UNIVERSIDADE DA CORUÑA

Escola Politécnica Superior

Trabajo Fin de Máster

CURSO 2016/2017

BUQUE LNG DE MEMBRANA DE 145.000 m³

Máster en Ingeniería Naval y Oceánica

ALUMNA/O

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FECHA

SEPTIEMBRE DE 2017

CUADERNO 5

En el presente cuaderno realizaremos el estudio de las condiciones de carga del buque, desglosando cada una en partidas de pesos varios. Se estudiará que el buque cumple con los criterios de estabilidad aplicables.

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TRABAJO FIN DE MÁSTER

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BUQUE LNG DE MEMBRANA DE 145.000 m³

Máster en Ingeniería Naval y Oceánica

CUADERNO 5

SITUACIONES DE CARGA

Escola Politécnica Superior
UNIVERSIDADE DA CORUÑA

DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

TRABAJO FIN DE MÁSTER

CURSO 2016-2017

PROYECTO NÚMERO: 17-32 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 m³.

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 2017

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 (Eq. Y hab.)	5.540,55	31,2	141,88
Maquinaria	1.754,55	11,42	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 (cargados o no según convenga).
- 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.

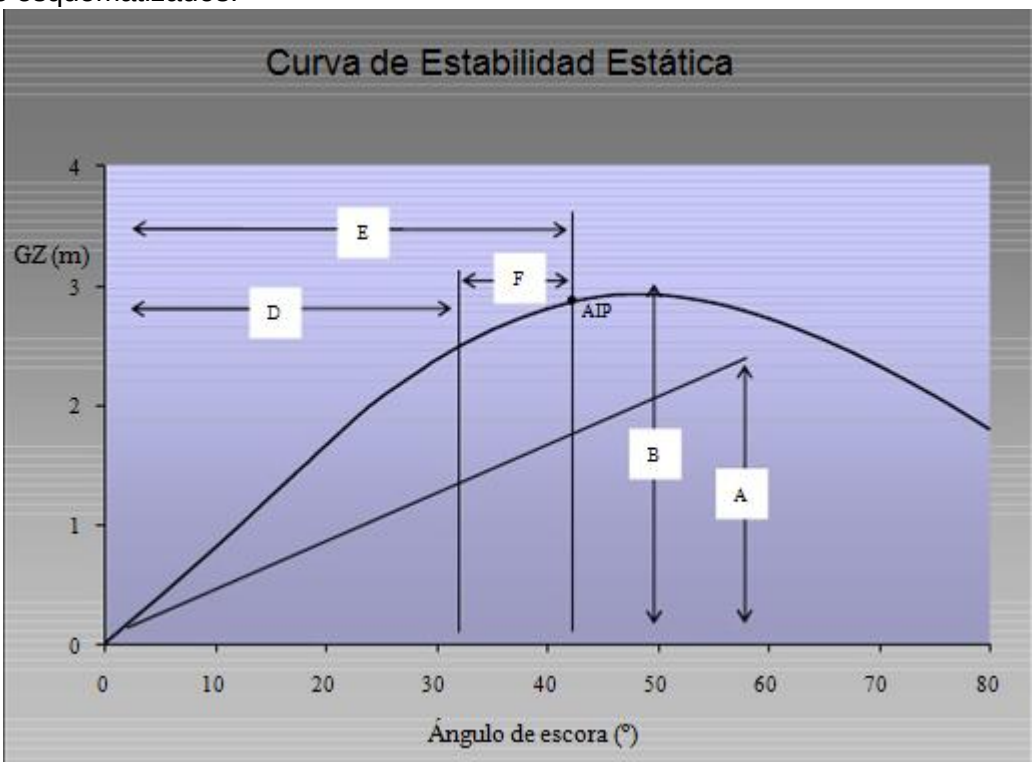
E) $d_{40\ o\ AIP}$ (brazo de estabilidad dinámica) ≥ 0,090 m·rad.

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) $d_{40\ o\ AIP-30}$ (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*.

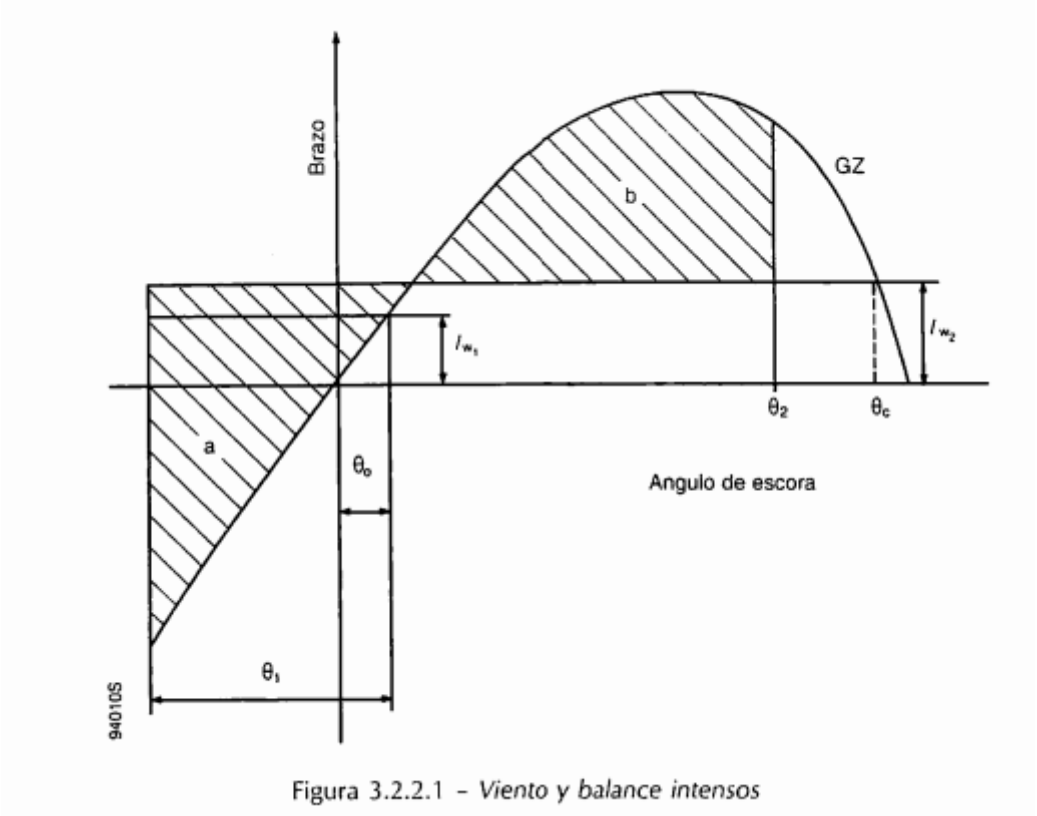


Figura 3.2.2.1 – *Viento y balance intensos*

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 (m²).

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/s²).

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 = 5699 m²

Z = 6,68 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 268,896 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. Deberá procurarse que la inmersión de las puntas de las palas, en su recorrido, sea el 10 % del diámetro, en todos los estados de carga, para evitar las grandes pérdidas en rendimiento propulsivo que tienen lugar para inmersiones muy pequeñas de la hélice.

Diámetro de la hélice: 8 m.

Distancia del punto más alto de la hélice a la línea base: 8,59 m.

10 % del diámetro de la hélice = 0,8 m.

Por tanto, tenemos que:

$$T_{pp} \geq 8{,}59 + 0{,}8 = 9{,}39\ m.$$

-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:

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

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

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

$k = \frac{\cos\theta}{8}\left(1 - \frac{\tan\theta}{b/h}\right) - \frac{\cot\theta}{12(b/h)^2}\left(1 - \frac{\cot^2}{2}\right)$ 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 (37.887 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	CORREGIE
Tangue 4	LNG	0,430	38432,766	40,700	37,136	28,968	43783,255	0,878	1,282	0,062	35856,519	0,946	SÍ
Tangue 3	LNG	0,430	43673,601	46,250	37,136	28,968	49753,699	0,878	1,282	0,062	40746,049	1,075	SÍ
Tangue 2	LNG	0,430	43673,601	46,250	37,136	28,968	49753,699	0,878	1,282	0,062	40746,049	1,075	SÍ
Tangue 1	LNG	0,430	28004,938	35,150	37,136	28,968	37812,811	0,741	1,282	0,062	23999,496	0,633	SÍ
FO Alm.	Fuel Oil	0,970	3428,012	14,100	16,194	20,300	4635,209	0,740	0,798	0,026	1192,891	0,031	SÍ
FO Sed.	Fuel Oil	0,970	148,305	5,230	5,600	4,440	130,039	1,000	1,261	0,058	46,660	0,001	NO
FO UD	Fuel Oil	0,970	98,611	4,620	4,800	4,620	102,453	1,000	1,039	0,050	22,957	0,001	NO
Diesel	Diesel	0,900	424,972	7,510	7,740	7,510	436,537	1,000	1,031	0,051	151,689	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	0,096	65,487	0,002	NO
Aguas grises	Aguas gr.	1,500	163,890	8,080	8,080	2,500	163,216	1,000	3,232	0,110	218,498	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			36.704
Carga		97	63691,917
Consumos			
	Fuel Alm. (2x)	97	6257,31
	Fuel Sed. (2x)	100	293,768
	Fuel UD (2x)	100	192,796
	Diesel (2x)	100	767,59
	Aceite (2x)	100	98,834
	Agua dulce (2x)	100	154,472
	Aguas gr.	0	0
	Lodos	0	0
Lastre		0	
Víveres		100	4,375
Pesos fijos			105,25
TOTAL Δ			108.270

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

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			36.704
Carga		0	0
Consumos			
	Fuel Alm. (2x)	97	6257,31
	Fuel Sed. (2x)	100	293,768
	Fuel UD (2x)	100	191,796
	Diesel (2x)	100	767,59
	Aceite (2x)	100	98,834
	Agua dulce (2x)	100	154,472
	Aguas gr.	0	0
	Lodos	0	0
Lastre		100	48364,661
Víveres		100	4,375
Pesos fijos			105,25
TOTAL Δ			92.942

En esta condición corrigen los tanques almacén de fuel.

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 100 % y los de almacén al 3,53 %). Las parejas de tanques se consumirán simultáneamente. Lodos y aguas grises al 100 %.

