Escola Politécnica Superior
UNIVERSIDADE DA CORUÑA

TRABAJO FIN DE GRADO

15 105 P / BUQUE LNG DE MEMBRANA DE 145.000 m³

ALUMNO: ISMAEL GRANDAL MOURIZ

TUTOR: RAÚL VILLA CARO

CUADERNO 5

SITUACIONES DE CARGA

Escola Politécnica Superior
UNIVERSIDADE DA CORUÑA

DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

TRABAJO FIN DE GRADO

CURSO 2014-2015

PROYECTO NÚMERO: 15 105 P

TIPO DE BUQUE: Buque tanque LNG de membrana

CLASIFICACIÓN, COTA Y REGLAMENTOS DE APLICACIÓN: DNV, SOLAS, MARPOL, CIG.

CARACTERÍSTICAS DE LA CARGA: gas natural licuado con capacidad para 145.000 m^3.

VELOCIDAD Y AUTONOMÍA: 19,5 nudos a la velocidad de servicio, 85% MCR + 15% MM. 12.000 millas a la velocidad de servicio.

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA: los habituales en este tipo de buque.

PROPULSIÓN: Propulsión Diesel eléctrico. Dos líneas de ejes

TRIPULACIÓN Y PASAJE: 35 tripulantes en camarotes individuales.

OTROS EQUIPOS E INSTALACIONES: Las habituales en este tipo de buque.

Ferrol, Abril de 2015

ALUMNO: D. Ismael Grandal Mouriz

ÍNDICE:

1-INTRODUCCIÓN

A lo largo de este cuaderno estudiaremos las diferentes condiciones de carga que pueden darse durante la vida útil de nuestro buque.

Para cada condición de carga verificaremos su estabilidad y los criterios que la rigen. Tendremos en cuenta el efecto de las superficies libres sobre la estabilidad en cada condición de carga y comprobaremos que se siguen cumpliendo los criterios de estabilidad.

Comprobaremos asimismo que cumplimos también el criterio de viento.

El compartimentado utilizado en este cuaderno será el definido en el cuaderno 4. Adjuntamos en los anexos el plano del mismo.

2-DESGLOSE DE PESOS Y CONSUMOS

Los datos utilizados en nuestras condiciones de carga son los siguientes:

Peso en rosca

Utilizaremos el peso en rosca desglosado en el cuaderno 2, repartido en toda la eslora del buque el peso del acero, y las partidas correspondientes a maquinaria y armamento con sus correspondientes centros de gravedad.

P. ROSCA	Peso (t.)	KG (m.)	XG (m.)
Acero	28.787	12,71	130,23
Armamento	5.575,30	31,2	141,1
Maquinaria	1.775,28	11,41	25,68

Tanques

La relación de tanques a estudiar en nuestras condiciones de carga son los definidos como tales en el cuaderno de compartimentado (4).

Carga

- 4 tanques de carga

Lastre

- 8 tanques de lastre (entre babor y estribor) en forma de L en toda la eslora de la zona de carga.
- Cofferdams entre tanques de carga.
- Zona pique de popa, divido en dos tanques, a babor y a estribor.
- Pique de proa, dividido en dos tanques, a babor y a estribor.

Consumos

- 2 tanques almacén de fuel oil a cada banda en la zona de proa.
- 2 tanques de diesel a cada banda en cámara de máquinas.
- 2 tanques de sedimentación de fuel oil a cada banda en cámara de máquinas.
- 2 tanques de uso diario de fuel oil a cada banda en cámara de máquinas.
- 2 tanques de aceite lubricante a cada banda en cámara de máquinas.
- 1 tanque de aguas grises en el doble fondo de cámara de máquinas.
- 1 tanque de lodos en el doble fondo de cámara de máquinas.
- 2 tanques de agua dulce centrados en crujía en el pique de popa.

Pesos fijos

Será necesario, además, definir una serie de pesos fijos que tendremos en nuestro buque, tales como:

Tripulación

Supondremos 150 kg por tripulante, por tanto, como tenemos 35 tripulantes el peso de los mismos será 5,250 ton. El centro de gravedad se sitúa en el centro de gravedad de la habilitación, por tanto, tomando como referencia los datos de nuestro buque base:

XG: 57 m.

KG: 39,2 m.

-Víveres

El peso máximo se calcula a partir de un consumo de 5kg por persona y día, lo que hace un total de 4,375 toneladas. El centro de gravedad se sitúa en el centro de gravedad de la habilitación. Por tanto, el centro de gravedad será:

XG: 57 m.

KG: 39,2 m.

-Pertrechos

Son aquellos elementos no consumibles que el armador añade como repuestos o necesidades adicionales al buque tales como hélice, estachas, respetos de la maquinaria...Este valor depende del tamaño del buque y estándar del armador y varía entre 10 y 100 ton. Para este buque se considera que pesarán 100 toneladas .Su centro de gravedad lo tomamos del buque base:

XG: 128 m.

KG: 28 m.

En la descripción de las condiciones de carga detallaremos las diferentes partidas que componen el desplazamiento, es decir, la carga de cada uno de los tanques.

3-CRITERIOS DE ESTABILIDAD APLICABLES

La estabilidad en estado intacto se encuentra regulada por la Organización Marítima Internacional a través de la enmienda ISC 2008.

En el cuaderno 4 obtuvimos las curvas KN para distintos ángulos de escora. Además en el cuaderno 2 calculamos el peso en rosca y el centro de gravedad. Así que estamos en condiciones de calcular el valor del brazo adrizante GZ para cada ángulo de escora.

$$GZ = KN - KG \cdot sen\theta$$

Una vez obtenidos los valores del brazo adrizante podemos obtener la curva de estabilidad. Sobre dicha curva aplicaremos los criterios vigentes.

Es importante además calcular la altura metacéntrica (GM). Hemos de distinguir entre la altura metacéntrica transversal y longitudinal, siendo más importante la primera a efectos de estabilidad.

Los criterios de estabilidad que se aplicarán al buque proyectado en este cuaderno son los que corresponden al "buque estado intacto".

En todo caso, para la estabilidad en caso de averías la normativa aplicable es la del código CIG (Código Internacional de Gaseros), que ya hemos visto en el cuaderno 2 en relación con el compartimentado, con los siguientes criterios:

Según el CIG, las dimensiones máximas de averías supuestas serán las siguientes:

1-En el costado

1.1-Extensión longitudinal: 1/3 $L^{2/3}$ o bien 14,5 metros, si este valor es menor.

1.2-Extensión transversal medida hacia el interior del buque, desde el costado, perpendicularmente al eje longitudinal, al nivel de la línea de carga de verano: B/5 o bien 11,5 metros, si este valor es menor.

1.3-Extensión vertical: hacia arriba, sin límite desde la línea de trazado de la chapa del forro del fondo en el eje longitudinal.

2-En el fondo

a) A 0,3 L de la perpendicular de proa del buque
b) En cualquier otra parte del buque

2.1-Extensión longitudinal:

-1/3 $L^{2/3}$ o bien 14,5 metros, si este valor es menor (a)

-1/3 $L^{2/3}$ o bien 5 metros, si este valor es menor (b)

2.2-Extensión transversal:

-B/6 o bien 10 metros, si este valor es menor (a).

-B/6 o bien 5 metros, si este valor es menor (b).

2.3-Extensión vertical:

-B/15 o bien 2 metros, si este valor es menor, midiendo desde la línea de trazado de la chapa del forro del fondo en el eje longitudinal (a).

-B/15 o bien 2 metros, si este valor es menor, midiendo desde la línea de trazado de la chapa del forro del fondo en el eje longitudinal (b).

Los criterios de estabilidad (estabilidad estática y dinámica) aplicables al buque en estado intacto son los siguientes:

A) GM_o (altura metacéntrica-inicial-) ≥ 0,150 m.

B) GZ (brazo adrizante) ≥ 0,200 m. para un α (ángulo de escora) ≥ 30º.

C) $GZ_{máx}$ (brazo adrizante máximo) ha de corresponder a un α (ángulo de escora) ≥ 25º.

D) d_{30} (brazo de estabilidad dinámica) ≥ 0,055 m·rad.

El área por debajo de la curva de brazos adrizantes no será inferior a 0,55 metros por radián hasta un ángulo de escora de 30 grados.

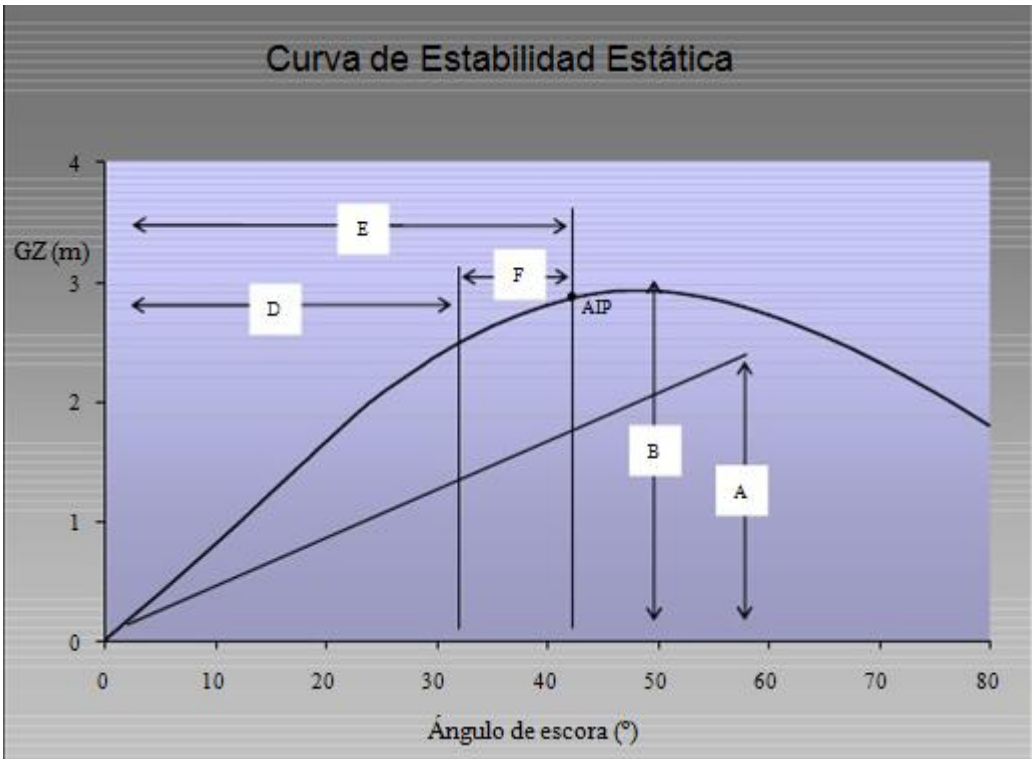
E) $d_{40\ o\ AIP}$ (brazo de estabilidad dinámica) ≥ 0,090 m·rad.

El área por debajo de la curva de brazos adrizantes no será inferior a 0,090 metros por radián hasta un ángulo de escora de 40 grados o el AIP (ángulo de inundación progresiva), si éste es menor.

F) $d_{40 \text{ o AIP-30}}$ (brazo de estabilidad dinámica) ≥ 0,030 m·rad.

El área bajo la curva de brazos adrizantes entre los ángulos de escora de 30 grados y 40 grados o AIP (el menor), no será inferior a 0,03 metros por radián.

En la siguiente imagen podemos una curva de GZ's típica con los distintos criterios esquematizados.



El CIG no nos obliga a calcular condiciones adicionales por lo que comprobaremos únicamente que las estipuladas por la OMI cumplen con los criterios de estabilidad.

Criterio de viento

Además, se comprobará el criterio de viento, según el cual se debe demostrar la capacidad del buque para resistir los efectos combinados del viento de través y del balance de forma que:

- Se somete al buque a una presión de viento de P = 504 N·m² constante, perpendicular al plano de crujía, que producirá un par escorante l_{w1}.

- Se supondrá que a partir del ángulo de equilibrio resultante, θ_0, el buque se balancea por la acción de las olas hasta alcanzar un ángulo de balance θ_1 a barlovento.
- A continuación se someterá al buque a la presión de una ráfaga de viento que dará como resultado el correspondiente brazo escorante l_{w2}.
- En estas circunstancias, el área *b* debe ser mayor que el área *a*.

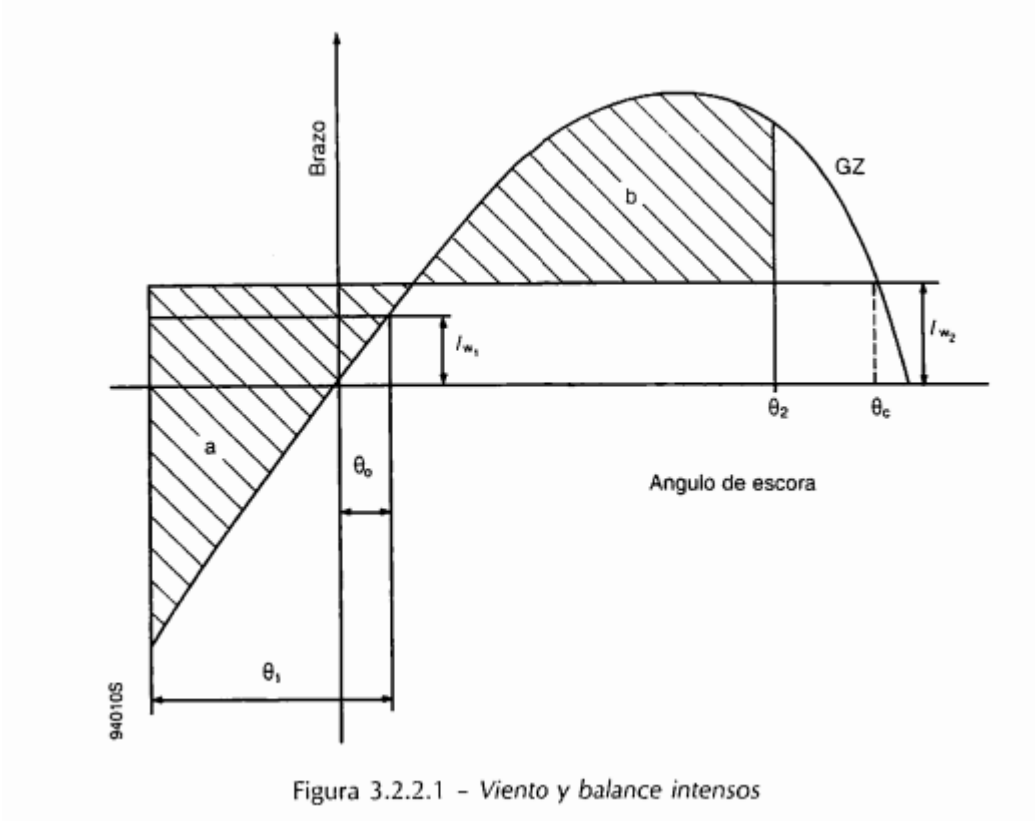


Figura 3.2.2.1 – *Viento y balance intensos*

Los brazos escorantes producidos por el viento se calculan de la forma que sigue

$$lw_1 = \frac{P \cdot A \cdot Z}{1000 \cdot g \cdot \Delta}$$

$$lw_2 = 1{,}5 \cdot lw_1$$

Donde:

P = 504 N/m²

A: área lateral proyectada de la parte del buque y de la cubertada que quede por encima de la flotación (m^2).

Z: distancia vertical desde el centro del área A hasta el centro del área lateral de la obra viva o aproximadamente hasta el punto medio del calado (m.).

Δ: desplazamiento (t.)

g: gravedad (9,81 m/s^2).

En las siguientes imágenes (sacadas del reglamento) podemos ver lo que representa cada ángulo así como la forma de calcularlos.

θ_o = ángulo de escora provocado por un viento constante (véase 3.2.2.1.2 y la correspondiente nota de pie de página)

θ_1 = ángulo de balance a barlovento debido a la acción de las olas

θ_2 = ángulo al que se produce inundación descendente (θ_f), o 50°, o θ_c, tomando de estos valores el menor,

donde:

θ_f = ángulo de escora al que se sumerjen las aberturas del casco, superestructuras o casetas que no puedan cerrarse de modo estanco a la intemperie. Al aplicar este criterio no hará falta considerar abiertas las pequeñas aberturas por las que no pueda producirse inundación progresiva,

θ_c = ángulo de la segunda intersección entre la curva de brazos escorantes lw_2 y la de brazos GZ.

