐ Steering unit ☐ Nozzle

The propeller blades (1) are mounted on the hub (2) incorporating the mechanism for the blade pitch setting. The servo piston (3) is mounted on a piston rod which a crosshead (4). In the pocket of this crosshead are placed sliding blocks connected to the crank pin rings (5). The servo piston movement is transmitted into a blade-turning movement. The pressure oil to the servomotor is led to the servo through the hollow-bored propeller shaft (6), inside of which is inserted a tube (7) to provide for the two oil passages to each side of the servo piston.
– The piston runs in a servo cylinder (8) which forms the aftermost part of the propeller hub.
In the case of a fixed pitch propeller (FPP) version the propeller is of monoblock type.
The gear housing (9) includes the main bearings (10) of the propeller shaft.
At the opposite end of the propeller shaft, the main gear wheel (11) and the oil input (to the main servo) – the oil distribution box (12) is mounted. At the extreme end the pitch feed-back transmission (13) is arranged, connecting the piston rod to the external pitch control or indication system.
The interior of the propeller hub, gear housing and the main stay are filled with overpressure oil to provide for lubrication and to prevent the ingress of seawater.
One strut (14) is connected to the gear housing, containing the input drive shaft (15) with pinion and bearings for same.
The propeller nozzle (16) is made of fabricated steel with a stainless steel ring in the way of the blade tips. The nozzle is attached to the strut flange and to the gear housing with two stays.
The hydrodynamic design of the unit is based on results from extensive model tests in the



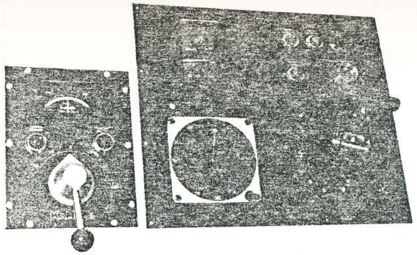
1. Propeller blades
2. Hub
3. Servo piston
4. Crosshead
5. Crank pin rings
6. Propeller shaft
7. Oil tube
8. Servo cylinder
9. Gear housing
10. Main bearings
11. Main gear wheel
12. Oil distribution box
13. Feed back transmission
14. Struts
15. Drive shaft
16. Propeller nozzle
17. Steering shaft
18. Sealing arrangement
19. Bearing casing
20. Gear wheel
21. Pinions
22. Oil distribution box with mechanical feed back
23. Drive shaft extension

cavitation laboratory and combines high specific thrust qualities with low cavitation/ noise generation.
The steering gear consists of the following main parts:
☐ The steering shaft (17) with roller bearings which carry the thruster unit. On the lower part of the shaft the seawater sealing arrangement (18) is situated. The sealing consists of stuffing-box type adjustable from inside the hull.
☐ A bearing casing (19) carrying the steering shaft and bolted to a flange integrated with the hull structure.
☐ The steering mechanism, which includes one gear wheel (20) fitted to the upper end of the steering shaft, two rotary hydraulic motors with pinions (21); all items mounted in a gear casing.
☐ For pitch control, an oil distribution box including mechanical pitch feed-back (22) is fitted in the support shaft.
– Inside the steering shaft a drive shaft extension (23) is journalled.

Drive systems

☐ For the CP propeller version of the thruster, a simple, non-reversing constant speed drive system can be used. The most common power source is the asynchronous squirrel cage motor. As the propeller can only be started in zero pitch (obtained through a zero-position-sensing switch in the starting circuit) a simple direct-on-line starter can normally be used, provided that sufficient alternator capacity is available.
Other suitable power sources are:
high-speed diesels, hydraulic motors, steam or gas turbines connected direct to the drive shaft or via a right-angle gear.
☐ The FP propeller version requires a drive system which includes suitable arrangements for control of shaft speed and direction of rotation, such as a thyristor-controlled electric motor.

Control Panel

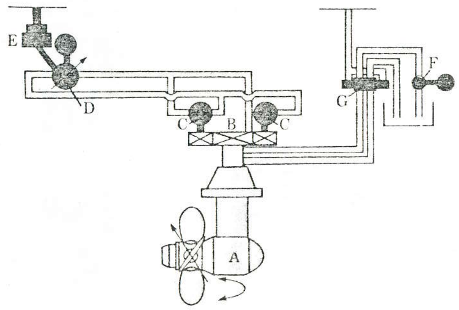


Hydraulic Systems

The CP propeller alternative includes two external hydraulic systems, one for the pitch setting and one for the steering gear.

PITCH CONTROL

The system consists of one hydraulic unit (oil tank, electric screw pump(s), one electric/hydraulic control valve, cooler and filters), one gravity tank and external piping. The mechanical pitch feed-back is connected to the response transmitter.



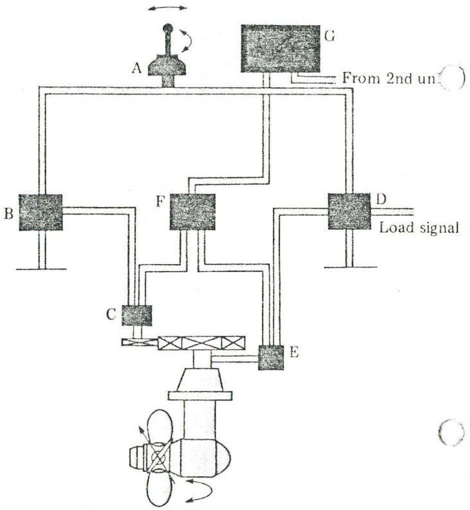
A. Thruster unit
B. Steering gear
C. Hydraulic motors for steering control
D. Variable displacement pump
E. Servo/electric control valve assembly for item D
F. Screw pump for pitch setting
G. Electric valve for pitch control

STEERING CONTROL

The rotary hydraulic motors are of the slow speed type. – The external hydraulic system consists of electric variable displacement pump(s) necessary valves and filters.
The output from the pump is controlled by a servomotor governed by an electric/hydraulic valve.
The FP propeller alternative includes only hydraulic systems for steering control. This is identical with the one described above.

Remote Control System

The remote controls of the thruster include the following features:
☐ Pitch control of the CP propeller or
☐ Shaft speed and direction of rotation control of the FP propeller
☐ Steering control (identical for CP and FP versions).
☐ Joystick control
The above systems include manual local control and interface for automatic dynamic positioning.
The CP version includes automatic load control of the prime mover, based on sensing of the prime mover power. The pitch is automatically adjusted to prevent overload and to maintain pre-set power in the upper range.

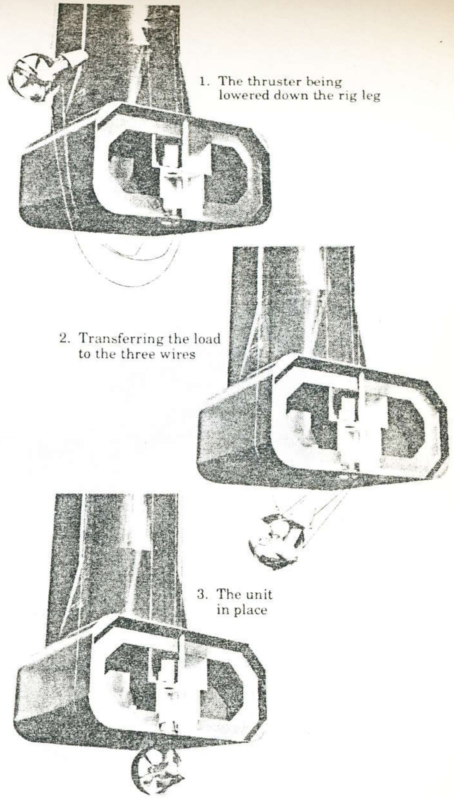


Remote Control/Indication System
A. Single lever for control of magnitude & direction of thrust
B. Central unit for steering control
C. Angle response transmitter
D. Central unit for pitch control
E. Pitch response transmitter
F. Central unit for display
G. Display of magnitude & Direction of thrust

The control includes a combined control lever for the setting of magnitude and direction of thrust, one for each thruster unit. Where a number of thrusters are installed, provision is made for either individual or combined control.
Indicators for thrust magnitude/direction are supplied as optional extras. Alternatively these functions can be combined in a display panel, which also will show resulting thrust.

Features of the KaMeWa Rotatable Thruster

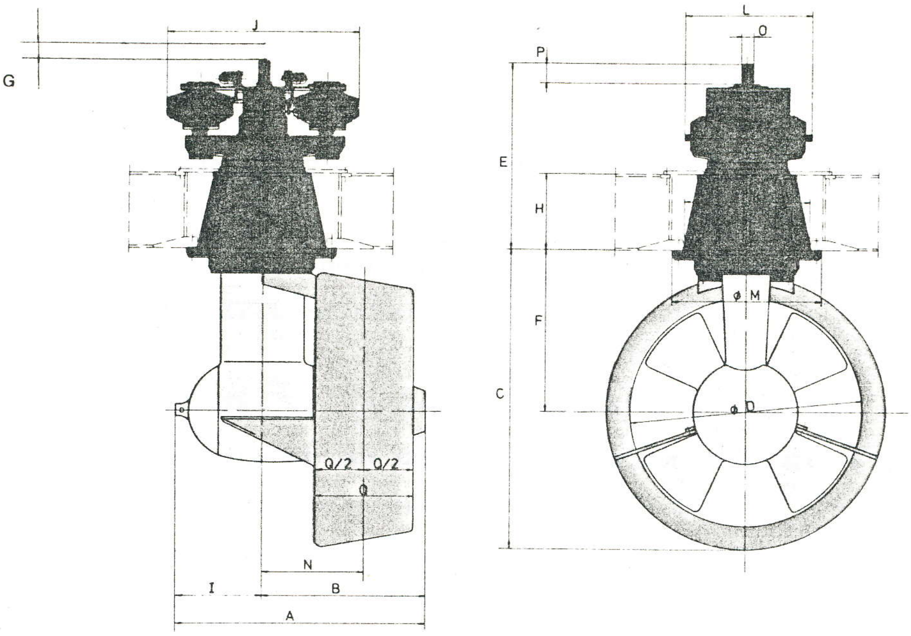
☐ The KaMeWa Thruster offers high thrust values per rated HP. The noise and vibration levels are low. Efficient propeller blade and nozzle designs have been developed in the KaMeWa Marine Laboratory.
☐ The mechanical design is rugged and reliable. 40 years of experience in the field of CP Propellers gives a valuable design background.
☐ The CP Propeller version offers high flexibility in the way of power utilization. At varying water velocity it is always possible to absorb full power and to deliver maximum thrust. Variations in thrust requirements are rapidly met.
☐ A special features, the U-design, makes it the possibility to remove/reinstall thruster units afloat. This means reduced time for inspection and overhaul.



1. The thruster being lowered down the rig leg
2. Transferring the load to the three wires
3. The unit in place

Thruster Data

D mm	Power Range kW	Power Range HP	Frequency (electric motor)	Input RPM	Propeller RPM
2000	735– 1320	1000– 1800	50 60	980 1190	319 319
2400	880– 1980	1200– 2690	50 60 60	980 1190 880	271 273 243
2800	1320– 2900	1800– 3940	50 60	980 880	240 216
3300	1910– 3970	2600– 5400	50 60	735 700	210 200
3900	2795– 5470	3800– 7440	50 60	590 590	163 163



Dimensions

Propeller dia. D mm	A CPP	B CPP	A FPP	B FPP	C	D	E	F	Dismantling space G
2000	2110	1410	1540	1030	2665	2020	1525	1445	200
2400	2530	1690	2020	1315	3200	2430	1830	1735	200
2800	2985	2005	2375	1555	3736	2835	1980	2025	240
→ 3300	3510	2355	2795	1820	4400	3345	2330	2385	280
3900	4140	2775	3300	2145	5200	3955	2750	2815	330

Propeller dia. D mm	H	I	J	K	L	M	N	O	P	Q
2000	675	700	2100	995	1280	1330	960	100	140	910
2400	810	840	2370	1195	1560	1580	1060	140	170	1050
2800	945	980	2370	1395	1560	1860	1240	150	200	1220
→ 3300	1115	1155	2790	1645	1840	2195	1460	180	235	1440
3900	1320	1365	3295	1945	2175	2595	1725	215	275	1700

Weights, kgs – CPP-type

Propeller dia. D mm	Thruster unit	Truster unit with auxiliaries	Handling weight, U-design
2000	15 700	17 700	11 500
2400	25 000	27 300	21 000
2800	37 500	40 000	32 500
→ 3300	57 500	60 600	49 500
3900	88 000	91 700	76 000

Dimensions and weights in the table are not binding. Right of alterations reserved.

KAMEWA

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8.14.

THE TUNNEL THRUSTERS

In order to choose the correct tunnel thruster or thrusters there are several things to take in mind:

1) To what extent is the power going to be designed in order to gain a high scoring at the DnV classification. The quality of the thrusters which is a part of the efficiency of the dynamic positioning system is marked with a ERN number xx.xx.xx. The highest mark is the ERN number 99.99.99. The Dannebrog no. 188 has got this mark. The scoring will tell the platform owner how safe it is to have the ship come near the platform to work in bad weather conditions.
2) How many thrusters are needed? One big, two minor or three small? In general it could be said that several thrusters increases the redundancy and therefore the safety of operation and that smaller thrusters have a lower turning time making them more flexible.

I have chosen to solve the problem by looking at similar ships.

Initially, I have choosed the Kamewa tunnel thruster of 1000 kW and three of these are placed in the bow section. In order to evaluate this we should compare the bow thruster power in relation to the projected lateral area above and below the waterline knowing the wind and water thrust for several ships. However, the diving ships that I have picked up for comparison are to some extent very alike in shape except for the size. Allow me to use the max. displacement of these ships to do the comparison. If you look at the bow thruster room there are space enough to increase the propeller diameter and the electrical engines if needed.

You will se the comparison on the next page:

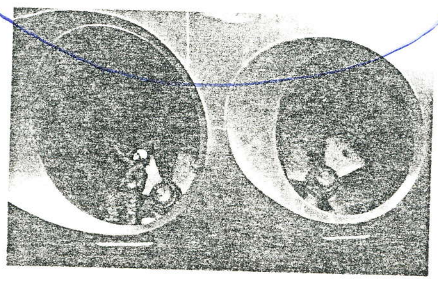
M/S Wildrake:	2 x 370 kW/4080 tons	=	0.18
Dannebrog NOS 188:	3 x 810 kW/6510 tons	=	0.37
M/V Seaway Pelican:	3 x 1100 kW/6417 tons	=	0.51
Stena Seawell:	3 x 1325 kW/12243 tons	=	0.32
Stena Seaspread:	2 x 1300 kW/9983 tons	=	0.26
Silver Searambler:	3 x 1000 kW/9200 tons	=	0.33

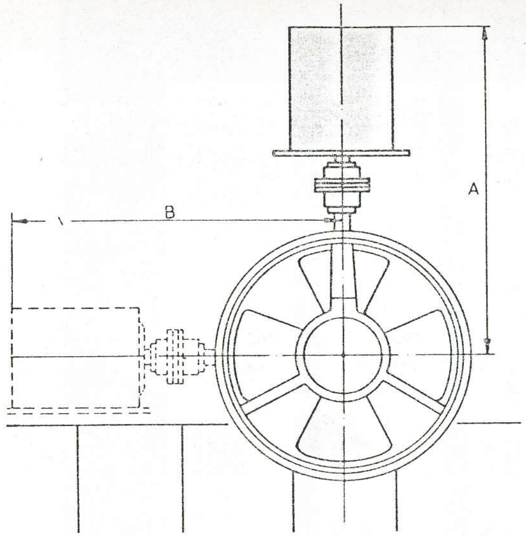
I do not find that the bow thruster power of Silver Searambler is too small, but it has to be verified by DnV for special purpose ships.

