Escola Politécnica Superior

TRABAJO FIN DE MÁSTER

CURSO 2017/18

Buque de Apoyo a Plataformas Offshore "PSV"

(1200 m^3 Oil Recovery Tanks & 400 m^2 Deck cargo)

Máster en Ingeniería Naval y Oceánica

CUADERNO 3

DISEÑO DE FORMAS

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UNIVERSIDADE DA CORUÑA

DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

MASTER EN INGENIERÍA NAVAL Y OCEÁNICA

CURSO 2.017-2018

PROYECTO NÚMERO 18-103

TIPO DE BUQUE: Buque tipo PSV, Buque de Apoyo a Plataformas petrolíferas, "PLATFORM SUPPLY VESSELS" (PSV)

CLASIFICACIÓN, COTA Y REGLAMENTOS DE APLICACIÓN: DNV (OILREC, FI-FI I, DYNPOS-AUTR.), SOLAS, MARPOL.

CARACTERÍSTICAS DE LA CARGA: 1200 M3 OIL RECOVERY TANKS. 400 M2 libres de espacio de carga en cubierta.

VELOCIDAD Y AUTONOMÍA: 14 nudos en condiciones de servicio al 85% MCR y margen de mar del 15%. 5000 millas de autonomía.

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA: Los específicos y normales para este tipo de buque.

PROPULSIÓN: Diésel eléctrica con propulsores azimutales. Estudio Específico de Viabilidad de propulsión Dual HFO/LNG

TRIPULACIÓN Y PASAJE: Capacidad para 25 personas.

OTROS EQUIPOS E INSTALACIONES: Los habituales en este tipo de buques.

Ferrol, Febrero de 2.018

ALUMNO: Dº. Diego Jesús Bellido Trujillo

ÍNDICE

TABLA DE ILUSTRACIONES

1 PRESENTACIÓN

En este cuaderno se obtendrá el plano de formas del buque proyecto a partir de los valores obtenidos hasta ahora.

Las dimensiones de partidas serán las dimensiones calculadas en el cuaderno 1, así como los coeficientes de formas que han sido calculados en dicho cuaderno:

DIMENSIONES PRINCIPALES	
Eslora total	85,00 m
Eslora entre pps	76,26 m
Manga	19,00 m
Puntal de Trazado	7,90 m
Calado de Trazado	6,15 m
Desplazamiento	6607 t
Peso Muerto	3211 t
Coeficiente de bloque	0,69

MAQUINARIA PRINCIPAL	
Propulsión	Diesel eléctrica, híbrida.
Motores principales	4 x 3840 kW Wärtsila Genset 8L34DF
Gen. Puerto/emergencia	1 x 920 kW Wärtsila Genset 4L 20

Realizaremos también el estudio necesario para saber si se requiere bulbo de proa o no.

Existen tres maneras diferentes de obtener las formas de un buque:

- A partir de series sistemáticas.
- Modificación de un modelo base mediante una transformación afín.
- Diseño libre a partir de parámetros iniciales

En este cuaderno, además, veremos las formas elegidas para nuestro buque proyecto.

2 PROCESO DE DISEÑO DE LAS FORMAS

En nuestro caso, se empleará el método de la modificación del buque base mediante transformación afín.

El buque base tendrá unas formas parecidas al ser un buque dedicado al mismo fin (PSV).

El buque base será el "Edda Fram" incluido en la base de datos del Cuaderno 1 y cuya cartilla de trazado se ha incluido en los anexos de este cuaderno.

El procedimiento para la distorsión de formas es por multiplicación proporcional de la caja de cuadernas obtenidas a partir de la disposición general anexa, con el objetivo de apoyarnos en un buque ya existente.

Los factores de escala pueden ser iguales o diferentes para los tres ejes, por ello el cambio de magnitud proporcional puede ser limitado a una de las dimensiones principales (Eslora - manga y puntal / calado), afectar a dos de ellas o a las tres.

Debido a que estas tres dimensiones pueden variarse arbitrariamente, es preciso señalar que las relaciones entre variables variarán igualmente, y otras no serán las mismas que las del buque antes de la distorsión.

Las expresiones utilizadas dentro de la distorsión afín serán:

$$L_i = \lambda_x * L_0$$

$$B_i = \lambda_y * B_0$$

$$D_i = \lambda_z * D_0$$

$$T_i = \lambda_z * T_0$$

Siendo (L_i, B_i, D_i, T_i) las dimensiones del buque transformado afínmente del que tiene las dimensiones (L_0, B_0, D_0, T_0).

Las características de nuestro buque base son las siguientes:

$$L = 85{,}80\ m$$

$$Lpp = 77{,}40\ m$$

$$B = 19{,}20\ m$$

$$D = 8\ m$$

$$T = 6{,}5\ m$$

El proceso seguido es el siguiente:

1. A partir del plano de formas del buque base, se ha obtenido la caja de cuadernas y su correspondiente cartilla de trazado.
2. Se ha escalado la cartilla de trazado del buque base para obtener la caja de cuadernas dimensionada para el buque a proyectar, mediante la multiplicación de las dimensiones por los siguientes factores:
   a. Eslora

$$\frac{LPPf}{Lppi} = \frac{76,266}{77,40} = 0,985$$

   b. Manga

$$\frac{Bf}{Bi} = \frac{19,044}{19,20} = 0,991$$

   c. Calado

$$\frac{Tf}{Ti} = \frac{6,152}{6,5} = 0,946$$

3. Introducir los puntos de la caja de cuaderna escalada en el Maxsurf en forma de markers.

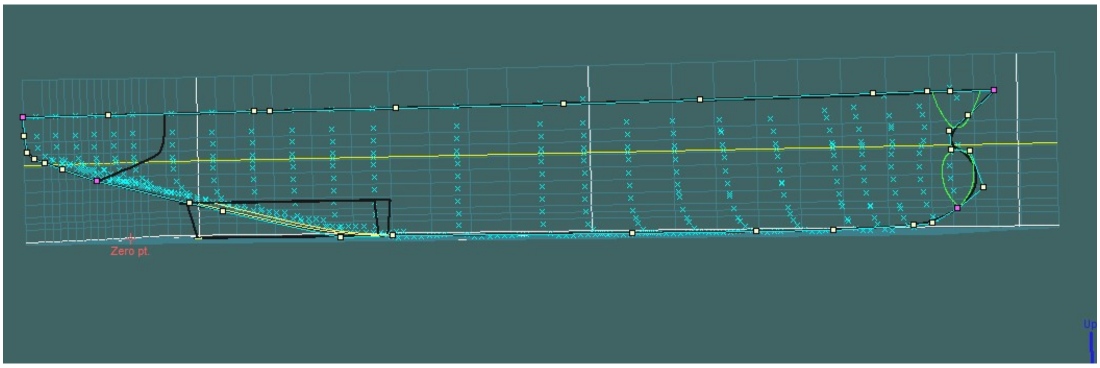

Ilustración 1. Markers en Maxsurf.
Fuente: Propia.

4. Modificamos un casco ya existente en la librería del programa y lo ajustamos a los markers.

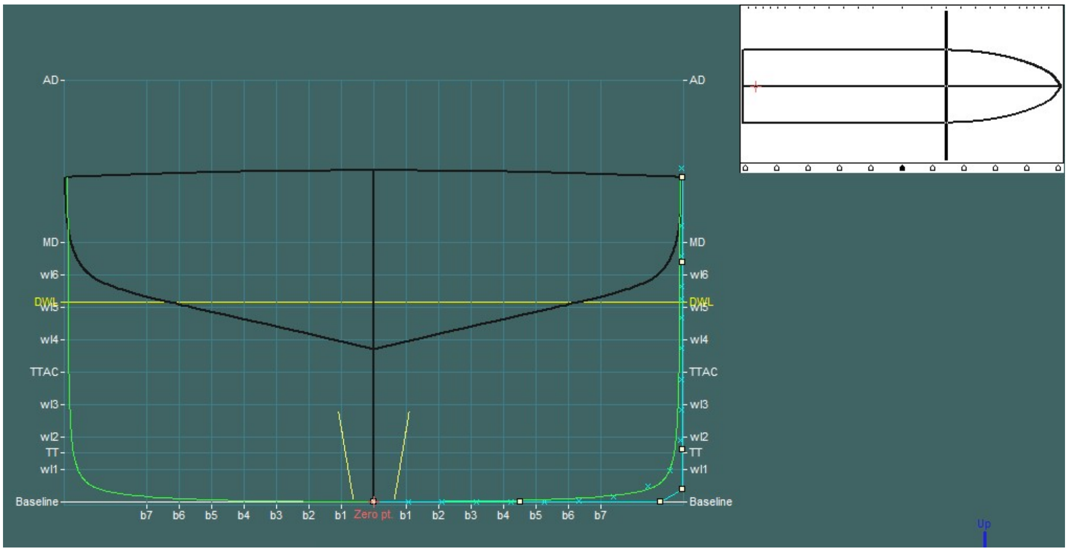

Ilustración 2. Markers en Maxsurf 2.
Fuente: Propia.

5. Mediante una transformación paramétrica, modificar las formas del buque (manteniendo las dimensiones) para obtener los coeficientes de forma finales.

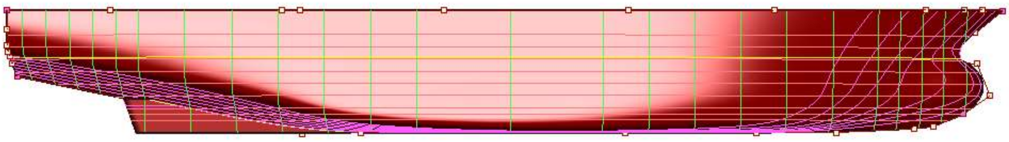

Ilustración 3. Formas obtenidas en Maxsurf 2.
Fuente: Propia.

3 CONTORNO DE PROA

Vamos a determinar la necesidad o no de la instalación de un bulbo de proa y el cálculo de sus parámetros básicos en caso de que sea necesario:

Según "*El proyecto básico del buque mercante*" de Alvariño [1], es recomendable la utilización de bulbo si:

$$0.65 < Cb < 0.815$$

$$5.5 < Lpp/B < 7.0$$

$$0.24 < Fn < 0.57$$

$$\frac{Cb * B}{Lpp} > 0.135$$

En el caso de nuestro buque obtenemos lo siguiente:

$$Cb = 0.71$$

$$\frac{Lpp}{B} = 4.03$$

$$Fn = 0.5145$$

$$\frac{Cb * B}{Lpp} = 0.175$$

Como podemos ver, se cumplen 3 de las 4 condiciones mencionadas anteriormente, por lo que se determina que es necesaria la instalación de un bulbo de proa.

Además de esto, la mayor parte de los buques PSV con características similares, también llevan instalados un bulbo.