$lw_1 = \frac{PAZ}{1000g\Delta}$ (m) y

$lw_2 = 1{,}5\ lw_1$ (m)

donde:

P = 504 N/m^2. El valor de P utilizado para los buques en servicio restringido podrá reducirse a reserva de que lo apruebe la Administración;

$\theta_1 = 109kX_1X_2\sqrt{rs}$ (grados)

where:

X_1 = factor indicado en el cuadro 3.2.2.3-1

X_2 = factor indicado en el cuadro 3.2.2.3-2

k = factor que corresponde a lo siguiente:

k = 1,0 respecto de un buque de pantoque redondo que no tenga quillas de balance ni quilla de barra

k = 0,7 respecto de un buque de pantoque quebrado

k = el valor que se indica en el cuadro 3 respecto de un buque con quillas de balance, quilla de barra o ambas

$r = 0{,}73 \pm 0{,}6\ OG/d$

donde: OG = distancia entre el centro de gravedad y la flotación (m) (positiva si el centro de gravedad queda por encima de la flotación, negativa si queda por debajo)

d = calado medio de trazado del buque (m)

s = factor indicado en el cuadro 3.2.2.3-4

Periodo de balance $T = \frac{2CB}{\sqrt{GM}}$ (s)

donde: $C = 0{,}373 + 0{,}023(B/d) - 0{,}043(L/100)$.

Cuadro 3.2.2.3-1 – *Valores del factor* X_1

B/d	X_1
⩽2,4	1,0
2,5	0,98
2,6	0,96
2,7	0,95
2,8	0,93
2,9	0,91
3,0	0,90
3,1	0,88
3,2	0,86
3,4	0,82
⩾3,5	0,80

Cuadro 3.2.2.3-2 – *Valores del factor* X_2

C_B	X_2
⩽0,45	0,75
0,50	0,82
0,55	0,89
0,60	0,95
0,65	0,97
⩾0,70	1,0

Cuadro 3.2.2.3-3 – *Valores del factor* k

$\frac{A_k \times 100}{L \times B}$	k
0	1,0
1,0	0,98
1,5	0,95
2,0	0,88
2,5	0,79
3,0	0,74
3,5	0,72
⩾4,0	0,70

Cuadro 3.2.2.3-4 – Valores del factor s

T	s
⩽6	0,100
7	0,098
8	0,093
12	0,065
14	0,053
16	0,044
18	0,038
⩾20	0,035

Posteriormente, y mediante el programa Maxsurf Stability, comprobaremos que se cumplen dicho criterio para la condición de carga más desfavorable, que en nuestro caso es la de llegada a puerto en lastre.

Introducimos en el programa los datos de nuestra condición de llegada en lastre, medidos en el plano de disposición general:

$$A = 4925 \text{ m}^2$$

$$Z = 5{,}77 \text{ m.}$$

Adicionalmente hemos de asegurarnos de cumplir una serie de requisitos básicos.

Para algunos cálculos utilizamos el 96 % de la eslora desde el extremo de la roda hasta el extremo del codaste en una flotación al 85 % del puntal mínimo de trazado. La hemos calculado en el cuaderno 4 y su valor es de 269,22 m.

En todas las condiciones de carga debemos cumplir con los siguientes requerimientos.

-El asiento apopante máximo no puede ser superior a:

$$t_{apopante} \leq 0{,}015 \cdot L = 4{,}0383\ m.$$

-En cualquier caso habrá que garantizar el hundimiento de la hélice. (En general la norma es lograr un resguardo del orden del 10 % del diámetro de la hélice sobre el punto más alto de ésta

Diámetro de la hélice: 9 m.

Distancia del punto más alto de la hélice a la línea base: 9,31 m.

10 % del diámetro de la hélice = 0,9 m.

Por tanto, tenemos que:

$$T_{pp} \geq 9{,}31 + 0{,}9 = 10{,}21\ m.$$

-Calado mínimo en proa, que permita una navegación sin excesivo "slamming", golpeteo de la proa. Una norma recomendada sería aplicar la exigencia IMO para petroleros:

$$T_{pr} \geq 0{,}02 \cdot L + 2 = 7{,}394\ m.$$

Donde:

L: eslora entre perpendiculares en este caso. (269,7 m.)

4-CONDICIONES DE CARGA A ESTUDIAR

Aplicando la resolución de la ISC 2008 para el caso de buques de carga en estado intacto las condiciones mínimas que hay que tener en cuenta son:

1-Buque en la condición de salida a plena carga, distribuida, ésta de forma homogénea en todos los espacios de carga y con la totalidad de provisiones y combustible.

2-Buque en la condición de llegada en plena carga, distribuida esta de forma homogénea en todos los espacios de carga y con el 10 % de provisiones y combustibles.

3-Buque en condición de salida, en lastre, sin carga, pero con la totalidad de provisiones y combustibles.

4-Buque en la condición de llegada en lastre, sin carga, y con el 10% de provisiones y combustible.

El CIG no nos obliga a calcular condiciones adicionales por lo que comprobaremos únicamente que las estipuladas por la OMI cumplen los criterios de estabilidad. A lo largo de este cuaderno se detallarán los cálculos requeridos para ello.

La norma ISC 2008 nos dice que los tanques al 98% de su carga no corrigen, pero nosotros vamos a hacer el estudio como si lo hicieran, ya que es una condición de estabilidad más desfavorable. De esta forma nos aseguraremos de que el buque no tenga problemas de estabilidad.

5-CORRECCIÓN POR SUPERFICIES LIBRES

A los criterios de estabilidad anteriormente citados habrá que aplicarles la corrección por superficies libres y el criterio de viento. La corrección por superficies libres consiste en evaluar la elevación virtual del centro de gravedad del buque debido al movimiento del fluido contenido en un tanque cuyo nivel de llenado sea inferior a un 98 % y superior al 2%. El movimiento en el tanque supone una variación del centro de gravedad total. Esta repercusión, que influye de forma negativa en la estabilidad, será mayor cuanto mayor sea la superficie libre en el tanque.

La OMI regula que el momento de superficie libre del líquido en el tanque se obtiene mediante la siguiente fórmula:

$$M_{SL} = v \cdot b \cdot \gamma \cdot k \cdot \delta^{1/2}$$

Donde:

-v: capacidad total del tanque en metros cúbicos.

-b: manga máxima del tanque en metros

-γ: peso específico del líquido en el tanque (t/m³).

-k: coeficiente adimensional obtenido de la tabla 3.3.8 de la resolución ISC 2008 de la OMI.

-δ: coeficiente de bloque del tanque.

Cuadro 3.3.8 - Valores del coeficiente "k" para calcular las correcciones por superficie libre

$k = \frac{\sin\theta}{12}\cdot\left(1 + \frac{\tan^2\theta}{2}\right) - \frac{b}{h}$ donde $\cot\theta \geq {}^{b}/_{h}$

$k = \frac{\cos\theta}{8}\left(1 + \frac{\tan\theta}{b/h}\right) - \frac{\cos\theta}{12(b/h)^2}\left(1 + \frac{\cot^2}{2}\right)$ donde $\cot\theta < {}^{b}/_{h}$

θ / b/h	5°	10°	15°	20°	30°	40°	45°	50°	60°	70°	75°	80°	85°	θ / b/h
20	0,11	0,12	0,12	0,12	0,11	0,10	0,09	0,09	0,09	0,05	0,04	0,03	0,02	20
10	0,07	0,11	0,12	0,12	0,11	0,10	0,10	0,09	0,07	0,05	0,04	0,03	0,02	10
5	0,04	0,07	0,10	0,11	0,11	0,11	0,10	0,10	0,08	0,07	0,06	0,05	0,04	5
3	0,02	0,04	0,07	0,09	0,11	0,11	0,11	0,10	0,09	0,08	0,07	0,06	0,05	3
2	0,01	0,03	0,04	0,06	0,09	0,11	0,11	0,11	0,10	0,09	0,09	0,08	0,07	2
1,5	0,01	0,02	0,03	0,05	0,07	0,10	0,11	0,11	0,11	0,11	0,10	0,10	0,09	1,5
1	0,01	0,01	0,02	0,03	0,05	0,07	0,09	0,10	0,12	0,13	0,13	0,13	0,13	1
0,75	0,01	0,01	0,01	0,02	0,02	0,04	0,04	0,05	0,09	0,16	0,18	0,21	0,16	0,75
0,5	0,00	0,01	0,01	0,02	0,02	0,04	0,04	0,05	0,09	0,16	0,18	0,21	0,23	0,5
0,3	0,00	0,00	0,01	0,01	0,01	0,02	0,03	0,03	0,05	0,11	0,19	0,27	0,34	0,3
0,2	0,00	0,00	0,00	0,01	0,01	0,01	0,02	0,02	0,04	0,07	0,13	0,27	0,45	0,2
0,1	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,02	0,04	0,06	0,14	0,53	0,1

Los tanques que verifiquen la siguiente ecuación no tendrán que evaluarse.

$$\frac{M_{SL\,(30°)}}{\Delta_{mín}} < 0{,}01$$

Donde:

-$\Delta_{mín}$: desplazamiento en rosca (37.945 t.).

En la siguiente tabla calculamos los tanques que corrigen:

En la tabla hemos evaluado una de las parejas de cada uno de los tanques puesto que para la otra la situación es idéntica. Teniendo en cuenta los resultados, los tanques que corregirán por superficies libres son los cuatro de carga.

TANQUE	LÍQUIDO	DENSIDAD	VOLUMEN	l	b	h	l·b·h	Cb	b/h	k (θ = 30°)	M (θ = 30°)	M/Δmín	CORRIGE
Tanque 4	LNG	0,450	41677,000	46,250	19,100	29,000	25617,875	0,830	0,659	0,024	7832,360	0,217	SÍ
Tanque 3	LNG	0,450	43721,000	46,250	19,100	29,000	25617,875	0,874	0,659	0,024	8431,463	0,234	SÍ
Tanque 2	LNG	0,450	43673,000	46,250	19,100	29,000	25617,875	0,872	0,659	0,024	8412,564	0,233	SÍ
Tanque 1	LNG	0,450	24405,000	40,700	18,860	29,000	22260,458	0,664	0,650	0,024	4016,928	0,111	SI
FO Alm.	Fuel Oil	0,900	2458,550	14,700	7,350	22,000	2376,990	1,000	0,334	0,013	211,423	0,006	NO
FO Sed.	Fuel Oil	0,900	148,305	5,230	5,320	4,440	123,537	1,000	1,198	0,050	35,504	0,001	NO
FO UD	Fuel Oil	0,900	98,611	4,620	4,620	4,620	98,611	1,000	1,000	0,050	20,501	0,001	NO
Diesel	Diesel	0,900	424,972	7,510	7,740	7,510	436,537	1,000	1,031	0,050	148,018	0,004	NO
Aceite	Aceite Lub.	0,900	54,873	3,800	3,920	3,920	58,392	1,000	1,000	0,050	9,680	0,000	NO
Lodos	Lodos	1,500	80,118	5,700	5,700	2,500	81,225	1,000	2,280	0,070	47,951	0,001	NO
Aguas grises	Aguas gr.	1,500	163,890	8,080	8,080	2,500	163,216	1,000	3,232	0,114	226,444	0,006	NO

6-CONDICIÓN DE CARGA 1: SALIDA DE PUERTO A PLENA CARGA

En este caso se supone que los consumos están al 100 % de su capacidad y la carga al 98 %, ya que el CIG establece que en ningún caso podrán superar este valor. Los tanques de servicio van llenos al 100 % de su capacidad y los de lastre vacíos. Los víveres irán al 100 %. Lodos y aguas grises al 0 %.

Resumen de la condición:

CC1		%	Peso (t)
Rosca			36.099
Carga		97	62094,911
Consumos			
	Fuel Alm. (2x)	100	4645,316
	Fuel Sed. (2x)	100	279,08
	Fuel UD (2x)	100	185,566
	Diesel (2x)	100	765,746
	Aceite (2x)	100	98,834
	Agua dulce (2x)	100	153,59
	Aguas gr.	0	0
	Lodos	0	0
Lastre		0	
Víveres		100	4,375
Pesos fijos			105,25
TOTAL Δ			104.432

En esta condición corrigen todos los tanques de carga, por tanto, irán al 97 %.

7-CONDICIÓN DE CARGA 2: SALIDA DE PUERTO EN LASTRE

El buque, en la condición de salida en lastre, lleva vacíos los tanques de carga. Para que no se vea afectada la estabilidad deberá utilizar los tanques de lastre, que llenaremos al 100%. Los víveres, los tanques de fuel, agua, aceite y diesel irán también al 100%.Lodos y aguas grises al 0%.

Resumen de la condición:

CC2		%	Peso (t)
Rosca			36.099
Carga		0	0
Consumos			
	Fuel Alm. (2x)	100	4645,316
	Fuel Sed. (2x)	100	279,08
	Fuel UD (2x)	100	185,566
	Diesel (2x)	100	765,746
	Aceite (2x)	100	98,834
	Agua dulce (2x)	100	153,59
	Aguas gr.	0	0
	Lodos	0	0
Lastre		100	55265,135
Víveres		100	4,375
Pesos fijos			105,25
TOTAL Δ			97.602

En esta condición no corrige ningún tanque.

8-CONDICIÓN DE CARGA 3: LLEGADA A PUERTO A PLENA CARGA

El buque en la condición de llegada en plena carga llevará carga al 98 %. Los tanques de lastre por no ser necesarios irán al 0%. Los víveres se supondrán consumidos durante la travesía quedando sólo el 10 %, al igual que el agua dulce, aceite, diesel y fuel. El fuel estará repartido primeramente en los tanques de uso diario, luego en sedimentación y posteriormente en almacenamiento (uso diario van al 100 %, sedimentación al 91,87 % y los de almacén vacíos). Las parejas de tanques se consumirán simultáneamente. Lodos y aguas grises al 100 %.

Resumen de la condición:

CC3		%	Peso (t)
Rosca			36.099
Carga		97	62094,911
Consumos			
	Fuel Alm. (2x)	0	0
	Fuel Sed. (2x)	91,87	256,39
	Fuel UD (2x)	100	185,566
	Diesel (2x)	10 (5+5)	38,288
	Aceite (2x)	10 (5+5)	4,942
	Agua dulce (2x)	10 (5+5)	7,68
	Aguas gr.	100	238,468
	Lodos	100	113,158
Lastre		0	
Víveres		10	0,4375
Pesos fijos			105,25
TOTAL Δ			99.144

En esta condición corrigen todos los tanques de carga, por tanto, irán al 97 %.

9-CONDICIÓN DE CARGA 4: LLEGADA A PUERTO EN LASTRE

El buque en la condición de llegada en lastre no llevará carga. Los tanques de lastre por motivos de estabilidad irán al 100 %. Los víveres se supondrán consumidos durante la travesía quedando sólo el 10 %, al igual que el agua dulce, aceite, diesel y fuel. El fuel estará repartido primeramente en los tanques de uso diario, luego en sedimentación y posteriormente en almacenamiento (uso diario van al 100 %, sedimentación al 91,87 % y los de almacén vacíos) Las parejas de tanques se consumirán simultáneamente. Lodos y aguas grises al 100 %.

Resumen de la condición:

CC4		%	Peso (t)
Rosca			36.099
Carga		0	0
Consumos			
	Fuel Alm. (2x)	0	0
	Fuel Sed. (2x)	91,87	256,39
	Fuel UD (2x)	100	185,566
	Diesel (2x)	10 (5+5)	38,288
	Aceite (2x)	10 (5+5)	4,942
	Agua dulce (2x)	10 (5+5)	7,68
	Aguas gr.	100	238,468
	Lodos	100	113,158
Lastre		100	55265,135
Víveres		10	0,4375
Pesos fijos			105,25
TOTAL Δ			92.315

En esta condición no corrige ningún tanque

10-RESUMEN CONDICIONES DE CARGA

Los valores de cada condición de carga (llenado de tanques; qué tanques corrigen en cada condición de carga; curvas de estabilidad, GZ, valores de desplazamientos, calados…en cada condición de equilibrio) se pueden ver con claridad en los anexos adjuntos como “Condiciones de equilibrio” y “Criterios de estabilidad”.