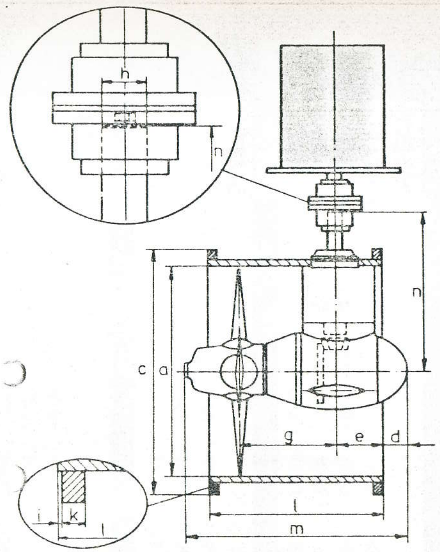
Special Vessels

Vessels like dredgers, drill ships and similar must be given special consideration with regard to selection of tunnel thruster size.

The determining of the size of a tunnel thrusters for a particular vessel is normally made having regard to its projected lateral area above and below the waterline. On this basis, thrust versus turning time can be calculated for various wind velocities and selection of an optimum size unit can readily be made.







Technical data

Dimensions

Propeller dia. D mm	A*	B*	a	c	d	e	g	h	i	k	l	m	n
1100	2320	2310	1120	1330	175	305	505	70	15	30	975	1283	842
1300	3280	2810	1328	1538	190	315	615	80	20	30	1130	1470	933
1650	3740	3270	1680	1910	260	360	730	90	15	50	1330	1797	1145
→ 2000	4480	4030	2026	2270	340	420	900	110	20	50	1620	2195	1395
2400	4640	4090	2430	2682	310	500	1080	140	20	50	1940	2532	1647
2800	5320	4770	2836	3206	395	620	1210	150	30	60	2280	2990	1930
3300	5800	5200	3340	3710	465	730	1425	175	30	70	2685	3530	2280

All dimensions in millimetres Not binding unless specifically stated
* Approx dimensions, depending on motor type.

Data for hydraulic system

D	Manoeuvre* time sec.	Pump Power kW AC 50	AC 60	Volumes-Litres Main tank	Gravity tank	Total system
1100	10	1.4	1.2	150	45	300
1300	12	2.1	1.8	150	45	400
1650	16	2.1	2.6	150	45	500
→ 2000	20	3.0	3.6	150	45	700
2400	24	4.4	3.6	150	100	1400
2800	32	11.0	7.5	150	100	1600
3300	40	12.0	12.0	200	100	1900

* Time for one complete reversal

General Data

Prop. D mm	Power kW	Frequency (Electric motors) hZ	Input shaft speed RPM	Torque O-pitch Nm***	J kgm²*	Weights Equipment**	Motor with starter kgs
1100	- 310	50	1450	250	1.2	2050	850
	- 335	60	1750	345			
1300	- 445	50	1450	340	1.9	2700	1300
	- 480	60	1750	470			
1650	- 710	50	1450	830	4.5	4700	2300
	- 770	60	1750	1120			
→ 2000	-1150	50	1450	1820	11.3	7450	3300
	-1000	60	1190	1340			
2400	-1580	50	980	2270	28.8	14000	4500
	-1720	60	1190	3050			
2800	-2000	50	980	3935	65	20500	5000
	-1910	60	880	3300			
3300	-3500	50	590	5600	358	31000	6000
	-3500	60	590	5600			

* Related to input shaft ** Excl. motor and starter *** Nm at 100 % RPM related to input shaft

Plate thickness in tunnels (t_1) and tunnel extensions (t_2)

D	t_1 mm	t_2 mm	D	t_1 mm	t_2 mm	D	t_1 mm	t_2 mm
1100	15	15	2000	22	20	3300	35	25
1300	15	15	2400	26	20			
1650	15	15	2800	35	25			

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8-15-

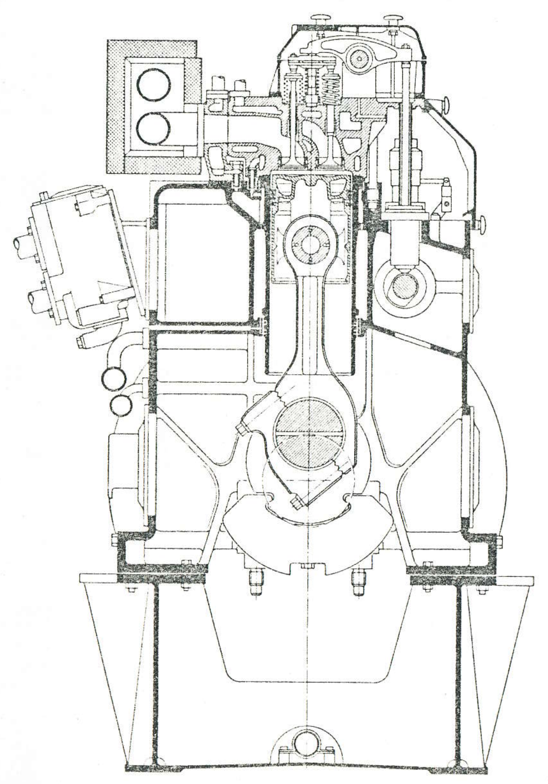
THE DIESEL ENGINE GENERATORS

Marine GenSet Programme

Engine type	Number of cylinders	720 rpm/60 Hz kW	720 rpm/60 Hz BHP	750 rpm/50 Hz kW	750 rpm/50 Hz BHP	Overall Dimensions Length[1]) mm	Overall Dimensions Width[2]) mm	Overall Dimensions Height[3]) mm	Dry Weight Engine[4]) t	Dry Weight GenSet t
T23LH										
5T23LH	5	530	725	550	750	5005	1580	2535	9.7	14.8
6T23LH	6	640	870	660	900	5320	1640	2635	11.0	16.4
7T23LH	7	740	1015	770	1050	5815	1640	2810	12.5	18.6
8T23LH	8	850	1160	880	1200	6255	1640	2810	13.5	20.2
L23/30										
6L23/30	6	780	1060	810	1100	5730	1640	2460	10.9	17.0
8L23/30	8	1040	1415	1080	1470	6670	1640	2575	13.5	20.8
9L23/30	9	1170	1590	1215	1650	7025	1790	2625	14.9	22.8
S28LH										
5S28LH	5	875	1200	925	1250	6180	1940	3065	14.4	21.3
6S28LH	6	1050	1440	1110	1500	6650	2000	3065	17.3	25.3
7S28LH	7	1225	1680	1295	1750	7120	1940	3320	19.3	27.5
8S28LH	8	1400	1920	1480	2000	7950	2000	3320	20.4	29.5
L28/32										
9 — 6L28/32	6	1260	1715	1320	1800	7020	1940	3130	18.7	26.9
8L28/32	8	1680	2285	1760	2400	8235	2000	3130	21.9	32.0
9L28/32	9	1890	2570	1980	2700	8995	2000	3350	23.2	34.4
U28LH										
12U28LH	12	2100	2880	2220	3000	8255	2240	3330	31.6	44.5
16U28LH	16	2800	3840	2960	4000	9485	2490	3580	39.1	54.0
18U28LH	18	3150	4320	3330	4500	10045	2490	3580	43.0	62.3
V28/32										
12V28/32	12	2520	3430	2640	3600	8125	2240	3300	32.2	46.1
→ 16V28/32	16	3360	4570	3520	4800	9765	2490	3300	39.9	59.8
18V28/32	18	3780	5140	3960	5400	10885	2490	3370	43.9	65.6

[1]) Total length incl. generator [2]) Total width [3]) Total height incl. bedplate [4]) Engine and engine bedplate

L28/32
Four-stroke Diesel engine 210/220 kW/cyl. 720/750 rpm



Ratings

General definition of Diesel engine ratings (Tropical conditions)

Cont. rating 10 % overload capacity for 1 hour's service within 12 hours

Reference conditions:

Air temperature	318° K (45° C)
Air pressure	1 bar
Cooling water temperature before charge-air cooler	305° K (32° C)
Specific fuel oil consumption under ISO conditions; Lower calorific value	42,700 kJ/kg (10,200 kcal/kg)
Tolerance	+ 3 % 198 g/kWh 146 g/BHPh
A reduction of 1 % can be expected after running-in of the engine	
Lubricating oil consumption	6 kg/cyl./24 h 1.1-1.2 g/kWh 0.8-0.9 g/BHPh

Technical Data

Working cycle:	4-stroke
Combustion process:	direct injection
Number of cylinders:	6, 8, 9, 12, 16, 18
Cylinder bore:	280 mm
Piston stroke:	320 mm
Swept vol. per cyl.:	19,7 dm³
Cylinder output:	at 720 rpm 210 kW/285 BHP at 750 rpm 220 kW/300 BHP

Performance data:

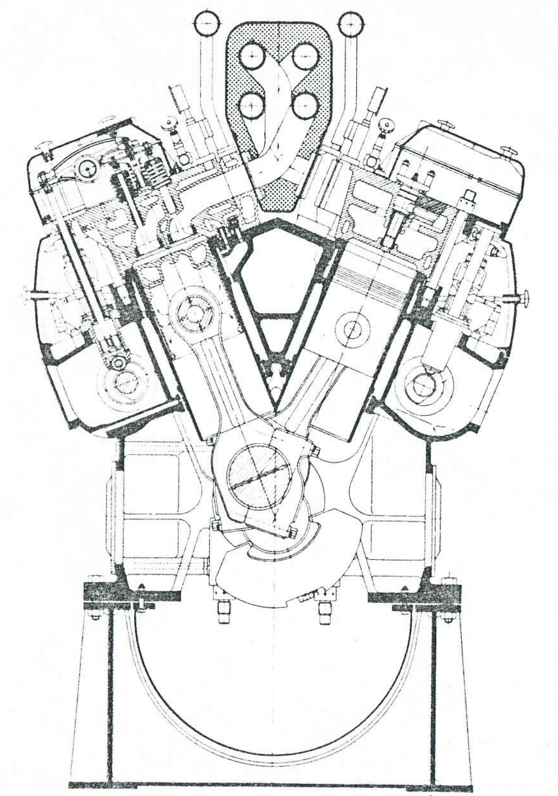
Speed: 720/750 rpm

Mean piston speed: 7.7/8.0 m/s

Mean effective pressure: 17.8/17.9 bar

		kW	BHP
6L28/32	6 cyl.	1260 1320	1715 1800
8L28/32	8 cyl.	1680 1760	2285 2400
9L28/32	9 cyl.	1890 1980	2570 2700
12V28/32	12 cyl.	2520 2640	3430 3600
16V28/32	16 cyl.	3360 3520	4570 4800
18V28/32	18 cyl.	3780 3960	5140 5400

V28/32
Four-stroke Diesel engine 210/220 kW/cyl. 720/750 rpm



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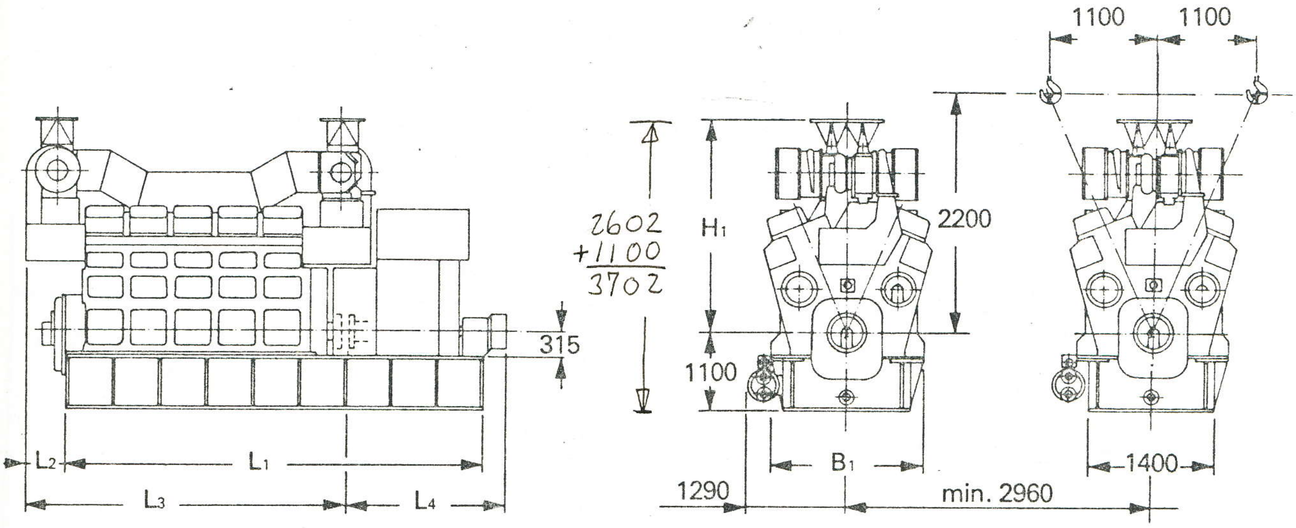
V28/32 Four-stroke Diesel engine 210/220 kW/cyl. 720/750 rpm

408



Engine type	Cyl.	L_1* mm	L_2 mm	L_3 mm	L_4* mm	B_1* mm	H_1 mm	Dry Wt** t
12V28/32	12	6510	980	4910	3195	1900	2542	32.2
16V28/32	16	7450	980	5930	3835	2400	2602	39.9
18V28/32	18	8090	1470	6930	3955	2400	2609	43.9

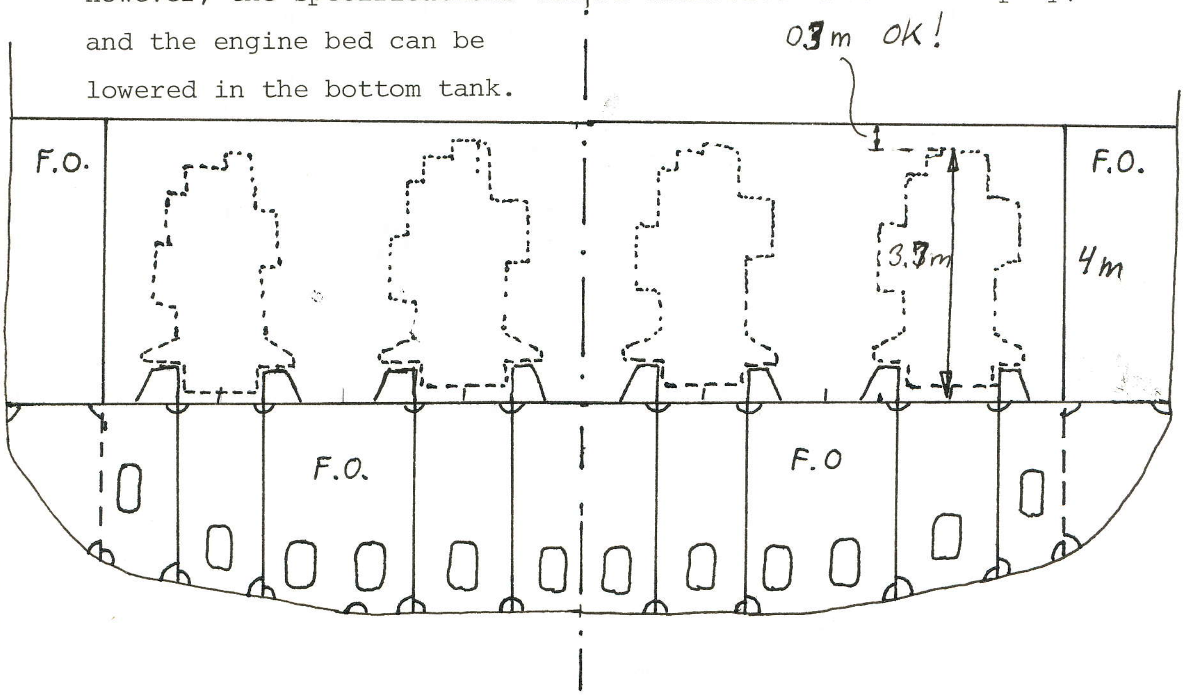
* Depending on alternator.
** Engine and engine bedplate.