"…el bulbo de proa supone una sustancial mejora en cuanto a la disminución de la velocidad en olas se refiere y, en general, un mejor comportamiento del buque en la mar con tiempos duros. Ello es particularmente importante, pues son harto conocidos los desfavorables efectos del "slamming" y, en general, del cabeceo y los fuertes pantocazos en la navegación, que ocasionan frecuentes averías en los fondos de proa, obligando a moderar la máquina tan pronto se endurecen las condiciones de la mar…" [2]

A continuación, se procede al cálculo de los parámetros básicos del bulbo, que son:

- Altura
- Protuberancia
- Área
- Manga

Para este cálculo se considerará como buque base uno de características similares de la base de datos.

Recordamos de nuevo las dimensiones principales de nuestro buque base para realizar los cálculos pertinentes:

$$Lpp = 77{,}40\ m$$

$$B = 18\ m$$

$$T = 6{,}5\ m$$

Y los coeficientes del bulbo obtenidos del buque base:

- Protuberancia del bulbo $X =$ ➔ $\frac{X}{Lpp} = 0{,}016$ (adimensionalizada con la eslora entre perpendiculares y medida desde la perpendicular de proa)
- Altura bulbo $h =$ ➔ $\frac{h}{T} = 0{,}738$ (adimensionalizada con el calado)
- Altura máxima bulbo $Z =$ ➔ $\frac{Z}{T} = 1{,}231$ (adimensionalizada con el calado)

Aplicando estos coeficientes a la eslora entre perpendiculares y al calado de nuestro buque, obtenemos los parámetros que definen nuestro bulbo:

Tabla 1. Parámetros del bulbo.

Parámetro	*Edda Fram*	*Coef. adimensionalizado*	*Buque proyecto*
Protuberancia	1,25 m	0,016	(75.54*0.016) = 1,21 m
Altura	4,80 m	0,730	(6,04*0,730) = 4,41 m
Altura Total	8,00	1,231	(6,04*1,231) = 7,43 m

Para el cálculo del área del bulbo nos remitimos de nuevo a la referencia citada anteriormente la cual nos indica que es un 7% del área de la maestra [2]:

$$A_{bulbo} = 0.070 * Am = 0.070 * Cm * B * T = 0{,}070 * 0{,}89 * 18{,}71 * 6{,}04 = 7{,}04\ m^2$$

Para realizar el modelado de las formas de proa, emplearemos el perfil mostrado a continuación:

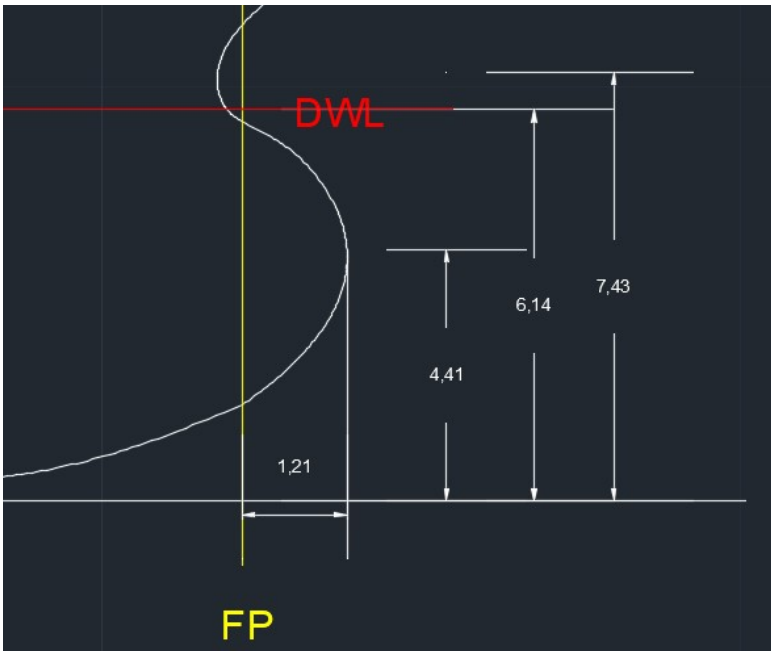

Ilustración 4. Medidas formas de proa.
Fuente: Propia.

4 CONTORNO DE POPA

Para el cálculo de las claras de la hélice para un buque de dos propulsores podemos encontrarlos en el DNV, en la Pt. 3 Ch. 3 Sec. 2 [3].

Table C1 Minimum clearances	
For single screw ships:	*For twin screw ships:*
a ≥ 0.2 R (m)	
b ≥ (0.7 – 0.04 Z_P) R (m)	
c ≥ (0.48 – 0.02 Z_P) R (m)	c ≥ (0.6 – 0.02 Z_P) R (m)
e ≥ 0.07 R (m)	

R = propeller radius in m
Z_P = number of propeller blades.

$$a \geq 0{,}2\ R$$

$$b \geq (0{,}7 - 0{,}04\ Zp)\ R$$

$$c \geq (0{,}6 - 0{,}02 * 4) * 1300mm)$$

$$e \geq (00{,}7 * R)$$

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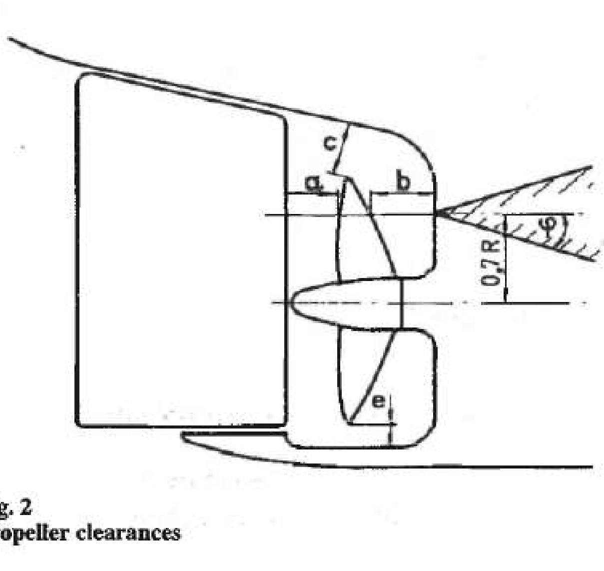


Fig. 2
Propeller clearances

Estos valores son para configuraciones tradicionales Para thrusters azimutales la norma remite en esta misma sección (en A103) a Pt. 4 Ch. 5 Secc. 2 y Secc.3. Dentro de estas dos secciones no se hace referencia a las claras, ya que los planos deben ser remitidos a la Sociedad para consideración. Debido a esto, y a que los propulsores elegidos estarán clasificados por todas las Sociedades consideraré que las claras han sido ya tenidas en cuenta. Sin embargo, utilizaré estos valores como referencia, y la distancia se fijará en 750 mm.

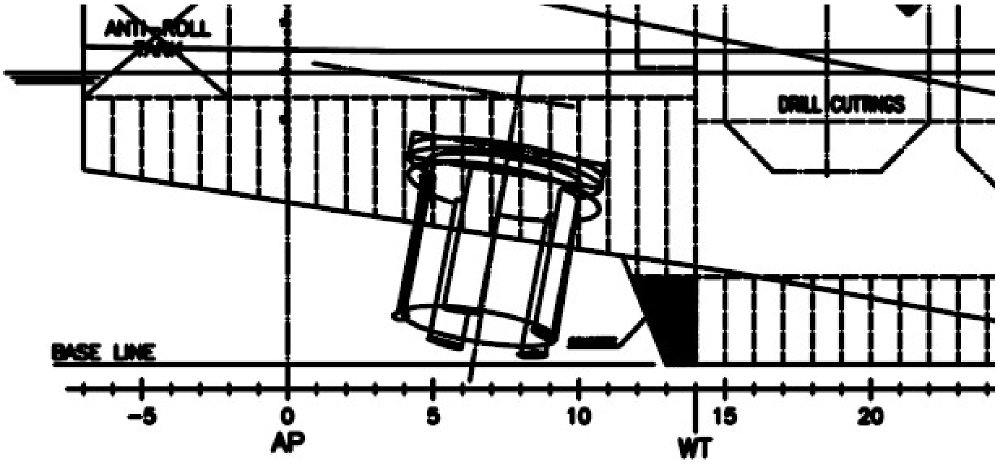
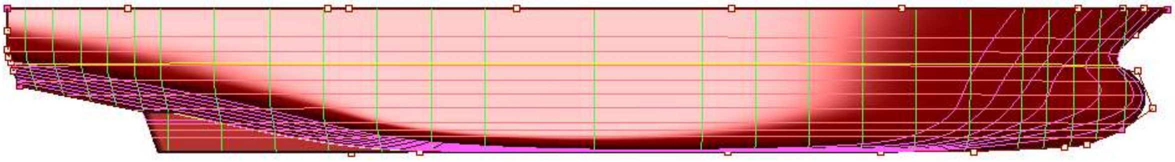
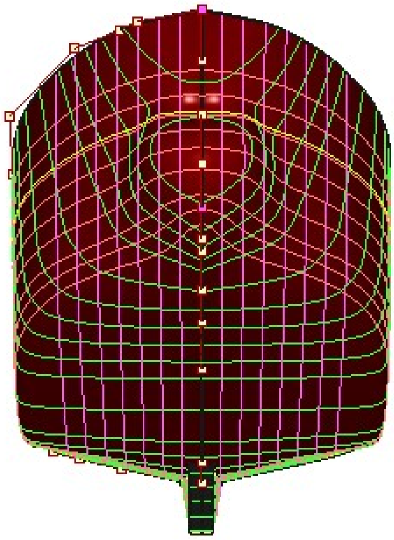


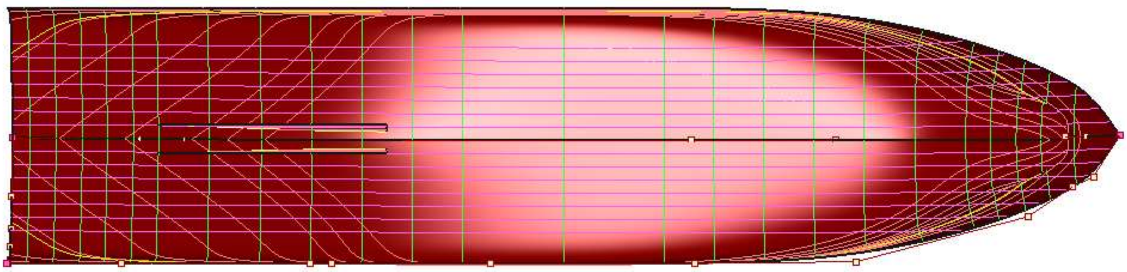
Ilustración 5. Formas de popa del buque de referencia "Edda Fram"
Fuente: Edda Fram Vessel

Por otro lado, para mejorar la estabilidad, y para proporcionar un flujo de entrada de propulsión adecuado, se dispondrá de un quillote vertical a crujía y en popa ("Skeg).

5 FORMAS OBTENIDAS







6 COMPROBACIÓN DE LOS RESULTADOS

Una vez definidas las formas de nuestro buque proyecto, los coeficientes de afinamiento obtenidos serán los que caracterizarán dicho buque. En la siguiente tabla podemos ver los resultados obtenidos directamente de las formas del software Maxsurf y los resultados que obtuvimos en el predimensionado del Cuaderno 1.