A continuación, se expone una tabla a modo de resumen con los valores de los calados, el desplazamiento y los criterios de estabilidad en cada condición de carga. Como se puede ver, cumplimos con los criterios sobradamente.

	C.C. 1	C.C. 2	C.C. 3	C.C. 4
Δ (t.)	104.432	97.596	99.144	92.323
t(apopante) = 4,0383 m.	-2,347	0,863	0,830	3,963
Tpp = 10,21 m.	10,974	11,803	11,941	12,725
Tpr = 7,394 m.	13,321	10,940	11,111	8,762
Criterio (GMo ≥ 0,150 m.)	2,411	7,334	2,869	8,181
Criterio (GZ ≥ 0,200 m., α ≥ 30°)	1,771	5,462	1,914	5,810
Criterio (Gzmáx, α ≥ 25°)	40	48,2	39,1	48,2
Criterio (d30 ≥ 3,15 m·deg)	20,84	59,76	23,92	65,88
Criterio (d40 ≥ 5,15 m·deg)	37,62	107,08	42,24	116,52
Criterio (d40-d30 ≥ 1,71 m·deg)	16,78	47,32	18,32	50,64

11-COMENTARIOS FINALES A CONDICIONES DE CARGA Y ESTABILIDAD

Como podemos observar en la tabla anterior, nuestro buque cumple con todos los criterios en las cuatro condiciones de carga estudiadas.

Los desplazamiento no varían excesivamente del buque cargado y en lastre, esto se debe a que hemos definido bastante lastre. Como cumple los criterios de estabilidad podríamos decir que es correcto, sin embargo, podríamos jugar con él según nuestras necesidades, como por ejemplo en la condición de carga 4 (llegada a puerto en lastre), donde tenemos un asiento apopante de 3,96 m. y nuestro límite está en 4,03.

En este caso, hemos probado a deslastrar el pique de popa y el resultado es el que se muestra en la siguiente tabla:

1	Draft Amidships m	10,322
2	Displacement t	86910
3	Heel deg	0,0
4	Draft at FP m	10,314
5	Draft at AP m	10,330
6	Draft at LCF m	10,322
7	Trim (+ve by stern) m	0,017
8	WL Length m	272,913
9	Beam max extents on	43,192
10	Wetted Area m^2	13270,5
11	Waterpl. Area m^2	9602,98
12	Prismatic coeff. (Cp)	0,704
13	Block coeff. (Cb)	0,696
14	Max Sect. area coeff. (	0,990
15	Waterpl. area coeff. (C	0,815
16	LCB from zero pt. (+ve	133,774
17	LCF from zero pt. (+ve	127,573
18	KB m	5,537
19	KG fluid m	12,337
20	BMt m	15,447
21	BML m	499,156
22	GMt corrected m	8,647
23	GML m	492,356
24	KMt m	20,984
25	KML m	504,693
26	Immersion (TPc) tonne/	98,431
27	MTc tonne.m	1598,06
28	RM at 1deg = GMt.Disp.	13116,0
29	Max deck inclination de	0,0036
30	Trim angle (+ve by ster	0,0036

Como podemos ver, el asiento nos queda prácticamente a cero y nos aumenta considerablemente el calado en proa (de 8,76 m. pasa a 10,31 m.), por el contrario nos disminuye el de popa hasta casi el límite (de 12,725 m. a 10,330 m., cuando el límite es de 10,21 m.), pero sigue cumpliendo el criterio.

En los anexos podemos ver más detalladamente cualquier valor de las condiciones de carga en equilibrio y criterios de estabilidad, así como el cumplimiento del criterio de viento.

12-BIBLIOGRAFÍA

-“El Proyecto Básico del Buque Mercante”; Ricardo Alvariño, Juan José Azpíroz y Manuel Meizoso.

-“Proyectos de Buques y Artefactos”, Fernando Junco Ocampo.

-Apuntes asignatura “Métodos Computacionales Aplicados al Proyecto del Buque”, EPS Ferrol.

-Reglamento Sociedad de Clasificación DNV

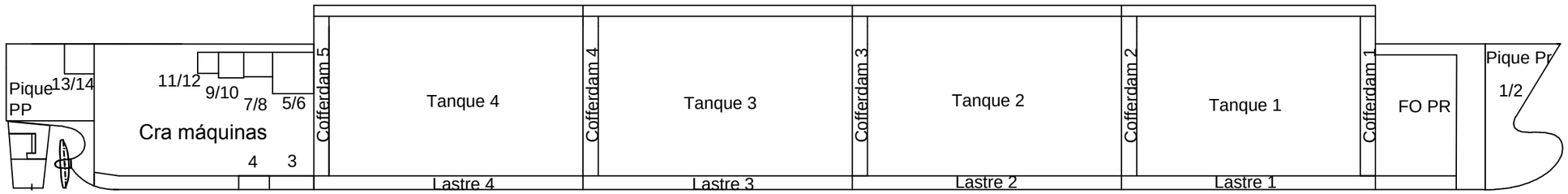
-CIG

-Código IS. MSC

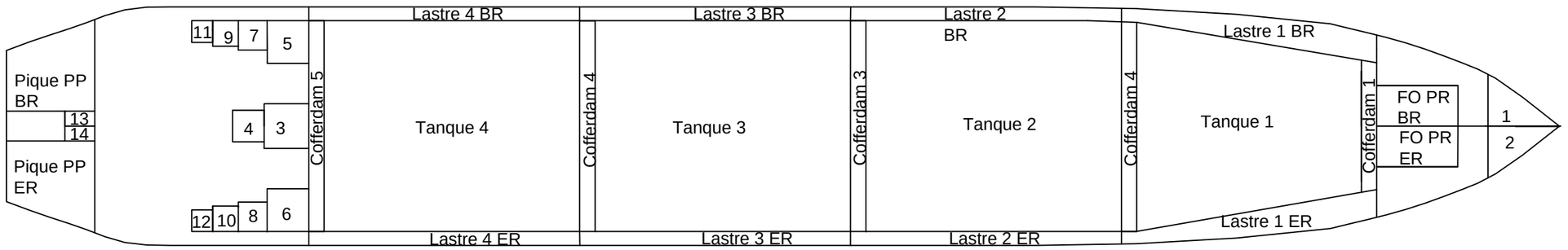
-Diverso material web

ANEXO I

Plano de compartimentado



1-Pique PR BR
2-Pique PR ER
3-Aguas grises
4-Lodos
5-Diesel BR
6-Diesel ER
7-FO Sed. BR
8-FO Sed. ER
9-FO UD BR
10-FO UD ER
11-Aceite BR
12-Aceite ER
13-Agua dulce BR
14-Agua dulce ER



UNIVERSIDADE DA CORUÑA
ESCOLA POLITÉCNICA SUPERIOR

PROYECTO:
15 105 P

PLANO DE COMPARTIMENTADO

AUTOR: ISMAEL GRANDAL MOURIZ

ESCALA 1:900

PRODUCIDO POR UN PRODUCTO EDUCATIVO DE AUTODESK

ANEXO II

Report hidrostáticas de las condiciones de carga

Equilibrium Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C1 Salida puerto a plena carga
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	97%	17383,695	16862,184	40427,198	39214,380	78,023	0,000	15,621	76274,061	IMO A.749(18)
Tanque 3	97%	18236,208	17689,122	42409,786	41137,493	126,285	0,000	15,074	81953,117	IMO A.749(18)
Tanque 2	97%	18216,099	17669,615	42363,021	41092,128	175,287	0,000	15,077	81817,608	IMO A.749(18)
Tanque 1	97%	10179,370	9873,990	23672,952	22962,767	218,195	0,000	15,726	33420,111	IMO A.749(18)
Total carga	97%	64015,373	62094,911	148872,958	144406,768	141,738	0,000	15,327	273464,897	
Pique PP BR	0%	2703,969	0,000	2638,019	0,000	8,257	-6,379	11,850	0,000	Maximum
Pique PP ER	0%	2704,001	0,000	2638,050	0,000	8,257	6,379	11,850	0,000	Maximum
Cofferdam 5	0%	2150,709	0,000	2098,253	0,000	54,119	0,000	6,423	0,000	Maximum
Cofferdam 4	0%	2608,203	0,000	2544,588	0,000	101,772	0,000	2,500	0,000	Maximum
Cofferdam 3	0%	2608,196	0,000	2544,581	0,000	150,798	0,000	2,500	0,000	Maximum
Cofferdam 2	0%	2512,692	0,000	2451,407	0,000	199,813	0,000	2,500	0,000	Maximum
Cofferdam 1	0%	717,353	0,000	699,857	0,000	241,926	0,000	6,329	0,000	Maximum
Pique PR BR	0%	411,594	0,000	401,555	0,000	268,543	-0,677	2,500	0,000	Maximum
Pique PR ER	0%	411,594	0,000	401,555	0,000	268,543	0,677	2,500	0,000	Maximum
Lastre 4 BR	0%	4509,134	0,000	4399,155	0,000	83,509	-0,005	0,000	0,000	Maximum
Lastre 4 ER	0%	4509,134	0,000	4399,155	0,000	83,509	0,005	0,000	0,000	Maximum
Lastre 3 BR	0%	5368,684	0,000	5237,740	0,000	126,364	-0,010	0,000	0,000	Maximum
Lastre 3 ER	0%	5368,684	0,000	5237,740	0,000	126,364	0,010	0,000	0,000	Maximum
Lastre 2 BR	0%	4765,443	0,000	4649,212	0,000	173,923	-0,012	0,000	0,000	Maximum
Lastre 2 ER	0%	4765,443	0,000	4649,212	0,000	173,923	0,012	0,000	0,000	Maximum
Lastre 1 BR	0%	4575,151	0,000	4463,562	0,000	212,133	-0,005	0,000	0,000	Maximum
Lastre 1 ER	0%	4575,151	0,000	4463,562	0,000	212,133	0,005	0,000	0,000	Maximum
Total lastre	0%	55265,135	0,000	53917,205	0,000	0,000	0,000	0,000	0,000	
Agua dulce BR	100%	76,795	76,795	76,795	76,795	8,655	-1,352	23,595	0,000	Maximum
Agua dulce ER	100%	76,795	76,795	76,795	76,795	8,655	1,352	23,595	0,000	Maximum

Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	22,900	0,000	Maximum
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	22,900	0,000	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	100%	139,540	139,540	143,855	143,855	41,235	-16,440	22,140	0,000	Maximum
FO Sed. ER	100%	139,540	139,540	143,855	143,855	41,235	16,440	22,140	0,000	Maximum
Diesel BR	100%	382,873	382,873	425,414	425,414	47,627	-15,230	21,045	0,000	Maximum
Diesel ER	100%	382,873	382,873	425,414	425,414	47,627	15,230	21,045	0,000	Maximum
Aguas grises	0%	238,468	0,000	158,979	0,000	47,624	0,000	0,000	0,000	Maximum
Lodos	0%	113,158	0,000	75,439	0,000	40,586	0,000	0,000	0,000	Maximum
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	-4,284	15,197	0,000	IMO A.749(18)
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	4,284	15,197	0,000	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			6132,507			199,949	0,000	16,816	0,000	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			104431,948	209406,816	150789,005	136,271	0,000	14,769	273464,897	
FS correction								2,619		
VCG fluid								17,388		

Draft Amidships m	12,148
Displacement t	104432
Heel deg	0,0
Draft at FP m	13,321
Draft at AP m	10,974
Draft at LCF m	12,085
Trim (+ve by stern) m	-2,347
WL Length m	267,974
Beam max extents on WL m	43,197
Wetted Area m^2	14376,499
Waterpl. Area m^2	9773,136
Prismatic coeff. (Cp)	0,728
Block coeff. (Cb)	0,663
Max Sect. area coeff. (Cm)	0,985
Waterpl. area coeff. (Cwp)	0,844
LCB from zero pt. (+ve fwd) m	136,366
LCF from zero pt. (+ve fwd) m	126,696
KB m	6,505
KG fluid m	17,388
BMt m	13,294
BML m	430,978
GMt corrected m	2,411
GML m	420,095
KMt m	19,799
KML m	437,467
Immersion (TPc) tonne/cm	100,175
MTc tonne.m	1638,415
RM at 1deg = GMt.Disp.sin(1) tonne.m	4394,446
Max deck inclination deg	0,5022
Trim angle (+ve by stern) deg	-0,5022

Equilibrium Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C2 Salida de puerto en lastre
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	0%	17383,695	0,000	40427,198	0,000	87,269	0,000	2,500	0,000	Maximum
Tanque 3	0%	18236,208	0,000	42409,786	0,000	126,285	0,000	2,500	0,000	Maximum
Tanque 2	0%	18216,099	0,000	42363,021	0,000	175,231	0,000	2,500	0,000	Maximum
Tanque 1	0%	10179,370	0,000	23672,952	0,000	207,390	0,000	2,500	0,000	Maximum
Total carga	0%	64015,373	0,000	148872,958	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	2703,969	2703,969	2638,019	2638,019	3,809	-8,973	19,875	0,000	Maximum
Pique PP ER	100%	2704,001	2704,001	2638,050	2638,050	3,809	8,973	19,875	0,000	Maximum
Cofferdam 5	100%	2150,709	2150,709	2098,253	2098,253	52,770	0,000	17,477	0,000	Maximum
Cofferdam 4	100%	2608,203	2608,203	2544,588	2544,588	101,772	0,000	15,460	0,000	Maximum
Cofferdam 3	100%	2608,196	2608,196	2544,581	2544,581	150,798	0,000	15,460	0,000	Maximum
Cofferdam 2	100%	2512,692	2512,692	2451,407	2451,407	199,813	0,000	15,509	0,000	Maximum
Cofferdam 1	100%	717,353	717,353	699,857	699,857	243,256	0,000	17,484	0,000	Maximum
Pique PR BR	100%	411,594	411,594	401,555	401,555	268,098	-1,679	15,907	0,000	Maximum
Pique PR ER	100%	411,594	411,594	401,555	401,555	268,098	1,679	15,907	0,000	Maximum
Lastre 4 BR	100%	4509,134	4509,134	4399,155	4399,155	77,576	-15,302	9,501	0,000	Maximum
Lastre 4 ER	100%	4509,134	4509,134	4399,155	4399,155	77,576	15,302	9,501	0,000	Maximum
Lastre 3 BR	100%	5368,684	5368,684	5237,740	5237,740	124,977	-15,690	8,340	0,000	Maximum
Lastre 3 ER	100%	5368,684	5368,684	5237,740	5237,740	124,977	15,690	8,340	0,000	Maximum
Lastre 2 BR	100%	4765,443	4765,443	4649,212	4649,212	172,522	-15,153	8,809	0,000	Maximum
Lastre 2 ER	100%	4765,443	4765,443	4649,212	4649,212	172,522	15,153	8,809	0,000	Maximum
Lastre 1 BR	100%	4575,151	4575,151	4463,562	4463,562	222,028	-13,012	14,284	0,000	Maximum
Lastre 1 ER	100%	4575,151	4575,151	4463,562	4463,562	222,028	13,012	14,284	0,000	Maximum
Total lastre	100%	55265,135	55265,135	53917,205	53917,205	134,036	0,000	12,308	0,000	
Agua dulce BR	100%	76,795	76,795	76,795	76,795	8,655	-1,352	23,595	0,000	Maximum

Agua dulce ER	100%	76,795	76,795	76,795	76,795	8,655	1,352	23,595	0,000	Maximum
Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	22,900	0,000	Maximum
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	22,900	0,000	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	100%	139,540	139,540	143,855	143,855	41,235	-16,440	22,140	0,000	Maximum
FO Sed. ER	100%	139,540	139,540	143,855	143,855	41,235	16,440	22,140	0,000	Maximum
Diesel BR	100%	382,873	382,873	425,414	425,414	47,627	-15,230	21,045	0,000	Maximum
Diesel ER	100%	382,873	382,873	425,414	425,414	47,627	15,230	21,045	0,000	Maximum
Aguas grises	0%	238,468	0,000	158,979	0,000	47,624	0,000	0,000	0,000	Maximum
Lodos	0%	113,158	0,000	75,439	0,000	40,586	0,000	0,000	0,000	Maximum
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	-4,284	15,197	0,000	IMO A.749(18)
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	4,284	15,197	0,000	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			6132,507			199,949	0,000	16,816	0,000	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			97602,172	209406,816	60299,441	131,528	0,000	13,021	0,000	
FS correction								0,000		
VCG fluid								13,021		