The dismantling height stated is valid for traveling crane arrangement.
Reduced height can be obtained by special arrangement.

The way the four engines will be placed on the engine bed can be seen on the sketch drawn on this page. First the engines was placed 2 on the tank top and 2 on the main deck becauce the original engine room width was only appr. 19 - 2 x 3 = 13 meter (minus insulation). However, due to problems of strength and distribution of weight load from the machines it was decided to change the layout and place all four engines at the tank top deck.

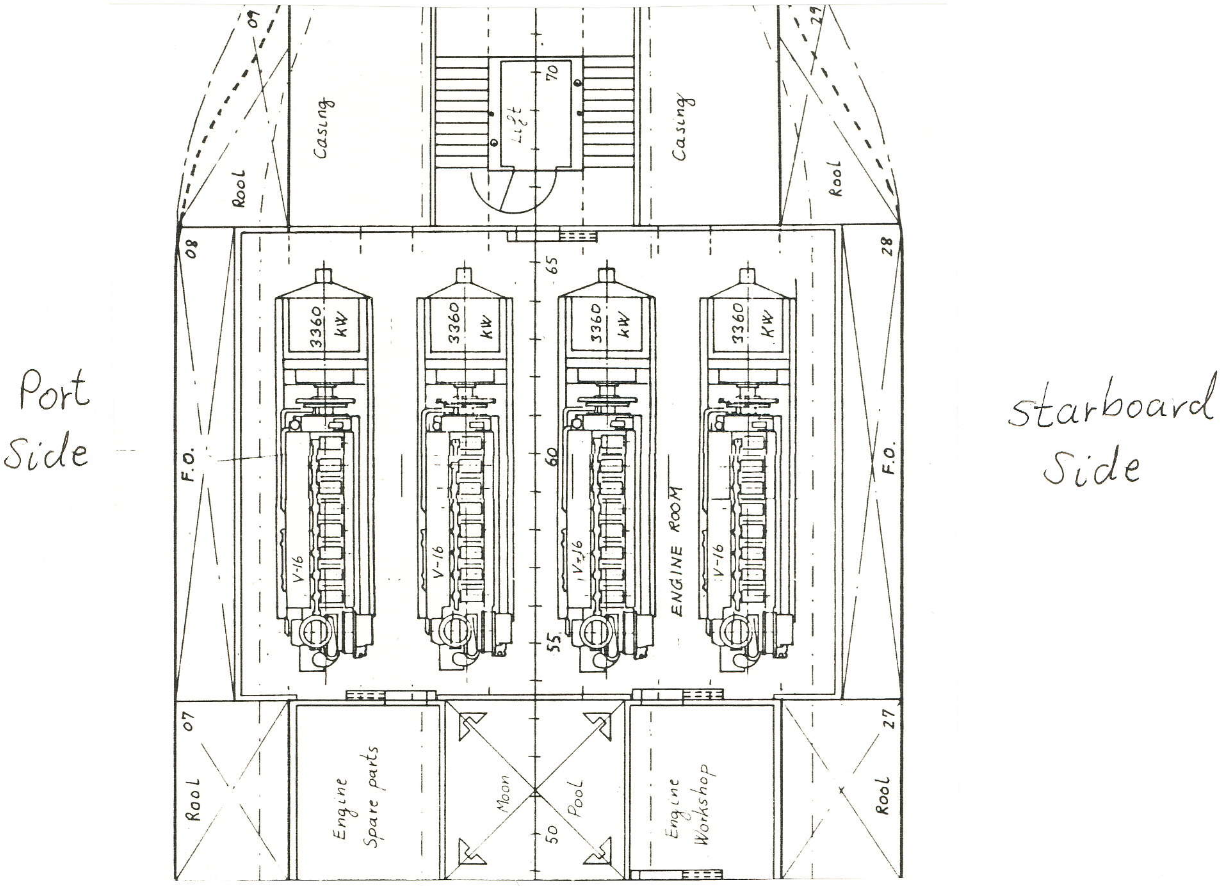
In doing so it became necessary to increase the width of the engine room to 16 meter, which means that the side tank width had to be lowered from 3 to 1.5 meter. You can see this on the drawing no. C-11 and look at the tank top deck.

If you look at the technical specifications of the machines you can see that the actual hight of the engine is 3.7 meters and the hight of the engine room is 4 meters. That leaves only 0.30 meter for checking and repairing the engines. However, the engines is of the V type, which leaves more space to do the piston repairing job. I was in the first round told that the space available is enough, but I am not 100% sure about it. However, the specifications can be delivered from the company, and the engine bed can be lowered in the bottom tank.



From this figure below you can see that the inner hull is moved creating sufficient space for the four main genset diesel engines. You can also see the noice/fire/water proof electric-hydraulic doors which seals of the engine room.

There are no engine control room due to that the engine room is equipped for unmanned operation (EO).



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8.16.

CALCULATION OF THE FUEL CONSUMPTION

At the service speed, V = 7.5 m/s, at the maximum ship load (displacement 9200 t), the two electrical main engines delivers together appr. 7000 kW. The energy comes from the main diesel driven generators. There are many other electrical consumers on board and the demand is fluctating all the time. Therefore it is difficult to estimate the correct number and sizes of the genset engines in order to reach the 0.85% work load of the engines where the kW/fuel is best.

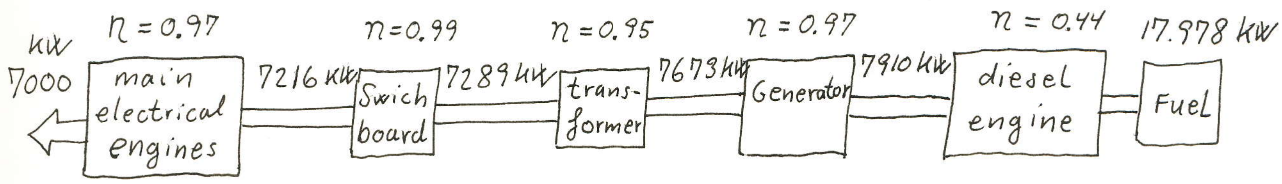
If we look at the similar ships, however, we can get a pretty good estimate of what the lay out should be:

Stena Seawell (6 eng.):	16800 kW/12243 tons	=	1.4 kW/ton
(speed: unknown)			
M/S Wildrake (4 eng):	9980 kW/4080 tons	=	2.4 kW/ton
(speed = 27 km/h)			
M/V Seaway Pelican (4 eng)	12000 kW/6417 tons	=	1.9 kW/ton
(speed = 25 km/h)			
Stena Seaspread (5 eng)	13250 kW/9983 tons	=	1.3 kW/ton
(speed = unknown)			
Dannebrog no. 188 (4 eng)	8600 kW/6510 tons	=	1.3 kW/ton
(speed = 24 km/h)			

It seems to be about 1.5 kW/ton for a deep diving vessel with a dynamic positioning system and a speed of appr. 26 km/h.

The Silver Searambler have a speed of appr. 27 km/hour at summer load line condition, with four diesel generators of 3360 kW each measured at the engines output shaft (not the generator output). That is very much the same as 1.5 kW/ton x 9200 tons = 13800 kw.

The energy consumption diagram looks like this:



If we look at the propulsion power need from the diesel engines shafts it would say 7910 kW. That is only appr. 60% of the total engine power. If only three diesel engines are used for propulsion power the rating would then be: 7910/(3 x 3360) = 0.78 = 78%. This is much better. The fourth diesel engine could be run to deliver energy to all the other consumers on board such as auxhiliary engines, ligth, computers, communication equipment, laundry and galley machines etc. These consumers´need for power is very difficult to calculate and I have no statistical information about this at this present time.

When the ship is on work site position and the diving and the dynamic positioning system is active the need is also very difficult to calculate because the power need is not constant. However, if 7910 kW is at a certain point of time used by the aft thrusters, appr. 3000/(.95 x .97) is used by the fore thrusters and appr. 500 kW by the diving system the need would round up to appr. 12000 kW. This is however, a high setting. If all four engines runs with 85% rating the power at engine shaft would be 4 x .85 x 3360 = 11424 kW. We are not in lack of power.

I called Olav Kongsted, engineer, B&W, Holeby, to get information about the efficiency and the fuel consumption of the V-16, 3360 kW engines. He told me that the fuel consumption is 210 gram/kWh when the load is 3360 at the shaft (100% rating). This means that the oil consumption is a little smaller at 85% work load (minus 2 per cent).

The electrical management system placed in the transformator room is supposed to distribute the energy from the genset as efficiently as possible. One or two engines might be stopped from time to time during operation. I will, however, calculate the fuel consumption at the rating of 78% - all engines running - with a specific oil consumption of 210 gram/kWh. The efficiency of the engines has to be calculated at this work load.

The marine fuel oil have had a decreasing quality level during the years. The density has increased from 0.85 t/m3 to 0.98 t/m3 and the amount of energy per ton is decreasing. Today the lower walue of the fuel oil would probably be 40000 kj/kg. I will calculate with these numbers:

The efficiency of the engine is a product of the thermal and the mechanical efficiencies, and can be calculated this way:

Machine efficiency = 3600/(.210 kg/kWh x 40000 kJ/kg) = 43%

The output energy (effect) from engines: 3 x 3360 x 0.78 = 7862 kW.

The power needed from the fuel oil: 7862/ 0.43 = 18284 kW.

Amount of fuel: $$\frac{18284 \ \text{kJ} \ \text{kg} \ 3600 \ \text{s} \ \text{tons}}{40000 \ \text{s} \ \text{kJ} \ 1000 \ \text{h} \ \text{kg}} = 1.7 \ \text{t/h}$$

Fuel consumption per day: 24 x 1.7 t/h = 41 tons
Fuel consumption per month: 30 x 41 = 1230 tons

But this is only the fuel consumption for propulsion at summer load draught and the speed 7.5 m/s.

M.A.N.-B&W medium-speed engines – minimised specific fuel consumption

In the family of the large medium-speed engines, i.e. the 32/36, 40/45 and 52/55 A the demand for minimum consumption has been catered for with the following developments:

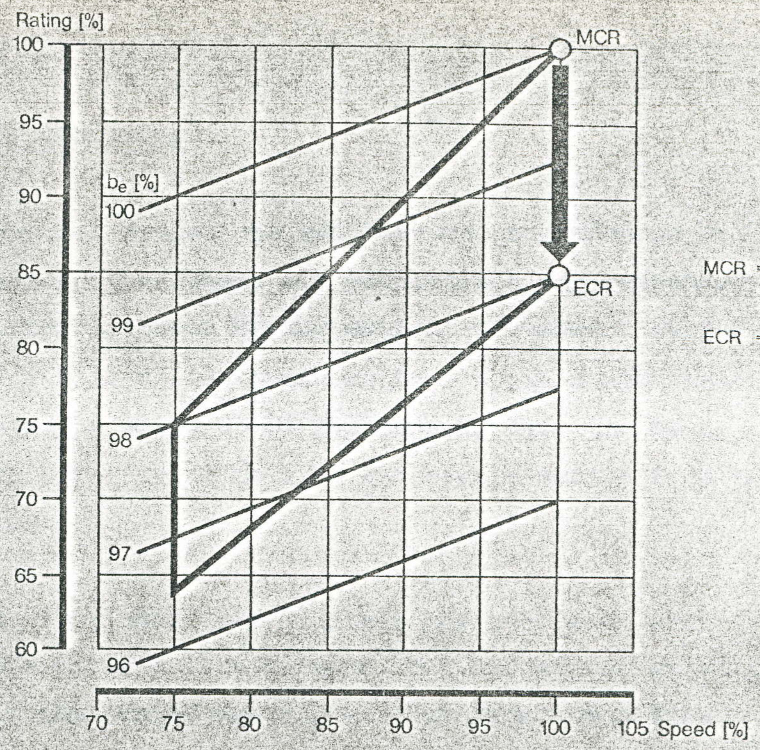
Power-optimised rating
The power outputs quoted in the sales data for marine main engines are defined as the maximum continuous rating (MCR, i. e. fuel stop power). The specific fuel consumption stated in the sales data applies to these ratings.
The output of all M.A.N.-B&W engines is rated to ensure low consumption and cost-effective engine operation, i. e. a balanced relationship is sought between power output, investment and the resultant capital service costs as well as the operating costs (fuel, lubricating oil and maintenance). The fuel costs have by far the greatest share in these costs.

Consumption-optimised rating
Lower consumption rates than those in the sales data can be warranted for M.A.N.-B&W engines if a lower rated output is chosen – the economy continuous rating (ECR). In this case the engine is adjusted for the ECR at the works and the fuel admission is blocked accordingly.
The percentage fuel saving achieved with this reduced engine rating can be ascertained from the diagram. In most cases a consumption-optimised rating of ECR = 85% MCR, yielding a 2% fuel saving, is sufficient and constitutes an economical alternative to the power-optimised engine rating.