Hydrostatics at DWL

	Measurement	Value	Units
1	Displacement	6607	t
2	Volume (displaced)	6445,866	m^3
3	Draft Amidships	6,159	m
4	Immersed depth	6,175	m
5	WL Length	79,250	m
6	Beam max extents o	18,996	m
7	Wetted Area	2130,919	m^2
8	Max sect. area	115,374	m^2
9	Waterpl. Area	1349,033	m^2
10	Prismatic coeff. (Cp)	0,705	
11	Block coeff. (Cb)	0,693	
12	Max Sect. area coeff	0,986	
13	Waterpl. area coeff.	0,896	
14	LCB length	38,714	from z
15	LCF length	33,809	from z
16	LCB %	48,851	from z
17	LCF %	42,662	from z
18	KB	3,461	m
19	KG fluid	0,000	m
20	BMt	5,615	m
21	BML	92,941	m
22	GMt corrected	9,076	m
23	GML	96,402	m
24	KMt	9,076	m
25	KML	96,402	m
26	Immersion (TPc)	13,828	tonne/c
27	MTc	83,514	tonne.
28	RM at 1deg = GMt.Di	1046,529	tonne.

Ilustración 6. Resultados obtenidos.
Fuente: Maxsurf software.

Tabla 2. Alternativa final de Dimensiones.

ALTERNATIVA FINAL. DIMENSIONES PRINCIPALES DEL BUQUE	
L (m)	85,06
Lpp (m)	76,266
B (m)	19,044
D (m)	7,908
T(m)	6,152
Δ (t)	6516,21
TPM (t)	3397,70
C_b	0,71
C_M	0,89
C_P	0,80
C_F	0,88
V (kn)	14
Superficie de cubierta (m^2)	400,00

Para facilitar la comparativa de resultados hemos realizado una tabla en la que se comparan los datos principales a tener en cuenta.

Tabla 3. Comparativa de resultados.

Parámetros	Preliminares (C1)	Resultantes (C3)
L (m)	85,06	85,00
Lpp (m)	76,26	76,26
B (m)	19,04	19,00
D (m)	7,91	7,90
T(m)	6,15	6,15
Δ (t)	6516,21	6607,00
C_b	0,71	0,69
C_M	0,89	0,98
C_P	0,80	0,71
C_F	0,88	0,89

Las pequeñas discrepancias que vemos entre ambos se asumen lógicas, debido a que en el proceso de cálculo en el Maxsurf están referidos estos a la eslora en la flotación y no a la eslora entre perpendiculares, con el objetivo de acercarnos más a la realidad.

Por otra parte, también comprobamos que nuestro calado de diseño nos ofrece una capacidad de carga coherente con nuestras RPA, debido a que la variación obtenida en este cuaderno y lo obtenido en el cuaderno 1, son unas discrepancias casi despreciables en cuanto a desplazamiento siendo esta 0,13% sobre el calculado.

7 REFERENCIAS

[1] Proyecto Básico del Buque Mercante. Alvariño et al. FEIN. 1997

[2] Apuntes de la asignatura de Proyecto de Buques y Artefactos. Profesor Fernando Junco Ocampo. E.P.S. Ferrol. Universidad de la Coruña.

[3] DNV, Det Norske Veritas. Pt. 3 Ch. 3 Sec. 2

ANEXO 1: DNV. CLARAS DEL CODASTE

RULES FOR
CLASSIFICATION OF

SHIPS

NEWBUILDINGS

HULL AND EQUIPMENT
MAIN CLASS

PART 3 CHAPTER 3

HULL EQUIPMENT AND APPENDAGES

JANUARY 2000

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DET NORSKE VERITAS

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is to effectively limit vertical movement of rudder in case of extreme (accidental) vertical load on rudder.

103 Effective means are to be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

104 If the rudder trunk is open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier.

An additional seal of approved type is required when the rudder carrier is below the summer load waterline.

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Guidance note:

The after body should be so shaped as to ensure a proper flow of water to the propeller, and so as to prevent uneven formation of eddies as far as possible. The apex of the waterlines in front of the propeller should have the least possible radius, together with a relatively small angle ϕ. Plane or approximately plane parts above the propeller tip should be avoided.

The strength of pressure impulses from propeller to hull will normally decrease with increasing clearances. However, even with large clearances to the propeller, a hull may be exposed to strong impulses if the propeller is subject to heavy cavitation.

For a moderately cavitating propeller, the following minimum clearances are proposed (see Table C1 and Fig. 2):

Table C1 Minimum clearances	
For single screw ships:	*For twin screw ships:*
$a \geq 0{,}2\ R$ (m)	
$b \geq (0{,}7 - 0{,}04\ Z_P)\ R$ (m)	
$c \geq (0{,}48 - 0{,}02\ Z_P)\ R$ (m)	$c \geq (0{,}6 - 0{,}02\ Z_P)\ R$ (m)
$e \geq 0{,}07\ R$ (m)	

R =propeller radius in m
Z_P =number of propeller blades.

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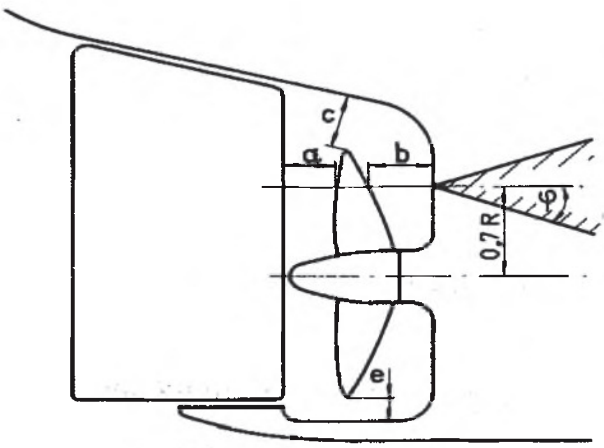

Fig. 2
Propeller clearances

106

Guidance note:

Rudders (one or more) working directly behind a propeller should preferably have a total area not less than:

$$A = \frac{TL}{100}\left[1 + 50C_B^{\,2}\left(\frac{B}{L}\right)^2\right] \quad (m^2)$$

For ships which frequently manoeuvre in harbours, canals or other narrow waters, the rudder area determined by the formula should be increased. For ships with a streamlined rudder post, half of the lateral area of the post may be included in the rudder area. For ships with a rudder horn, the whole area of the horn laying below a horizontal line from the top of the rudder may be included.

Rudders not working directly behind a propeller should have the area as given above, increased by at least 30%.

Rudders with special profiles or special configurations (e.g. flaps or nozzles) giving increased efficiency may have smaller total areas.

For ships with large freeboard and/or high continuous superstructures an increase of the rudder area ought to be considered.

Larger rudder area may result in excessive heeling angle when using the rudder in extreme position at full speed ahead. This is particularly relevant for passenger vessels, ferries, vehicle ro/ro carriers and other vessels where the combination of speed, draught, vertical centre of gravity and metacentric height may result in excessive heeling angle in case of smaller turning circles. For estimating the result angle of heel, reference is made to Pt.5 Ch.2 Sec.2 K400.

In cases where the resulting angle of heel may exceed 10 degrees, the Master should be provided with warning about this in the stability manual.

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Guidance note:

In order to minimise vibrations, the balancing and design of the rudders should be carried out as follows:

- the balanced portion should not be greater than 23% of the total area of the rudder
- the length of the balanced part at any horizontal section should nowhere be greater than 35% of the total length of the rudder
- the widest part of the rudder section should preferably be at least 30% aft of the leading edge of the rudder section considered.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

108 Over-balanced rudders are subject to special consideration with respect to type of steering gear and risk of an unexpected and uncontrolled sudden large movement of rudder causing severe change of ship's pre-set course. See J106.

Guidance note:

A rudder shall be considered over-balanced, when balanced portion exceed 30% in any actual load condition. Special rudder types, such as flap rudders, are subject to special consideration.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C 200 Steering gears

201 For arrangement and details of steering gear see subsection J.

D. Design Loads and Stress Analysis

D 100 Rudder force and rudder torque, general

101 The rudder force upon which the rudder scantlings are to be based is to be determined from the following formula:

$$F_R = 0{,}044\ k_1\ k_2\ k_3\ A\ V^2 \quad (kN)$$

A = area of rudder blade in m^2, including area of flap.
= vertical projected area of nozzle rudder