Draft Amidships m	11,371
Displacement t	97596
Heel deg	0,0
Draft at FP m	10,940
Draft at AP m	11,803
Draft at LCF m	11,399
Trim (+ve by stern) m	0,863
WL Length m	273,154
Beam max extents on WL m	43,196
Wetted Area m^2	13981,083
Waterpl. Area m^2	9822,196
Prismatic coeff. (Cp)	0,715
Block coeff. (Cb)	0,686
Max Sect. area coeff. (Cm)	0,990
Waterpl. area coeff. (Cwp)	0,832
LCB from zero pt. (+ve fwd) m	131,524
LCF from zero pt. (+ve fwd) m	125,349
KB m	6,123
KG fluid m	13,021
BMt m	14,231
BML m	471,067
GMt corrected m	7,333
GML m	464,169
KMt m	20,353
KML m	477,187
Immersion (TPc) tonne/cm	100,678
MTc tonne.m	1691,816
RM at 1deg = GMt.Disp.sin(1) tonne.m	12490,342
Max deck inclination deg	0,1847
Trim angle (+ve by stern) deg	0,1847

Equilibrium Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C3 Llegada a puerto a plena carga
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	97%	17383,695	16862,186	40427,198	39214,387	78,023	0,000	15,621	76274,061	IMO A.749(18)
Tanque 3	97%	18236,208	17689,121	42409,786	41137,491	126,285	0,000	15,074	81953,117	IMO A.749(18)
Tanque 2	97%	18216,099	17669,616	42363,021	41092,129	175,287	0,000	15,077	81817,608	IMO A.749(18)
Tanque 1	97%	10179,370	9873,988	23672,952	22962,763	218,195	0,000	15,726	33420,111	IMO A.749(18)
Total carga	97%	64015,373	62094,912	148872,958	144406,769	141,738	0,000	15,327	273464,897	
Pique PP BR	0%	2703,969	0,000	2638,019	0,000	8,257	-6,379	11,850	0,000	Maximum
Pique PP ER	0%	2704,001	0,000	2638,050	0,000	8,257	6,379	11,850	0,000	Maximum
Cofferdam 5	0%	2150,709	0,000	2098,253	0,000	54,119	0,000	6,423	0,000	Maximum
Cofferdam 4	0%	2608,203	0,000	2544,588	0,000	101,772	0,000	2,500	0,000	Maximum
Cofferdam 3	0%	2608,196	0,000	2544,581	0,000	150,798	0,000	2,500	0,000	Maximum
Cofferdam 2	0%	2512,692	0,000	2451,407	0,000	199,813	0,000	2,500	0,000	Maximum
Cofferdam 1	0%	717,353	0,000	699,857	0,000	241,926	0,000	6,329	0,000	Maximum
Pique PR BR	0%	411,594	0,000	401,555	0,000	268,543	-0,677	2,500	0,000	Maximum
Pique PR ER	0%	411,594	0,000	401,555	0,000	268,543	0,677	2,500	0,000	Maximum
Lastre 4 BR	0%	4509,134	0,000	4399,155	0,000	83,509	-0,005	0,000	0,000	Maximum
Lastre 4 ER	0%	4509,134	0,000	4399,155	0,000	83,509	0,005	0,000	0,000	Maximum
Lastre 3 BR	0%	5368,684	0,000	5237,740	0,000	126,364	-0,010	0,000	0,000	Maximum
Lastre 3 ER	0%	5368,684	0,000	5237,740	0,000	126,364	0,010	0,000	0,000	Maximum
Lastre 2 BR	0%	4765,443	0,000	4649,212	0,000	173,923	-0,012	0,000	0,000	Maximum
Lastre 2 ER	0%	4765,443	0,000	4649,212	0,000	173,923	0,012	0,000	0,000	Maximum
Lastre 1 BR	0%	4575,151	0,000	4463,562	0,000	212,133	-0,005	0,000	0,000	Maximum
Lastre 1 ER	0%	4575,151	0,000	4463,562	0,000	212,133	0,005	0,000	0,000	Maximum
Total lastre	0%	55265,135	0,000	53917,205	0,000	0,000	0,000	0,000	0,000	
Agua dulce BR	5%	76,795	3,840	76,795	3,840	8,655	-1,352	21,025	8,923	Maximum

Agua dulce ER	5%	76,795	3,840	76,795	3,840	8,655	1,352	21,025	8,923	Maximum
Aceite BR	5%	49,417	2,471	54,908	2,745	32,095	-17,140	21,095	17,168	Maximum
Aceite ER	5%	49,417	2,471	54,908	2,745	32,095	17,140	21,095	17,168	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	91,87%	139,540	128,195	143,855	132,160	41,235	-16,440	21,924	63,776	Maximum
FO Sed. ER	91,87%	139,540	128,195	143,855	132,160	41,235	16,440	21,924	63,776	Maximum
Diesel BR	5%	382,873	19,144	425,414	21,271	47,627	-15,230	17,478	262,388	Maximum
Diesel ER	5%	382,873	19,144	425,414	21,271	47,627	15,230	17,478	262,388	Maximum
Aguas grises	100%	238,468	238,468	158,979	158,979	47,383	0,000	1,318	0,000	Maximum
Lodos	100%	113,158	113,158	75,439	75,439	40,477	0,000	1,302	0,000	Maximum
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	-2,340	2,500	0,000	IMO A.749(18)
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	2,340	2,500	0,000	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			844,929			41,734	0,000	13,265	704,509	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			99144,371	209406,816	145152,524	131,527	0,000	14,630	274169,406	
FS correction								2,765		
VCG fluid								17,395		

Draft Amidships m	11,526
Displacement t	99144
Heel deg	0,0
Draft at FP m	11,111
Draft at AP m	11,941
Draft at LCF m	11,553
Trim (+ve by stern) m	0,830
WL Length m	272,910
Beam max extents on WL m	43,196
Wetted Area m^2	14080,654
Waterpl. Area m^2	9843,333
Prismatic coeff. (Cp)	0,717
Block coeff. (Cb)	0,689
Max Sect. area coeff. (Cm)	0,990
Waterpl. area coeff. (Cwp)	0,835
LCB from zero pt. (+ve fwd) m	131,483
LCF from zero pt. (+ve fwd) m	125,149
KB m	6,206
KG fluid m	17,395
BMt m	14,058
BML m	466,098
GMt corrected m	2,869
GML m	454,909
KMt m	20,264
KML m	472,302
Immersion (TPc) tonne/cm	100,894
MTc tonne.m	1684,353
RM at 1deg = GMt.Disp.sin(1) tonne.m	4964,535
Max deck inclination deg	0,1776
Trim angle (+ve by stern) deg	0,1776

Equilibrium Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C4 Llegada a puerto en lastre
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	0%	17383,695	0,000	40427,198	0,000	87,269	0,000	2,500	0,000	Maximum
Tanque 3	0%	18236,208	0,000	42409,786	0,000	126,285	0,000	2,500	0,000	Maximum
Tanque 2	0%	18216,099	0,000	42363,021	0,000	175,231	0,000	2,500	0,000	Maximum
Tanque 1	0%	10179,370	0,000	23672,952	0,000	207,390	0,000	2,500	0,000	Maximum
Total carga	0%	64015,373	0,000	148872,958	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	2703,969	2703,969	2638,019	2638,019	3,809	-8,973	19,875	0,000	Maximum
Pique PP ER	100%	2704,001	2704,001	2638,050	2638,050	3,809	8,973	19,875	0,000	Maximum
Cofferdam 5	100%	2150,709	2150,709	2098,253	2098,253	52,770	0,000	17,477	0,000	Maximum
Cofferdam 4	100%	2608,203	2608,203	2544,588	2544,588	101,772	0,000	15,460	0,000	Maximum
Cofferdam 3	100%	2608,196	2608,196	2544,581	2544,581	150,798	0,000	15,460	0,000	Maximum
Cofferdam 2	100%	2512,692	2512,692	2451,407	2451,407	199,813	0,000	15,509	0,000	Maximum
Cofferdam 1	100%	717,353	717,353	699,857	699,857	243,256	0,000	17,484	0,000	Maximum
Pique PR BR	100%	411,594	411,594	401,555	401,555	268,098	-1,679	15,907	0,000	Maximum
Pique PR ER	100%	411,594	411,594	401,555	401,555	268,098	1,679	15,907	0,000	Maximum
Lastre 4 BR	100%	4509,134	4509,134	4399,155	4399,155	77,576	-15,302	9,501	0,000	Maximum
Lastre 4 ER	100%	4509,134	4509,134	4399,155	4399,155	77,576	15,302	9,501	0,000	Maximum
Lastre 3 BR	100%	5368,684	5368,684	5237,740	5237,740	124,977	-15,690	8,340	0,000	Maximum
Lastre 3 ER	100%	5368,684	5368,684	5237,740	5237,740	124,977	15,690	8,340	0,000	Maximum
Lastre 2 BR	100%	4765,443	4765,443	4649,212	4649,212	172,522	-15,153	8,809	0,000	Maximum
Lastre 2 ER	100%	4765,443	4765,443	4649,212	4649,212	172,522	15,153	8,809	0,000	Maximum
Lastre 1 BR	100%	4575,151	4575,151	4463,562	4463,562	222,028	-13,012	14,284	0,000	Maximum
Lastre 1 ER	100%	4575,151	4575,151	4463,562	4463,562	222,028	13,012	14,284	0,000	Maximum
Total lastre	100%	55265,135	55265,135	53917,205	53917,205	134,036	0,000	12,308	0,000	
Agua dulce BR	5%	76,795	3,840	76,795	3,840	8,655	-1,352	21,025	8,923	Maximum

Agua dulce ER	5%	76,795	3,840	76,795	3,840	8,655	1,352	21,025	8,923	Maximum
Aceite BR	5%	49,417	2,471	54,908	2,745	32,095	-17,140	21,095	17,168	Maximum
Aceite ER	5%	49,417	2,471	54,908	2,745	32,095	17,140	21,095	17,168	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	91,87%	139,540	128,195	143,855	132,160	41,235	-16,440	21,924	63,776	Maximum
FO Sed. ER	91,87%	139,540	128,195	143,855	132,160	41,235	16,440	21,924	63,776	Maximum
Diesel BR	5%	382,873	19,144	425,414	21,271	47,627	-15,230	17,478	262,388	Maximum
Diesel ER	5%	382,873	19,144	425,414	21,271	47,627	15,230	17,478	262,388	Maximum
Aguas grises	100%	238,468	238,468	158,979	158,979	47,383	0,000	1,318	0,000	Maximum
Lodos	100%	113,158	113,158	75,439	75,439	40,477	0,000	1,302	0,000	Maximum
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	-2,340	2,500	0,000	IMO A.749(18)
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	2,340	2,500	0,000	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			844,930			41,734	0,000	13,265	704,509	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			92314,594	209406,816	54662,959	126,161	0,000	12,771	704,509	
FS correction								0,008		
VCG fluid								12,778		

Draft Amidships m	10,743
Displacement t	92323
Heel deg	0,0
Draft at FP m	8,762
Draft at AP m	12,725
Draft at LCF m	10,890
Trim (+ve by stern) m	3,963
WL Length m	280,021
Beam max extents on WL m	43,194
Wetted Area m^2	13665,822
Waterpl. Area m^2	9901,787
Prismatic coeff. (Cp)	0,680
Block coeff. (Cb)	0,594
Max Sect. area coeff. (Cm)	0,969
Waterpl. area coeff. (Cwp)	0,819
LCB from zero pt. (+ve fwd) m	126,056
LCF from zero pt. (+ve fwd) m	123,993
KB m	5,889
KG fluid m	12,778
BMt m	15,070
BML m	514,252
GMt corrected m	8,180
GML m	507,362
KMt m	20,957
KML m	520,085
Immersion (TPc) tonne/cm	101,493
MTc tonne.m	1749,333
RM at 1deg = GMt.Disp.sin(1) tonne.m	13180,151
Max deck inclination deg	0,8478
Trim angle (+ve by stern) deg	0,8478

ANEXO III

Report criterios de estabilidad

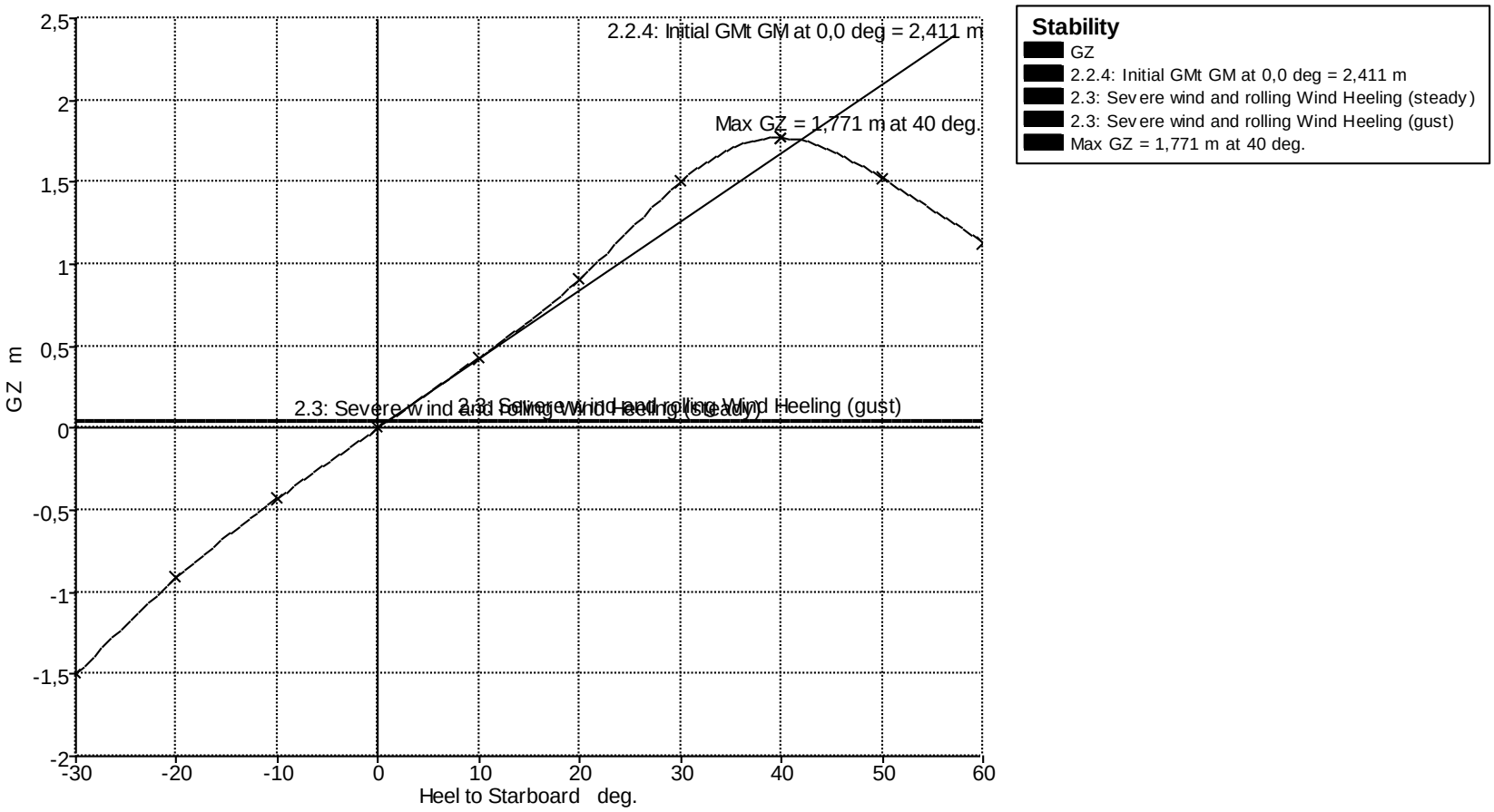
Stability Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C1 Salida puerto a plena carga
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	97%	17383,695	16862,186	40427,198	39214,387	78,023	0,000	15,621	76274,061	IMO A.749(18)
Tanque 3	97%	18236,208	17689,121	42409,786	41137,491	126,285	0,000	15,074	81953,117	IMO A.749(18)
Tanque 2	97%	18216,099	17669,616	42363,021	41092,129	175,287	0,000	15,077	81817,608	IMO A.749(18)
Tanque 1	97%	10179,370	9873,988	23672,952	22962,763	218,195	0,000	15,726	33420,111	IMO A.749(18)
Total carga	97%	64015,373	62094,912	148872,958	144406,769	141,738	0,000	15,327	273464,897	
Pique PP BR	0%	2703,969	0,000	2638,019	0,000	8,257	-6,379	11,850	0,000	Maximum
Pique PP ER	0%	2704,001	0,000	2638,050	0,000	8,257	6,379	11,850	0,000	Maximum
Cofferdam 5	0%	2150,709	0,000	2098,253	0,000	54,119	0,000	6,423	0,000	Maximum
Cofferdam 4	0%	2608,203	0,000	2544,588	0,000	101,772	0,000	2,500	0,000	Maximum
Cofferdam 3	0%	2608,196	0,000	2544,581	0,000	150,798	0,000	2,500	0,000	Maximum
Cofferdam 2	0%	2512,692	0,000	2451,407	0,000	199,813	0,000	2,500	0,000	Maximum
Cofferdam 1	0%	717,353	0,000	699,857	0,000	241,926	0,000	6,329	0,000	Maximum
Pique PR BR	0%	411,594	0,000	401,555	0,000	268,543	-0,677	2,500	0,000	Maximum
Pique PR ER	0%	411,594	0,000	401,555	0,000	268,543	0,677	2,500	0,000	Maximum
Lastre 4 BR	0%	4509,134	0,000	4399,155	0,000	83,509	-0,005	0,000	0,000	Maximum
Lastre 4 ER	0%	4509,134	0,000	4399,155	0,000	83,509	0,005	0,000	0,000	Maximum
Lastre 3 BR	0%	5368,684	0,000	5237,740	0,000	126,364	-0,010	0,000	0,000	Maximum
Lastre 3 ER	0%	5368,684	0,000	5237,740	0,000	126,364	0,010	0,000	0,000	Maximum
Lastre 2 BR	0%	4765,443	0,000	4649,212	0,000	173,923	-0,012	0,000	0,000	Maximum
Lastre 2 ER	0%	4765,443	0,000	4649,212	0,000	173,923	0,012	0,000	0,000	Maximum
Lastre 1 BR	0%	4575,151	0,000	4463,562	0,000	212,133	-0,005	0,000	0,000	Maximum
Lastre 1 ER	0%	4575,151	0,000	4463,562	0,000	212,133	0,005	0,000	0,000	Maximum
Total lastre	0%	55265,135	0,000	53917,205	0,000	0,000	0,000	0,000	0,000	
Agua dulce BR	100%	76,795	76,795	76,795	76,795	8,655	-1,352	23,595	0,000	Maximum