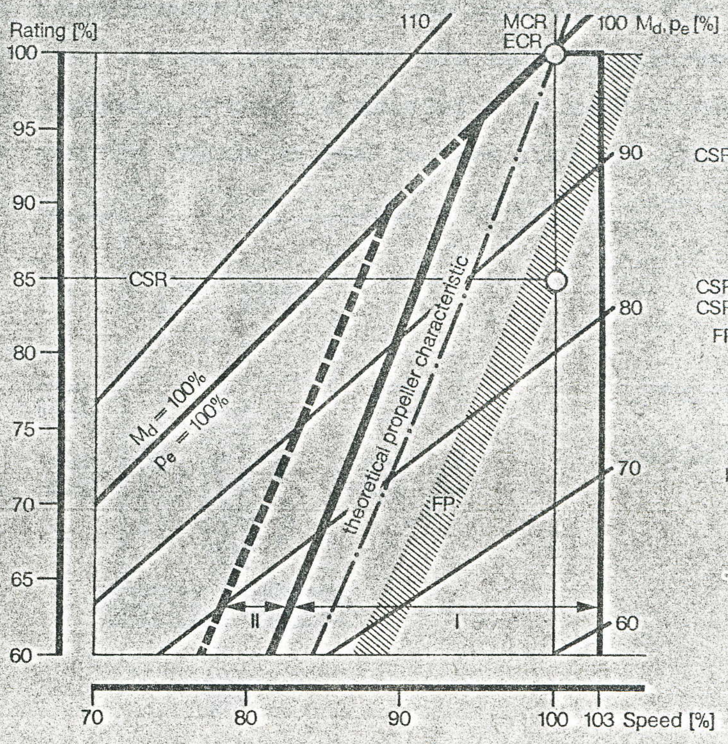
Selection of the operating range
The example of a marine main engine shows how adapting and adjusting the engines to the reduced outputs usual in daily operation can lead to further fuel savings. Depending on the engine rating selected, the continuous service rating (CSR) is thus either
☐ 85% MCR (power-optimised) or
☐ 85% ECR (consumption-optimised).

M.A.N. fuel injection pump
In comparison with conventional injection pumps, a distinct consumption minimum is obtained at 85% load in the power-optimised MCR version.
Thanks to the M.A.N. economy plunger, this fuel saving measure requires no adjustments on the injection pump.

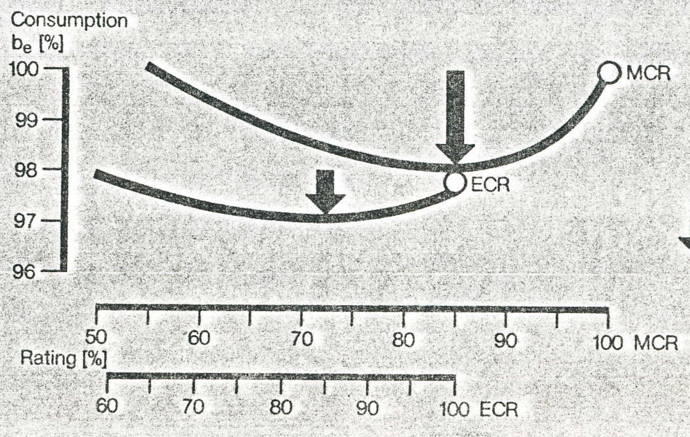
The consumption-optimised ECR version of M.A.N.-B&W four-stroke engines is distinguished by a particularly flat consumption curve in addition to extremely low specific consumption rates. The flat curve is especially beneficial in practical operation since minimum fuel consumption can be ensured at part load ...



MCR = Maximum Continuous Rating (power-optimised)
ECR = Economy Continuous Rating (consumption-optimised)



CSR = Continuous Service Rating (to reduce fuel consumption under service conditions)
CSR = 85% MCR or
CSR = 85% ECR
FP = design range for fixed-pitch propeller
I = Operating range for continuous service
II = Operating range temporarily admissible, e. g. during acceleration, manoeuvring (torque limit)



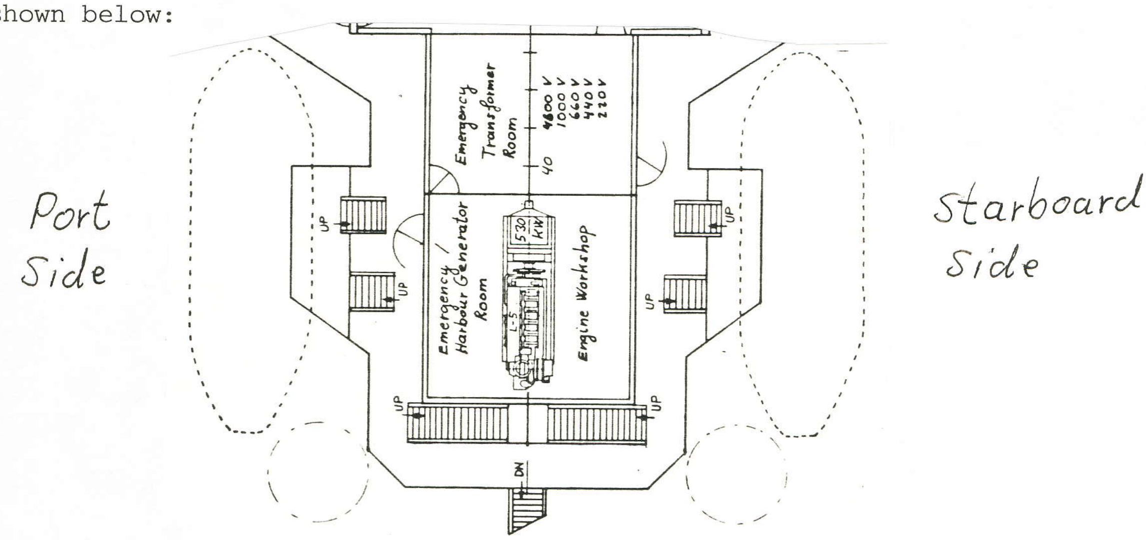
Reduction in consumption by means of M.A.N. economy plunger pump

8.17. THE EMERGENCY/HARBOUR GENERATOR

I did not find any special roules and regulations regarding special ships, but it can be seen that there are regulations for passenger and cargo ships in general stated by the Danish Government Ship Inspection Services. I will follow these roules. It is stated that the emergency generator is going to be placed away from the main engine room and that there are to be free and easily access from the main deck from outside.

As you can imagine it is a good idea to place the generator away from rooms where there excists fire hazards. The higher the generator is placed in the ship the longer the distance is from these fire hazards rooms to the generator.

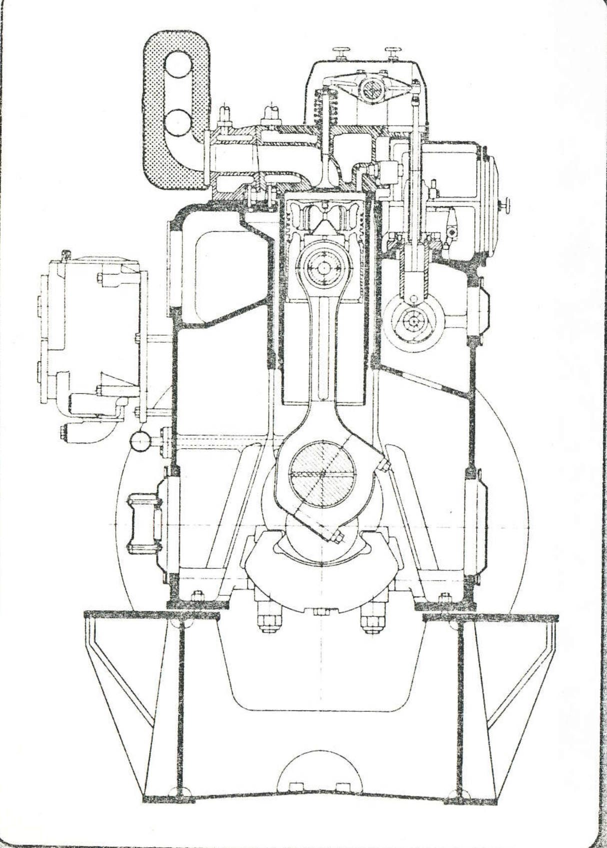
I have placed the emergency generator in its own room aft on the Heli/ACC I deck. There is a minor version of the main transformer room connected to the generator room. The generator is easy accessable from both the outside and the inside as you can see from the figure shown below:



The generator is a 5 cylinder B&W, 530 kW at 60 HZ. The specifications are presented on the following pages. If we compare the power of emergency with other ships we will see that the choice is good:

Stena Seaspread:	2 x 208 kW/13250 kW	=	3% (of main power)
Stena Seawell:	2 x 350 kW/16800 kW	=	4%
"Dannebrog" NOS 188:	1 x 500 kW/8600 kW	=	6%
Searambler:	1 x 530 kW/13440 kW	=	4%

T23LH-2
Four-stroke
Diesel engine
☐ For operation
on fuel oil
max. viscosity
I.F. 80
600 sec.
Redw. 1



Ratings
T23LH-2/T23LH-4

General definition of Diesel engine ratings (Tropical conditions)

Cont. rating 10 % overload capacity for 1 hour's service within 12 hours

Reference conditions:

Air temperature	318° K (45° C)
Air pressure	1 bar
Cooling water temperature before charge-air cooler	305° K (32° C)
Specific fuel oil consumption under ISO conditions; Lower calorific value	42,700 kJ/kg (10,200 kcal/kg)
Tolerance	+3 %
T23LH-2	T23LH-4
217 g/kWh	198 g/kWh
160 g/BHPh	146 g/BHPh
A reduction of 1 % can be expected after running-in of the engine	
Lubricating oil consumption	2-3 kg/cyl./24 h 1.0-1.3 g/kWh 0.8-1.0 g/BHPh

Technical Data
T23LH-2/T23LH-4

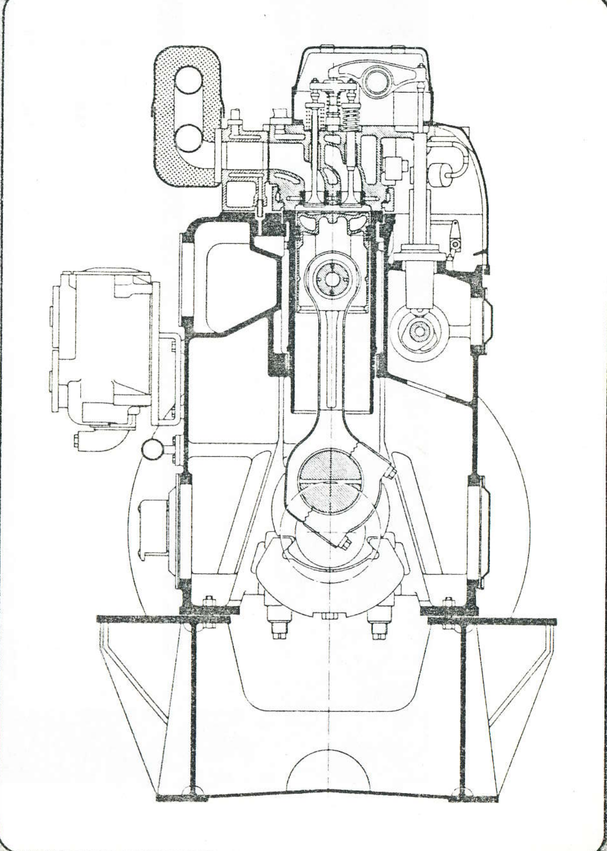
Working cycle:	4-stroke
Combustion process:	direct injection
Number of cylinders:	5, 6, 7, 8
Cylinder bore:	225 mm
Piston stroke:	300 mm
Swept vol. per cyl.:	11,93 dm³
Cylinder output:	at 720 rpm 105 kW/145 BHP at 750 rpm 110 kW/150 BHP

Performance data:

Speed:	720/750 rpm
Mean piston speed:	7.2/7.5 m/s
Mean effective pressure:	14.7/14.8 bar

		kW	BHP
5T23LH	5 cyl.	530 550	725 750
6T23LH	6 cyl.	640 660	870 900
7T23LH	7 cyl.	740 770	1015 1050
8T23LH	8 cyl.	850 880	1160 1200

T23LH-4
Four-stroke
Diesel engine
☐ For operation
on fuel oil
max. viscocity
I.F. 700
7000 sec.
Redw. 1



Marine GenSet Programme

Engine type	Number of cylinders	720 rpm/ 60 Hz kW	720 rpm/ 60 Hz BHP	750 rpm/ 50 Hz kW	750 rpm/ 50 Hz BHP	Overall Dimensions Length[1] mm	Width[2] mm	Height[3] mm	Dry Weight Engine[4] t	GenSet t
T23LH										
5T23LH	5	530	725	550	750	5005	1580	2535	9.7	14.8
6T23LH	6	640	870	660	900	5320	1640	2635	11.0	16.4
7T23LH	7	740	1015	770	1050	5815	1640	2810	12.5	18.6
8T23LH	8	850	1160	880	1200	6255	1640	2810	13.5	20.2
L23/30										
6L23/30	6	780	1060	810	1100	5730	1640	2460	10.9	17.0
8L23/30	8	1040	1415	1080	1470	6670	1640	2575	13.5	20.8
9L23/30	9	1170	1590	1215	1650	7025	1790	2625	14.9	22.8
S28LH										
5S28LH	5	875	1200	925	1250	6180	1940	3065	14.4	21.3
6S28LH	6	1050	1440	1110	1500	6650	2000	3065	17.3	25.3
7S28LH	7	1225	1680	1295	1750	7120	1940	3320	19.3	27.5
8S28LH	8	1400	1920	1480	2000	7950	2000	3320	20.4	29.5
L28/32										
6L28/32	6	1260	1715	1320	1800	7020	1940	3130	18.7	26.9
8L28/32	8	1680	2285	1760	2400	8235	2000	3130	21.9	32.0
9L28/32	9	1890	2570	1980	2700	8995	2000	3350	23.2	34.4
U28LH										
12U28LH	12	2100	2880	2220	3000	8255	2240	3330	31.6	44.5
16U28LH	16	2800	3840	2960	4000	9485	2490	3580	39.1	54.0
18U28LH	18	3150	4320	3330	4500	10045	2490	3580	43.0	62.3
V28/32										
12V28/32	12	2520	3430	2640	3600	8125	2240	3300	32.2	46.1
16V28/32	16	3360	4570	3520	4800	9765	2490	3300	39.9	59.8
18V28/32	18	3780	5140	3960	5400	10885	2490	3370	43.9	65.6

[1] Total length incl. generator [2] Total width [3] Total height incl. bedplate [4] Engine and engine bedplate

84

83,4

01

8.18.

STABILITY ANALYSIS

It is very importent to check what happens to the ship when it is being rolled (i.e. a heel angel occours) due to heavy sea, crane workover etc. This kind of ship has to be very stable not only when sailing but also when the ship is in the dynamic positioning mode.