ANEXO 2: CARTILLA DE TRAZADO BUQUE BASE

X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)
-1,98	1,06	5,26	3,86	2,13	4,38	11,58	1,06	2,82	19,41	9,55	6,00	30,99	4,26	0,03
-1,98	2,13	5,54	3,86	3,19	4,57	11,58	2,13	2,93	19,41	9,57	7,00	30,99	5,32	0,03
-1,98	3,19	5,82	3,86	4,26	4,76	11,58	3,19	3,04	19,41	9,57	8,00	30,99	6,38	0,04
-1,98	4,26	6,09	3,86	5,32	4,98	11,58	4,26	3,14	19,41	9,57	9,00	30,99	7,45	0,11
-1,98	5,32	6,37	3,86	6,38	5,29	11,58	5,32	3,27	19,41	0,00	1,44	30,99	8,51	0,30
-1,98	6,38	6,65	3,86	7,45	5,66	11,58	6,38	3,46	19,41	9,57	10,59	30,99	9,57	6,60
-1,98	7,45	6,93	3,86	8,51	6,06	11,58	7,45	3,83	23,27	1,06	0,89	30,99	9,53	1,00
-1,98	8,51	7,24	3,86	9,21	6,60	11,58	8,51	4,40	23,27	2,13	0,92	30,99	9,57	2,00
-1,98	6,20	6,60	3,86	5,38	5,00	11,58	9,53	6,60	23,27	3,19	0,95	30,99	9,57	3,00
-1,98	0,05	5,00	3,86	8,38	6,00	11,58	2,83	3,00	23,27	4,26	0,98	30,99	9,57	4,00
-1,98	3,90	6,00	3,86	9,40	7,00	11,58	7,79	4,00	23,27	5,32	1,01	30,99	9,57	5,00
-1,98	7,72	7,00	3,86	9,56	8,00	11,58	9,17	5,00	23,27	6,38	1,06	30,99	9,57	6,00
-1,98	9,46	8,00	3,86	9,57	9,00	11,58	9,47	6,00	23,27	7,45	1,20	30,99	9,57	7,00
-1,98	9,57	9,00	3,86	0,00	3,99	11,58	9,55	7,00	23,27	8,51	1,53	30,99	9,57	8,00
-1,98	0,00	4,99	3,86	9,57	10,60	11,58	9,57	8,00	23,27	9,57	6,60	30,99	9,57	9,00
-1,98	9,57	10,60	5,84	1,06	3,83	11,58	9,57	9,00	23,27	5,03	1,00	30,99	0,00	0,03
0,00	1,06	4,90	5,84	2,13	4,00	11,58	0,00	2,70	23,27	9,05	2,00	30,99	9,57	10,57
0,00	2,13	5,14	5,84	3,19	4,17	11,58	9,57	10,60	23,27	9,43	3,00	38,81	1,06	0,00
0,00	3,19	5,38	5,84	4,26	4,33	15,54	1,06	2,14	23,27	9,52	4,00	38,81	2,13	0,00
0,00	4,26	5,63	5,84	5,32	4,53	15,54	2,13	2,22	23,27	9,55	5,00	38,81	3,19	0,00
0,00	5,32	5,90	5,84	6,38	4,82	15,54	3,19	2,29	23,27	9,56	6,00	38,81	4,26	0,00
0,00	6,38	6,20	5,84	7,45	5,21	15,54	4,26	2,37	23,27	9,57	7,00	38,81	5,32	0,00
0,00	7,45	6,50	5,84	8,51	5,64	15,54	5,32	2,45	23,27	9,57	8,00	38,81	6,38	0,01
0,00	8,51	6,85	5,84	9,38	6,60	15,54	6,38	2,59	23,27	9,57	9,00	38,81	7,45	0,08
0,00	7,78	6,60	5,84	2,13	4,00	15,54	7,45	2,87	23,27	0,00	0,86	38,81	8,51	0,27
0,00	1,52	5,00	5,84	6,90	5,00	15,54	8,51	3,48	23,27	9,57	10,59	38,81	9,57	6,60
0,00	5,69	6,00	5,84	9,03	6,00	15,54	9,55	6,60	27,13	1,06	0,36	38,81	9,55	1,00
0,00	8,83	7,00	5,84	9,48	7,00	15,54	7,77	3,00	27,13	2,13	0,37	38,81	9,57	2,00
0,00	9,52	8,00	5,84	9,56	8,00	15,54	9,09	4,00	27,13	3,19	0,38	38,81	9,57	3,00
0,00	9,57	9,00	5,84	9,57	9,00	15,54	9,44	5,00	27,13	4,26	0,39	38,81	9,57	4,00
0,00	0,00	4,65	5,84	0,00	3,65	15,54	9,53	6,00	27,13	5,32	0,41	38,81	9,57	5,00
0,00	9,57	10,60	5,84	9,57	10,60	15,54	9,56	7,00	27,13	6,38	0,43	38,81	9,57	6,00
1,98	1,06	4,53	7,72	1,06	3,49	15,54	9,57	8,00	27,13	7,45	0,52	38,81	9,57	7,00
1,98	2,13	4,75	7,72	2,13	3,64	15,54	9,57	9,00	27,13	8,51	0,76	38,81	9,57	8,00
1,98	3,19	4,96	7,72	3,19	3,79	15,54	0,00	2,05	27,13	9,57	6,60	38,81	9,57	9,00
1,98	4,26	5,18	7,72	4,26	3,94	15,54	9,57	10,60	27,13	9,02	1,00	38,81	0,00	0,00
1,98	5,32	5,43	7,72	5,32	4,10	19,41	1,06	1,50	27,13	9,48	2,00	38,81	9,57	10,59
1,98	6,38	5,74	7,72	6,38	4,36	19,41	2,13	1,55	27,13	9,54	3,00	46,53	1,06	0,00
1,98	7,45	6,07	7,72	7,45	4,77	19,41	3,19	1,60	27,13	9,56	4,00	46,53	2,13	0,00
1,98	8,51	6,44	7,72	8,51	5,24	19,41	4,26	1,65	27,13	9,57	5,00	46,53	3,19	0,00
1,98	8,82	6,60	7,72	9,47	6,60	19,41	5,32	1,70	27,13	9,57	6,00	46,53	4,26	0,00

X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)	X (Eslora)	y (Manga)	z (Puntal)
1,98	3,37	5,00	7,72	4,70	4,00	19,41	6,38	1,79	27,13	9,57	7,00	46,53	5,32	0,00
1,98	7,21	6,00	7,72	7,98	5,00	19,41	7,45	1,99	27,13	9,57	8,00	46,53	6,38	0,01
1,98	9,26	7,00	7,72	9,29	6,00	19,41	8,51	2,48	27,13	9,57	9,00	46,53	7,45	0,08
1,98	9,55	8,00	7,72	9,52	7,00	19,41	9,56	6,60	27,13	0,00	0,35	46,53	8,51	0,28
1,98	9,57	9,00	7,72	9,57	8,00	19,41	7,49	2,00	27,13	9,57	10,58	46,53	9,57	6,60
1,98	0,00	4,31	7,72	9,57	9,00	19,41	9,01	3,00	30,99	1,06	0,03	46,53	9,54	1,00
1,98	9,57	10,60	7,72	0,00	3,34	19,41	9,43	4,00	30,99	2,13	0,03	46,53	9,57	2,00
3,86	1,06	4,19	7,72	9,57	10,60	19,41	9,52	5,00	30,99	3,19	0,03	46,53	9,57	3,00

ANEXO 3: CARTILLA DE TRAZADO BUQUE PROYECTO

X (Eslora)	y (Manga)	z (Puntal)
-1,95	1,05	4,98
-1,95	2,11	5,24
-1,95	3,16	5,51
-1,95	4,22	5,76
-1,95	5,27	6,03
-1,95	6,33	6,29
-1,95	7,38	6,56
-1,95	8,43	6,85
-1,95	6,15	6,24
-1,95	0,05	4,73
-1,95	3,87	5,68
-1,95	7,65	6,62
-1,95	9,37	7,57
-1,95	9,49	8,51
-1,95	0,00	4,72
-1,95	9,49	10,03
0,00	1,05	4,64
0,00	2,11	4,86
0,00	3,16	5,09
0,00	4,22	5,33
0,00	5,27	5,58
0,00	6,33	5,87
0,00	7,38	6,15
0,00	8,43	6,48
0,00	7,71	6,24
0,00	1,51	4,73
0,00	5,64	5,68
0,00	8,75	6,62
0,00	9,44	7,57
0,00	9,49	8,51
0,00	0,00	4,40
0,00	9,49	10,03
1,95	1,05	4,29
1,95	2,11	4,49
1,95	3,16	4,69
1,95	4,22	4,90
1,95	5,27	5,14
1,95	6,33	5,43
1,95	7,38	5,74
1,95	8,43	6,09
1,95	8,74	6,24
1,95	3,34	4,73
1,95	7,15	5,68
1,95	9,17	6,62
1,95	9,47	7,57
1,95	9,49	8,51
1,95	0,00	4,08
1,95	9,49	10,03
3,80	1,05	3,96

X (Eslora)	y (Manga)	z (Puntal)
3,80	2,11	4,14
3,80	3,16	4,32
3,80	4,22	4,50
3,80	5,27	4,71
3,80	6,33	5,00
3,80	7,38	5,35
3,80	8,43	5,73
3,80	9,13	6,24
3,80	5,33	4,73
3,80	8,31	5,68
3,80	9,32	6,62
3,80	9,48	7,57
3,80	9,49	8,51
3,80	0,00	3,77
3,80	9,49	10,03
5,75	1,05	3,62
5,75	2,11	3,78
5,75	3,16	3,94
5,75	4,22	4,10
5,75	5,27	4,29
5,75	6,33	4,56
5,75	7,38	4,93
5,75	8,43	5,34
5,75	9,30	6,24
5,75	2,11	3,78
5,75	6,84	4,73
5,75	8,95	5,68
5,75	9,39	6,62
5,75	9,48	7,57
5,75	9,49	8,51
5,75	0,00	3,45
5,75	9,49	10,03
7,61	1,05	3,30
7,61	2,11	3,44
7,61	3,16	3,59
7,61	4,22	3,73
7,61	5,27	3,88
7,61	6,33	4,12
7,61	7,38	4,51
7,61	8,43	4,96
7,61	9,38	6,24
7,61	4,66	3,78
7,61	7,91	4,73
7,61	9,20	5,68
7,61	9,44	6,62
7,61	9,49	7,57
7,61	9,49	8,51
7,61	0,00	3,16
7,61	9,49	10,03

X (Eslora)	y (Manga)	z (Puntal)
11,41	1,05	2,67
11,41	2,11	2,77
11,41	3,16	2,88
11,41	4,22	2,97
11,41	5,27	3,09
11,41	6,33	3,27
11,41	7,38	3,62
11,41	8,43	4,16
11,41	9,45	6,24
11,41	2,80	2,84
11,41	7,72	3,78
11,41	9,09	4,73
11,41	9,38	5,68
11,41	9,47	6,62
11,41	9,49	7,57
11,41	9,49	8,51
11,41	0,00	2,55
11,41	9,49	10,03
15,31	1,05	2,02
15,31	2,11	2,10
15,31	3,16	2,17
15,31	4,22	2,24
15,31	5,27	2,32
15,31	6,33	2,45
15,31	7,38	2,72
15,31	8,43	3,29
15,31	9,47	6,24
15,31	7,70	2,84
15,31	9,00	3,78
15,31	9,35	4,73
15,31	9,45	5,68
15,31	9,48	6,62
15,31	9,49	7,57
15,31	9,49	8,51
15,31	0,00	1,94
15,31	9,49	10,03
19,11	1,05	1,42
19,11	2,11	1,47
19,11	3,16	1,51
19,11	4,22	1,56
19,11	5,27	1,61
19,11	6,33	1,69
19,11	7,38	1,88
19,11	8,43	2,35
19,11	9,48	6,24
19,11	7,42	1,89
19,11	8,93	2,84
19,11	9,34	3,78
19,11	9,44	4,73

X (Eslora)	y (Manga)	z (Puntal)
19,11	9,47	5,68
19,11	9,49	6,62
19,11	9,49	7,57
19,11	9,49	8,51
19,11	0,00	1,36
19,11	9,49	10,02
22,92	1,05	0,84
22,92	2,11	0,87
22,92	3,16	0,90
22,92	4,22	0,93
22,92	5,27	0,96
22,92	6,33	1,00
22,92	7,38	1,14
22,92	8,43	1,45
22,92	9,49	6,24
22,92	4,99	0,95
22,92	8,97	1,89
22,92	9,34	2,84
22,92	9,44	3,78
22,92	9,47	4,73
22,92	9,48	5,68
22,92	9,49	6,62
22,92	9,49	7,57
22,92	9,49	8,51
22,92	0,00	0,81
22,92	9,49	10,02
26,72	1,05	0,34
26,72	2,11	0,35
26,72	3,16	0,36
26,72	4,22	0,37
26,72	5,27	0,39
26,72	6,33	0,41
26,72	7,38	0,49
26,72	8,43	0,72
26,72	9,49	6,24
26,72	8,94	0,95
26,72	9,39	1,89
26,72	9,46	2,84
26,72	9,48	3,78
26,72	9,49	4,73
26,72	9,49	5,68
26,72	9,49	6,62
26,72	9,49	7,57
26,72	9,49	8,51
26,72	0,00	0,33
26,72	9,49	10,01
30,53	1,05	0,03
30,53	2,11	0,03
30,53	3,16	0,03