Resumen de la condición:

CC3		**%**	**Peso (t)**
Rosca			36.704
Carga		97	63691,923
Consumos			
	Fuel Alm. (2x)	3,52	227,714
	Fuel Sed. (2x)	100	293,768
	Fuel UD (2x)	100	192,796
	Diesel (2x)	10 (5+5)	38,38
	Aceite (2x)	10 (5+5)	4,942
	Agua dulce (2x)	10 (5+5)	7,724
	Aguas gr.	100	247,326
	Lodos	100	110,858
Lastre		0	
Víveres		10	0,4375
Pesos fijos			105,25
TOTAL Δ			101.625

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

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 100 % y los de almacén al 3,53 %) Las parejas de tanques se consumirán simultáneamente. Lodos y aguas grises al 100 %.

Resumen de la condición:

CC4		%	Peso (t)
Rosca			36.704
Carga		0	0
Consumos			
	Fuel Alm. (2x)	3,52	227,714
	Fuel Sed. (2x)	100	293,768
	Fuel UD (2x)	100	192,796
	Diesel (2x)	10 (5+5)	38,38
	Aceite (2x)	10 (5+5)	4,942
	Agua dulce (2x)	10 (5+5)	7,724
	Aguas gr.	100	247,326
	Lodos	100	110,858
Lastre		100	52605,202
Víveres		10	0,4375
Pesos fijos			105,25
TOTAL Δ			90.538

En esta condición corrigen los tanques de almacén de fuel.

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.)	108.259	92.943	101.632	90.544
t(apopante) = 4,0383 m.	-2,071	0,692	1,536	2,319
Tpp = 9,39 m.	11,301	11,093	12,339	11,621
Tpr = 7,394 m.	13,371	10,401	10,803	9,302
Criterio (GMo ≥ 0,150 m.)	1,815	8,623	2,22	8,968
Criterio (GZ ≥ 0,200 m., α ≥ 30°)	1,608	6,525	1,702	6,639
Criterio (Gzmáx, α ≥ 25°)	38,2	50	38,2	50
Criterio (d30 ≥ 3,15 m·deg)	18,00	71,11	20,74	73,57
Criterio (d40 ≥ 5,15 m·deg)	33,39	126,58	37,21	130,16
Criterio (d40-d30 ≥ 1,71 m·deg)	15,38	55,47	16,47	56,59

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.

En este caso, hemos lastrado los cofferdams 1 y 2, puesto que de no hacerlo (como en la condición de carga 2), superaríamos el asiento apopante permitido, como podemos ver en la siguiente tabla:

1	Draft Amidships m	9,978
2	Displacement t	86303
3	Heel deg	0,0
4	Draft at FP m	7,832
5	Draft at AP m	12,124
6	Draft at LCF m	10,133
7	Trim (+ve by stern) m	4,292
8	WL Length m	282,206
9	Beam max extents on	43,187
10	Wetted Area m^2	13365,8
11	Waterpl. Area m^2	9959,78
12	Prismatic coeff. (Cp)	0,686
13	Block coeff. (Cb)	0,598
14	Max Sect. area coeff. (	0,922
15	Waterpl. area coeff. (C	0,817
16	LCB from zero pt. (+ve	124,949
17	LCF from zero pt. (+ve	124,195
18	KB m	5,486
19	KG fluid m	11,529
20	BMt m	15,819
21	BML m	568,215
22	GMt corrected m	9,776
23	GML m	562,172
24	KMt m	21,304
25	KML m	573,628
26	Immersion (TPc) tonne/	102,088
27	MTc tonne.m	1811,92
28	RM at 1deg = GMt.Disp.	14724,9
29	Max deck inclination de	0,9183
30	Trim angle (+ve by ster	0,9183

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

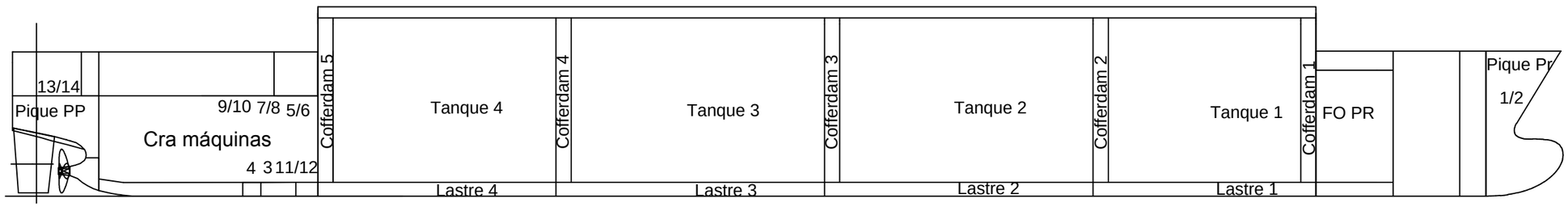
-CIG

-Código IS. MSC

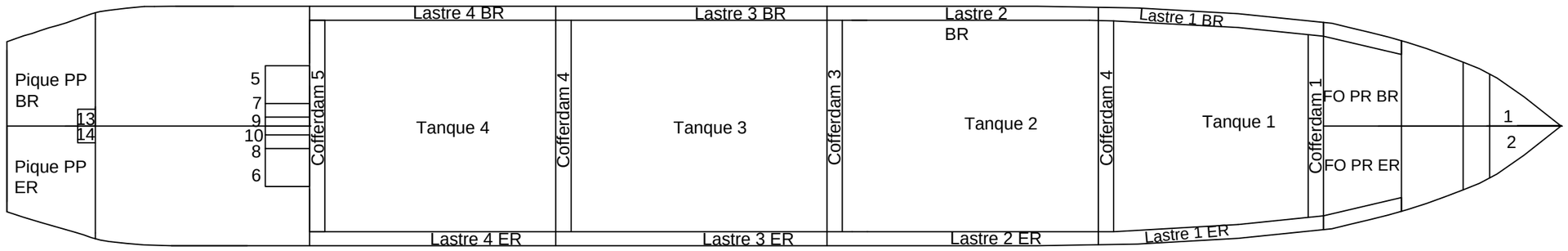
-Diverso material web

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:
17-32 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 - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	97%	16408,559	15916,303	38159,440	37014,657	74,485	0,000	16,594	60772,620	IMO A.749(18)
Tanque 3	97%	18646,092	18086,711	43363,003	42062,118	120,735	0,000	16,594	69059,801	IMO A.749(18)
Tanque 2	97%	18646,092	18086,709	43363,003	42062,113	169,760	0,000	16,594	69059,801	IMO A.749(18)
Tanque 1	97%	11961,030	11602,199	27816,349	26981,857	212,060	0,000	16,540	40699,562	IMO A.749(18)
Total carga	97%	65661,773	63691,921	152701,796	148120,745	139,735	0,000	16,584	239591,784	
Pique PP BR	0%	1728,991	0,000	1686,821	0,000	10,794	-1,532	8,029	0,000	User Specified
Pique PP ER	0%	1728,991	0,000	1686,821	0,000	10,794	1,532	8,029	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	0%	2666,833	0,000	2601,789	0,000	194,272	0,000	3,032	0,000	User Specified
Cofferdam 1	0%	1573,708	0,000	1535,325	0,000	232,157	0,000	3,032	0,000	User Specified
Pique PR BR	0%	581,031	0,000	566,859	0,000	269,203	-0,776	2,500	0,000	User Specified
Pique PR ER	0%	581,031	0,000	566,859	0,000	269,203	0,776	2,500	0,000	User Specified
Lastre 4 BR	0%	5014,252	0,000	4891,953	0,000	66,028	-0,013	0,000	0,000	User Specified
Lastre 4 ER	0%	5014,252	0,000	4891,953	0,000	66,028	0,013	0,000	0,000	User Specified
Lastre 3 BR	0%	6457,632	0,000	6300,129	0,000	95,113	-0,048	0,029	0,000	User Specified
Lastre 3 ER	0%	6457,632	0,000	6300,129	0,000	95,113	0,048	0,029	0,000	User Specified
Lastre 2 BR	0%	6146,861	0,000	5996,938	0,000	144,542	-3,597	0,046	0,000	User Specified
Lastre 2 ER	0%	6146,861	0,000	5996,938	0,000	144,542	3,597	0,046	0,000	User Specified
Lastre 1 BR	0%	4253,564	0,000	4149,819	0,000	200,429	-0,099	0,046	0,000	User Specified
Lastre 1 ER	0%	4253,564	0,000	4149,819	0,000	200,429	0,099	0,046	0,000	User Specified
Total lastre	0%	60566,752	0,000	59089,514	0,000	0,000	0,000	0,000	0,000	

Agua dulce BR	100%	77,236	77,236	77,236	77,236	9,610	-1,750	21,550	0,000	User Specified
Agua dulce ER	100%	77,236	77,236	77,236	77,236	9,610	1,750	21,550	0,000	User Specified
Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	20,200	0,000	User Specified
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	20,200	0,000	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	0,000	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	0,000	User Specified
Diesel BR	100%	383,795	383,795	426,439	426,439	47,608	-15,200	22,055	0,000	User Specified
Diesel ER	100%	383,795	383,795	426,439	426,439	47,608	15,200	22,055	0,000	User Specified
Aguas grises	0%	247,326	0,000	164,884	0,000	51,307	0,000	0,041	0,000	User Specified
Lodos	0%	110,858	0,000	73,905	0,000	41,955	0,000	0,510	0,000	User Specified
FO Almacén BR	97%	3225,417	3128,655	3325,172	3225,417	240,185	-6,205	13,372	2940,961	IMO A.749(18)
FO Almacén ER	97%	3225,417	3128,655	3325,172	3225,417	240,185	6,205	13,372	2940,961	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			7769,146			201,241	0,000	14,961	5881,922	
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			108270,287	220299,223	156190,358	135,533	0,000	15,403	245473,706	
FS correction								2,267		
VCG fluid								17,670		