I have performed the stability analysis on the computer facilities at the institute (Department of Ocean Technology) which have an in-built check facility to the Danish stability requirements of ships. The input is the ship hull data and the hydrostatic data performed earlier.

Several iterations have been performed and I will present only two of the most importent calculations here. I find - in comparison with all the computer readout - that they are the most communicateable readouts. Several load conditions have been examined and they all comply with the Danish regulations. The two which are presented in the following is the stability analysis of the maximum load condition:

Displacement = 9200 t, Draught = 6.8 m, x = 42.2 m and z = 6.6 m.

and the minimum expected load condition (after mission):

Displacement = 7201 t, Draught = 5.65, x = 43.7 m and z = 7.6 m.

As it can be seen the ship is extremely stabil, but that the meta-center-hight seems to be quite big, this will,however, be discussed in the Chapter about GM where the influence of the fluid tanks is being calculated.

The two stability analysises are presented in the following:

```
*  **  *   *   ----------------------------------   *  **  *   *
* *    *   *     ISH STYRKE - BASIC PROGRAMMEL      * *    *   *
*  **  *****   DEPARTMENT OF OCEAN ENGINEERING      *  **  *****
*    * *   *  THE TECHNICAL UNIVERSITY OF DENMARK   *    * *   *
*  **  *   *          DK 2800  LYNGBY               *  **  *   *
-----------------------------------------------------------------
*                     FORM STABILITY                            *
* BUILDERS:JOHN GENART                  PROGRAM FILE : WEIGHT   *
* IDENTIFICATION:SILVER SEARAMBLER      VERSION FEBRUARY 1986   *
* DATE: 22/7-86    INITIALS:  J.G.      DATA FILE : GEN         *
-----------------------------------------------------------------
```

MAIN PARTICULARS :

LENGTH between perpendiculars (Lpp)	87.800 metres
BREADTH moulded at DWL ..... (Bmld)	19.000 metres
DEPTH to highest point of shear ...	15.000 metres
DRAUGTH moulded at DWL ..... (Tmld)	5.600 metres

LOADING CONDITIONS :

LOADING CONDITION NO. 1 :

Total mass	9200 t
X-coordinate for C.O.G. .	42.2 metres
Y-coordinate for C.O.G. .	0 metres
Z-coordinate for C.O.G. .	6.6 metres

EQUILIBRIUM CALCULATION :

The equilibrium position is specified by three quantities:

The draught, defined as the length of the intersection line between the centre-plane and the amidship plane as measured from Z=0 to the water plane.

The trim, defined as the draught at AP minus the draught at FP.

The angle of heel, defined as the angle between the Y-axis and the waterplane, as measured in the planes X = constant.

DENSITY OF SEA WATER	1.025 t/m3
HULL ALLOWANCE FACTOR	1.004
LONGITUDINAL COORDINATE AT A.P. ...	0.000 metres
LONGITUDINAL COORDINATE AT AMIDSHIP	43.900 metres
LONGITUDINAL COORDINATE AT F.P. ...	87.800 metres
ANGLE OF FLOODING	80.000 deg.
MAXIMUM ERROR ACCEPTED IN DRAUGHT..	.006 metres
MAXIMUM ERROR ACCEPTED IN TRIM	.006 metres

Metacentric height GM = 2.402 metres

Angle of heel,deg	Draught metres	Trim metres	GZ metres	MS metres	KN metres	Dynamic height,m
0.0	6.827	.011	0.000	0.000	0.000	0.000
10.0	6.824	.012	.434	.017	1.580	.038
20.0	6.788	-.177	.885	.063	3.142	.153
30.0	6.782	-.221	1.200	-.002	4.500	.337
40.0	6.785	.286	1.407	-.137	5.649	.566
50.0	6.758	1.497	1.498	-.342	6.554	.821
60.0	6.792	3.291	1.376	-.704	7.092	1.075
70.0	6.874	6.760	1.093	-1.165	7.295	1.293
80.0	7.120	16.872	.714	-1.652	7.214	1.452

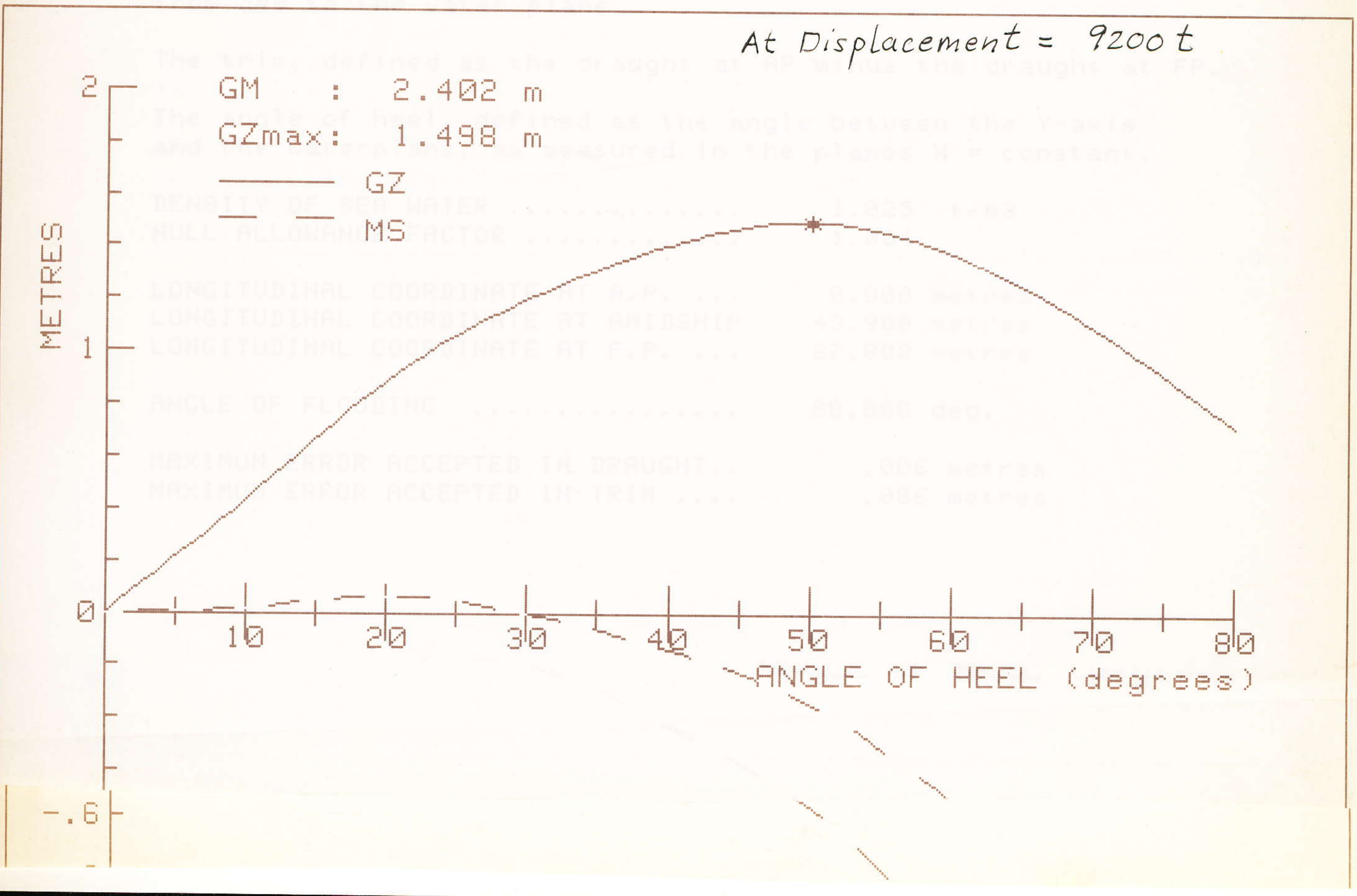
CHECK OF STABILITY REQUIREMENTS ACCORDING TO
THE DANISH GOVERNMENT SHIP INSPECTION SERVICES
JANUARY 9 - 1976
(NOTE 305, FEBRUARY 8, 1976, VOL 26, NO.2)

Paragraph 2.1.1a is fullfilled (area= 0.337 rad*m)
Paragraph 2.1.1b is fullfilled (area = 0.566 rad*m)
Paragraph 2.1.1c is fullfilled (area = 0.229 rad*m)
Paragraph 2.1.2 is fullfilled (GZmax= 1.407 metres)
Paragraph 2.1.3 is fullfilled (GZmax at 40.000 deg.)
Paragraph 2.1.4 is fullfilled (GM = 2.402 metres)

MAXIMUM KG (m) ACCORDING TO THE ABOVE-MENTIONED PARAGRAPHS :
8.707 8.635 8.588 8.599 8.558 8.852

THUS :