X (Eslora)	y (Manga)	z (Puntal)
30,53	4,22	0,03
30,53	5,27	0,03
30,53	6,33	0,04
30,53	7,38	0,10
30,53	8,43	0,28
30,53	9,49	6,24
30,53	9,45	0,95
30,53	9,49	1,89
30,53	9,49	2,84
30,53	9,49	3,78
30,53	9,49	4,73
30,53	9,49	5,68
30,53	9,49	6,62
30,53	9,49	7,57
30,53	9,49	8,51
30,53	0,00	0,03
30,53	9,49	10,00
38,23	1,05	0,00
38,23	2,11	0,00
38,23	3,16	0,00
38,23	4,22	0,00
38,23	5,27	0,00
38,23	6,33	0,01
38,23	7,38	0,08
38,23	8,43	0,26
38,23	9,49	6,24
38,23	9,47	0,95
38,23	9,49	1,89
38,23	9,49	2,84
38,23	9,49	3,78
38,23	9,49	4,73
38,23	9,49	5,68
38,23	9,49	6,62
38,23	9,49	7,57
38,23	9,49	8,51
38,23	0,00	0,00
38,23	9,49	10,02
45,84	1,05	0,00
45,84	2,11	0,00
45,84	3,16	0,00
45,84	4,22	0,00
45,84	5,27	0,00
45,84	6,33	0,01
45,84	7,38	0,08
45,84	8,43	0,26
45,84	9,49	6,24
45,84	9,46	0,95
45,84	9,49	1,89
45,84	9,49	2,84

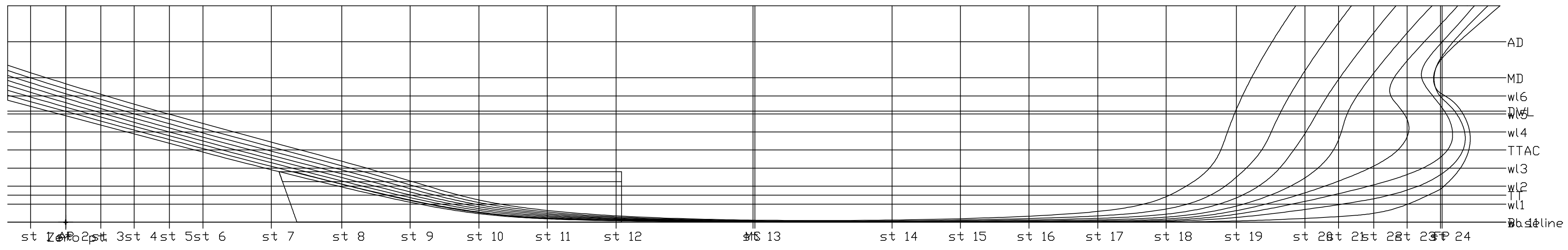
X (Eslora)	y (Manga)	z (Puntal)
45,84	9,49	3,78
45,84	9,49	4,73
45,84	9,49	5,68
45,84	9,49	6,62
45,84	9,49	7,57
45,84	9,49	8,51
45,84	0,00	0,00
45,84	9,49	10,09
49,64	1,05	0,00
49,64	2,11	0,00
49,64	3,16	0,00
49,64	4,22	0,00
49,64	5,27	0,00
49,64	6,33	0,03
49,64	7,38	0,14
49,64	8,43	0,48
49,64	9,48	6,24
49,64	9,11	0,95
49,64	9,45	1,89
49,64	9,48	2,84
49,64	9,48	3,78
49,64	9,48	4,73
49,64	9,48	5,68
49,64	9,48	6,62
49,64	9,48	7,57
49,64	9,48	8,51
49,64	0,00	0,00
49,64	9,49	10,29
53,44	1,05	0,00
53,44	2,11	0,00
53,44	3,16	0,00
53,44	4,22	0,01
53,44	5,27	0,05
53,44	6,33	0,16
53,44	7,38	0,48
53,44	8,43	1,31
53,44	9,31	6,24
53,44	8,08	0,95
53,44	8,81	1,89
53,44	9,12	2,84
53,44	9,22	3,78
53,44	9,27	4,73
53,44	9,29	5,68
53,44	9,32	6,62
53,44	9,34	7,57
53,44	9,37	8,51
53,44	0,00	0,00
53,44	9,48	11,32
57,25	1,05	0,00

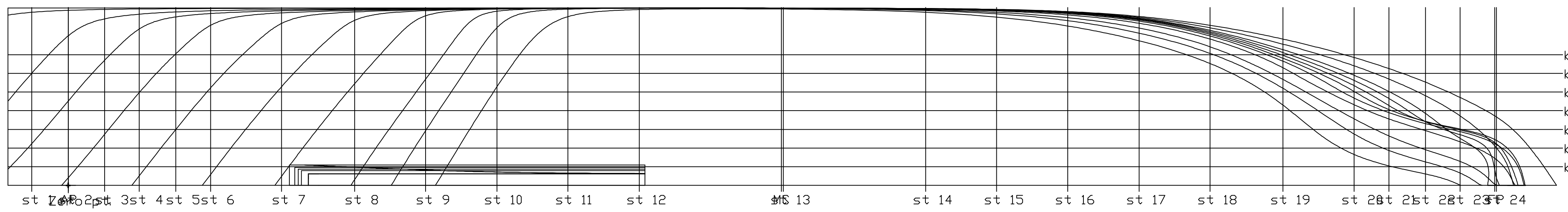
X (Eslora)	y (Manga)	z (Puntal)
57,25	2,11	0,00
57,25	3,16	0,01
57,25	4,22	0,06
57,25	5,27	0,19
57,25	6,33	0,49
57,25	7,38	1,24
57,25	8,43	3,24
57,25	8,87	6,24
57,25	7,07	0,95
57,25	7,86	1,89
57,25	8,31	2,84
57,25	8,56	3,78
57,25	8,71	4,73
57,25	8,80	5,68
57,25	8,90	6,62
57,25	8,99	7,57
57,25	9,09	8,51
57,25	0,00	0,00
57,25	9,38	12,28
61,05	1,05	0,00
61,05	2,11	0,01
61,05	3,16	0,05
61,05	4,22	0,18
61,05	5,27	0,51
61,05	6,33	1,22
61,05	7,38	3,03
61,05	8,43	7,74
61,05	8,13	6,24
61,05	6,02	0,95
61,05	6,84	1,89
61,05	7,31	2,84
61,05	7,62	3,78
61,05	7,84	4,73
61,05	8,02	5,68
61,05	8,20	6,62
61,05	8,40	7,57
61,05	8,59	8,51
61,05	0,00	0,00
61,05	9,16	12,52
64,95	1,05	0,01
64,95	2,11	0,05
64,95	3,16	0,19
64,95	4,22	0,58
64,95	5,27	1,45
64,95	6,33	3,67
64,95	7,38	7,60
64,95	8,43	11,21
64,95	6,96	6,24
64,95	4,77	0,95

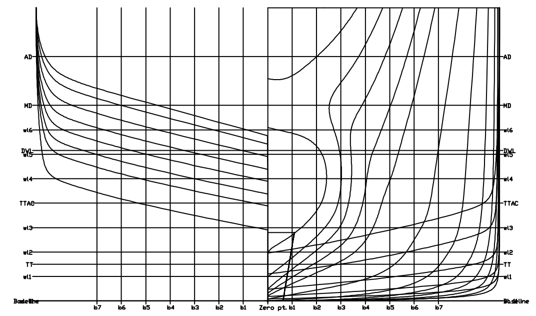
X (Eslora)	y (Manga)	z (Puntal)
64,95	5,59	1,89
64,95	6,05	2,84
64,95	6,36	3,78
64,95	6,61	4,73
64,95	6,82	5,68
64,95	7,05	6,62
64,95	7,37	7,57
64,95	7,72	8,51
64,95	0,00	0,00
64,95	8,69	12,58
68,75	1,05	0,03
68,75	2,11	0,18
68,75	3,16	0,81
68,75	4,22	2,23
68,75	5,27	6,47
68,75	6,33	8,99
68,75	7,38	11,83
68,75	5,23	6,24
68,75	3,30	0,95
68,75	4,03	1,89
68,75	4,49	2,84
68,75	4,78	3,78
68,75	4,99	4,73
68,75	5,13	5,68
68,75	5,31	6,62
68,75	5,66	7,57
68,75	6,10	8,51
68,75	0,00	0,00
68,75	7,61	12,58
70,61	1,05	0,09
70,61	2,11	0,50
70,61	3,16	1,87
70,61	4,22	6,42
70,61	5,27	9,20
70,61	6,33	11,50
70,61	4,21	6,24
70,61	2,51	0,95
70,61	3,17	1,89
70,61	3,64	2,84
70,61	3,94	3,78
70,61	4,12	4,73
70,61	4,21	5,68
70,61	4,24	6,62
70,61	4,50	7,57
70,61	4,93	8,51
70,61	0,00	0,00
70,61	6,77	12,58
72,56	1,05	0,41
72,56	2,11	1,65

X (Eslora)	y (Manga)	z (Puntal)
72,56	3,16	7,77
72,56	4,22	9,96
72,56	5,27	11,81
72,56	3,09	6,24
72,56	1,62	0,95
72,56	2,27	1,89
72,56	2,75	2,84
72,56	3,07	3,78
72,56	3,23	4,73
72,56	3,22	5,68
72,56	3,00	6,62
72,56	3,10	7,57
72,56	3,46	8,51
72,56	5,70	12,58
72,56	0,00	0,20
74,41	2,11	9,16
74,41	3,16	10,67
74,41	4,22	12,14
74,41	1,91	6,24
74,41	0,47	0,95
74,41	1,35	1,89
74,41	1,89	2,84
74,41	2,22	3,78
74,41	2,36	4,73
74,41	2,25	5,68
74,41	1,63	6,62
74,41	1,45	7,57
74,41	1,77	8,51
74,41	4,55	12,58
74,41	0,00	0,77
76,36	1,05	10,48
76,36	2,11	11,51
76,36	0,03	6,24
76,36	0,75	2,84
76,36	1,18	3,78
76,36	1,33	4,73
76,36	1,02	5,68
76,36	3,15	12,58
76,36	0,00	9,72
78,31	1,29	12,58
78,31	0,00	12,03

ANEXO 4: PLANO DE FORMAS BUQUE PROYECTO







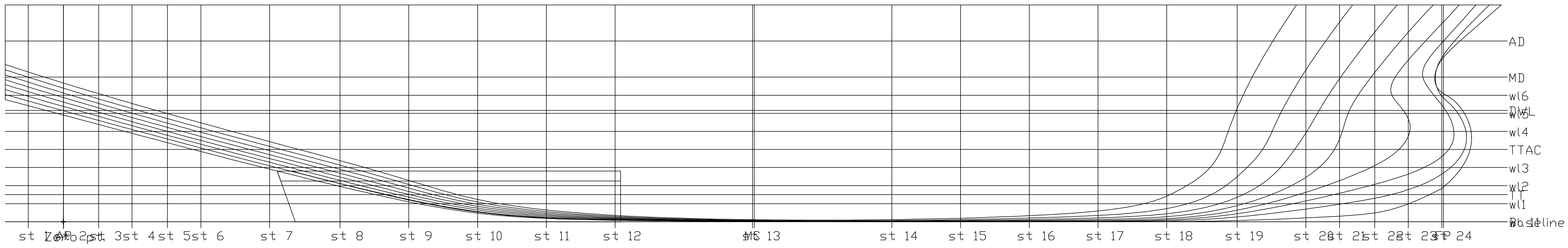
DIMENSIONES PRINCIPALES

ESLORA TOTAL	LOA	85.00	M
ESLORA EN LA FLOTACION	LWL	79.25	M
ESLORA ENTRE PERPENDICULARES	LBP	76.26	M
MANGA DE TRAZADO	B	19.00	M
PUNTAL DE TRAZADO	D	7.90	M
COEFICIENTE DE BLOQUE	CB	0.69	-
COEFICIENTE DE SECCION MEDIA	CM	0.98	-
CALADO DE PROYECTO	T	6.15	M
COEFICIENTE DE FLOTACION	CWL	0.89	-