Draft Amidships m	12,336
Displacement t	108259
Heel deg	0,0
Draft at FP m	13,371
Draft at AP m	11,301
Draft at LCF m	12,277
Trim (+ve by stern) m	-2,071
WL Length m	271,858
Beam max extents on WL m	43,196
Wetted Area m^2	14669,309
Waterpl. Area m^2	9957,889
Prismatic coeff. (Cp)	0,734
Block coeff. (Cb)	0,676
Max Sect. area coeff. (Cm)	0,987
Waterpl. area coeff. (Cwp)	0,848
LCB from zero pt. (+ve fwd) m	135,618
LCF from zero pt. (+ve fwd) m	126,224
KB m	6,600
KG fluid m	17,670
BMt m	12,886
BML m	442,656
GMt corrected m	1,815
GML m	431,586
KMt m	19,486
KML m	449,243
Immersion (TPc) tonne/cm	102,068
MTc tonne.m	1744,922
RM at 1deg = GMt.Disp.sin(1) tonne.m	3430,087
Max deck inclination deg	0,4431
Trim angle (+ve by stern) deg	-0,4431

Equilibrium Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	0%	16408,559	0,000	38159,440	0,000	74,485	0,000	3,032	0,000	User Specified
Tanque 3	0%	18646,092	0,000	43363,003	0,000	120,735	0,000	3,032	0,000	User Specified
Tanque 2	0%	18646,092	0,000	43363,003	0,000	169,760	0,000	3,032	0,000	User Specified
Tanque 1	0%	11961,030	0,000	27816,349	0,000	211,541	0,000	3,032	0,000	User Specified
Total carga	0%	65661,773	0,000	152701,796	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	1728,991	1728,991	1686,821	1686,821	4,740	-7,841	14,783	0,000	User Specified
Pique PP ER	100%	1728,991	1728,991	1686,821	1686,821	4,740	7,841	14,783	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	0%	2666,833	0,000	2601,789	0,000	194,272	0,000	3,032	0,000	User Specified
Cofferdam 1	0%	1573,708	0,000	1535,325	0,000	232,157	0,000	3,032	0,000	User Specified
Pique PR BR	100%	581,031	581,031	566,859	566,859	268,686	-1,906	16,155	0,000	User Specified
Pique PR ER	100%	581,031	581,031	566,859	566,859	268,686	1,906	16,155	0,000	User Specified
Lastre 4 BR	100%	5014,252	5014,252	4891,953	4891,953	73,863	-15,611	9,342	0,000	User Specified
Lastre 4 ER	100%	5014,252	5014,252	4891,953	4891,953	73,863	15,611	9,342	0,000	User Specified
Lastre 3 BR	100%	6457,632	6457,632	6300,129	6300,129	119,611	-15,946	8,500	0,000	User Specified
Lastre 3 ER	100%	6457,632	6457,632	6300,129	6300,129	119,611	15,946	8,500	0,000	User Specified
Lastre 2 BR	100%	6146,861	6146,861	5996,938	5996,938	167,618	-15,733	8,698	0,000	User Specified
Lastre 2 ER	100%	6146,861	6146,861	5996,938	5996,938	167,618	15,733	8,698	0,000	User Specified
Lastre 1 BR	100%	4253,564	4253,564	4149,819	4149,819	213,247	-13,942	11,812	0,000	User Specified
Lastre 1 ER	100%	4253,564	4253,564	4149,819	4149,819	213,247	13,942	11,812	0,000	User Specified
Total lastre	79,85%	60566,752	48364,661	59089,514	47185,035	134,167	0,000	9,941	0,000	
Agua dulce BR	100%	77,236	77,236	77,236	77,236	9,610	-1,750	21,550	0,000	User Specified
Agua dulce ER	100%	77,236	77,236	77,236	77,236	9,610	1,750	21,550	0,000	User Specified

Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	20,200	0,000	User Specified
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	20,200	0,000	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	0,000	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	0,000	User Specified
Diesel BR	100%	383,795	383,795	426,439	426,439	47,608	-15,200	22,055	0,000	User Specified
Diesel ER	100%	383,795	383,795	426,439	426,439	47,608	15,200	22,055	0,000	User Specified
Aguas grises	0%	247,326	0,000	164,884	0,000	51,307	0,000	0,041	0,000	User Specified
Lodos	0%	110,858	0,000	73,905	0,000	41,955	0,000	0,510	0,000	User Specified
FO Almacén BR	97%	3225,417	3128,655	3325,172	3225,417	240,185	-6,205	13,372	2940,961	IMO A.749(18)
FO Almacén ER	97%	3225,417	3128,655	3325,172	3225,417	240,185	6,205	13,372	2940,961	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			7769,146			201,241	0,000	14,961	5881,922	
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			92943,027	220299,223	55254,649	131,943	0,000	11,751	5881,922	
FS correction								0,063		
VCG fluid								11,814		

Draft Amidships m	10,747
Displacement t	92943
Heel deg	0,0
Draft at FP m	10,401
Draft at AP m	11,093
Draft at LCF m	10,766
Trim (+ve by stern) m	0,692
WL Length m	276,534
Beam max extents on WL m	43,190
Wetted Area m^2	13725,658
Waterpl. Area m^2	9847,548
Prismatic coeff. (Cp)	0,714
Block coeff. (Cb)	0,694
Max Sect. area coeff. (Cm)	0,991
Waterpl. area coeff. (Cwp)	0,825
LCB from zero pt. (+ve fwd) m	131,922
LCF from zero pt. (+ve fwd) m	126,397
KB m	5,776
KG fluid m	11,814
BMt m	14,662
BML m	505,015
GMt corrected m	8,624
GML m	498,976
KMt m	20,438
KML m	510,789
Immersion (TPc) tonne/cm	100,937
MTc tonne.m	1731,969
RM at 1deg = GMt.Disp.sin(1) tonne.m	13988,175
Max deck inclination deg	0,1481
Trim angle (+ve by stern) deg	0,1481

Equilibrium Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	97%	16408,559	15916,303	38159,440	37014,658	74,485	0,000	16,594	60772,620	IMO A.749(18)
Tanque 3	97%	18646,092	18086,710	43363,003	42062,115	120,735	0,000	16,594	69059,801	IMO A.749(18)
Tanque 2	97%	18646,092	18086,710	43363,003	42062,116	169,760	0,000	16,594	69059,801	IMO A.749(18)
Tanque 1	97%	11961,030	11602,199	27816,349	26981,858	212,060	0,000	16,540	40699,562	IMO A.749(18)
Total carga	97%	65661,773	63691,922	152701,796	148120,747	139,735	0,000	16,584	239591,784	
Pique PP BR	0%	1728,991	0,000	1686,821	0,000	10,794	-1,532	8,029	0,000	User Specified
Pique PP ER	0%	1728,991	0,000	1686,821	0,000	10,794	1,532	8,029	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	0%	2666,833	0,000	2601,789	0,000	194,272	0,000	3,032	0,000	User Specified
Cofferdam 1	0%	1573,708	0,000	1535,325	0,000	232,157	0,000	3,032	0,000	User Specified
Pique PR BR	0%	581,031	0,000	566,859	0,000	269,203	-0,776	2,500	0,000	User Specified
Pique PR ER	0%	581,031	0,000	566,859	0,000	269,203	0,776	2,500	0,000	User Specified
Lastre 4 BR	0%	5014,252	0,000	4891,953	0,000	66,028	-0,013	0,000	0,000	User Specified
Lastre 4 ER	0%	5014,252	0,000	4891,953	0,000	66,028	0,013	0,000	0,000	User Specified
Lastre 3 BR	0%	6457,632	0,000	6300,129	0,000	95,113	-0,048	0,029	0,000	User Specified
Lastre 3 ER	0%	6457,632	0,000	6300,129	0,000	95,113	0,048	0,029	0,000	User Specified
Lastre 2 BR	0%	6146,861	0,000	5996,938	0,000	144,542	-3,597	0,046	0,000	User Specified
Lastre 2 ER	0%	6146,861	0,000	5996,938	0,000	144,542	3,597	0,046	0,000	User Specified
Lastre 1 BR	0%	4253,564	0,000	4149,819	0,000	200,429	-0,099	0,046	0,000	User Specified
Lastre 1 ER	0%	4253,564	0,000	4149,819	0,000	200,429	0,099	0,046	0,000	User Specified
Total lastre	0%	60566,752	0,000	59089,514	0,000	0,000	0,000	0,000	0,000	
Agua dulce BR	10%	77,236	3,862	77,236	3,862	9,610	-1,750	18,462	12,505	User Specified
Agua dulce ER	10%	77,236	3,862	77,236	3,862	9,610	1,750	18,462	12,505	User Specified

Aceite BR	10%	49,417	2,471	54,908	2,745	32,095	-17,140	18,395	17,168	User Specified
Aceite ER	10%	49,417	2,471	54,908	2,745	32,095	17,140	18,395	17,168	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	63,776	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	63,776	User Specified
Diesel BR	10%	383,795	19,190	426,439	21,322	47,608	-15,200	18,488	267,113	User Specified
Diesel ER	10%	383,795	19,190	426,439	21,322	47,608	15,200	18,488	267,113	User Specified
Aguas grises	100%	247,326	247,326	164,884	164,884	46,898	0,000	1,435	0,000	User Specified
Lodos	100%	110,858	110,858	73,905	73,905	38,565	0,000	1,804	0,000	User Specified
FO Almacén BR	3,52%	3225,417	113,535	3325,172	117,046	240,148	-4,107	3,038	2940,961	IMO A.749(18)
FO Almacén ER	3,52%	3225,417	113,535	3325,172	117,046	240,148	4,107	3,038	2940,961	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			1123,300			81,548	0,000	10,982	6603,046	
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			101624,443	220299,223	149151,100	129,913	0,000	15,388	246194,831	
FS correction								2,423		
VCG fluid								17,811		

Draft Amidships m	11,571
Displacement t	101632
Heel deg	0,0
Draft at FP m	10,802
Draft at AP m	12,339
Draft at LCF m	11,627
Trim (+ve by stern) m	1,537
WL Length m	278,972
Beam max extents on WL m	43,194
Wetted Area m^2	14328,778
Waterpl. Area m^2	10065,597
Prismatic coeff. (Cp)	0,716
Block coeff. (Cb)	0,682
Max Sect. area coeff. (Cm)	0,991
Waterpl. area coeff. (Cwp)	0,835
LCB from zero pt. (+ve fwd) m	129,845
LCF from zero pt. (+ve fwd) m	124,068
KB m	6,246
KG fluid m	17,811
BMt m	13,785
BML m	490,299
GMt corrected m	2,219
GML m	478,733
KMt m	20,030
KML m	496,536
Immersion (TPc) tonne/cm	103,172
MTc tonne.m	1817,047
RM at 1deg = GMt.Disp.sin(1) tonne.m	3936,224
Max deck inclination deg	0,3288
Trim angle (+ve by stern) deg	0,3288