(KG)max .... 8.558 metres
MAXIMUM DISPLACEMENT MOMENT . 772400 kNm



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* ** *  * ------------------------------------  * **  *  *
**  *  *     ISH STYRKE - BASIC PROGRAMMEL        **    *  *
*  ** *****  DEPARTMENT OF OCEAN ENGINEERING      *  **  *****
*  * *  *  THE TECHNICAL UNIVERSITY OF DENMARK    *    * *  *
* **  *  *          DK 2800 LYNGBY                * **  *  *
-----------------------------------------------------------------
*                     FORM STABILITY                           *
* BUILDERS:                             PROGRAM FILE : WEIGHT *
* IDENTIFICATION:                       VERSION FEBRUARY 1986 *
* DATE:              INITIALS:          DATA FILE : GEN       *
-----------------------------------------------------------------
```

MAIN PARTICULARS :

LENGTH between perpendiculars (Lpp) 87.800 metres
BREADTH moulded at DWL ..... (Bmld) 19.000 metres
DEPTH to highest point of shear ... 15.000 metres
DRAUGTH moulded at DWL ..... (Tmld) 5.600 metres

LOADING CONDITIONS :

LOADING CONDITION NO. 1 :

Total mass .... 7201 t
X-coordinate for C.O.G. . 43.7 metres
Y-coordinate for C.O.G. . 0 metres
Z-coordinate for C.O.G. . 7.6 metres

EQUILIBRIUM CALCULATION :

The equilibrium position is specified by three quantities:

The draught, defined as the length of the intersection line between the centre-plane and the amidship plane as measured from Z=0 to the water plane.

The trim, defined as the draught at AP minus the draught at FP.

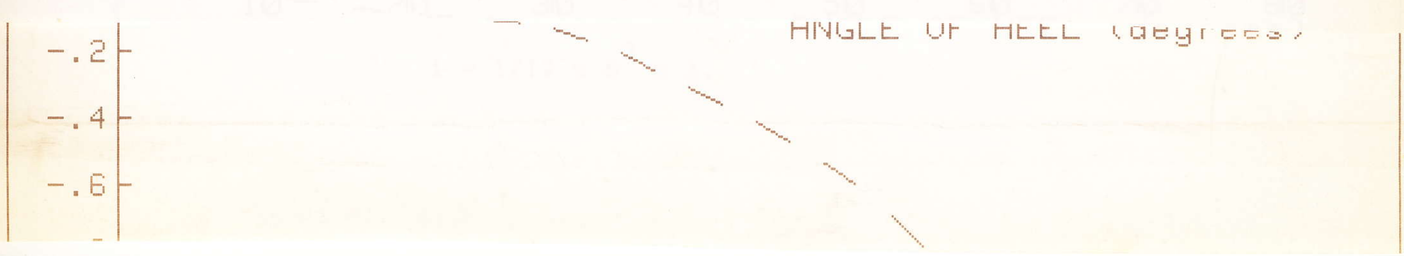
The angle of heel, defined as the angle between the Y-axis and the waterplane, as measured in the planes X = constant.

DENSITY OF SEA WATER 1.025 t/m3
HULL ALLOWANCE FACTOR 1.004

LONGITUDINAL COORDINATE AT A.P. ... 0.000 metres
LONGITUDINAL COORDINATE AT AMIDSHIP 43.900 metres
LONGITUDINAL COORDINATE AT F.P. ... 87.800 metres

ANGLE OF FLOODING .... 80.000 deg.

MAXIMUM ERROR ACCEPTED IN DRAUGHT.. .006 metres
MAXIMUM ERROR ACCEPTED IN TRIM .... .006 metres



GZ : arm of statical stability
GM : metacentric height
MS = GZ - GM * sin(angle of heel)
KN = GZ + KG * sin(angle of heel)
KG : centre of gravity above base
Dynamic height : area below the GZ-curve (heel in radians)

Metacentric height GM = 2.132 metres

Angle of heel,deg	Draught metres	Trim metres	GZ metres	MS metres	KN metres	Dynamic height,m
0.0	5.659	-.067	0.000	0.000	0.000	0.000
10.0	5.641	-.185	.338	-.033	1.657	.029
20.0	5.561	-.586	.641	-.089	3.240	.116
30.0	5.359	-1.281	.931	-.135	4.731	.253
40.0	5.041	-1.694	1.044	-.327	5.929	.428
50.0	4.452	-1.593	1.050	-.583	6.872	.612
60.0	3.499	-1.129	.842	-1.005	7.423	.781
70.0	1.734	-.212	.456	-1.547	7.598	.897
80.0	-3.411	2.741	-.038	-2.138	7.446	.934

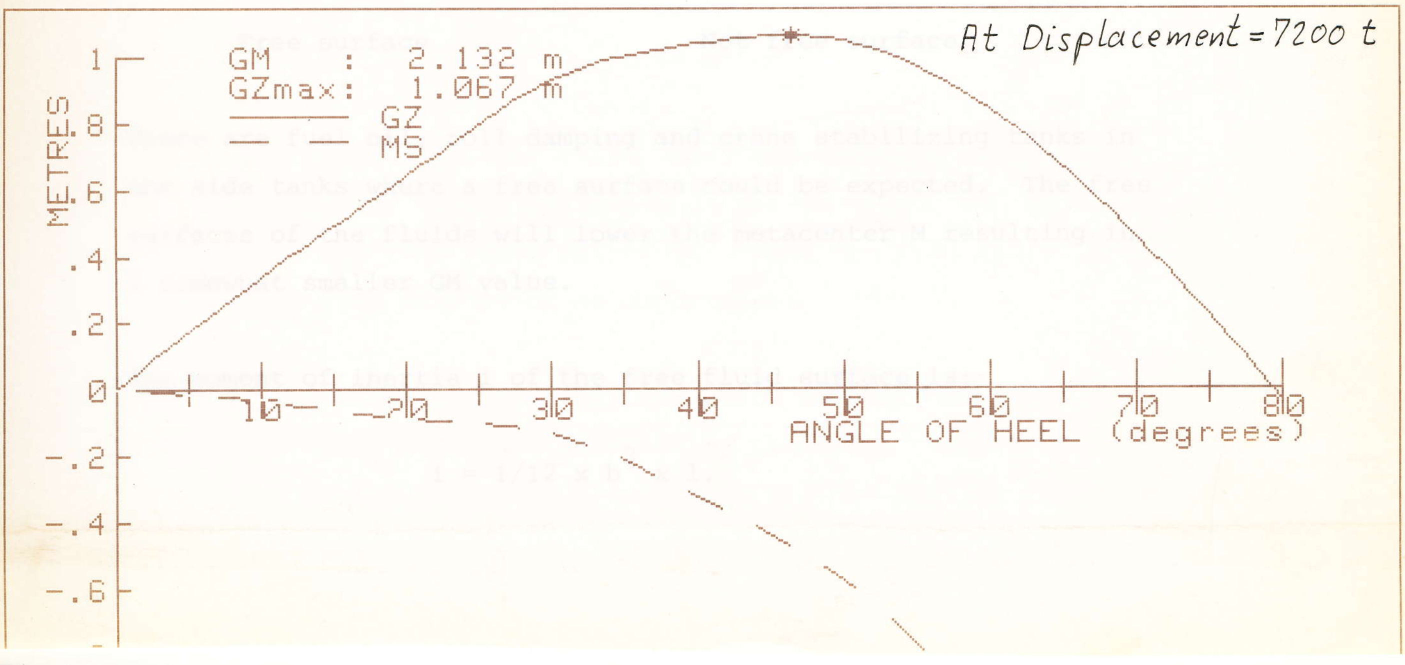
CHECK OF STABILITY REQUIREMENTS ACCORDING TO
THE DANISH GOVERNMENT SHIP INSPECTION SERVICES
JANUARY 9 - 1976
(NOTE 305, FEBRUARY 8, 1976, VOL 26, NO.2)

Paragraph 2.1.1a is fullfilled (area= 0.254 rad*m)
Paragraph 2.1.1b is fullfilled (area = 0.428 rad*m)
Paragraph 2.1.1c is fullfilled (area = 0.174 rad*m)
Paragraph 2.1.2 is fullfilled (GZmax= 1.044 metres)
Paragraph 2.1.3 is fullfilled (GZmax at 40.000 deg.)
Paragraph 2.1.4 is fullfilled (GM = 2.132 metres)

MAXIMUM KG (m) ACCORDING TO THE ABOVE-MENTIONED PARAGRAPHS :
9.085 9.047 9.045 9.062 9.526 9.582

THUS :

(KG)max .... 9.045 metres
MAXIMUM DISPLACEMENT MOMENT . 639000 kNm



8.19.

REDUCTION OF THE METACENTERHIGHT GM

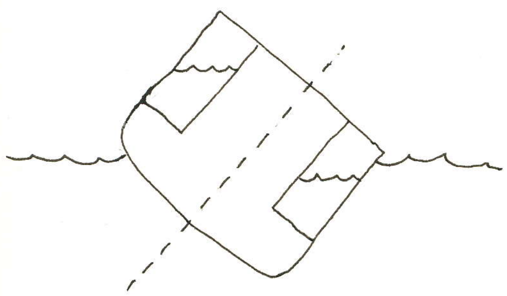
It can be seen from the stability computer analysis that the GM is quite big:

GM at full load condition:................2.41 meter
GM at low load condition:.................2.13 meter

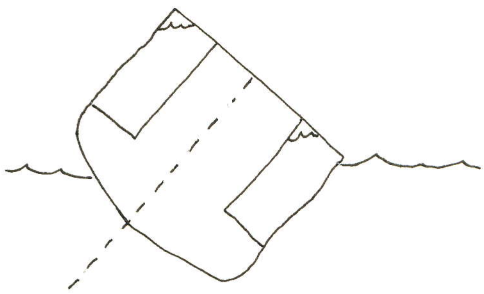
The stability of the ship is extremely good, but the high value of of the GM means that the dynamic movements of the ship during roll could be too strong, i.e. the ship is so stable that it moves fast towards its newtral position after being pushed by waves, windshear etc. This can lead to high accelerations on crew and equipment. The experience tells us that a GM of appr. 1 meter gives a more gently rolling ship.

The GM can be reduced by lowering the metacenter M or hightening the ships gravety center G.

There are several side tanks onboard where the surface of the fluid will be free from time to time:



Free surface



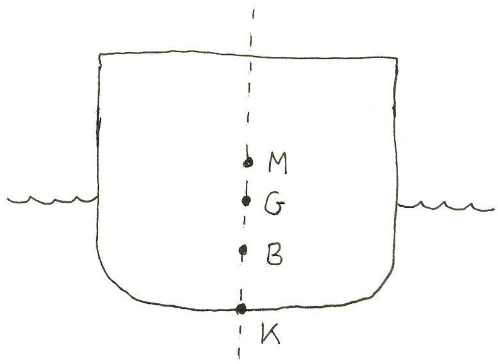
Not free surface

There are fuel oil, roll damping and crane stabilizing tanks in the side tanks where a free surface could be expected. The free surfaces of the fluids will lower the metacenter M resulting in a somewhat smaller GM value.

The moment of inertia i of the free fluid surface is:

$$i = 1/12 \times b^3 \times l.$$

GM = KB + KM - KB - KG



The KM will be reduced by $\frac{i}{\text{Displacement}}$, so we can write:

$$GM = KB + KM - KB - KG - \text{reduction, or}$$

$$GM(\text{new}) = GM(\text{old}) - \text{reduction}$$

We wil now calculate the reduction from the tanks, which is the sum of the single tanks reductions:

i(tank 02 and 22) = $2 \times 1/12 \times 3^3 \times (7 + 2.5)$ = $42.75\ m^4$

i(tank 03 and 23) = $2 \times 1/12 \times 1^3 \times (12)$ = $2.00\ m^4$

i(tank 04 and 24) = $2 \times 1/12 \times 3^3 \times (26 - 19)$ = $31.50\ m^4$

i(tank 05 and 25) = $2 \times 1/12 \times 3^3 \times (35.5 - 26)$ = $42.75\ m^4$

i(tank 06 and 26) = $2 \times 1/12 \times 3^3 \times (48.8 - 35.5)$ = $59.85\ m^4$

i(tank 07 and 27) = $2 \times 1/12 \times 3^3 \times (53.5 - 48.8)$ = $21.15\ m^4$

i(tank 08 and 28) = $2 \times 1/12 \times 1.5^3 \times (66 - 53.5)$ = $7.03\ m^4$

i(tank 09 and 29) = $2 \times 1/12 \times 2^3 \times (6)$ = $8.00\ m^4$

Moment of inertia $215.00\ m^4$

Reduction = $215\ m^4 / 8000\ m^3 = 0.03\ m$

GM will be reduced by this value, but this value is very small, so that it almost has no influence on the GM value. You can understand from this rough calculation that the free fluid surfaces on this ship is of no importance.

The fuel oil tnaks portside and starboard are not connected, but the roll damping and crane stabilizing tanks are connected. Since this is the case the GM reduction will be further reduced:

i(04 and 24)	=	$1/12(26-19)(19^3 - 13^3)$	=	$2720\ m^4$
i(05 and 25)	=	$1/12(35.5 - 26)(19^3 - 13^3)$	=	$3691\ m^4$
i(07 and 27)	=	$1/12(53.5 - 48.8)(19^3 - 13^3)$	=	$1826\ m^4$
i(09 and 29)	=	$1/12(6)(19^3 - 15^3)$	=	$1742\ m^4$
42.75 + 2.00 + 59.85 + 7.03			=	$112\ m^4$
The new moment of inertia				$10091\ m^4$

You can see that the difference is enormous when some of the tanks are connected and it is assumed that the flow of water from one tank to the other is sufficient.

New reduction = $10091\ m^4/8000\ m^3$ = 1.3 m

The GM is now reduced to: 2.3 - 1.3 = 1 meter
=======

This is a very good metacenterhight - the ship will roll gently from side to side. The rolling time will be independent of the amplitude of the roll. The amplitude of the roll will be held small by using the roll damping tanks.

In order to calculate the roll time T, we can use the following formulae:

$$T = 2 \times pi \times \sqrt{k^2/(g \times GM)}.$$

The k is the weight moment of inertia arm for the whole ship in relation to the center axis of the roll. This arm k is very difficult to calculate directly because every single weight moment has to be calculated for both the steel, outfit, diving equipment, dead weight etc. The longer the distance is from the center axis to the weight of fx. equipment such as the diving gas tube system the bigger is the arm. However, I was told that a usable guideline is to calculate the arm as being 40% of the breadth B of ship.:

k = .40 x 19 m = 7.6 meter.

g is the acceleration 9.81 m/s^2. We can then calculate the roll time T:

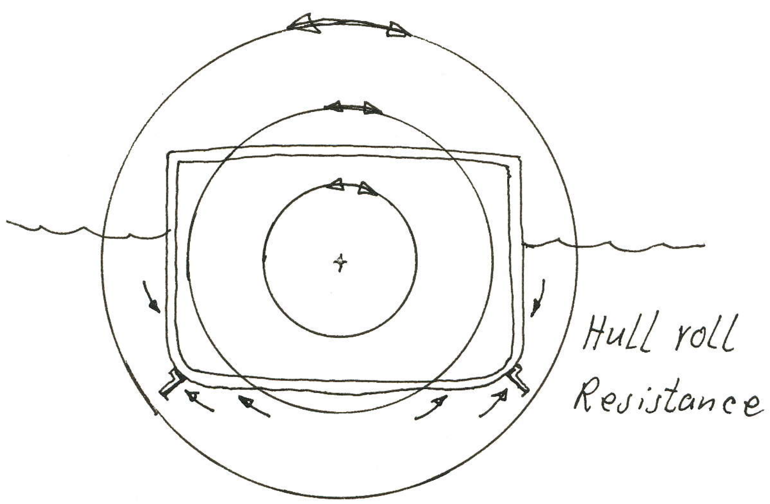
$$T = 2 \times pi \times \sqrt{7.6^2\ m^2/(9.81\ m/s^2 \times 1\ m)}$$

$$T = 15\ s.$$

That is a very long time for a roll from starboard to portside and back again. The acceleration which is strongest at max. heel in each roll is not very big and is depending of where you are on the ship. The divers in the saturation chamber complex are placed very near to roll center axis where the accelerations will be almost zero.

It is possible to lower the value of the GM even more (it should, however, not be less than 0.2 meter for this kind of ship) by moving the center of gravety further up. This is very easy to do on this ship. Placed down in the center bottom tanks we find appr. 1300 tons of water ballast which can be pumped out, and additional weight can be placed at the work decks high up. So, you can see that there are a lot of possibilities of mingeling with the GM. Of course it should be remenbered that the stability criteria should be regarded in each case.

Another thing that reduces the roll time and the roll accelerations is the shape of the hull and the special roll damping precautions which have been taken:



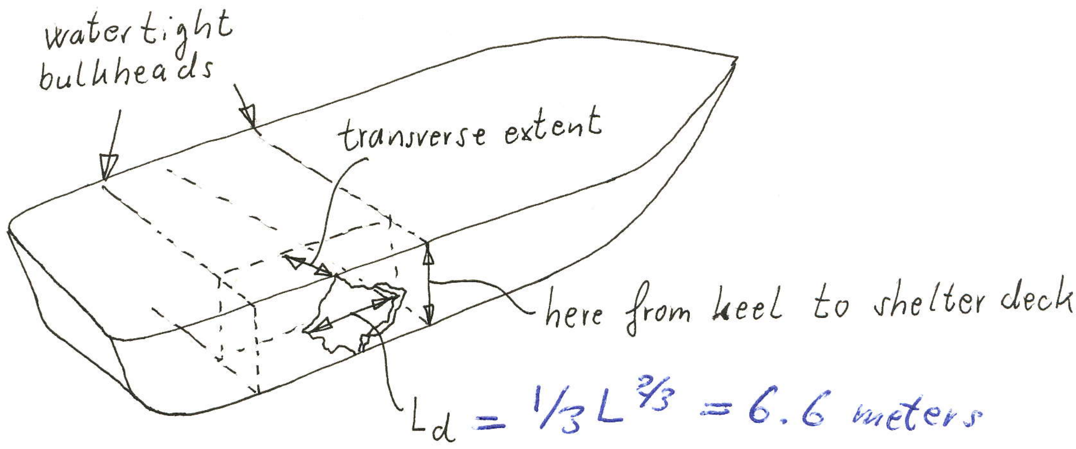
8.20.

DAMAGE STABILITY

Very late in the project I received the code of Safety for Special Purpose Ships, IMO, 1984. Before this there were no specific rules about special ships.

In the SOLAS convention only crew and passenger ships are defined. The divers onboard are not defined as crew nor passangers.

If we look at the new IMO rules we can see that for a special ship such as mine which is longer than 50 meters but carries less than 50 special personnel (divers) a damage is defined as follows:



This is more than the statistical damage for such a ship according to th old rules. Here the length of damage was:

$$L_d = 3.05 \text{ m} + 3\% \times L = 5.7 \text{ meters}$$

The transverse damage extent is still B/5 = 19/5 = 3.8 meters.

The Dannebrog NOS 188 and 189 which are being built right now do not comply with this rules. The B/5 has been replaced by 1.5 meter. Therefore, the side tanks is 1.5 meters wide. At my ship ship the side tanks has been extented to 3 meters, which makes the ship more safe. The inner hull of the whole diving section ranging from x = 19 m to x = 66 m. is a waterproof shell. The lift and staircase is waterproof too.

The static angle of heel should not exceed 7 degrees after that the statistical damage has occoured between two watertight bulkheads.

This can be analyzed using the computer facilities at the department of Ocean Engineering. However, I do not have any computer time left.

In stead I will calculate what happens if the damage occours in the probably most dangerous section of the ship and we assume that the angle of heel is zero:

The most dangerous rooms are the auxhiliary machine room and the sheltered aft workdeck:

	Tons	x	z
Auxhiliary machine room	372	15	5.5
Sheltered workdeck	1400	10	9.0
both filled with water	1772	11	8.3
The max loaded ship	9200	42.2	6.6
Total	10972		

Now, according to the hydrostatic curves a displacement of 10972 tons would load the ship to a draught of appr. 7.8 meters (if there was no trim). However, the gravety center has moved further behind than the center of bouyancy:

Center of gravety		37 meters
Center of bouyancy	(43.9 - 2.5)	41.5 meters

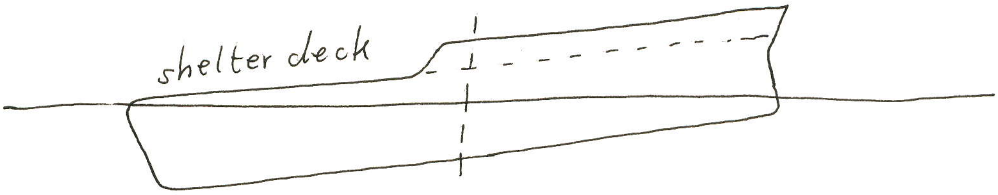
The ship is too heavy in the aft section to ensure a zero trim.

At a displacement of 10972 we can see from the MCT-curve on the hydrostatic curve diagram that MCT = tons x meter / meter. = 12.800

The torque is, therefore, 1772 tons x (43.9 - 11) = 58299 tm information at examination:

Close the bottom valves, which connects the side tanks, in case of damage and the GM will rise to 2.4 m, so that there is no danger at all. The stability can be maintained even at large damages.

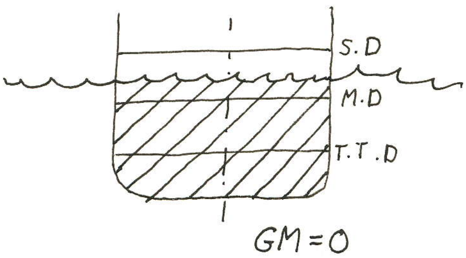
Therefore, the trim draught is: 58299/12800 = 4.6 meters, i.e. the half of this is seen in the aft section and the other is seen in the fore section (as a negative trim).

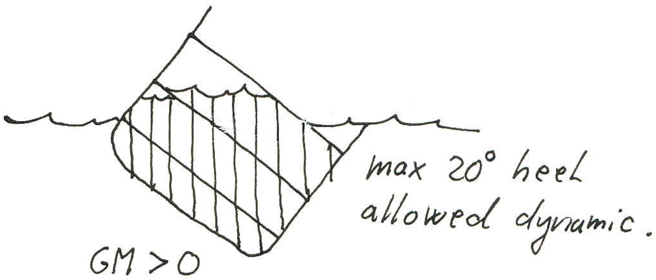