UNIVERSIDADE DA CORUÑA

Buque de apoyo y suministros a plataformas offshore - PSV

Realizado por: Diego Jesús Bellido Trujillo	Archivo CAD: DG.DWG	Fecha 16/07/2018	Escala 1/300	T. Papel A/3
Master en Ingeniería Naval y Oceánica	Descripción del plano: Plano de Formas			
	Número de Plano: UDC-2018-0015		Edición 0	Hoja nº: 1/1



DIMENSIONES PRINCIPALES

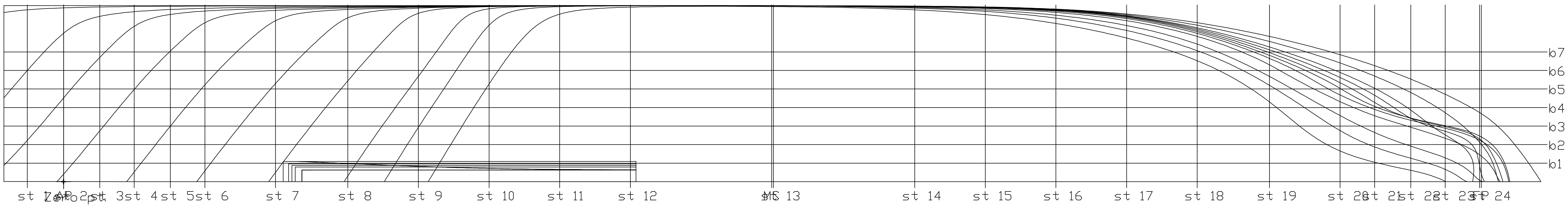
ESLORA TOTAL	LOA	85.00	M
ESLORA EN LA FLOTACION	LWL	79.25	M
ESLORA ENTRE PERPENDICULARES	LBP	76.26	M
MANGA DE TRAZADO	B	19.00	M
PUNTAL DE TRAZADO	D	7.90	M
COEFICIENTE DE BLOQUE	CB	0.69	-
COEFICIENTE DE SECCION MEDIA	CM	0.98	-
CALADO DE PROYECTO	T	6.15	M
COEFICIENTE DE FLOTACION	CWL	0.89	-

UNIVERSIDADE DA CORUÑA

Buque de apoyo y suministros a plataformas offshore - PSV

Realizado por:	Archivo CAD:	Fecha	Escala	T. Papel
Diego Jesús Bellido Trujillo	DG.DWG	16/07/2018	1/250	A/3

Master en Ingeniería Naval y Oceánica	Descripción del plano: Perfil Longitudinal Buque Proyecto		
	Número de Plano: UDC-2018-0010	Edición: 0	Hoja nº: 1/1



DIMENSIONES PRINCIPALES

ESLORA TOTAL	LOA	85.00	M
ESLORA EN LA FLOTACION	LWL(1)	79.25	M
ESLORA ENTRE PERPENDICULARES	LBP(1)	76.26	M
MANGA DE TRAZADO	B	18.99	M
PUNTAL DE TRAZADO	D	7.91	M
COEFICIENTE DE BLOQUE	CB(1)	0.69	-
COEFICIENTE DE SECCION MEDIA	CM(1)	0.98	-
CALADO DE PROYECTO	T	6.15	M
COEFICIENTE DE FLOTACION	CWL(1)	0.89	-

UNIVERSIDADE DA CORUÑA

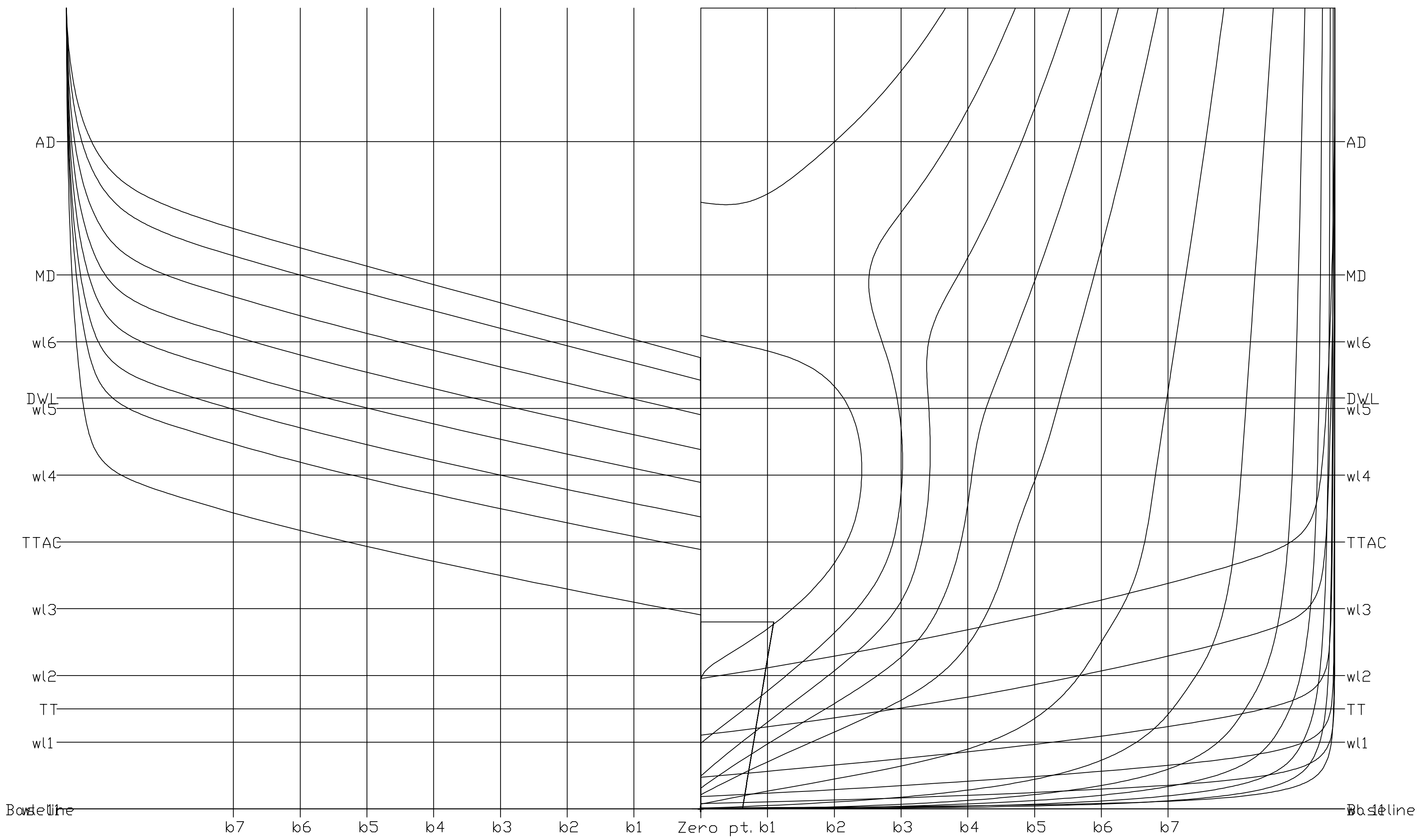
Buque de apoyo y suministros a plataformas offshore - PSV

Realizado por: Diego Jesús Bellido Trujillo	Archivo CAD: DG.DWG	Fecha 16/07/2018	Escala 1/250	T. Papel A/3

Master en Ingeniería Naval y Oceánica

Descripción del plano: Lineas de Agua Buque Proyecto

Número de Plano: UDC-2017-0012 | Edición 0 | Hoja nº: 1/1



DIMENSIONES PRINCIPALES

ESLORA TOTAL	LOA	85.00	M
ESLORA EN LA FLOTACION	LWL	79.25	M
ESLORA ENTRE PERPENDICULARES	LBP	76.26	M
MANGA DE TRAZADO	B	19.00	M
PUNTAL DE TRAZADO	D	7.90	M
COEFICIENTE DE BLOQUE	CB	0.69	-
COEFICIENTE DE SECCION MEDIA	CM	0.98	-
CALADO DE PROYECTO	T	6.15	M
COEFICIENTE DE FLOTACION	CWL	0.89	-

UNIVERSIDADE DA CORUÑA

Buque de apoyo y suministros a plataformas offshore - PSV

Realizado por: Diego Jesús Bellido Trujillo	Archivo CAD: DG.DWG	Fecha 16/07/2018	Escala 1/100	T. Papel A/3
Master en Ingeniería Naval y Oceánica	Descripción del plano: Secciones Buque Proyecto			
	Número de Plano: UDC-2018-0014		Edición 0	Hoja nº: 1/1

ANEXO 5: INFORMACIÓN ADICIONAL BUQUE DE REFERENCIA

ST-216

85.8m x 19.2 Platform Supply Vessel

MAIN CHARACTERISTICS

LENGTH O.A.:	85.8
BEAM:	19.2
DEPTH:	8.0
SPEED:	16.5
DEADWEIGHT:	at max draft abt. 4400 t
ACCOMMODATION:	23 pers

DECK AREA:	900 m2
FEATURES:	Voith Schneider propulsion
:	Integrated drill cutting tanks
:	High LFL* capacity
:	RIM tunnel thruster

SKIPSTEKNISK AS
Klaus Nilsens gt. 4, P.O.Box 36 Sentrum, NO-6001 Aalesund, Norway
PHONE: +47 70 10 33 44 FAX: +47 70 10 33 48 E-MAIL: office@skipsteknisk.no WEB: www.skipsteknisk.no

Skipsteknisk ™

Edda Fram is the first vessel with integrated tanks below deck for carrying large volumes of drill cuttings

Long relationship puts PSV at the forefront

The design of Østensjø's innovative *Edda Fram* draws on experience gained by shipowner and charterer over many years of co-operation; highlights include its drill cuttings system and the first use of Voith Schneider Propellers on a PSV

Due to enter service with Østensjø Rederi shortly, *Edda Fram* will replace *Edda Sprite* (also formerly called *Edda Fram*) on a long-term contract with Shell UK Ltd. The name *Edda Fram* is a special one for Østensjø Rederi: the company's founder, Johannes Østensjø, gave it to a PSV built in Durban, South Africa, in 1976, which marked the start of the company.

Østensjø has had a long association with Shell, one that dates back to the late 1980s, the second *Edda Fram* having first been chartered by the oil major in 1981. Vessels bearing the name *Edda Fram* in the past have also been innovative in their own right, one being the first with high bulwarks to provide a safer environment for the crew, and with windows on the roof of the bridge, which enabled the master to see cargo being received from offshore installations. Another 'first' was a supply vessel with a DP system.