Equilibrium Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	0%	16408,559	0,000	38159,440	0,000	74,485	0,000	3,032	0,000	User Specified
Tanque 3	0%	18646,092	0,000	43363,003	0,000	120,735	0,000	3,032	0,000	User Specified
Tanque 2	0%	18646,092	0,000	43363,003	0,000	169,760	0,000	3,032	0,000	User Specified
Tanque 1	0%	11961,030	0,000	27816,349	0,000	211,541	0,000	3,032	0,000	User Specified
Total carga	0%	65661,773	0,000	152701,796	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	1728,991	1728,991	1686,821	1686,821	4,740	-7,841	14,783	0,000	User Specified
Pique PP ER	100%	1728,991	1728,991	1686,821	1686,821	4,740	7,841	14,783	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	100%	2666,833	2666,833	2601,789	2601,789	194,272	0,000	17,036	0,000	User Specified
Cofferdam 1	100%	1573,708	1573,708	1535,325	1535,325	232,175	0,000	17,045	0,000	User Specified
Pique PR BR	100%	581,031	581,031	566,859	566,859	268,686	-1,906	16,155	0,000	User Specified
Pique PR ER	100%	581,031	581,031	566,859	566,859	268,686	1,906	16,155	0,000	User Specified
Lastre 4 BR	100%	5014,252	5014,252	4891,953	4891,953	73,863	-15,611	9,342	0,000	User Specified
Lastre 4 ER	100%	5014,252	5014,252	4891,953	4891,953	73,863	15,611	9,342	0,000	User Specified
Lastre 3 BR	100%	6457,632	6457,632	6300,129	6300,129	119,611	-15,946	8,500	0,000	User Specified
Lastre 3 ER	100%	6457,632	6457,632	6300,129	6300,129	119,611	15,946	8,500	0,000	User Specified
Lastre 2 BR	100%	6146,861	6146,861	5996,938	5996,938	167,618	-15,733	8,698	0,000	User Specified
Lastre 2 ER	100%	6146,861	6146,861	5996,938	5996,938	167,618	15,733	8,698	0,000	User Specified
Lastre 1 BR	100%	4253,564	4253,564	4149,819	4149,819	213,247	-13,942	11,812	0,000	User Specified
Lastre 1 ER	100%	4253,564	4253,564	4149,819	4149,819	213,247	13,942	11,812	0,000	User Specified
Total lastre	86,85%	60566,752	52605,202	59089,514	51322,149	140,146	0,000	10,513	0,000	
Agua dulce BR	10%	77,236	3,862	77,236	3,862	9,610	-1,750	18,462	12,505	User Specified
Agua dulce ER	10%	77,236	3,862	77,236	3,862	9,610	1,750	18,462	12,505	User Specified

Aceite BR	10%	49,417	2,471	54,908	2,745	32,095	-17,140	18,395	17,168	User Specified
Aceite ER	10%	49,417	2,471	54,908	2,745	32,095	17,140	18,395	17,168	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	63,776	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	63,776	User Specified
Diesel BR	10%	383,795	19,190	426,439	21,322	47,608	-15,200	18,488	267,113	User Specified
Diesel ER	10%	383,795	19,190	426,439	21,322	47,608	15,200	18,488	267,113	User Specified
Aguas grises	100%	247,326	247,326	164,884	164,884	46,898	0,000	1,435	0,000	User Specified
Lodos	100%	110,858	110,858	73,905	73,905	38,565	0,000	1,804	0,000	User Specified
FO Almacén BR	3,52%	3225,417	113,535	3325,172	117,046	240,148	-4,107	3,038	2940,961	IMO A.749(18)
FO Almacén ER	3,52%	3225,417	113,535	3325,172	117,046	240,148	4,107	3,038	2940,961	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			1123,301			81,548	0,000	10,982	6603,046	
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			90537,723	220299,223	52352,501	128,949	0,000	11,714	6603,046	
FS correction								0,073		
VCG fluid								11,787		

Draft Amidships m	10,461
Displacement t	90543
Heel deg	0,0
Draft at FP m	9,302
Draft at AP m	11,621
Draft at LCF m	10,535
Trim (+ve by stern) m	2,319
WL Length m	281,815
Beam max extents on WL m	43,189
Wetted Area m^2	13603,841
Waterpl. Area m^2	9916,690
Prismatic coeff. (Cp)	0,697
Block coeff. (Cb)	0,645
Max Sect. area coeff. (Cm)	0,990
Waterpl. area coeff. (Cwp)	0,815
LCB from zero pt. (+ve fwd) m	128,894
LCF from zero pt. (+ve fwd) m	125,346
KB m	5,664
KG fluid m	11,787
BMt m	15,090
BML m	531,769
GMt corrected m	8,968
GML m	525,647
KMt m	20,754
KML m	537,414
Immersion (TPc) tonne/cm	101,646
MTc tonne.m	1777,428
RM at 1deg = GMt.Disp.sin(1) tonne.m	14170,800
Max deck inclination deg	0,4963
Trim angle (+ve by stern) deg	0,4963

ANEXO III

Report criterios de estabilidad

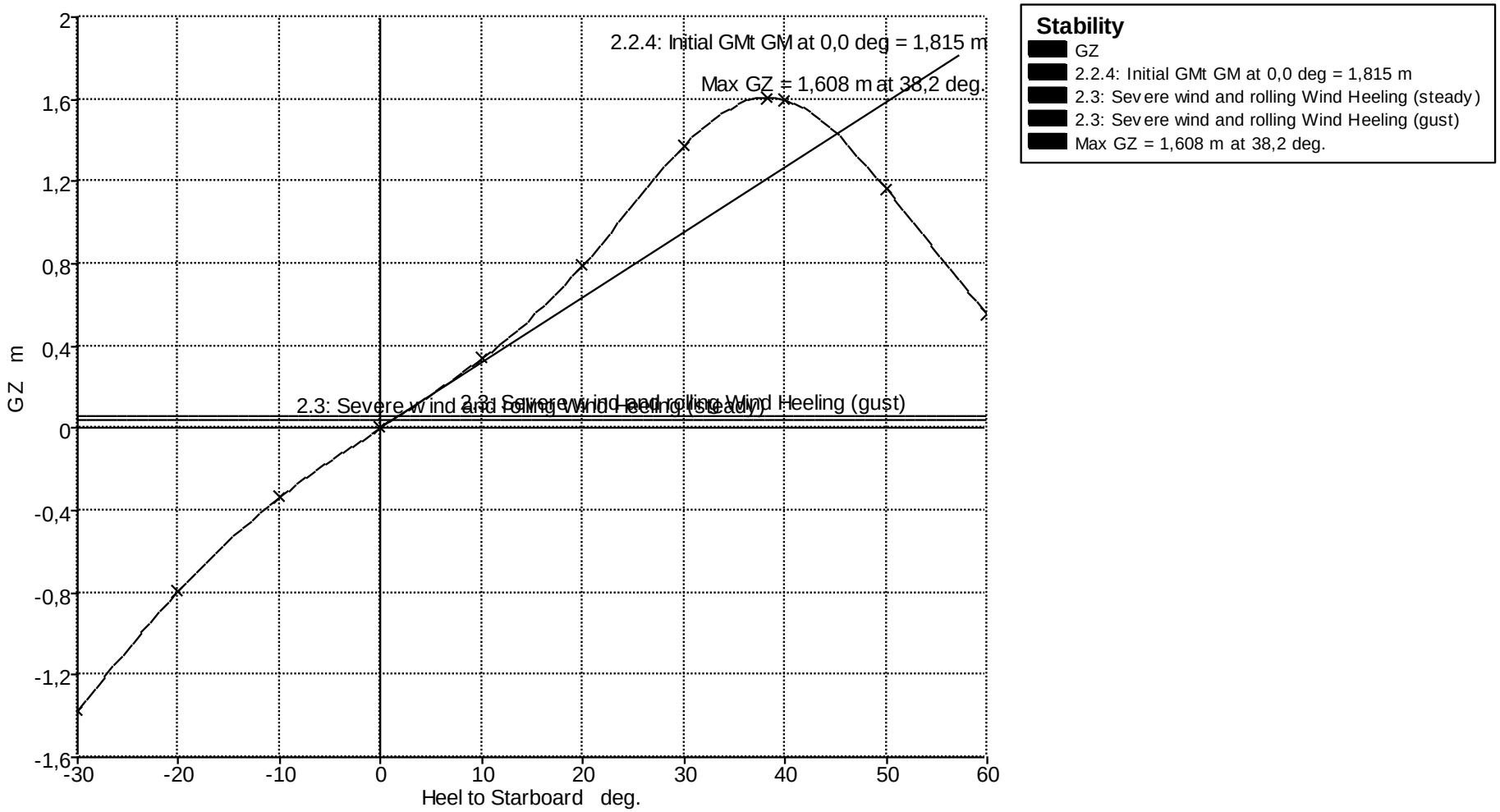
Stability Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	97%	16408,559	15916,304	38159,440	37014,661	74,485	0,000	16,594	60772,620	IMO A.749(18)
Tanque 3	97%	18646,092	18086,709	43363,003	42062,114	120,735	0,000	16,594	69059,801	IMO A.749(18)
Tanque 2	97%	18646,092	18086,708	43363,003	42062,112	169,760	0,000	16,594	69059,801	IMO A.749(18)
Tanque 1	97%	11961,030	11602,200	27816,349	26981,861	212,060	0,000	16,540	40699,562	IMO A.749(18)
Total carga	97%	65661,773	63691,922	152701,796	148120,747	139,735	0,000	16,584	239591,784	
Pique PP BR	0%	1728,991	0,000	1686,821	0,000	10,794	-1,532	8,029	0,000	User Specified
Pique PP ER	0%	1728,991	0,000	1686,821	0,000	10,794	1,532	8,029	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	0%	2666,833	0,000	2601,789	0,000	194,272	0,000	3,032	0,000	User Specified
Cofferdam 1	0%	1573,708	0,000	1535,325	0,000	232,157	0,000	3,032	0,000	User Specified
Pique PR BR	0%	581,031	0,000	566,859	0,000	269,203	-0,776	2,500	0,000	User Specified
Pique PR ER	0%	581,031	0,000	566,859	0,000	269,203	0,776	2,500	0,000	User Specified
Lastre 4 BR	0%	5014,252	0,000	4891,953	0,000	66,028	-0,013	0,000	0,000	User Specified
Lastre 4 ER	0%	5014,252	0,000	4891,953	0,000	66,028	0,013	0,000	0,000	User Specified
Lastre 3 BR	0%	6457,632	0,000	6300,129	0,000	95,113	-0,048	0,029	0,000	User Specified
Lastre 3 ER	0%	6457,632	0,000	6300,129	0,000	95,113	0,048	0,029	0,000	User Specified
Lastre 2 BR	0%	6146,861	0,000	5996,938	0,000	144,542	-3,597	0,046	0,000	User Specified
Lastre 2 ER	0%	6146,861	0,000	5996,938	0,000	144,542	3,597	0,046	0,000	User Specified
Lastre 1 BR	0%	4253,564	0,000	4149,819	0,000	200,429	-0,099	0,046	0,000	User Specified
Lastre 1 ER	0%	4253,564	0,000	4149,819	0,000	200,429	0,099	0,046	0,000	User Specified
Total lastre	0%	60566,752	0,000	59089,514	0,000	0,000	0,000	0,000	0,000	