Agua dulce ER	100%	76,795	76,795	76,795	76,795	8,655	1,352	23,595	0,000	Maximum
Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	22,900	0,000	Maximum
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	22,900	0,000	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	100%	139,540	139,540	143,855	143,855	41,235	-16,440	22,140	0,000	Maximum
FO Sed. ER	100%	139,540	139,540	143,855	143,855	41,235	16,440	22,140	0,000	Maximum
Diesel BR	100%	382,873	382,873	425,414	425,414	47,627	-15,230	21,045	0,000	Maximum
Diesel ER	100%	382,873	382,873	425,414	425,414	47,627	15,230	21,045	0,000	Maximum
Aguas grises	0%	238,468	0,000	158,979	0,000	47,624	0,000	0,000	0,000	Maximum
Lodos	0%	113,158	0,000	75,439	0,000	40,586	0,000	0,000	0,000	Maximum
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	-4,284	15,197	0,000	IMO A.749(18)
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	4,284	15,197	0,000	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			6132,507			199,949	0,000	16,816	0,000	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			104431,949	209406,816	150789,006	136,271	0,000	14,769	273464,897	
FS correction								2,619		
VCG fluid								17,388		


2.2.4: Initial GMt GM at 0,0 deg = 2,411 m
Max GZ = 1,771 m at 40 deg.
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
GZ m
Heel to Starboard deg.
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
-30
-20
-10
0
10
20
30
40
50
60
Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 2,411 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 1,771 m at 40 deg.

Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0	50,0	60,0
GZ m	-1,501	-0,911	-0,429	0,000	0,429	0,911	1,501	1,771	1,530	1,133
Area under GZ curve from zero heel m.deg	20,7507	8,7540	2,1332	0,0000	2,1392	8,7297	20,8420	37,6283	54,4282	67,7701
Displacement t	104427	104432	104432	104432	104432	104432	104432	104432	104432	104437
Draft at FP m	13,578	13,477	13,365	13,321	13,366	13,476	13,577	13,457	13,164	12,303
Draft at AP m	9,548	10,395	10,835	10,974	10,835	10,396	9,550	7,867	5,319	1,210
WL Length m	273,649	267,359	267,828	267,973	267,828	267,360	273,648	273,618	274,051	276,156
Beam max extents on WL m	47,916	45,887	43,858	43,197	43,858	45,887	47,917	40,861	37,617	36,112
Wetted Area m^2	14538,767	14400,860	14375,931	14376,480	14375,935	14400,907	14539,110	14659,999	14602,495	14498,450
Waterpl. Area m^2	10437,683	10073,503	9841,523	9773,095	9841,509	10073,576	10437,933	9715,425	9070,085	8826,551
Prismatic coeff. (Cp)	0,730	0,738	0,731	0,728	0,731	0,738	0,730	0,739	0,743	0,736
Block coeff. (Cb)	0,388	0,462	0,568	0,663	0,568	0,462	0,388	0,431	0,459	0,483
LCB from zero pt. (+ve fwd) m	136,426	136,393	136,373	136,367	136,373	136,391	136,421	136,460	136,505	136,527
LCF from zero pt. (+ve fwd) m	129,897	128,699	127,259	126,696	127,260	128,697	129,894	129,831	132,404	134,236
Max deck inclination deg	30,0084	20,0092	10,0141	0,5024	10,0141	20,0092	30,0084	40,0087	50,0085	60,0071
Trim angle (+ve by stern) deg	-0,8624	-0,6594	-0,5414	-0,5024	-0,5415	-0,6590	-0,8617	-1,1960	-1,6783	-2,3724

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	16,2	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	20,8420	Pass	+561,38
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	37,6283	Pass	+629,71
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	16,7863	Pass	+876,57
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	1,771	Pass	+785,50
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	40,0	Pass	+60,00
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	2,411	Pass	+1507,33
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	0,9	Pass	+94,54
	Area1 / Area2 shall not be less than (>=)	100,00	%	867,50	Pass	+767,50

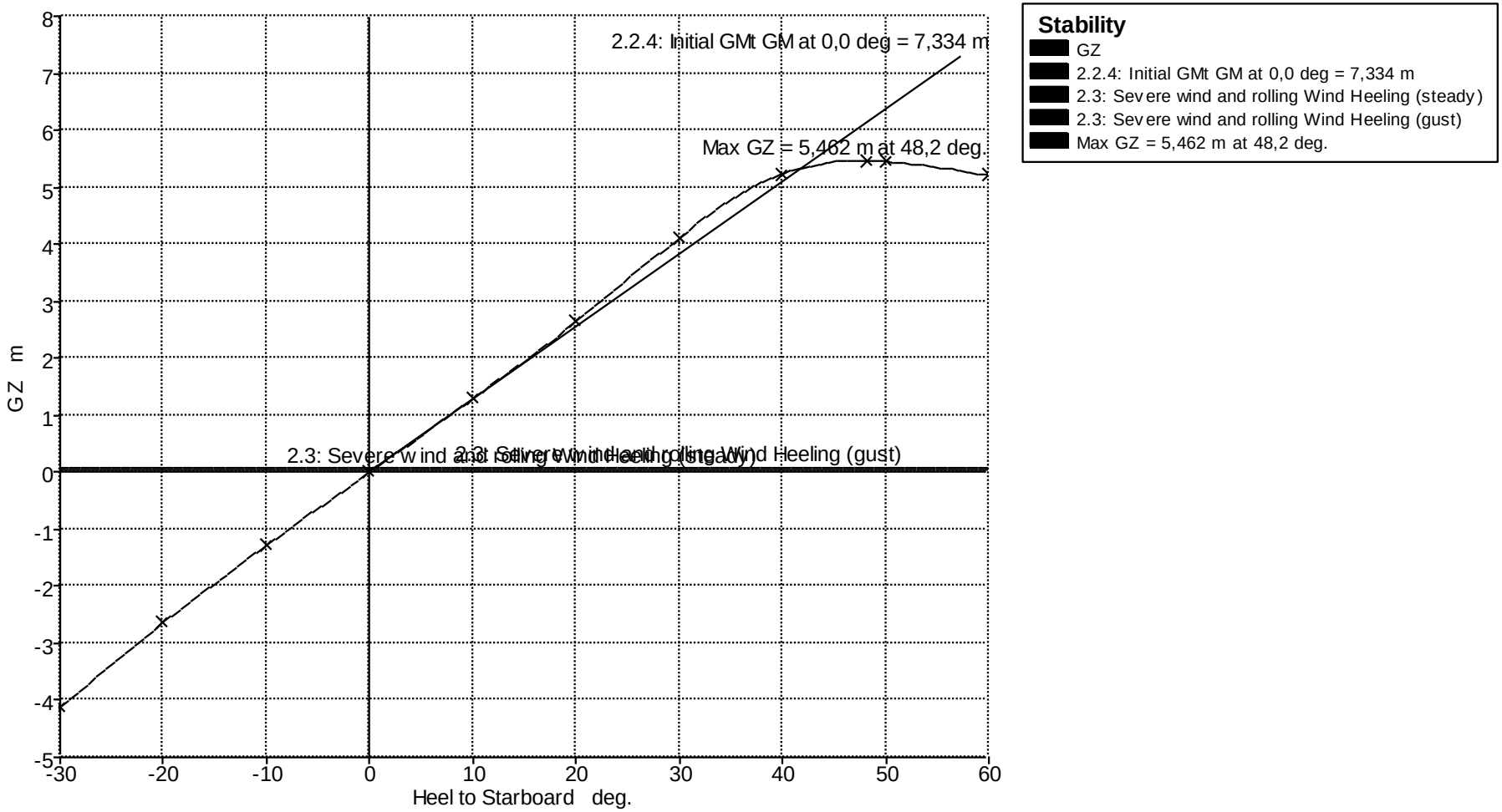
Stability Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C2 Salida de puerto en lastre
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	0%	17383,695	0,000	40427,198	0,000	87,269	0,000	2,500	0,000	Maximum
Tanque 3	0%	18236,208	0,000	42409,786	0,000	126,285	0,000	2,500	0,000	Maximum
Tanque 2	0%	18216,099	0,000	42363,021	0,000	175,231	0,000	2,500	0,000	Maximum
Tanque 1	0%	10179,370	0,000	23672,952	0,000	207,390	0,000	2,500	0,000	Maximum
Total carga	0%	64015,373	0,000	148872,958	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	2703,969	2703,969	2638,019	2638,019	3,809	-8,973	19,875	0,000	Maximum
Pique PP ER	100%	2704,001	2704,001	2638,050	2638,050	3,809	8,973	19,875	0,000	Maximum
Cofferdam 5	100%	2150,709	2150,709	2098,253	2098,253	52,770	0,000	17,477	0,000	Maximum
Cofferdam 4	100%	2608,203	2608,203	2544,588	2544,588	101,772	0,000	15,460	0,000	Maximum
Cofferdam 3	100%	2608,196	2608,196	2544,581	2544,581	150,798	0,000	15,460	0,000	Maximum
Cofferdam 2	100%	2512,692	2512,692	2451,407	2451,407	199,813	0,000	15,509	0,000	Maximum
Cofferdam 1	100%	717,353	717,353	699,857	699,857	243,256	0,000	17,484	0,000	Maximum
Pique PR BR	100%	411,594	411,594	401,555	401,555	268,098	-1,679	15,907	0,000	Maximum
Pique PR ER	100%	411,594	411,594	401,555	401,555	268,098	1,679	15,907	0,000	Maximum
Lastre 4 BR	100%	4509,134	4509,134	4399,155	4399,155	77,576	-15,302	9,501	0,000	Maximum
Lastre 4 ER	100%	4509,134	4509,134	4399,155	4399,155	77,576	15,302	9,501	0,000	Maximum
Lastre 3 BR	100%	5368,684	5368,684	5237,740	5237,740	124,977	-15,690	8,340	0,000	Maximum
Lastre 3 ER	100%	5368,684	5368,684	5237,740	5237,740	124,977	15,690	8,340	0,000	Maximum
Lastre 2 BR	100%	4765,443	4765,443	4649,212	4649,212	172,522	-15,153	8,809	0,000	Maximum
Lastre 2 ER	100%	4765,443	4765,443	4649,212	4649,212	172,522	15,153	8,809	0,000	Maximum
Lastre 1 BR	100%	4575,151	4575,151	4463,562	4463,562	222,028	-13,012	14,284	0,000	Maximum
Lastre 1 ER	100%	4575,151	4575,151	4463,562	4463,562	222,028	13,012	14,284	0,000	Maximum
Total lastre	100%	55265,135	55265,135	53917,205	53917,205	134,036	0,000	12,308	0,000	
Agua dulce BR	100%	76,795	76,795	76,795	76,795	8,655	-1,352	23,595	0,000	Maximum

Agua dulce ER	100%	76,795	76,795	76,795	76,795	8,655	1,352	23,595	0,000	Maximum
Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	22,900	0,000	Maximum
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	22,900	0,000	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	100%	139,540	139,540	143,855	143,855	41,235	-16,440	22,140	0,000	Maximum
FO Sed. ER	100%	139,540	139,540	143,855	143,855	41,235	16,440	22,140	0,000	Maximum
Diesel BR	100%	382,873	382,873	425,414	425,414	47,627	-15,230	21,045	0,000	Maximum
Diesel ER	100%	382,873	382,873	425,414	425,414	47,627	15,230	21,045	0,000	Maximum
Aguas grises	0%	238,468	0,000	158,979	0,000	47,624	0,000	0,000	0,000	Maximum
Lodos	0%	113,158	0,000	75,439	0,000	40,586	0,000	0,000	0,000	Maximum
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	-4,284	15,197	0,000	IMO A.749(18)
FO Almacén	100%	2322,658	2322,658	2394,493	2394,493	251,161	4,284	15,197	0,000	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			6132,507			199,949	0,000	16,816	0,000	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			97602,172	209406,816	60299,441	131,528	0,000	13,021	0,000	
FS correction								0,000		
VCG fluid								13,021		


Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 7,334 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 5,462 m at 48,2 deg.
2.2.4: Initial GMt GM at 0,0 deg = 7,334 m
Max GZ = 5,462 m at 48,2 deg.
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
GZ m
Heel to Starboard deg.
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-30
-20
-10
0
10
20
30
40
50
60

Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0	50,0	60,0
GZ m	-4,112	-2,642	-1,289	0,000	1,289	2,642	4,112	5,230	5,450	5,209
Area under GZ curve from zero heel m.deg	59,6955	25,9892	6,4238	0,0000	6,4284	25,9696	59,7630	107,0833	161,1333	214,5913
Displacement t	97602	97601	97602	97602	97602	97602	97601	97602	97602	97602
Draft at FP m	11,105	11,057	10,970	10,935	10,970	11,059	11,110	10,688	9,837	8,080
Draft at AP m	10,415	11,259	11,680	11,808	11,679	11,257	10,411	8,740	6,282	2,387
WL Length m	277,569	277,583	272,996	273,173	272,994	277,578	277,558	278,623	280,343	281,159
Beam max extents on WL m	46,361	45,846	43,854	43,196	43,854	45,846	46,362	40,870	36,325	34,905
Wetted Area m^2	14066,708	14017,711	13966,391	13981,534	13966,406	14017,614	14066,750	14010,379	14051,001	13957,529
Waterpl. Area m^2	10287,200	10108,267	9871,671	9822,847	9871,624	10107,956	10286,958	9755,551	8938,980	8695,391
Prismatic coeff. (Cp)	0,738	0,718	0,718	0,715	0,718	0,718	0,738	0,744	0,741	0,736
Block coeff. (Cb)	0,382	0,433	0,546	0,686	0,546	0,433	0,382	0,409	0,450	0,476
LCB from zero pt. (+ve fwd) m	131,526	131,510	131,507	131,505	131,509	131,517	131,541	131,576	131,612	131,639
LCF from zero pt. (+ve fwd) m	128,183	126,889	126,021	125,341	126,021	126,893	128,188	129,724	131,313	133,298
Max deck inclination deg	30,0002	20,0000	10,0011	0,1869	10,0011	20,0000	30,0003	40,0011	50,0018	60,0019
Trim angle (+ve by stern) deg	-0,1476	0,0432	0,1520	0,1869	0,1518	0,0423	-0,1496	-0,4167	-0,7607	-1,2182