We would then have a ~~trim~~ Draught in the aft section of 7.8 + 4.6/2 = 10.1 meter

Now, the waterline will come almost to the shelter deck level in the aft section but it will not exceed it (the shelter deck is at level 11 meter). The ship will not sink.

As you can see the draught and trim were calculated assuming that the huge sheltered workdeck would be totally filled with seawater. This is however, as you can see, not the case. But this may not be to our benefit because we will then have a big free water surface splashing from side to side. The big free watersurface will reduce the metacenterhight GM - and this could be dangerous to the stability. I will calculate what the new GM is if the free watersurface is the same as the sheltered work-deck area. In fact the situatiation is a little bit better due to the fact that the free surface will be reduced when a hell angle starts to occour:





The sheltered work-deck has the following dimensions:
b = B = 19 meters and l = 19 meters. We can then calculate:

$i = 1/12 \times b^3 \times l = 1/12 \times 19^3 \times 19 = 10860$ m4. The new displacement is 10972 t/1.025 t/m3 = 10704 m3. We can now calculate the new GM:

GM(new) = 1 meter - 10860/10704 = - 0.015 meter. It should not be below 0.2 meters, but the maximum dynamic heeling is 20 degrees, and here the free surface is much smaller.

9. ADMINISTRATION

9.1.

LIST OF DRAWINGS

Name	Originals	Copies
Tank Top Deck	O-1 (1:100)	C-1 (1:200)
Main Deck	O-2 (1:100)	C-2 (1:200)
Shelter Deck	O-3 (1:100)	C-3 (1:200)
Superstructure	O-4 (1:100)	C-4 (1:200)
Heli/ACC I Deck	O-5 (1:100)	C-5 (1:200)
ACC II Deck	O-6 (1:100)	C-6 (1:200)
ACC III Deck	O-7 (1:100)	C-7 (1:200)
Bridge Deck	O-8 (1:100)	C-8 (1:200)
FI/FI Deck	O-9 (1:100)	C-9 (1:200)
General Arrangement	O-10 (1:100)	C-10 (1:200)
General Arrangement	------------	C-11 (1:200)
Diving System	O-12 (1:70.71)	------------
Diving System	O-13 (1:70.71)	------------
DDC I Pipes	O-14 (N/A)	------------
Gas Pipe Diagram	------------	C-12 (N/A)
Hull Definition	O-15 (1:200)	------------

The Original Drawings will be garded by the Depatment of Ocean Engineering. The Copies will be in my possession. The drawing General Arrangement C-11 (1:200) will be supplied with the copy of the report (delivered beside the report).

9.2.

LIST OF BOOKS:

Announcement of rules about diving systems,
(not completet 14 January 1986)
The Danish Government Ship Inspection Services   Got it!

Code of Safety for Diving Systems (CSDS)
IMU, London, 1985   Got it!

Code of Safety for Special Purpose Ships (CSSPS)
IMO, London, 1984.   Got it!

Havteknologi
Sv. Aa. Harvald
The Technical University of Denmark   Got it!
Department of Ocean Engineering.

Manned Submersibles
R. Frank Busby,
Office of the Oceanographer of the Navy, 1976,
Received free of charge from NOAA.   Got it!

The National Oceanic and Atmospheric Administration (NOAA)
US Department of Commerce, NOAA diving Manual, Second Edition,
1979. Received free of charge from NOAA.   Got it!

Prediction of Power of Ships,
Sv. Aa. Harvald
The Technical University of Denmark   Got it!
Department of Ocean Engineering

Rules for Certification of Diving Systems, 1982   Got it!
DnV

Rules for Certification of Steel Ships,   Got it!
DnV

Offshore Literature and Magazines:

- Noroil
- Ocean Industry
- The Oilman
- Norwegian Oil Review
- Marine Technology
- Underwater Systems and Design etc.

Subsea Manned Engineering,
Gerhard Haux, 1982
Can be bought from Haux-Life-Support,
Descostrasse 19, D-7516 Karlsbad
(price: DM 152) On it's way

Subsea Production Annual Review, 1981,
Volume 1, 3210 Marquart Street,
Houston Texas 77027, USA,
Can be ordered. Got it!

The Underwater Handbook
~~Millers~~, 1976, Shilling, Werts and Schandelmeier
Duke University, USA,
The Technical Library of Denmark

US NAVY Diving Manual, Volume 1, Air Diving Got it!
NAVSEA 0994-LP001-9010
Revision 1, June 1985
Not retrivable in Denmark, must be
bought from the Superintendent of Documents, USA.

US NAVY Diving Manual, Volume 2, Mixed gas Diving, Got it!
NAVSEA 0994-LP001-9020,
Revision 1, July 1981,
Not retrievable in Denamrk, must be
bought from the Superintendent of Documents, USA.

LIST OF COMPANIES, PERSONS AND INSTITUTIONS

I used a lot of time finding out the companies, persons and institutions which was important for the gathering of information. I have shown both the companies which were very helpful and those who could not help me. Companies which turned out to be only perifically involved in diving are omitted.

The list is intented to be a help for those who want to gain further information. In each case the information will be listet as follows:

1) Company address and telephone
2) Contact person
3) area of business within diving technology
4) my personal comments

---

1) ACB Offshore
Avenue du Cap Pinede
B.P. 135
13318 Marseille Cedex 15
33 - 9158 2505
Yves Guez, Commercial Manager
The new owner of Comex diving systems
I received good pamphlets

2) Aerospatiale
Division Helicopters
Etablissement de la Courneuve
2 a 20, avenue Marcel Cachin
93126 La Courneuve, Cedex, France
1 483891 78
Mr. G. Temime
Super Puma Helicopter
I received the data I asked for

Jörg Haas
Dipl.-Ing.
Managing Director

BRUKER
MEERESTECHNIK
GMBH

D-7500 Karlsruhe 21
Wikingerstraße 13
Telefon (0721) 5967-180
Telex 7825656

MacArtney ApS
Underwater Technology

Martin MacArtney
Managing Director

Guldagervej 2
DK-6710 Esbjerg V
Denmark
Tel.: 05116677
Telex: 54272 mac dk
Telefax: 05117220

mødt 11/5-87 ved.
EDTC sammenkomst
på Hotel Britannia

THE DANISH GOVERNMENT
SHIPS INSPECTION SERVICE

J. E. GRØNBERG
SHIP SURVEYOR

GL. VARDEVEJ 17
DK-6700 ESBJERG

TELEPHONE: + 45 5 12 70 66

3) Bruker Meerestechnik GmbH
Wikingerstrasse 13
D-7500 Karlsruhe 21
00949 0721 5967-180
Jörg Haas, managing director
Dagmar Mäge, Marketing manager
Producer of high quality German submersibles and the only producer of a flying bell in Europe.
Six hours visit, received detailed information about flying bell and diving techniques. Did newer receive information about the handling system of the flying bell.

4) Comex Industries, France
Diving systems
See the ACB company, France

5) Dan Motorfabrik
Martin MacArtney Aps
Guldagervej 2
DK-6710 Esbjerg V
Mr. Bjerregård
Subdelivery to the Dräger system on Safe Regalia
Umbilical cords etc.
No reply to mail

6) The Danish Governement Ships Investigation Servises
Diving depatment
Snorresgade 19
DK-2300 Copenhagen S
01-547131
Lasse B. Mikkelsen
Makes rules for diving when Danish flag used
two hours visit, received an outline of the new rules for diving systems

Dannebrog Værft AS
Århus

Dannebrog Shipyard Ltd.
Balticagade. Postbox 23, DK-8100 Århus C, Denmark
Telephone +45-6-13 40 00
Telex 64462 dokken dk. Telefax +45-6-13 40 38

Niels Levinsen
Project Manager
Naval Architect M.Sc.

A/S DANSK ILT- & BRINTFABRIK

ERIK HALMØE
Industrial Applications Technology

SCANDIAGADE 29
DK-2450 KØBENHAVN SV

TELEFON 01-21 88 40
TELEX 19676/DIB-DK

7) Dannebrog Shipyard LtD
Baltigade, Postboks 23
DK-8100 Aarhus C
Denmark, 45-6-134083
Niels Levinsen, project ~~manager~~ engineer
Speciel vessels, are producing two deep sea diving vessels for DIFKO for a Dutch contractor,
Supplied me with vital ship information,
six hours visit.

Christiansø, project manager

8) A/S Dansk Ilt & Brintfabrik
Scandiagade 29
DK-2450 Copenhagen SV
01-218840
Erik Halmøe, consultant
The company is owned by the French company L'Air Liquide,
Imports and produces various gases. Can deliver He-gas, but has not yet been delivering He-gas to Svitzer,
four hours meeting, received vital information about gases, prices and how to calcualte the need for gas volume to diving systems.

9) Deutsche Dampfschiffahrtsgesellschaft "HANSA"
Schlachte 6
D-2800 Bremen 1
Message received: Stopped all diving and shipping activities since December 1980.

10) C. G. Doris Servises UK LtD
Unit 4E, Dyce Industrial Estate
Aberdeen, UK
Returned mail message: Gone away

009 49

ANDREAS FRAHM

Area Manager

DRÄGERWERK AG

Industrial Safety Division

Export Western Europe

Molslinger Allee 53/55 · D-2400 Lübeck 1

Federal Republic of Germany

☎ (451) 882-27 26 · Tx 26 807-32

FAX (451) 882-20 80

Dräger

Klaus Brand

Project Manager

Drägerwerk Aktiengesellschaft
Werk Druckkammertechnik
P.O.Box 15 01 49
Auf dem Baggersand 17
D-2400 Lübeck-Travemünde 1
Phone: FRG -(45 02) 83-53
Tx: 2 61 455 dwdkt d
FAX: FRG -(4 51) 8 82-20 80

DRÄGER

MILJØ- OG DYKKERTEKNIK

Solveig Henriksen.

Nina Andersen

Generatorvej 6 B
DK-2730 Herlev
Tlf. (02) 84 52 11

DRÄGER TEKNIK ApS

Claus Frey
Kleverkoppel 15
D-2420 Eutin

Claus and his wife came visiting me after the project at my house in Charlottenlund, Denmark. They stayed a week and I showed them Copenhagen and the Naval Base Holmen

11) DRASS
Hyperbaric TechnologyUnderwater Engineering
Diving Research & Associated Scientific Services
Via Venezia 9-24040 Zingonia (BG)
Italia
39 35 882104
Biggest Italian diving system producer
reminds of Dräger and GUSI activities and equipment
Received detailed pamphlets and technical data

12) Drägerwerk Aktiengesellschaft
Werk Druckkammertechnik
P.O. Box 150149
Auf dem Baggersand 17
D-2400 Lübeck-Travemünde 1
~~451 882 2080.~~
Claus Frey, Project engineer, Safe Regalia.

0049(4502) 8 30 } Druckkammer
00949(4502) 83-0 }
00949(4502)8318 Claus Frey
00949(4521) 71781 privat

German high quality producer of diving systems, known among professional divers as the Rolls Royce of diving systems,
Two days visit. First day a visit to the production plant. The next day a talk with Claus Frey for several hours - almost a small education in diving emgineering,
Received detailed information later by mail.

13) Dräger Teknik Aps
Generatorvej 6B
DK-2730 Herlev
Nina Andersen 02-845211
Subsiduary of Dräger
very good service has been given to me, effected contact to Dräger in Germany

14) Duke University Medical Center
Durham, North Carolinia
F.G.Hall Environmental Laboratory
Box 3823
27710 USA
919 684-5514
Professor Peter B. Bennet
Testing the limits of man in the sea
Received deep diving medical results

HOYER SERVICE

TORBEN HANSEN
Projektleder

Asbest
Jobs.

Tjørnevej 16-18, 2800 Lyngby
Tel.: 02 87 13 79
Tlx.: 37369 hoyer dk

Privat tel.:
02 73 32 63

2 år: 135 timer Helium. grense.

5 år:

CHR. HOYER GROUP

Nigel E. J. Griffiths
Business Development Manager

02-871379

16-18, Tjoernevej, DK-2800 Lyngby
Telph.: 02-87 13 79
TELEX: 37369
DENMARK

Private:
Telph.: 01-56 12 68

GKSS
FORSCHUNGSZENTRUM GEESTHACHT GMBH

Prof. Dr.-Ing. HEINRICH-GUENTER SCHAFSTALL
Lecturer at University of Hannover and University of Hamburg
Director of the Institute of Technical Installations
(Underwater Technology)

GKSS-Research Center
Max-Planck-Straße
D 2054 Geesthacht, Germany

Phone (04152) 12-921
Telex 0218712 gkssg

GKSS
FORSCHUNGSZENTRUM GEESTHACHT GMBH

Dipl.-Ing. DIETRICH SEELIGER
Institut für Anlagentechnik
Underwater Technology
Technical Manager

GKSS-Research Center
Max-Planck-Straße
D 2054 Geesthacht, Germany

Phone (04152) 12(1)-536/537
Telex 0218732 gksse
Telefax (04152) 12618

15) Galeazzi Apa
Via Venezia 12
19020 Ceparana (SP)
Italy
0039 187 932181
Producer of diving systems - mostly for surface diving, seams to be a more old fashioned equipment. Received technical describtions of diving bells and chambers.

16) Haux-Life-Support
Descostrasse 19 (new address)
D-7516 Karlsbad
00949 7248 - 1050
T. Haux, engineer and managing director
Produces life support systems
Very little information received. The director is the narrator of the diving engineers' bible: "manned subsea Engineering. I payed for the book by check but did newer receive the book.

17) Chr. Hoyer Group
16-18 Tjoernevej
DK-2800 Lyngby
02-871379
Nigel E.J. Griffiths, Business Development Manager
Ship owner, new areas of business: Sub sea production support.
Four hours of discussion with Nigel about the future of the industry (only English language)