Agua dulce BR	100%	77,236	77,236	77,236	77,236	9,610	-1,750	21,550	0,000	User Specified
Agua dulce ER	100%	77,236	77,236	77,236	77,236	9,610	1,750	21,550	0,000	User Specified
Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	20,200	0,000	User Specified
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	20,200	0,000	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	0,000	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	0,000	User Specified
Diesel BR	100%	383,795	383,795	426,439	426,439	47,608	-15,200	22,055	0,000	User Specified
Diesel ER	100%	383,795	383,795	426,439	426,439	47,608	15,200	22,055	0,000	User Specified
Aguas grises	0%	247,326	0,000	164,884	0,000	51,307	0,000	0,041	0,000	User Specified
Lodos	0%	110,858	0,000	73,905	0,000	41,955	0,000	0,510	0,000	User Specified
FO Almacén BR	97%	3225,417	3128,655	3325,172	3225,417	240,185	-6,205	13,372	2940,961	IMO A.749(18)
FO Almacén ER	97%	3225,417	3128,655	3325,172	3225,417	240,185	6,205	13,372	2940,961	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			7769,147			201,241	0,000	14,961	5881,922	
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			108270,289	220299,223	156190,362	135,533	0,000	15,403	245473,706	
FS correction								2,267		
VCG fluid								17,670		


Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 1,815 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 1,608 m at 38,2 deg.
2.2.4: Initial GMt GM at 0,0 deg = 1,815 m
Max GZ = 1,608 m at 38,2 deg.
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
GZ m
2
1,6
1,2
0,8
0,4
0
-0,4
-0,8
-1,2
-1,6
-30
-20
-10
0
10
20
30
40
50
60
Heel to Starboard 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	-1,375	-0,790	-0,338	0,000	0,338	0,790	1,375	1,598	1,161	0,552
Area under GZ curve from zero heel m.deg	17,9145	7,1597	1,6406	0,0000	1,6467	7,1349	18,0068	33,3949	47,5712	56,1541
Displacement t	108263	108270	108270	108270	108270	108270	108270	108270	108267	108271
Draft at FP m	13,653	13,541	13,416	13,373	13,416	13,541	13,653	13,535	13,265	12,493
Draft at AP m	9,865	10,715	11,164	11,301	11,163	10,715	9,867	8,300	5,865	1,694
WL Length m	274,620	274,570	272,187	271,861	272,185	274,570	274,620	274,593	274,587	276,511
Beam max extents on WL m	48,145	45,879	43,854	43,196	43,854	45,879	48,145	40,903	37,911	36,525
Wetted Area m^2	14907,342	14803,950	14708,348	14669,979	14708,330	14803,976	14907,776	15071,113	14930,841	14863,661
Waterpl. Area m^2	10741,003	10422,002	10092,100	9958,060	10092,050	10422,022	10741,234	9993,181	9138,146	8859,717
Prismatic coeff. (Cp)	0,744	0,736	0,735	0,734	0,735	0,736	0,744	0,755	0,760	0,754
Block coeff. (Cb)	0,397	0,463	0,574	0,676	0,574	0,463	0,397	0,442	0,467	0,491
LCB from zero pt. (+ve fwd) m	135,680	135,645	135,624	135,619	135,625	135,644	135,676	135,715	135,755	135,786
LCF from zero pt. (+ve fwd) m	128,723	126,756	126,175	126,223	126,176	126,756	128,722	128,542	133,815	136,543
Max deck inclination deg	30,0074	20,0077	10,0111	0,4432	10,0111	20,0077	30,0074	40,0077	50,0076	60,0067
Trim angle (+ve by stern) deg	-0,8105	-0,6048	-0,4819	-0,4432	-0,4821	-0,6047	-0,8100	-1,1201	-1,5831	-2,3096

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	16,0	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	18,0068	Pass	+471,41
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	33,3949	Pass	+547,61
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	15,3880	Pass	+795,22
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	1,608	Pass	+704,00
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	38,2	Pass	+52,73
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	1,815	Pass	+1110,00
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	1,2	Pass	+92,49
	Area1 / Area2 shall not be less than (>=)	100,00	%	969,99	Pass	+869,99

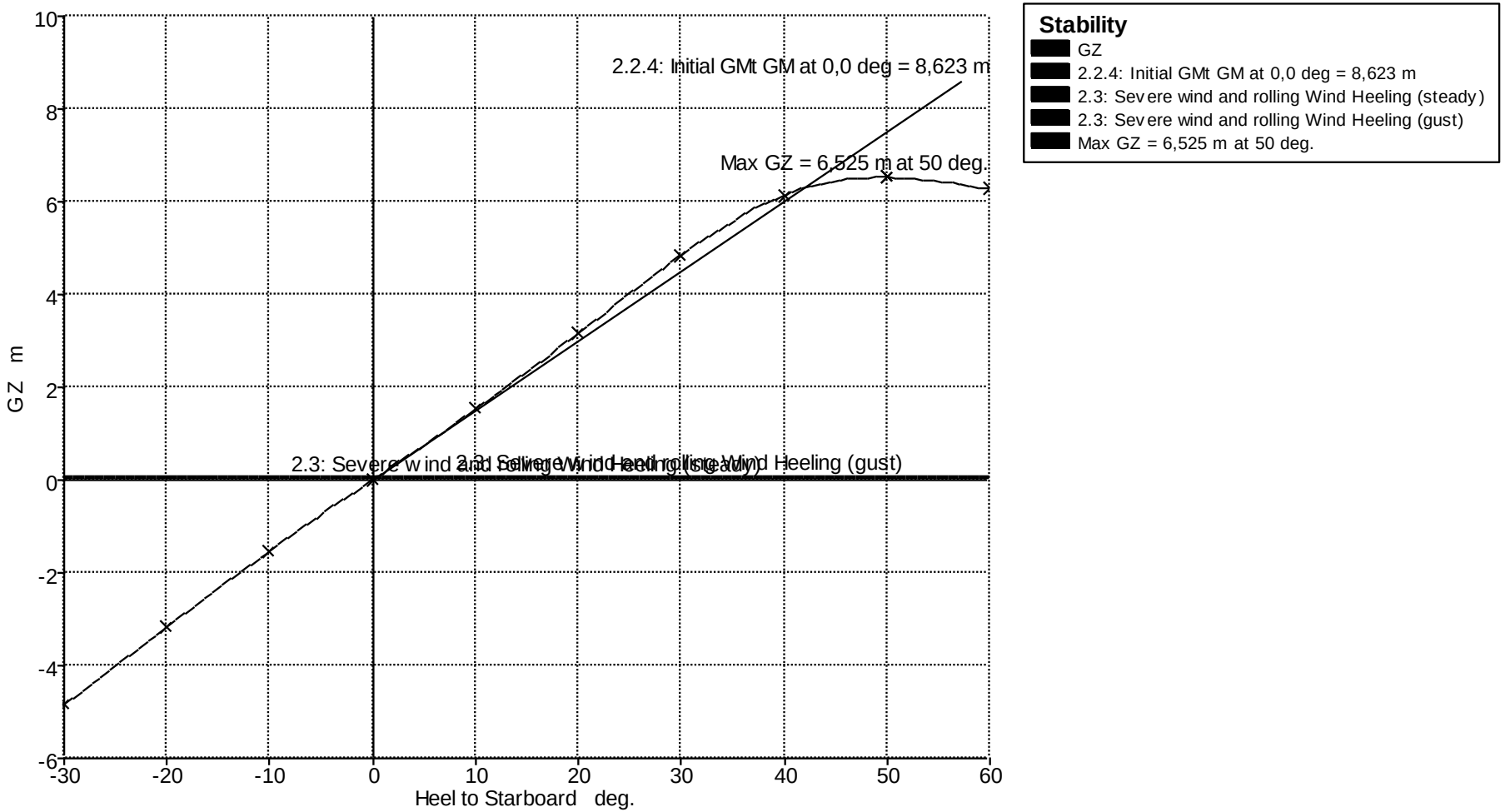
Stability Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	0%	16408,559	0,000	38159,440	0,000	74,485	0,000	3,032	0,000	User Specified
Tanque 3	0%	18646,092	0,000	43363,003	0,000	120,735	0,000	3,032	0,000	User Specified
Tanque 2	0%	18646,092	0,000	43363,003	0,000	169,760	0,000	3,032	0,000	User Specified
Tanque 1	0%	11961,030	0,000	27816,349	0,000	211,541	0,000	3,032	0,000	User Specified
Total carga	0%	65661,773	0,000	152701,796	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	1728,991	1728,991	1686,821	1686,821	4,740	-7,841	14,783	0,000	User Specified
Pique PP ER	100%	1728,991	1728,991	1686,821	1686,821	4,740	7,841	14,783	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	0%	2666,833	0,000	2601,789	0,000	194,272	0,000	3,032	0,000	User Specified
Cofferdam 1	0%	1573,708	0,000	1535,325	0,000	232,157	0,000	3,032	0,000	User Specified
Pique PR BR	100%	581,031	581,031	566,859	566,859	268,686	-1,906	16,155	0,000	User Specified
Pique PR ER	100%	581,031	581,031	566,859	566,859	268,686	1,906	16,155	0,000	User Specified
Lastre 4 BR	100%	5014,252	5014,252	4891,953	4891,953	73,863	-15,611	9,342	0,000	User Specified
Lastre 4 ER	100%	5014,252	5014,252	4891,953	4891,953	73,863	15,611	9,342	0,000	User Specified
Lastre 3 BR	100%	6457,632	6457,632	6300,129	6300,129	119,611	-15,946	8,500	0,000	User Specified
Lastre 3 ER	100%	6457,632	6457,632	6300,129	6300,129	119,611	15,946	8,500	0,000	User Specified
Lastre 2 BR	100%	6146,861	6146,861	5996,938	5996,938	167,618	-15,733	8,698	0,000	User Specified
Lastre 2 ER	100%	6146,861	6146,861	5996,938	5996,938	167,618	15,733	8,698	0,000	User Specified
Lastre 1 BR	100%	4253,564	4253,564	4149,819	4149,819	213,247	-13,942	11,812	0,000	User Specified
Lastre 1 ER	100%	4253,564	4253,564	4149,819	4149,819	213,247	13,942	11,812	0,000	User Specified
Total lastre	79,85%	60566,752	48364,661	59089,514	47185,035	134,167	0,000	9,941	0,000	
Agua dulce BR	100%	77,236	77,236	77,236	77,236	9,610	-1,750	21,550	0,000	User Specified
Agua dulce ER	100%	77,236	77,236	77,236	77,236	9,610	1,750	21,550	0,000	User Specified