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	21,0	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	59,7630	Pass	+1796,45
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	107,0833	Pass	+1976,63
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	47,3203	Pass	+2652,94
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	5,462	Pass	+2631,00
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	48,2	Pass	+92,73
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	7,334	Pass	+4789,33
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	0,3	Pass	+97,92
	Area1 / Area2 shall not be less than (>=)	100,00	%	542,89	Pass	+442,89

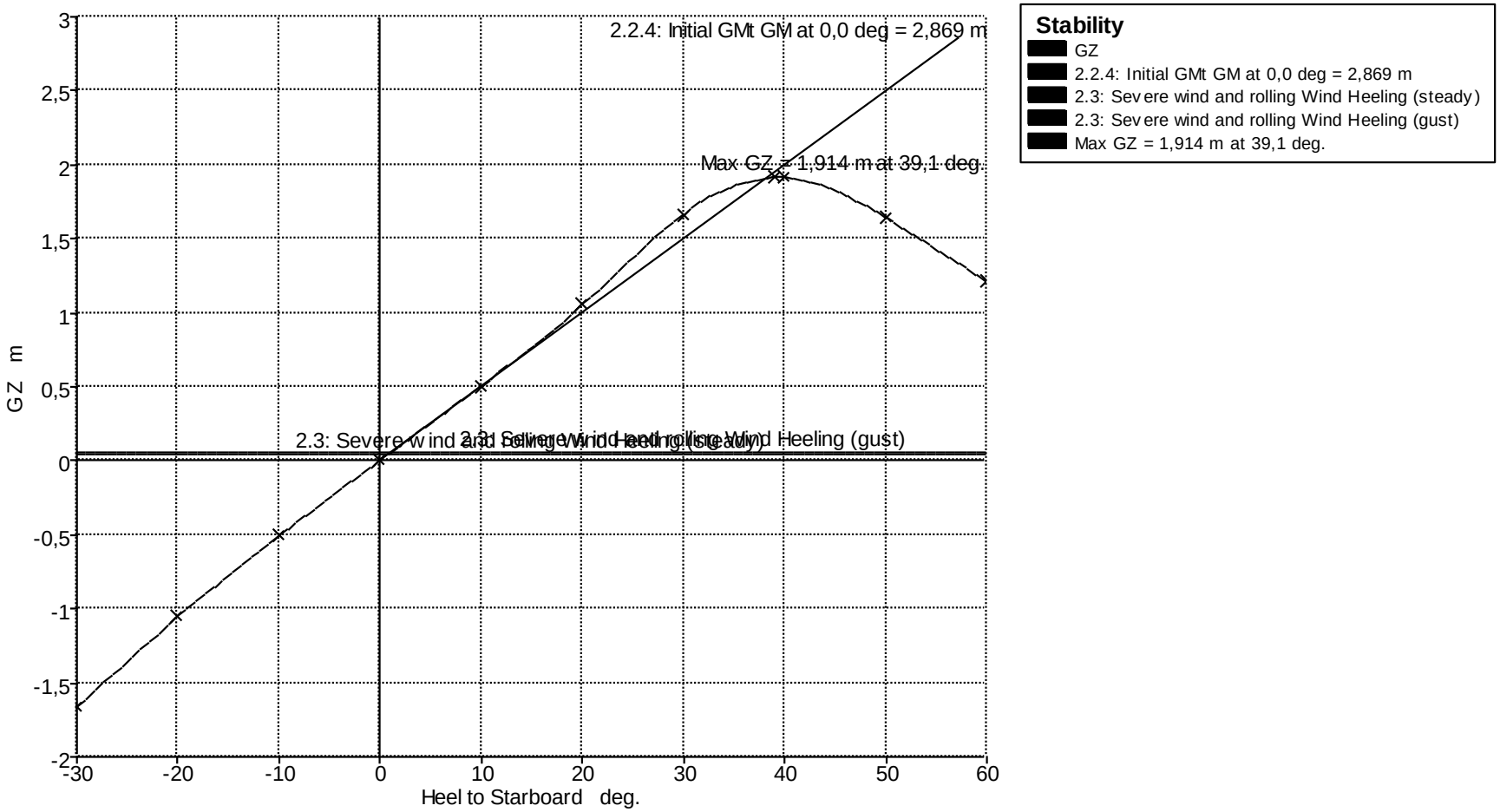
Stability Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C3 Llegada a puerto a plena carga
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	97%	17383,695	16862,184	40427,198	39214,382	78,023	0,000	15,621	76274,061	IMO A.749(18)
Tanque 3	97%	18236,208	17689,122	42409,786	41137,493	126,285	0,000	15,074	81953,117	IMO A.749(18)
Tanque 2	97%	18216,099	17669,616	42363,021	41092,130	175,287	0,000	15,077	81817,608	IMO A.749(18)
Tanque 1	97%	10179,370	9873,988	23672,952	22962,763	218,195	0,000	15,726	33420,111	IMO A.749(18)
Total carga	97%	64015,373	62094,911	148872,958	144406,768	141,738	0,000	15,327	273464,897	
Pique PP BR	0%	2703,969	0,000	2638,019	0,000	8,257	-6,379	11,850	0,000	Maximum
Pique PP ER	0%	2704,001	0,000	2638,050	0,000	8,257	6,379	11,850	0,000	Maximum
Cofferdam 5	0%	2150,709	0,000	2098,253	0,000	54,119	0,000	6,423	0,000	Maximum
Cofferdam 4	0%	2608,203	0,000	2544,588	0,000	101,772	0,000	2,500	0,000	Maximum
Cofferdam 3	0%	2608,196	0,000	2544,581	0,000	150,798	0,000	2,500	0,000	Maximum
Cofferdam 2	0%	2512,692	0,000	2451,407	0,000	199,813	0,000	2,500	0,000	Maximum
Cofferdam 1	0%	717,353	0,000	699,857	0,000	241,926	0,000	6,329	0,000	Maximum
Pique PR BR	0%	411,594	0,000	401,555	0,000	268,543	-0,677	2,500	0,000	Maximum
Pique PR ER	0%	411,594	0,000	401,555	0,000	268,543	0,677	2,500	0,000	Maximum
Lastre 4 BR	0%	4509,134	0,000	4399,155	0,000	83,509	-0,005	0,000	0,000	Maximum
Lastre 4 ER	0%	4509,134	0,000	4399,155	0,000	83,509	0,005	0,000	0,000	Maximum
Lastre 3 BR	0%	5368,684	0,000	5237,740	0,000	126,364	-0,010	0,000	0,000	Maximum
Lastre 3 ER	0%	5368,684	0,000	5237,740	0,000	126,364	0,010	0,000	0,000	Maximum
Lastre 2 BR	0%	4765,443	0,000	4649,212	0,000	173,923	-0,012	0,000	0,000	Maximum
Lastre 2 ER	0%	4765,443	0,000	4649,212	0,000	173,923	0,012	0,000	0,000	Maximum
Lastre 1 BR	0%	4575,151	0,000	4463,562	0,000	212,133	-0,005	0,000	0,000	Maximum
Lastre 1 ER	0%	4575,151	0,000	4463,562	0,000	212,133	0,005	0,000	0,000	Maximum
Total lastre	0%	55265,135	0,000	53917,205	0,000	0,000	0,000	0,000	0,000	
Agua dulce BR	5%	76,795	3,840	76,795	3,840	8,655	-1,352	21,025	8,923	Maximum

Agua dulce ER	5%	76,795	3,840	76,795	3,840	8,655	1,352	21,025	8,923	Maximum
Aceite BR	5%	49,417	2,471	54,908	2,745	32,095	-17,140	21,095	17,168	Maximum
Aceite ER	5%	49,417	2,471	54,908	2,745	32,095	17,140	21,095	17,168	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	91,87%	139,540	128,195	143,855	132,160	41,235	-16,440	21,924	63,776	Maximum
FO Sed. ER	91,87%	139,540	128,195	143,855	132,160	41,235	16,440	21,924	63,776	Maximum
Diesel BR	5%	382,873	19,144	425,414	21,271	47,627	-15,230	17,478	262,388	Maximum
Diesel ER	5%	382,873	19,144	425,414	21,271	47,627	15,230	17,478	262,388	Maximum
Aguas grises	100%	238,468	238,468	158,979	158,979	47,383	0,000	1,318	0,000	Maximum
Lodos	100%	113,158	113,158	75,439	75,439	40,477	0,000	1,302	0,000	Maximum
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	-2,340	2,500	0,000	IMO A.749(18)
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	2,340	2,500	0,000	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			844,929			41,734	0,000	13,265	704,509	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			99144,370	209406,816	145152,523	131,527	0,000	14,630	274169,406	
FS correction								2,765		
VCG fluid								17,395		


Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 2,869 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 1,914 m at 39,1 deg.
2.2.4: Initial GMt GM at 0,0 deg = 2,869 m
Max GZ = 1,914 m at 39,1 deg.
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
GZ m
Heel to Starboard deg.
3
2,5
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
-30
-20
-10
0
10
20
30
40
50
60

Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0	50,0	60,0
GZ m	-1,663	-1,054	-0,506	0,000	0,506	1,054	1,663	1,913	1,646	1,210
Area under GZ curve from zero heel m.deg	23,8242	10,2683	2,5164	0,0000	2,5231	10,2406	23,9237	42,2471	60,3478	74,6689
Displacement t	99144	99143	99144	99144	99144	99144	99144	99144	99144	99144
Draft at FP m	11,294	11,238	11,148	11,114	11,148	11,240	11,298	10,906	10,112	8,424
Draft at AP m	10,564	11,396	11,813	11,939	11,813	11,395	10,561	8,925	6,530	2,734
WL Length m	277,143	277,191	272,748	272,900	272,746	277,186	277,135	278,158	279,818	281,101
Beam max extents on WL m	46,687	45,859	43,855	43,196	43,855	45,859	46,687	40,870	36,488	35,057
Wetted Area m^2	14177,639	14123,003	14064,899	14080,665	14064,910	14122,977	14177,659	14141,101	14179,876	14078,854
Waterpl. Area m^2	10343,995	10141,492	9893,499	9843,061	9893,441	10141,264	10343,798	9754,352	8975,820	8725,459
Prismatic coeff. (Cp)	0,740	0,720	0,721	0,717	0,721	0,720	0,740	0,746	0,745	0,738
Block coeff. (Cb)	0,383	0,436	0,550	0,690	0,550	0,436	0,383	0,413	0,452	0,477
LCB from zero pt. (+ve fwd) m	131,538	131,509	131,497	131,492	131,499	131,516	131,549	131,596	131,639	131,661
LCF from zero pt. (+ve fwd) m	128,101	126,651	125,840	125,152	125,841	126,654	128,105	129,733	131,351	133,249
Max deck inclination deg	30,0003	20,0000	10,0010	0,1765	10,0010	20,0000	30,0003	40,0011	50,0018	60,0019
Trim angle (+ve by stern) deg	-0,1562	0,0339	0,1424	0,1765	0,1422	0,0330	-0,1578	-0,4239	-0,7663	-1,2175

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	17,5	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	23,9237	Pass	+659,17
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	42,2471	Pass	+719,28
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	18,3233	Pass	+965,99
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	1,914	Pass	+857,00
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	39,1	Pass	+56,36
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	2,869	Pass	+1812,67
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	0,8	Pass	+94,86
	Area1 / Area2 shall not be less than (>=)	100,00	%	699,94	Pass	+599,94

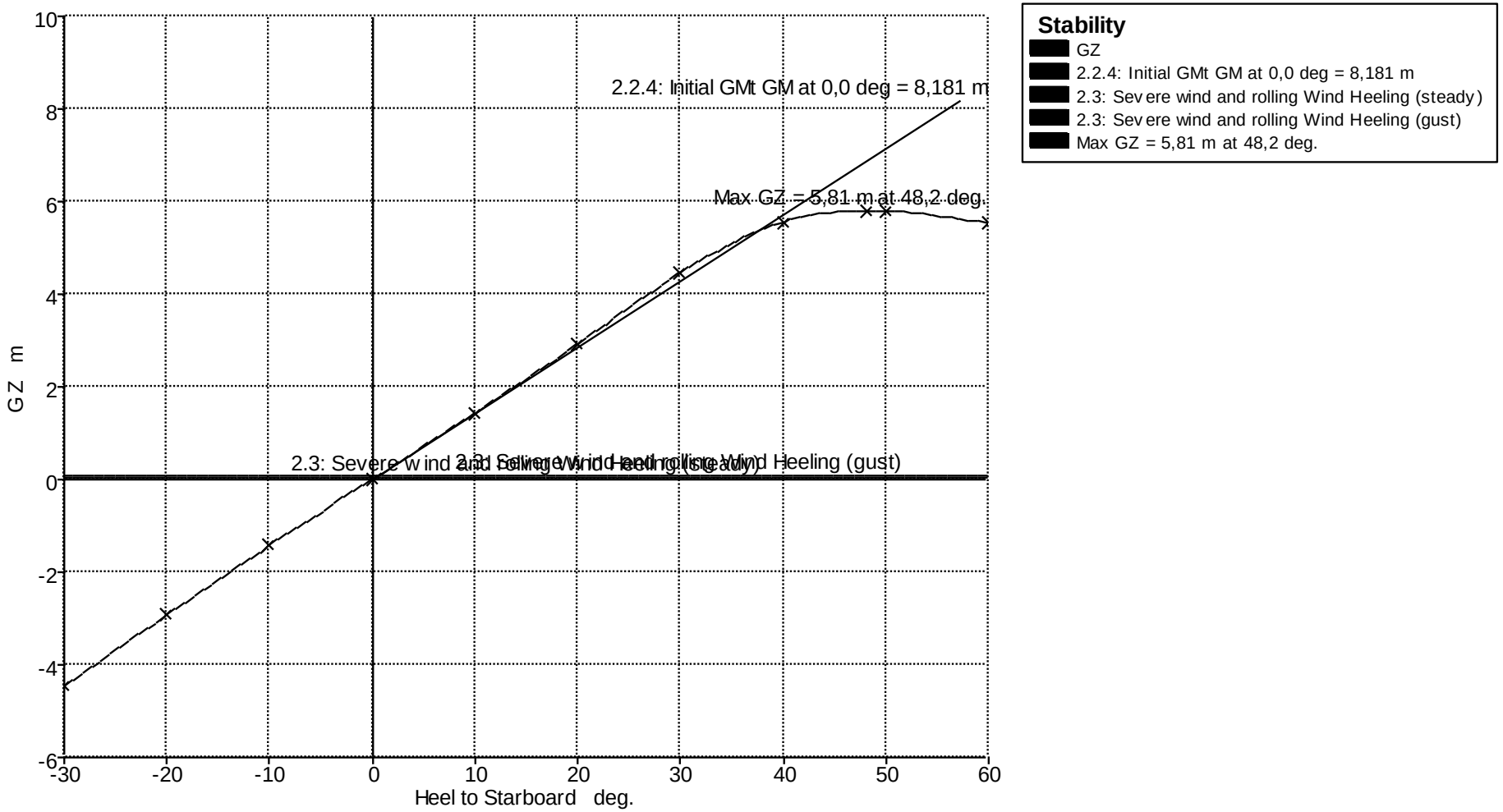
Stability Calculation

Stability 20.00.04.9, build: 9
Model file: C:\Users\Usuario\Desktop\TFG\CUADERNO 4\TANQUES BUENOS (Medium precision, 65 sections, Trimming off, Skin thickness not applied). Long. datum: AP; Vert. datum: Baseline. Analysis tolerance - ideal(worst case): Disp.%: 0,01000(0,100); Trim%(LCG-TCG): 0,01000(0,100); Heel%(LCG-TCG): 0,01000(0,100)