Over the years, Østensjø has listened carefully to Shell's evolving requirements, and responded to the company's needs – specifically regarding safety improvements and enhancements, so it perhaps no surprise that the company is now chartering another innovative ship in the form of the new *Edda Fram*.

Shell UK's PSV contract holder, Colin Stratton, said of the decision to use the vessel: "Østensjø Rederi has always come up with innovative ideas, and the new *Edda Fram* foots the bill perfectly. Østensjø had been in discussions with Shell UK since 2000 on methods of transporting drill cuttings in bulk, and this concept has now come to fruition in this newest ship.

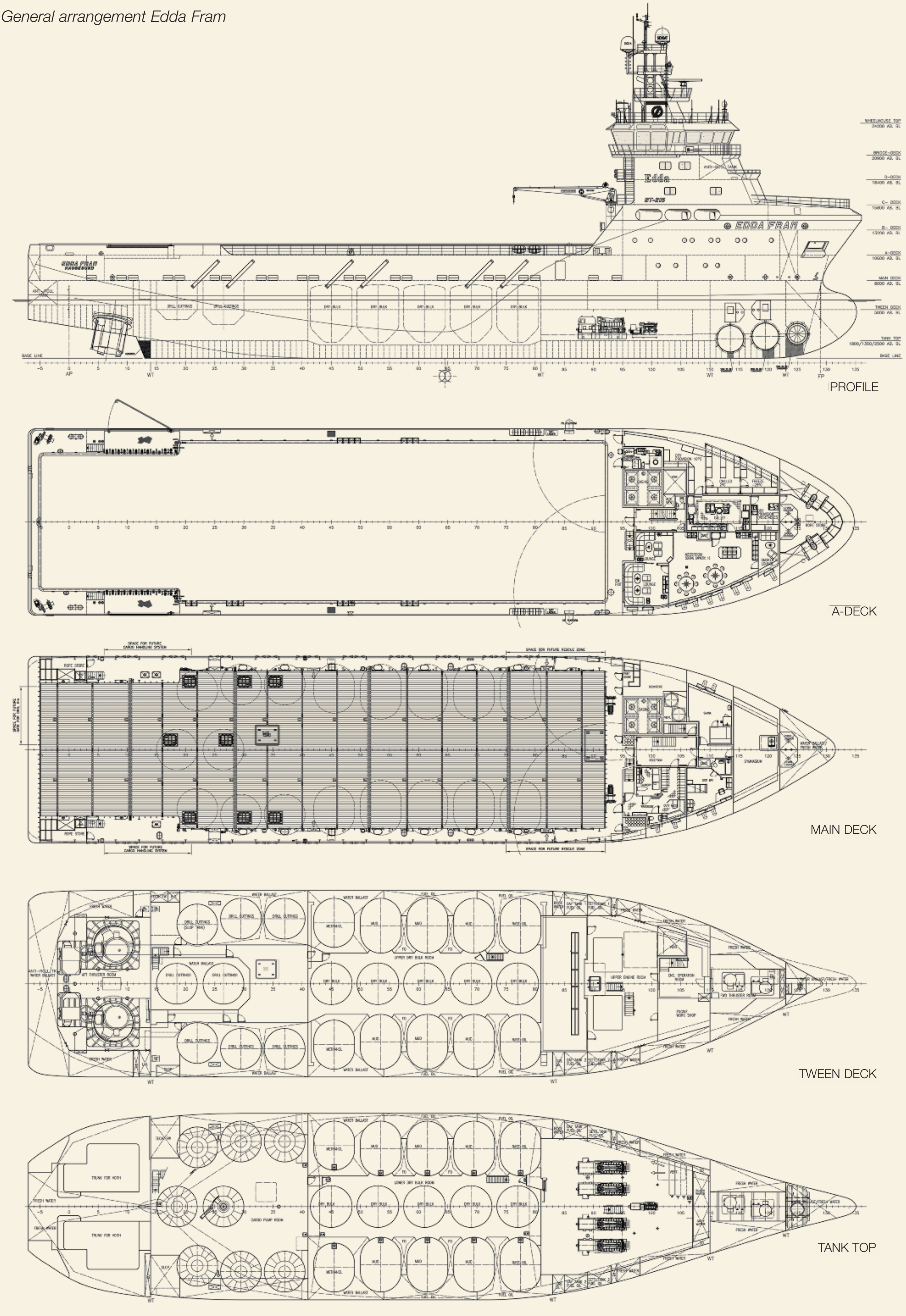
"Shell is also keen to be part of a revolution with the Voith Schneider propulsion system, which has been a proven success on tugs, but which is being fitted on a PSV for the first time. This propulsion concept, as well as providing manoeuvrability, will also reduce fuel consumption and emissions, both of which are beneficial, economically and environmentally."

Asked if Shell UK might need more vessels built to the same specification (a sister to *Edda Fram* is already under construction at Astilleros Gondan in Spain, and is due for delivery in March 2009), Mr Stratton said the answer had to be 'yes,' noting that, today, 60 per cent of the Shell chartered fleet is less than five years old. "The success of the new *Edda Fram* will lead to these innovations becoming the industry norm," he forecast.

Østensjø Rederi developed the concept for the advanced new PSV design together with design

ST216 EDDA FRAM	
Owner	Østensjø Rederi
Designer	Skipsteknisk
Builder	Astilleros Gondan
Length, oa	85.80m
Length, bp	77.40m
Beam	19.20m
Depth to main deck	8.00m
Depth to A-deck	10.60m
Draft max	6.50m
Deadweight	4,200 tonnes
Deck cargo	2,500 tonnes
Deck area	915m^2
Diesel oil	1,212m^3
Potable water	825-1,252m^3
Water ballast/drill water	1,107m^3
Mud/brine	951m^3
Methanol (in stainless steel tanks)	163m^3
Special products/drill cuttings	427m^3
Dry bulk tanks	353m^3
Recovered oil capacity (ORO)	1,036m^3
Class	DNV +1A1, Supply Vessel, SF, E0, DYNPOS-AUTR, HL(2,8), dk+, LFL*, ICE-C, CLEAN, COMF – C(3)-V(3), NAUT OSV 3

General arrangement Edda Fram



Østensjø Rederi developed the concept for the advanced new PSV design together with design consultancy and naval architectural concern Skipsteknisk

Edda Fram can carry a variety of cargoes and slops, including low flashpoint liquids

consultancy and naval architectural concern Skipsteknisk. The design carries forward the successful concept of high bulwarks and multi-access safe havens, which first was introduced to the market in early 1980 with the company's series of SK60/09 type vessels; however, the new design, the ST216, has diesel-electric propulsion and will benefit from a specially-developed low resistance hullform. This has been extensively model tested at Marintek in Trondheim, Norway, and at the Vienna Model Basin in Austria.

The Voith Schneider cycloidal propellers (VSPs) are a concept developed by Voith Turbo Marine. This plant is expected to have a number of operational benefits.

In the VSP, a rotor casing which ends flush with the ship's bottom is fitted with a number of axially parallel blades and rotates about a vertical axis. To generate thrust, each of the propeller blades performs an oscillating motion about its own axis. This is superimposed on the uniform rotary motion. Blade excursion determines the amount of thrust, while the phase angle of between 0 and 360 degrees determines its direction. As a result, the same amount of thrust can be generated in any direction. Both variables – the magnitude and the direction of thrust – are controlled by a technique known as mechanical kinematic transmission.

The new delivery will be the first anywhere with integrated tanks below deck for transporting large volumes of drill cuttings. *Edda Fram* is fitted with eight fully integrated special purpose tanks which can be utilised for a variety of different cargoes. The cargo systems are remotely operated through an integrated automation system and are designed for high efficiency and flexibility.

For some time, Ostensjø Rederi has been working with key manufacturers such as PG Marine on the development of technology that could radically improve on the safety, capacity and costs involved transporting and handling drill cuttings. This project was initiated as a co-operative one between Shell UK and the company.

Edda Fram's eight circular tanks are arranged and connected to different systems with chemical type separation flanges. These tanks can be used for a variety of cargoes and slops, including low flashpoint liquids. Tank suctions and pumps are placed underneath the tanks, allowing for best possible suction and draining.

Østensjø Rederi says it believes that the diesel-electric power and propulsion arrangement with Voith Schneider propulsion will ensure a high level of redundancy and safety, and particularly low fuel oil consumption – especially during manoeuvring and operation at offshore installations. VSPs offer potential fuel savings compared with alternatives such as contra-rotating azimuth thrusters (see box).

The principal elements comprise four 1,950kW main diesel generators, an auxiliary/harbour generator of approximately 400kW, two 2,500kW VSPs aft as the main propulsors, and two 1,400kW tunnel thrusters forward.

Edda Fram also employs a 690V diesel-electric system based on the newly-developed Wärtsilä Low Loss Concept (LLC). The LLC concept will, notes the shipowner, provide for increased power and thruster availability in case of any failure on the switchboards, especially in DP mode.

In the case of a short-circuit on one switchboard, available power will only be reduced by 14.6-33 per cent, and available thruster capacity by 25 per cent (in a conventional system, with a split switchboard, a reduction of 50 per cent of both available power and thruster capacity would occur in the same circumstances).

Østensjø has worked closely with Voith Turbo Marine over the years, optimising the performance of the German company's VSP thrusters, particularly with regard to their use on escort tugs, but also, more recently, on offshore vessels. Lately, this work has also focused on using VSPs for active roll reduction, a function which, as the company points out, is particularly attractive for offshore ships. The VSPs, which have a particularly fast response time, allow thruster forces to be used to counteract actively rolling movements by up to 90 per cent, depending on circumstances (see box).

The ST216's hull lines have been optimised, with an operational speed of 15-16 knots in mind, and the slender form of the hull has been extended all the way up to the forecastle deck, in order to achieve high speeds for all loading conditions and sea states. The design also has a relatively small block coefficient to obtain the operational speed required whilst at the same time providing low fuel consumption in all operating conditions.

In keeping with its operating philosophy, and that of its customer Shell, Østensjø Rederi also sought an environment-friendly design. The new vessel was constructed in compliance with DNV's Clean class notation, and has a number of features designed to further enhance the ship's 'green' credentials.

The ship will comply with noise and vibration requirements in accordance with DNV's Comfort class notation. In order to meet the necessary noise level with all thrusters running, the diesel generators are elastically mounted, as are the tunnel thrusters forward; and floating floors and elastic mountings support the accommodation.

Last but by no means least, crew comfort is emphasised by the company – and considered to be of major importance for the safety and quality of operation. In addition to elastic machinery mountings, *Edda Fram* has high quality accommodation featuring single cabins with TV and entertainment equipment, satellite TV, a spacious lounge and messroom, a separate lounge for smokers, a gymnasium/recreation room with sauna and a range of office facilities. *OSJ*

VSPs: assessing the benefits

Voith claims a PSV such as Edda Fram which is driven by two VSPs needs 10-20 per cent less power, depending on the load conditions and the sailing speed. This saves fuel costs and increases the service life of the vessel.