Aceite BR	100%	49,417	49,417	54,908	54,908	32,095	-17,140	20,200	0,000	User Specified
Aceite ER	100%	49,417	49,417	54,908	54,908	32,095	17,140	20,200	0,000	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	0,000	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	0,000	User Specified
Diesel BR	100%	383,795	383,795	426,439	426,439	47,608	-15,200	22,055	0,000	User Specified
Diesel ER	100%	383,795	383,795	426,439	426,439	47,608	15,200	22,055	0,000	User Specified
Aguas grises	0%	247,326	0,000	164,884	0,000	51,307	0,000	0,041	0,000	User Specified
Lodos	0%	110,858	0,000	73,905	0,000	41,955	0,000	0,510	0,000	User Specified
FO Almacén BR	97%	3225,417	3128,654	3325,172	3225,417	240,185	-6,205	13,372	2940,961	IMO A.749(18)
FO Almacén ER	97%	3225,417	3128,654	3325,172	3225,417	240,185	6,205	13,372	2940,961	IMO A.749(18)
Viveres	1	4,375	4,375			57,000	0,000	39,200	0,000	User Specified
Total consumos			7769,146			201,241	0,000	14,961	5881,922	
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			92943,027	220299,223	55254,649	131,943	0,000	11,751	5881,922	
FS correction								0,063		
VCG fluid								11,814		



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	-4,843	-3,168	-1,528	0,000	1,528	3,168	4,843	6,134	6,525	6,278
Area under GZ curve from zero heel m.deg	71,0337	30,9813	7,5738	0,0000	7,5788	30,9594	71,1104	126,5842	190,6126	254,9070
Displacement t	92936	92942	92943	92943	92943	92943	92942	92943	92943	92943
Draft at FP m	10,589	10,548	10,438	10,402	10,440	10,550	10,587	10,043	9,077	7,239
Draft at AP m	9,528	10,475	10,952	11,092	10,950	10,474	9,531	7,773	4,863	0,139
WL Length m	279,571	279,612	276,689	276,525	276,679	279,607	279,577	280,859	281,810	282,180
Beam max extents on WL m	45,069	45,779	43,843	43,190	43,843	45,779	45,070	40,847	35,781	34,553
Wetted Area m^2	13831,671	13858,372	13764,091	13725,597	13764,086	13858,435	13832,073	13698,512	13707,459	13660,226
Waterpl. Area m^2	10259,721	10240,620	9969,882	9847,366	9969,685	10240,484	10260,042	9980,354	8799,092	8502,360
Prismatic coeff. (Cp)	0,743	0,724	0,718	0,714	0,718	0,724	0,743	0,743	0,740	0,735
Block coeff. (Cb)	0,387	0,429	0,542	0,694	0,542	0,429	0,387	0,401	0,450	0,475
LCB from zero pt. (+ve fwd) m	131,973	131,934	131,924	131,927	131,930	131,939	131,962	131,994	132,040	132,084
LCF from zero pt. (+ve fwd) m	127,884	126,560	126,262	126,399	126,265	126,562	127,881	128,822	133,057	135,748
Max deck inclination deg	30,0006	20,0000	10,0006	0,1476	10,0006	20,0000	30,0006	40,0014	50,0025	60,0029
Trim angle (+ve by stern) deg	-0,2270	-0,0157	0,1098	0,1476	0,1092	-0,0163	-0,2258	-0,4857	-0,9016	-1,5189

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	21,5	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	71,1104	Pass	+2156,54
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	126,5842	Pass	+2354,80
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	55,4737	Pass	+3127,28
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	6,525	Pass	+3162,50
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	50,0	Pass	+100,00
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	8,623	Pass	+5648,67
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	0,3	Pass	+97,87
	Area1 / Area2 shall not be less than (>=)	100,00	%	514,46	Pass	+414,46

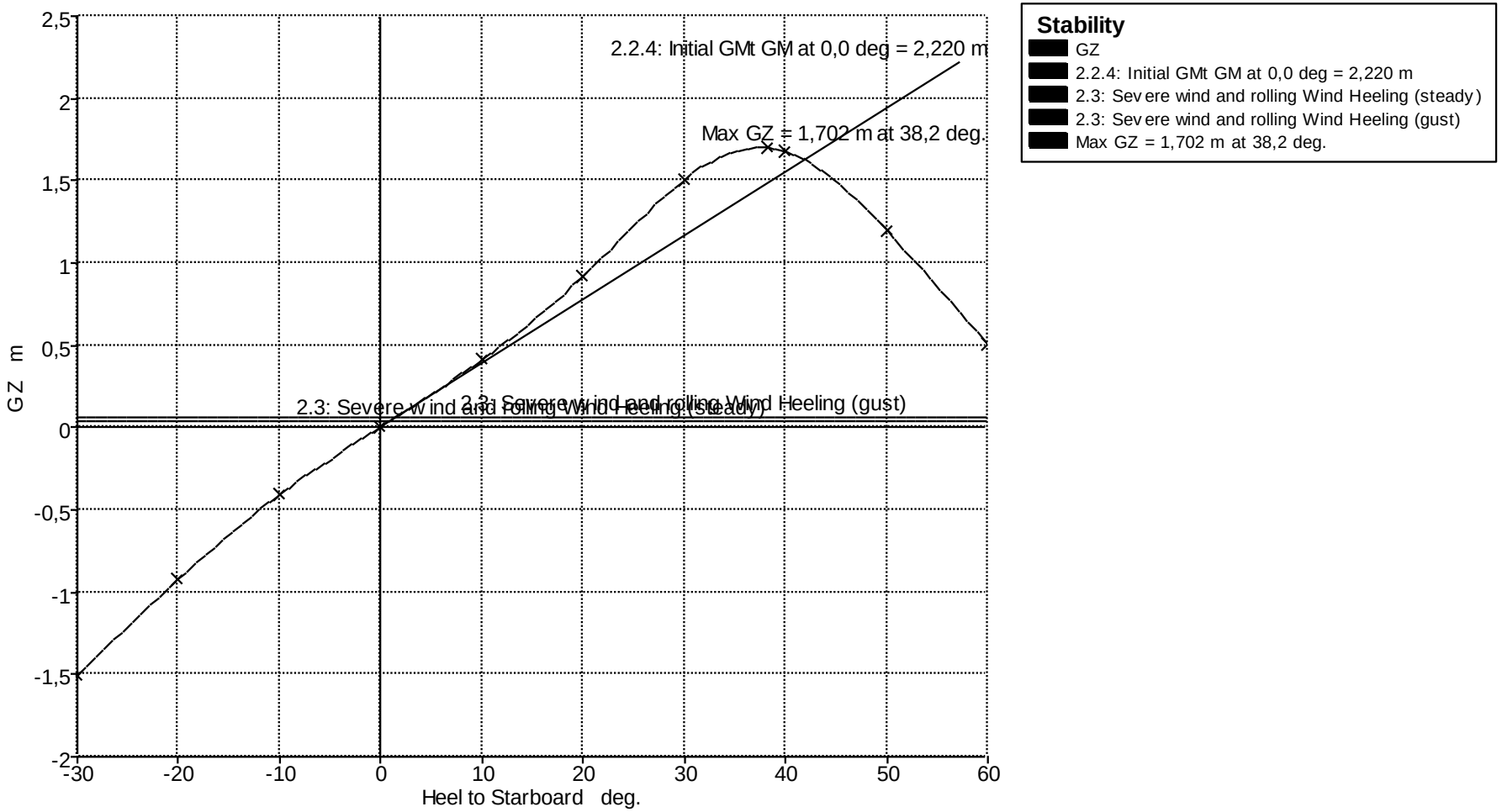
Stability Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	97%	16408,559	15916,303	38159,440	37014,657	74,485	0,000	16,594	60772,620	IMO A.749(18)
Tanque 3	97%	18646,092	18086,711	43363,003	42062,118	120,735	0,000	16,594	69059,801	IMO A.749(18)
Tanque 2	97%	18646,092	18086,709	43363,003	42062,113	169,760	0,000	16,594	69059,801	IMO A.749(18)
Tanque 1	97%	11961,030	11602,199	27816,349	26981,857	212,060	0,000	16,540	40699,562	IMO A.749(18)
Total carga	97%	65661,773	63691,921	152701,796	148120,745	139,735	0,000	16,584	239591,784	
Pique PP BR	0%	1728,991	0,000	1686,821	0,000	10,794	-1,532	8,029	0,000	User Specified
Pique PP ER	0%	1728,991	0,000	1686,821	0,000	10,794	1,532	8,029	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	0%	2666,833	0,000	2601,789	0,000	194,272	0,000	3,032	0,000	User Specified
Cofferdam 1	0%	1573,708	0,000	1535,325	0,000	232,157	0,000	3,032	0,000	User Specified
Pique PR BR	0%	581,031	0,000	566,859	0,000	269,203	-0,776	2,500	0,000	User Specified
Pique PR ER	0%	581,031	0,000	566,859	0,000	269,203	0,776	2,500	0,000	User Specified
Lastre 4 BR	0%	5014,252	0,000	4891,953	0,000	66,028	-0,013	0,000	0,000	User Specified
Lastre 4 ER	0%	5014,252	0,000	4891,953	0,000	66,028	0,013	0,000	0,000	User Specified
Lastre 3 BR	0%	6457,632	0,000	6300,129	0,000	95,113	-0,048	0,029	0,000	User Specified
Lastre 3 ER	0%	6457,632	0,000	6300,129	0,000	95,113	0,048	0,029	0,000	User Specified
Lastre 2 BR	0%	6146,861	0,000	5996,938	0,000	144,542	-3,597	0,046	0,000	User Specified
Lastre 2 ER	0%	6146,861	0,000	5996,938	0,000	144,542	3,597	0,046	0,000	User Specified
Lastre 1 BR	0%	4253,564	0,000	4149,819	0,000	200,429	-0,099	0,046	0,000	User Specified
Lastre 1 ER	0%	4253,564	0,000	4149,819	0,000	200,429	0,099	0,046	0,000	User Specified
Total lastre	0%	60566,752	0,000	59089,514	0,000	0,000	0,000	0,000	0,000	
Agua dulce BR	10%	77,236	3,862	77,236	3,862	9,610	-1,750	18,462	12,505	User Specified
Agua dulce ER	10%	77,236	3,862	77,236	3,862	9,610	1,750	18,462	12,505	User Specified
Aceite BR	10%	49,417	2,471	54,908	2,745	32,095	-17,140	18,395	17,168	User Specified
Aceite ER	10%	49,417	2,471	54,908	2,745	32,095	17,140	18,395	17,168	User Specified

FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	63,776	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	63,776	User Specified
Diesel BR	10%	383,795	19,190	426,439	21,322	47,608	-15,200	18,488	267,113	User Specified
Diesel ER	10%	383,795	19,190	426,439	21,322	47,608	15,200	18,488	267,113	User Specified
Aguas grises	100%	247,326	247,326	164,884	164,884	46,898	0,000	1,435	0,000	User Specified
Lodos	100%	110,858	110,858	73,905	73,905	38,565	0,000	1,804	0,000	User Specified
FO Almacén BR	3,52%	3225,417	113,535	3325,172	117,046	240,148	-4,107	3,038	2940,961	IMO A.749(18)
FO Almacén ER	3,52%	3225,417	113,535	3325,172	117,046	240,148	4,107	3,038	2940,961	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			1123,300			81,548	0,000	10,982	6603,046	
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			101624,441	220299,223	149151,097	129,913	0,000	15,388	246194,831	
FS correction								2,423		
VCG fluid								17,811		


Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 2,220 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 1,702 m at 38,2 deg.
2.2.4: Initial GMt GM at 0,0 deg = 2,220 m
Max GZ = 1,702 m at 38,2 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.
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	-1,504	-0,920	-0,409	0,000	0,409	0,920	1,504	1,682	1,196	0,510
Area under GZ curve from zero heel m.deg	20,6372	8,5482	1,9922	0,0000	1,9991	8,5196	20,7420	37,2133	51,9946	60,5567
Displacement t	101624	101624	101624	101624	101624	101624	101624	101625	101624	101625
Draft at FP m	10,996	10,953	10,847	10,802	10,848	10,953	10,997	10,547	9,635	7,884
Draft at AP m	10,950	11,762	12,194	12,338	12,193	11,761	10,948	9,431	7,254	3,460
WL Length m	278,633	278,693	278,909	278,973	278,907	278,692	278,630	279,806	281,436	282,125
Beam max extents on WL m	46,695	45,844	43,849	43,194	43,849	45,844	46,695	40,844	36,476	35,198
Wetted Area m^2	14444,991	14403,138	14361,668	14328,285	14361,688	14403,173	14444,984	14440,536	14388,998	14336,037
Waterpl. Area m^2	10583,181	10425,268	10184,457	10065,446	10184,384	10425,252	10583,125	10030,218	9004,451	8721,339
Prismatic coeff. (Cp)	0,754	0,732	0,720	0,716	0,720	0,732	0,754	0,760	0,758	0,754
Block coeff. (Cb)	0,392	0,447	0,554	0,682	0,554	0,447	0,392	0,422	0,461	0,486
LCB from zero pt. (+ve fwd) m	129,906	129,875	129,852	129,846	129,855	129,876	129,911	129,956	129,985	130,024
LCF from zero pt. (+ve fwd) m	127,025	125,250	124,072	124,070	124,073	125,250	127,027	128,407	132,682	135,560
Max deck inclination deg	30,0000	20,0006	10,0040	0,3287	10,0040	20,0006	30,0000	40,0003	50,0008	60,0011
Trim angle (+ve by stern) deg	-0,0098	0,1731	0,2883	0,3287	0,2879	0,1730	-0,0104	-0,2386	-0,5094	-0,9465

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	16,7	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	20,7420	Pass	+558,20
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	37,2133	Pass	+621,66
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	16,4714	Pass	+858,25
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	1,702	Pass	+751,00
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	38,2	Pass	+52,73
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	2,220	Pass	+1380,00
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	1,1	Pass	+92,97
	Area1 / Area2 shall not be less than (>=)	100,00	%	804,47	Pass	+704,47

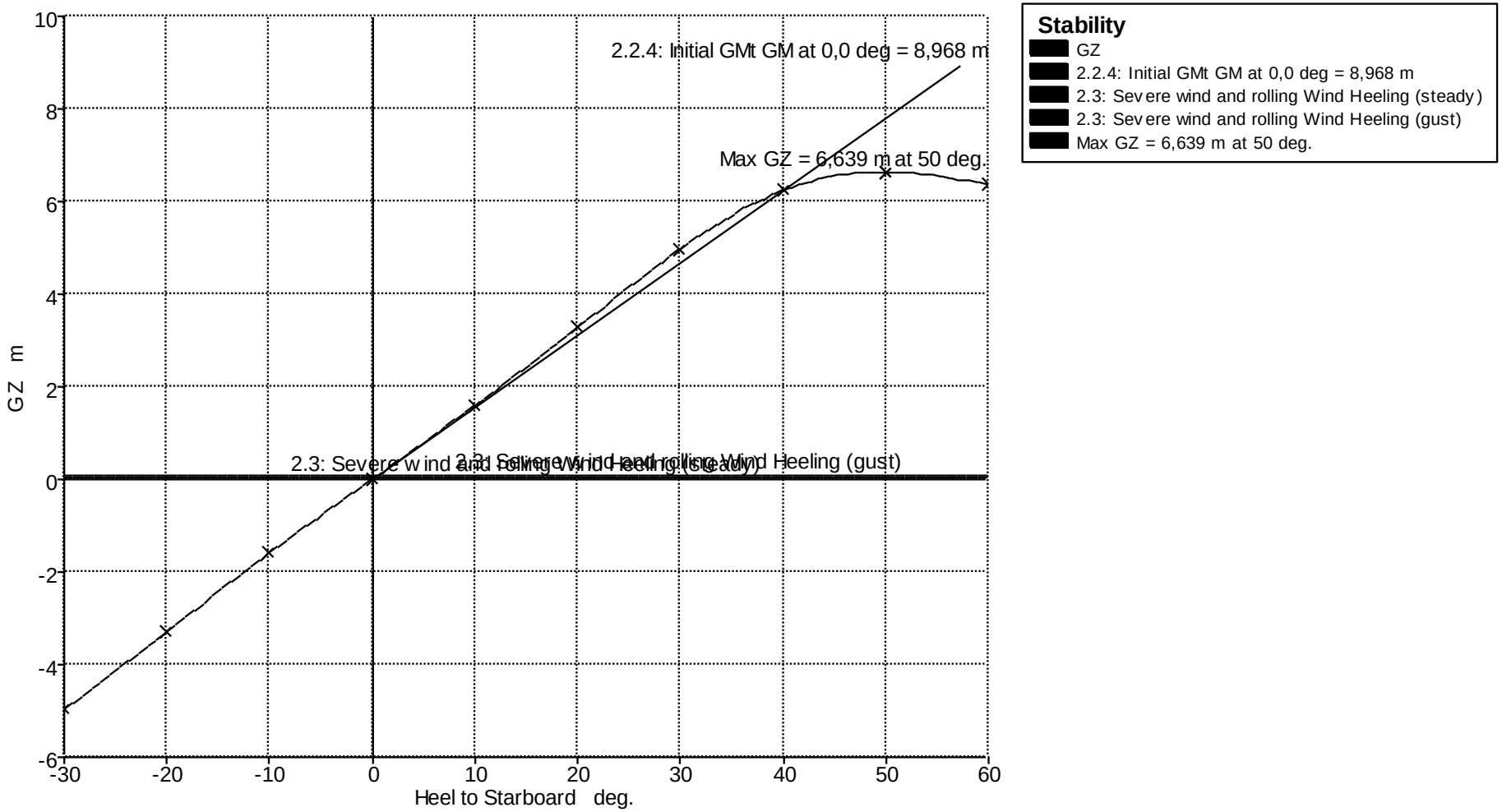
Stability Calculation - Tanques final - copia (2)