Loadcase - C4 Llegada a puerto en lastre
Damage Case - Intact
Free to Trim
Specific gravity = 1,025; (Density = 1,025 tonne/m^3)
Fluid analysis method: Use corrected VCG

Item Name	Quantity	Unit Mass tonne	Total Mass tonne	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m	Total FSM tonne.m	FSM Type
rosca	1	36099,280	36099,280			116,086	0,000	13,421	0,000	
Total rosca			36099,280			116,086	0,000	13,421	0,000	
Tanque 4	0%	17383,695	0,000	40427,198	0,000	87,269	0,000	2,500	0,000	Maximum
Tanque 3	0%	18236,208	0,000	42409,786	0,000	126,285	0,000	2,500	0,000	Maximum
Tanque 2	0%	18216,099	0,000	42363,021	0,000	175,231	0,000	2,500	0,000	Maximum
Tanque 1	0%	10179,370	0,000	23672,952	0,000	207,390	0,000	2,500	0,000	Maximum
Total carga	0%	64015,373	0,000	148872,958	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	2703,969	2703,969	2638,019	2638,019	3,809	-8,973	19,875	0,000	Maximum
Pique PP ER	100%	2704,001	2704,001	2638,050	2638,050	3,809	8,973	19,875	0,000	Maximum
Cofferdam 5	100%	2150,709	2150,709	2098,253	2098,253	52,770	0,000	17,477	0,000	Maximum
Cofferdam 4	100%	2608,203	2608,203	2544,588	2544,588	101,772	0,000	15,460	0,000	Maximum
Cofferdam 3	100%	2608,196	2608,196	2544,581	2544,581	150,798	0,000	15,460	0,000	Maximum
Cofferdam 2	100%	2512,692	2512,692	2451,407	2451,407	199,813	0,000	15,509	0,000	Maximum
Cofferdam 1	100%	717,353	717,353	699,857	699,857	243,256	0,000	17,484	0,000	Maximum
Pique PR BR	100%	411,594	411,594	401,555	401,555	268,098	-1,679	15,907	0,000	Maximum
Pique PR ER	100%	411,594	411,594	401,555	401,555	268,098	1,679	15,907	0,000	Maximum
Lastre 4 BR	100%	4509,134	4509,134	4399,155	4399,155	77,576	-15,302	9,501	0,000	Maximum
Lastre 4 ER	100%	4509,134	4509,134	4399,155	4399,155	77,576	15,302	9,501	0,000	Maximum
Lastre 3 BR	100%	5368,684	5368,684	5237,740	5237,740	124,977	-15,690	8,340	0,000	Maximum
Lastre 3 ER	100%	5368,684	5368,684	5237,740	5237,740	124,977	15,690	8,340	0,000	Maximum
Lastre 2 BR	100%	4765,443	4765,443	4649,212	4649,212	172,522	-15,153	8,809	0,000	Maximum
Lastre 2 ER	100%	4765,443	4765,443	4649,212	4649,212	172,522	15,153	8,809	0,000	Maximum
Lastre 1 BR	100%	4575,151	4575,151	4463,562	4463,562	222,028	-13,012	14,284	0,000	Maximum
Lastre 1 ER	100%	4575,151	4575,151	4463,562	4463,562	222,028	13,012	14,284	0,000	Maximum
Total lastre	100%	55265,135	55265,135	53917,205	53917,205	134,036	0,000	12,308	0,000	
Agua dulce BR	5%	76,795	3,840	76,795	3,840	8,655	-1,352	21,025	8,923	Maximum

Agua dulce ER	5%	76,795	3,840	76,795	3,840	8,655	1,352	21,025	8,923	Maximum
Aceite BR	5%	49,417	2,471	54,908	2,745	32,095	-17,140	21,095	17,168	Maximum
Aceite ER	5%	49,417	2,471	54,908	2,745	32,095	17,140	21,095	17,168	Maximum
FO UD BR	100%	92,783	92,783	95,653	95,653	36,305	-16,790	22,490	0,000	Maximum
FO UD ER	100%	92,783	92,783	95,653	95,653	36,305	16,790	22,490	0,000	Maximum
FO Sed. BR	91,87%	139,540	128,195	143,855	132,160	41,235	-16,440	21,924	63,776	Maximum
FO Sed. ER	91,87%	139,540	128,195	143,855	132,160	41,235	16,440	21,924	63,776	Maximum
Diesel BR	5%	382,873	19,144	425,414	21,271	47,627	-15,230	17,478	262,388	Maximum
Diesel ER	5%	382,873	19,144	425,414	21,271	47,627	15,230	17,478	262,388	Maximum
Aguas grises	100%	238,468	238,468	158,979	158,979	47,383	0,000	1,318	0,000	Maximum
Lodos	100%	113,158	113,158	75,439	75,439	40,477	0,000	1,302	0,000	Maximum
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	-2,340	2,500	0,000	IMO A.749(18)
FO Almacén	0%	2322,658	0,000	2394,493	0,000	251,111	2,340	2,500	0,000	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			844,930			41,734	0,000	13,265	704,509	
Tripulacion	1	5,250	5,250			57,000	0,000	39,200	0,000	User Specified
Perterechos	1	100,000	100,000			128,000	0,000	28,000	0,000	User Specified
Total pesos fijos			105,250			124,458	0,000	28,559	0,000	
Total Loadcase			92314,594	209406,816	54662,959	126,161	0,000	12,771	704,509	
FS correction								0,008		
VCG fluid								12,778		


Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 8,181 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 5,81 m at 48,2 deg.
2.2.4: Initial GMt GM at 0,0 deg = 8,181 m
Max GZ = 5,81 m at 48,2 deg.
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
GZ m
Heel to Starboard deg.
10
8
6
4
2
0
-2
-4
-6
-30
-20
-10
0
10
20
30
40
50
60

Heel to Starboard deg	-30,0	-20,0	-10,0	0,0	10,0	20,0	30,0	40,0	50,0	60,0
GZ m	-4,456	-2,925	-1,435	0,000	1,435	2,924	4,456	5,551	5,801	5,531
Area under GZ curve from zero heel m.deg	65,7823	28,8967	7,1480	0,0000	7,1546	28,8670	65,8855	116,5258	173,9269	230,8054
Displacement t	92310	92314	92314	92315	92315	92314	92314	92315	92314	92314
Draft at FP m	8,795	8,843	8,780	8,762	8,783	8,845	8,794	8,135	6,693	4,046
Draft at AP m	11,397	12,204	12,612	12,723	12,610	12,203	11,399	9,785	7,507	3,950
WL Length m	281,074	281,080	281,101	280,012	281,101	281,079	281,075	281,175	281,143	280,468
Beam max extents on WL m	45,495	45,797	43,850	43,194	43,850	45,797	45,496	40,874	35,368	33,871
Wetted Area m^2	13654,579	13704,697	13679,092	13665,229	13678,892	13704,744	13654,767	13520,509	13614,886	13512,757
Waterpl. Area m^2	10138,360	10147,600	9974,319	9901,574	9973,909	10147,534	10138,525	9691,155	8772,533	8522,516
Prismatic coeff. (Cp)	0,717	0,694	0,681	0,681	0,681	0,694	0,717	0,733	0,739	0,740
Block coeff. (Cb)	0,373	0,416	0,517	0,594	0,517	0,416	0,373	0,393	0,447	0,479
LCB from zero pt. (+ve fwd) m	126,094	126,065	126,053	126,059	126,061	126,069	126,088	126,124	126,144	126,168
LCF from zero pt. (+ve fwd) m	126,413	125,248	124,225	123,995	124,231	125,249	126,410	128,599	129,837	131,374
Max deck inclination deg	30,0035	20,0109	10,0322	0,8476	10,0321	20,0109	30,0035	40,0008	50,0001	60,0000
Trim angle (+ve by stern) deg	0,5567	0,7191	0,8197	0,8476	0,8188	0,7186	0,5574	0,3531	0,1741	-0,0205

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	20,8	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	65,8855	Pass	+1990,74
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	116,5258	Pass	+2159,74
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	50,6403	Pass	+2846,09
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	5,810	Pass	+2805,00
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	48,2	Pass	+92,73
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	8,181	Pass	+5354,00
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	0,3	Pass	+97,92
	Area1 / Area2 shall not be less than (>=)	100,00	%	537,21	Pass	+437,21

ANEXO IV

Cógido IS. MSC.

ANNEX 2

RESOLUTION MSC.267(85)
(adopted on 4 December 2008)

ADOPTION OF THE INTERNATIONAL CODE ON INTACT STABILITY, 2008
(2008 IS CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution A.749(18) entitled "Code on Intact Stability for All Types of Ships Covered by IMO Instruments", as amended by resolution MSC.75(69),

RECOGNIZING the need to update the aforementioned Code and the importance of establishing mandatory international intact stability requirements,

NOTING resolutions MSC.269(85) and MSC.270(85), by which it adopted, *inter alia*, amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended (hereinafter referred to as "the 1974 SOLAS Convention") and to the Protocol of 1988 relating to the International Convention on Load Lines, 1966 (hereinafter referred to as "the 1988 Load Lines Protocol"), respectively, to make the introduction and the provisions of part A of the International Code on Intact Stability, 2008 mandatory under the 1974 SOLAS Convention and the 1988 Load Lines Protocol,

HAVING CONSIDERED, at its eighty-fifth session, the text of the proposed International Code on Intact Stability, 2008,

1. ADOPTS the International Code on Intact Stability, 2008 (2008 IS Code), the text of which is set out in the Annex to the present resolution;

2. INVITES Contracting Governments to the 1974 SOLAS Convention and Parties to the 1988 Load Lines Protocol to note that the 2008 IS Code will take effect on 1 July 2010 upon the entry into force of the respective amendments to the 1974 SOLAS Convention and 1988 Load Lines Protocol;

3. REQUESTS the Secretary-General to transmit certified copies of the present resolution and the text of the 2008 IS Code contained in the Annex to all Contracting Governments to the 1974 SOLAS Convention and Parties to the 1988 Load Lines Protocol;

4. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and the Annex to all Members of the Organization which are not Contracting Governments to the 1974 SOLAS Convention or Parties to the 1988 Load Lines Protocol;

5. RECOMMENDS Governments concerned to use the recommendatory provisions contained in part B of the 2008 IS Code as a basis for relevant safety standards, unless their national stability requirements provide at least an equivalent degree of safety.

ANNEX

INTERNATIONAL CODE ON INTACT STABILITY, 2008 (2008 IS CODE)

CONTENTS

PREAMBLE

1 This Code has been assembled to provide, in a single document, mandatory requirements in the introduction and in part A and recommended provisions in part B relating to intact stability, based primarily on existing IMO instruments. Where recommendations in this Code appear to differ from other IMO Codes, the other Codes should be taken as the prevailing instrument. For the sake of completeness and for the convenience of the user, this Code also contains relevant provisions from mandatory IMO instruments.

2 Criteria included in the Code are based on the best "state-of-the-art" concepts, available at the time they were developed, taking into account sound design and engineering principles and experience gained from operating ships. Furthermore, design technology for modern ships is rapidly evolving and the Code should not remain static but should be re-evaluated and revised, as necessary. To this end, the Organization will periodically review the Code taking into consideration both experience and further development.

3 A number of influences such as the dead ship condition, wind on ships with large windage area, rolling characteristics, severe seas, etc., were taken into account based on the state-of-the-art technology and knowledge at the time of the development of the Code.

4 It was recognized that in view of a wide variety of types, sizes of ships and their operating and environmental conditions, problems of safety against accidents related to stability have generally not yet been solved. In particular, the safety of a ship in a seaway involves complex hydrodynamic phenomena which up to now have not been fully investigated and understood. Motion of ships in a seaway should be treated as a dynamical system and relationships between ship and environmental conditions like wave and wind excitations are recognized as extremely important elements. Based on hydrodynamic aspects and stability analysis of a ship in a seaway, stability criteria development poses complex problems that require further research.

INTRODUCTION

1 Purpose

1.1 The purpose of the Code is to present mandatory and recommendatory stability criteria and other measures for ensuring the safe operation of ships, to minimize the risk to such ships, to the personnel on board and to the environment. This introduction and part A of the Code address the mandatory criteria and part B contains recommendations and additional guidelines.

1.2 This Code contains intact stability criteria for the following types of ships and other marine vehicles of 24 m in length and above, unless otherwise stated:

.1 cargo ships;

.2 cargo ships carrying timber deck cargoes;

.3 passenger ships;

.4 fishing vessels;

.5 special purpose ships;

.6 offshore supply vessels;

.7 mobile offshore drilling units;

.8 pontoons; and

.9 cargo ships carrying containers on deck and containerships.

1.3 Administrations may impose additional requirements regarding the design aspects of ships of novel design or ships not otherwise covered by the Code.

2 Definitions

For the purpose of this Code the definitions given hereunder shall apply. For terms used, but not defined in this Code, the definitions as given in the 1974 SOLAS Convention, as amended, shall apply.

2.1 *Administration* means the Government of the State whose flag the ship is entitled to fly.

2.2 *Passenger ship* is a ship which carries more than twelve passengers as defined in regulation I/2 of the 1974 SOLAS Convention, as amended.

2.3 *Cargo ship* is any ship which is not a passenger ship, a ship of war and troopship, a ship which is not propelled by mechanical means, a wooden ship of primitive build, a fishing vessel or a mobile offshore drilling unit.

2.4 *Oil tanker* means a ship constructed or adapted primarily to carry oil in bulk in its cargo spaces and includes combination carriers and any chemical tanker as defined in Annex II of the MARPOL Convention when it is carrying a cargo or part cargo of oil in bulk.

2.4.1 *Combination carrier* means a ship designed to carry either oil or solid cargoes in bulk.

2.4.2 *Crude oil tanker* means an oil tanker engaged in the trade of carrying crude oil.

2.4.3 *Product carrier* means an oil tanker engaged in the trade of carrying oil other than crude oil.

2.5 *Fishing vessel* is a vessel used for catching fish, whales, seals, walrus or other living resources of the sea.

2.6 *Special purpose ship* has the same definition as in the Code of Safety for Special Purpose Ships, 2008 (resolution MSC.266(84)).

2.7 *Offshore supply vessel* means a vessel which is engaged primarily in the transport of stores, materials and equipment to offshore installations and designed with accommodation and bridge erections in the forward part of the vessel and an exposed cargo deck in the after part for the handling of cargo at sea.

2.8 *Mobile offshore drilling unit* (MODU or unit) is a ship capable of engaging in drilling operations for the exploration or exploitation of resources beneath the sea-bed such as liquid or gaseous hydrocarbons, sulphur or salt.

2.8.1 *Column-stabilized unit* is a unit with the main deck connected to the underwater hull or footings by columns or caissons.

2.8.2 *Surface unit* is a unit with a ship- or barge-type displacement hull of single or multiple hull construction intended for operation in the floating condition.

2.8.3 *Self-elevating unit* is a unit with moveable legs capable of raising its hull above the surface of the sea.

2.8.4 *Coastal State* means the Government of the State exercising administrative control over the drilling operations of the unit.

2.8.5 *Mode of operation* means a condition or manner in which a unit may operate or function while on location or in transit. The modes of operation of a unit include the following:

.1 *operating conditions* means conditions wherein a unit is on location for the purpose of conducting drilling operations, and combined environmental and operational loadings are within the appropriate design limits established for such operations. The unit may be either afloat or supported on the sea-bed, as applicable;

.2 *severe storm conditions* means conditions wherein a unit may be subjected to the most severe environmental loadings for which the unit is designed. Drilling operations are assumed to have been discontinued due to the severity of the environmental loadings, the unit may be either afloat or supported on the sea-bed, as applicable; and

.3 *transit conditions* means conditions wherein a unit is moving from one geographical location to another.

2.9 *High-speed craft* (HSC)[1] is a craft capable of a maximum speed, in metres per second (m/s), equal to or exceeding:

$$3.7 * \nabla^{0.1667}$$

where: ∇ = displacement corresponding to the design waterline (m^3).

2.10 *Containership* means a ship which is used primarily for the transport of marine containers.

2.11 *Freeboard* is the distance between the assigned load line and freeboard deck[2].