As Voith's naval architect Ingo Beu explained, initial model test series were carried out at Marintek in Trondheim, Norway, in 2002 in which the power uptake of the two types of propulsor – a contra-rotating propeller (CRP) and a VSP – were established.

The tests demonstrated that the PSV fitted with VSPs needed approximately 10 per cent less power at various hull drafts and across the entire speed range, and a second series of model test series at SVA in Vienna in February 2005 confirmed the earlier results.

"The VSP ship requires less brake power, and the ship has a higher overall level of efficiency," Mr Beu said. "This means that the propulsion performance of the ship is better and fuel consumption is lower."

With the VSP, says Voith, a fuel saving of 10 per cent is obtained in free running mode at 14 knots; a fuel saving of 20 per cent is obtained at 10 knots; and a fuel saving of 15 per cent is obtained at 3-35 knots; with a fuel saving of about 10 per cent in DP mode.

The VSP is proven on smaller vessels but Edda Fram is its first use on a PSV

Voith says there are also a number of other advantages to be gained by using VSPs – these include, as mentioned above, reduced powering; plus roll stabilisation at standstill and during sailing; fast and accurate steering; long service life; low maintenance costs; high availability; and high reliability. Other advantages include a much faster response time, no swiveling thrust vectors, and further power savings as a result of faster and more precise thrust control.

Propulsors can be used to reduce roll

Different types of propulsor can provide different types of advantages, such as enhanced propulsive efficiency, higher speeds, reduced fuel consumption, enhanced manoeuvrability or a combination of these. Voith Turbo Marine believes studies it has carried out suggest that VSPs could have an important role to play in roll stabilisation on board a wide range of vessels, particularly those that need to operate at low speed or remain stationary.

VSPs are, of course, not yet widely used on mainstream merchant ships or in the support vessel market, but their popularity is increasing. Voith believes that they can provide an efficient, cost-effective main propulsor, *and* play a key role in suppressing rotational movement about a ship's longitudinal axis.

Ingo Beu, a naval architect at Voith Turbo Marine, said that conventional roll stabilisation techniques are usually divided in two broad types, these being 'active' operation and 'passive' operation. The key to successful roll stabilisation is to produce a moment opposing the moment causing the rolling motion. Active operation produces a counteracting moment by means of actively controlled machines, with a sensor used to detect the rolling motion, and a regulator that controls the counteracting moment as required.

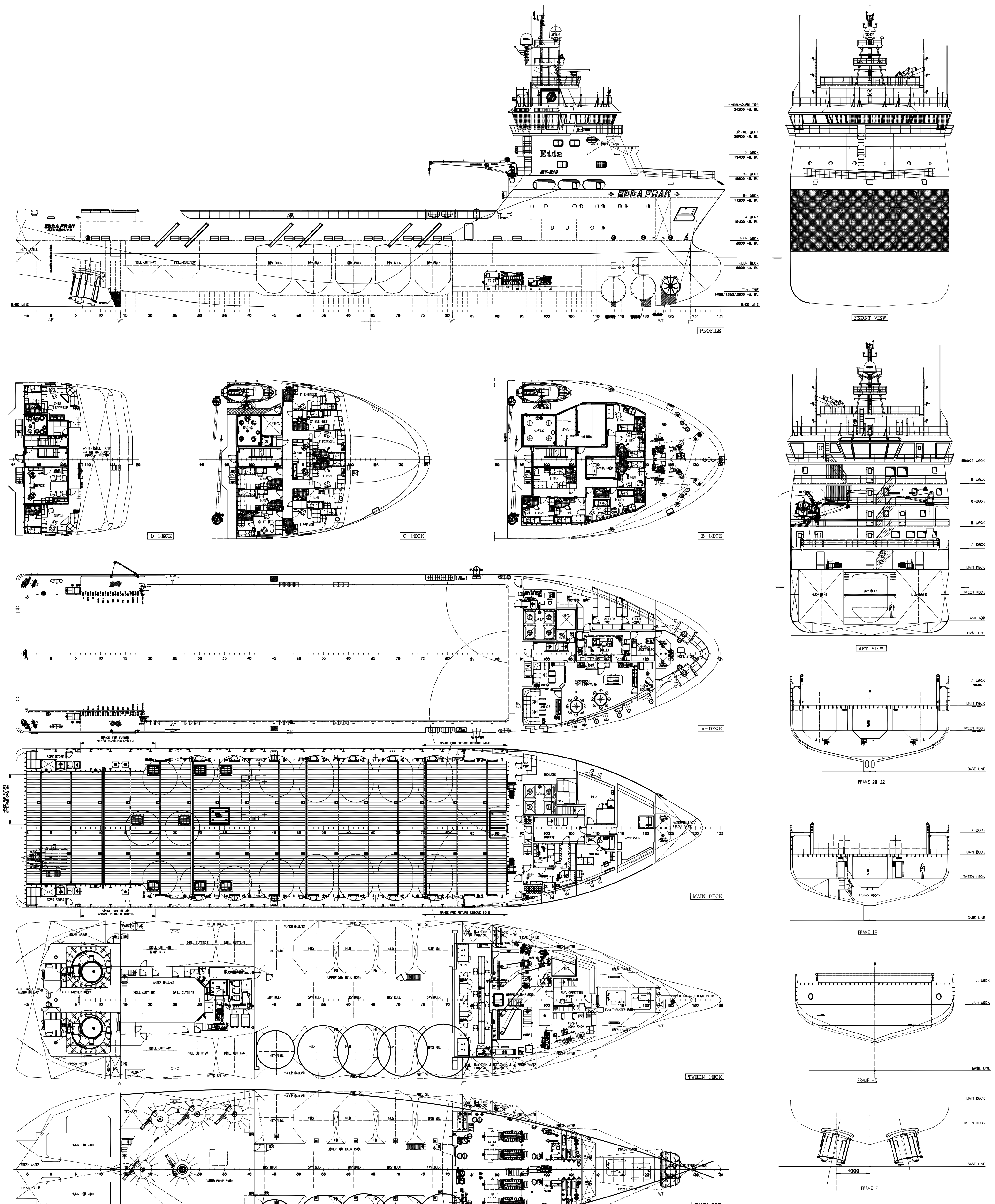
VSPs can generate propulsion and steering forces and be used to reduce roll

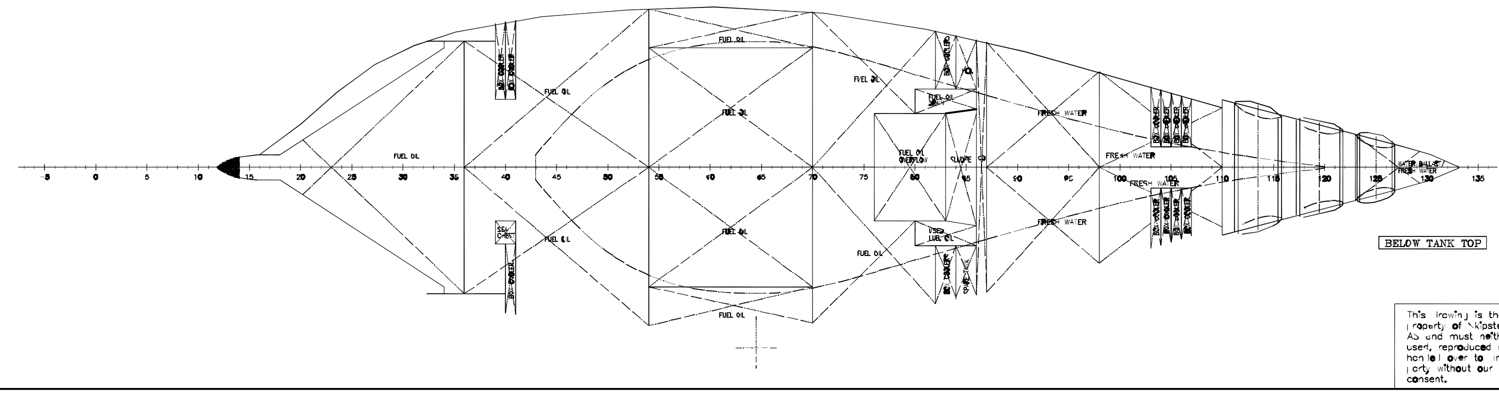
Examples of active roll stabilisation techniques include fin stabilisers (retractable or fixed), and active roll stabilisation tanks. The advantage of such systems is that they have good damping properties. Disadvantages include their complexity and expense; the fact that they are heavy (particularly the liquid used to fill roll stabilising tanks); they take up a lot of space on board; and they require a high level of maintenance. Other potential disadvantages include the fact that fin stabilisers only work at design speed, they have a high level of resistance (even when retracted), and they increase the draft of a vessel to which they are fitted.

Passive roll stabilisation works on the principle of increasing roll resistance, and thus damping the rolling motion, a typical example being the use of bilge keels. However, as Mr Beu points out, VSPs can generate both propulsion and steering forces, and the thrust they produce can be precisely tailored and adjusted extremely rapidly in magnitude and direction.

"This combination of very rapid thrust variation and generation of very high moments make it possible to use the VSP for efficient reduction of a ship's rolling motion," he told *OSJ*, "in particular when the ship is stationary or during slow motion along the longitudinal axis."

ANEXO 6: DISPOSICIÓN GENERAL BUQUE BASE





MAIN DIMENSIONS:

LENGTH O.A.	85,80 m
LENGTH P.P.	77,40 m
BREADTH	19,20 m
DEPTH TO TWEEN DECK	5,00 m
DEPTH TO MAIN DECK	8,00 m
DEPTH TO A-DECK	10,60 m
DEPTH TO B-DECK	13,20 m
MAX. DRAUGHT	6,50 m
FRAME SPACING:	600 mm

ACCOMMODATION FOR 23 PERSONS

CLASS: DNV ✠ 1A1, SUPPLY VESSEL, SF, E0, DYNPOS AUTR, HL 2,8, dk+, LFL*, ICE-C, CLEAN, COMF-C-V, OIL REC, NAUT OSV

REV:	DESCRIPTION:	DATE APPR:	DATE REV:	SIGN:
A	MISC. UPDATE.		11.07.05	BS
B	MISC. UPDATE.		14.07.05	BH
C	MISC. UPDATE		08.11.05	BH
D	MISC. UPDATE		12.01.06	BS
E	UPDATE ACCOMONDATION.		28.02.06	BS
F	MISC. UPDATE		18.07.06	BH
G	VARIOUS UPDATED.		28.08.06	A.G.
H	UPDATED ACCORDING OWNER COMMENTS.		29.09.06	A.G.
I	MISC. UPDATE		02.02.07	A.G.
J	AS BUILT		29.06.07	A.G.

ORDER: ASTILLEROS GONDAN	YARD NO. 432	FORMAT A0
TITLE: GENERAL ARRANGEMENT	SCALE 1:150	DATE 16.03.05 / SGN. jag/bok / CHECKED
SKIPSTEKNISK AS	PROJECT NO. 2005054	
	DRAWING NO. 432-101-001-J	

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