Stability 20.00.04.9, build: 9
Model file: F:\TFM\CONTENIDO\TFG\CUADERNO 4\MÁSTER\Tanques final - copia (2) (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	36703,970	36703,970			114,365	0,000	13,409	0,000	
Total rosca			36703,970			114,365	0,000	13,409	0,000	
Tanque 4	0%	16408,559	0,000	38159,440	0,000	74,485	0,000	3,032	0,000	User Specified
Tanque 3	0%	18646,092	0,000	43363,003	0,000	120,735	0,000	3,032	0,000	User Specified
Tanque 2	0%	18646,092	0,000	43363,003	0,000	169,760	0,000	3,032	0,000	User Specified
Tanque 1	0%	11961,030	0,000	27816,349	0,000	211,541	0,000	3,032	0,000	User Specified
Total carga	0%	65661,773	0,000	152701,796	0,000	0,000	0,000	0,000	0,000	
Pique PP BR	100%	1728,991	1728,991	1686,821	1686,821	4,740	-7,841	14,783	0,000	User Specified
Pique PP ER	100%	1728,991	1728,991	1686,821	1686,821	4,740	7,841	14,783	0,000	User Specified
Cofferdam 5	0%	2627,904	0,000	2563,809	0,000	52,768	0,000	3,032	0,000	User Specified
Cofferdam 4	0%	2666,826	0,000	2601,782	0,000	96,222	0,000	3,032	0,000	User Specified
Cofferdam 3	0%	2666,819	0,000	2601,774	0,000	145,247	0,000	3,032	0,000	User Specified
Cofferdam 2	100%	2666,833	2666,833	2601,789	2601,789	194,272	0,000	17,036	0,000	User Specified
Cofferdam 1	100%	1573,708	1573,708	1535,325	1535,325	232,175	0,000	17,045	0,000	User Specified
Pique PR BR	100%	581,031	581,031	566,859	566,859	268,686	-1,906	16,155	0,000	User Specified
Pique PR ER	100%	581,031	581,031	566,859	566,859	268,686	1,906	16,155	0,000	User Specified
Lastre 4 BR	100%	5014,252	5014,252	4891,953	4891,953	73,863	-15,611	9,342	0,000	User Specified
Lastre 4 ER	100%	5014,252	5014,252	4891,953	4891,953	73,863	15,611	9,342	0,000	User Specified
Lastre 3 BR	100%	6457,632	6457,632	6300,129	6300,129	119,611	-15,946	8,500	0,000	User Specified
Lastre 3 ER	100%	6457,632	6457,632	6300,129	6300,129	119,611	15,946	8,500	0,000	User Specified
Lastre 2 BR	100%	6146,861	6146,861	5996,938	5996,938	167,618	-15,733	8,698	0,000	User Specified
Lastre 2 ER	100%	6146,861	6146,861	5996,938	5996,938	167,618	15,733	8,698	0,000	User Specified
Lastre 1 BR	100%	4253,564	4253,564	4149,819	4149,819	213,247	-13,942	11,812	0,000	User Specified
Lastre 1 ER	100%	4253,564	4253,564	4149,819	4149,819	213,247	13,942	11,812	0,000	User Specified
Total lastre	86,85%	60566,752	52605,202	59089,514	51322,149	140,146	0,000	10,513	0,000	
Agua dulce BR	10%	77,236	3,862	77,236	3,862	9,610	-1,750	18,462	12,505	User Specified
Agua dulce ER	10%	77,236	3,862	77,236	3,862	9,610	1,750	18,462	12,505	User Specified

Aceite BR	10%	49,417	2,471	54,908	2,745	32,095	-17,140	18,395	17,168	User Specified
Aceite ER	10%	49,417	2,471	54,908	2,745	32,095	17,140	18,395	17,168	User Specified
FO UD BR	100%	96,398	96,398	99,380	99,380	36,305	-16,700	20,610	0,000	User Specified
FO UD ER	100%	96,398	96,398	99,380	99,380	36,305	16,700	20,610	0,000	User Specified
FO Sed. BR	100%	146,884	146,884	151,427	151,427	41,235	-16,300	20,960	63,776	User Specified
FO Sed. ER	100%	146,884	146,884	151,427	151,427	41,235	16,300	20,960	63,776	User Specified
Diesel BR	10%	383,795	19,190	426,439	21,322	47,608	-15,200	18,488	267,113	User Specified
Diesel ER	10%	383,795	19,190	426,439	21,322	47,608	15,200	18,488	267,113	User Specified
Aguas grises	100%	247,326	247,326	164,884	164,884	46,898	0,000	1,435	0,000	User Specified
Lodos	100%	110,858	110,858	73,905	73,905	38,565	0,000	1,804	0,000	User Specified
FO Almacén BR	3,52%	3225,417	113,535	3325,172	117,046	240,148	-4,107	3,038	2940,961	IMO A.749(18)
FO Almacén ER	3,52%	3225,417	113,535	3325,172	117,046	240,148	4,107	3,038	2940,961	IMO A.749(18)
Viveres	1	0,438	0,438			57,000	0,000	39,200	0,000	User Specified
Total consumos			1123,300			81,548	0,000	10,982	6603,046	
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			90537,723	220299,223	52352,501	128,949	0,000	11,714	6603,046	
FS correction								0,073		
VCG fluid								11,787		


Stability
GZ
2.2.4: Initial GMt GM at 0,0 deg = 8,968 m
2.3: Severe wind and rolling Wind Heeling (steady)
2.3: Severe wind and rolling Wind Heeling (gust)
Max GZ = 6,639 m at 50 deg.
2.2.4: Initial GMt GM at 0,0 deg = 8,968 m
Max GZ = 6,639 m at 50 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	-4,970	-3,284	-1,589	0,000	1,588	3,284	4,970	6,233	6,639	6,366
Area under GZ curve from zero heel m.deg	73,4831	32,1876	7,8722	0,0000	7,8782	32,1611	73,5763	130,1665	195,2582	260,6044
Displacement t	90538	90537	90537	90538	90538	90537	90537	90538	90537	90538
Draft at FP m	9,417	9,434	9,336	9,301	9,338	9,435	9,416	8,763	7,470	5,159
Draft at AP m	10,088	11,007	11,478	11,620	11,476	11,007	10,088	8,362	5,615	1,134
WL Length m	281,675	281,690	281,518	281,816	281,505	281,689	281,675	281,992	282,161	281,821
Beam max extents on WL m	44,342	45,750	43,840	43,189	43,840	45,750	44,342	40,847	35,180	33,980
Wetted Area m^2	13638,274	13708,345	13645,550	13603,458	13645,358	13708,384	13638,192	13476,590	13496,025	13442,051
Waterpl. Area m^2	10186,326	10257,062	10039,791	9916,548	10039,398	10257,012	10186,292	9959,792	8718,846	8412,983
Prismatic coeff. (Cp)	0,738	0,715	0,702	0,697	0,702	0,715	0,738	0,744	0,745	0,743
Block coeff. (Cb)	0,384	0,420	0,528	0,645	0,528	0,420	0,384	0,394	0,451	0,479
LCB from zero pt. (+ve fwd) m	128,930	128,904	128,891	128,895	128,898	128,907	128,929	128,960	128,990	129,024
LCF from zero pt. (+ve fwd) m	126,950	125,771	125,125	125,347	125,130	125,772	126,950	127,984	132,209	134,646
Max deck inclination deg	30,0002	20,0024	10,0101	0,4962	10,0100	20,0024	30,0002	40,0000	50,0005	60,0009
Trim angle (+ve by stern) deg	0,1436	0,3367	0,4583	0,4962	0,4574	0,3362	0,1438	-0,0859	-0,3968	-0,8610

Code	Criteria	Value	Units	Actual	Status	Margin %
267(85) Ch2 - General Criteria	2.3: IMO roll back angle	21,3	deg			
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 30	3,1513	m.deg	73,5763	Pass	+2234,79
267(85) Ch2 - General Criteria	2.2.1: Area 0 to 40	5,1566	m.deg	130,1665	Pass	+2424,27
267(85) Ch2 - General Criteria	2.2.1: Area 30 to 40	1,7189	m.deg	56,5902	Pass	+3192,24
267(85) Ch2 - General Criteria	2.2.2: Max GZ at 30 or greater	0,200	m	6,639	Pass	+3219,50
267(85) Ch2 - General Criteria	2.2.3: Angle of maximum GZ	25,0	deg	50,0	Pass	+100,00
267(85) Ch2 - General Criteria	2.2.4: Initial GMt	0,150	m	8,968	Pass	+5878,67
267(85) Ch2 - General Criteria	2.3: Severe wind and rolling				Pass	
	Angle of steady heel shall not be greater than (<=)	16,0	deg	0,3	Pass	+97,84
	Area1 / Area2 shall not be less than (>=)	100,00	%	517,55	Pass	+417,55

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.

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[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.

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[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°.

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[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:

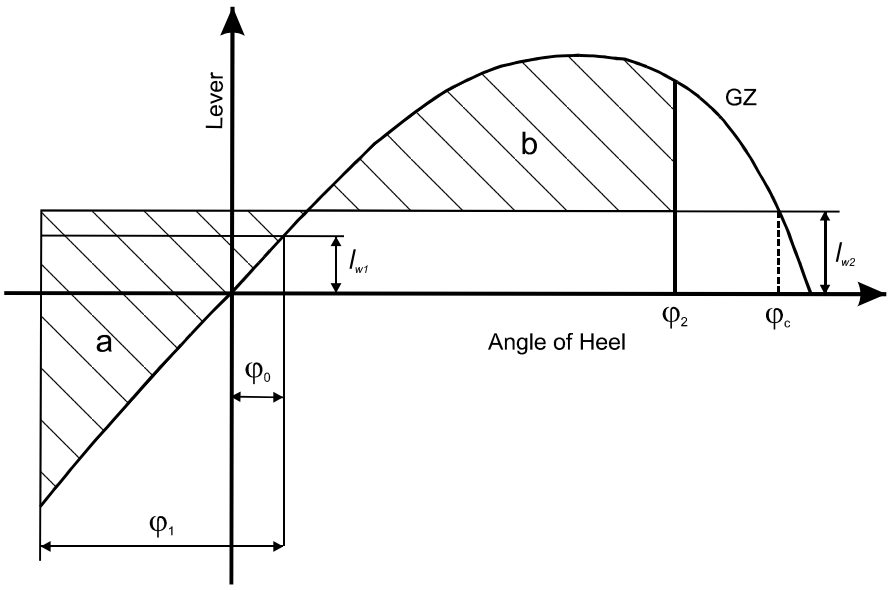

Figure 2.3.1 – Severe wind and rolling

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.