2.12 *Length of ship*. The length should be taken as 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or as the length from the fore side of the stem to the axis of the rudder stock on the waterline, if that be greater. In ships designed with a rake of keel the waterline on which this length is measured should be parallel to the designed waterline.

2.13 *Moulded breadth* is the maximum breadth of the ship measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

2.14 *Moulded depth* is the vertical distance measured from the top of the keel to the top of the freeboard deck beam at side. In wood and composite ships, the distance is measured from the lower edge of the keel rabbet. Where the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inwards cuts the side of the keel. In ships having rounded gunwales, the moulded depth should be measured to the point of intersection of the moulded lines of the deck and side shell plating, the lines extending as though the gunwale were of angular design. Where the freeboard deck is stepped and the raised part of the deck extends over the point at which the moulded depth is to be determined, the moulded depth should be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

2.15 *Near-coastal voyage* means a voyage in the vicinity of the coast of a State as defined by the Administration of that State.

---

[1] The Code of Safety for High-Speed Craft, 2000 (2000 HSC Code) has been developed following a thorough revision of the Code of Safety for High-Speed Craft, 1994 (1994 HSC Code) which was derived from the previous Code of Safety for Dynamically Supported Craft (DSC Code) adopted by IMO in 1977, recognizing that safety levels can be significantly enhanced by the infrastructure associated with regular service on a particular route, whereas the conventional ship safety philosophy relies on the ship being self-sustaining with all necessary emergency equipment being carried on board.

[2] For the purposes of application of chapters I and II of Annex I of the International Convention on Load Lines, 1966 or the Protocol of 1988 as amended, as applicable to open-top containerships, "freeboard deck" is the freeboard deck according to the International Convention on Load Lines, 1966 or the Protocol of 1988 as amended, as applicable as if hatch covers are fitted on top of the hatch cargo coamings.

2.16 *Pontoon* is considered to be normally:

.1 non self-propelled;

.2 unmanned;

.3 carrying only deck cargo;

.4 having a block coefficient of 0.9 or greater;

.5 having a breadth/depth ratio of greater than 3; and

.6 having no hatchways in the deck except small manholes closed with gasketed covers.

2.17 *Timber* means sawn wood or lumber, cants, logs, poles, pulpwood and all other types of timber in loose or packaged forms. The term does not include wood pulp or similar cargo.

2.18 *Timber deck cargo* means a cargo of timber carried on an uncovered part of a freeboard or superstructure deck. The term does not include wood pulp or similar cargo.[3]

2.19 *Timber load line* means a special load line assigned to ships complying with certain conditions related to their construction set out in the International Convention on Load Lines and used when the cargo complies with the stowage and securing conditions of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (resolution A.715(17)).

2.20 *Certification of the inclining test weights* is the verification of the weight marked on a test weight. Test weights should be certified using a certificated scale. The weighing should be performed close enough in time to the inclining test to ensure the measured weight is accurate.

2.21 *Draught* is the vertical distance from the moulded baseline to the waterline.

2.22 The *inclining test* involves moving a series of known weights, normally in the transverse direction, and then measuring the resulting change in the equilibrium heel angle of the ship. By using this information and applying basic naval architecture principles, the ship's vertical centre of gravity (VCG) is determined.

2.23 *Lightship condition* is a ship complete in all respects, but without consumables, stores, cargo, crew and effects, and without any liquids on board except that machinery and piping fluids, such as lubricants and hydraulics, are at operating levels.

2.24 A *lightweight survey* involves taking an audit of all items which should be added, deducted or relocated on the ship at the time of the inclining test so that the observed condition of the ship can be adjusted to the lightship condition. The mass, longitudinal, transverse and vertical location of each item should be accurately determined and recorded. Using this information, the static waterline of the ship at the time of the inclining test as determined from measuring the freeboard or verified draught marks of the ship, the ship's hydrostatic data, and the

[3] Refer to regulation 42(1) of the International Convention on Load Lines, 1966 or the Protocol of 1988 as amended, as applicable.

sea water density, the lightship displacement and longitudinal centre of gravity (LCG) can be obtained. The transverse centre of gravity (TCG) may also be determined for mobile offshore drilling units (MODUs) and other ships which are asymmetrical about the centreline or whose internal arrangement or outfitting is such that an inherent list may develop from off-centre mass.

2.25 An *in-service inclining test* means an inclining test which is performed in order to verify the pre-calculated GM_C and the deadweight's centre of gravity of an actual loading condition.

2.26 A *stability instrument* is an instrument installed on board a particular ship by means of which it can be ascertained that stability requirements specified for the ship in the Stability Booklet are met in any operational loading condition. A Stability Instrument comprises hardware and software.

PART A

MANDATORY CRITERIA

CHAPTER 1 – GENERAL

1.1 Application

1.1.1 The criteria stated under chapter 2 of this part present a set of minimum requirements that shall apply to cargo[4] and passenger ships of 24 m in length and over.

1.1.2 The criteria stated under chapter 3 are special criteria for certain types of ships. For the purpose of part A the definitions given in the Introduction apply.

1.2 Dynamic stability phenomena in waves

Administrations shall be aware that some ships are more at risk of encountering critical stability situations in waves. Necessary precautionary provisions may need to be taken in the design to address the severity of such phenomena. The phenomena in seaways which may cause large roll angles and/or accelerations have been identified hereunder.

Having regard to the phenomena described in this section, the Administration may for a particular ship or group of ships apply criteria demonstrating that the safety of the ship is sufficient. Any Administration which applies such criteria should communicate to the Organization particulars thereof. It is recognized by the Organization that performance oriented criteria for the identified phenomena listed in this section need to be developed and implemented to ensure a uniform international level of safety.

1.2.1 *Righting lever variation*

Any ship exhibiting large righting lever variations between wave trough and wave crest condition may experience parametric roll or pure loss of stability or combinations thereof.

1.2.2 *Resonant roll in dead ship condition*

Ships without propulsion or steering ability may be endangered by resonant roll while drifting freely.

1.2.3 *Broaching and other manoeuvring related phenomena*

Ships in following and quartering seas may not be able to keep constant course despite maximum steering efforts which may lead to extreme angles of heel.

---

[4] For containerships of 100 m in length and over, provisions of chapter 2.3 of part B may be applied as an alternative to the application of chapter 2.2 of this part. Offshore supply vessels and special purpose ships are not required to comply with provisions of chapter 2.3 of part A. For offshore supply vessels, provisions of chapter 2.4 of part B may be applied as an alternative to the application of chapter 2.2 of this part. For special purpose ships, provisions of chapter 2.5 of part B may be applied as an alternative to the application of chapter 2.2 of this part.

CHAPTER 2 – GENERAL CRITERIA

2.1 General

2.1.1 All criteria shall be applied for all conditions of loading as set out in part B, 3.3 and 3.4.

2.1.2 Free surface effects (part B, 3.1) shall be accounted for in all conditions of loading as set out in part B, 3.3 and 3.4.

2.1.3 Where anti-rolling devices are installed in a ship, the Administration shall be satisfied that the criteria can be maintained when the devices are in operation and that failure of power supply or the failure of the device(s) will not result in the vessel being unable to meet the relevant provisions of this Code.

2.1.4 A number of influences such as icing of topsides, water trapped on deck, etc., adversely affect stability and the Administration is advised to take these into account, so far as is deemed necessary.

2.1.5 Provisions shall be made for a safe margin of stability at all stages of the voyage, regard being given to additions of weight, such as those due to absorption of water and icing (details regarding ice accretion are given in part B, chapter 6 – Icing considerations) and to losses of weight such as those due to consumption of fuel and stores.

2.1.6 Each ship shall be provided with a stability booklet, approved by the Administration, which contains sufficient information (see part B, 3.6) to enable the master to operate the ship in compliance with the applicable requirements contained in the Code. If a stability instrument is used as a supplement to the stability booklet for the purpose of determining compliance with the relevant stability criteria such instrument shall be subject to the approval by the Administration (see part B, chapter 4 – Stability calculations performed by stability instruments).

2.1.7 If curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) are used to ensure compliance with the relevant intact stability criteria those limiting curves shall extend over the full range of operational trims, unless the Administration agrees that trim effects are not significant. When curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) versus draught covering the operational trims are not available, the master must verify that the operating condition does not deviate from a studied loading condition, or verify by calculation that the stability criteria are satisfied for this loading condition taking into account trim effects.

2.2 Criteria regarding righting lever curve properties

2.2.1 The area under the righting lever curve (GZ curve) shall not be less than 0.055 metre-radians up to $\varphi = 30°$ angle of heel and not less than 0.09 metre-radians up to $\varphi = 40°$ or the angle of down-flooding φ_f[5] if this angle is less than 40°. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and φ_f, if this angle is less than 40°, shall not be less than 0.03 metre-radians.

2.2.2 The righting lever GZ shall be at least 0.2 m at an angle of heel equal to or greater than 30°.

---

[5] φ_f is an angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

2.2.3 The maximum righting lever shall occur at an angle of heel not less than 25°. If this is not practicable, alternative criteria, based on an equivalent level of safety[6], may be applied subject to the approval of the Administration.

2.2.4 The initial metacentric height GM_0 shall not be less than 0.15 m.

2.3 Severe wind and rolling criterion (weather criterion)

2.3.1 The ability of a ship to withstand the combined effects of beam wind and rolling shall be demonstrated, with reference to figure 2.3.1 as follows:

.1 the ship is subjected to a steady wind pressure acting perpendicular to the ship's centreline which results in a steady wind heeling lever (l_{w1});

.2 from the resultant angle of equilibrium (φ_0), the ship is assumed to roll owing to wave action to an angle of roll (φ_1) to windward. The angle of heel under action of steady wind (φ_0) should not exceed 16° or 80% of the angle of deck edge immersion, whichever is less;

.3 the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever (l_{w2}); and

.4 under these circumstances, area *b* shall be equal to or greater than area *a*, as indicated in figure 2.3.1 below:

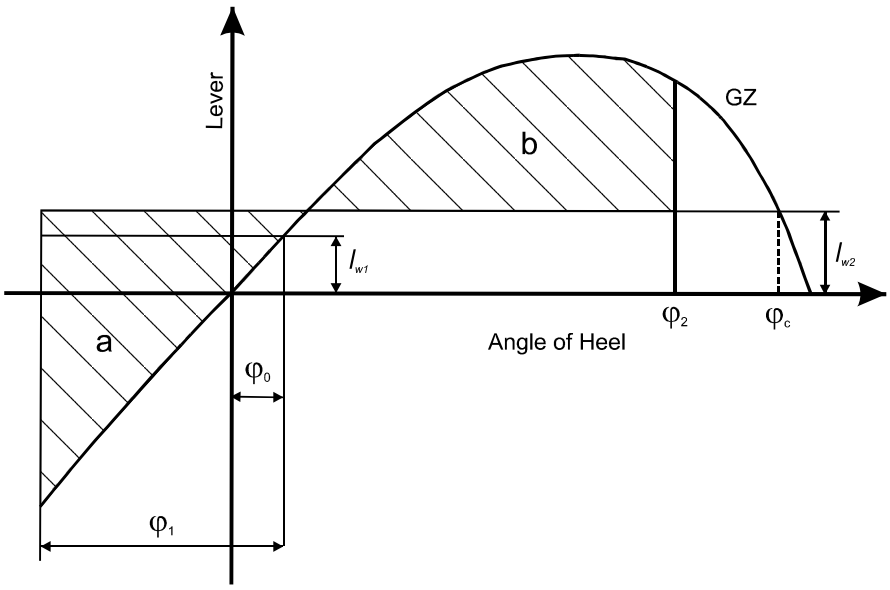


Figure 2.3.1 – Severe wind and rolling

6 Refer to the Explanatory Notes to the International Code on Intact Stability, 2008 (MSC.1/Circ.1281).

where the angles in figure 2.3.1 are defined as follows:

φ_0 = angle of heel under action of steady wind

φ_1 = angle of roll to windward due to wave action (see 2.3.1.2, 2.3.4 and footnote 6)

φ_2 = angle of down-flooding (φ_f) or 50° or φ_c, whichever is less,

where:

φ_f = angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open

φ_c = angle of second intercept between wind heeling lever l_{w2} and GZ curves.

2.3.2 The wind heeling levers l_{w1} and l_{w2} referred to in 2.3.1.1 and 2.3.1.3 are constant values at all angles of inclination and shall be calculated as follows:

$$l_{w_1} = \frac{P * A * Z}{1000 * g * \Delta} \quad (m) \quad \text{and}$$

$$l_{w_2} = 1.5 * l_{w_1} \quad (m)$$

where:

P = wind pressure of 504 Pa. The value of P used for ships in restricted service may be reduced subject to the approval of the Administration

A = projected lateral area of the portion of the ship and deck cargo above the waterline (m^2)

Z = vertical distance from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the mean draught (m)

Δ = displacement (t)

g = gravitational acceleration of 9.81 m/s^2.

2.3.3 Alternative means for determining the wind heeling lever (l_{w1}) may be accepted, to the satisfaction of the Administration, as an equivalent to calculation in 2.3.2. When such alternative tests are carried out, reference shall be made based on the Guidelines developed by the Organization[7]. The wind velocity used in the tests shall be 26 m/s in full scale with uniform velocity profile. The value of wind velocity used for ships in restricted services may be reduced to the satisfaction of the Administration.

[7] Refer to the Interim Guidelines for alternative assessment of the weather criterion (MSC.1/Circ.1200).

2.3.4 The angle of roll (φ_1)[8] referred to in 2.3.1.2 shall be calculated as follows:

$$\varphi_1 = 109 * k * X_1 * X_2 * \sqrt{r * s} \quad (degrees)$$

where:

X_1 = factor as shown in table 2.3.4-1

X_2 = factor as shown in table 2.3.4-2

k = factor as follows:

k = 1.0 for round-bilged ship having no bilge or bar keels

k = 0.7 for a ship having sharp bilges

k = as shown in table 2.3.4-3 for a ship having bilge keels, a bar keel or both

r = $0.73 + 0.6\ OG/d$

with:

OG = KG – d

d = mean moulded draught of the ship (m)

s = factor as shown in table 2.3.4-4, where T is the ship roll natural period. In absence of sufficient information, the following approximate formula can be used:

Rolling period $$T = \frac{2 * C * B}{\sqrt{GM}} \ (s)$$

where:

C = $0.373 + 0.023(B/d) - 0.043(L_{wl}/100)$.

The symbols in tables 2.3.4-1, 2.3.4-2, 2.3.4-3 and 2.3.4-4 and the formula for the rolling period are defined as follows:

L_{wl} = length of the ship at waterline (m)

B = moulded breadth of the ship (m)

d = mean moulded draught of the ship (m)

[8] The angle of roll for ships with anti-rolling devices should be determined without taking into account the operation of these devices unless the Administration is satisfied with the proof that the devices are effective even with sudden shutdown of their supplied power.

C_B = block coefficient (-)

A_k = total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas (m²)

GM = metacentric height corrected for free surface effect (m).

Table 2.3.4-1 – Values of factor X_1

B/d	X_1
≤ 2.4	1.0
2.5	0.98
2.6	0.96
2.7	0.95
2.8	0.93
2.9	0.91
3.0	0.90
3.1	0.88
3.2	0.86
3.4	0.82
≥ 3.5	0.80

Table 2.3.4-2 – Values of factor X_2

C_B	X_2
≤ 0.45	0.75
0.50	0.82
0.55	0.89
0.60	0.95
0.65	0.97
≥ 0.70	1.00

Table 2.3.4-3 – Values of factor k

$\frac{A_k \times 100}{L_{WL} \times B}$	k
0	1.0
1.0	0.98
1.5	0.95
2.0	0.88
2.5	0.79
3.0	0.74
3.5	0.72
≥ 4.0	0.70

Table 2.3.4-4 – Values of factor *s*

T	*s*
≤ 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
≥ 20	0.035

(Intermediate values in these tables shall be obtained by linear interpolation)

2.3.5 The tables and formulae described in 2.3.4 are based on data from ships having:

.1 *B/d* smaller than 3.5;

.2 *(KG/d-1)* between - 0.3 and 0.5; and

.3 *T* smaller than 20 s.

For ships with parameters outside of the above limits the angle of roll (φ_1) may be determined with model experiments of a subject ship with the procedure described in MSC.1/Circ.1200 as the alternative. In addition, the Administration may accept such alternative determinations for any ship, if deemed appropriate.