Hoyer SUBSEA. Services A/S 05-130777
Morten Jepsen. i Esbjerg.
(Ocean Technical SUBseas)

operations base
Mælkevejen 2
DK-6700 Esbjerg

18) GUSI, GKSS - Research Center
Max Plack Strasse
D-2054 Geesthacht, Germany
04152 12-921
Prof. Dr. Ing. Heinrich-Guenter Schafstall,
Former State nuclear research center - now diving research and test center.
Had one day visit, received scientific and industrial information about the maximum performance limits of man in sea at this present point of time.

Thorbjörn Friman
President

HÄGGLUNDS

HÄGGLUNDS LIDAN

HÄGGLUNDS LIDAN AB, Box 854 , S-531 18 Lidköping, SWEDEN
Tel. int: +46 510 223 55 Telex 67166 LIDAN S.
Teletex: 826 50 39 Telefax: +46 510 284 10

KURT GELFGREN
MARKET AND PRODUCT RESEARCH

009-46

HÄGGLUNDS

AB HÄGGLUND & SÖNER · S-891 01 ÖRNSKÖLDSVIK
Sweden · Tel. Nat. 0660-800 00 / Int. + 46 660 800 00 · Telex 6051 Haegg S

CLAES G SPENS
VICE PRESIDENT
BUSINESS DEVELOPMENT & COORDINATION

HÄGGLUNDS

AB HÄGGLUND & SÖNER · S-891 01 ÖRNSKÖLDSVIK
Sweden · Tel Nat. 0660-800 00 / Int. + 46 660 800 00 · Telex 6050 Haegg S
Telefax 0660-841 78

19) Hunting Oilfield Services LtD
Main Cross Road
Great Yarmouth, Norfolk, UK
Returned mail message: Gone away

20) Hägglunds AB
S-891-01, Örnskjöldsvik
Sweden
009-46-660 800 00
Claes G. Spens, business development
Kurt Gelfgren, product research
Thorbjörn Friman, President
Producer of off shore winches, heave compensators, cranes,
Very used by the diving industri in the North Sea region,
One visit, two letters, many telephone calls, but very
little information received. The company seems closed
and not very helpful to me - student?

21) Infabco Diving Services LtD
International Base
Grennwell Road
East Tullas
Aberdean, UK
Returned mail message: Gone away

22) Ingenieurkontor Lübeck GmbH
Postfach 1690
D-2400 Lübeck 1
Prof. Gabler, Nachf. GmbH
producer of submersibles
Received good information, but is not used in the
report.

23) International Submarine Engineering LtD.
2601 Murray Street
Port Moody B.C.
Canada V3H 1x1
James R. McFarlane, President
ROV systems etc.
I received a booklet about their products (Svitzer has
one of their ROVs) - not used in the project.

SVEN-ÅKE NILSSON
MANAGER
CIVILIAN UNDERWATER ENGINEERING

Hälsningar Sven-Åke

KOCKUMS AB
S-205 55 MALMÖ
SWEDEN

Tel. +46 40 34 80 00
Dir. +46 40 34 81 96

Teletex 830 5075
Telefax +46 40 97 32 81
Telex 33190 kockum s

LIDANS

AB Lidans Motorverkstad
P.O. Box 854
S-531 18 Lidköping Sweden
Phone 0510-223 55 Telex 671 66

Mats Pålsson
Marine Elektro-hydraulic Engineer

24) Kockums Shipyard AB
S-201 10 Malmø
Sweden
Sven Åke Nilsson, manager underwater engineering
They have problems with the civilian part of the ahipyard. They have produced a resque submarine, but in the case of the flying bell - they did not get the order.
I visited the shipyard. They are not producing anything for the diving industri for the moment. I received later a picture of their plastic model of the Kockums flying bell ROB.

25) Kværner (UK) LtD
Newcastle Road
Simonside Industrial Estate
South Shields
Tyne and Wear, NE34 9PB
091 455 5601
R.G. Chalmers, managing director
This is the department of the Norwegian Kværner Group in the UK which produces hatches for moon pools.
They mailed me detailed information about the Stena Seawell moon pool hatches.

26) Lidan, AB Lidans Motorverkstad
P.O. Box 854
S-531 18 Lidköping, Sweden
Mr. Mats Pålsson
The deliver components such as baskets for the divers, handling systems etc. Has been a subdeliver to Dräger.
No reply to mail.

27) Mannesmann Röhrenwerke AG
Postfach 0325
4220 Dinslaken, Germany
009 49 2134 67 1
Mr. I. A. Schaufler,
They are a major vendor of gas tubes of all sizes.
Has been delivering tubes to most systems in the North Sea Region.
They asked for my specification for a gas tube system and made a proposal for me.

MÆRSK

Jens K. Olsen
Senior Supervisor
Structural Maintenance

Mærsk Olie og Gas A/S, 1, Kanalen, DK-6700 Esbjerg
Phone: (05) 13 05 11. Telex: 54213

MÆRSK

Hans Pedersen
Inspection Engineer

Mærsk Olie og Gas A/S, 1, Kanalen, DK-6700 Esbjerg
Phone: 05 13 05 11. Telex: 54213

Personaleafdelingen: Ingrid Nielsen. Esplanaden 50 01-114676

28) MAERSK OIL & GAS A/S
Esbjerg Branch
1 Kanalen
DK-6700 Esbjerg
05-130511
Bjarne Bach-Henriksen, diving engineer
Major ship-owner and contractor, owner of the saturation diving vessel "Maersk Defender".
A meeting was planned but we newer succeded in having the meeting.

29) Normalair-Garret Limited
Yeovil Somerset
BA20 24D
England
Message from the company: We have stopped all production of diving systems.

30) Det Norske Veritas (DnV) in Denmark
Nyhavn 16
DK-1051 Copenhagen K.
01-159137
P. R. Carlsen
Mailed me the Rules of Diving Systems.
In case of any questions about diving systems a direct call should be done to:
Alf Peter Höjlund, Oslo Department 009 47 2 479002

31) Osel Offshore Systems Eng, LtD
Boundary Road
Harfreys Industrial Estate
Great Yarmouth, Norfolk
NR31 0lY, UK
0493 659916
Mr. B. G. Mann, marketing
ROV systems.
I received detailed information on ROV systems.

Bjarne Bach-Henrichsen

AODC = Association of Diving Contractors.
(Department of Energy);
Tom Holleborn, Secretary.

DUC Rules:

TYPE GTV 700. SMÅ SEMI SUB.
↓
Göteborg werft.

32) Herbert Ott Vertriebsges
MbH + Co.
Daimlerstrasse 17
D-7250 Leonberg
07 152-47041
Mr. B.C. Schwarz
Administers import of French Burton Corblin Helium
compressors as a subcontract to Dräger.
Supplied me with very fine and detailed information
about the compressors.

33) Pacific Coast Welding and Machine Inc.
2330 Cleveland Avenue
Natioanl City
CA 92050, USA
Return of post message: Gone away

34) Pneu Hydraulics LtD
14 Brookside Crescent
Cuffley, Herts
England
Umbilicals for bells and divers.
I was told that they were a major producer of
umbilicals.
Return of mail message: Gone away

35) Alfred Paulsen AS
Stavanger, Norway
Message from company: Stopped all production of
diving systems

36) The Royal Danish Navy
Dykkerkursus Nyholm, Holmen
DK-1437 Copenhagen K.
01-541313 - 2064 cheif of School
H. Holten Møller, kaptajnløjtnant, Lieutenant Commander
Education of military and civilian industry divers
only for surface oriented diving and testing of
equipment for the Danish Ships Inspection Services.
Four hours visit. Information about valid equipment.

Søværnets Våbenskole
Dykkerkursus Nyholm
Holmen
1437 København K
H. Holten Møller
Kaptajnløjtnant

SABRE

Sabre Safety Limited,
Registered Office,
Ash Road, Aldershot,
Hampshire. GU12 4DD. England.
☎ 0252 - 316611 (10 lines)
Telex: 858251 Sabre G

Breathing Apparatus:
Resuscitation Apparatus:
Survival Equipment:
Gas Detection Equipment:
Quality Assurance: Approved to Defence Standard 05-24

WITH COMPLIMENTS

SAFEMAN A/S
Marielundvej 41
DK 2730 Herlev
Tlf. 02 - 94 95 16
Telex 35358

BENNY MATHIESEN

37) Safe Offshore AB
P.O. Box 40
S-401 20 Gothenburg
Produces Alluminium Heli-platforms
I received no reply to mail

38) Seaforth Maritime Limited
Seaforth Centre Waterloo Quay
Aberdeen AB2 1BS
0224 573401
Mr. C. H. Sharpe, project manager, MSV Stadive
Producer of diving systems and is main supplier
to the MSV Stadive semisubs.
I received good pamphlets and information

39) Siebe Gorman & Company Limited
Avondale Way, Cwmbran, Gwent
Wales, NP44 1TS, GB
Siebe Gorman is one of the oldest diving companies in the world. All divers learns something about the ancient diving equipment from Siebe Gorman.
I received the following message from this historical company: We have stopped all production of diving systems and equipment.

40) SKUM
Swedish Experts in Fire Fighting
Svenska Skumsläcknings AB
Box 32
S-442 21 Kungälv
I received no reply to mail

Copyright:

Birthe Harder . OTH .

Terkil Lund Nielsen, advokat.

teknologistyrelsen:
Opfinderkontoret.
teknologisk Institut:

02-996611

Møller Sørensen.

Box 141
2630 Tåstrup.

SUBSPEK LTD.
INSPECTION EQUIPMENT SPECIALISTS

Unit 4,
Farburn Industrial Estate,
Dyce, Aberdeen AB2 0HG
Tel: (0224) 771888 Telex: 739767

Howard Kelsall
Managing Director

Home Tel: Ellon (0358) 22990

SVITZER DIVING SERVICES A/S
(A/S EM. Z. SVITZER)

CHARLES G. HOOGHKIRK
OPERATIONS MANAGER

8 D.LAURITZENSVEJ
DK-6700 ESBJERG

PHONE: +45 5 12 23 55
24 HOURS

TELEX: 54356 SVIDIV DK
CABLE: SVITZERSALVAGE
FAX: +45 5 45 27 58 · GR. 3

meeting 27/8-86.

A/S EM. Z. SVITZER

BENNY LUND
DEPUTY GENERAL MANAGER

1 KVAESTHUSGADE
DK-1251 COPENHAGEN K

PHONE: +45 1 15 51 95
24 HOURS

TELEX: 15983 SVITZR DK
CABLE: SVITZERSALVAGE
FAX: +45 1 15 55 25 · GR. 3

Svitzer:
Helium diver:
Henrik Block
Østergade 50
6270 Tønder
04-725825

A/S EM. Z. SVITZER

SØREN LUND CHRISTENSEN
PROJECT ENGINEER, M.SC.

Svitzer Diving School, Svendborg.

1 KVAESTHUSGADE
DK-1251 COPENHAGEN K

PHONE: +45 1 15 51 95
24 HOURS

TELEX: 15983 SVITZR DK
CABLE: SVITZERSALVAGE
FAX: +45 1 15 55 25 · GR. 3

41) SUBTECH Norway AS
P.O. Box 261
5501 Haugesund, Norway
A company which in reality is a administrative collaboration of several Swedish and Norwegian companies in order to produce high technology sub products.
I received no reply to mail

42) Superintentant of Diving
ARE Experimental Diving Unit
C/o HMS Vernon
Portsmluth, Hampshire
PO1 3ER
0705 822351
Mr. M. J. Harwood, Lieutenant Commander
They are testing a new marine deep diving support vessel right now.
I received a message saying that no information is available for public release.

43) Superintentant of Documents
U. S. Government Printing Office
Washington D. C. 20402, USA
Here can the US NAVY Diving manuals be ordered

44) Em. Z. Svitzer Salvage Co. LtD
Kvæsthusgade 1
DK-1251 Copenhagen K. Director: Jörn Hansen
01-155195
It is a major diving contractor in Denmark using the "Maersk Defender" for deep sea jobs in the North Sea.
I visited the Svitzer station in Esberg. I had an appointment with the company but there were nobody to receive me when I came there, but I found my way onboard the diving vessel.
I visited the headquarter in copenhagen and received some specifications from P. G. Nielsen about a diving ship that Svitzer once had plans about (1982).

THRIGE TEKNIK

Thrige Teknik A/S
Servicecenter Odense
Skibhusvej 42
DK-5000 Odense C
Tlf.: 09 · 11 13 15

John Jensen
Serviceinspektør
Privat tlf.: 09 · 10 91 35

45) Thrige Teknik AS
Service Center Odense
Skibhusvej 42
DK-5000 Odense C.
09 - 111315
John Jensen, Service inspector
Imports heavy duty lifts from Sweden
John Jensen supplied me with usable information about a heavy duty lift usable for marine implementation.

46) United States Department of Commerce
National Oceanic and Atmospheric Administration
Rockville, Md. 20852, USA
William S. Busch, Program Manager
They are setting regulations and guidelines for diving in the USA.
Mr. Busch mailed me two very big and good books about diving free of charge.

SKIBSTEKNISK SELSKAB

GRUPPEN AF FRIE SKIBSTEKNIKERE: SKIBSGRUPPEN, DANSK INGENIØRFORENING
SKIBSTEKNISK GRUPPE, INGENIØRSAMMENSLUTNINGEN: SØFARTSTEKNISK FORENING
The Danish Society for Naval Architecture and Marine Engineering
KRONPRINSESSEGADE 26 - 1306 KØBENHAVN K

Mandag den 2. september 1991, kl. 17.00

DTH, Mødelokale 1, bygn. 101 (over PF-butikken)

»Afskedsarrangement/reception«

I anledning af Prof. Svend Aage Harvalds pensionering arrangerer Skibsteknisk Selskab i samarbejde med Instituttet for Skibs- og Havteknik følgende:

Kl. 17.00: Indledning ved Leif J. Møller, Skibsteknisk Selskab.
Kl. 17.10: »Skibsprojekting« ved Allan M. Friis, Dwinger Marineconsult A/S.
Kl. 17.30: »30 Years of Model Testing« ved Fred Pucill, Skibsteknisk Laboratorium (DMI).
Kl. 17.50: Afslutning ved J. Juncher Jensen, Instituttet for Skibs- og Havteknik.
Kl. 18.00: Reception med snitter og drikkevarer.

Selvom arrangementet er gratis vil tilmelding være nødvendig af hensyn til planlægningen.

Tilmelding til ISH tlf.nr. 45 93 12 22 lok. 1361, Vivi Jensen (før kl. 14.00) og senest den 28. august.